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Designing Tourist Complexes Based on the Ecosystem of Coral Islands

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Abstract:- Development of tourist beaches requires the construction of new buildings, which leads to the highest amounts of energy consumption, waste production, and environmental pollution. Therefore, it is essential to provide proper solutions to revise consumption patterns and reduce contamination. This paper proposes an optimum pattern for the design of public and residential buildings, focusing on reducing pollution and energy consumption, taking into account the ecosystem of the coral Hendorabi island and its environmental and climatic parameters. Simulated and field observations were used to determine the relationship between the environment and buildings through energy and bioclimatic analyses. With the help of environmental analysis in Design Builder software, the energy demand in the interior and exterior of the building was analyzed. The results show that a large part of the required energy could be provided by passive methods through environmental interaction. Moreover, through hybrid vertical and horizontal shades, continuous porches, ventilated shields on windows, lightweight materials, atriums, homogeneous polymer isolators, and rotating buildings towards coastal winds, the energy production expenses and required cooling load can be decreased by up to 75 kW-h/m2 every year. In the simulated model, 126 tons of greenhouse gas emissions were indirectly reduced by applying the proposed strategies.

Keywords: *Tourism, climatic design, Hendorabi Island, energy, cost, comfort, simulation*

Introduction

Over recent decades, the tourism industry has received global attention and is considered an indicator of the economic growth of countries. Among different forms of tourism, coastal tourism is the most popular one, having the highest profitability and growth rate (Veisi, 2015). Coastal areas in Northern and Southern Iran, particularly the coral islands of the Persian Gulf, have numerous attractions and are always welcomed by tourists, given their crystal-clear water and elegant ecosystem under the water. Hence, the government and investors have sought to develop Kish Island decades ago and the intact Hendorabi island over recent years. Accordingly, in 2010, the government assigned Hendorabi to Kish to develop tourism focused on ecotourism. Over recent years, by constructing an airport and a harbor, the Kish Free Zone Organization began to take civil engineering measures to develop tourism. On the other hand, according to environmental monitoring reports, the development and construction in the Kish and Qeshm islands, ignoring their special environment, have resulted in extensive damages to their resources, most of which are not recoverable. The increased recreational uses without taking environmental considerations into account, extended construction in the harbors, marine structures, and land reclamation have destructed coral reefs on Kish Island (Ganbari et al., 2012).

Since the design and architecture of tourism buildings and complexes have a key role in the physical development of tourist beaches, providing suitable solutions to achieve this goal seems necessary. As it is evident, the planning and design procedure in coastal areas and beaches, which intrinsically confront functional and ecological complexities, is different from that in cities and areas in deserts and requires an integrated and environmentalist approach. Such developments have been harmful regarding ecological and social impacts since they are planned and designed without basic investigations of the region's ecosystem and lead to their destruction. Although such impacts cannot be thoroughly eliminated, they can be remarkably mitigated through a proper planning and supervision framework in the construction of recreational facilities (Amraie, 2013). Yazdani et al. (2015) studied the buildings' 40% portion of energy consumption, indicating that they contribute to the production of more than 30% of contaminant gases and adverse environmental impacts. The solution is to plan based on a sustainable development model and investigate the environmental characteristics and integrated design. This requires a plan proposed based on taking advantage of environmental resources for recreational and educational tourism and improving the business capacities while preserving the environmental structures of the living ecosystems of the region. Such a goal can be achieved by determining sensitive areas and necessary borders, providing creative design methods and proper infrastructures to allow for recycling vital resources, minimizing the dependency on the consumption of fossil fuels, coordinating the form and design of buildings with natural and local characteristics of the region, and supplying local materials compatible with the environment. Assessing the ecosystem of Hendorabi Island and taking its climatic and environmental parameters into account, the present study proposes an optimum pattern for the design of residential buildings on this island with a focus on sustainability. The research seeks to answer the following question.

How can an effective step be taken to achieve harmony with nature and reduce operational costs and improper impacts of fossil fuels regarding influential factors, such as form, location, and orientation of buildings; shades; building color; materials used in surrounding walls; and zonation of interior spaces?

Theoretical basis and research background

Energy consumption optimization is a national issue in Iran, requiring the awareness and activity of all individuals and groups associated with it, including the construction industry. Of the total energy produced annually in the country, 40% is consumed by this industry, which is responsible for the production of half of the greenhouse gases (Kamali, 2014). Accordingly, by making wise decisions and employing designs proportional to environmental conditions, designers involved in the construction industry can play a key role in reducing energy consumption and, consequently, environmental contaminations (Mazor, 2011). As has been mentioned in previous studies and will be shown in the present article, the physical properties of a building, such as its form and orientation on the site, size of windows, shades, and materials used, if properly selected, can remarkably reduce energy consumption and greenhouse gas emissions, as well as the operating costs.

