Mansoura University
Faculty of Engineering
Department of Architectural Engineering

Zero Carbon Architecture In The Future Scenarios, In Egypt

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As a part of the requirements for The Doctore of Philosophy Degree in Architectural Engineering

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Dedication

To every virtue owner, and every student is aware.

To the spirit of my grandfather beloved God's mercy and dwell in paradise.

To my loving grandmother, God prolong her life.

To my lovely father and mother, whose prayers were the secret of my success, God prolonged their lives.

To my dear husband and daughters, God bless them.

To my siblings Ahmad & Fatima and all my family may God protect them.

Abstract

Global warming is one of the most public problems on everyone's minds, since industrialized societies suffer from complete energy dependency, which causes increased carbon emissions and greenhouse gases that cause global warming, whereas the US Energy Information Administration reveals that buildings account for about half of energy usage, accounting for about 48 per cent of all energy consumption, and gases.

The problem of research is therefore important to minimize carbon emissions in the building sector by applying the principles of zero carbon architecture (ZCA) to achieve green architecture using new technology and using renewable resources to reduce energy consumption, and to obtain a scale for ZCA, such as LEED certification in Egypt.
The research aims Approaching and calculating Zero Carbon Architecture (ZAC) in Egypt, describing the value of ZCA, reflecting on the influence of architecture and architectural thought in the design of buildings, acknowledging the local market for ZCA definition, then clarifying the returns of applying ZCA for the state and scenarios of ZCA implementation in Egypt.

In accordance with the goals of the research, the thesis relied on the use of the theoretical, analytical and then practical methodology of research as a tool to scientifically prove these hypotheses (Zero Carbon Architecture to enhance Architecture Design & urban sustainability to reduce global warming , *Future Scenarios* for Zero Carbon Architecture will lead to long-term sustainable feasibility architecturally, urbanely, economically, environmentally and visually).

First: The Theoretical Study

Chapter 1: **The Global Warming in the Building Sectors**
This chapter will illustrate global warming and CO2 Emissions in general but will focus on greenhouse gases emitted from a building sector.

Chapter 2: **From Technologies for Low Carbon to Zero Carbon Architecture**
This chapter will explain technologies for low carbon in the building sector, these technologies are classified to three categorize (material, energy, design) passing to Zero Carbon Architecture and their definition.

Second: The Analytical Study

Chapter 3: **Analysis for ZCA Applications**

This chapter will illustrate ZCA Applications in (energy, design)

Chapter 4: **Contemporary paradigms of ZCA**

This chapter will be focused on contemporary paradigms of zero carbon building
These building are chosen from around the world Germany, UK, Hong Kong, UAE and Egypt, these building selected upon its energy efficiency, renewable energy and awards which had got.
as well as mentioning the various measuring applications used to measure the energy used and carbon emissions.

Third: Applied Study

Chapter 5: **How to apply& measure Zero Carbon Architecture in Egypt (ZCAE) in Industrial sector**

A Case Study

This chapter will create a future scenario of zero carbon architecture in Egypt ZCAE in industrial sector (industrial zone in New Damietta city in Egypt).
Then studying the impact of buildings turning into ZCAE (Architecturally, urbanely, economically and visually), and how measure the status of buildings from ZCAE by applying **Zero Tool**.

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List of Abbreviations

(AHUs) Air Handling Units
(AI) artificial intelligence
(AIAU)American institute of architects unites
(AIRS) Alliance of Information and Referral Systems
(BEAM) Building Environmental Assessment Method
(BIPV) Building Integrated Photovoltaic
(BMS) Building Materials
(BMUB) The Federal Minister for the Environment, Nature Conservation, and Nuclear Safety, abbreviated BMU, is a cabinet-level ministry of the Federal Republic of Germany.
(BTU) British thermal unit = 1.060 KJ
(CAE) Canadian manufacturer of simulation technologies
(CDD) cooling degree day
(CH4) Methane
(CIGS) Copper indium gallium selenide
(CO2) Carbon dioxide
(DEWA) Dubai Electricity and Water Authority's
(ECMS12) conference
(EE) Energy Efficiency
(EFQM) European Foundation for Quality Management
(EU) European Union
(EUI) energy use intensity
(EUI) European University Institute
(FSI) floor space index
(GHG) Green House Gas
(GW) Global warming
(GWp) Global warming potential
(HDD) heating degree day
(HERS) Home Energy Rating System
(HVAC) Heating, ventilation, and air conditioning
(HVLS) High-Volume-Low-Speed Ceiling
(ICT) Information and communications technology
(IoT) Internet of Things
(JPL) Jet Propulsion Laboratory
(LCB) Low Carbon Building
(LEED) Leadership in Energy and Environmental Design
(LTHW) Low Temperature Hot Water
(MWT) Education Consultancy
(N2O) oxide of Nitrogen
(NCM)National Calculation Method
(NVS) Nano Vent-Skin
(NZEB) net Zero Energy Building
(OLED) Organic light-emitting diode
(OTTV) Overall Thermal Transfer Value
(PEF) Punjab Education Foundation

(PFA) pulverized fuel ash
(pI) professional liability
(ppm) parts per million
(PV) Photovoltaic Systems
(QBTU) 1 QBtu = annual energy output of 40 - 1,000 MW power plants
(R&D) Research and development
(RE) Renewable Energy
(SOI) southern oscillation index
(Tg CO2 Eq) teragrams of carbon dioxide equivalent
(UAE) United Arab Emirates
(UK) United Kingdom
(USGBC) The U.S. Green Building Council,
(UV) Ultraviolet
(VAV) Variable Air Volume
(ZCA) Zero Carbon Architecture
(ZCAE) Zero carbon architecture in Egypt
(ZCB) Zero Carbon Building
(ZCE) Zero carbon architecture in Egypt
(ZEB) Zero Energy Building
(zEPI) Zero Energy Performance Index
(ZNE) zero net energy

INTRODUCTION

Modern society is heavily dependent on energy and any progress in this field is affecting a very large spectrum of sectors which are important, for example, security and diversification of energy supply, climate changes and pollution, industrial competitiveness and sustainable growth.
Thus the development of alternative energy sources, environmentally friendly and a capable ofreducing dependence on fossil fuels is becoming increasingly urgent. The growing number of energy - hungry equipment and devices demands efficient and compact energy sources with reduced heat production[1].
Thus, worldwide construction faces an unparalleled challenge to consider and resolve the reality that building energy consumption accounts for a large proportion of carbon dioxide emissions, because of increased CO2 emissions leading to global warming that affects human thermal comfort.

Research problem

Global warming is already happening, and it has become the biggest challenge facing the world. The challenge is to find avenues for the world to move from the direction of increased pollution to the direction of higher sophisticated tech such as Zero Carbon Architecture, where most GHG emissions are eliminated.[2]
Accordingly, the research is an issue faced by communities in accordance with the sustainability of urbanization.

The Green Buildings theory is therefore simply the concept of how to save energy use in buildings and reduce co2 emissions, such as insulation, building air circulation, sun shading and windows quality, as part of a low emission strategy[3]which aim to obtain for thermal comfort.

From this point on, the research aims to explore the successful use of zero carbon architecture (ZCA) technologies to scale carbon emissions in the building sector, to make building certifications like LEEDs and to achieve sustainable architecture

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[1] AIRI/Nanotec IT. January 2006. p59

[2] Energy and Climate Department of The Bellona Foundation. Oslo, 2008 https://network.bellona.org/content/uploads/sites/2/How-to-Combat-Global-Warming.pdf access 2021

[3] World Renewable Energy Congress XI, 25-30 September 2010, Abu Dhabi, UAE https://www.solarthermalworld.org/calendar/world-renewable-energy-congress-2010-abu-dhabi access 2021

design in line with potential scenarios that will enable our planet to reduce pollution and help minimize warming impact through a case study in Egypt.

Research Objectives

Main Objective:

Approaching to Zero Carbon Architecture (ZAC) in Egypt.

Sub Objectives:

-Explain the value of ZCA and concentrate on the influence of architecture and architectural thought in the design of buildings.

- How to reach ZCA.

- Achieve market acceptance of Zero Carbon houses and sustainable communities.

- Strengthen the leadership in sustainable residential community design and ZCA at residence and internationally.

- Obtaining a suitable scale for buildings in Egypt to measure the reach of building to zero carbon.

- Meditation for the better by using ZCA scenarios to achieve sustainability in architecture.

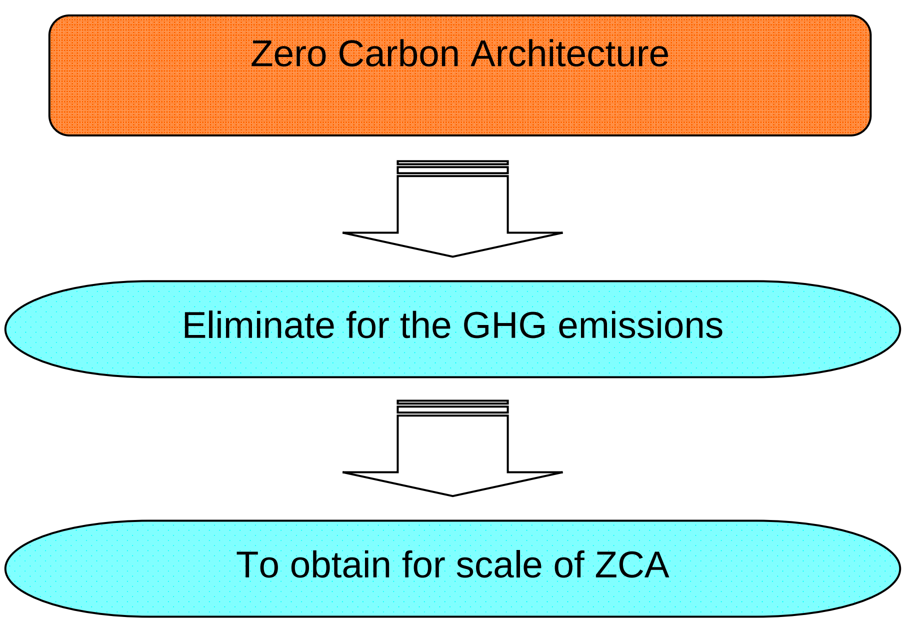

Fig (**1**) introduction chart by researcher

Research Hypotheses

1. Zero Carbon Architecture to enhance Architecture Design & urban sustainability to reduce global warming.
2. *Future Scenarios* for Zero Carbon Architecture will lead to long-term sustainable feasibility architecturally, urbanly, economically, environmentally and visually.

Research Methodology:

Research parameters:

Qualitative field: where the research area deals with Zero Carbon Architecture.

Locative field: is expanded during the theoretical and analytical study of research to include buildings locally and globally.

Temporal field: The research area deals with existing buildings (industrial buildings) in new cities.

The Methodology:

Presenting a theoretical background to the concept of global warming, technologies for low carbon, zero carbon architecture.
Analysis of examples globally, regionally as well as mentioning the various measuring applications used to measure the energy used and carbon emissions.
Making a case study of an existing industrial building in a new city and modify it to fit the principles of ZCA in Egypt.
Then present a case study according to the results of the previous studies and obtained conclusions after measuring the energy uses in the industrial building by zero tool application.

Previous studies

By looking for the previous studies, the researcher found that there are a few studies in this area, there are some of them:

- **first study(Master Thesis):**

ZERO CARBON ARCHITECTURE

The future challenges & the ***Nanotechnology*** *solutions,*

By **Ahmed Mohamed Magdy Mohamed, (2010),** University of Alexandria

This Research aimed to:
1-Explain what has resulted from a rise in the proportion of carbon in the environment caused by climate change.
2-Identify the issues facing the world in terms of reducing global warming and reducing emissions from buildings by the use of alternative or green energy to save our planet.
3 – The use of sophisticated tech, such as nanotechnology, which has led to the creation of materials with modern high-tech support in meeting the greatest challenge is how to achieve Zero Carbon Architecture.......

This research points out several strategies to minimize GHG emissions during service, including:
-Reduce the consumption of electricity.
-The transition to solar and wind power includes:

Renewable hydro-Biofuels (under some conditions)-Geothermal.

-Turn to emerging sources of technology, such as nanotechnology.

- **second study(Master Thesis):**

Zero Carbon Architecture and Built Environment

By: Lamiaa Moustafa Moustafa Abd-Rabo, **(2013)**, University of Alexandria

This study will contribute to building with net - zero carbon dioxide emissions in a year and the use of heat efficient construction materials and insulation will reduce energy consumption to a zero. All energy used for construction, heating, building illumination, machine tools and other uses would have to be replaced by zero carbon solutions, including wind power, solar cells and heating systems, and by the use of off-site renewable power.
This research Helps to define standards for CO2 emissions (ZCA) through the use of rating strategies and processes for assessing CO2 emissions, and also introduces ZCA systems and techniques in practice using actual examples. Finally, it will illustrate the technical toolbox and related policies for promoting ZCA by general guidelines and conclusions.
As a consequence of the reduction of building emissions has become a global concern (e.g. in the United States, several organizations that have taken important measures to encourage the

reduction of GHG emissions, the 2030 Challenge, which recommends that all new constructions be carbon neutral by 2030, all parts of this study would help to achieve sustainability targets and to save our environment through the use of carbon neutral (ZERO CARBON ARCHITECTURE).

- **third study(Paper):**

Low –energy residential building in New Borg El Arab

By : Reda, F., Tuominen, P., Hedman, Å., & Ibrahim, M. G. E.,**(2015**),
Energy and Buildings journal.vol,93

The investigation used an outstanding model of a building that does not exist and based the entire investigation on simulation performance. This illustrates the importance of researching projects such as this current thesis. In addition, the paper also described several opportunities for future research including the integration of the economics of solutions that this research offers based on the actual market prices.

- **fourth study(Master Thesis):**

FEASIBILITY OF CONVERTING EXISTING RESIDENTIAL BUILDINGS TO NET ZERO-ENERGY BUILDINGS IN EGYPT

A Case Study

By SOMAYA **ALBADRY, (2016),** American University in Cairo.

The study begins by examining the current situation in both Egypt's existing buildings and the energy market. First, the classification of the current building styles in the Egyptian context is discussed, energy consumption patterns and inefficiency patterns are analysed, and the nZEB concept is described so that readers can be familiar with the various aspects of this concept. The analytical portion of the analysis uses many cases in Egypt for a variety of residential prototypes. In end, a proposed rule is applied to a real existing building and simulation checks its viability.
Applying NZEB techniques to existing buildings in Egypt concludes the research by making a possible energy savings. For the validation of the NZEB in various building types, further research is required.

- **fifth study(Paper):**

Northern European nearly zero energy building concepts for apartment buildings using integrated solar technologies and dynamic occupancy profile: Focus on Finland and other Northern European countries

By : Reda, F.,Fatima, Z,**(2019)**, Applied Energy ,Volume 237.

The study examines virtually zero energy construction principles for buildings in northern Europe, with a focus on Finland and the expansion of the analysis to Sweden, Norway and

Estonia. Particular attention has been paid to the different principles of construction process and the use of integrated solar energy. In contrast to the studies available, the authors considered dynamic behavior of use in comparison to the available research, the authors considered complex usage behavior in order to mimic more practical household electrical consumption as well as internal heat gain, and according to published studies, this showed the important impact of occupants in building energy use. Results stress that there is no solution for almost zero energy building in turn. In reality, many ideas that create near zero energy can be achieved through the implementation of more energy per formant design principles or the installation of solar on-site technology.

Centered on the key source of heating for homes, solar thermal and heat pumps in northern regions, there is a probability of right building concepts, typology and scale of solar energy. In Finland, almost no energy building concepts can be achieved without the on-site installation of renewable energy systems in compliance with the principles of Finnish passive architecture.

Research structures

The research structure used to achieve the above objectives is divided into three parts (theoretical part - analytical part - applied part), the study concludes with results and recommendations.

Part 1: Theoretical study:

Chapter 1: **The Global Warming in the Building Sectors**

This chapter will illustrate global warming and CO2 Emissions in general but will focus on greenhouse gases emitted from a building sector.

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This chapter will explain technologies for low carbon in the building sector, these technologies are classified to three categorize (material, energy, design) passing to Zero Carbon Architecture and their definition.

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This chapter will illustrate ZCA Applications in (material, energy, design).

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These building are chosen from around the world Germany, UK, Hong Kong, UAE and Egypt.
These building selected upon its energy efficiency, renewable energy and awards which had got.
as well as mentioning the various measuring applications used to measure the energy used and carbon emissions.

Part 3: Applied study:

Chapter 5: **How to apply& measure Zero Carbon Architecture in Egypt (ZCAE) in Industrial sector**

A Case Study

This chapter will create a future scenario of zero carbon architecture in Egypt ZCAE in industrial sector.
Then studying the impact of buildings turning into ZCAE (Architecturally, urbanely, economically and visually), and how measure the status of buildings from ZCAE by applying **Zero tool**.
And also we will be maximizing the benefits of ZCA implementation by applying it to the industrial zone as a whole to provide economic, environmental and urban benefits to the state as will be seen.

Conclusions & Recommendations

In this section draws conclusions through monitoring, analysis, comparison, application, validation of hypotheses, and then prepares recommendations that are recommended in existing projects.

Open the way for research and studies that complement the findings and recommendations of the study.

Research structures

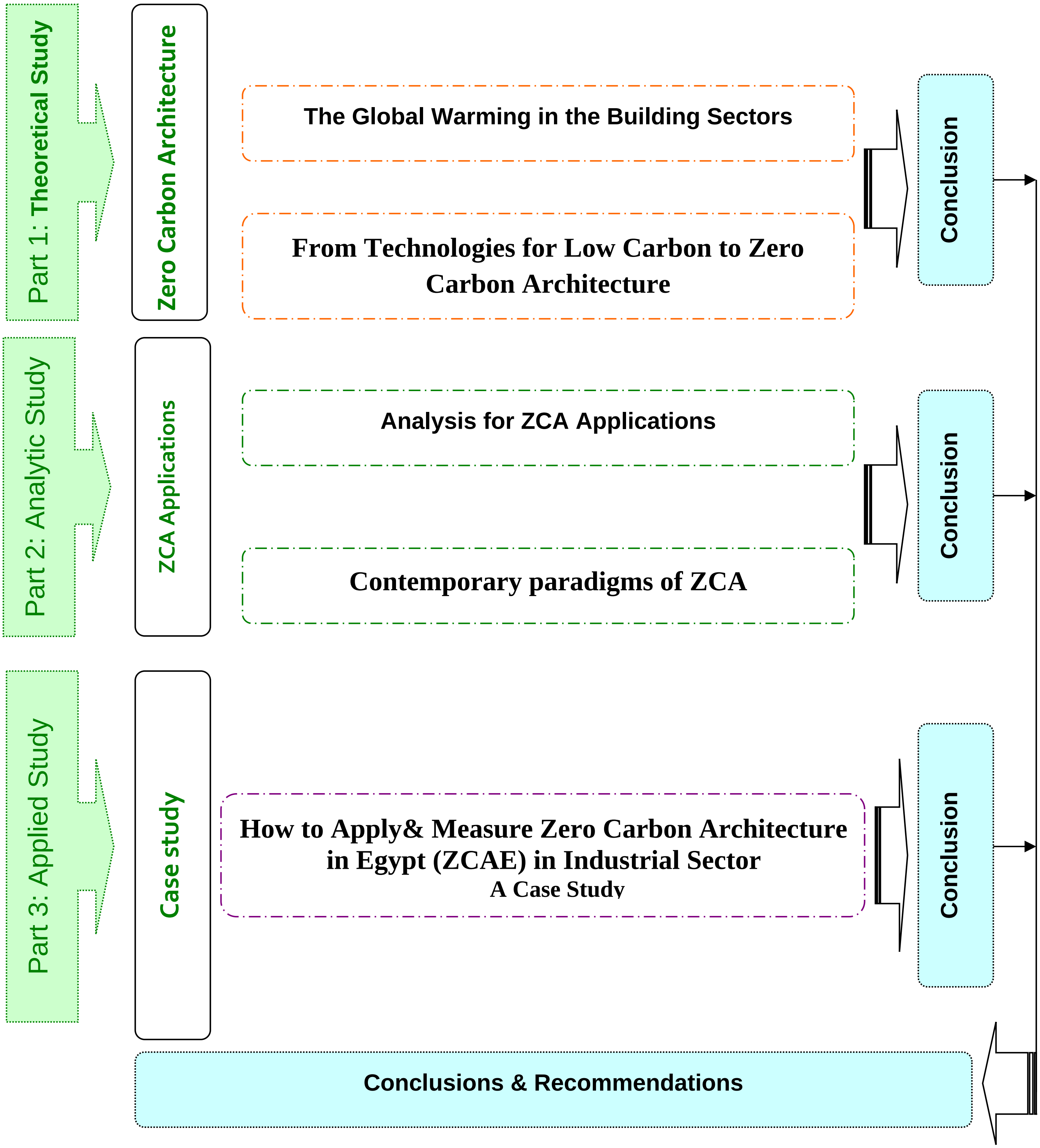
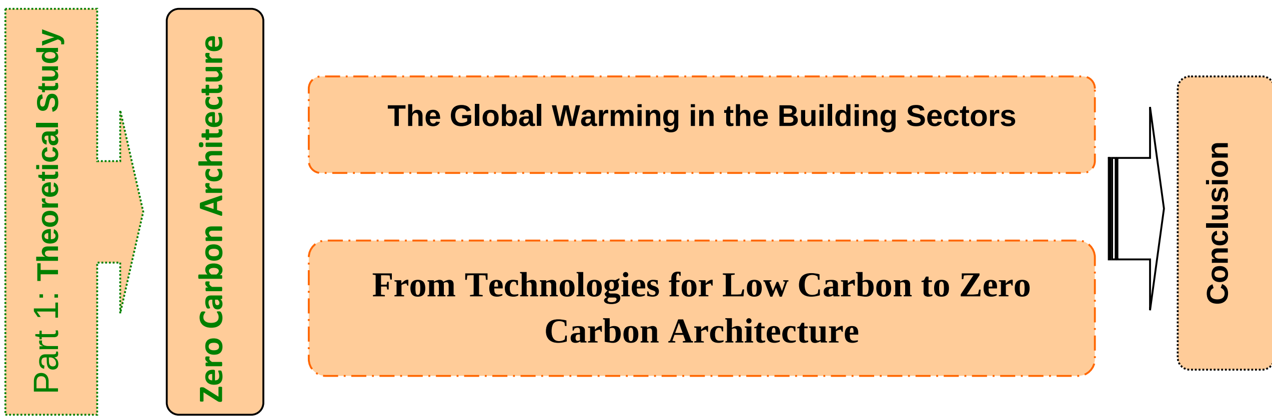


