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ENVIRONMENTAL SUSTAINABILITY IMPROVEMENTS FOR TERMINAL BUILDING IN AN INTERNATIONAL AIRPORT

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Abstract- In the last three decades or so, there has been a great effort towards developing more environmentally sustainable airport terminal buildings due to their growing importance. Many old terminals, which were constructed prior to this era, do not comply with the sustainability measures especially in terms of the consumption of energy and the emissions of carbon dioxide CO_2. The main objective of this article is to study and analyze the passenger's terminal buildings in Baghdad International Airport to determine the most applicable building alterations to improve its environmental sustainability. To this purpose, the Autodesk Revit 2021 was used to create the building's 3D drawings which were used in optimizing the energy consumption analysis and CO_2 emissions using Green Building Studio (GBS). Several scenarios were consulted in which many building material alternatives were tested. The results revealed that the most applicable modifications are; the Installation of double-glazed curtain walls, spreading foam concrete on roofs, and partial replacement of curtain walls by block walls which produced the highest reduction in the (EUI) from 924 MJ/m2/year to 857, 856, and 851 MJ/m^2/year respectively, while the CO_2 emissions were reduced from 472.2 Mg to 343.9, 344.2 and 339.9 Mg respectively. Another approach was adopted by which the terminal building capacity is increased by reconfiguring the arrival counters without increasing the terminal area. This measure increased the annual capacity for the studied building from 2,500,000 to some 2,774,000 passenger/ year what in turn contributed in lowering the passenger share of the CO_2 emissions from 0.178 g/passengers-mile to 0.117 g/passengers-mile.

Keywords: Airport Terminal Building; Airport Terminal Capacity; GBS Green Building Studio; Energy Use Intensity; Carbon Dioxide Emissions.

1. INTRODUCTION

Airports represent an important part of the complicated global transportation system perform the movements of people, freight, and visitors around the globe. In the last two decades or more, there has been a significant growth in public awareness of the environmental consequences of human activities [1-3]. Emission of Carbon Dioxide CO_2 levels in the atmosphere is continuously rising, and in 2016 they remained above 400 ppm which has never been recorded earlier. The aviation industry produces a substantial amount of environmentally harmful gases. Due that; an intensive work has been witnessed on airports, as the most important component of this industry, to lower their carbon impact. A viable approach is to use clean energy sources in order to ensure that the conventional power sources at the airport are replaced [4], [5].

As complex infrastructure with various functional subsystems that; airport master planning process, should be able to meet predicted traffic demand over time. Examining airport capacity is a typical method of determining whether or not a given airport system is suitable for a given traffic demand [6].

The optimal nominal capacity can be obtained when infrastructure construction synchronized for the ability to take the people, cargo, aircraft and airport terminal capacity is fully described [7]. The construction business has seen tremendous growth in the previous decade as a result of information technology and its use. The inclusion of Building Information Modeling (BIM) as an efficient construction strategy was the key reason for this evolution. BIM is now widely regarded as the tool for ushering in a new age in the construction industry. It's also seen to be a useful tool across the entire project lifecycle [8]. Building Information Modeling (BIM) is a unified and comprehensive system for all aspects of a building project [9], [10], [11], so adoption was carried out as part of this project. A terminal area's primary function is to connect "landside" and "airside," making it integral to all other airport activities [12].

Airport passenger buildings cater to a wide range of consumers' requirements. The buildings serve, besides passengers, all of; airlines that operate the planes, the sponsors who provide the funds, and terminal services operators [13]. To accommodate the many sorts of traffic at the airport, the terminal building design should have hybrid designs. They should also be very adaptable in terms of expansion, as well as changes in the percentage of transfer passengers and the airline's industrial structure [14]. As demand for passenger and freight air traffic grew, there was a need to create new passenger terminals, or expand and operate existing stations, decreasing environmental costs and impacts by being aware of and recognizing the issues of sustainable development.

Various approaches to achieve a balanced approach in order to optimize their potential. In terms of the environment, society, and the economy [15], [16].

Environmental sustainability is impacted by actions used to increase the capacity of airport or control traffic demand for a specific level of service. Air transport consumes about ten percent of total energy consumed for transportation in the EU and produces about fifteen percent of total CO_2 emissions [17]. Furthermore, not only increase in air traffic, but there has also been an increase in Road traffic around the airport that must be considered. Indeed, number of passengers variations necessitate a rethinking of airport access. As a result, any change in airport capacity affects and is influenced by airport operators' environmental policies as well as social and economic factors [18], [19].

This paper aims to increase the environmental sustainability of the terminal building of Baghdad International Airport (BIAP). To achieve this aim, two approached were adopted; The first included the Simulation of different alternatives in green building studio to determine how to reducing of CO_2 emissions. The second approach represented by reconfiguring the internal components of the terminal building in a way that increases the overall capacity of the building without increasing its acreage, and consequently the CO_2 emissions and the consumed energy is reduced per annual passengers.

