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Integrating Zero Carbon and High Performance Green Building in Resorts in Western Northern Coast, Marsa Matrouh, Egypt

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Abstract

The Tyndall Climate Centre in a call for papers for its December 2013 “Radical Emissions Reductions” Conference said, “Today, in 2013, we face an unavoidably radical future. Both the World Bank and International Energy Agency released reports in November 2012 and July 2013 respectively which evaluated current climate change policies and targets and concluded that “business as usual” was likely to result in four degrees of warming. The 2013 atmospheric CO_2 levels are at about 400ppm. It is generally accepted by climate scientists that the CO_2 level was 280ppm during the Holocene Period - a ten thousand year era of stable climates, which supported the development of human civilization. Now there is already too much carbon in the atmosphere. The current level of emissions has led to a 0.8 degree temperature increase. Already the planet is experiencing the impact of high emissions and rising temperatures. The 2012 summer arctic sea ice levels had record minimum in area and volume. Some scientists have predicted the total loss of arctic sea ice with the next decade. Positive feedback mechanisms are being triggered as the reduction in Arctic ice reduces the reflectivity of the globe and the melting of permafrost leads to release of trapped methane. These feedback mechanisms could lead to a global temperature rise between 1.8^0C and 2.3^0C above pre-industrial levels regardless of any action that may be taken subsequently to reduce emissions. The current estimate for the melting of Greenland’s ice sheets is 1.6^0C above pre-industrial levels, well within the range of two degrees that is considered a safe guardrail. The melting of Greenland’s ice sheets would lead to an eventual sea level rise of seven meters.

Keywords: Zero carbon definitions; passive design; Building envelope; Thermal insulation materials; Comfort; Energy conservation; Renewable Energy; Egyptian Northern Coast Features; Application; Guidelines.

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1. Introduction

During the last century, coastal urbanization has grown dramatically and coastal cities have expanded rapidly, strongly influencing marine and coastal ecosystems, and raising the importance of preserving the coastal environment as a major urban planning issue for sustainable development. The paper focuses on the North-Western coast of Egypt, where population increase and economic growth exerted a remarkable pressure on the coastal environment, also due to a non-integrated urban coast planning. The overall growth of population and rural-urban migration flow in Egypt has resulted in a tremendous growth of the main cities. Hoping to divert the people's movement away from these urban centers, the Egyptian government organized several development programs. One of these programs is directed to the coastal zone of the western desert.

2. Research objectives

Due to the emergence of the problem of global warming facing the whole world, so it has to be the trend to new resorts in the Western Northern Coast to resolve this problem, so as to achieve self-efficiency in energy needs and sources of water and doesn't rely on public network of the state. The objectives of this research lies in five main points:

- The trend towards the western Northern Coast and interest in order to serve its residents throughout the year and not just one month at year.
- Comprehensive knowledge of the definitions of Zero Carbon.
- Design new resorts are zero carbon and self-sufficient for itself from energy and water resources and can contribute to solve energy problems for other regions in the city in addition to reducing global warming.
- Try to apply techniques of zero carbon in line with the climate of this region and the region and the resources available there.
- Access to in the end design guidelines for designers and planners to achieve zero carbon building in this area.

3. Methods and tools

This research is an analytical research and will end up with a design guidelines for architects, when starting the new projects at the Northern West Coast Area.

So that, simulation tools as Ecotect and Design Builder Soft wares were selected as the platform on which to build the simulation model of the net-zero carbon building. These tools were chosen over other methods for a reason that it allows the user to determine exactly how detailed the model should be in terms of its geometry, constructions and materials, operational details and control systems.

A dynamic modelling approach was taken for case study to achieve net zero carbon building. By simulating the building ‘as built’ that the operational performance of it’s could be assessed to determine whether or not it was operating as it was expected to should be. By making modifications to this model, building simulation can then be used as a design tool in order to deliver one of the main objectives of the project is to achieve net zero carbon building.

4. Zero Carbon: Concepts, types and design criteria

4.1. Zero Carbon definitions& types

Zero carbon means that they must have zero net emissions from all energy use in the building over the course of a year. And also Zero Carbon building must be Zero energy building [1]. To achieve efficient energy use, there are many considerations that must be taken to reach Zero carbon building.

4.2. Passive design strategies

There are many factors effects on passive design such as

- **Site & climate:** One of the important factors which effects on passive design of building is climate. In warm & humid climate, to minimize impact of solar radiation & maximize ventilation , the long axes of buildings should be oriented in the east-west direction (with deviations up to 30°) so that the longest walls face north west (wind direction) and south, and only the short wall face east and west(solar radiation) [2], as illustrated in Fig (1) .

Building typologies (form) can be ranked by a parameter called "compactness" which measured using the ratio of surface area to volume (S/V).S/V ratio should be as small as possible so that the heat gain can be improve in winter and reduced in summer (Achieving energy efficiency) in hot humid climate [3], as shown in Fig (2).

Figure 1: Best directions for buildings with least need for vertical screens to prevent overheating [10].

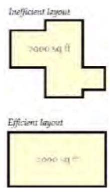


Figure 2: Efficient Building Layout [3]

Average temperature of buildings' walls can be 5-15^0 C less than that of unshaded ones depending on the local climates and planting details. Also, a roof garden can reduce temperature for 10-30^0 C about other exposed roof surface, depending on the roof construction, planting details and surrounding conditions [4].

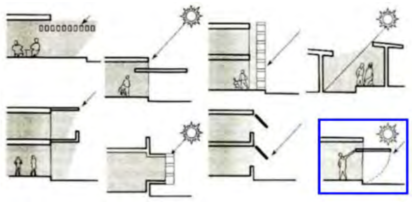


Figure 3: Different types of shading devices [7].

- **Building envelope:** The building envelope is the structure which separates the interior environment from the exterior environment which supports passive design [5].

Proper insulation is essential for avoiding heat gain (for interior cooling) and heat loss (for interior heating) which achieved by insulating (low U-value) throughout the building [2].

Walls: Reduce heat transmission into building is by designing appropriate thermal insulation which depend on wall thickness, materials and finishes. The basic elements of the insulated Wall system are Exterior cladding; Drainage plane (s); Air barrier system(s); Vapour Retarder (s); Insulating Element(s) and Structural elements [6]. The main types of insulation materials are bulk, reflective, and foam. The benefits of insulating the building fabric are significant that include: reduce the expense of heating and cooling in the home by about 50%, improvement of the comfort of building occupants, long life and low maintenance, reduction of air infiltration & good sound absorption [6].The design of effective shading devices, as shown in Fig (3), will depend on the solar orientation of a particular building facade. Simple fixed overhangs are very effective at shading south-facing windows in the summer when sun angles are high [7].

Windows & Glazing: Designing windows that contribute to passive heating in the cooler winter months without affecting rise heat in the summer depend on location, size and thermal quality. Window-to-wall ratio (WWR) should not exceed 2/3 of the envelope. The higher the window head, the deeper will be the penetration of daylight. Suitable height from floor to the bottom of window should to be 1.0 to 0.3 m. The four metrics define window energy performance for materials are: Insulation value (U-factor), Solar Heat Gain Coefficient (SHGC), Visible Transmittance (VT), Air Leakage (AL).The lowest window's SHGC, the less solar heat it transmits, the greater it's shading ability and helps in reducing cooling loads. The lower the U-factor, the greater a window's resistance to heat flow and the better its insulating value. The lower a window's AL rating, the better is its air tightness. To design a shading device to cut the VSA, HSA: The length and spacing can be calculated either by the drafting soft wares, graphical method or manually calculated by the mathematical formula VSA (Depth of shading device = Spacing between the shading device x {tan (90 – VSA)}, HAS (Depth of vertical fins = Spacing between the vertical fins x {tan (90 -HSA)} [6], as shown in Fig (4).

Roofs: The passive home requires that the roof achieve a very high R-value which reach to 0.75 in hot roofs [5]. This is achieved by covering surface with inverted earthen pots, using vermiculite concrete or using green roofs. In addition to, an ideal exterior surface coating of a building, would have reflectance near 1, and absorptance near zero, and Emissivity near 1 to radiate absorbed heat back to the sky. There are four types of insulated materials like Expanded Polystyrene slabs, Extruded Polystyrene slab, Polyurethane / Polyisocyanurate slabs&

Perlite boads. Spray applied Polyurethane is formed by mixing Isocyanate and Polyol to create insulation cover of the roof. It has highly efficient thermal insulation, great ease of application surface moisture resistance and low density of material thus light weight [6]. There are five types of insulated roofs covering material such as concrete or galvanized iron sheets, deciduous plants and creepers, earthen pots, broken china mosaic or ceramic tiles &Painting of the canvas white [7].

