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CARBON NEUTRAL URBAN SPACES UNDER CLIMATE CHANGE CASE STUDY: RENOVATION OF SIDI GABER NEIGHBORHOOD IN ALEXANDRIA, EGYPT

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Abstract

With growing pressure from the public on governments and organizations to address climate change, the term ‘carbon neutral’ has become increasingly used in recent years. Carbon neutral is an emerging definition that relates to measuring, reducing and offsetting carbon energy used by either a building or an organization as a whole. Buildings are a significant source of greenhouse gas emissions when they operated by fossil fuel energy resources. Sustainable urban development is essential issue to enhance the quality of life of city residents and to decrease the negative impact of conventional type of energy through using the renewable energy resources. This research discusses the issue of the planning future sustainable cities and how to apply all the innovative renewable energy solutions for construction and operation of these developments. It aims to achieve the criteria of renovation existing conventional neighborhood to be a prototype of carbon neutral urban area and maximize the benefits of sustainable technologies through an integrated planning and design approaches. The research’s case study concentrates on renovating of Sidi Gaber neighborhood and its surroundings in Alexandria city, Egypt as a prototype for a high quality. of life where inhabitants can find the carbon is neutral through applying the sustainable development criteria. Moreover, carbon measurements and residents’ questionnaire are used to achieve the proposed renovation alternatives according to the sustainability criteria.

Keywords

Environmental Problems, Sustainable Development, Renewable Energy, Neutral Carbon Neighborhood.

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A. F. MOHAMED[1]

ABSTRACT

With growing pressure from the public on governments and organizations to address climate change, the term 'carbon neutral' has become increasingly used in recent years. Carbon neutral is an emerging definition that relates to measuring, reducing and offsetting carbon energy used by either a building or an organization as a whole. Buildings are a significant source of greenhouse gas emissions when they operated by fossil fuel energy resources. Sustainable urban development is essential issue to enhance the quality of life of city residents and to decrease the negative impact of conventional type of energy through using the renewable energy resources. This research discusses the issue of the planning future sustainable cities and how to apply all the innovative renewable energy solutions for construction and operation of these developments. It aims to achieve the criteria of renovation existing conventional neighborhood to be a prototype of carbon neutral urban area and maximize the benefits of sustainable technologies through an integrated planning and design approaches. The research's case study concentrates on renovating of Sidi Gaber neighborhood and its surroundings in Alexandria city, Egypt as a prototype for a high quality. of life where inhabitants can find the carbon is neutral through applying the sustainable development criteria. Moreover, carbon measurements and residents' questionnaire are used to achieve the proposed renovation alternatives according to the sustainability criteria.

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1. INTRODUCTION

Once upon a time, when the world's population was a fraction of the 6.5 billion it is today, assuming that fertility levels continue to decline, and the world population is expected to reach 9.1 billion in 2050 and to be increasing by about 31 million persons annually at that time, according to the medium variant (Girardet, 2008). There are many challenges that cities may actually face to set up zero-carbon cities or to make the cities more environmentally friendly. There are innovative renewable energy solutions which can be applied to the construction and operation of these cities to become an epicenter for the development and commercialization of clean energy technologies (Sinclair, H., 2008). Responding to global warming and climate change, sustainable design approach came from the rising concern about the environment. At the same time, the high initial costs, the absence of qualified skilled workers and the difficulty of persuading people to accept the advanced ideas represent the disadvantages and points of weakness of the sustainable technology applications (Mosad, G. 2010). Accordingly, new types of cities have arisen that reduce carbon emissions on the annual basis.

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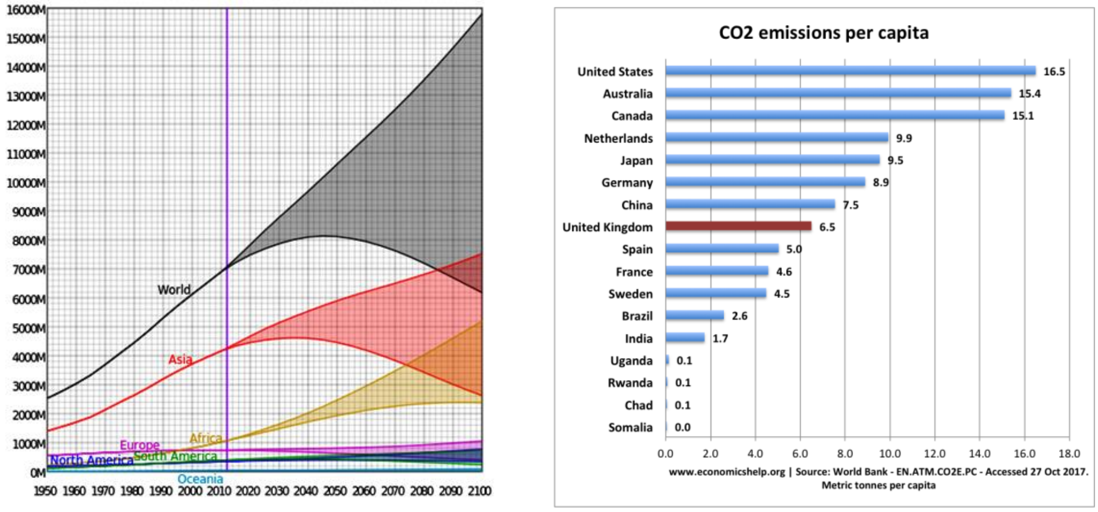