Fig (2) Research structures

Part 1: **Theoretical Study**

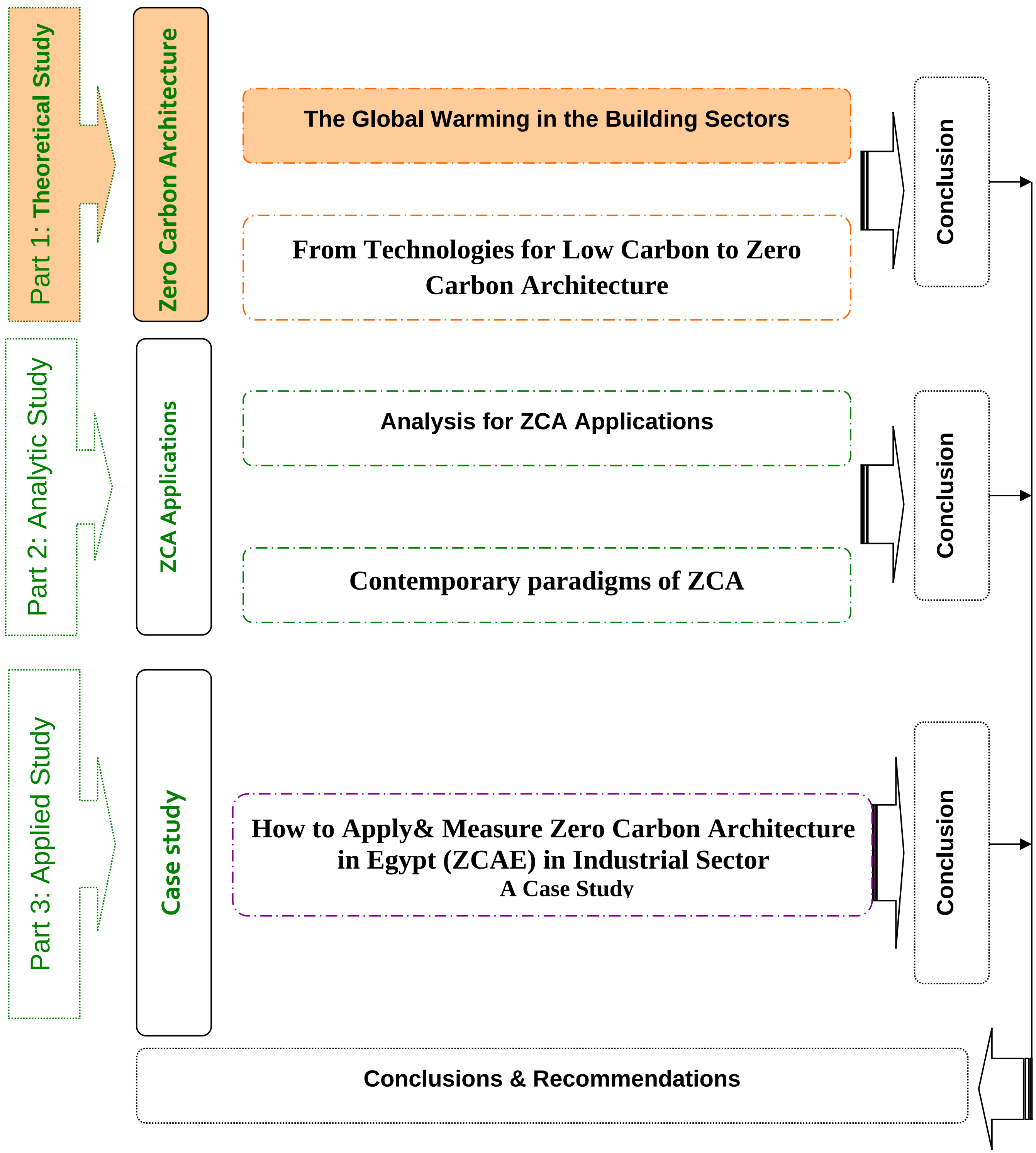
INTRODUCTION

The first part of the research is the theoretical study that contains two chapters, the first one represents global warming in the building sector and carbon dioxide emissions from the buildings sector; the other chapter will present building technologies from low carbon technologies to ZCA in smart buildings.
This part will target the first sub objectives (Explain the importance of ZCA and focus on the influence in architecture and the architect thinking in the design of buildings), and the background of global warming in the building sectors.



Part 1: **Theoretical Study**

The Global Warming in the Building Sectors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INTRODUCTION

The climate change challenge is encouraging us to consider a complete overhaul of our built environment and all the goods and services we use.
Buildings use 45-50 % of world energy, much of which is strongly associated with fossil fuel combustion resulting in CO2 emissions[1].
This chapter will illustrate global warming and CO2 Emissions in general but will focus on greenhouse gases emitted from a building sector.

1-1 The Global Energy Balance:

The global balance of energy really is the equilibrium between the energy of the Sun going in and heat coming out of the world. The earth-atmosphere energy balance controls the state of the Earth's environment and changes in it due to the natural and human climate that drives change.[2] Fig (1-1).

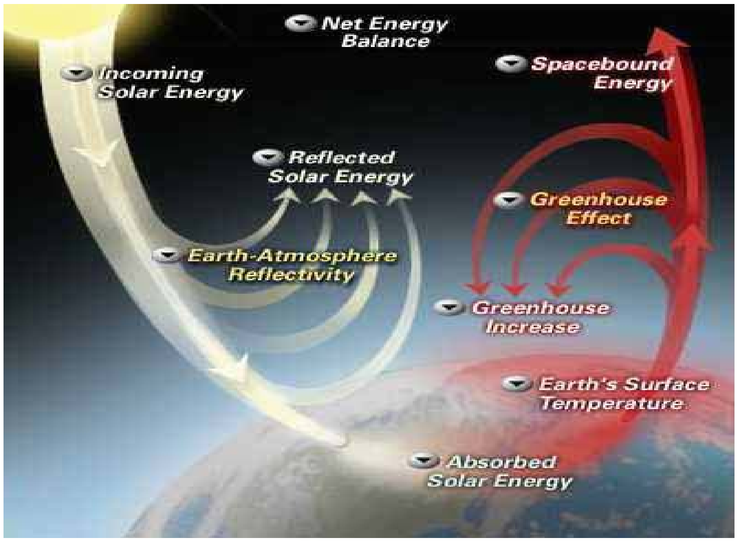


Fig (1-1): The earth-atmosphere energy balance the amount of energy the Planet produces from the Sun is balanced by how much it loses back to space .Ref :Magdy ,2010.

1-1-1The Energy Consumption:

Many people are surprised to hear that buildings are the single largest contributor to global warming, with so much attention given to transport pollution. To explain this misunderstanding, this study has reshaped the discussion regarding climate change and GHG emissions to identify and include a construction sector.

[1] Hetherington, Robina; Laney, Robin and Peake, Stephen. 2010. p1
[2] Eugene S, Takle. (2007). Global Energy Balance. https://meteor.geol.iastate.edu/gccourse/alumni/forcing/text.html

Figure (1-2) shows the distribution of the building sector's various elements into several industries, i.e. manufacturing, industrial, residential, transportation, etc.

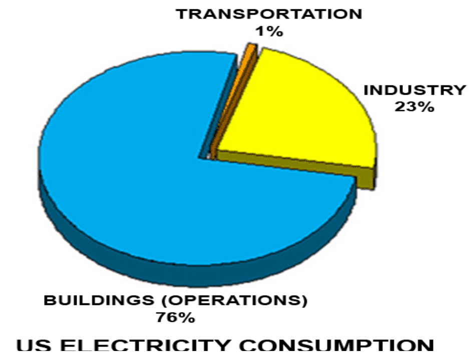


Fig (1-2): the distribution of the building sector's various elements into several industries, i.e. manufacturing, industrial, residential, transportation,
.Ref :Magdy . 2010.

US Energy Information Administration statistics show that almost half (48 per cent) of all consumption of energy and GHG emissions are accounted for buildings annually, although worldwide the figure is even higher.
76% of all electricity produced by power plants is used for buildings. In order to prevent dangerous climate change, urgent action is obviously necessary in the building sector.
The Residential (Operations) sector (20.4 QBtu), Trade (Operations) sector (17.2 QBtu), Industrial sector – Building operations (2.0 QBtu) and the Industry Sector is combined with the annual energy forecast for construction and materials encompassing energy (8.57 QBtu).

Total annual consumption in the building sector in 2000 was 48,17 QBtu, with a total annual consumption of 99,38 QBtu for the US in 2000[1].

1-2 CO2 Emissions:

The Kyoto Protocol shall apply from February 2005. It is intended to reduce global greenhouse gas emissions (fig (1-3)).

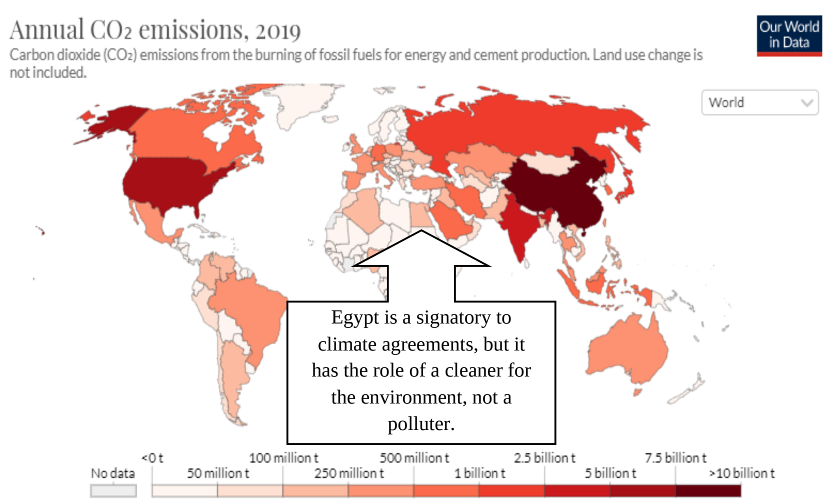


Fig (1-3): Annual production-based emissions of carbon dioxide (CO_2), measured in tons per year.

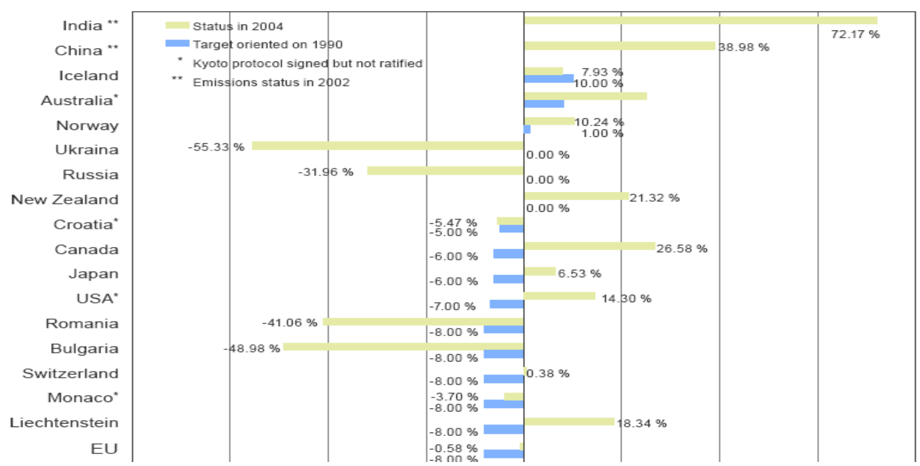
Ref: Global Carbon Project. (2020). Supplemental data of Global Carbon Budget 2020 (Version 1.0) [Data set]. Global Carbon Project. https://doi.org/10.18160/gcp-2020

[1] Magdy, April 2010, p 13.

The origins It can be traced to 1997 from this Protocol. In 2012, the 39 participating industrialized countries signed an international environmental treaty agreed to reduce by 5 percent, as opposed to 1990, their accumulator emissions of environmentally dangerous gases such as carbon dioxide (CO2). The target reduction in Germany is just 21 per cent within the European Community. As shown in Fig (1-4) many developing countries do not fulfil their objectives.

It is important to reduce CO2 emissions. Green building practices may significantly minimize or eliminate harmful impacts on the environment and change current unsustainable growth architecture Fig (1-5)[1].

Fig (1-4) Reduction goals as negotiated under the Kyoto Protocol and the existing CO2 rate for the highest global intake in the world. Ref: Bauer, Mosel, Schwarz, 2009



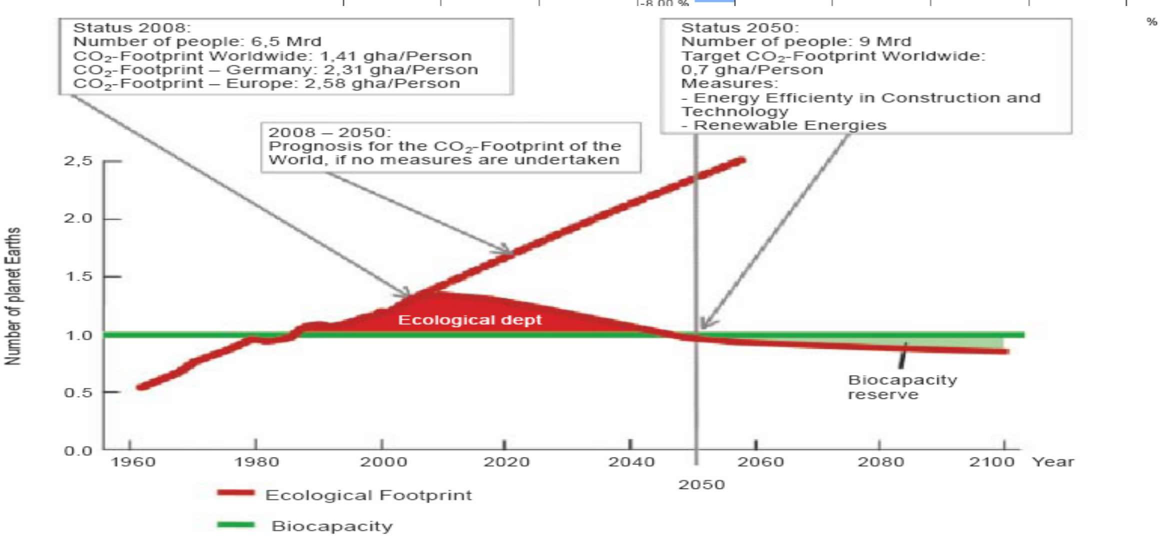


Fig (1-5) Sustainability wedges and an end to overshoot. Ref: Bauer, Mosel, Schwarz, 2009

[1]Michael Bauer, Peter Mosel, Michael Schwarz 2009, p 14,15,27

1-2-1 Hygienic Requirement for Air Exchange:

The space needs to be provided with outside air as clean as possible in order to maintain the pollutant load in a room to a minimum. This can be accomplished through natural ventilation, through windows or by mechanical instruments such as ventilation systems. When emission is only assessed at CO2 levels (1-6),

Fig (1-6) Values for indoor CO2 concentration
Ref: Bauer, Mosel, Schwarz, 2009

For indoor carbon concentration levels a person requires at least 20 m3 of open air, to comply with the hygienically acceptable essential value of 1500 ppm. When also considering the hazardous material emissions from construction components, the air at this CO2 concentration is no longer treated as new and hygienic. Figure (1-7) lists outdoor airflow-related surface levels as recommended if the following conditions apply: sufficient space ventilation, low-emission extension equipment and sensible consideration of energy efficiency[1].

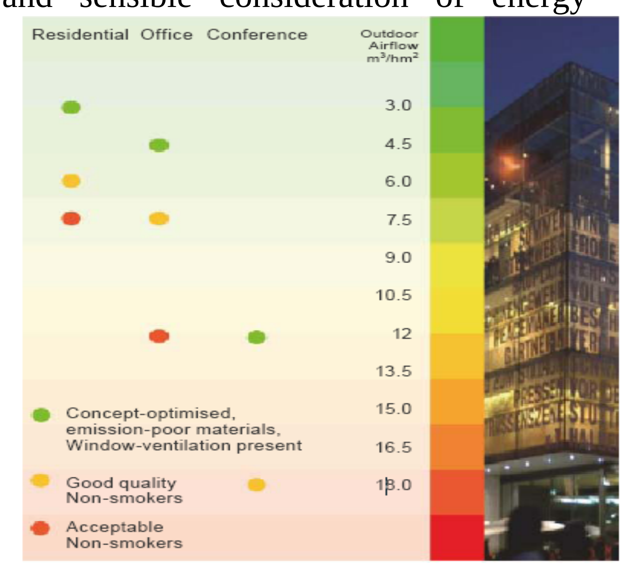


Fig (1-7) hygienically needed surface-related outdoor air flow rates for different uses, Ref: Bauer, Mosel, Schwarz, 2009

[1] Ibid, 45.

1-3 Global warming:

Global warming has been the increase and the predicted continuity of the Earth's average atmosphere and oceans since the late 19th siècle. Earth's medium surface temperature has risen since the beginning of the 20th century around 0.8 ° C (1,4 ° F) and has increased since 1980 by around two thirds. [1], fig (1-8).

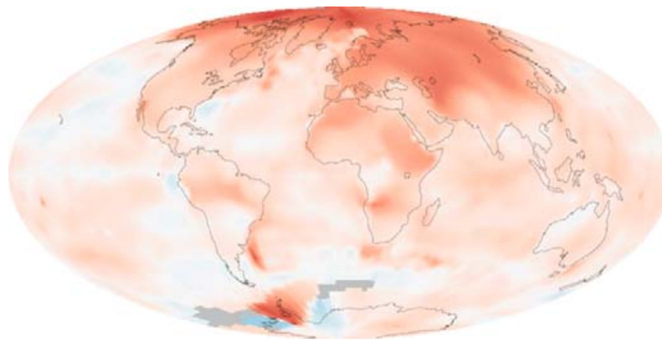


Fig (1-8) The map shows the 10-year average (2000–2009) global mean temperature Ref: Washington . 2011

Mitigation of additional emissions; adaptation to mitigate the harm caused by warming; and geo-engineering to reverse global warming, are the available choices. More precisely.

The Kyoto protocol to minimize greenhouse gas emissions has been signed and ratified by several national governments [2].

1-3-1 Global warming controversy:

A series of debates about the nature , causes and effects of global warming that are substantially more important in the media than in academic literature are discussed in the global warming debate. The disputed problems include the causes of an increase in global average air temperature, particularly as of the mid-20th century, regardless of whether or not this warming trend has been unprecedented, whether humans have made substantial contributions to it and whether it is a result of weak measurements in whole and in part.

Other conflicts include figures on climate sensitivities, other warming predictions and the impacts of global warming. The scientific literature is widely accepted that global surface temperatures have risen in recent decades, mainly due to pollution of humans. This view is not disagreed by any national or international scientific body, although some organizations do not hold commitment positions.[3].

[1] Washington, D.C, America's Climate Choices, the National Academies Press. 2011. p. 15
[2] http://en.wikipedia.org/wiki/Global_warming#Climate_models , op. cit.,11/3/13
[3] Ibid.

1-3-2 The Climate change:

Climate change is a transition from decades to millions of years in the statistical weather cycle. The average conditions can change or the distribution of weather events changes on average. Climate change can be restricted to a small area or occur worldwide[1].

Climate change is expected to be mostly due to increased emissions of anthropogenic GHG. CO2 is one of the largest greenhouse emissions in the world[2], fig (1-9).

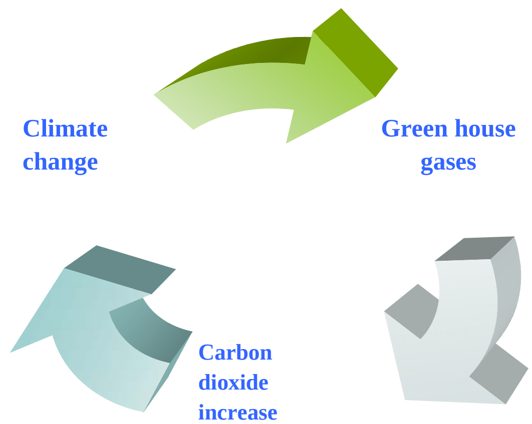


Fig (1-9) the relation between climate change, GHG & CO2, by researcher

1-3-2-1 scientific evidence for warming of the climate system:

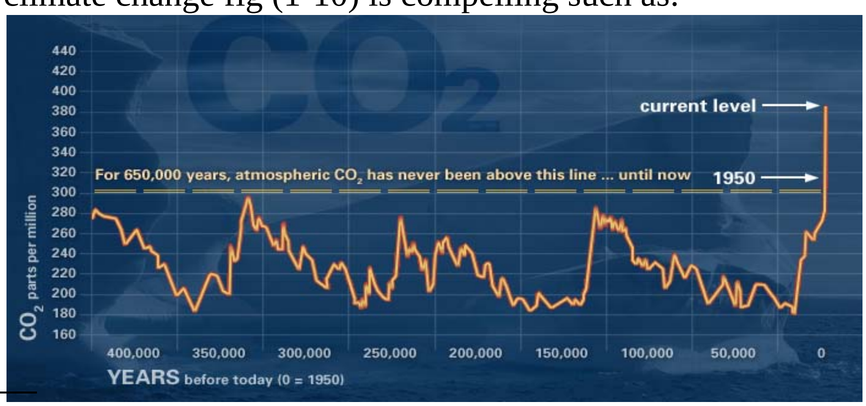
"Scientific evidence for climate change warming is unequivocal." Ninety-seven per cent of climate scientists believe, and several of world's leading scientific organizations have made public statements supporting this stance, that the climate warming patterns of the last century are very likely due to human activities.