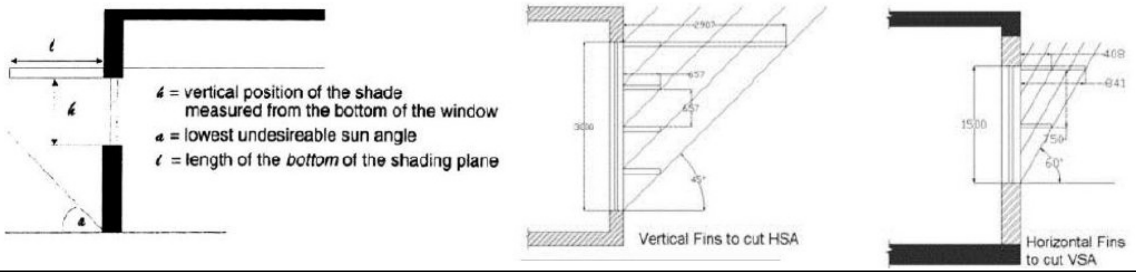


Figure 4: Design a shading device [6]

Floors: The floor is appropriate for a hot-humid climate; it is capable of protecting against heat flow down and allows minimal heat conduction and moisture penetration. Its properties are: Characteristic of mass - it decreases heat transfer by conduction, Low conductivity (U-value) - An air space between two materials of roof layers and Low moisture penetration – a desiccant is installed in a perimeter frame inside air space to prevent the penetration of moisture [8].

Thermal comfort depends on many factors, of which air temperature, humidity, air movement, thermal radiation, the metabolic rate and the level of clothing are fundamental. The summertime comfort zone ranges from about 23.5^0C at 25% relative humidity (RH) to about 26^0C at 60% RH [4] , as appeared in Fig (5).

High thermal resistances of insulation materials (R-Value) will contribute internal thermal comfort [3] .U-values ranging from 0.09 to 0.15 W/ (m^2K) [9].Thermal performance of walls can be improved by increasing wall thickness, providing air cavity between walls and hollow masonry blocks, using insulation on the external surface and using light colored on the external side of the wall [6].

A good day lighting system can be achieved by number of elements like: orientation; space organization and geometry of the space; Location, form & dimension of the fenestrations and Location & surface properties of internal partitions. The minimum corresponding VLT of glass is required to meet the recommended day light factor for space [6].

Frequently used rooms (such as the living or dining rooms of a residential building), should be located on the Northern side where there is a good ventilation, rooms (such as kitchen, Bathroom), should be located on the southern side and rooms (such as Bedrooms) should be located on the eastern side to be effective daylight [3] , as illustrated in Fig (6).

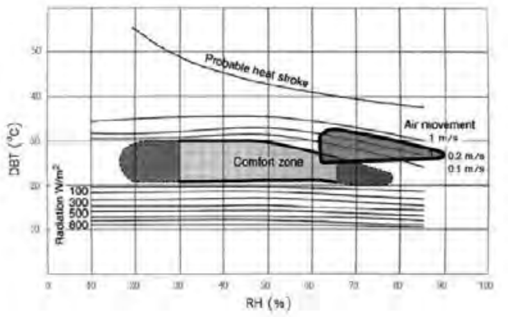


Figure 5: Bioclimatic chart modified for hot humid climates. The new comfort zone is shown on the right of the original one [4].

Figure 6: Ideal Plan for passive house [3]

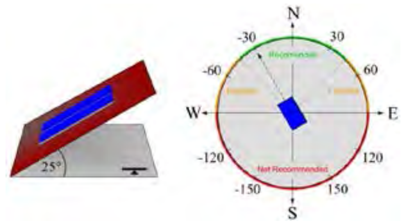


Figure 7: The Components of a Grid-Tied PV System [14] .

Several considerations to achieve good ventilation must be taken such as: raise above the ground, at a 20- 408 angle; build 18 m downwind above a 3 m height from building; each room needs 2 exterior walls, with many windows or vents, including low openings; use shutters or casement windows that open outward and use Openings between rooms to allow air circulation. The factors which then affect the speed of airflow through the building are: the ratio of outlet to inlet opening sizes& the degree of obstruction to the flow [10].

4.3. Active Design strategies

Using the renewable technologies provides the desired effect of reducing local greenhouse gas emissions (GHG) and support future energy solutions for buildings [11].

- **The Solar Source:** The excess heat in summer can be efficiently stored and then utilized in winter with an increased efficiency [12].

Photovoltaic Cells (PV): The annual electrical power output of a PV plant depends on different factors. Among them: the tilt angle for the panels could be made less in summer and tilted more vertical in winter [13]; ideally PV panels should face true north, however the angle is ultimately determined by the orientation of the roof where they are installed , as illustrated in Fig (7); PV panels have built-in diodes to reduce the effect of partial shading ; it is important to avoid heating the cells by restricting airflow underneath the panels and the warranty on the power output of the panels guarantees a degradation of less than 0.9% per annum, resulting in a minimum efficiency of 80% after 25 years [14] .Single crystalline Silicon (Mono crystalline) is the most effective type, next (Multi-crystalline silicon) Polycrystalline silicon. Thin Films (Amorphous silicon (a-Si) is the least effective type at the same period [15].

Thermal Solar Hot Water: There are three common types of solar collectors, which are flat plate collectors, Integral collector-storage systems and evacuated tube collectors [16]. Evacuated tube collectors is the best collector. Solar Water Heaters usually need to have an unshaded area that faces south at an angle of 30 to 45 degrees to the horizontal or on the ground using a frame; this has the benefit of allowing optimum tilt and azimuth [17].

Solar Desalination: Solar energy could provide potential resources for water desalination because the length of daylight in the summer in the Mediterranean coast increases to 14 hours, this increases the amount of solar radiation [18]. Solar still is an air tight basin, usually constructed out of concrete/cement, galvanized iron sheet (GI) or fiber re-enforced plastic (FRP) with a top cover of transparent material like glass, plastic etc. The performance of solar stills affects by the meteorological parameters namely wind velocity, solar radiation, sky temperature, ambient temperature and salt concentration [18].

- **The Wind Source:** For building mounted wind turbines to be successful in generating electricity, the average wind speed should not be less than 5.5 m/s [19].

Micro Wind Turbines: The building roof should be approximately 50% higher than its surroundings, and the turbine located near the center of the roof on the most common wind direction for the location, with the lowest position of the rotor at least 30% of the building height above the roof level [19] . At speed 5.5 m/s, a decent SMWT produces 350 kWh per square meter rotor surface annually [20].There are many types of turbine, the best of them Swift turbine because of its high efficiency and long Life expectancy [21].

- **The water Sources:** A Precious Resource can be utilized by assembled and used in a lot of purposes.

Rain Water Harvesting System: It depends on several factors, including density and distribution of rain and Times of rain per year [22]. It is important to recognize that the rainfall is not constant throughout the year; therefore, planning the storage system with an adequate capacity is required for the constant use of rainwater even during dry periods. For the design of a rainwater harvesting system, following details must be available: Annual water harvesting potential from roof (m^3) = A X R X C, whereas Area of the catchment (A) m^2, Average annual rainfall (R) mm, Runoff coefficient (C) ,Dry season (D) (days) = Year days – Rainy season(S) (days)&Drinking water requirement for the family (dry season) (liters) =D X F X M ,As: Rainy season(S) (months), dry season (D) (days), Drinking water requirement for the family (dry season) (F)(liters),safety factor (F)20%, member family (M) [23].

Sea Water (Tidal / Hydro): If the difference between high and low tides is more than 16 feet, the tidal energy can be used to produce electricity but generating energy for only 6-12 hours in each 24 hour period .A single 11-meter blade tidal turbine outside of coast will be capable of generating 300 kW of electricity (enough to power approximately 75 homes) [24].

- **The Ground Source:** It is inexpensive, because once the energy source is captured the energy is basically free [25].

Geothermal Energy (GHPs) save about 42% of the preretrofit electrical consumption for heating, cooling, and water heating in housing units (average annual savings of 6,445 kWh per housing unit).And also, the potential for utilizing GSHP results in reduction of running costs of up to 70% and reduced CO_2 emissions of up to 50% [25]. The effectiveness of a GSHP system is measured by COP (coefficient of performance) is defined as the ratio between heat delivered by the heat pump and the electricity supplied to the heat pump to deliver the useful heat. COP is also dependent on the difference between the ground and the required distribution temperature [26].

- **Waste Management:** It is widely recognized as one of the easiest, cheapest and fastest ways to reduce greenhouse gas emissions. This could result in a 77% reduction in global greenhouse emissions associated with the buildings sector by 2050 [27].