2. RESEARCH METHODOLOGY

This research deals with the possible improvements on an airport terminal building by which its environmental sustainability is enhanced in terms of energy consumption and Co_2 emissions. The selected case study is the terminal building (Nineveh) which is one of three identical terminal buildings in Baghdad international airport. The data collection process included the collection of hard copy of the building's lay-out maps provided by the airport technical library, and the aviation data including the number of flight operations, passengers' movements, and routes lengths, mainly provided by the Iraqi Airways. In addition to the required field measurements to complement collection process.

The collected hard copy maps were transformed into electronic cope in the form of 2D drawings through the use of Auto CAD 2021, while the Autodesk Revit was used to create the 3D drawings. These drawing models are then used in estimating energy consumptions and CO_2 emissions after simulating 3D model to green building studio, with the simulation of different alternatives in this software to determine how to re-duce the energy consumptions and CO_2 emissions.

In the same approach, and to reduce the CO_2 emissions per passenger-kilometer of the terminal building passengers, a suggested scenario is analyzed by which the arriving passenger reception counters are to be increased in order to increase the arriving passenger's capacity and consequently increasing the total annual capacity of the terminal building what may reduce the share of the CO_2 emissions per passenger-kilometer.

3. THE CASE STUDY

To meet the study's objectives, one terminal building at Baghdad International Airport (Nineveh) was chosen. The layout of the terminal construction determines the architecture of the terminal. The services and operations of each structure are completely intertwined. The units are organized in a semi-circle around the perimeter, with two-story vehicles serving as departure and arrival points. Each terminal can handle 2.5 million passenger per year, for a total of 7.5 million passengers per year.

Nineveh terminal building is com-posed of two floors their combined area is about 25,000 m^2. The ground floor is designed to accommodate the arrival passengers while the first floor is dedicated to the departing passengers. Assuming that the distribution of passengers is homogeneous between departures and arrivals passengers demand [20], [21]. Accordingly, the design of the existing facilities provides the capability of processing about 1,250,000 passengers per year in each floor.

These capacities are governed by the available spaces for each facility as compared by the standard requirements. The capacity of passageways and tunnels is mostly de-signed by their width, while in any passenger-holding point, such as immigration or passport checking counters, the capacity is governed by the available space for the queue length for the level of service provided by a queue is deter-mined by the amount of available space.

4. PROGRAMS ANALYSES

One of the newest technologies is the BIM (Building Information Modeling) which allow multidisciplinary information to be integrated as a compact single model, which creates an opportunity to perform sustainability measures percentages of CO_2 emissions in the early design stage by exported the project model from Revit software to green building studio. Green Building Studio (GBS) allows to simulate the performance of the building for improving energy performance, work towards carbon neutrality, increase water efficiency, and climate analysis in the early stages of the design [22].

4.1. Creating 2D AutoCAD Model

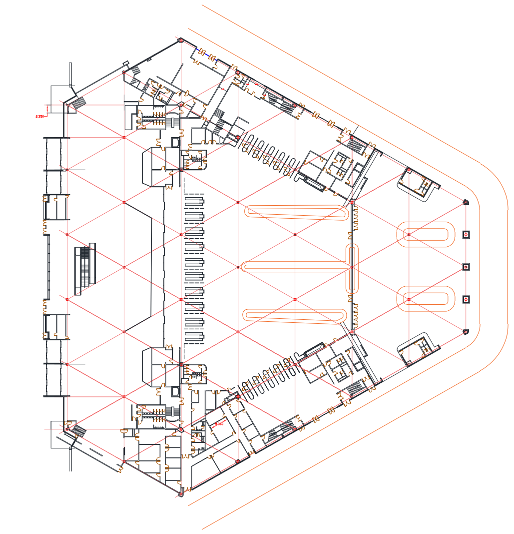
AutoCAD 2021 has been used to create a two-dimensional model of the maps obtained from the airport administration, this electronic 2D model has the capability to be exported to the Revit program, such as shown in Figures 1a and 1b.

4.2. Creating 3D BIM Model

Revit 2021 has been used for achieving the purpose of this study because it allows the exporting the model in various languages (such as gbXML) in order to get the capability to evaluate and analyze the building performance in conjunction with other software programs and tools. Figure 2 shows the rendering of case study in Revit 2021 after completing the finishing works.

4.3. Energy Simulation

The 3D model generated by BIM will be optimized for energy consumption analysis and CO_2 emissions using Green Building Studio (GBS). Detailed information of model will be saved directly through the optimization of the model to insight cloud for the purpose of energy simulation, as shown in Figure 3.