The heat trapping aspect of carbon dioxide and other gases was demonstrated in the mid-19th century.

Their ability to control the atmospheric transfer of infrared energy is the theoretical basis for many JPL-designed instruments, such as AIRS. Higher greenhouse gas levels would warm the world as a response.[3].

The evidence for rapid climate change fig (1-10) is compelling such as:

Fig (1-10): This graph, based on a study of atmospheric samples in ice cores and more recent direct measurements, shows that atmospheric CO2 has risen since the Industrial Revolution. Ref:http://climate.nasa.gov/evidence ,access 18/ 3/2013



[1] Magdy .2010. op. cit., p 3.
[2] Hetherington, Robina; Laney, Robin and Peake.2010. op. cit., p1.
[3] http://climate.nasa.gov/evidence ,access 18/ 3/2013

- Sea level rise
- Global temperature rise
- Warming oceans
- Shrinking ice sheets
- Declining Arctic sea ice
- Glacial retreat
- Ocean acidification

1-3-2-2 Climate change Causes:

Weather forcing is forces that can influence the weather they involve mechanisms such as fluctuations in sun energy, differences in Earth's orbit, mountain building and continental drift, and increases in GHG concentrations. [1]. Most climate scientists believe that the main cause of the current trend of climate change is the man extension of the "greenhouse gases" that warms up the results as the atmosphere absorbs heat from Earth to space.

Natural greenhouse changes with human activities. The concentration of ambient carbon dioxide has increased over the last decade since fossil fuels such as coal and oil have been burned. This is because the biomass or oil burning cycle combines carbon with airborne oxygen to produce CO2. To a lesser degree, land clearing increased the production of greenhouse gases for forestry, industry and other human activities.

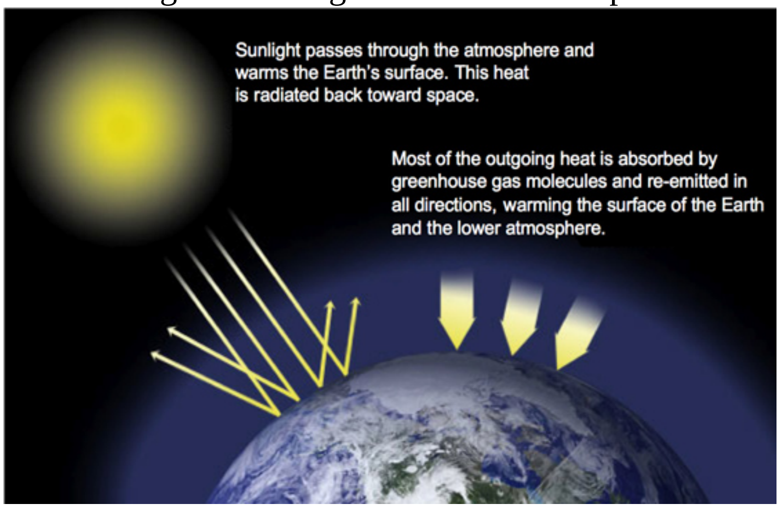


Fig (1-11): A greenhouse gas layer predominantly of water vapour, with much smaller quantities of carbon dioxide, methane and nitrous oxide – serves as the Earth's thermal shield, trapping heat and heating the surface to a life-sustaining temperature of 59 degrees Fahrenheit (15 degrees Celsius). Ref: http://climate.nasa.gov/causes,op.cit.,acess 18/3/13

The natural greenhouse shifts with human activities[2], fig (1-11)

1-4 Greenhouse effect:

Greenhouse gasses are atmospheric gasses that absorb and emit radiation within the thermal infrared range, and greenhouse gasses are included [1]:

[1] http://en.wikipedia.org/wiki/Climate_change,op.cit., access 18/3/13
[2] http://climate.nasa.gov/causes,op.cit.,acess 18/3/13

- Water vapor
- Carbon dioxide (CO_2).
- Methane
- Nitrous oxide, and ozone

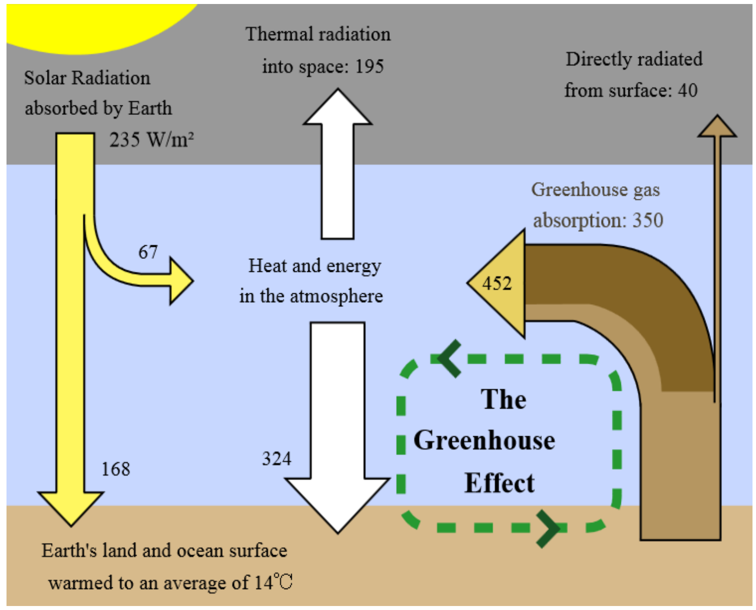


Fig (1-12): Schematic Greenhouse Effect showing energy flows between space, atmosphere, and Ground surface. Energy swaps shall be expressed in watts per square metre

.Ref: Alfons P, M. Baede. (2018). Glossary. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_appendix.pdf

The "greenhouse effect" is the warming which occurs in the trap heat of the atmosphere in some gases. Such chemical substances, like the glass walls of a greenhouse, allow light but avoid the escape of heat.

Sunlight first shines on the Earth's surface, where it is absorbed and radiates into the atmosphere as heat. Some of this heat is absorbed into the atmosphere by greenhouse gases and the remainder flees into space, the hotter the more greenhouse gases are trapped in the atmosphere, fig (1-12).

Since 1824, when Joseph Fourier calculated it would be much cooler if Earth had no atmosphere, scientists have known of the greenhouse effect. This greenhouse effect holds the atmosphere of the Planet alive. Otherwise, the atmosphere of the Planet will be about 60 degrees colder in average. By producing the carbon dioxide , a greenhouse gas, human beings were discovered in 1895 by the Swedish chemist Svante Arrhenius. He launched 100 years of climate research that has helped us to understand global warming sophisticatedly.

The amounts of greenhouse gas (GHG) have risen and fallen in earth history and in the last few thousand years have been relatively constant. The global average temperatures remained remarkably constant during this period until

[1] Alfons P, M. Baede. (2018). Glossary. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_appendix.pdf

recently. The greenhouse impact of humans is enhanced and the earth is warmed by burning fossil fuels and other GHG emissions.

The reason is that with rising average temperatures on this planet, winds and ocean streams move heat across the globe in ways that can cool down some areas and warm others and alter the amount of rain and snow falling. The reason is that the global warming is also used by scientists. Climate shifts thus vary in various areas[1].

1-4-1 (GHG) emissions from the building sector:

During every stage of building life GHG is released into the atmosphere [2]:

- Building construction
- Building operation
- Building renovation and deconstruction

GHG reduction calculations should consider all stages of the building life: construction (incl. renovation and deconstruction) and operation.

Table (1-1) :(GHG) emissions from the building sector

Construction	Operation
GHG emissions from buildings are primarily generated from: 1. Production of materials (e.g. concrete) 2. Transportation of materials 3. Demolition of transportation waste 4. Treatment of demolition waste The average emissions of 1000-1500 kgCO2e / m2 (around 500 kgCO2e / m2 for construction , renovation and deconstruction of a typical building). Building only). LCB 's methods for reducing emissions of GHGs during construction include:	The primary source of GHG pollution from building activities is: 1. Consumption of electricity 2. Consumption of power, hot water and heat fossil fuels on site. 3. Waste water collection on site 4. On-site recycling of solid waste 5. Industrial processes in construction For example , natural gas, propane, etc. are fossil fuels. Operating emissions can range from 0 to over 100 kgCO2e / m2 per year, depending on the environment in which the building is situated and the building

[1] NUNEZ, CHRISTINA. (2019). CAUSES AND EFFECTS OF CLIMATE CHANGE.http://environment.nationalgeographic.com/environment/global-warming/gw-overview

2 Li, Danny H.W.; Yang, Liu; Lam, Joseph C. (2013-06-01). "Zero energy buildings and sustainable development implications – A review". Energy. 54: 1–10 doi:10.1016/j.energy.2013.01.070. ISSN 0360-5442.

1. Reduce the content quantity used 2. Choose products with related low emission factors (e.g. recycled materials) 3. Choose material providers as close to the const as possible 4. Divert waste from demolition into recycling rather than waste or incineration	energy mix. Usually, LCB produces less than 10 kgCO2e / m2 annually. LCB 's techniques for reducing GHG emissions during service include: 1. Reduces energy use 2. Switch to energy sources for clean energy

1-4-2 Fossil Fuel Combustion Emissions by Residential and Commercial Sectors:

Six and four per cent of Carbon dioxide emissions fuels, 43 % and 11 % of CH_4 emissions from fossil fuels, and two per cent and one per cent of Nitrogen emissions from fossil fuels were from residential and industrial sectors. This industry was mainly due to the use of fossil fuel energy products, mainly for heating and cooking purposes. Coal use was a minor component of energy usage in both of these end-use markets. In 2010, Carbon, Methane and Nutrient content were 1,195.2 tg CO_2 Eq in the residential and industrial end-use segments of combustion and electricity fossil fuels. That was in 2010, 1.004.9 Tg carbon dioxide, respectively.
Total CO_2, CH_4 and N_2O residential emission and trade sectors have risen respectively by 5.2 and 2.0% between 2009 and 2010.

Pollution from the residential and industrial sector generally have been rising since 1990 and are frequently correlated, rather than prevailing economic conditions, with short-term weather-based energy fluctuations. In the longer term, the population growth, increases throughout regional migration, and shifts in housing and construction characteristics (e.g. size, insulation) are also affecting both sectors.

Residential and industrial direct carbon dioxide emissions range from 76% to 75% of direct Carbon dioxide emissions fuels. In 2010, natural gas emissions from residential and industrial gas remained relatively stable and reduced by 0.3 per cent, respectively.[1], fig (1-13) (1-14).

[1] INVENTORY OF U.S., APRIL15 ,2012, p312

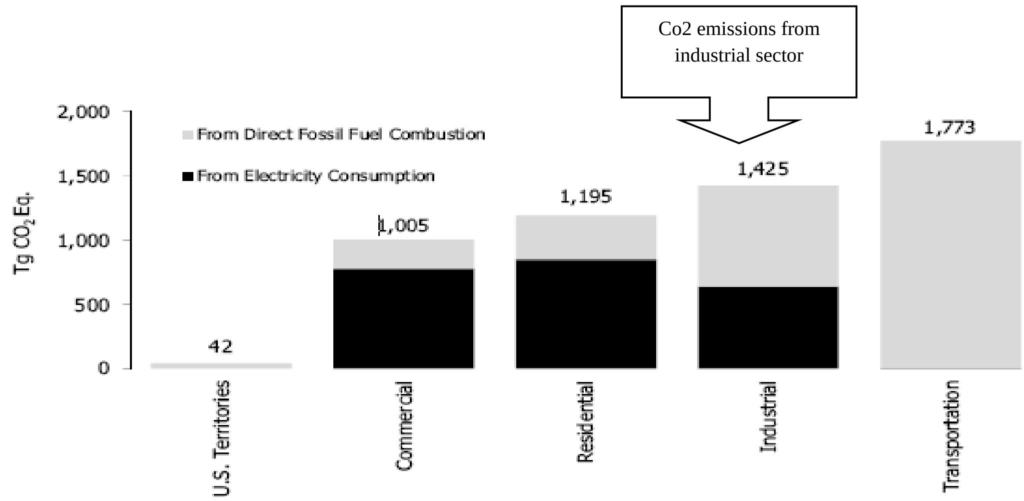


Fig (1-13): 2010 CO2 Emissions from fossil fuel Combustion by sector and form of fuel
Note: Power production also requires emissions of less than 0.5 Tg of CO2 Eq. From the geothermal generation of electricity.
Ref: INVENTORY OF U.S., APRIL15 ,2012, p ES-6

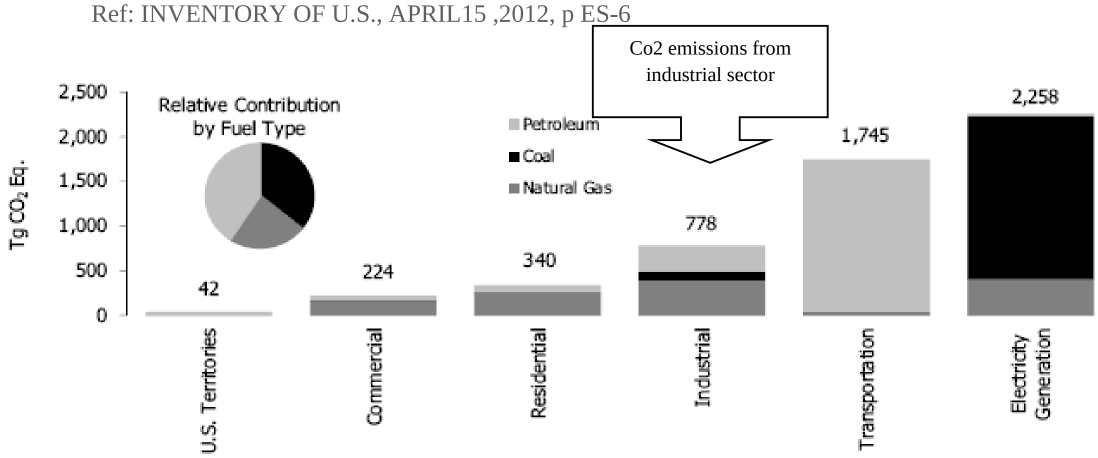


Fig (1-14): 2010 End-Use Industry CO2, CH4 and N2O emissions from Fossil Fuel Burning

Ref: INVENTORY OF U.S., APRIL15, 2012,, p ES-7

1-5 Conclusions:

- Global warming reflects a rise since the mid-20th century in earth's average temperature and the expected continuation of air and oceans near the surface.
– Climate change is a long-term climate shift in the region or world in a particular area. The change in weather conditions, including temperature, wind patterns and precipitation, tests the shift
- The "greenhouse effect" is the warming ,those gases that trap heat in the Earth's atmosphere. These gases are like a glass wall of a greenhouse, allowing light while retaining heat.
– In the government's strategy to combat pollution , especially under emission trading systems and very long-term impediments to climate policy implementation at our fast growing urban centres, the building sector could play a significant role in reducing the cost of economic reduction across the board:
• Lack of experience in urban climate policies •

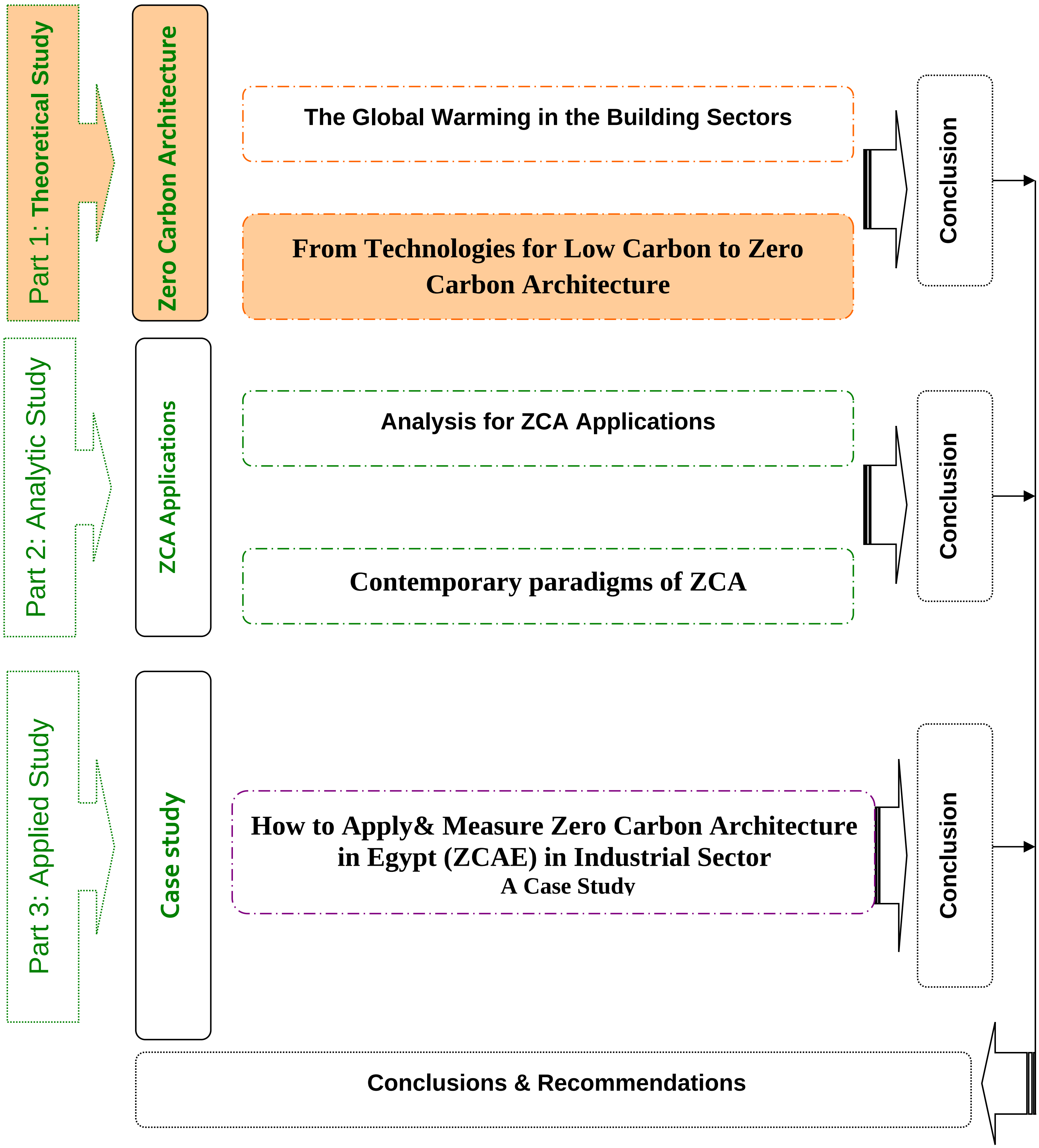
• lack of a national structure for environmental policy incorporating climate change issues •

• Climate change impacts on built environments can cause risk and liability issues

The transition to a low-carbon, more sustainable urban form has major policy challenges to finance and control.

Part 1: **Theoretical Study**

From Technologies for Low Carbon to Zero Carbon Architecture


Part 1: Theoretical Study
Zero Carbon Architecture
The Global Warming in the Building Sectors
From Technologies for Low Carbon to Zero Carbon Architecture
Conclusion
Part 2: Analytic Study
ZCA Applications
Analysis for ZCA Applications
Contemporary paradigms of ZCA
Conclusion
Part 3: Applied Study
Case study
How to Apply& Measure Zero Carbon Architecture in Egypt (ZCAE) in Industrial Sector
A Case Study
Conclusion
Conclusions & Recommendations

Contents

INTRODUCTION:

This chapter will explain technologies for low carbon in the building sector; these technologies are classified to (energy, design).
All these technologies have given us excellent new materials, energy & designs. Architects now commonly agree That due consideration should be given to conserving energy; the use of natural daylight and the use of renewable energy for air conditioning; as well as improved ventilation systems and reduced environmental impacts.[1].

In this chapter, Zero carbon architecture may be described in various of ways, depending on the boundary and the metric, different definitions may be relevant, based on project objectives and the values of the designers and the house owner, such as (Net Zero Site Energy, Net Zero Source Energy, Net Zero Energy Costs and Net Zero Energy Emissions) and the Advantages and Disadvantages.
So, in the end of this chapter we will get smart buildings from using Zero carbon architecture.

2-1 Technologies in Energy:

Use solar energy and wind energy are very important technologies for low carbon. This part will illustrate these technologies and how applied in the following:

2-1-1 solar energy:

• If solar energy is to be used to produce heat, adequate roof space must be enough to position the collectors. The glazing was just suitable for this in a limited way, since daylight is needed for most of the rooms, and yet the amount of light on the glazing is only a max of 70% of the optimum performance. In order to cover a substantial proportion of the requirements for the heat of water supply by solar energy, the building should have no more than 10 to no more than 20 floors. (Fig (2-1), (2-2))[2].

[1] C. Gallo, M. Sala, A.A.M. Sayigh. 1998, p1
[2] Michael Bauer, Peter Mosel, Michael Schwarz.2009.op.cit, p 70.