4.4. Energy Star

EPA uses a consistent set of criteria in the development and revision of specifications for ENERGY STAR qualified products. Products covered under this specification included: Analog Cable TV Set-top Box, Digital TV Converter Set-top Box, Internet Access Device, Video Game Console and Videophone Set-top Box is needed about 3 watt but Digital Cable TV Set-top Box, Satellite TV Set-top Box*, Wireless TV Set-top Box and Personal Video Recorder needed 7watt (for satellite systems, add # 5 Watts for each LNB) [28].

5. Egyptian Northern Coast Features :Study area Features

5.1. Hydrology of the Study Region

The study includes identification of natural resources and climate situation which covering a part of the coastal zone includes Sidi Abd El Rahman resort at the North Western Egyptian Mediterranean, as shown in Fig(8).

The studied area is located 136 Km from Alex at Matrouh Desert Road, Sidi Abd El Rahman, North coast Near To Marassi Village, on the North-western coast of Egypt, as illustrated in Fig (8).

5.2. Geological and Geomorphologic features

The structural plateaus constitute the active and semi-active watershed areas, whereas the low plains can contain productive aquifers and, in some cases, they are also areas of groundwater discharge [29].

There are many features for the study area like Coastal plain elevation varies from sea level from 0 to 200 m [29], as shown in Fig (9). Beaches are 500 m to more than 1.5 km long, Coastal Dunes are composed of loose white oolitic carbonate sand, and Coastal Ridge is composed of white cross bedded, friable oolitic limestone and covered by snow white carbonate sand. Its width between 100 m and more than 500 m, Coastal Depressions is occupied by reddish brown soil deposits, Salt Marshes and Lagoons is mostly covered with carbonate dune, Off shore land are the remnants of younger ridges, Inland dunes are composed of both carbonate and quartz sands, Inland depression is covered by alluvial deposits& Inland ridges are composed of hard Oollitic limestone [30].

Figure 8: Study area

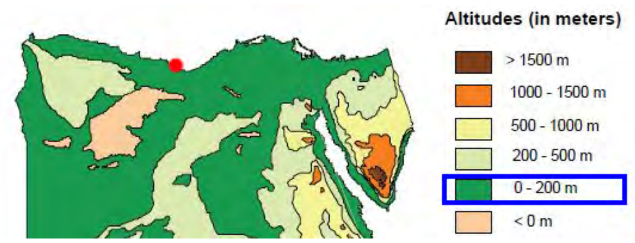


Figure 9: Topography of Study area [29]

5.3. Physiographic Setting

It can be described as a temperate Mediterranean climate, transitioning from a moderate coastal climate in the north to an arid-semiarid desert climate in the south.

- **Location:** The northwestern Mediterranean coastal zone occupies the northern extremity of the great Marmarica homoclinal plateau which extends to the north of the Qattara Depression. The surface of this plateau rises about 200 m above sea level and slopes gently to the north, in the direction of the Mediterranean Sea [31], [32].
- **Climate:** Its Climate is semi-desert, characterized by hot dry summers, moderate winters, a lot of rainfall and good wind regimes [30] . As shown in Fig (10), the study area is affected by climate change significantly [18].

Air temperature: In summer, when they may range from 7^0 C at night to 43^0 C during the day. During winter, temperatures fluctuate less dramatically, but they can be as low as 0 C at night and as high as 18^0 C during the day [33].

Humidity: There is high relative humidity in the study area, due to the effect of the sea. The relative humidity is high in July (73%) and is low in March (63 %).The average recorded value of evaporation in Mersa Matruh station reaches 2420 mm annually [31], [34].

Rainfall: It affects greatly the amount of water stored in these aquifers [31]. The rainy season starts in October to January are the rainiest months, and the dry season extends for seven months [35] . The Mediterranean North West coastal zone of Egypt receives noticeable amounts of rainfall, especially in winter, when it ranges from 95 to 160 mm [32].

Wind: Wind speed in the Northern Coastal of Egypt is from 200 to 300 W/m2, as shown in Fig (11). This speed is sufficiently high to drive a wind turbine at a high power rating [36].

Moisture Regime: The evaporative power of the air varies in January in June from 14.0 mm/day in the Bahariya Oasis to 24.3 mm/day in the Dakhla Oasis [34].

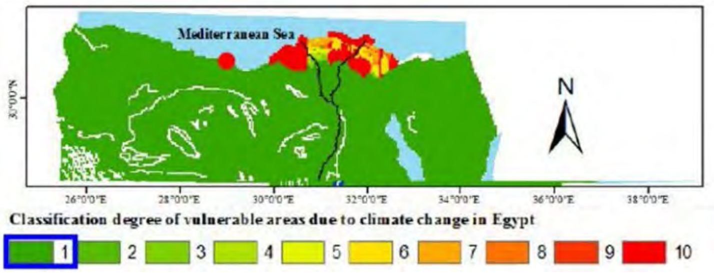


Figure 10: Classification degree of vulnerable area due to climate change, sea level Rise (SLR) and Seawater intrusion in Egypt [18]

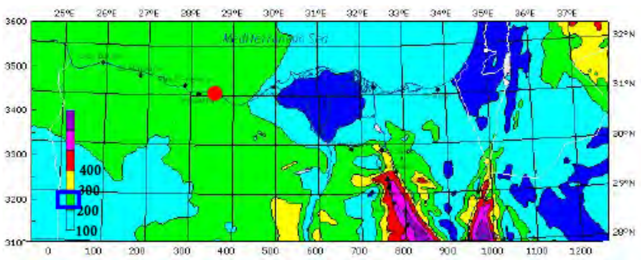


Figure 11: Wind atlas for Egypt (power density at 50 m, in W/m^2) [36]

5.4. Resources

In the Northern Coast, many resources are found like

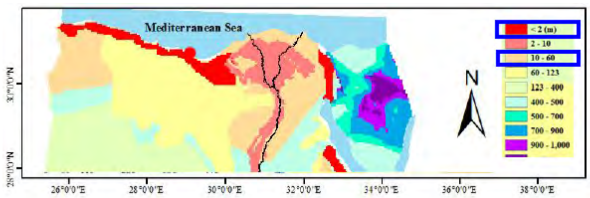
- **Hydrogeological Frame work:** Notice that, In North West coastal area, the person average is about

240 m^3/year decreases to nearly 130 m^3/year in summer due to the internal tourism, water shortage increase rapidly. So that, there are attempts to solve the water shortage based exclusively on technology *[31]*, such as*:*

Water resources: Consequently, insufficient water often activities so natural water sources like precipitation, groundwater and seawater were used instead of it. The per capita available water also varies 810 m3/year. And also, the share of household water consumption is from 9% to 15 % *[37]*.

The largest precipitation amounts (annual total larger than 250mm) were found in the northern coast during the last four decades, as shown in Fig (12). For El Salum station, the precipitation amount varies dramatically from winter to winter. In addition to, it is difficult to predict the variability of precipitation in the northern coast [38].

The depth of the water table varies from less than 1 m to more than 50 m. Water quality also varies with seasons [39] .Fig (13) shows for the entire country these trends indicating that northern regions has become wetter and southern regions dryer [40].From the study, it is appeared that the study area has a groundwater which its depth near the beach is between 10 to 60 meter and whenever move away from the beach is less than 2 meter [18].



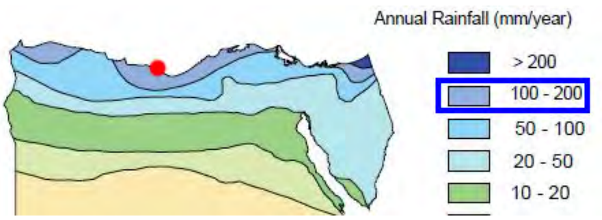


Figure 12: Annual rainfall (mm/year) [29], [42] **Figure 13:** Average Groundwater depth [18]

Recently, it was realized that the desalination of Sea water, saline and brackish water is less expensive than transporting Nile water to tourist areas around northwestern coast [41]. The final output of the (SDSS) model is a digital map of pilot areas of solar desalination potentiality. The potential of solar desalination is greatest in the Northern Coast [18].

Recent recycling plans include the reuse of about 7.0 bcm/year of land drainage water which goes unused to the Mediterranean Sea and the coastal lakes [42].

Soil resources: The northern foreshore ridge; composed of white friable Oolitic limestone which is locally covered by loose carbonate sand with an estimated porosity of about 45%.But,the southern inland ridges are composed of hard oolitic limestone (second porosity) of dark color [31].

- **Nonrenewable Energy:** The present and future situation of energy challenges necessitates the extending of implementation and development of the use of renewable energy resource *[34]*.Fossil fuels can be considered as the main energy resource.

Natural gas: The study area of the most areas in Egypt where natural gas is available. The amount of the production of natural gas at this region, ranging from 8.9 to 11 million metric ton /year in this area [18], as shown in Fig (14).