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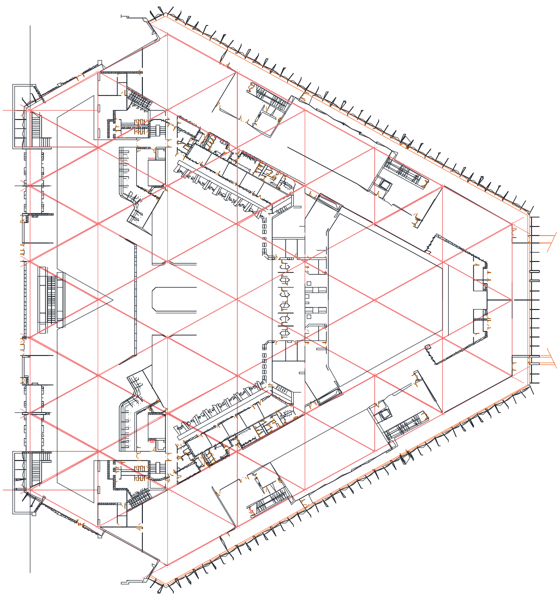

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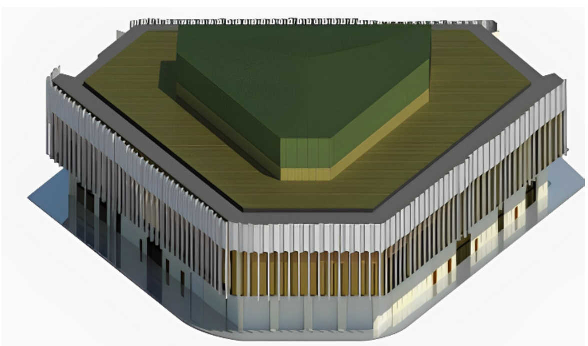
Figure 1. Terminal building (Nineveh) ground and first floors



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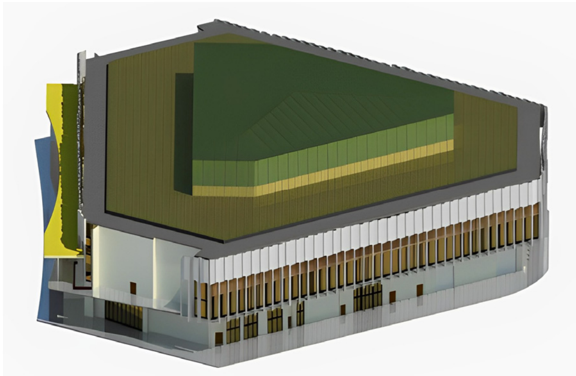

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Figure 2. Rendering the case study building in Revit

5. RESULTS AND DISCUSSION

5.1. CO_2 Emissions

The energy simulation revealed that the annual electricity consumption is 4,465,558 kwh/year, the annual emissions of carbon were 472.4 Mg, and annual consumption of fuel was 9,472,795 MJ/year as explained in Table 1.

Table 1. Summary of energy simulation

Project Template Applied: Airport Project	Building Type: Terminal
Location: Baghdad	Floor Area: 24,789 m^2
1) Base Run	
Energy, Carbon and Cost Summary	
Annual Energy Cost	\$ 489,694
Lifecycle Cost	\$ 6,669,630
Annual CO_2 Emissions	
Electric	0.0 Mg
Onsite Fuel	472,4 Mg
Large SUV Equivalent	47.3 SUVs/Year
Annual Energy	
Energy Use Intensity (EUI)	924 MJ/M^2/year
Electric	4,465,558 kWh
Fuel	9,472,795 MJ
Annual Peak Demand	1,009,9 kW
Lifecycle Energy	
Electric	133,966,740 kW
Fuel	284,183,850 MJ

5.2. Scenarios

To improve the environmental condition for this terminal building in terms of minimizing the energy consumption and CO_2 emissions, several scenarios were suggested to enhance the performance for this terminal building, knowing that the original energy use intensity EUI was 924 MJ/m^2/year, and the CO_2 emissions was 472.2 Mg, and furthermore, an attempt for the reconfiguration of internal passenger's processing facilities is studied by which the share of CO_2 emissions per passenger-kilometer is meant to be minimized.