By reviewing the previous studies, the research background can be categorized into several groups. Some studies have investigated the building and site design principles to reduce energy consumption and environmental impacts. For instance, in a study entitled "Effect of Building Form on Energy Consumption in Kish Island," Yazdani et al. (2015) reported that choosing the proper form for a building by a designer and architect has a key role in decreasing energy consumption. In another study, Rashidzadeh et al. (2012) investigated the role of the architecture and design of tourist complexes in mitigating environmental effects. According to the obtained results, employing various architectural methods, especially taking advantage of new principles of sustainable architecture, and the way such complexes are designed directly contribute to the reduction of destructive environmental effects. Moreover, using recyclable materials and taking into account the location of land uses, the natural basis of design, and climatic zonation are effective in reducing such impacts. Kiper (2013) argued that in coral islands, dispersion of buildings should be prevented, and residential complexes should be designed to provide comfort for humans. As a result, the need to produce electricity lowers.

Maddahi et al. (2016) investigated the impact of window size in reducing energy consumption in buildings. They showed that by providing light through the design of windows based on the orientation and climate of the region, the energy consumption could be lowered. In their study, Iyendo et al. (2016) pointed out the application of material color in reducing solar heat absorption, architecture tailored to precipitation and altitude, passive techniques to preserve the heat inside the building, and harmony between building form and urban fabric in tropical areas as efficient and compatible layers.

Roustaie et al. (2015) studied the role of exterior shades in energy consumption reduction of residential buildings in the tropical climate of Bushehr. The outcomes revealed that the proper design of shades could lower the cooling load by up to 23%. Qoraishi (2017) assessed the parameters limiting energy consumption and concluded that taking local climatic considerations into account can result in saving the energy of residential buildings by up to 15% per year. In a study on the buildings on the southern border of the Persian Gulf, Al-Sallal (2013) stated that designing buildings without considering the proper form, orientation, and envelope can remarkably increase the heat gain and energy consumption to provide comfort. Mohammadzadeh et al. (2014) emphasized the role of local architecture in lowering energy consumption and found that exterior surface insulation and orientation, interior green spaces, and the relationship between site and building form micro-climate can reduce cooling and heating energy consumption by 45% through a field survey, simulation in IES and Energy Plus analytical software, and comparative-analytical research into a new building and a central courtyard form in Yazd, Iran.

A review of the literature reveals that some researchers have employed a multidisciplinary approach to achieve energy saving, as well as thermal comfort. Budaiwi (2011) investigated the impact of different measures for energy preservation and productivity in heating, ventilation, and air conditioning (HVAC) systems and their characteristics on the thermal performance of buildings, including thermal comfort. The obtained results indicated that in a building with low thermal gain, residents could adjust the temperature of HVAC systems to higher values in the summer, contributing to remarkable energy savings without lowering the thermal comfort (Tham, 1993). Al-Homoud et al. (2009) studied the energy consumption and thermal comfort of mosques in the tropical areas of Saudi Arabia and achieved similar outcomes. As a crucial finding, they reported that applying thermal insulation in the environment of a mosque can significantly enhance thermal comfort. Some studies have also investigated passive cooling systems. For instance, Mushtaha and Helmy (2016) assessed the influence of building forms on the thermal performance and thermal comfort inside public religious buildings in the tropical climate of the cities around the Persian Gulf. Their findings revealed that:

1. Buildings with a smaller facade area have better thermal conditions and lower heat gain. In particular, compared to square and rectangular shapes, the octagonal shape is known as the best form chosen for the design of mosques and public halls.
2. Besides choosing the optimum design method, incorporating passive components, especially thermal insulation and shades, in the walls of mosques notably improves thermal comfort. The energy audit performed in the present study indicated that by implementing the passive cooling strategies, the cooling load could be decreased by up to 10%.
3. While this study was performed on the mosques in the United Arab Emirates with a tropical climate, the proposed solutions can be adopted in constructing other buildings in this region. They believe that more efficient methods, along with more precise measurements, valuably coordinate the environmental and architectural conditions of public and religious buildings with the nature and climate of tropical areas.