Hydropower: The total available hydropower energy is about 2.7 Mtoe (12.2 TWh) in 1997/98 [42].

Crude oil: The present level of production of crude oil is about 44 Mtoe [42].

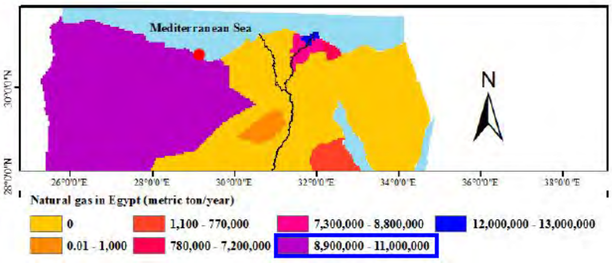


Figure 14: Natural Gas [29,42]

Coal: The deposits are estimated at only about 36 Mt of workable recoverable reserves, with the possibility of reaching about 55 Mt in a future [42].

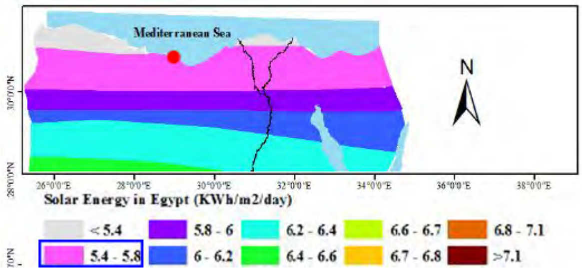


Figure 15: Solar Energy intensity [29,42]

- **Renewable Energy:** The northern Coast has also good potential renewable resources due to its geographic location [42].

Solar Energy: In 1991, according to the Solar Atlas, direct solar intensity ranges in the study area between 5.4 and 5.8 kWh / m^2 / day [18], as illustrated in Fig (15).

Wind Energy: Wind speed mapping showed that the potential areas in the Northern Western Coast has some good locations with an average annual wind speed of about 10 m/s capable of producing competitive wind energy from wind turbines [18,42]

- **Waste management:** It is estimated that 75% of solid waste management (domestic garbage) is generated from urban areas. The national average per-capita waste generation rate is equal to 6120Gg [42].

There is a pressing need for reusing water from the drains and reducing the flow from drains to the sea. Proven technologies are used for the primary treatment of sewage before disposal [42].For domestic & Commercial, BOD values are taken as 0.037Gg/year/1000capita for the coastal zones. And, the water consumption/cap/day was estimated as 270 lit, and the domestic wastewater was assumed as the rate of water consumption [42]. For industrial wastewater, Methane emissions from the waste management sector amounted to 271Gg of which nearly 98% was produced from solid wastes, mainly from open dumps [42].

6. Case study: Sidi Abd EL-Rahamman, Northern Coast

6.1. Project Description

- **Name and location of development:** Amwaj resort, Sidi Abdel Rahman, located on the 136 kilos from Alexandria.

- **Climate Region:** Very Hot_Humid (Tropical)

- **Building Type:** 4 bedroom semi-detached house (renovation)

- **Aims of project:** zero energy building & near zero carbon emitters.

- **Environmental parameters assessment:** External wind flow, internal temperatures, ventilation performance & day lighting performance.

- **Energy efficiency Measures:** Include: Triple glazed windows and double air seals, Thermal wall insulation, High airtightness including use of membranes in walls, High thermal mass using compressed earth blocks, Passive design, Low energy lighting and appliances& natural system ventilation.

- **Computer simulation programs:** Using Ecotect for day lighting performance &shadows and Design Builder for calculate Co_2 production, internal gains, fossil fuel, comfort zone & site data.

- **On-site generation Measures:** Photovoltaic modules in roofs, solar hot water, 1.5kWp Swift roof-mounted wind turbine, Biomass heating for space and water heating.

- **Energy savings:** A study was carried out for the main developer, the aim of which was to provide guidelines for reducing the energy demand of the residential units compared to the current standard.

  To optimize energy performance by identifying variations of orientation, overshadowing, and buildings of different height, internal gains, and construction type (in relation to thermal performance).In this case not only to reduce operating energy costs but also to reduce the energy supply infrastructure.

6.2. Site analysis and climate conditions at selected locations

The simulation project is aiming to understand how much influence of weather include Dry-Bulb Temperature , Dew-Point Temperature , Wind Speed ,Wind Direction, Solar Altitude, Solar Azimuth &Atmospheric Pressure. The table illustrate that site's climate condition in different seasons at year.

Table 1: Climate conditions at selected locations

Period	From 1 January to 31 January	From 1 June to 31 June
Outside Dry-Bulb Temperature (^{0}C)	14.67	24.62
Outside Dew-Point Temperature (^{0} C)	9.33	18.27
Wind Speed (m/s)	3.35	4.42
Wind Direction (0)	181.46	278.41
Solar Altitude (0)	-14.17	15.59
Solar Azimuth (0)	181.42	183.63
Atmospheric Pressure (Pa)*10^3	101.95	101.18
Direct Normal Solar(KWh)	111.36	118.74
Diffuse Horizontal Size (KWh)	12.97	129.92

- **Wind:** It is important to know the wind pressures on building facades in order to design for natural ventilation, for which there should be sufficient pressure differences to promote cross-ventilation.

Example results from the study are shown in Fig (16) for a single block located within the development. They indicate that for most apartments, for average wind speeds, a suitable background ventilation rate of around 3.35 m/s could be achieved in winter, while higher rates of around 4.42 m/s could be achieved in summer.

Therefore, Wind Turbine has used as one of renewable energy resources because of sufficient wind speed.

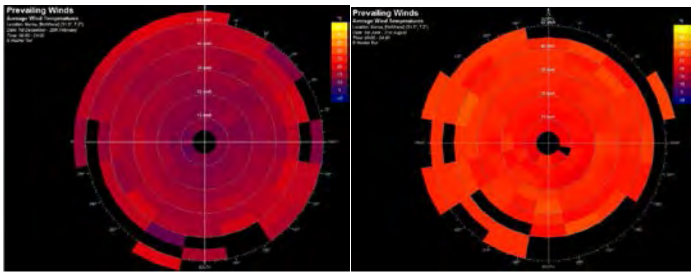


Figure 16: Wind speed around study building in different seasons of year.

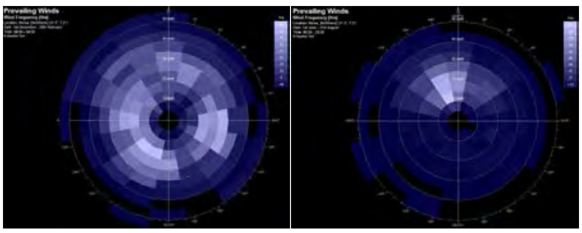


Figure 17: Average temperature in different seasons of year.

- **Temperature :**From Autodesk Ecotect, average temperature is found from 10 to 25 ^{0}C in Summer especially in August but average temperature in Winter in January is found from 20 to 35 ^{0}C,as shown in Fig (17).This allow to use solar panels.

6.3. Building Analysis

It can be quickly set up to construct the development in Revit and the necessary data files downloaded like Design Builder &Autodesk Ecotect to the building energy model.

- **Building outline:** This type which consists of ground floor and two stories and each floor contains two apartments. Each units is planned in 85m", each apartment consists of two bedrooms, living room, bathroom and kitchen and every space is sort by its activity,as illustrated in Fig (18).

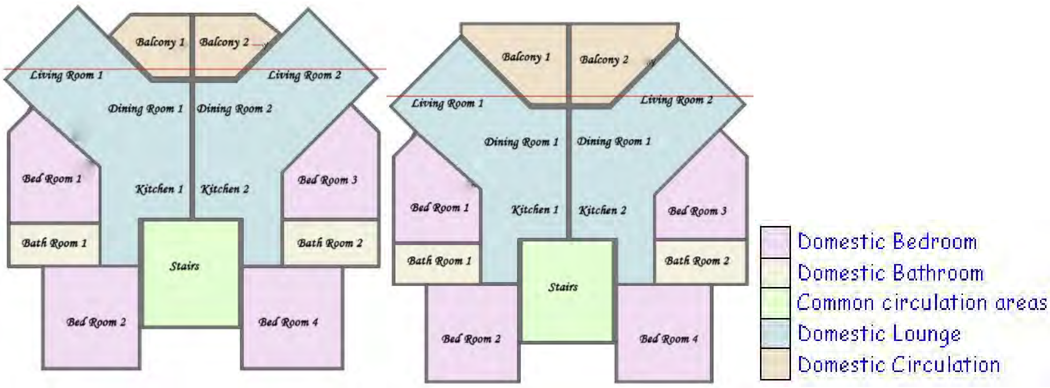


Figure 18: Building Outline (Ground Floor plan, First Floor plan).