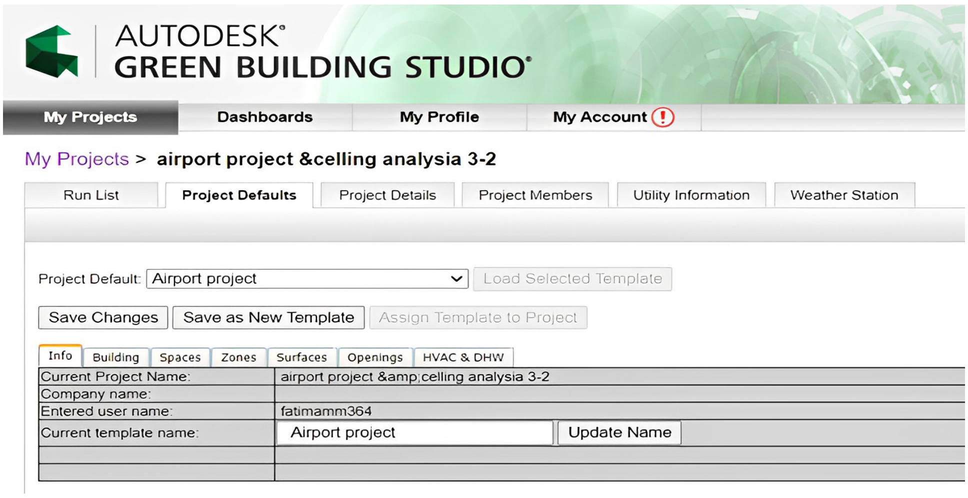


Figure 3. Import setting method

5.2.1. Installing Double Glazed Curtain Walls

Since these double-glazing walls are characterized by their excessive resistance to heat transfer that explain their capability of decreasing thermal conductivity of buildings, it was suggested to use double glazing curtain walls to examine their performance in decreasing the consumption of energy and CO_2 emissions [23]. The results showed that this process reduces the annual (EUI) to 857 MJ/m²/year and the electrical energy consuming to become 4,600,951 kwh and fuel to 6,896,210 MJ, as illustrated in Table 2.

Table 2. Using double-glazed curtain wall

Project Template Applied: Airport Project-Double Glazing	Building Type: Terminal
Location: Baghdad	Floor Area: 24789 m^2
1) Base Run	
Energy, Carbon and Cost Summary	
Annual Energy Cost	$ 483,265
Lifecycle Cost	$ 6,582,063
Annual CO_2 Emissions	
Electric	0.0 Mg
Onsite Fuel	343.9 Mg
Large SUV Equivalent	34.5 SUVs/Year
Annual Energy	
Energy Use Intensity (EUI)	857 MJ/M^2/year
Electric	4,600,951 kWh
Fuel	6,896,210 MJ
Annual Peak Demand	1,038.4 kW
Lifecycle Energy	
Electric	138,028,530 kW
Fuel	206,886,300 MJ

5.2.2. Using Foam Concrete Over Roofs

Foam concrete as an excellent thermal insulation material, which is very different from the nominal concrete, has been tested and analyzed and shows that its usage in applicable locations in the terminal building resulted in reducing the EUI, electricity consumption, Fuel consumption, and CO_2 emissions to some 856 MJ/m²/year, 4,602,698 kWh, 6,901,601 MJ, and 344.2 Mg, respectively as could be seen in Table 3.

5.2.3. Using Lime Stone in Wall Finishing

It is advised that lime stone be used to determine how beneficial could it be in lowering the consumption of energy and gas emissions percentages to determine the usage or not. Table 4 explains the proof of decreasing the EUI to 922 MJ/m²/year, while the electricity consumption is reduced to become 4,467,911 kWh, and the Fuel consumption is decreased to 9,428,548 MJ and the CO_2 emissions is decreased to be 470.2 Mg.

Table 3. Using foam concrete

Project Template Applied: Airport Project-Foam	Building Type: Terminal
Location: Baghdad	Floor Area: 24789 m^2
1) Base Run	
Energy, Carbon and Cost Summary	
Annual Energy Cost	$ 483,469
Lifecycle Cost	$ 6,584,843
Annual CO_2 Emissions	
Electric	0.0 Mg
Onsite Fuel	433.2 Mg
Large SUV Equivalent	34.5 SUVs/Year
Annual Energy	
Energy Use Intensity (EUI)	856 MJ/M^2/year
Electric	4,602,698 kWh
Fuel	6,901,601 MJ
Annual Peak Demand	1,038.7 kW
Lifecycle Energy	
Electric	138,080,940 kW
Fuel	207,048,030 MJ

Table 4. Using lime stone in wall finishing

Project Template Applied: Airport Project-lime stone	Building Type: Terminal
Location: Baghdad	Floor Area: 24789 m^2
2) Base Run	
Energy, Carbon and Cost Summary	
Annual Energy Cost	$ 489,586
Lifecycle Cost	$ 6,666,162
Annual CO_2 Emissions	
Electric	0,0 Mg
Onsite Fuel	470.2 Mg
Large SUV Equivalent	47.1 SUVs/Year
Annual Energy	
Energy Use Intensity (EUI)	922 MJ/M^2/year
Electric	4,467,911 kWh
Fuel	9,426,548 MJ
Annual Peak Demand	1,010.5 kW
Lifecycle Energy	
Electric	134,037,330 kW
Fuel	282,856,440 MJ

5.2.4. Using Granite in Wall Finishing

Granite boards for wall finishing was effective in reducing the energy use and gas emissions. Table 5 depicts the results, which demonstrate a reduction in the EUI to be 921 MJ/m2 / year, while the consumption of electricity becomes 4,462,097 kWh, the fuel consumption is 9,396,405 MJ, and the emissions of CO_2 is 468.6 Mg. These findings revealed that using granite for wall finishing lowered energy usage and reduced emissions by a minor proportion.