Hanan (2014) studied eight passive methods to reduce the cooling load in residential buildings of a coastal town in the tropical climate of Dubai using the IES energy simulation software. The outcomes indicated that these methods make interior temperature variations limited within the comfort range. The thorough analysis showed that the approach was well capable of lowering the cooling load by 9%, exerting a marked effect on the reduction of greenhouse gas emissions. Overall, the annual energy consumption would decline by 23.6%.

Another group of studies argues the necessity of using an ecologic pattern in designing residential and tourist buildings on natural coasts and areas. For example, Amraie (2013) worked on ecologic sustainability solutions to design ecotourism recreational facilities. He presented the design criteria of such complexes and emphasized the capacity to use local architectural species of the region regarding their passive performance. In another study, Akrami and Damyar (2017) evaluated the commonalities of local architecture and sustainable architecture from perspectives of public participation, natural constructivism, natural exemplars, natural absolutism, and holism. Their findings showed that the local architecture is an ideal model for sustainable architecture from every perspective and can be thoroughly modeled.

Several studies examined site intervention and interpolation in ecological borders of islands, investigating the location of hotels and tourist complexes based on the reduced intervention of landscaping and human waste. Mahmoudi et al. (2010) performed a study under the title of "Desirable Land Use Zonation in Hendorabi Island through Multi-Criteria Spatial Assessment" from environmental-ecological and socio-economic perspectives and identified 15 criteria for the feasibility of locating tourist complexes on this island. They concluded that solely

43.5% of the island is suitable for tourism, and 25.6% of it is proper for other land uses such as residence. These findings warn how hazardous the previous approaches in Kish and Qeshm islands have been. In this regard, through multi-criteria spatial assessment, Abedini et al. (2012) determined the suitable tourist zones in Hendorabi Island based on eight major criteria and 17 subcriteria. They found the north-eastern area of the island appropriate for creating tourist camps and residences without any interference with ecological borders.

Research Methodology

Creating a building model and evaluating mediating environmental variables and susceptibility of dependent variables, i.e., comfort conditions and energy levels, allow for analyzing the relationship between a building and the environment and satisfying comfort conditions. Today, computer simulation offers the opportunity to implement the verified model as a testing basis for investigating the impacts of energy consumption optimization measures in buildings. The energy required in the interior and exterior in passive conditions can be analyzed using the environmental analysis software of Design Builder. In the first step, the building was simulated, and its cooling and heating demands were computed. Then, concerning the bioclimatic building analyses and climatic design requirements inspired by climatic zonation of group eight and subgroup three, the influential environmental factors and passive parameters, such as location method, the surface area of openings, insulation level of walls, specific heat capacity, and thermal capacity of materials and shading, were assessed to optimize the thermal performance of the building. To this end, each of the parameters was separately simulated and analyzed, and the results of the comparisons were provided in the design rules. In the next step, the combination of the chosen optimum parameters was simulated, and the level of reduction in energy demand was calculated.

The suitable air temperature considered as the thermal comfort range for the simulation of the building was 21.5-27℃ for residential and office spaces according to ASHRAE 2010-55 and 21.5-28℃ for public spaces based on the experiences in the project site.

The initial model was developed in the DesignBuilder software to evaluate the thermal performance and consumed energy in the residential building, including one story with an area of almost 1470 m^2. In the first stage, the building was assessed with no climate-compatible design. In the next stage, regarding the bioclimatic concepts extracted from a psychrometric chart, the required passive elements were assigned to it. The energy level was calculated in three separate stages for the cooling, heating, and lighting load. In the third step, the best design considerations compatible with the comfort needs and lowest energy level were introduced into the form composition and executive details step by step and compared with the initial conditions, among which the most efficient strategies were selected and added to the building as a whole. ??? The result obtained from the combination of all factors indicated the optimum design of the building.

Hendorabi Island, study area

Hendorabi is an intact coral island with an area of 21.95 km^2 in the north of the Persian Gulf, among the subsidiary islands of Kish in Hormozgan Province. The overall form of the island is similar to an ellipse with a major axis of almost 7.5 km and a minor axis of 3 km. Regarding natural terrains and features, the island is almost level, leading to the sea with a slight slope. Accordingly, its highest point has a height of only 11.21 m above sea level. Hendorabi has a distance of 9 km from the Bandar-e Chiruiyeh on the mainland and a distance of 28 km from Kish Island (Fig. 1). In suitable seasons, Hendorabi attracts many tourists for diving.