- **Orientation of building:** The results indicate that the original orientation of building facing north in site before building development. But the results indicate the best orientation of building facing north in site to achieve zero energy building, as appeared in Fig (19).

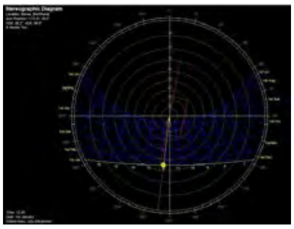


Figure 19: Original orientation and best orientation of building.

- **Annual sun path:** The brightest day of 3rd June and the most overcast day of 23rd October. In order to acquire sufficient daylight all days, the brightest day and the most overcast day were used in simulations, as illustrated in Fig (20).

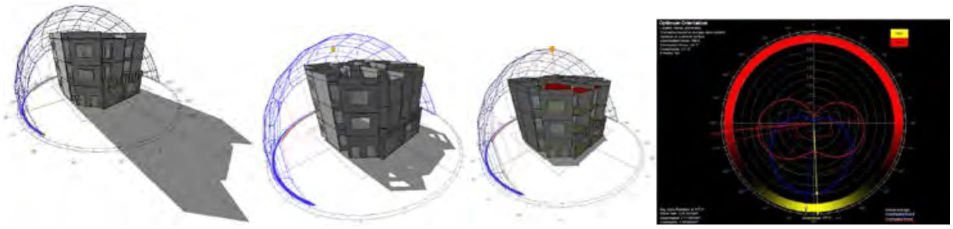


Figure 20: Shadow of building.

- **Layers:** Layers have been identified for the walls, ceilings and floors in each case.

External walls layers with U-value = 1.923 W/m^2-K, R-value = 0.52 W/m^2-K, consists of (1) Outer surface (External rendering =2.5 cm) With Embodied Carbon= 0.1 Kg, (2) Concrete blocks/tiles-block, hollow, lightweight=15 cm With Embodied Carbon= 0.08 Kg, (3) Inner surface (External rendering=2.5 cm) With Embodied Carbon=0.1 Kg.

New External walls layers with U-value = 0.07 W/m^2-K,R-value =10.01 W/m^2-K ,consists of (1)Outer surface (Lightweight Metallic cladding =0.6 cm) With Embodied Carbon=8.55Kg,(2) XPS Extruded Polystyrene - CO_2 Blowing=40 cm With Embodied Carbon=2.88Kg,(3) Concrete blocks/tiles - block, hollow, lightweight150mm=15Cm With Embodied Carbon=0.08Kg,(4) Air gap 10mm=1 Cm ,(5) Concrete blocks/tiles - block, hollow, lightweight150mm=15Cm With Embodied Carbon=0.08Kg,(6)Inner surface (Gypsum Plasterboard=2.5 cm)With Embodied Carbon=0.12Kg.

Internal Partition Layers with U-value = 1.216 W/m^2-K, R-value = 0.823W/m^2-K, consists of (1) Outer surface (plaster Light weight =2.5 cm) With Embodied Carbon=0.12 Kg, (2) Concrete blocks/tiles-block, hollow, lightweight=12 cm With Embodied Carbon=0.08 Kg, (3) Inner surface (plaster Light weight =2.5 cm) With Embodied Carbon= 0.12 Kg.

New Internal Partition Layers with U-value = 0.16 W/m^2-K, R-value = 6.35 W/m^2-K,consists of (1) Outer surface (Gypsum Plasterboard =1.3 cm) With Embodied Carbon=0.12Kg,(2) EPS Expanded Polystyrene (Standard) =10 cm With Embodied Carbon=2.5Kg, (3) Concrete blocks/tiles - block, hollow, lightweight, 150mm =10 cm With Embodied Carbon=0.08Kg,(4) Air gap 10mm=1 Cm,(5) Concrete blocks/tiles - block, hollow, lightweight, 150mm =10 cm With Embodied Carbon=0.08Kg ,(6) EPS Expanded Polystyrene (Standard) =10 cm With Embodied Carbon=2.5Kg,(7) Inner surface (Gypsum Plasterboard =1.3 cm)With Embodied Carbon=0.12Kg.

Ground floor layers with U-value = 0.542 W/m^2-K, R-value = 1.845 W/m^2-K, consists of (1)Inner surface (Carpet/textile flooring =2.5cm)With Embodied Carbon=3.89Kg, (2)Ceramic/clay tiles – clay tile, hollow, 2.03cm, 2cells=3 cm With Embodied Carbon= 0.46 Kg, (3)Cement/plaster/mortar-cement plaster =2.5 cm With Embodied Carbon= 0.16 Kg, (4)Sand =3cm With Embodied Carbon= 0.08 Kg, (5)Miscellaneous materials – aggregate (sand-gravel-stone) = 10 cm With Embodied Carbon= 0.08 Kg, (6)Polyethylene foam = 2.5 cm With

Embodied Carbon=1.94 Kg, (7) Miscellaneous materials – aggregate (sand-gravel-stone) = 10 cm With Embodied Carbon= 0.08 Kg,(8)Outer surface (Earth gravel= 15 cm)With Embodied Carbon= 0.02 Kg.

New Ground floor layers with U-value = 0.1 W/m^2-K, R-value = 9.15 W/m^2-K, consists of (1) Outer surface (Earth, gravel=20 cm)With Embodied Carbon= 0.02 Kg, (2) Cast Concrete (Lightweight)=10 cm With Embodied Carbon= 0.08 Kg, (3) Urea Formaldehyde Foam =30 cm With Embodied Carbon= 1.78Kg, (4) Cast Concrete (Lightweight)=10 cm With Embodied Carbon= 0.08 Kg, (5) Floor/Roof Screed = 7 cm With Embodied Carbon= 0.16 Kg,(6) Inner surface (Timber Flooring = 5 cm)With Embodied Carbon= 0.46 Kg.

External roof layers :With U-value = 1.232 W/m^2-K, R-value = 0.812 W/m^2-K, consists of (1) Outer surface (Ceramic/clay tiles – clay tile, hollow, 2.03cm, 2cells=1 cm) With Embodied Carbon= 0.46 Kg, (2)Cement/plaster/mortar-cement plaster =2.5 cm With Embodied Carbon= 0.16 Kg, (3)Sand =3cm With Embodied Carbon=0.08 Kg, (4)Miscellaneous materials – aggregate (sand-gravel-stone) = 10 cm With Embodied Carbon=0.08 Kg, (5)Polyethylene foam = 2.5 cm With Embodied Carbon=1.94 Kg, (6)Concrete reinforced (with 2% steel) =10 cm With Embodied Carbon= 0.31 Kg, (7)Inner surface (External rendering = 2.5 cm) With Embodied Carbon= 0.1 Kg.

New External roof layers with U-value = 0.05 W/m^2-K, R-value = 17.27 W/m^2-K, consists of (1) Outer surface (Grass/straw materials - straw thatch) =10 Cm, (2) XPS Extruded Polystyrene - CO2 Blowing=40 cm with Embodied Carbon=2.88 Kg, (3) Refectory Insulating Concrete =20 cm, (4) Air gap 10mm = 1 cm, (5) Inner surface (Plasterboard= 1.3 cm).

Internal floors Layers with U-value = 1.665 W/m^2-K, R-value = 0.601 W/m^2-K, consists of (1)Inner surface (Carpet/textile flooring =2.5cm) with Embodied Carbon= 3.89 Kg,(2)Ceramic/clay tiles – clay tile, hollow, 2.03cm, 2cells=1 cm with Embodied Carbon=0.46 Kg,(3)Cement/plaster/mortar-cement plaster =2.5 cm with Embodied Carbon=0.19 Kg,(4)Sand =3cm with Embodied Carbon=0.08 Kg,(5) Concrete reinforced (with 2% steel) =10 cm with Embodied Carbon=0.31 Kg,(6)Outer surface (External rendering = 2.5 cm) with Embodied Carbon=0.1 Kg.

New Internal floors Layers: With U-value = 0.1 W/m^2-K, R-value = 9.33 W/m^2-K, consists of (1)Inner surface (Timber Flooring =5 cm) with *Embodied Carbon= 0.46 Kg* ,(2) Floor/Roof Screed = 7 cm With Embodied Carbon= 0.16 Kg,(3) Urea Formaldehyde Foam =30 cm With Embodied Carbon= 1.78Kg,(4)Cast Concrete (Lightweight)= cm With Embodied Carbon= 0.08 Kg,(5) Air gap 10mm = 1 cm,(6)Outer surface (Plasterboard =1.3cm).