Table 5. The use of Granite

Project Template Applied: Airport Project-Granite	Building Type: Terminal
Location: Baghdad	Floor Area: 24789 m^2
3) Base Run	
Energy, Carbon and Cost Summary	
Annual Energy Cost	$ 488,801
Lifecycle Cost	$ 6,657,473
Annual CO_2 Emissions	
Electric	0,0 Mg
Onsite Fuel	468.6 Mg
Large SUV Equivalent	47.0 SUVs/Year
Annual Energy	
Energy Use Intensity (EUI)	921 MJ/M^2/year
Electric	4,462,097 kWh
Fuel	9,396,405 MJ
Annual Peak Demand	1,009.5 kW
Lifecycle Energy	
Electric	133,862,910 kW
Fuel	281,892,150 MJ

5.2.5. Using Fiber Glass Insulation in Walls Finishing

The fiberglass insulation was tested in term of decreasing CO_2 emissions and energy consumption in the terminal building. It was revealed that the use of this material would lead to a decrease in electric consumption to reach about 2,077,133 kWh, but it showed a very high increase in the EUI to be 1573 MJ/m²/year. An increment was also noticed in the CO_2 emissions and fuel consumption to reach 533.1 Mg and 10,689,200 MJ, respectively see Table 6. These results are highly discouraging.

Table 6. Using fiber glass

Project Template Applied: Airport Project-Fiber Glass	Building Type: Terminal
Location: Baghdad	Floor Area: 24789 m^2
4) Base Run	
Energy, Carbon and Cost Summary	
Annual Energy Cost	$ 274,458
Lifecycle Cost	$ 3,736,117
Annual CO_2 Emissions	
Electric	0,0 Mg
Onsite Fuel	533.1 Mg
Large SUV Equivalent	53.4 SUVs/Year
Annual Energy	
Energy Use Intensity (EUI)	1,573 MJ/M^2/year
Electric	2,077,133 kWh
Fuel	10,689,200 MJ
Annual Peak Demand	542.7 kW
Lifecycle Energy	
Electric	62,313,990 kW
Fuel	320,676,000 MJ

5.2.6. Partial Replacement of Curtain Walls by Concrete Block Walls

In this test, it was considered to partial re-placement of curtain walls with the hollow concrete blocks wall as an alternative because the first-floor walls are mostly made of curtain walls and due to the prevailing weather condition in Baghdad characterized by high temperature in summer, these walls will be not capable of isolating the excessive heat in the building successfully, what may lead to high consumption of energy for cooling.

The analysis results showed that an EUI of 851 MJ/m²/year, Electricity consumption of 4,593,784 kWh, Fuel consumption of 6,815,141 MJ and CO_2 emissions of 339.9 Mg as shown in Table 7. These results are encouraging with respect to the reduction in EUI, Fuel consumption and CO_2 Emissions. The effect of all the previously mentioned alternatives on the performance of the building are presented in Figure 4 which shows the improvements on electrical and fuel consumption, while Figure 5 shows the effect of alternatives on the percentage of CO_2 emissions.

Table 7. Partial replacement of Curtin walls with block wall

Project Template Applied: Airport Project-Block for Curtin Walls	Building Type: Terminal
Location: Baghdad	Floor Area: 24789 m^2
5) Base Run	
Energy, Carbon and Cost Summary	
Annual Energy Cost	$ 481,989
Lifecycle Cost	$ 6,564,694
Annual CO_2 Emissions	
Electric	0,0 Mg
Onsite Fuel	339.9 Mg
Large SUV Equivalent	34.1 SUVs/Year
Annual Energy	
Energy Use Intensity (EUI)	851 MJ/M^2/year
Electric	4,593,784 kWh
Fuel	6,815,141 MJ
Annual Peak Demand	1,037.0 kW
Lifecycle Energy	
Electric	137,813,520 kW
Fuel	204,454,230 MJ

5.3. Optimum Alternative Materials

To differentiate between the most applicable alternatives, a cross-comparison was introduced to reveal the best of highest reduction in the consumption of energy and the emissions of CO_2 in passenger's terminal building. Such comparison is presented in Table 8 which lists all the alternatives results.

Accordingly; it is recommended to use the double-glazed curtain walls, foam concrete on top of exposed roofs and the partial replacement of existing curtain walls by concrete blocks to lessen the emissions of CO_2 and consumption of energy by a considerable rate due to the reduction of the operation times of heating and cooling devices. Other alternatives produced lower reducing in the emissions of CO_2 and consumption of energy. Heat transfer is greater through the roof and outer walls in addition to the huge areas of the curtain walls, which explains the difference between the ceiling and curtain wall and other alternatives.