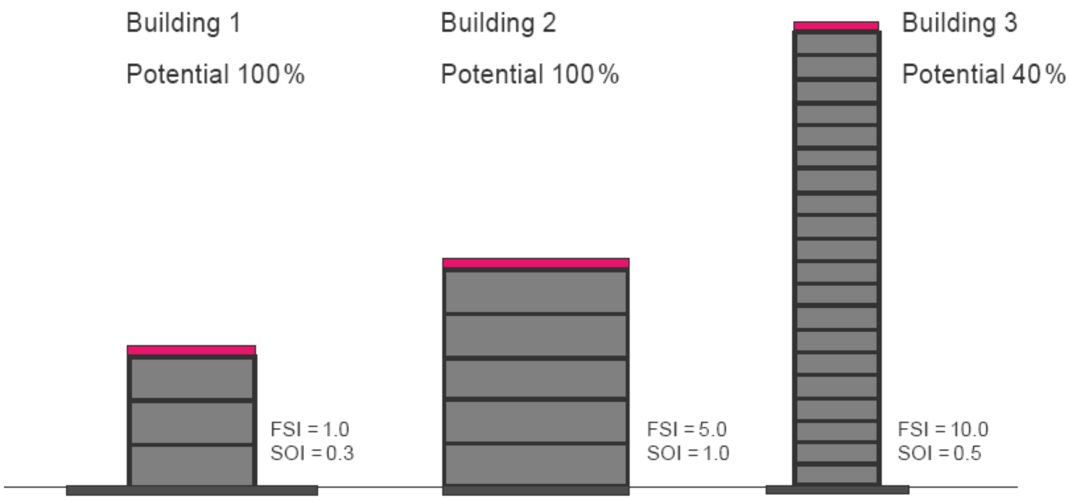


Fig (2-1) Potentials for the use of heat solar power for various amounts of roof area to cube building material. Possible proportion of solar power use for the purpose of water supplies heating in residential buildings is seen here. . Ref: Bauer, Mosel, Schwarz, 2009

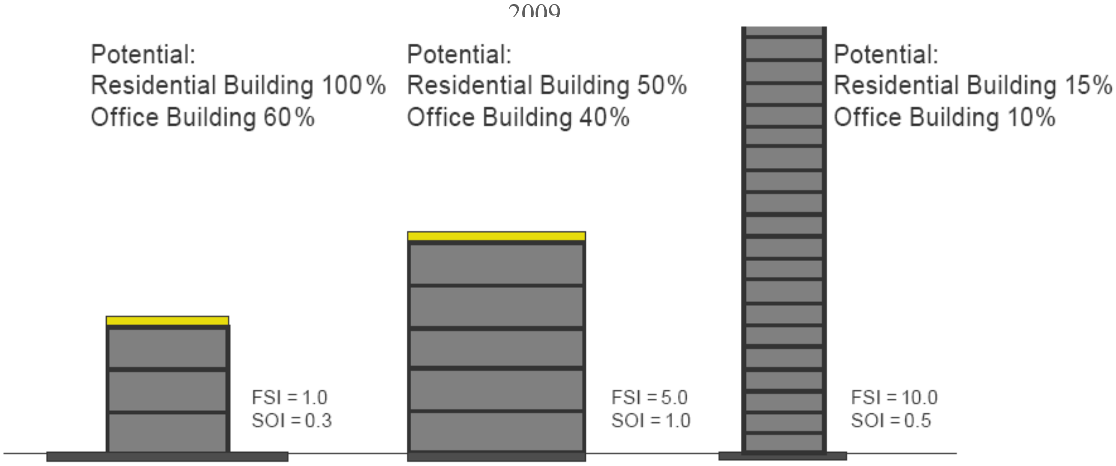


Fig (2-2) Potentials for solar pv energy use at various ratios From rooftop area to cubic material house. The proportion shown here is probable, Solar energy use to meet power needs in residential and office buildings.

Ref: Bauer, Mosel, Schwarz, 2009

2-1-2 Photovoltaic Systems (PV):

Photovoltaic power worldwide GWp[2]	
2005	5.4
2006	7.0
2007	9.4
2008	15.7
2009	22.9
2010	39.7
2011	67.4
2012	**100**
Year end capacities	

Table (2-1): pv power worldwide Ref:https://en.wikipedia.org/wiki/Photovoltaic_system. Access.23/3/2013

Photovoltaics (PV) It is a process of creating electrical energy by transforming solar radiation into direct current electricity by means of photovoltaic semiconductors. Pv uses solar panels consisting of a number of photovoltaic cells containing photovoltaic material. Photovoltaic materials widely used include mono - crystalline silicone, poly - crystalline silicone, amorphous silicone, cadmium telluride, and copper indium selenide/sulphide. In recent years, the production of solar cells and pv grids has increased considerably due to the increasing demand for renewable energy sources,Table (2-1).[1]

A typical domestic PV (photovoltaic) like photovoltaic wall Fig (2-3), PV device will save around 1200 kg of carbon dioxide per year – about 30 tons of carbon dioxide over its lifetime .

Fig (2-3) Photovoltaic wall at MNACTEC Terrassa in Spain Ref:https://en.wikipedia.org/wiki/Photovoltaic_system. Access.23/3/2013

2-1-3 Wind turbines (Wind power):

A **wind turbine** Is a mechanical energy process which converts kinetic energy, also called wind power. If electricity is produced by mechanical energy, this unit may be called a wind turbine or a wind turbine. [2].

Wind turbines are the buildings at Tropico 3 and Tropico 4. They produce electricity using wind, which supplies renewable energy. Depending on how high the turbine is constructed, every turbine generates between 10 and 40 megawatts.[3]

[1] https://en.wikipedia.org/wiki/Photovoltaic_system. Access.23/3/2013
[2] Annette, Evans. Vladimi, rStrezov .(2009). Assessment of sustainability indicators for renewable energy technologies. https://www.sciencedirect.com/science/article/abs/pii/S1364032108000555?via%3Dihub
[3] Wind Turbine (Tropico 4). http://tropico.wikia.com/wiki/Wind_Turbine. access 24/3/13

Bahrain Trade Center Fig (2-4), a twin high-rise structure, was successfully constructed with three wind turbine blades. This is the first time that massive wind turbines have been integrated into a commercial enterprise to harness wind power within its architecture. The three massive turbines, 29 meters in diameter, are supported by bridges spanning between the two buildings of the complex. Due to its location and the revolutionary aerodynamic nature of the buildings, the prevalent Gulf breeze on the shore is drawn in the direction of the turbine, helping to create efficiency in the production of electricity.

Fig (2-4) Bahrain World Trade Center
Ref: Derek Markham. (updated 2020). Bladeless Wind Turbine Could Be 2X as Efficient as Conventional Designs.

When running, wind turbines can provide about 11-15% of the building's electricity demand, or 1100-1300 megawatt-hours each year to provide electricity in 300 homes per year. [1].

2-2 Design:

Some of these technologies classified (solar design, wall design, roof design and Building Shape) as the following:

2-2-1 solar design:

2-2-1-A Passive solar design

As the sun moves each part of the atmosphere, it is fair to define the technics used in buildings as 'solar design.' The simplest response is to call them 'solar passive architecture.' [2].

There are a variety of requirements for access to solar radiation:

[1] Derek Markham. (updated 2020). Bladeless Wind Turbine Could Be 2X as Efficient as Conventional Designs. http://www.treehugger.com/renewable-energy/worlds-first-building-integrated-wind-turbines.html access 24/3/13
[2]Peter F. Smith,2005,P54

● The location of the sun related to the main exteriors of the building (solar altitude and azimuth);
● Location and slope orientation;
● current on-site obstructions;
● ability to overshadow obstructions beyond the boundaries of the building.

Window, ceilings and walls are designed to capture, store and distribute solar energy as winter heat and to refuse solar energy in summer under the Passive Solar Building Design ,Solar passive design or climate design because, contrast active solar heating systems, it does not require the use of mechanical and electrical equipment[1].

2-2-1-B Solar Protection:

A good degree of solar protection is critical for Green Buildings. The goal here is to provide the building with adequate solar protection to hold cooling energy demands as low as possible and to keep the planned cooling load as low as possible. Solar protection arrangement depends on the manner and forms of glazing and can be modified in either a rigid or movable version through an additional feature. Aside from the direction of the sun for the particular area, we do need to understand how steady the wind is during the design stage for mobile solar protection systems that are placed on the outside of the fig (2-5). As the amount of daylight in a given space influences window and sun protection, the energy requirements for space cooling and artificial lighting have a direct proportional effect. [2].

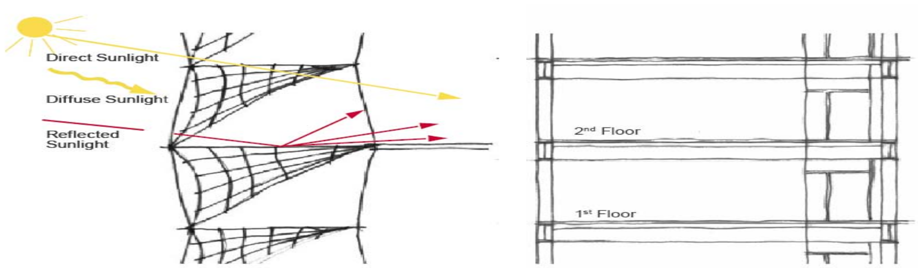


Fig (2-5) Simulation model for the measurement of solar inflow, depending on the geometry of the sail and the location of the sun. Ref: Bauer, Mosel, Schwarz, 2009

[1] Williams collage. (2013).Passive Solar Design. https://sustainability.williams.edu/green-building-basics/passive-solar-design/
[2] Michael Bauer, Peter Mosel, Michael Schwarz. 2009.op.cit., p 80,81,83

2-3 Low and zero carbon technologies

The principle of 'zero carbon house;' over the course of a year, they should have zero net emission levels from all household energy consumption. The Government is proposing a three-tiered plan for achieving net zero emissions[1], Fig (2-6).

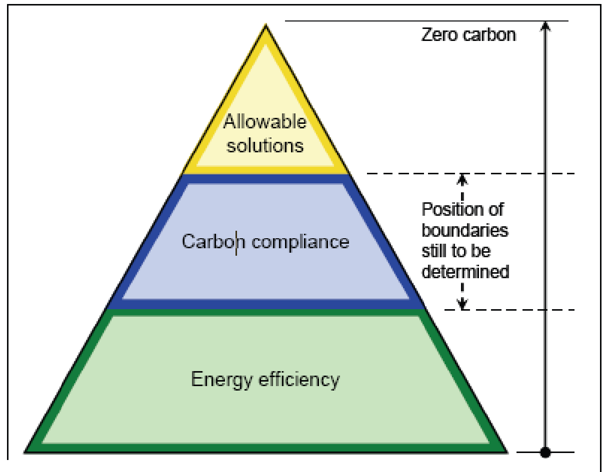


Fig (2-6) Hierarchy of permissible methods to achieve zero carbon developments
Ref: Hetherington, Robina; Laney, Robin and Peake.2010.

The goal, illustrated in Figure 2-6 is the bottom level of the triangle is to design building envelopes with very high 'efficiency' criteria, such that little or no energy is needed to heat or cool the building. This includes very high levels of fabric insulation (U-values), thermal bridging strength, significantly reducing air permeability, incorporating thermal mass and utilising indirect benefits such as metabolism, illumination, solar and devices. Robust methods are bound to lead in long life costs than other, potentially maintenance costs, low or zero tech in the other two phases. The impact of the measures on fabric and energy efficiency is minimal. 'Carbon compliance,' the middle portion of the triangle, covers a variety of steps, including generation tech, such as fabric-integrated photovoltaic panels, ground source heating systems and combined heat and power plants within or closely related to development.

Technically it may not be feasible for certain types of buildings to achieve net zero carbon emissions by energy efficiency and on-site 'climate compliance' programmes. There may be a need to incorporate (primarily) off-site or 'permitted solutions' to satisfy the proposed requirement. Off-site options considered for evaluation include local energy systems, payment credits for local power networks, improvements to existing local buildings, as shown in Fig (2-7).

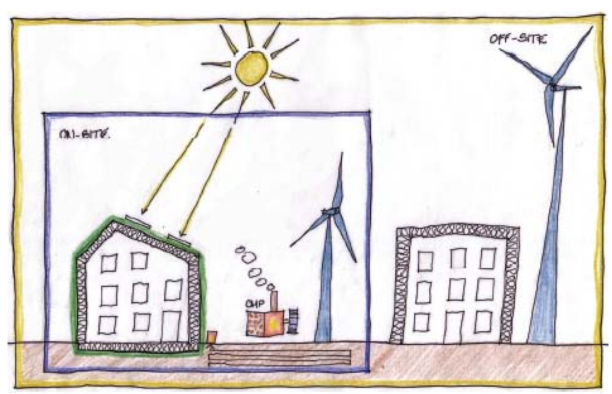


Fig (2-7) On-site and off-site Operation

Ref: Hetherington, Robina; Laney, Robin and Peake.2010

[1] Hetherington, Robina; Laney, Robin and Peake, Stephen, 2010. op.cit. p2.

Other acceptable solutions can include building tools such as energy-efficient equipment, ultra-low-energy IT devices or sophisticated heating/cooling/lighting process control.

2-3-1 ICT for a Low Carbon Economy Smart Buildings

Between 2002 to 2025, global energy use for buildings would rise by 45 percent FIG (2-8) Buildings account for around 40 per cent of energy consumption, 33 per cent for commercial buildings including industrial building and 67 per cent for residential buildings. This study is also strongly supported by national climate change studies, which identify the "specific used sectors " as the biggest contributors to next year's GHG emissions. Reducing energy use by using ICT as a main enabler technology is estimated to be about 15 per cent in the coming years[1].

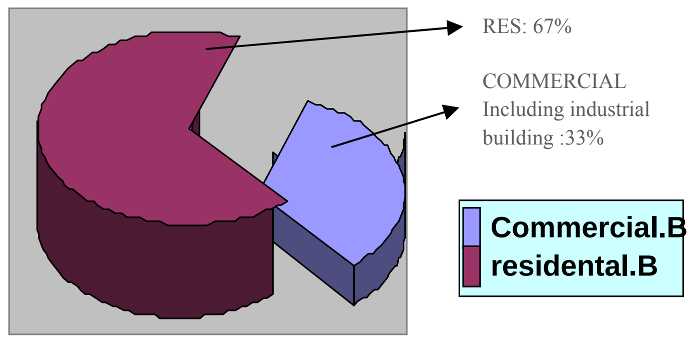


Fig (2-8) energy demand of building by researcher

The study estimates contributions from different technologies and policies to the reduction figure emphasizing the ICT methods fig (2-9) for enhancing building energy efficiency during the design process and smart management systems can get the greatest effect. To this end, research and development on the EE will be based around the following main pillars in future smart buildings:

1-The “intelligent” objects. 2-The communications
3-The “smart BMS / ECMS12” 4-The multimodal interactive interfaces
5-Wired and wireless sensors
6-Wireless and wireline connection models & protocols
7—Proprietary networks & platforms 8—"Dumb" traditional services
9 – Multi - modal knowledge devices
10 – Real effects on energy savings 11-Possibilities of replication
12-Level of interoperability 13-User-friendliness
14-Economic efficiency

[1]European Commission. July 2009,p18,19,20,21

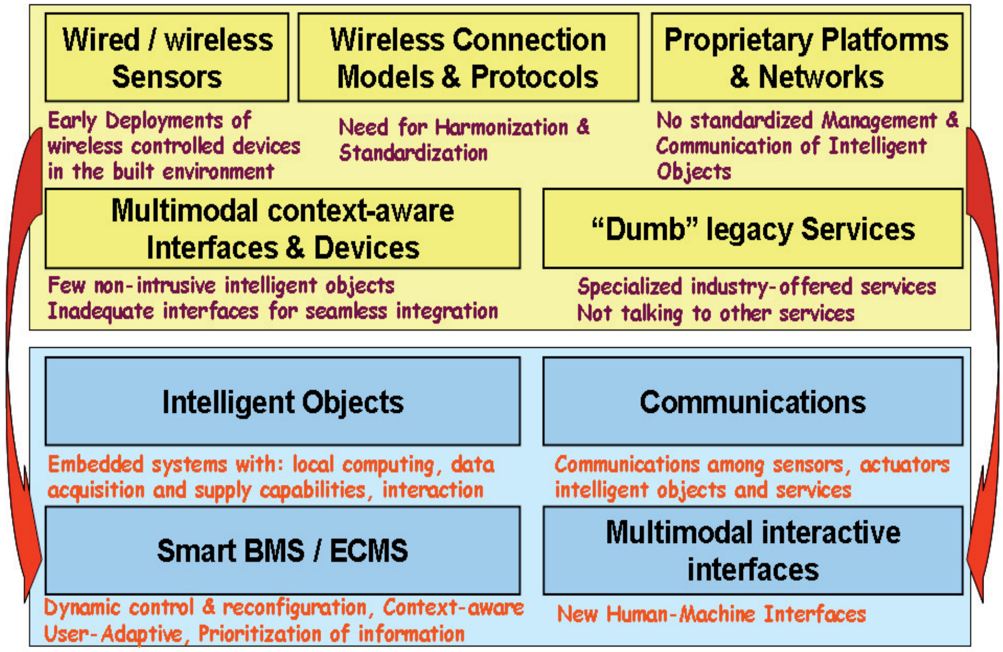


Fig (2-9) technologies for smart buildings

Ref: European Commission. July 2009

2-3-2 New Low Carbon Paradigms

The innovative building construction from the previous decades must be replaced by energy modeling and detailed performance analyzes to build houses for the twenty - first century. We cannot afford the cost of testing out the structures of houses in a field where every product is simply a model and where building performance problems may take years or decades to come into being[1]. We will begin to enhance buildings which its energy efficiency is well below what we need to do without combine the stringent performance analysis that is brought about by construction engineering physics with architectural design and industry-leading scientific construction expertise.

In practice construction science, environmental engineering, sustainable design and low-carbon consulting are different names that characterize building Engineering Physics. In any of the conventional professional designs there is not an approved range of low carbon design services.

Building service engineers dealing with energy concerns also lack good awareness of design and fabrics. Architects and building planners are not aware of energy

[1] Doug King. 2010. p 431,432

problems and the interdependency of service systems. While a quantity surveyor is in a position to comment on the economic repercussions of design choices, few teams get the ability to advise on the impact of carbon emissions decisions.

The building configuration is decided by the architect, but the low carbon approach now requires thermal insulation, air tightness, Sun Shading and Windows Quality. It is therefore common for the building services engineer to look at these components in order to explain their performance, but they simply are not Section of the facilities of the building facility. This is contributing to misunderstanding about design obligations for parts and all. charges charged to an engineer for construction services do not include any additional work required for the proper testing of building materials, and neither does PI Insurance company pay damages in a field outside its competence.

The energy efficiency of buildings can be affected by different factors, from their site and design to its application of IT. We need to incorporate all fields to provide holistic solutions to adapt sustainability to the construction projects. Economic and environmental sustainability goals can be accomplished by defining element of solutions that enhance each other, preventing over-engineering and construction parts that offer multiple benefits, such as the use of a cement thermal storage system.

System engineering accepts that multiple interdependent systems are required to function in harmony complex objects as buildings. Each one can impact the building's final energy efficiency as well as building services installations through design, structure, aesthetics and material choice. In order to achieve the best solution it can also be difficult to identify incompatible functional, structural and performance requirements and a technological decision needs to be made to achieve a proper balance. The physicists of buildings already work with such a systemic approach to design by established architecture, layout, planning and construction frameworks.

However, in the current design team members, the skills needed for a low-carbon approach also exist. The construction engineer is specialized in energy efficiency, comfort and thermal effects and uses professional practice to absorb knowledge of windows design, shading and room planning. The systematic introduction into the education of all construction professionals of a device engineering approach to the basics of construction engineering physics would greatly enhance their capability to create low-carbon houses.

Knowing that low carbon architecture is a genuinely multidisciplinary complexity, individuals may monitor the construction of a large array of elements and strategies for most significant advantage of project success.

2-4 Zero-energy building.

A **zero-energy building**[1] is a Construction with zero net energy consumption and null CO2 outflow per annum. NZEB building It is also recognized as a Zeros Net Energy building (ZNE). Constructions that generate energy surpluses over the year may be referred to as "power plus buildings," and the buildings that intake a little more power than generated is referred to as "near-zero power buildings" or "ultra-low energy buildings.

Traditional houses make use of 40 percent of the total U.S. and European Union fossil fuel resources and make major GHG contributions.

The zero net energy consumption concept is seen to minimize co2 exuding and decrease reliance on fossil fuels and even in developing countries, while zero energy building is still rare, it is growing in value and approval.

Certain zero-energy buildings apply electricity in power net, while others depend on the grid. Energy is generated at the facility usually through the integration of solar and wind power generation technologies, thus reducing overall energy consumption with the most powerful HVAC and lighting tech.

The zero-energy objective is become more realistic as the cost of renewable energy technology declines and even the price of conventional fossil fuels rises.

Building of contemporary zero carbon structures was made possible not only through the creation of new energy and building technology, but also by academic research which collects detailed information on the energy performance in traditional and trial buildings and sophisticated computer models with performance parameters to prevent effectiveness of such buildings.

With its many options for generating and saved energy and its many methods of calculating energy (in terms of cost, energy or carbon emissions), the zero-energy principle lets for a wide variety of methods.

[1]U.S. Department of Energy by The National Institute of Building Sciences. (2015). A Common Definition for Zero Energy Buildings.
https://www.energy.gov/sites/prod/files/2015/09/f26/A%20Common%20Definition%20for%20Zero%20Energy%20Building

2-4-1 Zero-Energy Buildings: Definitions Zero Carbon Architecture (ZCA)

Zero-energy building[1] ,depending on the boundary and the metric, different definitions may be appropriate based on project goals and the principles of the designer and the owner.