Windows: The same size of windows in Case 1&2. In Case 1, using Single clear glass with thickness 3mm with SHGC =0.861, Direct solar transmission =0.837, light transmission =0.898, U value =5.829 W/m^2-K.In Case 2, using Triple clear glass with thickness 10 mm with SHGC=0.679 , Direct solar transmission =0.595, light transmission =0.739 , U value = 1.94 W/m^2-K.

In Case 1, using fixed windows with painted wood frames. (A) Dividers (Width =5 cm, Outside projection =2.5cm, Inside projection = 2.5cm) & (2 Horizontal dividers & 1 Vertical dividers), (B) Frames (Width = 10 cm, Outside projection =2.5cm, Inside projection = 2.5cm).In Case 2, using fixed windows with UPVC frames. (A) Dividers (Width =5 cm, Outside projection =2.5cm, Inside projection = 2.5cm) & (2 Horizontal dividers & 1 Vertical dividers), (B) Frames (Width = 10 cm, Outside projection =2.5cm, Inside projection = 2.5cm)

In Case 1&2, using the same ratio of Window to Wall ratio% =30%. Using shading devices in Case 2 to minimize temperature in building and reach to thermal comfort.

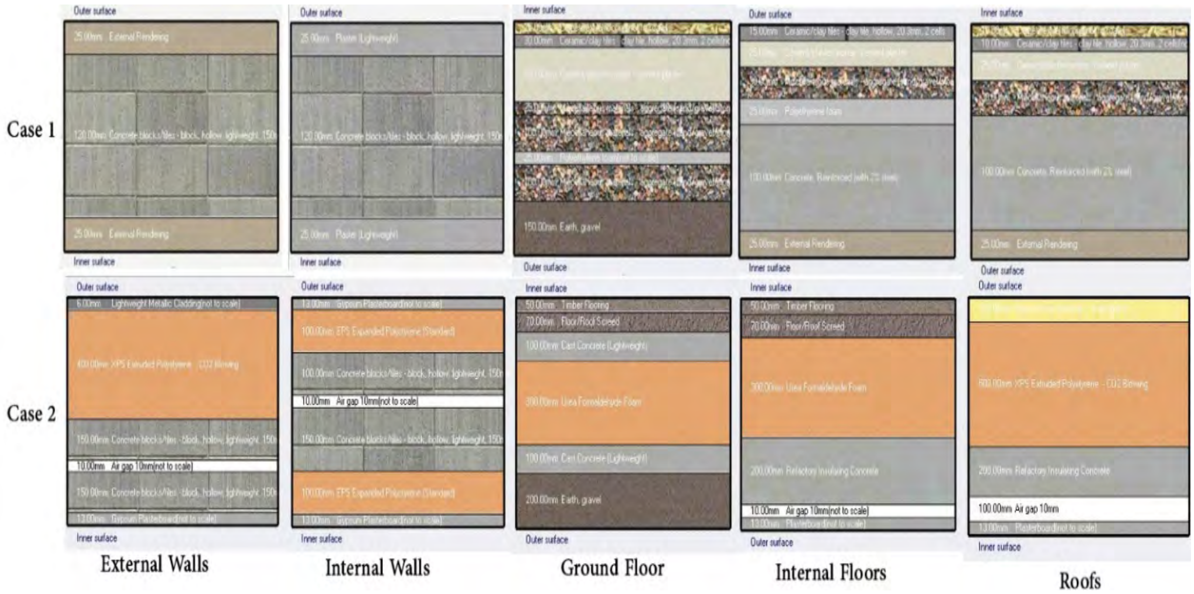


Figure 21: Layers of study building before and after development.

- **Openings:** It consists of glazed windows and doors.

Doors: For external doors, in case 1, using wooden doors with Width 1.1m& Height 2.2m.In case 2, using aluminum doors with Width 1.1m& Height 2.2m.For Internal doors, in case 1, using wooden doors with Width 0.9 m& Height 1.9 m. In case 2, using aluminum with Width 0.9 m& Height 1.9 m.

- **Daylight Analysis:** Computer modeling also can be used to illustrate these effects; Design Builder being used to estimate the level of daylight falling on the external facade, as appeared in Fig (22), Table (2). At the top of the tower daylight and sunlight are in abundance while at the bottom some apartments 'see' very little sky. With this data, the maximum daylight would be between June to September and the minimum day light would be between Octobers to January.

Actually, average daylight factors of the case 1 are positive, excepted for Kitchen 1, 2 and Stairs .These results are caused by large sizes of windows. However, the other aspects of environment, such as temperature, should be influenced negatively. Therefore, daylight factors of the case 1 are minimized through changing type of glazing and shading devices.

Table 2: Daylight factors of Spaces

Room Type	Average Daylight Factor	
	Case 1	**Case 2**
Living Room 1,2	1.6,1.3	0.99,0.96
Dining Room1,2	0.46,0.45	0.6,0.6
Kitchen 1,2	0.079,0.075	0.071,0.052
Balcony 1,2	4.11,3.97	4.96,4.47
Bed Room 1,2.3,4	0.79,1.77,0.68,1.8	0.55,1.07,0.43,1.06
Stairs	0.072	0.033
Bath Room 1,2	0.58,0.32	0.29,0.21

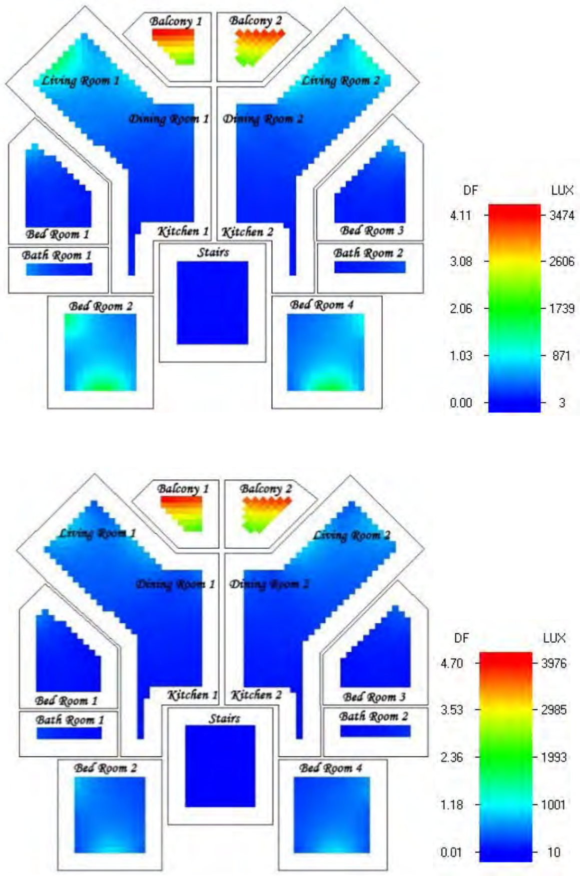
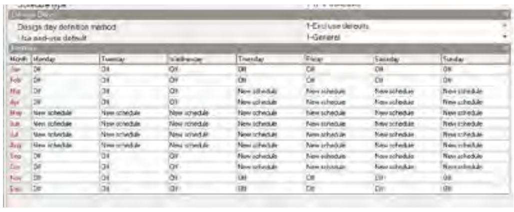


Figure 22: Day lightning simulation of building (Case 1, Case 2).

- **Zones properties:** A study of each space is located in each unit such as comfort criteria for each zone like (temperatures, activity, winter& summer clothing & air supply rate for each person).

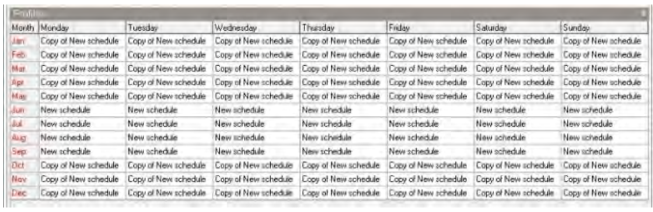
A study of each zone is located in each unit such as bathrooms, bedrooms, living rooms, stairs, landing& kitchen. With determining density of people, activity, IL luminance, equipment, computers & catering devices which used in each zone and operating schedule for this unit all day and over the year. In Case 2, energy star appliances and luminance is used to reduce use of electricity.

Building utilization annually: The building is used for the highest use in summer (May and June, July and August) and also run in the days of weekends in spring and autumn (March ,April , September and October), while the suspended use of the building in winter (November, December, January and February). But after development, building is used for the same use in all seasons of year, as shown in Fig (23).