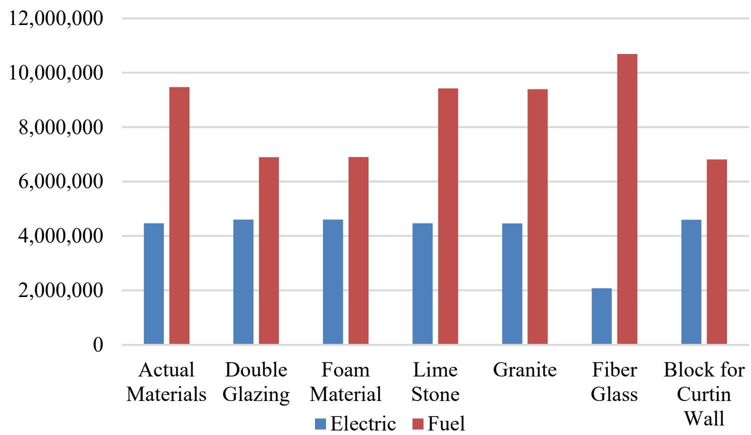


Figure 4. The effect of alternatives on electric and fuel consumption

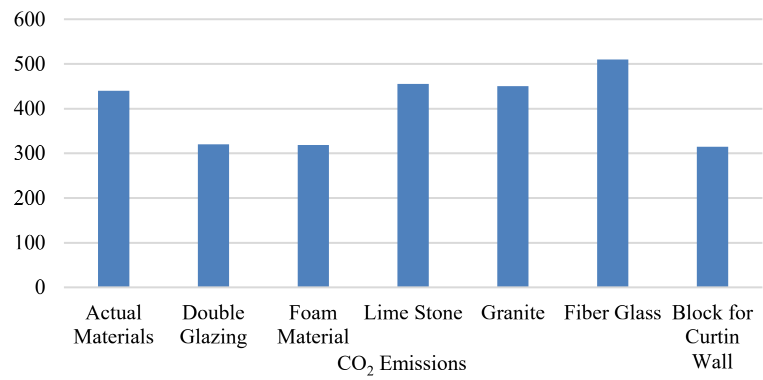


Figure 5. The effect of alternatives on CO_2 emissions

Table 8. Analysis results for existing and alternative materials

Materials	(EUI) MJ/m^2/year	Electricity (kWh)	Fuel consumption (MJ)	CO_2 emissions (Mg)
Existing Materials	924	4,465,558	9,472,795	472.2
double glazing	857	4,600,951	6,896,210	343.9
Foam material	856	4,602,698	6,901,601	344.2
lime stone	922	4,467,911	9,428,548	470.2
Granite	921	4,462,097	9,396,405	468.6
Glass Fiber	1537	2,077,133	10,689,200	533.1
Block wall for Curtin Wall	851	4,593,784	6,815,141	339.9

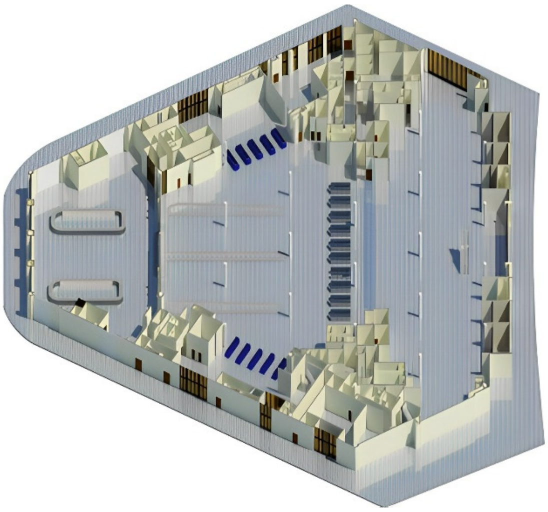
5.4. Terminal Capacity Expansion

Any attempt to increase the terminal building capacity by increasing its area would consequently increase the building's energy consumption as well as its CO_2 emissions [24]. In this research, the attempt for improving the performance of the terminal building in addition to increase its capacity includes only the procedures that elevate the capability of any of the passengers processing facilities in which noticeable delay maybe encountered without adding any further construction. Such facilities like; security check point in the main terminal interface, ticketing and baggage check-in counters, passport checking stations, baggage claim carousels, and customs facilities.

In fact, many possibilities were studied for this purpose which covered all the facilities that witness frequent bottleneck capacity during the working day of a terminal such as entrance checkup facilities, customs, immigration checking, and many other components, all of which were either difficult to modify or their increment may violate the space requirements of other adjacent facilities what may reduce their processing capability. The most applicable choice was the possibility of adding arrival passenger counters within the same available area of the building, and taking into considerations the distance requirements for passengers in terminal ac-cording to level of service C. One counter was added on each side of the ground floor. Figure 6 illustrates the actual five arrival counters in the ground floor on each side and Figure 7 illustrates the counters after the addition of one counter on each side.