• **Net Zero Site Energy**: When compensated for at the location, a site ZEB creates the minimum as much electricity as it absorbs in a year's time.

• **Net Zero Source Energy**: When compensated for at the source, a source ZEB generates at nearly as much power as a year from now. Source – this refers to the primary energy used to generate and supply energy to the site. Imported and exported energy is measured by the necessary site-to-source conversion multipliers to calculate the total energy source of the building.

• **Net Zero Energy Costs**: The total of money paid by the utility to the owner of the building for the electricity exported to the grid by the building shall be at least equal to the total charged by the owner for the power supply and power consumed during the year.

• **Net Zero Energy Emissions**: A zero-emission net building creates minimum as much emission- free alternative energy from sources of energy that produce emissions.

Architecture expressly designed with a view to reducing GHG. Therefore, (ZCA) are buildings that emit substantially less GHG than normal buildings.

Advantages and disadvantages

Advantages	Disadvantages[2]
1. Isolation from potential electricity price rises for building owners	1-Initial expense can demand extra effort to recognize, submit and qualify for ZEB funds.

[1] P. Torcellini, S. Pless, and M. Deru, June 2006. p 4,5
[2]Ibid.
[2] Banerjee, Reshmi.(2015). Importance of Net Zero Energy Building. International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163.Issue 5, Volume 2 (May 2015). https://www.ijirae.com/volumes/Vol2/iss5/19.MYAE10116.pdf

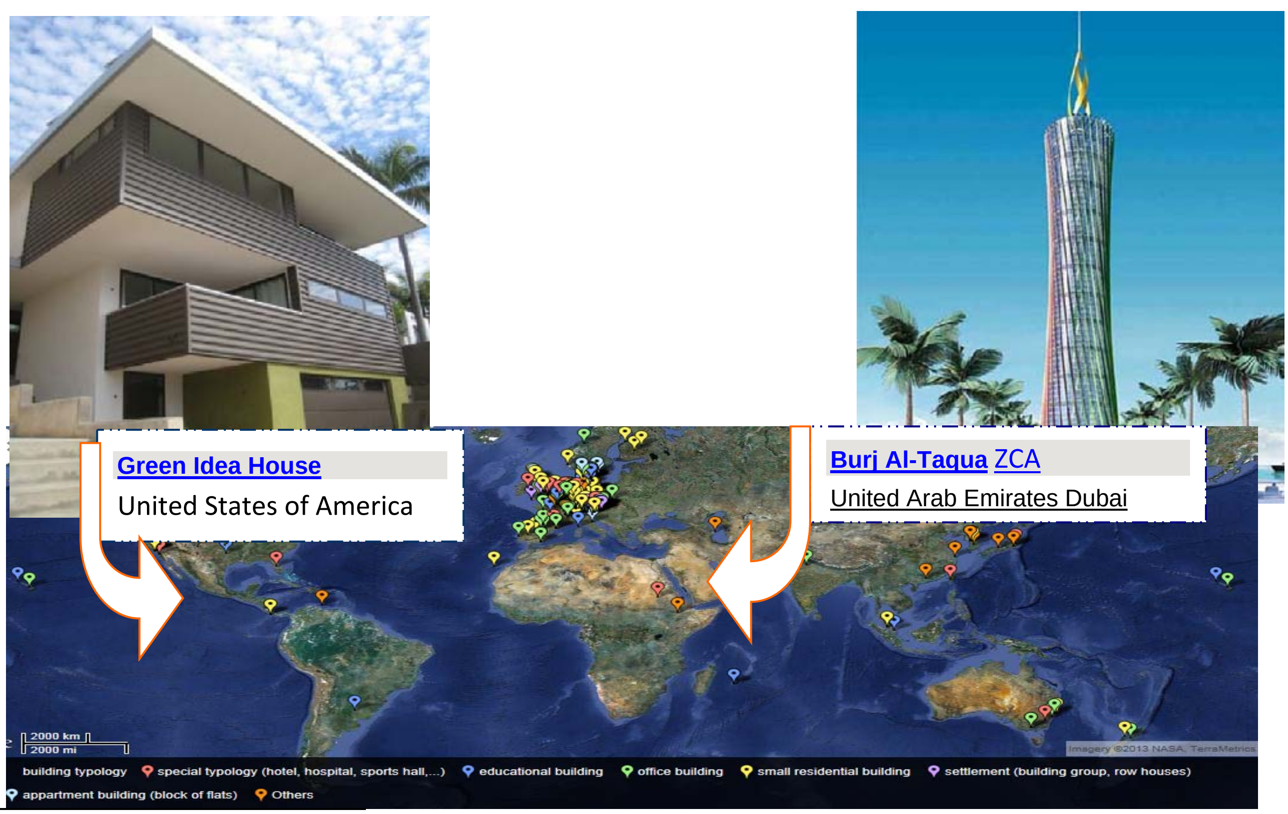
Advantages	***Disadvantages***
2. Greater comfort due to more standardized temperatures in the interior	2 – So few engineers or suppliers have the skills or experience to manufacture ZEBs.
3. Shortened energy austerity requirements	3-In the case of utility companies, potential declines in future costs of renewable power will decrease the cost of the investment capital in energy efficiency.
4. Reduced overall ownership costs due to increased energy efficiency	4 – The cost of new pv solar cell technological devices has dropped by around 17 % per year.
5. Reduced gross monthly net living costs	5- Recovery of higher initial costs for the resale of buildings
6. Improved reliability-25-year warranty for photovoltaic systems-uncommon failure during weather problems	6-While a single house would use a net zero energy average for one year, rising energy is needed at a time when the grid's peak demand is occurring. Therefore, the ZEB should not reduce the necessary capacity of the power plant.
7. Compared to an afterthought retrofit, additional costs for new building are reduced compared to	7 – The use of incarnated electricity, heating and cooling energy and of resources without an optimised thermal envelope is greater than necessary. By clarity, ZEB does not need a lowest heating and cooling effectiveness and can fill the energy gap through broad renewable energy systems.
8. Greater resale rate as more ZEBs are needed by potential owners than the supply available	8 – The processing of solar energy using the house surface only takes place in areas unimpeded from the south. In the south (for the northern hemisphere, or in the north for the southern hemisphere), confronting shade or wooded environments, solar power capture will not be optimized.
9. Compared to similar conventional buildings, any time energy costs rise, the value of the ZEB building should be increased.	
10. Future law-making restrictions and carbon fee/ would require expensive upgrades to obsolete buildings.	

Table (2-2) Advantages and disadvantages of ZCA

2-4-2 Zero energy building versus green building

Green building	Zero energy building[1]
Apply capital more productive and reduced the building's harmful environmental impact. They require manufactured energy and/or fossil fuel to be sustainable and to meet customers' desires.	Achieving one main green-building objective of lowest energy usage and GHG excretion entirely or quite substantially for the life of the building. "In all respects, zero energy houses should or should not be called " green, " such as the elimination of waste, the use of reused building materials, etc. Net-zero buildings appear to provide a significantly smaller environmental effect on the life of the construction.

Table (2-3) Zero energy building vs. green building



[1] Ibid.

FIG (2-10) Global map of 360 globally recognized Net Zero Energy Buildings. By researcher

2-4-3 THE CARBON NEUTRAL DESIGN PROCESS

Carbon neutral design is a very detailed plan, with a specific "order of operations" reflecting a change in thought. Current Green Building Assessment methods reinforce the concept of reducing impact. Although a laudable and necessary first move, we need to drive our goals forward. Reduce, reuse, and recycle to10[1]:

- *Reduce: less build, habitat protection, smarter building, and productive design.*

-*Renovation: use of renewable energies, preservation of natural environments, refilling of natural construction materials, recycling and re-usability of materials in closed loop systems..*

-*Offset: offset carbon, emphasis on local offset projects that can not be removed.*

2-4-4 Future Energy Benchmark – Primary Energy Demand over the Life Cycle of a Building

In the case of any room cooling system, primary energy demand would be below certain critical values for new buildings and renovation programmers, depending on usage. power-based evaluation of energy-efficient and sustainable buildings must take into account all energy flows, such as power demand for construction materials, restoration and repair and energy demands for furniture supplied by the occupying person.[2].

Only if special provisions are in place to restrict the total energy flow would all those participating in the project be required to follow new routes. Current business plans for large organizations use life-cycle costs as a management tool.

2-5 Towards smart buildings:

Architects planned to integrate the latest technology to make life simpler and quicker for communities and to make their surrounding living spaces more comfortable.

Several designers started incorporating the language of intelligent materials. New plans emerged for buildings to be fully coated with "smart" gel, or for "smart"

[1] Christopher Black, Kevin Van Ooteghem, Terri Meyer Boake, 2010. p5

[2] Michael Bauer, Peter Mosel, Michael Schwarz. 2010 op.cit., p 52

rooms that would deform individually according to their own psychological and physiological requirements for each resident[1].
Smart buildings depend on a lot of technologies and applications. The most two important ones are the Nanotechnology and the zero carbon architecture. They aim to increase energy efficiency, enhance the building technological abilities and materials and save time and effort.

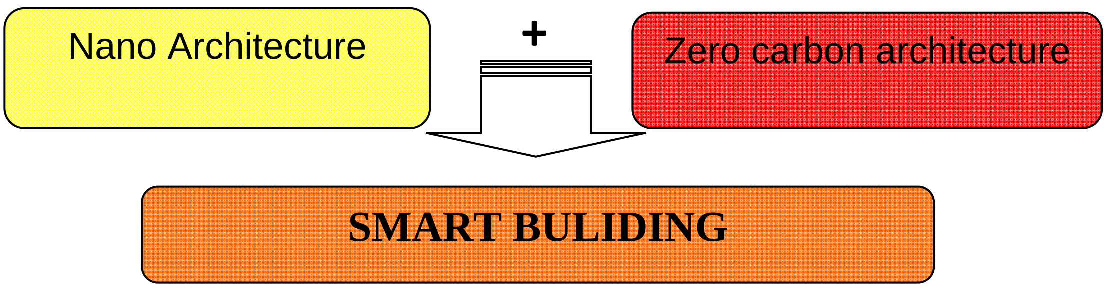


Fig (2-11) to smart building By researcher

2-6 Conclusions:

Technologies for low carbon include energy and design; these technologies consider with reduction of consumption of non- renewable energy and replace it with renewable energy.

In **energy**, solar energy and Photovoltaic's (PV) for heating and generate electricity in residential buildings, Wind turbines (Wind power) used to produce electricity.

In **design**, Solar designs classified, such as (Passive Solar Design, Solar Protecting), Solar energy collection, storage and distribution in winter, refusing solar heat in the summer, Solar Protection used to provide adequate solar energy protection to ensure that the building retains the energy requirements of cooling as well as the projected cooling load as low as possible.

Low and zero carbon technologies; However, skills essential for low carbon training are needed to train the engineer for Conservation of energy, comfort and thermal quality and commonly learn knowledge about passive design, shading and room design through professional practice.

[1] Addington, D. M., & Schodek, D. L. (2005), p vii.

Technologies are number of levels of growth, so approaches will concentrate both on near-market marketing for those technologies and on study, growth and demonstration for those further away.

- A zero-energy building, a zero-energy building (NZEB) or a non-net building is a building with a non-annual gross energy usage and zero carbon emissions. Structures that produce an energy surplus over the year can be referred to as "energy-plus buildings" and buildings that consume slightly more power than they generate are referred to as "near-zero energy buildings" or "ultra-low energy buildings".

Building and renewable energy suppliers must apply integral design concepts, taking benefit of the free natural resources accessible (passive sun alignment, natural ventilation, sunshine, thermal mass), etc.) in order to efficiently address energy needs at a building and in the renewables industry (solar , wind, geothermal).

- Zero carbon architecture aim to increase energy efficiency and enhance smart building technology.

conclusions on the theoretical study

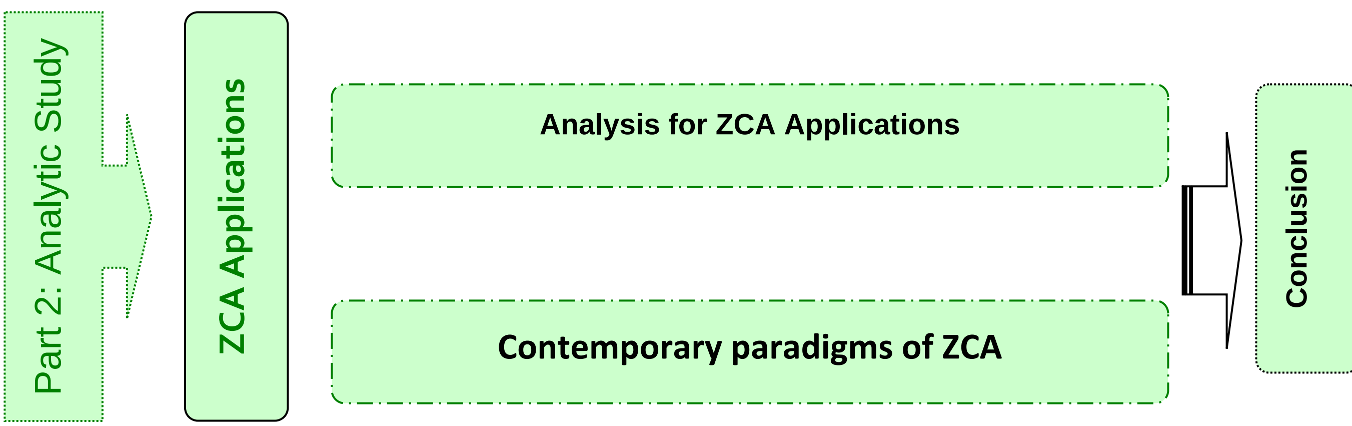
At the end of the theoretical part of the study and after addressing the issue of global warming in the building sector, this is an issue that deserves to be studied at the present time for the importance of energy efficiency and the lowering of co2 emanation, as well as presentation of certain low-carbon technologies to the ZCA.
Where research has tried to present and describe the causes of the issue of global warming and its effects on architecture as a starting point for the use of technologies to reduce carbon emissions in the buildings sector that are difficult to collect in research, some of them have been listed in terms of using renewable alternative energy to preserve the environment and reduce carbon emissions.
With the conclusion of the theoretical part of the study, it tells us the feasibility of the first research hypothesis, including that the use of ZCA and its applications reduces global warming in order to minimize energy consumption. It will also be checked in the next part of the study.

Part 2: Analytic Study

INTRODUCTION

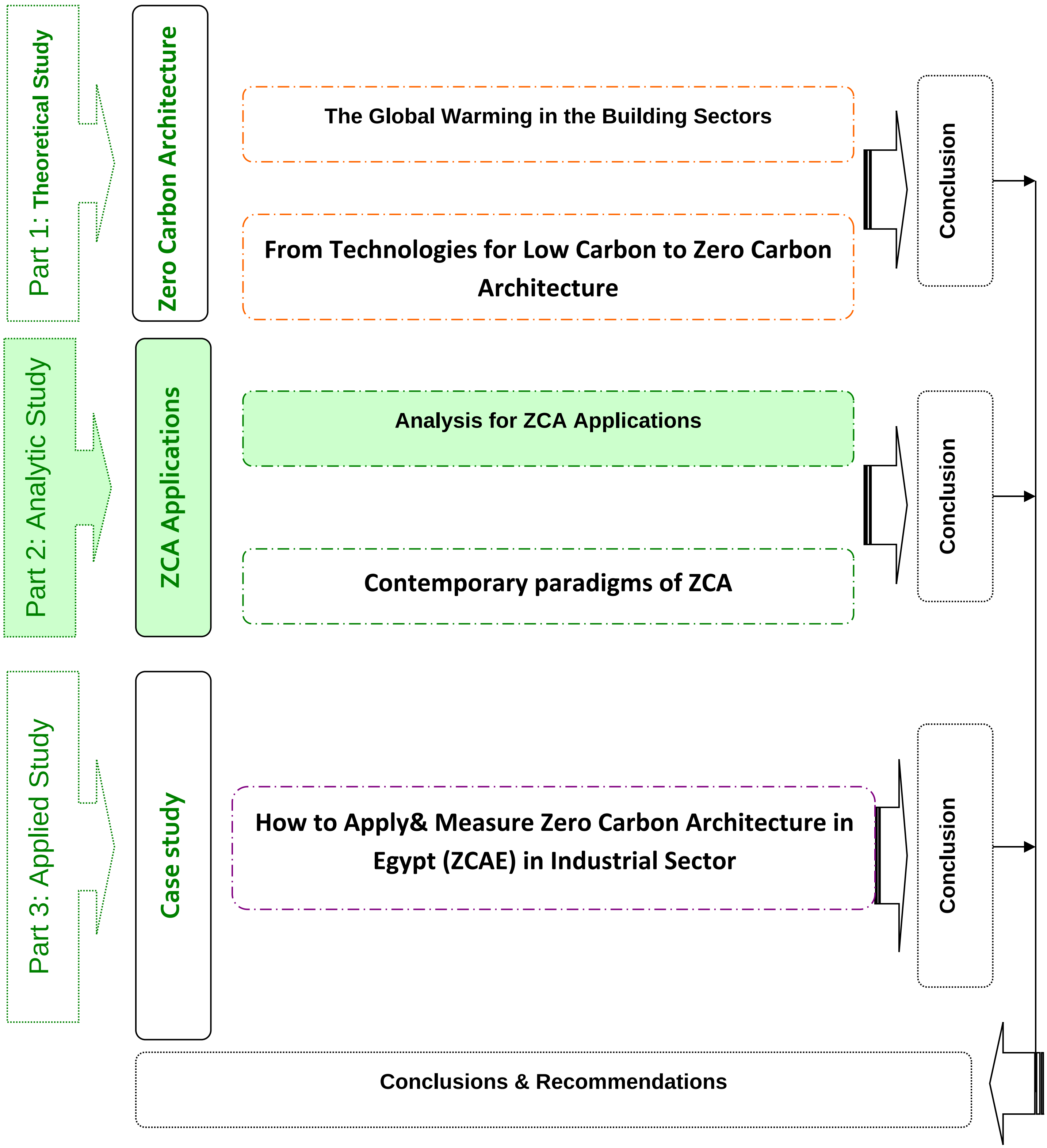
The second part of the research is the analytical study that contains two chapters, the first one is Analysis for ZCA Applications; which illustrate ZCA Applications in (energy, design) With an explanation of its benefits, use and impact on architecture ; the other chapter will focus on contemporary paradigms of zero carbon building Which will be analyzed starting from the site, the area and the envelope of the building, the energy of the building, its consumption from the renewable energy used in it, and the awards won.

So the aim of this analytical part is an analysis of the data of the models collected by the researcher that relied on the criteria that will be mentioned later in this part with testing the first hypothesis that states that ZCA reduces global warming and energy consumption.



Part 2: Analytic Study

Analysis for ZCA Applications


Part 1: Theoretical Study
Zero Carbon Architecture
The Global Warming in the Building Sectors
From Technologies for Low Carbon to Zero Carbon Architecture
Conclusion
Part 2: Analytic Study
ZCA Applications
Analysis for ZCA Applications
Contemporary paradigms of ZCA
Conclusion
Part 3: Applied Study
Case study
How to Apply& Measure Zero Carbon Architecture in Egypt (ZCAE) in Industrial Sector
Conclusion
Conclusions & Recommendations

Contents

INTRODUCTION

This chapter will illustrate ZCA Applications in (energy, design).
These architectural applications can differ widely from the beginning of the design phase to the finishing touches and over the life of the building.

3-1 APPLICATIONS IN ENERGY

3-1-1 Insulated paints

Insulated paints	
Definition	The complex mix of void ceramic microscopic balls that make up INSULADD has a vacuum in it like a mini-thermos flask.
Features	Ceramic materials have specific energy conservation properties that radiate heat during dissipation. The reflective nature of the empty ceramic microspheres affects the heating effect called the "Mean Radiant Temperature," in which warm air waves from an origin such as natural light cause a people to feel warm even though the actual air temperature does not vary between a shady and a sunny spot. It is the chemical friction within the skin generated by the sun's glowing waves of energy that makes the people feel hotter.
Benefits	Thermal paint insulation technology produces very literally a thermal barrier that reflects heat until the paint or coating has dried up[1].

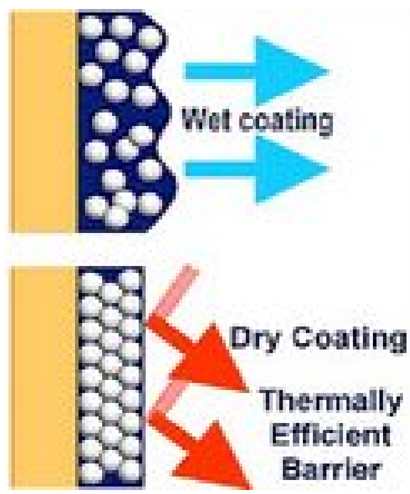


Fig (3-1) Insulated paints.
Ref: Rawlins Paints. (2020).Thermal Paint .https://www.rawlinspaints.com/thermal-paint access 3/20

[1] Rawlins Paints. (2020). Thermal Paint .https://www.rawlinspaints.com/thermal-paint access 3/20

	The INSULADD ceramic particles generate a thermal obstacle. These particles are refracting, reflecting and dispeling heat.	
Use	While INSULADD is extremely beneficial for use on internal walls, the use on external walls is much more dramatic because it blocks the sun's intense heat. INSULADD Ceramic filled wall paint looks like normal, flat paint on interior walls.[1].	
Disadvantages	-More Expensive Than Regular Paint -Need to Get the Right Product: Just like any product on the market, you're going to find more than one variety available[2].	
Effects on Architecture	In reality, these paints affect the future of architecture and energy in terms of providing electrical energy use in heating and cooling in the building, thus reducing carbon emissions and thus a step towards ZCA.	