Figure 1: aerial image of Hendorabi Island (source: Kish ICZM studies)

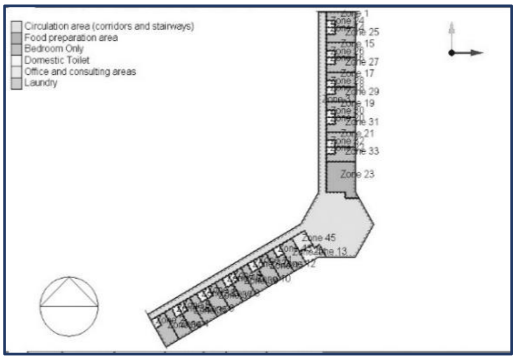

Figure 2: Plan of the accommodation building on Hendorabi Island- Hendorabi master plan (source: research findings)

The weather in Hendorabi Island falls into the desert region climatic category. However, this desert climate differs from the central areas of the country that receive extremely insignificant humidity throughout the year. The annual average temperature typically does not drop lower than 18˚C. The absolute maximum temperature recorded on the island hits a peak of 46˚C which increases evaporation and causes sultry weather due to the saturation of water vapor. Winter is the season with the most precipitation on Hendorabi Island, and the precipitation regime can be considered Mediterranean since the dry months coincide with the warm months of the year while rainy months occur in winter.

A study of the native architecture of kish Island demonstrates the role of climatic factors in the construction of this island throughout history. The scattered fabric on the island could have been a rational response to the need for ventilation and a way to reduce the humidity by allowing wind currents. This approach can be observed in the old residential fabrics of Kish and other villages in the southern regions of the country, where wind currents were used to reduce temperature and humidity.

The hotel building on the Island was modeled and simulated in the software to investigate the influence of climatic factors on energy consumption in the building, the results of which will be discussed in the following.

Results and interpretation

The building of the existing hotel underwent energy consumption from the three aspects of cooling, heating, and lighting assuming a year-round function. As Figure 1 demonstrates, the building has a total energy consumption of 194kWatt hours per square meter. The electric energy consumed to provide power for cooling systems (over the hot days of the year) by split units makes up the largest portion of the energy consumed in the building which is justified given the climate (hot and humid). On the contrary, the energy consumed by heating systems is quite insignificant at around 6.5kWatt hours per square, which is generally used to warm water to wash and bathe. The ratio of cooling to heating energy consumption is approximately 26. The largest portion of the energy consumed in the building is used in cooling systems throughout the year. Cooling needs to increase over the warmer months and decline during the cold months of the year (Figure 2).

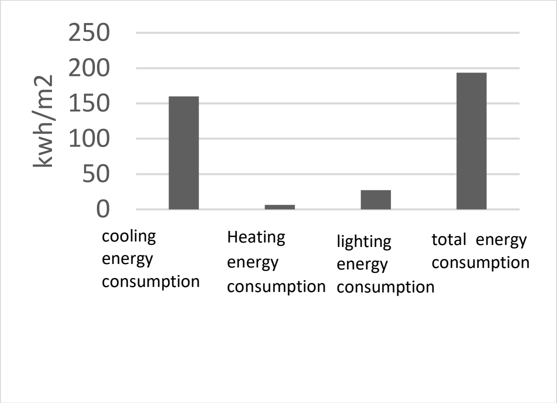

Diagram 1: energy consumption levels divided by needs (source: research findings)

It can thus be concluded that all the efforts in supplying energy for the building must be directed at cooling systems. It must be mentioned that the energy consumed in lighting has been calculated at around 27kWatt hours per square, which is due to the presence of internal shields to provide privacy and reduce glare and the need for artificial lighting.

Diagram 1: energy consumption balance in the building per needs (source: research findings)

Recommendations to modify energy consumption

To optimize comfort and take advantage of the buildings' potential, strategies need to be devised based on the concepts in the climatic life table to correct and improve the building physically. Given the many similarities between Hendorabi Island and Lengeh Port, the chart provided for this port has also been used in the present study. This chart indicates that over 30% of the months of the year and hours of the day require ventilation systems, and airflow needs to be established inside the building throughout the night. Buildings are capable of taking advantage of natural ventilation and using large wind towers over a large portion of the middle months of the year. There is a need for deep shades and materials with low thermal capacity over the middle and warmer months of the year. The opening need to be closed during the night and in the early morning over the cold months of the year, and climatic comfort can thus be provided through color and homogeneous thermal insulation without any additional facilities during over 70% of the days in the year.