Fig. 1 Estimated World Population (UN, 2012) & CO2 Emissions per Capita (World Bank, 2017)

"Cities are hard to reshape. The 'built environment' is a heavy, fixed thing that is slow and expensive to change" (Gleeson, 2008). Incompatible designs and planning of cities are always created many problems in the environment and human health. These trends in city designs and planning led to an increase in energy consumption in their buildings and the cost of the sustainable components is still too high to encourage it on a large scale. Therefore, studies and methods to balance costs with benefits are urgently needed.

This research aims to increase the public awareness regarding the importance of environment quality and energy reduction in future Egyptian cities. This awareness is oriented to utilization of renewable energy resources and conserving water supplies in addition to recycling wastes.

2. GREENHOUSE GAS EMISSIONS

The basic principle of natural atmosphere warming can be considered by the radiation energy from the sun that warms the Earth's surface and the thermal radiation from the Earth and the atmosphere that is radiated out to space. On average, these two radiation streams must be balanced. The major components of the atmosphere are two-atom molecules too tightly bound together to vibrate and thus they do not absorb heat and contribute to the greenhouse effect (as shown in table 1) (IPCC, 2007). Carbon dioxide, water vapor, methane, nitrous oxide, and a few other gases are greenhouse gases.

Table 1 Current Greenhouse Gas Concentrations (IPCC, 2007)

Gas	Pre-1750 Tropospheric Concentration	Recent Tropospheric Concentration	Absolute increase since 1750	Percentage increase since 1750	Increased Radiative Forcing (W/m2)
Carbon Dioxide	280 ppm	390.5 ppm	110.5 ppm	39.5%	1.79
Methane (CH4)	700 ppb	1871/1750 ppb	1171/1050 ppb	167/150%	0.50
Nitrous Oxide (N2O)	270 ppb	323/ 322 ppb	53/52 ppb	19.6/19.3%	0.18
Ozone (O3)	25 ppb	34 ppb	9 ppb	36%	0.35

ppm (part per million) – ppb (part per billion)

2.1 Carbon Neutral Strategy

Carbon Neutral is a term used to describe the reduction of carbon dioxide emissions to such an extent that they do not contribute to the greenhouse effect. Achieving carbon neutrality can involve offsetting emissions or replacing fossil-fueled energy systems with green energy (Sinclair, H., 2008). The built environment has been recognized as playing a significant role within cities, in terms of energy usage and CO2 emissions. This role, coupled with the extent of the climate change issue, and pressures on cities for new development, means that the introduction of carbon neutral development projects can assist in pursuing long term sustainability in the built environment (Hennessey, 2008). It has been recognized that giving greater consideration to the strategic development of urban areas, and "avoiding mistakes in urban

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design at early stages could genuinely lead to more sustainable cities and less greenhouse gas emission" (Lehmann, 2008; 409).

2.1.1 Carbon Neutral Development

Carbon neutral developments are able to achieve high levels of efficiency due to design for passive temperature regulation, high-quality insulation and production of heat and energy from renewable sources. Where traditional development has focused primarily on delivering economic returns, acknowledgment of the severity of climate change and the need for implementation of more sustainability measures to combat it, has provided an invaluable opportunity for new heights of efficiency and sustainability to be pursued in the built environment (Lehmann, 2008).

In the United Kingdom, legislation requires that new buildings become increasingly efficient over the next decade, with all new building stock to be carbon neutral from 2016. In the United States of America, the American Institute of Architects have adopted the guidelines of Architecture 2030 challenge'; aiming to reduce energy use in buildings by 90% in 2030, based on 2003 levels. It also requires energy use reduction in new buildings of at least 50%, and will be instrumental in promoting the design and construction of more resource-efficient communities (Yudelson, 2008).

2.1.2 Cities' Green Spaces Per Capita

Green space per capita is one view on quality of life. Green spaces are parks and gardens that exist inside a city spaces to play, exercise or enjoy the day. These spaces contribute to the quality of life of the people of a city by increasing air quality, reducing the heat island effect, and improving the health of people in the community, among other benefits. The World Health Organization (WHO) in its concern for public health, produced a document on the subject stating that every city should have a minimum of 9 m^2 of green space per person. In London the average in $20m^2$, in Shanghai it is $10m^2$ while in the sprawl of Los Angeles it is less than $7m^2$ as shown in figure 2 (a) and figure 2 (b) (Sustainable Cities, 2011).