Table (3-1) Insulated paints

3-1-2 Energy coating

	Energy coating	
Definition	Due to the way plants soak up light to fuel plant growth, energy coatings soak	

[1] Green dimensions. (2009). Nanotechnology in Architecture. Architectural applications http://greendimensions.wikidot.com/nanotechnology-in-architecture. access16/5/13
[2] Homelogic,2019,Pros and Cons Of Thermal Insulation Paint Coatings, https://www.homelogic.co.uk/pros-and-cons-of-thermal-insulation-paint-coatings, access 6/2021

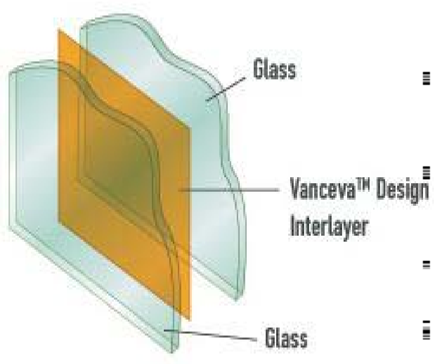
	up light and transform it into electricity[1].	
Features	Energy coatings are formed by the injection of tio2 nanoparticles, a white pigment commonly used in toothpaste and nanoscale paint. The complexion, which is adapted to a versatile material, soak up energy from both the daylight and the inner light. This light energy is converted by tio2 nanoparticles and a variety of electrodes into electrical energy.	
Benefits	The leading energy coating manufacturer Konarka develops and produces low-cost, lightweight , flexible and versatile power plastics. In machines, systems and structures the light active power plastic film can be integrated.	
Use	The film can be made in every colour and opacity, since the production process uses the printing technology. The film can be spread to concrete structures, windows ,walls, roofs and absorbs energy efficiently..	
Disadvantages	-Disguises the substrate – as thermal spray coatings are so efficient in many cases it is impossible to tell what material the substrate was made of after the coating process, unless stringent records are kept. For more info contact Green Leaf Business Solutions here. -Cannot precisely evaluate effectiveness – once the thermal spray coating has been applied it is often	Fig (3-2) Energy coating. Ref: Green dimensions. (2009). Nanotechnology In Architecture. Architectural applications http://greendimensions.wikidot.com/ nanotechnology-in-architecture. access16/5/13

[1] Ibid.

	difficult to tell exactly how well the coating has gone on, other than by a visual assessment. -Costly set up – some of the methods of thermal spray coatings require very expensive apparatus, which can result in a high initial set up cost[1].	
Effects on Architecture	Effects on Architecture These coatings, in fact, affect the future of architecture and Especially energy in terms of providing energy using daylight and thus a step towards ZCA.	

Table (3-2) Energy coating

3-1-3 Heat absorbing windows

Heat absorbing windows		
Definition	glass heat Window absorption is a type of glass walls containing special shades that allow that window to soak up to 45 % of the energy from the sun in order to reduce solar heat in the interiors. , Tinted glass reduces the coefficient of sunlight, visible transmittance (VT) and shine.	 Fig (3-3) Heat absorbing windows. Ref: David Darling. (2013). heat absorbing window glass. https://www.daviddarling.info/encyclopedia/H/AE_heat_absorbing_window_glass.html access 2020
Features	A very famous grey and silver windows are not light spectrum specific, reducing both heat and light penetration. Green and blue windows have better visibility of light and slightly lower heat transfer compared to other curved glass colours. Black-	

[1] IRS surfacing technologies LTD ,2018,Advantages and Disadvantages of Thermal Spray Coatings, https://www.irsltd.co.uk/advantages-and-disadvantages-of-thermal-spray-coatings.access (6/2021)

.

	tinted glass should be ignored in hot countries because it collects more light than heat. Coloured, thermally windows only reflects a tiny amount of sunlight, so reflective glass doesn't really appear like a mirror. [1]	
Benefits	• Quality in electricity Holding heat energy out of the house thus maintaining full light source transmission, lowering operating costs for power generation systems and lowering operation cost for equipment • Ensuring the safety Window and solar layer merge to withstand the strength properties. when exposed to unintended impact. If the force is enough to split the glass, the effects appear to stay attached to The interlayer of the solar. • Ultraviolet protection 95 to 100 percent of the sun's UV rays blocks solar interlayers and permits the passage of significant visible light.	
Use	Is used in glazing, windows, skylights, doors, shop faces and almost every other application [2].	
Disadvantages	-very expensive initially. However, over a period it becomes very cost effective as it drastically helps in reducing the electricity costs.	

[1] David Darling. (2013). heat absorbing window glass. https://www.daviddarling.info/encyclopedia/H/AE_heat_absorbing_window_glass.html access 2020
[2] Green dimensions. (2009). Nanotechnology In Architecture. Architectural applications http://greendimensions.wikidot.com/nanotechnology-in-architecture. access16/5/13 op.cit.

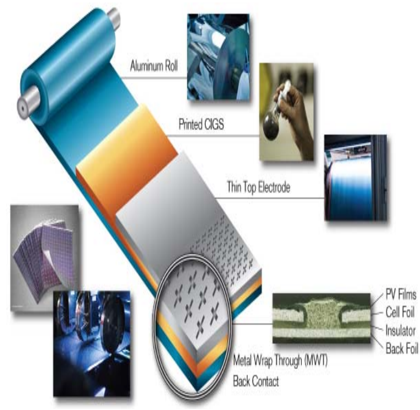
	-The Insulated glass unit must be carefully sealed with a silicone sealant to prevent any leakage of the air that is present in between the glass panes. Any leakage might result in condensation and damage of the Insulated Glass unit. Once damaged the glass pieces cannot be removed and repaired because of which the whole window will have to be replaced[1].	
Effects on Architecture	The innovative glazing interlayer provides new, cost-effective solutions for managing Energy and heat loads in the architectural market place in houses. Such solar efficiency interlayers build vitrification systems through a selective minimization of the solar power transmission versus visual light that can save both the equipment and the costs of service for climate control equipment in terms of capital cost.	

Table (3-3) Heat absorbing windows

3-1-4 Solar cells

Solar cells		
Definition	Pv cells contain of a diode from semiconductor materials placed between two electrical sheets and, as the light is stored in the semi - conductor, they contain ions and electrons, divided by a diode that	

[1]Team McCoy Mart,2020What are the advantages and disadvantages of Insulated Glass , https://mccoymart.com/post/advantages-disadvantages-insulated-glass ,access 6/ 2021

	diffuses to the different contacts to produce a current[1].	
Features	The pv system can be divided into two systems: 1- stand-alone systems 2- grid-connected system in the first one which corresponds to the energy demand of the solar energy. The public electricity grid acts as an energy store in grid-connected systems[2].	
Benefits	Generating electricity from solar energy and exporting it to the grid, thereby providing clean energy and reducing carbon emissions	Fig (3-4) thin-film solar panels
Use	This can be used on building roofs, as well as installation on building facades or in building courtyards.	Ref: nanosolar. (2010).Technology Overview .http://www.nanosolar.com/technology /technology-overview/ 27/3/13
Disadvantages	-It cannot be used in absence of the light from any source. -It incurs very high initial cost for installation. -During cloudy weather, less power is being generated. -Very large geographical area is needed in order to deploy solar panels or cells. -Off grid applications require energy storage. -Photo-Voltaic solar cells generate direct current (DC). It requires DC appliances or inverters (to convert DC	

[1] AIRI/Nanotec IT, ROADMAPS AT 2015 ON NANOTECHNOLOGY APPLICATION",op.cit.,p60,61,64
2 Planning and Installing Photovoltaic Systems. 2013, p9.

	to AC) for use with solar cells-based plants[1].	
Effects on Architecture	The solar cells and their multiple applications, as well as the extent of their growth, reflect positively on the architecture and its applications for obtaining ZCA and obtaining electricity from solar energy while reducing carbon emissions with economic, environmental and architectural feasibility in the light of the booming in solar cell materials like technological innovation on solar cell level fig (3-4) [2], the end result is a lower level zed cost of energy than competing solar technologies.	

Table (3-4) solar cells

3-1-5 Heat insulation and conductance

Heat insulation and conductance		
Definition	The basic heat insulation requirement is that it decreases the rate of heat transfer by radiation ,convection, conduction or some combined effect of these processes.. Usually used insulating materials include fiberglass, rockwool, and slag cloth. Even though they have recently appeared on the scene, aereogels are now known as one of the most effective insulation materials, but their high cost to date makes them	 Fig (3-5) VIP insulation must be made to measure & fitted precisely on site. Ref: [1] AIRI/Nanotec IT, 2015

1 RF wireless word, 2012, Advantages of Solar Cell | Disadvantages of Solar Cell, https://www.rfwireless-world.com/Terminology/Advantages-and-Disadvantages-of-Solar-Cell.html, access6/2021

2 nanosolar. (2010).Technology Overview .http://www.nanosolar.com/technology/technology-overview/ 27/3/13

	largely ideal for specialist applications.
Features	There are two principal methods of achieving Heat insulation and conductance: ▪ To use a porous material that traps and immobilises air or the other gas, that is reducing heat transfer. ▪ Implementing a coat to radiate heat (such coatings will be used on glazing and can be glassy to visible light).
Benefits	helping to reduce energy waste, particularly in residences and industrial sector. The resultant decrease in energy demand would be environmentally friendly and will help to mitigate the increase in energy costs.
Use	Insulating materials are used to maintain constant temperature in a confined area, such as a building[1].
Disadvantages	1. Membrane aging. When insulation is used directly under the roof membrane, solar heat does not readily pass through the roofing system, which increases the roof's surface temperature. 2. Thermally induced expansion and contraction. The roof membrane may experience increased expansion and contraction from the increased surface temperature and rapid daily temperature changes. Rapid daily temperatures are caused by the lack of heat transfer through the roof

[1] AIRI/Nanotec IT, ROADMAPS AT 2015 ON NANOTECHNOLOGY APPLICATION ",op.cit.,p74,75

	assembly. 3.Moisture within the roofing system. The interior and exterior surface temperature range caused by thermal insulation may increase the likelihood of water vapor entering through the warm side and condensing within the roof system. Moisture may enter the roof system during the installation phase or while in service. Ventilation and vapor barriers help to mitigate these effects[1].	
Effects on Architecture	This will have a significant effect on the architecture and all its fields in reducing energy use in an innovative and efficient way suitable for the future, thus eliminating carbon emissions and using them in ZCA and its new applications to minimize energy consumption	

Table (3-5) Heat insulation and conductance

3-1-6 Nanostructured antireflection layers

Nanostructured antireflection layers		
Definition	Antireflective layers based on silicon dioxide nonporous coating[2].	
Features	The porosity enables the modification of the effective refraction index between glass and ambient air, which typically helps to minimize glass refraction losses by 8%.	
Benefits	Therefore, it is possible to increase	

[1] CCPIA.org,2021,ADVANTAGES AND DISADVANTAGES OF THERMAL INSULATION IN COMMERCIAL ROOFING,https://ccpia.org/advantages-and-disadvantages-of-thermal-insulation-in-commercial-roofing ,access 6/2021

[2] Hessian Ministry of Economy, Transport, Urban & Regional Development, 8/ 2008, p40

	solar collectors' annual heat yield by up to ten percent.
Use	This can be used on building facades
Disadvantages	the necessity to precisely engineer the periodic nanostructures, the incompatibility with the nanoscale thick organic films, the limited spectral response, or complicated fabrication procedures over large areas[1].
Effects on Architecture	This offers the architectural industry innovative and cost-effective options for the control of heat and energy loads in buildings. It will contribute to their potential use to save energy consumption and thus to achieve ZCA.

Fig (3-6) Antireflection coating
Ref: Hessian Ministry of Economy. 8/ 2008

Table (3-6) Nanostructured antireflection layers

3-1-7 Nano Vent-Skin (NVS):

Nano Vent-Skin (NVS)	
Definition	Nano Vent-Skin is aimed to a stimulating latest solution into extra energy safe and renewable systems. This aims to make objects greener with a skin constructed from micro wind turbines[2].
Features	To check the wind turbines and make adjustments that could support the design, a scale model was created. Rising wind turbine is 25mm in length with 10.8mm NVS long. **Concept work**: The structure's outer

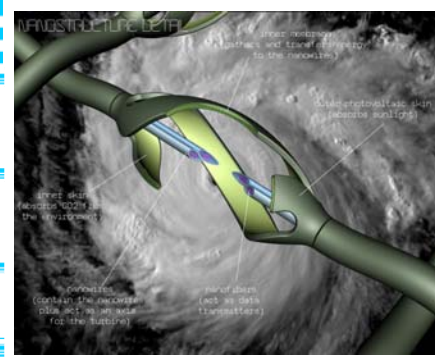


Fig (3-7) the wind turbines Every wind turbine is 25mm in length and 10.8mm wide.
Ref: NOS. (2008). NANO VENT SKIN.http://nanoventskin.blogspot.com/ access 27/3/13

[1] Jing-De Chen, Lei Zhou, Qing-Dong Ou, Yan-Qing Li, Su Shen, Shuit-Tong Lee, Jian-Xin Tang,2014, Enhanced Light Harvesting in Organic Solar Cells Featuring a Biomimetic Active Layer and a Self-Cleaning Antireflective Coating, https://doi.org/10.1002/aenm.201301777,access 6/2021
[2] NOS. (2008). NANO VENT SKIN.http://nanoventskin.blogspot.com/ access 27/3/13

	surface absorbs light through an inorganic solar layer and converts it to nano fibers within nano-wires. at the end of each panel which are then sent to the storage units. ■ The turbine on the grid generates energy from chemical processes at every edge where the structure is in contact. Polarized organisms take responsibility for the cycle at the turn of each turbine. The inner skin of each turbine serves as a barrier that absorbs Carbon dioxide from the atmosphere as the winds blow through it.	 Fig (3-8) This structure was constructed to demonstrate how Nano Vent-Skin will be used for new design concepts. Ref: NOS. (2008). NANO VENT SKIN.http://nanoventskin.blogspot.com/ access 27/3/13
Benefits	It absorbs carbon dioxide from the air when the wind crosses it, in addition to converting the wind energy into electrical energy.	
Use	To optimize the absorption of wind energy, NVS is mostly designed for specific wind turbines like "Hedera helix"· It is not yet practical to apply NVS panels to cars or trains due to friction and other factors that need to be tested. · Nano Vent-Skin used for power supply on existing structures. · Nano Vent-Skin used to power lights on road barriers in which there is no electrical connection. NVS wrapped across the subway tunnels uses the wind produced by the acceleration of the rails to power the lights of the next station.[1].	

[1]Ibid.

Disadvantages	-Need higher construction costs - Decrease fire protection - Reduction of building useful spaces - Need additional maintenance and operational Costs - Overheating problems if not properly designed. - Increasing air flow velocity. - Increasing construction weight[1]
Effects on Architecture	In architecture Nano Vent-Skin will be used for new models , ideas to revolutionize construction destinations to minimize carbon emissions produce energy and turn buildings into zero carbon building.

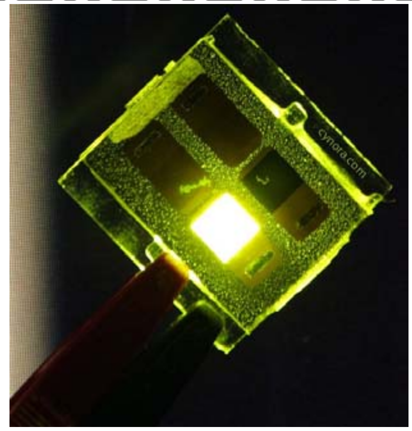
Table (3-7) Nano Vent-Skin (NVS)

3-1-8 Organic light-emitting diode(OLED):

Organic light-emitting diode(OLED)	
Definition	OLED (organic light emitting diode) is a light emitting diode (LED) in which the emissive electroluminescent layer is a film of organic compounds emitting light in reaction to electrical current[2].
Features	-- OLEDs can cover large areas; they are incredibly thin and can be built on substrates of almost any form. -- This high degree of design and implementation versatility makes them particularly appealing to lighting

[1] Dewaidar Khaled,Mahmoud Ayman, Magdy Norhan, Ahmad Safie, The role of intelligent façades in energy conservation , http://csfs.bue.edu.eg/files/Library/Papers/Sustainability%20and%20the%20Future/143.pdf access 6/2021

[2] Amtekar, K. T.; Monkman, A. P.; Bryce, M. R. (2010). "Recent Advances in White Organic Light-Emitting Materials and Devices (WOLEDs)". Advanced Materials. 22 (5): 572–582. doi:10.1002/adma.200902148. PMID 20217752. 27/3/13

	designers, producers and consumers alike. -- There is a multitude of colours, and the brightness of the light emitted is high. -- In addition, OLEDs are a highly effective light source with the ability to achieve significant energy savings[1].	 Fig (3-9) a green emitting OLED device Ref: Amtekar, K. T.; Monkman, A. P.; Bryce, M. R. (2010). "Recent vances in White Organic Light-mitting Materials and Devices LEDs)". Advanced Materials. 22 (5): 572–582. 10.1002/adma.200902148. PMID 20217752. 27/3/13
Benefits	▪ The Reduced Cost in the Future ▪ Light weight & versatile plastic substrates ▪ POLY Large viewing angles & enhanced brightness ▪ POLY Better efficiency of electricity ▪ No Answer Time	
Use	OLED can be used on interior and building facades also. All this makes OLEDs an enticing new form of solid-state lighting that is a convincing candidate to replace traditional large-area illumination lighting systems.	
Disadvantages	-Their lifetime is shorter compare to other display types. White, Red and Green OLED offer lifetime of about 5 to 25 years where as blue OLED offers about 1.6 years. -It is expensive compare to LCD. -It is susceptible to water and hence it can be easily damaged by water. -OLED screens are even worse compare to LCD when subjected to direct sunlight. -Overall luminance degradation. -Limited market availability[1].	

[1] Magdy 2010. *op.cit.*, p 56

Effects on Architecture	This will have a big effect on energy-saving interior design, which can also be found in facades.	

Table (3-8) Organic light-emitting diode(OLED)

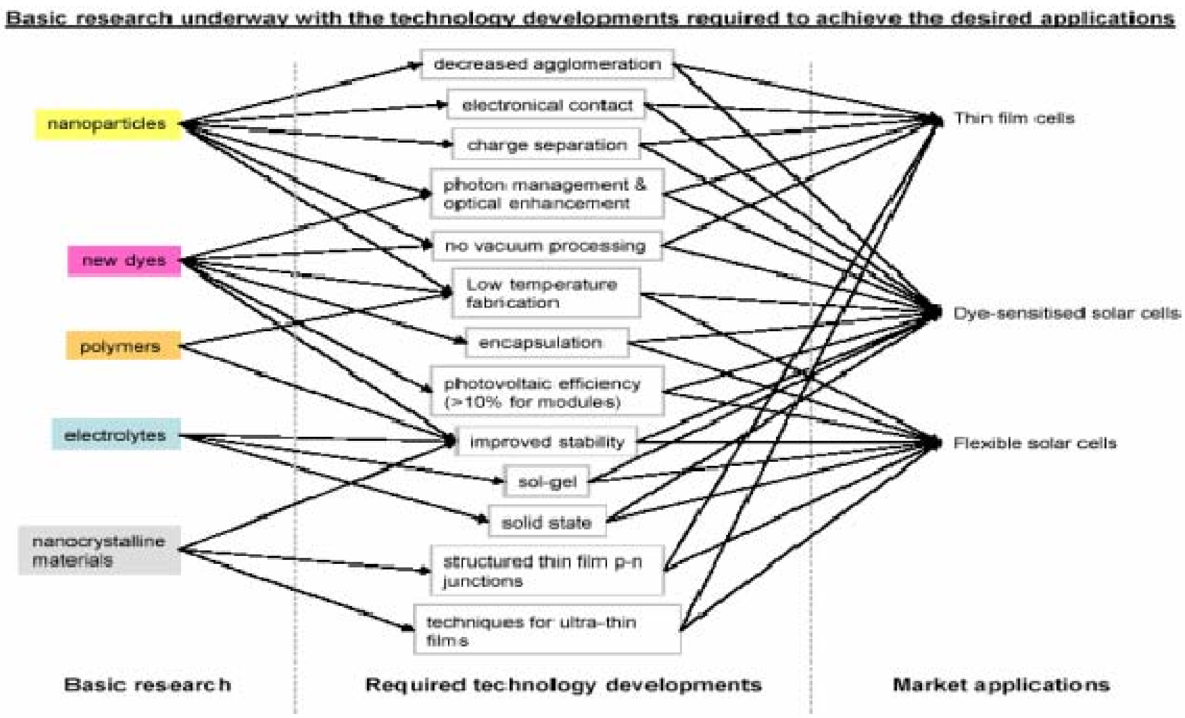


Fig (3-10) Energy Road Map
Ref: nanosolar. (2010).Technology Overview .http://www.nanosolar.com/technology/technology-overview/ 27/3/13

In fig (3-10) show the required technology developments for energy application at market in.