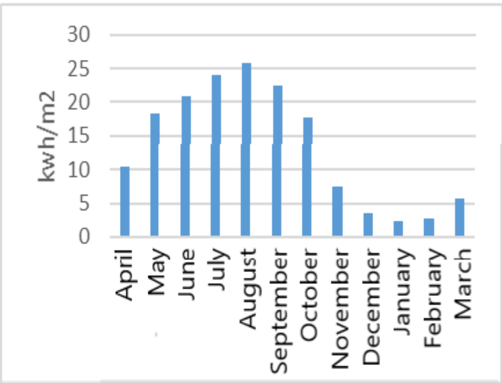

Diagram 2: cooling energy consumption in the building over the month of the year (source: research findings)

Improving the thermal condition of the building through passive[1] techniques

1. The use of materials

Studying the thermal behavior of materials is among the ways to assess the amount of thermal change in a building façade. Coral rocks from Persian Gulf beaches used to be prevalent as a material for building façades in the past and have been abundantly used in the Portuguese Castle on Hormoz Island. This type of perforated rock is the result of coral sediment settlement and compression which is corroded and brought to the coast through waves and is considered endogenous materials. Its compatibility with the environment and ability to prevent the infiltration of humidity are among the advantages of this type of rock. Coral rocks have a low density and insignificant thermal capacity to the extent that they are capable of keeping interior spaces cool if used in a large thickness as material in the walls. Modern materials inspired by these features have also been introduced into the market and can be of great impact if used wisely by engineers and architects. Results of a comparative analysis of the thermal function indicated that using coral rocks at a thickness of 20cm would increase the energy consumed for cooling in the building by around 8kw hours compared to similar materials, whereas using LECA concrete reduces the cooling energy consumed per meter square. Using cement and clay blocks also proved to be quite efficient and increased the cooling load significantly given the area of external walls.

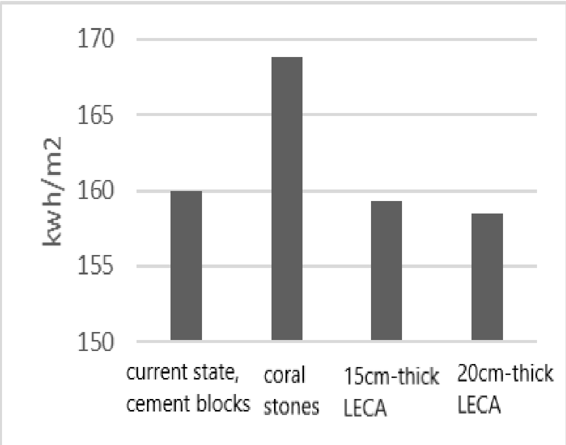

Diagram 3: cooling energy consumption per wall material (source: research findings)

2. Insulation

Thermal insulation on the inside or outside of the walls is among the simplest ways to reduce energy consumption in various climates. Thermal-insulated walls and ceilings with extruded polystyrene at various thicknesses were entered into the model separately to test the impact of insulation on the studied building and its influence on the cooling load and internal comfort conditions. When insulating the walls, the surface of the side walls was insulated from the inside in one stage and the outside in the next stage.

As Diagram 4 demonstrates, results suggested that insulating the walls around the building on the inside would not only not reduce the energy consumed for cooling, but also increase it. This could be due to the fact the suing polymer thermal insulation prevents interior air ventilation and reduction of the interior humid air temperature through the walls, as a result of which the heat generated inside the building gets trapped and more energy is thus required to cool the environment. The use of homogeneous insulation with sufficient porosity is thus recommended for the walls around the building.

On the other hand, results indicated the extremely favorable effect of insulating the roof on reducing energy consumption, so that cooling energy consumption dropped by around 60kwatt hours per meter square as a result

[1] Passive systems are mechanisms that provide heating and cooling without the need to purchase any equipment or facilities, e.g. allowing more light into the building over the winter by adjusting building orientation or façade color.

of roof insulation. Using insulations thicker than 10cm was revealed to reduce energy consumption more significantly and prevent thermal absorption and conduction to a greater extent. Using thermal insulation on the roof through an inverted roof system is thus recommended to reduce cooling energy consumption.

Double-walling the vertical shells with the layer of air is among the other techniques used to reduce energy consumption in buildings constructed in hot climates. Another technique is to use an insulation layer (extruded polystyrene) placed between two cement-block layers.