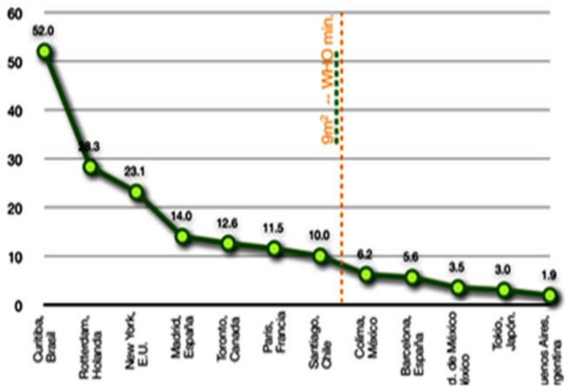

Fig. 2 (a)

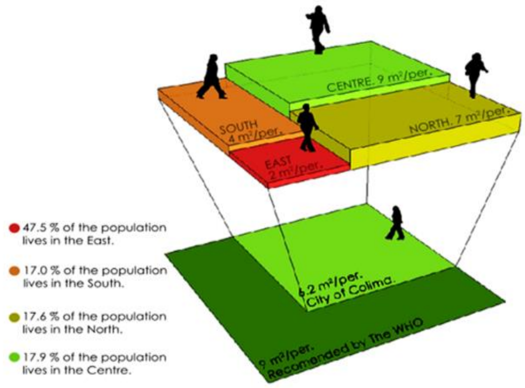

Fig. 2 (b)

Fig. 2 (a) and (b) Green Space M2 per person in Cities of the World (Sustainable Cities, 2011)

2.1.3 Knowledge Society

Society should be prepared to be in a neutral carbon environment as it depends mostly on its activities and knowledge of how to improve its habits in all sorts of ways in order to decrease the amount of carbon emission and thus decrease the global warming as it all starts from communities and become a knowledge society by sharing the knowledge as well to be a way of living in the cities and countries. Low carbon society should be independent economically which depends on their products and it also should be more transparent with their people throughout knowledge rights and sharing them in important decisions (Lehmann, 2008).

3. SUSTAINABLE DESIGN CRITERIA

According to the comparison between the international & national sustainability assessment schemes for Buildings which are the main components of any neighborhoods and cities (as shown in the table 2) are participated in the following criteria:
Sustainable Sites, Energy Efficiency, Water Management, Materials, Waste Management, Pollution, and Transport. (A. Farouk, 2013)

Table 2 Comparison between international certifications schemes of sustainability (A. Farouk, 2013)

Scheme	International			National	
	BREEAM	LEED	CASBEE	NABERS	GPRS
Country	UK	USA	Japan	Australia	Egypt
Definition	The Building Research Establishment Environmental Assessment Method	leadership in Energy and Environmental Design	Comprehensive Assessment Sys. For Building Environment-al Efficiency	The National Australian Built Environment Rating System	Green Pyramid Rating System
Introduced	1990	1998	2001	2003	2009
Updated	2011	2012	2011	2013	2010
Category	Management Health & wellbeing Energy Transports Water Materials Waste Land use & Ecology Pollution	Sustainable sites Energy & Atmosphere Water management Materials Indoor air Quality Innovation in Operation	Energy efficiency Resource efficiency Local environment Indoor environment	Management Indoor Environment Quality Energy Transport Water Materials Ecology Emissions & Innovation	Sustainable Development Water Saving Energy Efficiency Materials selection Indoor Air Quality

4. CASE STUDY

Sidi Gaber neighborhood locates on the East district of Alexandria city and distinguishes of its site and services as shown in figure 3. Although, this area has advantages such as open spaces, adequate parking spaces, green areas, and separated houses, it has disadvantages like high traffic, waste collection and energy problems.

Fig. 3 Existing Sidi Gaber neighborhood location, Jan. 2019

4.1 Neighborhood Description

Sidi Gaber neighborhood consists of Sea Cornish, Military Camp and Moustafa Kamel Residential Area which contains the following: Residential Buildings: it has 98 residential buildings each one has 14 floors. Each building contains 3 apartments with area 110 m^2. In addition, there are 6 investment residential buildings towards the sea; each one has 15 floors and contains 4 apartments 100 m2 in each floor (total apartments is 4672 units in 104 buildings) as shown in table 3.

Table 3 Neighbourhood data (Site investigations by the researcher)

Area (Km^2)	0.36
Population (Thousands)	21,024

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Density (person/ Km^2)	58,400
Green Spaces (m^2 /Person)	4.6

Service Buildings: consumer services, restaurants, cafes, shops and new bridge in the Sea Cornish.
Recreational Buildings: New under construction luxury hotel will be replaced El-Salam center and the beach clubs & hotels and city square mall.
Historical places & tourism: the tombs of the ancient roman (early second century BC)
Military camp: There is a northern area military camp
Healthcare Buildings: Military hospital in addition to clinics.
Educational Buildings: there are many schools near to the area in Sidi-Gaber and Roushdy.