[1]RF wireless word, 2012, Advantages of OLED | disadvantages of OLED ,https://www.rfwireless-world.com/Terminology/Advantages-and-Disadvantages-of-OLED.html, access 6/2021

3-2 APPLICATIONS IN DESIGN

3-2-1 Passive House Design

Passive House Design[1]	
Objective	▪ Reducing energy usage enough to give up the need for a traditional heating system.
Solution	▪ By Material: ➢ Super insulating the walls, floor and roof. ➢ Healthy thermal mass to hold the heat in the building. ▪ By Energy: ➢ Use a hydraulic heating and ventilation system to preserve quality of the air and to conserve 80 per cent of internal heat. ➢ Advanced low-e, gas-filled, triple-glazing window technology to reach better thermal comfort through the sun than energy loss. ➢ Renewable energy room and water heaters such as solar water heaters and ground - source heat heating systems. ▪ By Design: ➢ Orientation / passive solar gain. ➢ Renewable energy production like micro-hydro systems ,wind turbines, and solar PV panels
Features	▪ decreasing the impact on global warming ▪ Will efficiently grant the building a net Zero Carbon status. ▪ It gives an improved way of life with clean, fresh air and a near constant temperature.
Benefits	▪ On average, a passive house would consume between 70 - 90 per cent less power than a house designed to meet the minimum specifications for building standards.
Disadvantages	-the main disadvantage to building a passive house is the upfront cost -it can be implemented to optimal standards only in new construction -whether a well-built passive house will retain its value[2].

[1] Hedlund ,Ken. (2013). passive house http://www.candwarch.co.uk/projects/low_energy_houses/zero-carbon-homes.shtml,access 4/13
[2]Convers energy future,2021,Passive House Design: How It Works and Misconceptions Explained ,https://www.conserve-energy-future.com/passive-house-design-works.php, access 6/2021

EXAMPLE
This example was chosen as it is more common and more detailed

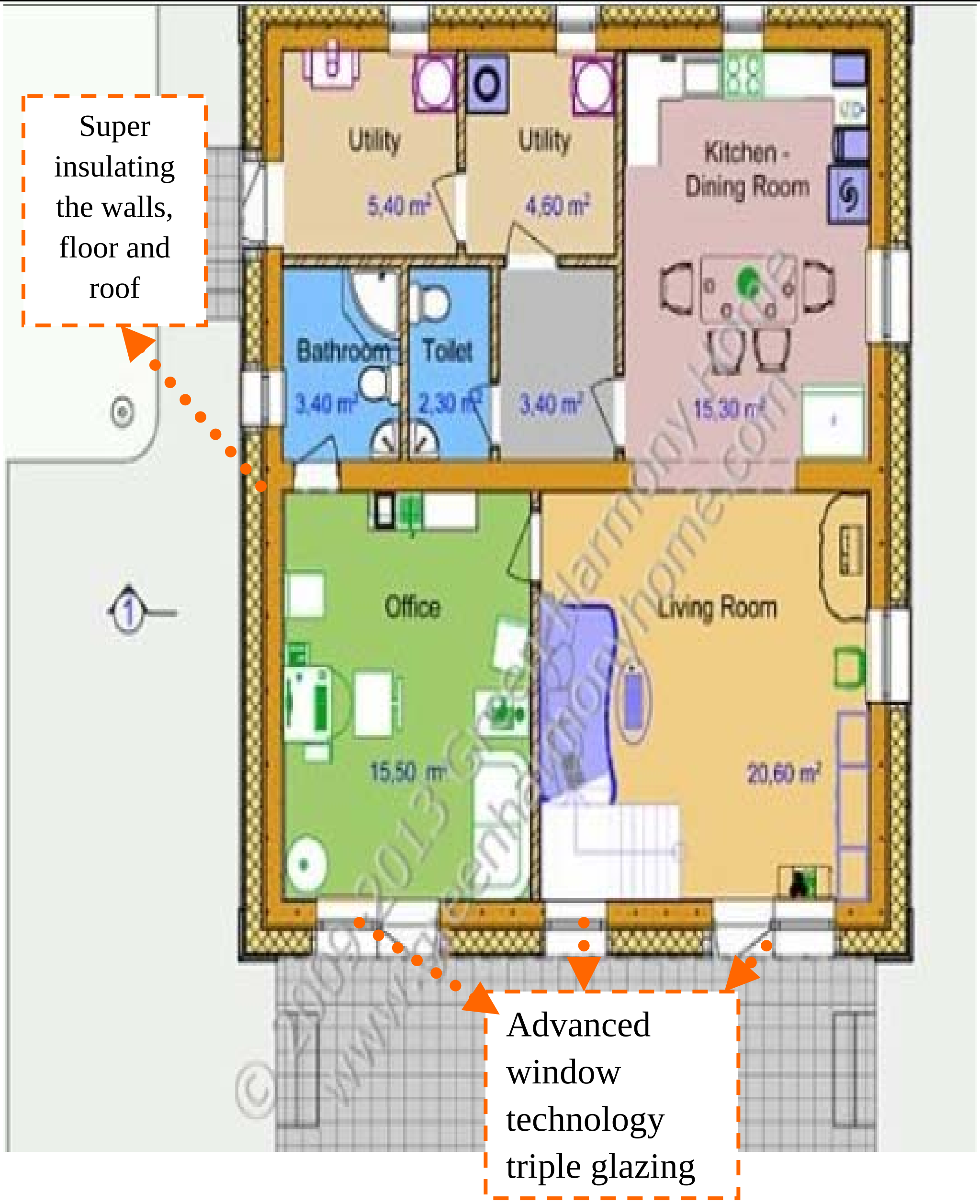
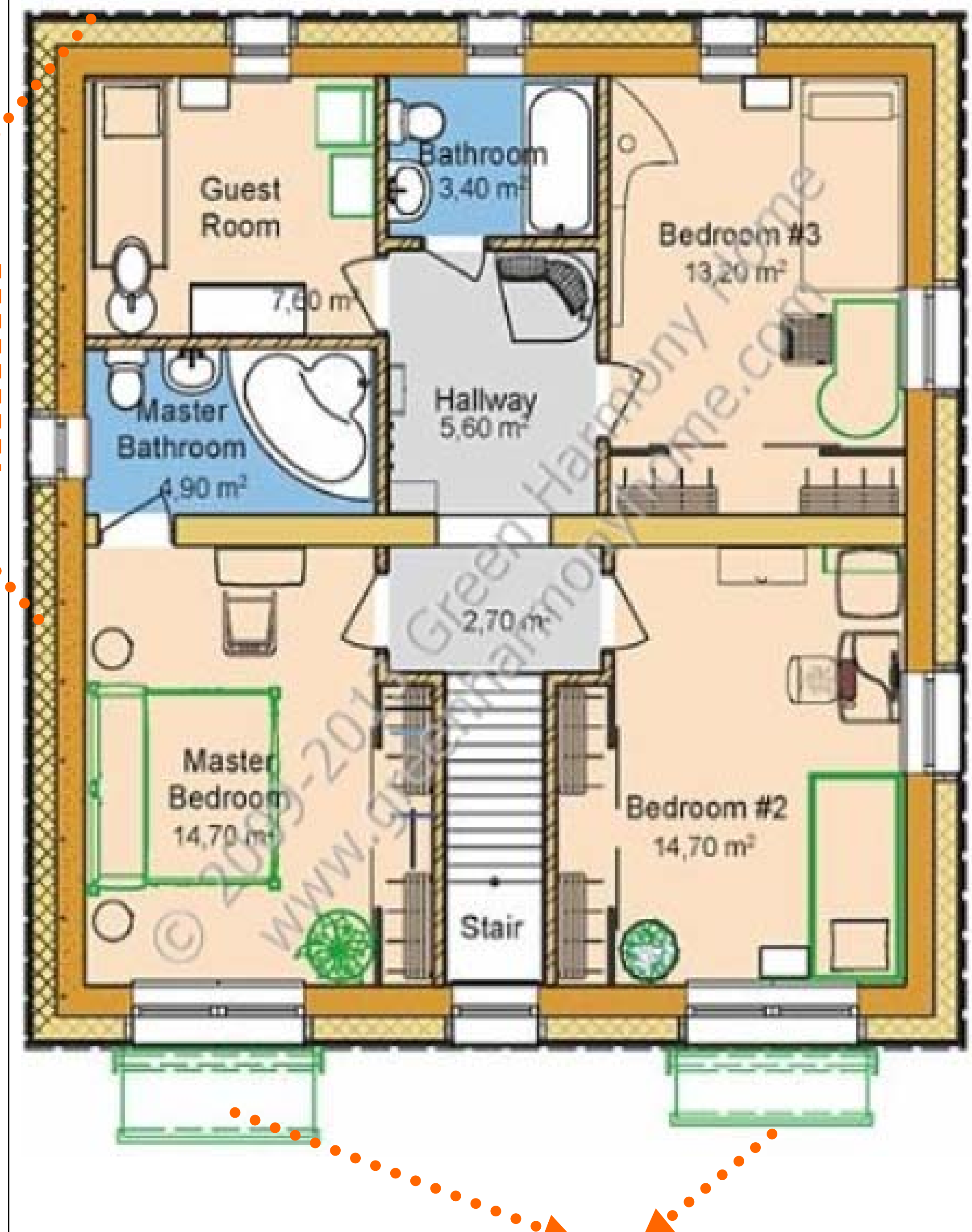


Fig (3-11) First floor plane

Ref: Green harmony home. (2009) .http://greenharmonyhome.com/Green_Passive_Solar_House_3/album/Passive_House3.html. access 9/7/15

Super insulating the walls, floor and roof



Sun shading + orientation

Fig (3-12) Second floor plane

Ref: Green harmony home. (2009)

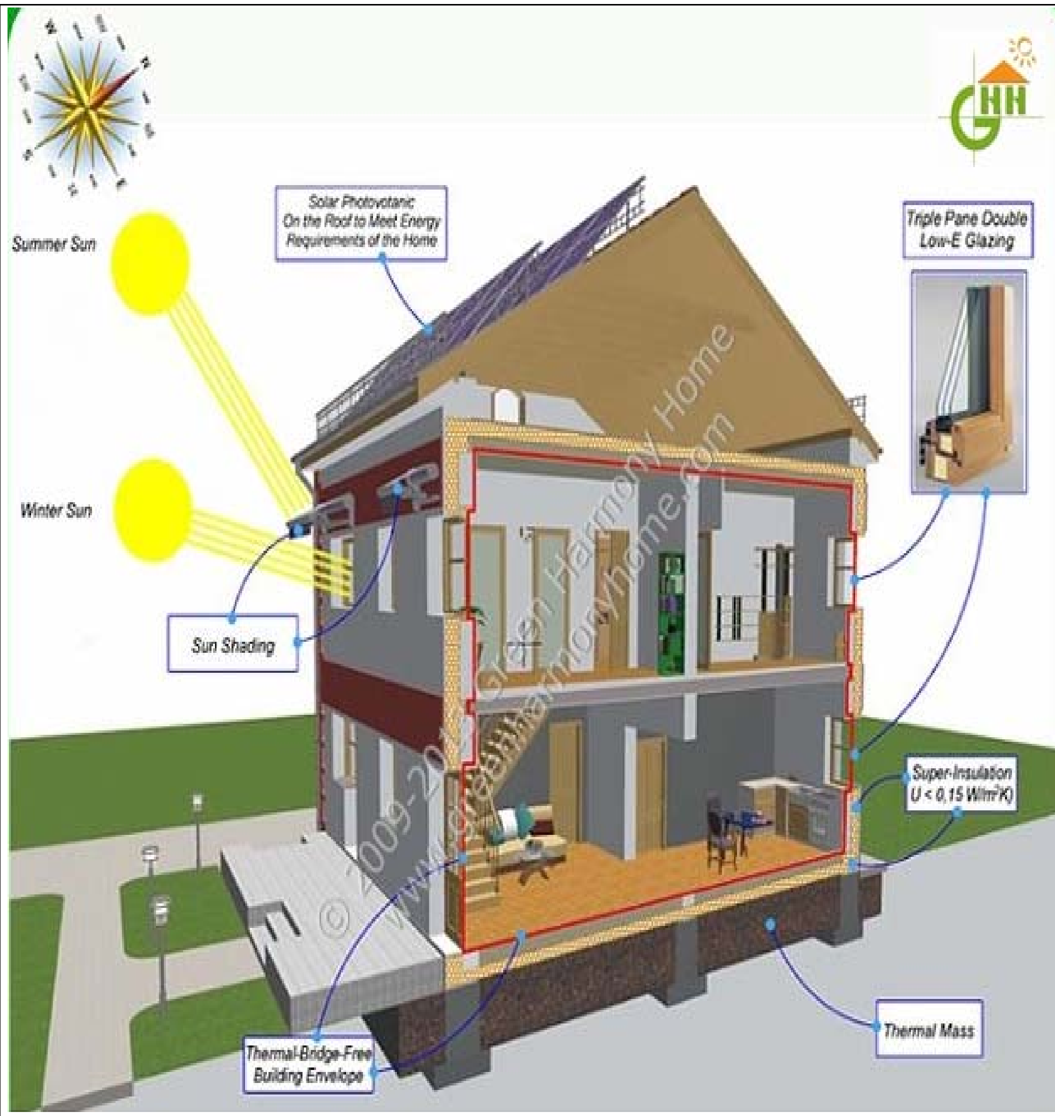
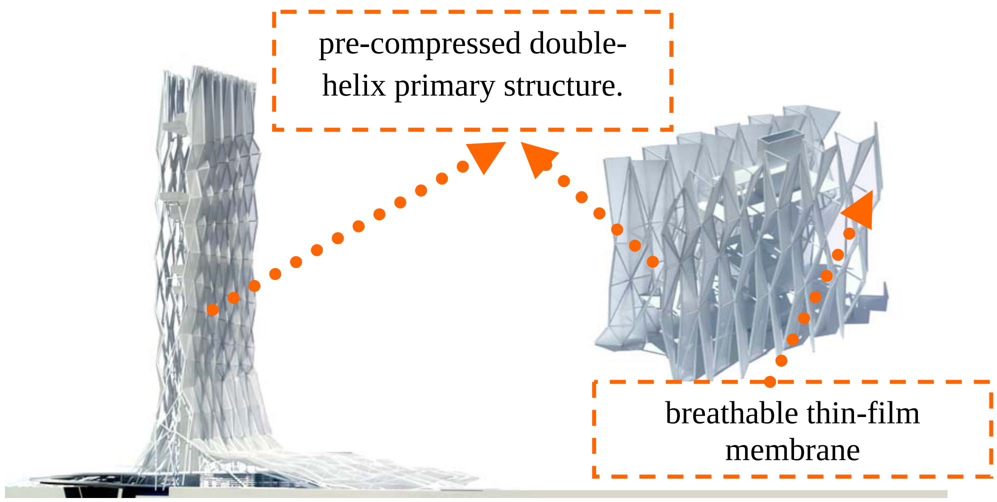


Fig (3-13) passive house design
Ref: Green harmony home. (2009)
.http://greenharmonyhome.com/Green_Passive_Solar_House_3/album/Passive_House3.html.
access 9/7/15

Table (3-9) passive house design

3-2-2 Zero and Low Carbon Buildings application: Carbon Tower

Carbon tower[1]	
Objective	▪ Zero and Low Carbon Buildings
Solution	▪ The Carbon Building Prototype is a 40-story high-rise mixed-use system that integrates five revolutionary technologies. ▪ By Material: ➢ tensile-laminated composite floors ➢ breathable thin-film membrane ▪ By Energy: ➢ virtual duct displacement ventilation ▪ By Design: ➢ two external filament-bound ramps ➢ pre-compressed double-helix primary structure.
Features	▪ Link The building will be the powerfully built and lightest building of its kind.
Benefits	▪ The complexity of contemporary buildings
Disadvantages	- Higher Initial Cost - Weather Dependence [2]
EXAMPLE	 Fig (3-14) Carbon Tower. Ref:Gourdoukis ,Dimitris .(2010). Carbon Tower. Axi:Ome llc, Dubai, UAE.http://www.axiome.net/index.php?/projects/025--carbon-tower/access 15/9/15

[1]Green dimensions. (2009). Nanotechnology In Architecture. Architectural applications http://greendimensions.wikidot.com/nanotechnology-in-architecture. access16/5/13,op.cit.
[2]Brian Ashworth, 2020, The Advantages and Disadvantages of Zero Carbon Housing,https://anewhouse.com.au/2020/09/the-advantages-and-disadvantages-of-zero-carbon-housing/ access6/2021.

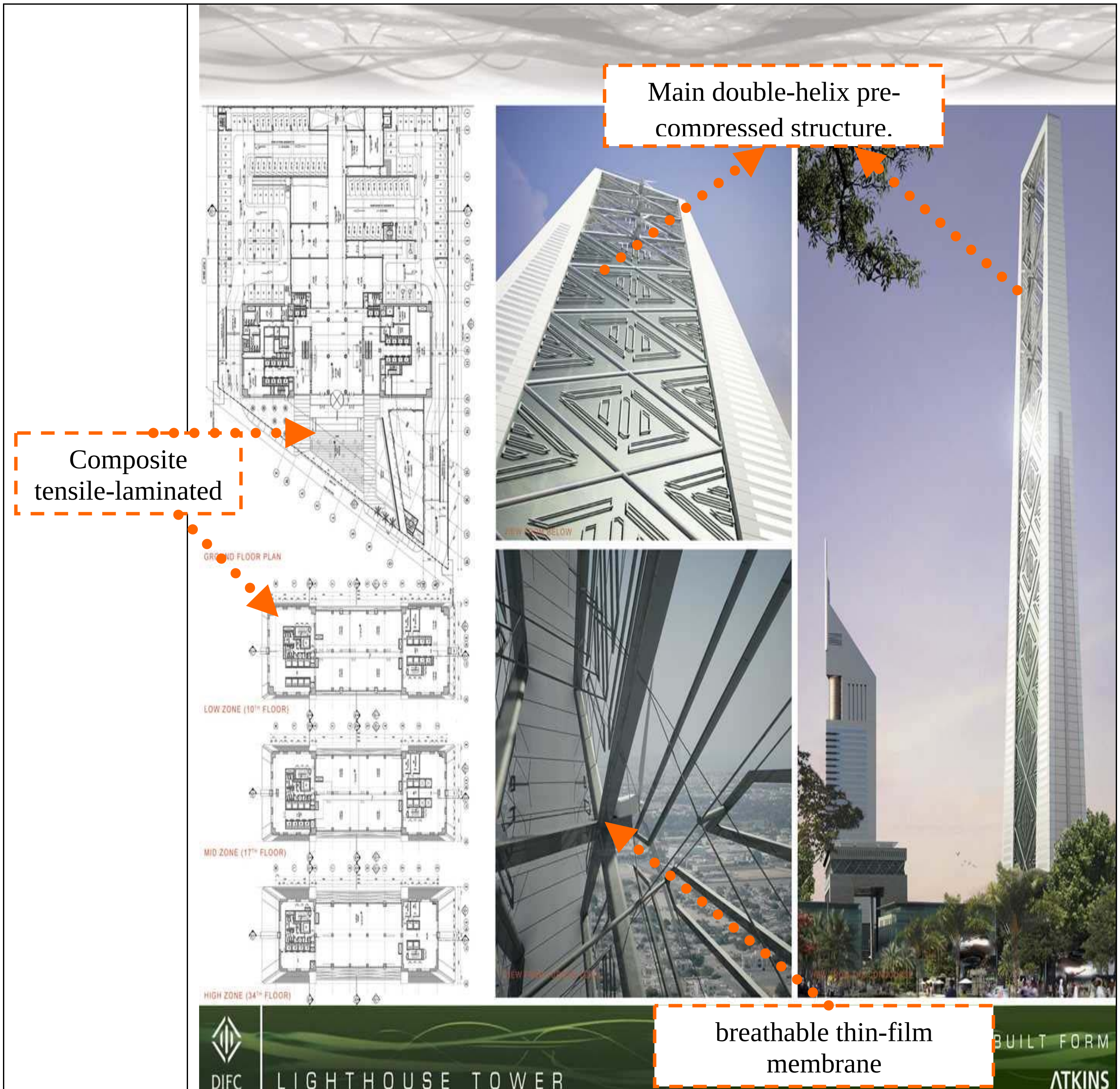


Fig (3-15) Dubai Carbon Tower.
Ref:LafargeHolcim Foundation, Committed to Sustainable Construction since 2003. (2015). Lighthouse tower with low-carbon footprint. https://www.lafargeholcim-foundation.org/projects/lighthouse-tower-with-low-carbon-footprint-dubai-uae. Access 4/ 2020

Table (3-10) **Carbon tower**

3-3 Conclusions

- ❖ Analysis of ZCA applications:

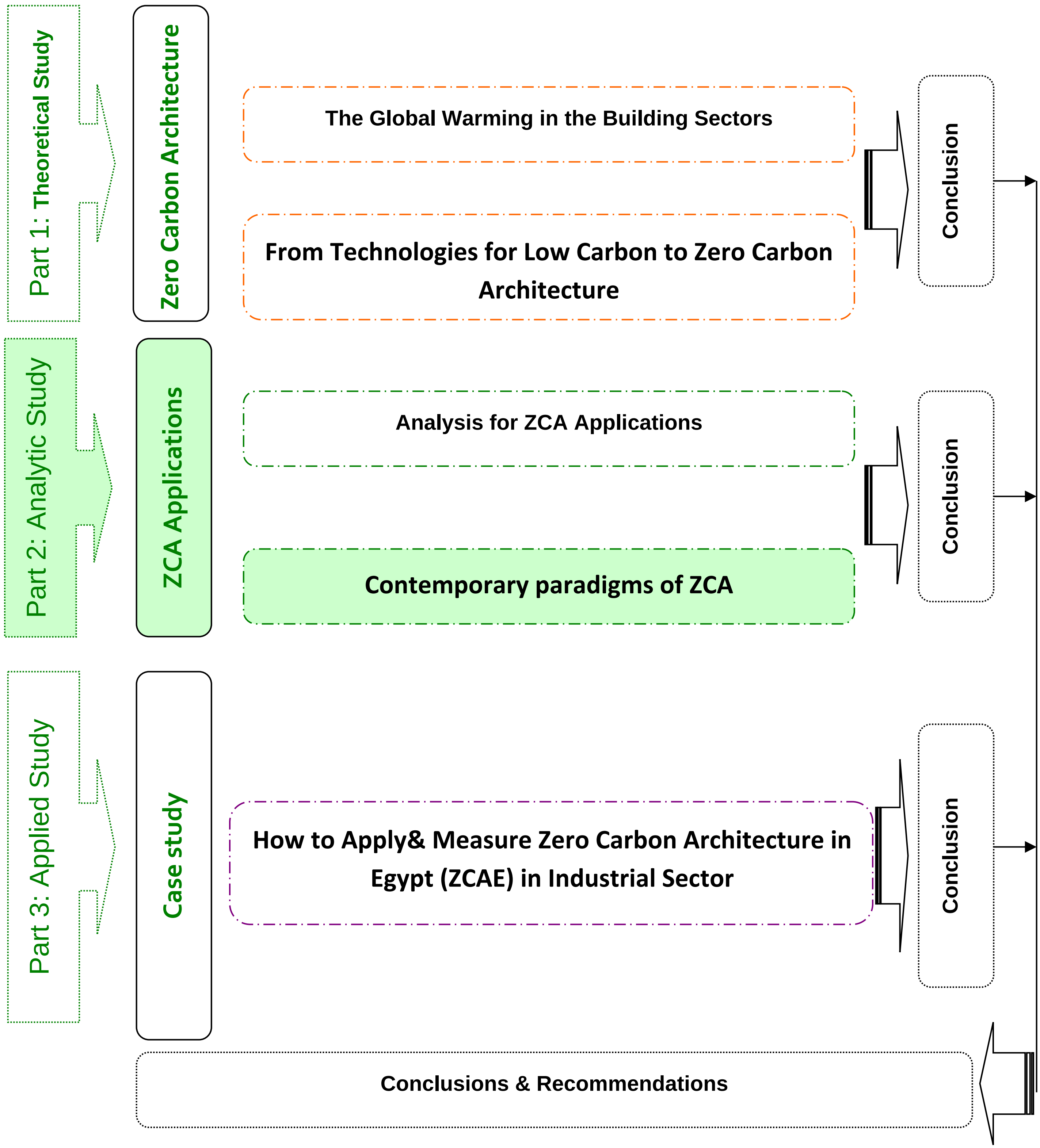
Energy application	Design application
- Energy saving technologies It offers us the ability to step into new high-value-added fields, both by building new architectures and fundamentally changing old styles. -The main advantage of energy coating is the properties of the materials stored can be obtained by the skin, absorbed by sunlight and interior light and converted into electricity - The main disadvantage of energy coating is high cost.	-Zero and Low Carbon Structures will make improvements to the working processes by using computer simulations and visual analytics to minimize carbon dioxide emissions connected with the physical environment. -In the future, it will be important to recognize major technological factors and specifics in order to resolve this energy penalty at a very early time. -The design of zero carbon buildings would take an ongoing paradigm change in the construction and design of new projects. -In future designers, new and challenging expertise concerning the design of sustainable and zero carbon buildings will be required.