Design day definition method	1-Exclude defaults
Use end-use default	1-General

Month	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Jan	Off	Off	Off	Off	Off	Off	Off
Feb	Off	Off	Off	Off	Off	Off	Off
Mar	Off	Off	Off	New schedule	New schedule	New schedule	New schedule
Apr	Off	Off	Off	New schedule	New schedule	New schedule	New schedule
May	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule
Jun	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule
Jul	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule
Aug	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule
Sep	Off	Off	Off	New schedule	New schedule	New schedule	New schedule
Oct	Off	Off	Off	New schedule	New schedule	New schedule	New schedule
Nov	Off	Off	Off	Off	Off	Off	Off
Dec	Off	Off	Off	Off	Off	Off	Off



Profiles

Month	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Jan	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule
Feb	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule
Mar	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule
Apr	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule
May	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule
Jun	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule
Jul	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule
Aug	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule
Sep	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule	New schedule
Oct	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule
Nov	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule
Dec	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule	Copy of New schedule

Figure 23: Periods of operation of the building throughout the year.

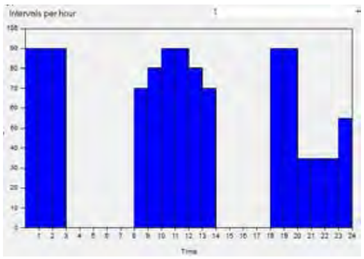


Figure 24: Hours of operation of building during day.

Building Utilization daily: The same schedule in case 1 and case 2 at summer, The building is used for the highest use in morning from (8 am-12 pm) by nearly proportion from (70_90 %) because of practicing activates like wakeup and breakfast , in afternoon (6 pm-12am)by nearly proportion from (40_60 %) because some users practice activates like launch and other users go to walk out, in mid-night (12 am-3am) by nearly proportion 90% because of practicing activates like dinner ,watch television & others ,while the suspended use of the building in morning from (2pm-6pm) because of going to the beach and in mid-night (3 am-8am) because of sleeping, as illustrated in Fig(24).

- **Simulation results:** A comparison between simulation results of the building which is with un-insulated medium height, single Glazing, no shading devices and simulation results of the building which is with insulated medium height, triple Glazing, shading devices in summer.

Internal Gains includes electric equipment, solar gains and zone sensible cooling &heating. The results show that computer and equipment, lightning and solar gains exterior windows produce the same kilowatts of gains which is about 160 kw/hr. in Case 2. Computer and equipment gains is reduced approximately hundred-fold in Case 2 and fourty-fold of catering gains is diminished by house modification and also lightning reduced five times at second simulation. While, solar gains exterior windows is decreased from 7000 to 160 Kw/hr. and solar gains interior windows is reduced from 100 to 50 Kw/hr. But the same of kilowatts of gains that is produced from occupancy, as shown in Fig (25).

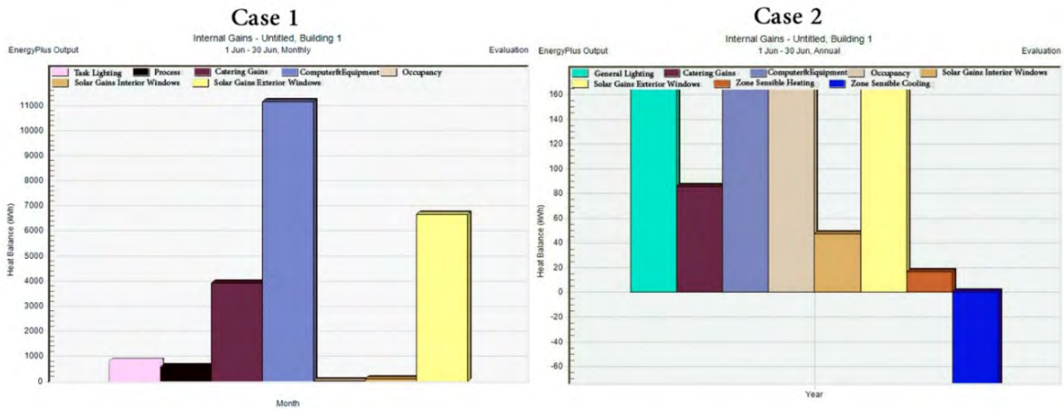


Figure 25: Internal gains from building before and after development.

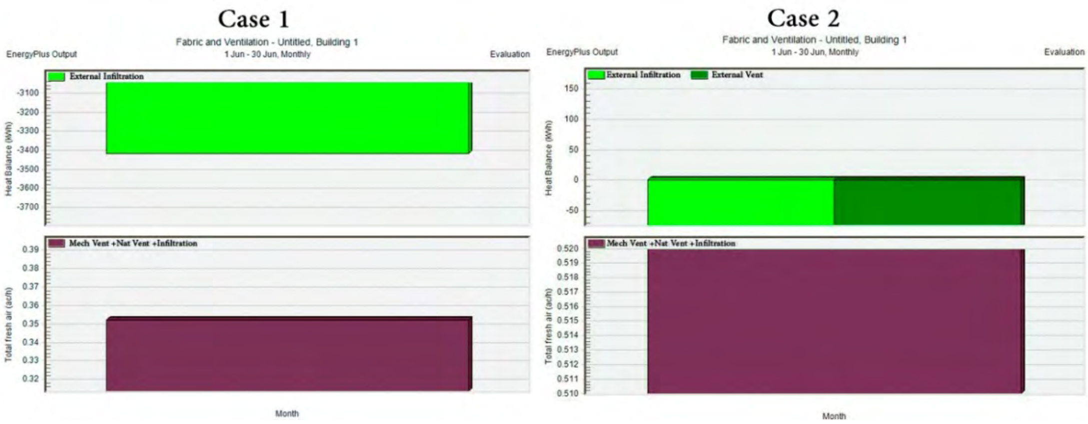


Figure 26: Fabric and ventilation from building before and after development.

Fabric and ventilation includes surfaces, window heat loss/gains, infiltration, and ventilation, air and air flow. And, when a rapprochement is make between fabric and ventilation in Case 1 and Case 2, noticed that external infiltration is increased approximately seventy-fold in Case 2 and also mechanical ventilation, natural ventilation& infiltration are the highest in Case 2. External ventilation is used after building development, as shown in below Fig (26).

Fuel totals includes electricity, gas, oil, solid, bottled gas and other fuel consumption. Studies have proven in below Fig (27) that total electricity is reduced from 12000 to 55 Kw/hr. and natural gas reached about the same percentage of used electricity in case 2 but Bot gas is not used in case 2.

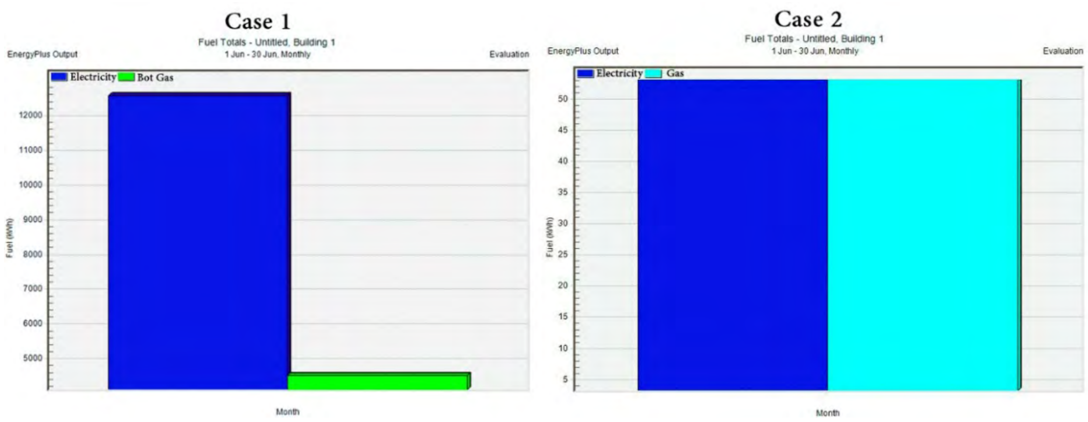


Figure 27: Fuel totals from building before and after development.

Fuel breakdown includes compact and detailed HVAC, simple HVAC, AHU supply fan, pump electric consumption, Fan electric consumption, electric equipment, domestic hot water consumption, preheat energy, lighting, room electricity, room gas, room oil, room solid, room bottled gas and room other. The simulation results pointed out that room electricity, natural gas and lightning produce the same kilowatts of fuel breakdown which is about 50 kw/hr. in Case 2,as appeared in below Fig(28).