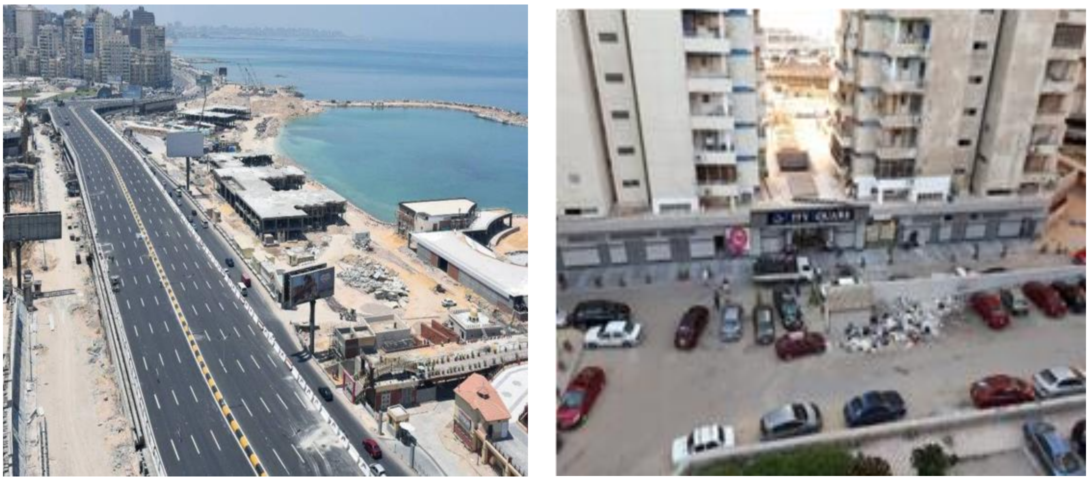
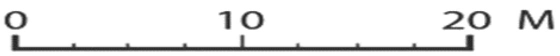


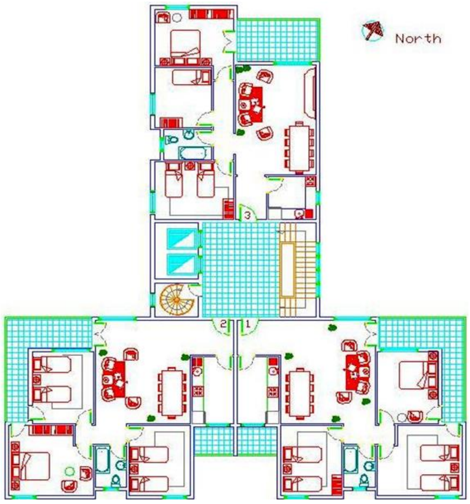
Fig. 4 Existing Neighborhood with New Cornish Bridge (photographed by the researcher, 2017)

4.1.1 Residential Building Prototype

The researcher already illustrated one residential building in details throughout its plans and required energy loads for each apartment and for whole building. This building has 14 floors, each floor contains 3 apartments with area 110 m^2 in the North and the rest are 2 apartments with 125 m2 in the East and West, as shown in figure 5 (a) and figure 5 (b).

Typical Floor Plan	
Total Area	410 m^2
Units No.	3
Flat 1 Area	125 m^2
Flat 2 Area	125 m^2
Flat 3 Area	110 m^2





Figs. 5 (a) and 5 (b) The typical residential units plan in the case study area (by the researcher)

4.2 Neighborhood Energy Resources

Electricity: There is a main electricity distribution plant in the Military Camp and secondary plants are divided in the Sidi Gaber area with approximately loads as the following :
Residential Building Electricity load = 40 MW
Commercial, Recreational, and Services and Streets Lighting = 10 MW
Total Electricity Load = 50 MW (Site Investigations, 2017)
Natural Gas: There is a natural gas main but it was constructed in the middle of the residential area which is considered a very dangerous element for the environment and the residents.
The evaluation in table 4 explains the area existing case according to the Green Pyramid Rating System criteria which are concluded from the comparison between the international and national assessment schemes for sustainability.

Table 4: Evaluation of neighbourhood according to the Green Pyramid Scheme

	Criteria	National Scheme GPRS	Case study Score
1	Sustainable Site	15%	5%
2	Energy Efficiency	25%	5%
3	Water Management	30%	5%
4	Eco Materials	10%	3%
5	Waste Management	10%	3%
6	Indoor Environmental Quality	10%	3%
7	Innovation & Added Value	Bonus	-
Total		100%	24%

4.3 Renovation Proposals

These renovation proposals are similar to the essential neutral carbon design criteria, but they differ in how can benefit of the military camp (60,000 m^2) by keeping in its place, replacing with park area or using it for solar energy generating area (photovoltaic plant).
Proposal (1): Renovation processes with keeping the military camp in its place.
Proposal (2): Renovation processes with replacing the military camp into park and recreational Area .
Proposal (3): Renovation processes with replacing the military camp into solar energy plant.