The present study investigated the influence of double-walling the wall with various air layer thicknesses (5, 10, and 15cm). As Figure 9 demonstrates, a 5cm air layer could only reduce energy consumption by approximately 1kwatt hour per square meter which indicates the inefficiency of double-walling the building. On the other hand, double-walling requires specific operations to prevent perspiration in the air layer, whereas using an extruded polystyrene insulation layer between the two layers of the wall would reduce energy consumption by approximately 2-kilowatt hours.

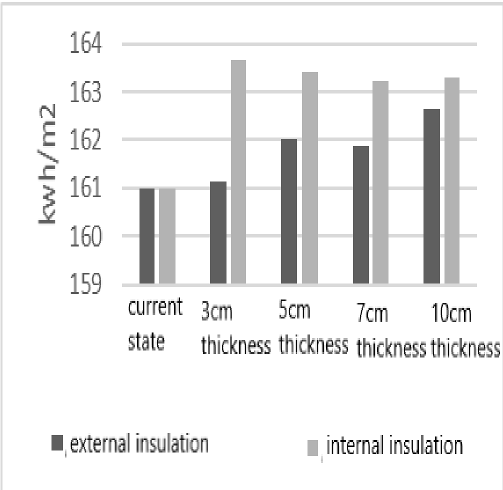

Diagram 4: cooling energy consumption after adding internal and external wall insulation (source: research findings)

3. Adding shades

The studied building needs special arrangements in terms of opening due to its form and orientation in every direction. The windows face east and west on the northern wing of the building and south-east and north-west on the southern wing. Hence, the calculation and analysis of window shading were performed in three steps. At the first step, a horizontal shade with depths of 0.5 and 1.5m was entered into the model. In the second step, a vertical shade entered the model; and in the final step, the combination of the two types of shades was examined.

Diagram 5 demonstrates that a vertical shade managed to reduce cooling energy consumption better than a horizontal shade. The use of a horizontal shade also reduces energy consumption, but its combination with a vertical shade proved to be more efficient. Using a vertical shade with a depth of one meter reduced the cooling load by around 5kwatt hours per meter square, whereas combining the two types of shade would reduce the consumption by approximately 7kwatt hours per meter square. Architectural considerations and construction costs suggested that the horizontal shade could be incorporated at depths smaller than one meter so that eastern and western windows can be equipped with a ventilated protector or enjoy diffused light from the adjacent surfaces of walls and ceilings. Using interior shades while considering the lack of need to consume more lighting energy (not exceeding the threshold of 27kwatt hours per meter square) was investigated in a separate analysis. In this stage, interior louvers (blinds) that allowed set constant lighting energy were used energy (not exceeding the threshold of 27kwatt hours per meter square). Suing this type of blinds is extremely easy and cost-convenient and will reduce cooling energy consumption by approximately 5kwatt hours per meter square.

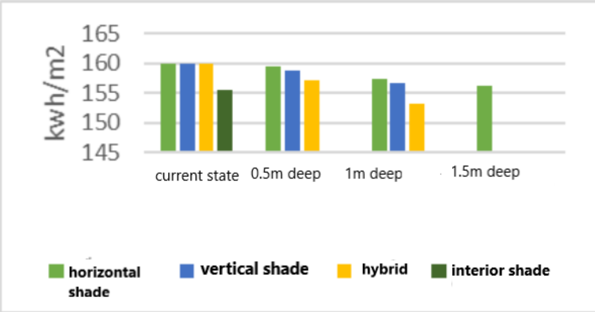

Diagram 5: cooling energy consumption after adding shades (source: research findings)

4. Changing the ceiling height

Changing the ceiling height is another technique recommended and explored to reduce energy consumption. The height of the ceiling is currently 270cm from the floor to the roof shell. At this stage, the ceiling height was altered by 10cm units to simulate the buildings' energy consumption accordingly. As Diagram 6 demonstrates, results suggested that reducing ceiling height would slightly change the energy consumed for cooling which could be due to preventing the ascend of hot air under the roof since reducing the distance between the hot air layer and living area would require more cooling energy. On the other hand, reducing ceiling height would not make for favorable conditions in terms of architecture and visual and psychological comfort.

Moreover, increasing ceiling height would also increase energy consumption due to the volume of the air that needs to be controlled. It was thus found that changing the ceiling height would not contribute significantly to energy consumption and that the current conditions are favorable in this regard.