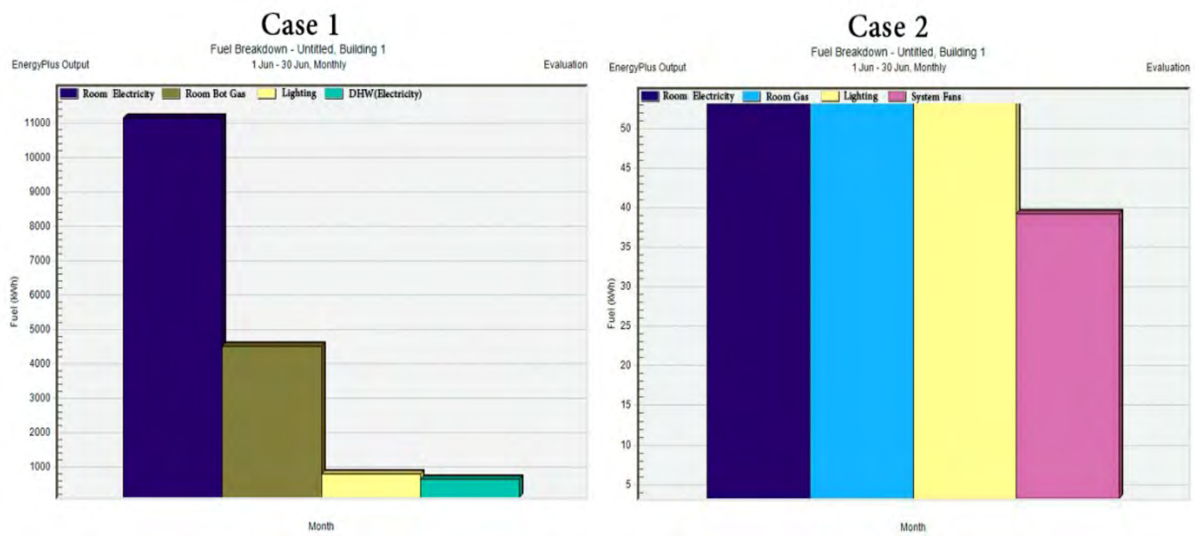


Figure 28: Fuel breakdown from building before and after development.

Environmental /comfort output includes temperatures, humidity, clothing and index (PMV).Fig (29) illustrate that temperature reduce from 50^0C to 30^0C but humidity increased twice.

Noticed that Co_2 production is about 9500 Kg in Case 1, but it is 900 Kg in Case 2.

6.4. Comparison between simulation results in case 1&case 2

The zero carbon approach to design aims to minimize energy demand and then generate energy from renewable sources. These renewable energy supplies could be integrated into the building design, into the neighborhood specifically to serve the new development. The main aim was to predict the energy demand for electrical power from renewable systems. Building energy models use weather information, for example, solar radiation and wind speed, to predict the solar heat gains and to estimate the heat transfer at external surfaces. This information can also be used to simulate the potential energy supply from solar and wind on the same timescale, for a given system specification. In particular, the orientation and overshadowing effects that determine how much solar radiation falls on a façade can also be used to estimate how much solar radiation a solar panel would receive; a solar panel can be considered as a wall that generate energy.

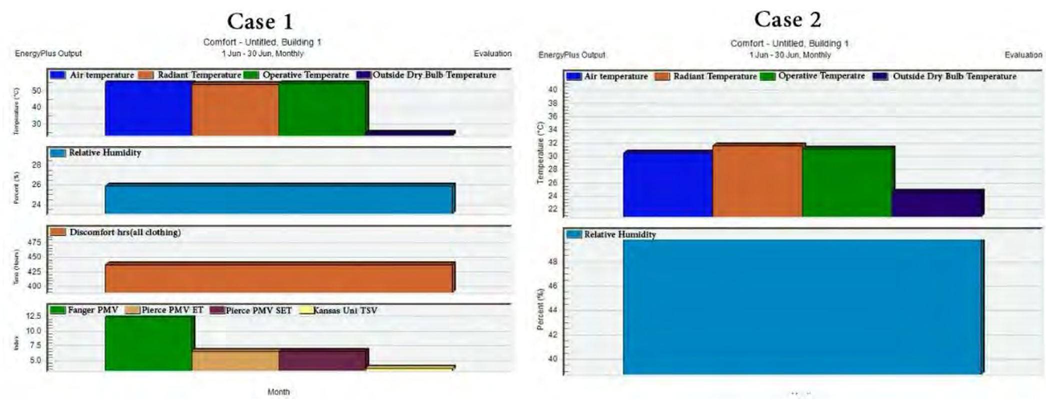


Figure 29: Comfort Output from building before and after development.

According to (Fig 30) to obtain the highest efficiency from solar panels so that it must be placed on the roof or on the southern facade of building. From pervious results, the amount of carbon-producing in case 2 (uninsulated building) is twice to the amount of carbon producing in case 1 (insulated building) in summer. The quantities of electricity is reduced for building operation in case 1 (insulated building) from 12000 to 55 Kwh in case 2 (uninsulated building). From pervious results, noticed that the amount of carbon-producing in case 2 (the highest use of building) in January is twice to the amount of carbon producing in case 1 (non-use of building) in January.

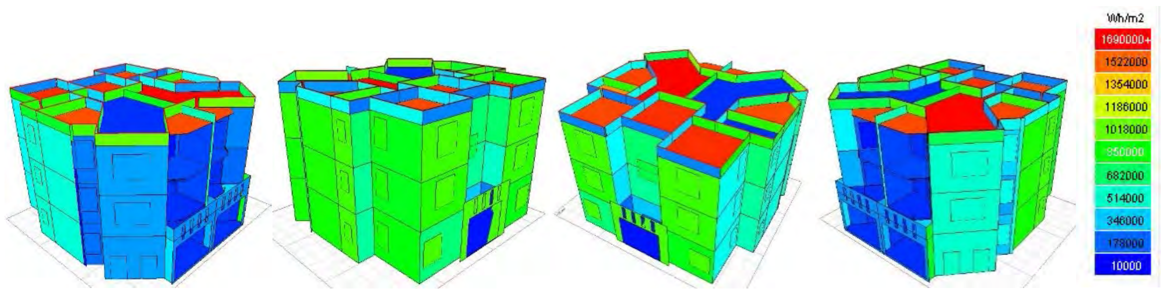


Figure 30: Facades of building with the highest efficiency from solar intensity.

7. Discussion

This paper discusses the need for energy and environmental modeling at residential resorts. It stresses the importance of carrying out such modeling at an early master planning stage of a new design. It also considers modeling the existing built environment at residential resorts. A variety of modeling methods are introduced, from simple annual energy calculations, to how more complex energy models developed for individual building simulation. A case study can be used to illustrate the modeling applications. Finally, a general framework for zero carbon building design is introduced.

Models can be used to predict annual energy consumption and carbon dioxide emissions, such as the Design Builder tool. And other models, such as Ecotect can be used to predict the hourly thermal and energy performance of buildings typically over a year. The focus is on a range of different environmental features, there is an emphasis on reducing energy demand and carbon dioxide emissions. So that, they were mainly based on computer simulation; such as sunlight, daylight, and wind flow scale-modeling has also been used for urban-scale environmental modeling.

8. Conclusion &Recommendations

8.1. Passivhaus Standard

- **Design requirements:** Variety of design strategies, construction methods and technologies Institute. Building energy requirement annual total electricity of 1480 kWh/m^{2}a treated floor area total primary energy demand for space and water heating, ventilation, electricity for fans and pumps, household appliances and lighting not exceeding 17700 kWh/m^{2}a.
- **Design advices:** Significant energy saving potential if adopted for new build housing. Analysis region climate found that the requirements could be relaxed to achieve the thermal energy target.Can be achieved both hallow blocks and UPVC frame construction methods.
- **Design and Construction skills:** National framework for training and at all levels and in energy efficient Design and Construction skills design and construction. Interdisciplinary training of designers - UCD undergraduate, post graduate and midcareer level to achieve integrated design approach for performance achievement. Provision of innovative components and technologies are essential for client confidence and designer specification.
- **Design and Construction performance evaluation:** Design and Construction performance evaluation UCD ERG research on the relationship between building performance and indoor air quality in dwellings. Completed new build demonstration projects should be rigorously tested, commissioned, monitored, post occupancy studies - results disseminated.
- ***Building users:*** Provide user information on energy technologies and systems. Face to face training in buildings with passive design features and sophisticated energy systems. Understand the impact which their lifestyle has on energy usage and related carbon emissions.

8.2. Increasing standards for new build

Architects& Designers are increasingly requesting higher energy performance than building regulation standard. ‘Energy Efficiency Regulations for New Dwellings and Options for Improvement’ study, found that performance improvement in energy use and CO_2 emissions was possible in the majority of representative new build dwelling types through improved building design and construction. Proposed target of performance improvement signaled will require a combination of energy efficient materials, innovative components and technologies and increasing renewable supply systems to be integrated for its' achievement.

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