4.3.1 Sustainable site & Smart Infrastructures

- Green areas and sitting areas
- Photovoltaic car shades & Electrical car charging

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Fig. 6 Existing green areas and proposed PV shading devices

4.3.2 Energy Efficiency "renewable energy"

According to the sustainable building criteria, fossil fuel resources should be replaced by the renewable energy resources such as solar, wind energy to protect environment from pollution.

4.3.2.1 Solar Energy

Using PV panels to generate electricity & hot water as shown in figures 6 - 7

- Photovoltaic System Design

The average solar input over the year, H (kWh/m2/day):

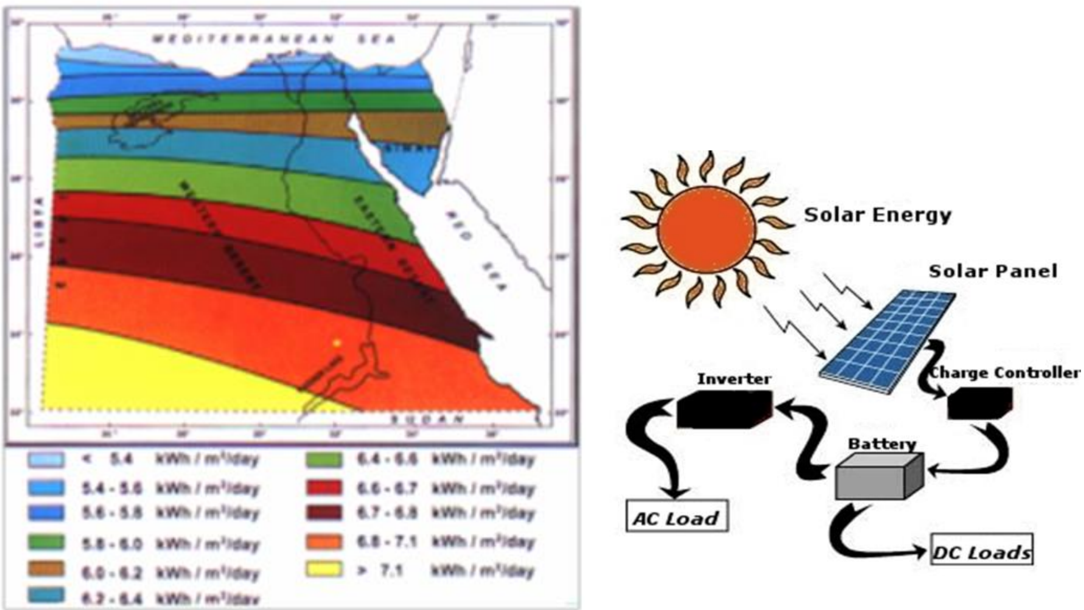

Fig. 7 the average values of daily solar energy over Egypt - *http://eeer-ibpsaegypt.com*

According to fig. 7 Average H in Alexandria = 5.5 kWh/m^2/day (1)
Calculating the average daily load energy requirements for residential units:

Table 5: the average daily load energy requirements for residential units (by the researcher)

Load	No. of units	Load power (W)	Winter operating periods/day	Spring operating periods/day	Summer operating periods/day	Autumn operating periods/day
DC Saving	12	15	From 17.00 to	From 18.00 to	From 20.00 to	From 18.00 to

lamps (light)			23.00	24.00	02.00	24.00
Refrigerator AC	1	200	24 h/day	24 h/day	24 h/day	24 h/day
TV & Receiver DC	1	100	From 17.00 to 22.00	From 16.00 to 23.00	From 14.00 to 24.00	From 17.00 to 23.00
Computer & Printer DC	1	100	From 18.00 to 20.00	From 17.00 to 22.00	From 16.00 to 24.00	From 18.00 to 20.00
Washing machine AC	1	250	From 12.00 to 14.00	From 12.00 to 15.00	From 12.00 to 16.00	From 12.00 to 15.00
Electric Fan DC	5	50	_	From 14.00 to 18.00	From 12.00 to 20.00	From 14.00 to 17.00
Buildings Services AC	1	10	24 h/day	24 h/day	24 h/day	24 h/day
Total Energy (W h/day)			7300	9070	10920	8320

The average daily energy load of typical residential unit E = 8.903 kWh/day (table 5)
The average daily energy load of residential Building = 8.903×44 = 391.73 kWh/day (2)
Total average daily energy load of units = 8.903×4672 = 41,595.0 Kwh/day (3)
Commercial buildings average daily energy load = 5000 Kwh/day
Recreational buildings average daily energy load = 4000 Kwh/day
Roads Light and other services average daily energy load = 1000 Kwh/day
Total average daily energy load= 41,595+5,000+4,000+1,000= 50,595 Kwh/day (4)

- PV Array Sizing: $PV\ (Area) = \dfrac{E}{H \times \eta_{PV} \times TCF \times \eta_{out}}$ (Buresch, 1983) (5)