In order to determine the impact of this increment on the annual number of air passengers, the relation between the design peak hour traffic (DPH) and the total annual traffic is ought to be consulted. The relation as in Equation (1) [13].

$$DPH = AnnualTraffic / 3000 \quad (1)$$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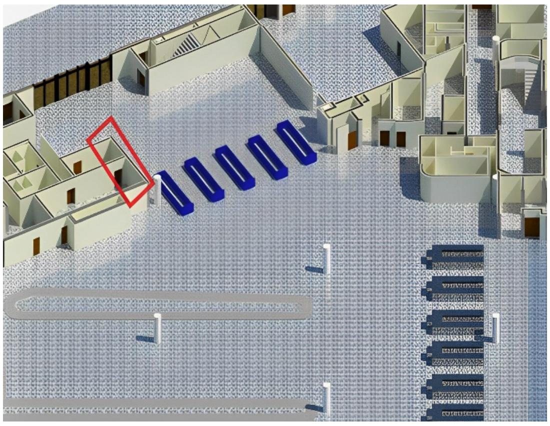
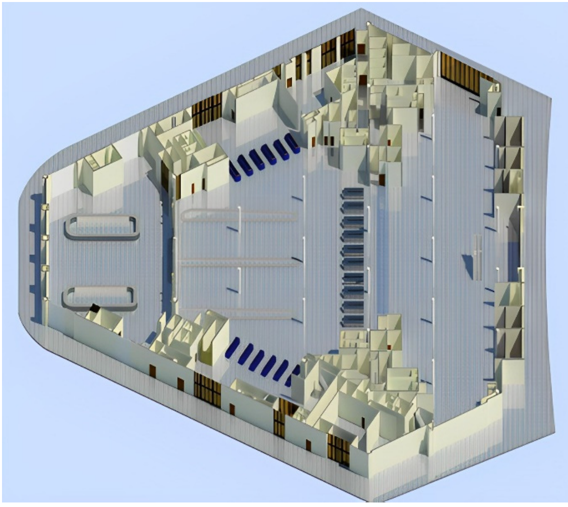

(b)

Figure 6. Ground floor with actual numbers of counters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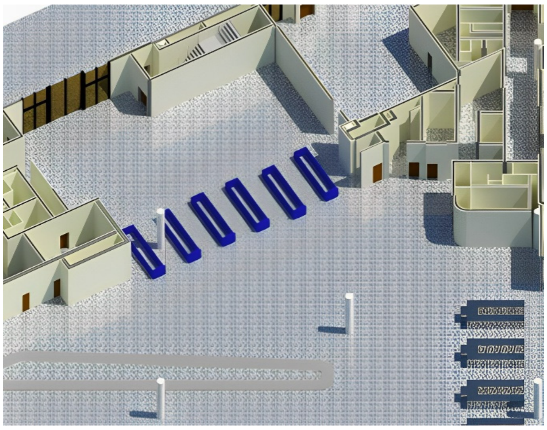
(b)

Figure 7. Ground floor with increasing numbers of counters

Since the original design of the terminal considers that the enplanements and deplanements are equal due to the nature of the Baghdad International Airport [20], [21], the reconfiguration of the arrival counters is expected to affect only one half of the annual passenger's traffic.

The basic capacity calculation regarding the arrival checking station assumed that each counter takes about 85 seconds to process a passenger what makes it the controlling process that consumes the longest time among the sequential facilities in the arrival station. In fact, the arrival station capacity is calculated depending on it for the 10 counters will make a total processing capacity of arrival counters, considered here as the design peak hour traffic (DPHT) as follows:

$$DPHT = 10 \times \frac{3600}{85} = 424\,\text{p/h}$$

The arrival annual traffic, according to equation 1 and the DPH traffic is approximately 1,250,000 which is equal to the departing annual traffic in this terminal building whose total annual capacity is considered as 2,500,000 passenger/ year. The increment in the annual capacity gained by increasing arrival counters from 10 to 12, makes the arrival DPH traffic 508 passenger/ hour and the arrival annual capacity about 1,524,000 passenger/ year. Consequently, the total terminal building capacity becomes 2,774,000 passenger/year, gaining an increment of about 11%.

5.5. Distribution of CO_2 Emissions Per Passenger-Mile

This part aims to measure the amount of CO_2 emissions produced by the terminal building as it distributed among the passengers accommodated by the building. It is a standard procedure to have these emissions scaled in terms of passenger-mile i.e., the destination distances of the served passengers affect to a great deal the level of emissions per passenger. The increment in annual passenger capacity of the building will reduce the level of emission per each passenger-mile since this increment did not require any additional space or expansion in building.

In order to scale the reduction in these emission rates, it is necessary to check the level of original emissions per each passenger for the original capacity and the recalculate it for the new configuration, after applying the appropriate alternatives, with respect to the increased capacity. As for the measurement of the distances traveled by passengers, it is not an easy task. It requires the knowledge of the distances for each route as well as the number of passengers traveled there. An extension to the Google Earth Pro. Software was utilized to calculate the distance for each flight destination. Then the number of passengers traveled this route are determined as provided by the Iraqi Airways log for the past five years. The weighted average is then calculated to estimate the average distance traveled by each passenger.