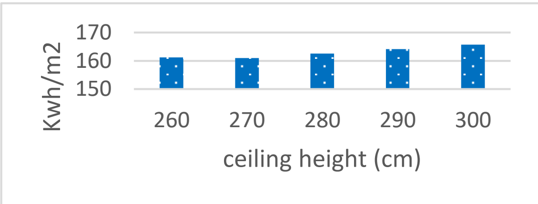

Diagram 6: cooling energy consumption by changing ceiling heigh (source: research findings)

5. Using porticos around the building

Incorporating semi-open and shaded spaces such as porticos around the buildings is another strategy examined in the present study. Besides its architectural function, a portico would also cast shade on the façade and prevent direct sunlight. The building's energy consumption was re-simulated assuming the establishment of a portico as deep as 2m around it, the results of which demonstrated that constructing a portico around the building would reduce energy consumption by 5 KlWh/m^2 aside from its effective architectural qualities as demonstrated in Diagram 7. Although the establishment of a portico would help reduce cooling energy consumption, it was revealed that its depth did not make much of a difference in the amount of energy saved.

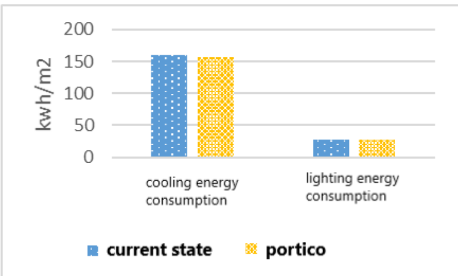

Diagram 7: cooling and lighting energy consumption in the current state vs. establishing a portico (source: research findings)

6. Using an atrium

An atrium is among the elements used in cold climates to gather solar energy; however, an atrium could also reduce energy consumption if used in a lobby with a non-glass ceiling where side windows are used for ventilation. Using this technique could reduce energy consumption by 4kwatt hours, but ventilation must be arranged properly. This means that the wind flow must be favorable and the temperature allows the use of breeze coolness and ventilation (it should not be too high). Valves can thus be opened during the temperature difference between days and nights (typically at night) to allow airflow to continue, which would make for a considerable decline in energy consumption by around 8kwatt hours.

7. Orientation

The following technique was used to perform a loss investigation of the right orientation for the building to take advantage of solar heat and cooling. All construction factors influential on energy consumption such as the volume of users, materials, opening sizes, the use of spaces, etc. were considered while simulating the energy consumption of the building in various orientations, each 10˚ rotated from the 0˚north (as shown in Figure 3)compared to its previous orientation. Judgment was made based on cooling energy consumption since the energy consumed for heating purposes was insignificant and negligible. Since the building has a centripetal form, different parts of the building would face various directions in each rotation, as a result of which no considerable change in energy consumption was observed in each rotation. However, the difference between energy consumption at 280-320˚ north revealed a more significant difference in energy consumption compared to the current orientation, in which case cooling energy consumption would reduce by approximately 10 KlWh/m^2.

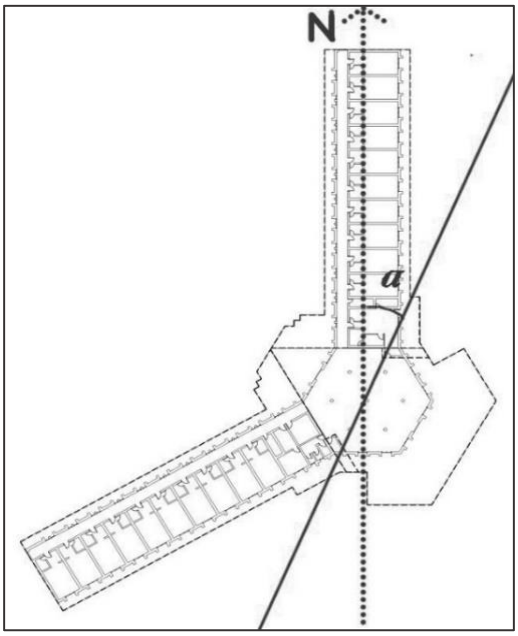

Figure 3: Comparison of energy consumption based on building orientation (source: research findings)

This small amount of decline in energy consumption is justifiable given the form of the building, but the building would be more sensitive to changes in direction if it were not centripetal, in which case proper orientation would be of greater significance.

Economic analysis

This section is concerned with analyzing the economic consequences of implementing the aforementioned strategies in Hendorabi accommodation buildings in the two subsections of economic benefits of reducing pollution and cost savings.