If the cell temperature is assumed to reach 60 C°, then the temperature correction factor (TCF) will be 0.8 (as introduced by Buresch, 1983). Assuming $\eta_{PV} = 17\%$,

$\eta_{out} = 0.85 \times 0.9 = 0.765$ (inverter & batteries efficiency)

PV (Area) for one residential unit= $\dfrac{8.903}{5.5 \times 0.17 \times 0.8 \times 0.765} = 15.55\ m^2$ (6)

PV (Area) for one typical residential building = 15.55 × 44 units = 685 m^2
The available roof area for photovoltaic panels is 320 m^2 from total roof area 410 m
The available PV panels for the available roof area = 320 / 15.55= 20.57= 20 units (7)

These load energy calculations from equation (6) & (7) mean that the available PV panel's area for each residential building covered 20 apartments only from 44 units (45% from total residential buildings which is equal 391.73 Kwh/day). This is the worst case in the summer season but it will cover the occupied apartments in the rest of year (as shown in fig. 8). In addition, it is without air conditioning units and other additional house appliances. So, to complete the total energy load for one residential building should use another electricity resource like wind and waste to energy.

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Fig. 8 Proposed Solar Energy for Residential Building in the summer, winter, spring and autumn (made by the researcher)

- Design of the storage system

Battery storage = $N_C E_L / DOD \times \eta_{out}$ (Ahmed, 2002) (8)

N_C : Number of continuous cloudy days = 4 days (CAPMAS, 2013)

DOD: The allowable depth of discharge for the batteries.

Battery storage = $\frac{8903 \times 4}{0.8 \times 0.765}$ = 58189 W h

If a 24 V system is chosen the required amp. Hours of batteries = 58189 /24= 2424 AH

This battery bank can drive the loads for continuous 4 days without any sunshine.

- DC/AC Inverter

The inverter has to be capable of handling the maximum expected power of AC loads. Thus, it can be chosen 20% higher than the rated power of the summation of AC loads.

Total power of AC loads = 200+250+20 = 470 ×1.2 = 564 W

The specifications of inverter will be 564W, 24 V_{DC}, and 220 V_{AC}.

- Solar Energy shearing in case study area electricity

It will cover 45% of total neighborhood load = 50.595 MWh × 45% = 22.77 MWh

Electricity load for residential building = 392 KWh/day × 45% = 176.4 kWh/day

Photovoltaic panels on the building's roof (75% of roof area).

In case of using Nano-solar panels which is covered with Nano-crystal material in order to provide a small area of photovoltaic panels and gain an extra of 22% power efficiency than the traditional solar panels. (A. Farouk, 2018)

- Wind energy

Wind in Alexandria City is 18 km/h - 5.1 m/s from NW (Intermeteo.com, 2012). It will cover 45% of total electricity load = 50,595 MW × 45% = 22.77 MW

Wind turbines numbers = 22.77MW / 1.5MW = 15.18 = 16 Turbines located in the Sea.

- Waste to energy

Waste management can help neighborhoods to generate an adequate value of electricity from the city waste which considered approximately 10% of the required energy (A. Farouk, 2013). As shown in fig. 9 the renewable energy resources in Sidi Gaber neighborhood case study area:

    - Solar Energy 45%
    - Wind Energy 45%
    - Waste- to- Energy 10%

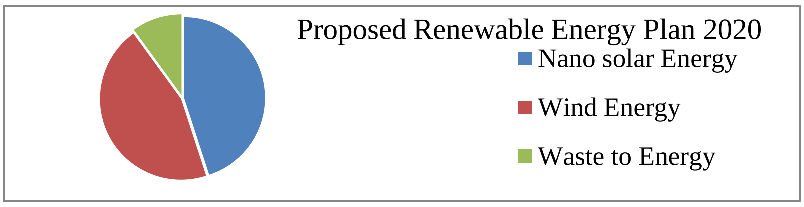

Fig. 9 Proposed renewable energies for Neighbourhood

This is the main future energy strategy for this residential area and it will be applied gradually. For instance, each 5 years we can reduce the fossil fuel resources about 10% and the renewable energy will take its place and so on till completion of the future energy plan.