The weighted average distance traveled by passengers using the terminal building could be calculated according to Equation 2, keeping in mind that this average will not significantly change since the percentage of passengers travelling to and from each destination are not materially changed. Table 9 lists all the important flight destinations with the number of passengers on each route.

$$WAv = \frac{\sum passengers \times distence}{\sum passengers} \tag{2}$$

The application of Equation 2 on the distances and passengers in Table 9, it reveals a weighted average distance of 1,057.6 miles. Accordingly; the actual CO_2 emissions produced by the existing terminal building, which is equals to 472.2 as calculated previously, when it is distributed among the current annual passengers, which are assumed 2.5 million, for the stated average distance of (1,057.6 miles) is equal to 0.178 gram per passenger-mile. This amount is much higher than the acceptable limit of 0.09 g/passenger-mile.

On the other hand; when the improvements on the terminal building are considered, making the annual CO_2 emissions 343.9 Mg and the reconfiguration of the arrival counters are adopted what increases the annual capacity to 2.774 million passengers and the average distance is unchanged as the expanding was assumed homogeneous, then the amount of CO_2 emission will be 0.117 g/passenger-mile. Table 10 summarizes all these calculations. This result means a reduction in this rate of about 34% which is very good outcome to these processes but still it is slightly higher than the standard of 0.09 g/passenger-mile. This shortcoming is expected to be rectified in the few coming years after the launching of several remote airline destinations, which were stopped for many years due to the unpleasant circumstances surrounded the local aviation industry, what may increase the weighted average traveled by passengers and consequently reduce the passenger share of CO_2 emission.

Table 9. Flights distances incorporated in calculating average flight distance

Sectors	Travelers		Sum passengers	Flight Distance	Distance × Passengers
	Departed	Arriving			
Baghdad - Amman-Baghdad	48481	48942	97423	489	47,639,847
Baghdad- Istanbul- Baghdad	20998	17900	38,898	1002	38,975,796
Baghdad - Beirut - Baghdad	93469	86143	179,612	506	90,883,672
Baghdad – Dubai -Baghdad	59441	64764	124205	869	107,934,145
Baghdad - Cairo - Baghdad	49074	51712	100786	786	79,217,796
Baghdad - Tehran - Baghdad	36385	36764	73,149	422	30,868,878
Baghdad-Mashhad- Baghdad	50045	58365	108,410	899	97,460,590
Baghdad - Delhi - Baghdad	49664	51043	100,797	1971	198,670,887
Baghdad - London -Baghdad	69308	53981	123,289	2556	315,126,684
Baghdad-Ankara - Baghdad	30664	30305	60969	782	47,677,758
Baghdad-Copenhagen -Baghdad	9646	10600	20,246	2,161	43,751,606
Baghdad - Baku - Baghdad	20632	21593	42,225	572	24,152,700
Baghdad - Bombay - Baghdad	5596	3979	9,575	2032	19,456,400
Total			1,079,584	15,047	1,141,816,759

Table 10. Capacity and CO_2 emissions before and after improvement

	CO_2 Emissions (Mg)	Design annual passengers	Average Distance (Mile)	CO_2 emissions (g/passengers-mile)
Actual state	472.2	2500000	1,057.6	0.178
Improved state	343.9	2774000	1,057.6	0.117
Improvement	27%	10.96%	--------	34%

6. CONCLUSIONS

This research was dedicated to study the possible modifications on passenger's terminal building in Baghdad Airport for improving environmental sustainability in terms of energy consumptions and CO_2 emissions. This old building, in its current situation, do not comply with the modern sustainability measures despite the major role it leads in processing the air travel demands in the Iraqi major hub. By the use of BIM technology, Rivet 2021 and Green Building Studio, many scenarios were adopted in which multiple material alternatives were tested. Based on the outcomes of these tests we can conclude the following:

- Among many alternatives, three of them represented by the Installation of double-glazed curtain walls, spreading foam concrete on roofs, and partial replacement of curtain walls by block walls, proved their efficiency in reducing both energy consumption and CO_2 emissions with a very close proximity.
- The reduction in the EUI by the use of; double-glazed curtain walls, foam concrete on roofs, and partial replacement of curtain walls by block walls, was 7.25%, 7.36% and 7.9%, respectively while they reduced CO_2 emissions by 27.17%, 27.11% and 28.02%, respectively.
- The use of lime stone and granite in wall finishing seems to have minimal effect for their use only resulted in a reduction of the EUI about 0.2% for the lime stone and 0.3% for the granite. The CO_2 emissions were also minimally reduced by 0.4% in the case of lime stone and 0.7% in the case of granite.
- The reconfiguration of arrival counters was the most applicable alternative to increase the terminal annual capacity in its current space. The available space that grants the possibility of adding one counter on each side of

the ground floor what may increase the annual capacity of the building by 11%. By considering the average distances traveled by the passengers, the reduction in each passenger share of CO_2 emissions is about 8% if no improvement is made in the terminal building. If the building was improved by the use of the best alternative choice, then the passenger share is reduced from 0.178 g/passenger-mile to 0.117 g/passenger-mile to produce a reduction of 34%.

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