Table 1: energy consumption decline through passive system strategies

No.	Strategy			Reduction in energy consumption			Reduction in costs (IRR)
				KlWh/m2	%	Type of change	
1	Building shell	Changing materials	**LECA blocks**	1	--	↓	720
		Thermal insulation	**Invert roof**	60	37%	↓	43200
		Double walls	**5cm middle layer**			↓	
2	Ventilation	Natural	**Atrium**	1	--	↓	
3		Portico	**2m deep**	8	5%	↓	720

Source: research findings

a. An economic study of pollution reduction

Given that the implementation of the passive strategies recommended in the present study will reduce the cooling load of the building and subsequently its power consumption and production of greenhouse gasses from power plants, the economic influence of reducing electricity production on air pollutants among other types of pollutants (water, soil, etc.) will be discussed as follows.

Calculations suggest that around 37.5% of worldwide carbon emissions are caused by power generation operations (Mastouri et al., 2010), and a report by the National Environmental Protection Organization declares that over 93% of the power in the country was produced by thermal plants in 2016. Reducing 1KIWH/m^2 power consumption could prevent the generation of up to 1.2kg of greenhouse gases.

Table 2: annual reduction in air pollutant generation

Weight (tons)	pollutant
126	greenhouse gases

Source: research findings

b. Cost savings

Five of the strategies that were most efficient in energy consumption reduction including the use of LECA blocks, thermal insulation on the roof, creation of an atrium, incorporation of shades, and establishment of a portico around the building were examined in terms of cost-saving.

As Table 2 demonstrates, annual costs saved for a hotel building with an area of 1,400m^2 (one story) on Hendorabi Island (hot and humid climate) would be the equivalent of 75KIWH/M^2 provided that the strategies recommended in the present study are implemented, which would amount to a total of 105,000KIW for the entire hotel.

Table 3: energy costs

Type of energy	Costs (IRR)
Per KIW heating with gas	--
Per KIW heating with power	125tons

Source: Ministry of Power

The final cost per KIWH of power energy in Iran is IRR 7,209 without accounting for the subsidies[2] which means IRR591,138 saved per meter square annually. This would bring about a 42% saving in energy costs and IRR7 56,000,000 annually in the modeled building given the 194KIWH energy demands.

Table 4: Price addition (net) of implementing strategies

Strategy	price different (IRR)
LECA blocks- per meter square of walls	120,000
Thermal insulation on the roof-per square meter of roof	300,000
Atrium construction- per square meter compared to the central skylight	3,000,000
Hybrid shades- square meter length	No added cost
Surrounding portico- square meter length	4,000,000
The studied building with a constructed area of 1,400m^2	IRR 1,720,000,000

Source: Management and Planning Organization - Price list tables of 2018

Table 5: cost-benefit

Type of cost/benefit	Price (IRR)
Costs of strategy implementation (net)	1,720,000,000
Overhead costs	510,000,000
Annual savings	756,000,000

Source: research findings

The break-even point was calculated after calculating the additional costs of implementing the strategies and the amount of money saved due to energy savings.

$$the\ break - even\ point\ (year(= \frac{\text{additional costs of implementing the strategies(IRR)}}{\text{annual savings due to energy saving(IRR)}}$$

The break-even point would be 2.9 years (around 32 months) for this hotel. The break-off point refers to the point at which profitability equals investment. This means that the operator would make no profit for 32 months, from which point they would gain profits from energy savings.

Renewable Energies Association [2]

Conclusions

The present study sought to explain the results of studies on the establishment of tourism complexes in the southern islands of Iran assuming that environmental zones were respected. Investigations suggested that most buildings constructed in the southern regions and the two large islands in the Persian Gulf were established with little regard for environmental conditions and thus had a significant cooling, ventilation, and lighting load, supplying which from fossil fuel power plants would cause considerable pollution and costs. Results of the present study suggest that up to 126tons of pollutant generation could be reduced provided that the recommended strategies are implemented (note that energy generation and supply is highly more difficult and pollutant on the southern islands of the country). Considering that passive techniques based on the experiences obtained from the native architecture of the region and previous studies revealed to be able to supply a large portion of the energy needed in the building through interaction with the environment, the results of the present study demonstrated that using a combination of vertical and horizontal shades, ventilated protections on the windows, continuous porticos, using materials with low thermal capacity, using invert roof insulation and polymer insulation on the exterior walls, creating currents Convection by increasing ceiling height, the establishment of an atrium, and rotating toward the coastal winds could reduce the cooling loads of the building throughout the year by around 40% (approx. IRR756, 000,000). Comfortable conditions for tourists could be achieved with less energy consumption if renewable active –e.g. solar panels and water heaters and wind turbines- and passive strategies were considered in the designing stage in highly energy-efficient buildings.

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