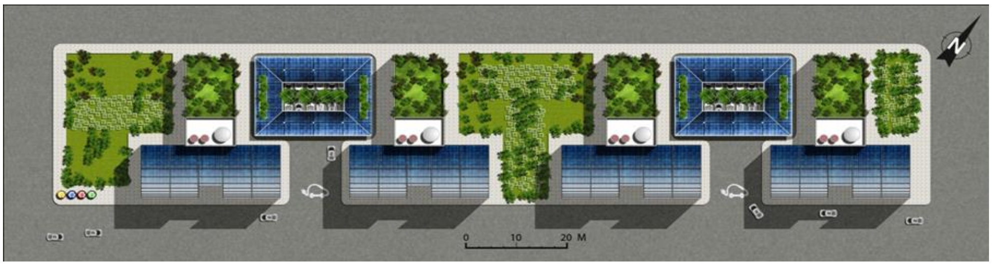

Fig. 10 Proposed neutral carbon Elements in Neighborhood Site

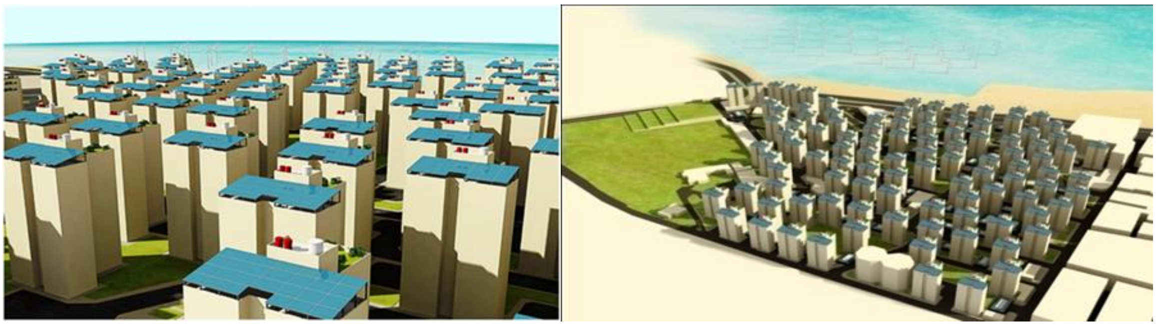

Fig. 11 Proposed neutral neighbourhood perspectives

4.3.3 Transportation Systems

- Electrical Cars and bicycles

Only electrical vehicles and bicycles are allowed to enter Residential Area. Fossil fuel cars are eliminated from the area and they can park in the multi-story garage which constructed in the area entrance from El-Mosheer Ahmed Ismaeel.

4.4 Renovation Proposals 1, 2, 3 as a Carbon Neutral Sidi Gaber Neighborhood

The shown figure presents the proposed alternatives of Sidi Gaber Neighbourhood

Fig. 12 Proposed Alternatives of Sidi Gaber Neighborhood (Made by the researcher)

4.4.1 Comparison between renovation proposals 1, 2, 3

Table 6 Comparison between Sidi Gaber Neighborhood Proposals

Criteria	Proposal (1)	Proposal (2)	Proposal (3)
Military Camp (60000 m^2)	Existing	Replacing into park recreational area	Replacing into photovoltaic planet
Sustainable Sites	Green Areas PV car shades Sitting Areas	Green Areas PV car shades Sitting Areas	Green Areas PV car shades Sitting Areas
Energy Efficiency	Roof solar energy Wind energy in Sea Waste-to-energy	Roof solar energy Wind energy in Sea Waste-to-energy	Solar energy in camp Wind energy in the Sea Waste-to-energy
Water Management	Grey water system Water treatment Trickle Irrigation Solar hot water	Grey water system Water treatment Trickle Irrigation Solar hot water	Grey water system Water treatment Trickle irrigation Solar hot water
Waste Management	Collected Recycled Reused	Collected Recycled Reused	Collected Recycled Reused
Indoor and outdoor Materials	Eco-paints Green roofs and Terraces	Eco-paints Green roofs and Terraces	Eco-paints Green roofs and Terraces
Transportation	Electrical cars Bicycles	Electrical cars Bicycles	Electrical cars Bicycles
Pollution	Elimination of fossil fuel energy and vehicles	Elimination of fossil fuel energy and vehicles	Elimination of fossil fuel energy and vehicles
Green areas	100000 m^2	160000 m^2	100000 m^2
Green areas roofs	12000 m^2	12000 m^2	42000 m^2
Total Green Areas	112000 m^2	172000 m^2	142000 m^2
Green Area per Person	5.6 m^2	8.6 m^2	7 m^2
Advantages	Green roofs. Photovoltaic car shades.	The biggest green areas.(park) Military Camp doesn't exist	PVs cover the required electricity for Area. Military Camp doesn't exist.
Disadvantages	Military camp exists Photovoltaic panels don't cover the required electricity for the residential buildings in summer.	Photovoltaic panels don't cover the required electricity for the residential buildings in summer.	The area of military land is used for the photovoltaic panels' installation instead of park.

According to the neutral carbon design criteria, and the questionnaire results; proposal (2) is the best alternative

4.4.2 Questionnaire Results

There is a research questionnaire which asked the 50 residents' families and visitors in the case study area. The following charts show the questionnaire results:

- Military camp

Military camp exists (4 families) = 8%
Replacing Military camp into Park (38 families) = 76%
Replacing Military camp into PV Planet (8 families) = 16%

- Transportation systems

Total residents who approved using Electrical Cars are (28 families) = 56%
Total residents who choose Walking are (7 families) = 14%
Total residents who approved using Bicycles are (4 families) = 8%
Total residents who rejected the Proposed Transportation Systems are (11 families) = 22%

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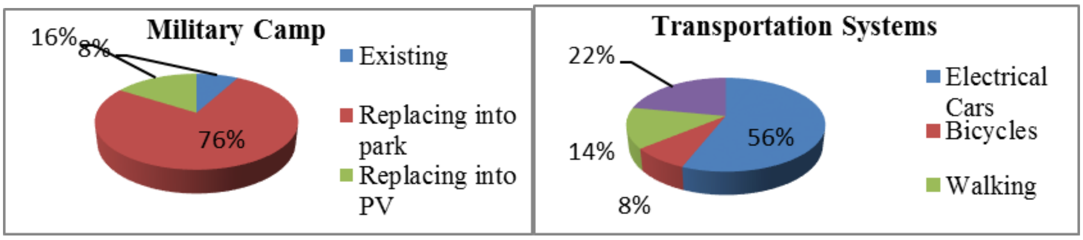

Fig. 13 Military Camp & Transportation Systems Questions

- Solar energy on buildings' roof

Total residents who approved are (49 families) = 98%

- Wind energy on Mediterranean sea

Total residents who approved are (48 families) = 96%

Fig. 14 Solar Energy & Wind Energy Questions

- Green Roofs

Total residents who approved are (49 families) = 98%

- Data Center

Total residents who approved are 50 = 100%

Fig. 15 Data Centre & Green Roofs Questions

- The questionnaire outcomes are the following:

Total residents who choose Proposal 1 are 10%
Total residents who choose Proposal 2 are 74% (Proposal 2 has the highest votes)
Total residents who choose Proposal 3 are 16% (as shown in fig. 16)

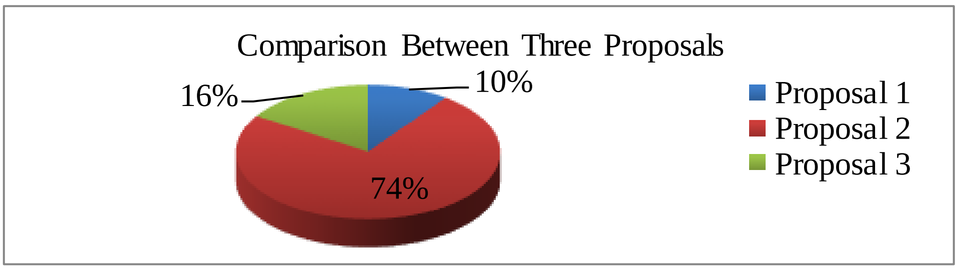

Fig. 16 Comparison between Three Renovation Proposals

Table 7 Comparison between Sidi Gaber neighborhood before and after renovation according to the Green Pyramid Rating Systems

	Scope	National Scheme GPRS	Sidi Gaber Score (Before)	Sidi Gaber Score (After)
1	Sustainable Site	15%	5%	12%
2	Energy Efficiency	25%	5%	21%
3	Water Management	30%	5%	25%
4	Eco Materials	10%	3%	7%
5	Waste Management	10%	3%	8%
6	Indoor Environmental Quality	10%	3%	7%
7	Innovation & Added Value	Bonus	-	5+
Total		100%	24%	80%

(Made by the researcher)

5. CONCLUSION

- Carbon neutral strategies are the minimizing the ecological footprint, developing low carbon economy and making people aware of their carbon impact and developing of carbon capture, storage technologies and encouraging energy efficient designs.
- The case study "Sidi Gaber Neighborhood" is perceived that such measures will be central to encourage the proliferation of innovative and highly-sustainable development. It is only through provision of development incentives, requirements and support structures that the individual, community and more widespread environmental benefits of such projects can be realized with the neutral carbon design criteria as the following:
  - Green area - Photovoltaic car parking shade - sitting areas & shaded walkways Smart and Digital Infrastructures' Features
  - Central satellite service, internet service and data center
  - Solar energy (PV panels on the 2/3 a building's roof area or on the military camp's land)
  - Wind energy (Wind turbines in the Sea)
  - Waste-to-energy sources
  - Grey water system - solar hot water - trickle irrigation systems
  - Waste separation (paper – organic – plastic – glass), recycled and reused.
  - Waste-to-energy
  - Roof & Walls insulation material - green Roofs & terraces - eco-paintings
  - Electrical cars – bicycles - monorail
  - Green roofs and terraces
  - Fossil fuel energy and vehicles are eliminated from the neighborhood.
- Carbon neutral design features are the promising solutions to face the future challenges particularly; climate change and global warming.
- Carbon neutral development outcomes are understood to play an important role in maintaining the ongoing viability and functionality of urban areas, reducing their fossil fuel dependence, energy use and waste outputs.
- Economically, life cycle costing of renewable energy like photovoltaic system is less than that of the diesel generator system or electricity supply without the government subsidization.
- When choosing an environmental rating system for neutral carbon cities around the world, it is generally preferred to use the local environmental rating system.
- Carbon neutral cities' governments should provide the transparency and knowledge rights for their people and share them in the important decisions which will effect on their present and future. Finally, neutral carbon is not only environmental practices but also a full life style for people

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