Table (3-11) **Conclusions**

- This is an opportunity for us to catch and for policymakers to set up public services, such as a world-class research & tech infrastructure, incentive programs for transfer of knowledge and higher education systems, to allow businesses to place innovations at the core of their technological development strategies.

Part 2: Analytic Study

Contemporary paradigms of ZCA


Part 1: Theoretical Study
Zero Carbon Architecture
The Global Warming in the Building Sectors
From Technologies for Low Carbon to Zero Carbon Architecture
Conclusion
Part 2: Analytic Study
ZCA Applications
Analysis for ZCA Applications
Contemporary paradigms of ZCA
Conclusion
Part 3: Applied Study
Case study
How to Apply& Measure Zero Carbon Architecture in Egypt (ZCAE) in Industrial Sector
Conclusion
Conclusions & Recommendations

Contents

INTRODUCTION

In the previous chapter (the analytical part of the study), an analysis of the applications of the ZCA in energy and architecture as materials and design ideas and how to use them to obtain the buildings of ZCA starting from the design of the building to the completion of the exterior envelope of the building was carried out during the concept building's lifetime.
This chapter in the analytical part will focus on contemporary paradigms of zero carbon building, this analyses start from example location (from around the world) that were picked on several parameters selected upon its energy efficiency, renewable energy, awards which had got and building use.
Some programs & application used to measure carbon emissions (carbon footprint) in buildings and measuring energy use and efficiency will be highlighted in this chapter.

4-1 THE KEY COMPONENTS OF THE ZERO CARBON BUILDING STANDARD

1- **ZERO CARBON BALANCE** No net greenhouse gas (GHG) emissions are related to the construction operations. GHG emissions are offset by generating clean, on-site or offsite renewable energy.
2- **Durability** New construction designs recognize peak energy while optimizing efficiency, with emphasis on building envelopes and air circulation techniques that reduce heat supply.
3- **On-site renewable energy** is embedded into building projects to provide additional sustainable development, reduce off-site environmental effects as well to prepare houses for the future of distributed power. [1]

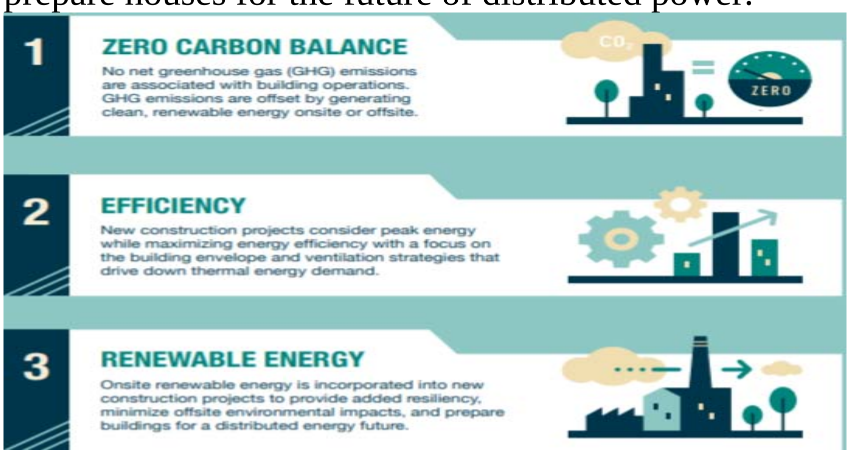


Fig (4-1) THE KEY COMPONENTS OF THE ZERO CARBON BUILDING STANDARD
Ref:CanadaGreenBuildingCouncil®.(2017).ZEROCARBONBUILDINGSTANDARD.https://www.cagbc.org/cagbcdocs/zerocarbon/CaGBC_Zero_Carbon_Building_Standard_EN.pdfaccess,2019

[1]CanadaGreenBuildingCouncil®.(2017).ZEROCARBONBUILDINGSTANDARD.https://www.cagbc.org/cagbcdocs/zerocarbon/CaGBC_Zero_Carbon_Building_Standard_EN.pdfaccess,2019

4-2 Criteria for selecting paradigms:

1- **Variety of usage:**

Different buildings have been chosen in terms of use (residential-industrial-educational-administrative)

2- **Modernity:**

Newly built buildings have been chosen with the modern design style of ZCA

3- **Location:**

Unique buildings have been chosen from all over the worlds that vary geographically and climatically.

4- **Exclusivity:**

These chosen buildings are awarded, as well as through the use of modern technology to achieve the concepts of ZCA.

5- **Implementation:**

Executed buildings have been chosen and ZCA design results have been obtained, and buildings under implementation are examples of implementation and have been taken as a guide for buildings with ZCA verification.

6- **Economically:**

Cost analysis for building on the long run and analysis for energy consumption.

7- **environmental load (carbon footprint):**

These models were chosen as they have a light environmental load and do not have high carbon emissions.

4-3 Examples of successful zero carbon buildings around the world:

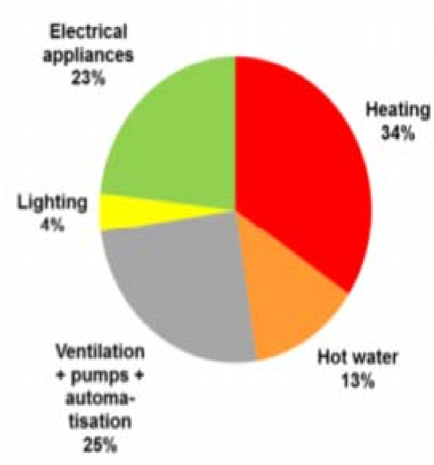
- Efficiency House Plus with E-mobility in Berlin, Germany
- East London University, Stratford Library, London, United Kingdom
- The first zero carbon building in Hong Kong
- DEWA to build the largest zero energy building UAE(Dubai)
- Credit Agricole new headquarters Egypt
- Sand dune-shaped Bee'ah headquarters in Sharjah, UAE
- ABB’s first carbon neutral factory in Lüdenscheid, Germany

These Zero carbon building achieves zero net carbon emissions through maximizing energy efficiency, comprehensive architectural design, resource recycling and green land.

4-3-1 Efficiency House Plus with E-mobility in Berlin, Germany

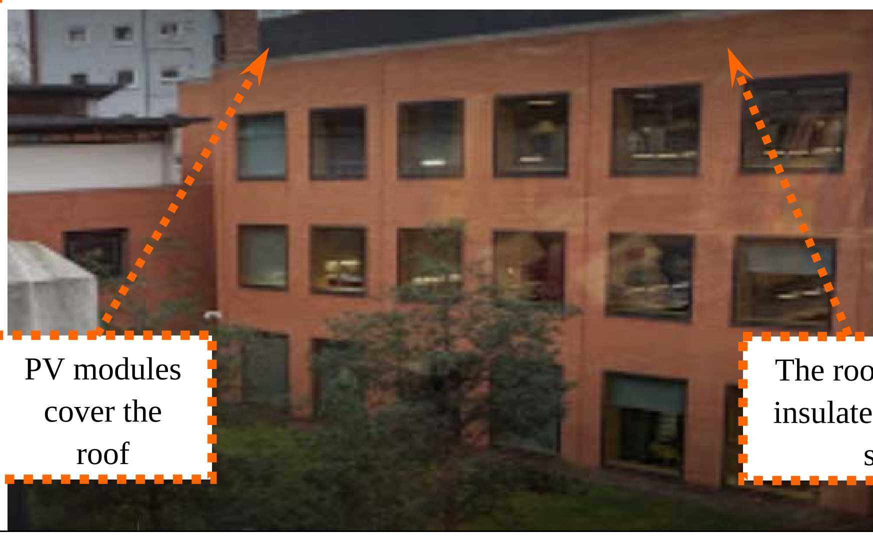
Table (4-1) Efficiency House Plus Includes Electro-mobility in Berlin[1]	
Author(s):	Heike Erhorn-Kluttig, Hans Erhorn, Antje Bergmann, Fraunhofer Institute for Building Physics
Illustration:	 Fig (4-2) Efficiency House Plus with E-mobility in Berlin Ref: Hans Erhorn, Heike Erhorn-Kluttig.2014
Project aim:	This building conduct its energy providing it for electric vehicles as well for common users. Exceeding energy returned back to grid or can be deposited in a battery cells. For primary and final use of energy an annual positive energy balance is necessary.
Building address:	This residential building has been implemented recently in Germany (Fasanenstraße 87a, 10623 Berlin) to achieve the principles of ZCA.
Building type:	Residential-Single-family house with 2 floors
Building size:	203 m² useful floor area, 138 m² living area
Building envelope construction:	This building is fabricated from timber panels that is filled with cellulose insulation up to 52 cm. Roof and façade are covered with Photo Voltaic modules.

[1] Hans Erhorn, Heike Erhorn-Kluttig, Selected examples of Nearly ZeroEnergy Buildings Detailed Report, September 2014,p33,34

	The windows have triple glazing fig (4-2). Thermal bridges have been minimized. **All components of the house can be segregated and relocated to another position or discarded of when the life of the housing complex has passed.**
Building service systems:	1-The house is heated by a central heating system with an air-to-water heat pump and floor heating. 2-A balanced mechanical ventilation system with 80% heat recovery and a building energy management system with touch pads are installed. 3- The PV systems on the roof and facades generate electricity that is used by the building, fed into the grid or stored in a battery. 4- The battery, with a capacity of 40 kWh, is made of 7,250 single second-hand battery cells formerly used in electric cars.
Included renewable energy technologies:	Two huge photovoltaic plants have been constructed: 1- 98 m2 of mono-crystalline PV modules are roof mounted 2- 73 m^2 of thin-film modules on the façade.
Concluded power usage:	Heating 20.8 kWh/m^2.year Hot water 8.1 kWh/m^2.year Cooling 0.0 kWh/m^2.year Ventilation incl. pumps and automatization 15.3 kWh/m^2.year Lighting 2.6 kWh/m^2.year Electrical appliances (household electricity) 14.3 kWh/m^2.year Total 61.1 kWh/m^2.year E-mobility 19.6 kWh/m^2.year PV energy generated. - 65.6 kWh/m^2.year thereof self-used - 32.3 kWh/m^2.year thereof fed-in - 33.3 kWh/m^2.year Electricity from grid 28.8 kWh/m^2.yea Electricity surplus - 4.5 kWh/m^2.year  Fig (4-3) final energy use chart Ref: Hans Erhorn, Heike Erhorn-Kluttig.2014
Renewable energy contribution ratio:	107% of the total final energy

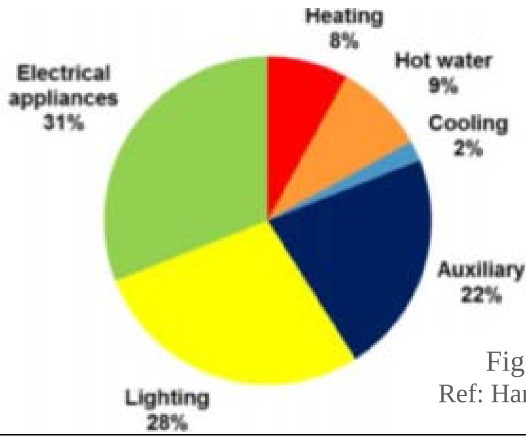
Improvement compared to national requirements:	78% Compared to: Maximum primary energy use according to EnEV 2009.
Experiences/ lessons learned:	Because of the use of common energy, the sample family loved living at home without having a rough experience. As the ventilation system was not operated manually, warm hot air was released into rooms in the summer, which is now a concern. Calculations indicate that efficiency house target has been accomplished but could cover just 25-percent of the electric power used for Electro-mobility.
Costs:	The cost of a house is very massive, with €1,080,000 for building projects and €566,000 for related service systems. Those houses demonstrate that now the extra costs especially in comparison to usual new construction can be reduced by around €50,000.
Awards:	Architect Werner Sobek won the architectural competition for the BMUB pilot project. Issue has been illustrated on the EU BUILD UP portal in February 2014.
Links to further information:	- website: BMVI. (2013). Efficiency House Plus Includes Electro-mobility in Berlin .http://www.bmvi.de/DE/EffizienzhausPlus/effizienzhaus-plus_node.html,access: 5/2017 - Case on BUILD UP: Heike Erhorn, Hans Erhorn, Antje Bergmann .(2014). Efficiency House Plus in Berlin. http://www.buildup.eu/cases/40001,access 5/2017- Monitoring report of the Fraunhofer Institute for Building Physics link: - videos: http://www.youtube.com/watch?v=mNCZxovLHRo; http://www.youtube.com/watch?v=LgLVuFWhIgM

4-3-2 University of East London, Stratford New Library, London, United Kingdom

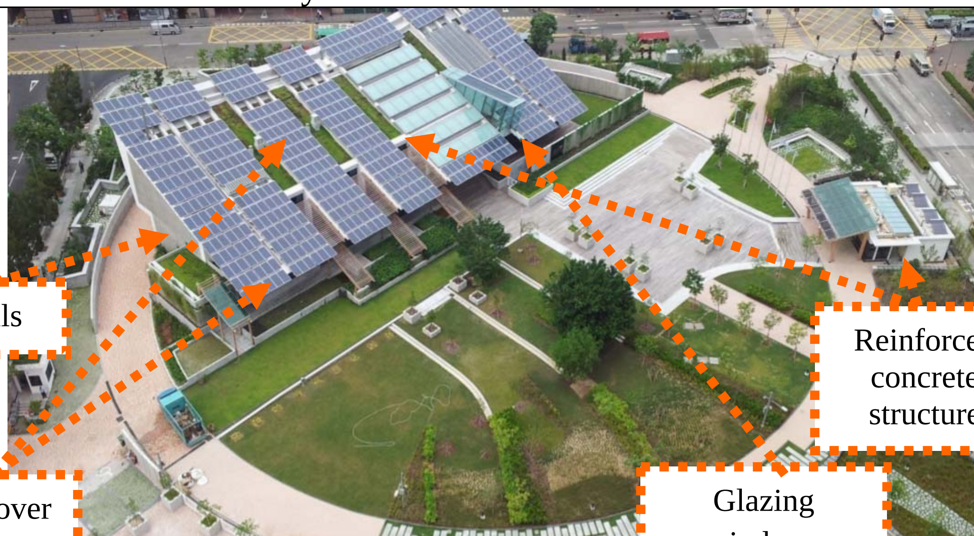
Table (4-2) University of East London, Stratford New Library, London[1]	
Author(s):	Lionel Delorme, Cornelius Kelleher, AECOM
Illustration:	 Fig (4-4) University of East London, Stratford New Library, London Ref: Ref: Hans Erhorn, Heike Erhorn-Kluttig.2014 
Project aim:	1- Provide the University's students with modern library facilities. 2- The building attained a BREEAM Excellent architecture stage (Higher Education 2008).

[1] Hans Erhorn, Heike Erhorn-Kluttig, Selected examples, op.cit.,p71,72

Address of building:	This building has been implemented recently in London (Stratford Library and Learning Centre, University of East London, Romford Road, London, E15 4LZ)
Type of Building:	University library (students access only)
Size of Building:	overall, perfectly usable floor space is 3,847 m2
Building envelope construction:	-A roof is a well-insulated concrete slab. -There are 2 kinds of wall: Isolated wall of brick cavity The insulated wall of the spandrel glazed curtain. -The air permeability certificate (based on in-situ testing) was received as well as the building accomplished air permeability of 2.9 m3/h per m2 at 50 Pa. -The construction has a very high thermal mass. -The combination of windows and roof lights can be used to provide daylight. -There is a PV array on the roof as well.
Building service systems:	1 – Low temp. Hot water (LTHW) is heated to the perimeter of the building by methods of radiators, trench heating systems or finned pipelines in the wall, fed by either a gas boiler. 2 – Four Air Handling Units (AHUs) also provide substantial portion of the building with a ventilation and cooling system through a variable air volume (VAV) system. 3 – The technologies are including heat recovery and requirement control using CO_2 detectors as well as provide cooling for much of the year.
Renewable energy technologies includes:	There is a PV array on the top of the house (409.7 m2). It is supposed to generate 12.21 kWh per m2 (floor area) annually.
Final energy use:	Calculation: Part L Heating (gas) 8.15 kWh/m².year Hot water (gas) 9.50 kWh/m².year Cooling 2.54 kWh/m².year Ventilation incl. in auxiliary (fans and pumps) 23.94 kWh/m².year Lighting 30.06 kWh/m².year Electrical appliances (unregulated) 33.85 kWh/m².year Total 108.04 kWh/m².year

	 Fig (4-5) final energy use for library Ref: Hans Erhorn, Heike Erhorn-Kluttig.2014
Ratio of contribution to renewable energy	The PV array is intended to generate 12.21 kWh/m2.year equal amount to a primary energy output of 35.65 kWh/m2.year. This constitutes 14.4 per cent of the 248 kWh / m2.year total primary energy demand. The ratio is 16.5 per cent compared to the total (regulated) final energy.
Enhancement in comparison to national requirements:	31.3% Compared to: target Carbon dioxide emissions percentage for national buildings.
Outcomes:	The library actually participates in the programmer Soft Landing. This established a calibration problem that is being rectified with the energy meters.
Costs:	Total project cost was £14 million.
Earnings:	Civic Trust Awards 2014 National/International Finals building has accomplished an excellent BREEAM design stage (Higher Education 2008).
URL to more information:	Hans Erhorn ,Heike Erhorn-Kluttig. (2014) . Selected examples of Nearly ZeroEnergy Buildings Detailed Report. http://www.uel.ac.uk/news/press-releases/2014/03/stratpctadwards.htm https://www.uel.ac.uk/

4-3-3 The first zero carbon building in Hong Kong

Table (4-3) The first zero carbon building in Hong Kong[1]	
Author(s):	Construction Industry Council
Illustration:	 Fig (4-6) The first zero carbon building in Hong Kong Ref: the first zero carbon building in Hong Kong, This article was published in BUILDING JOURNAL Hong Kong July 2012, http://www.building.com.hk/feature/2012_0813zcb.pdf
Project aim:	ZCB's first energy efficiency goal is by passive architecture, achieving 20 per cent energy savings.
Building address:	This building has been implemented in Hong Kong (Sheung Yuet Road, Kowloon Bay, Kowloon, Hong Kong)
Building type:	Multi-purpose project: Exhibition and education center, eco-office, eco-home and multi-purpose hall in eco-plaza building, outdoor exhibition area.
Building size:	Total area of the site 14,700m2.
Building envelope construction:	-The construction has brick walls and glazing windows -The ceiling are made of reinforced concrete structure -The construction of the roof made of photovoltaic solar panels.
Building service systems:	-ZCB's main energy preservation priority is inactive design, which accomplishes 20% of saving energy. -Cross ventilated design can provide air circulation and reduces the quantity and the need for air conditions.

[1] the first zero carbon building in Hong Kong, This article was published in BUILDING JOURNAL Hong Kong July 2012, http://www.building.com.hk/feature/2012_0813zcb.pdf,p32,33,34

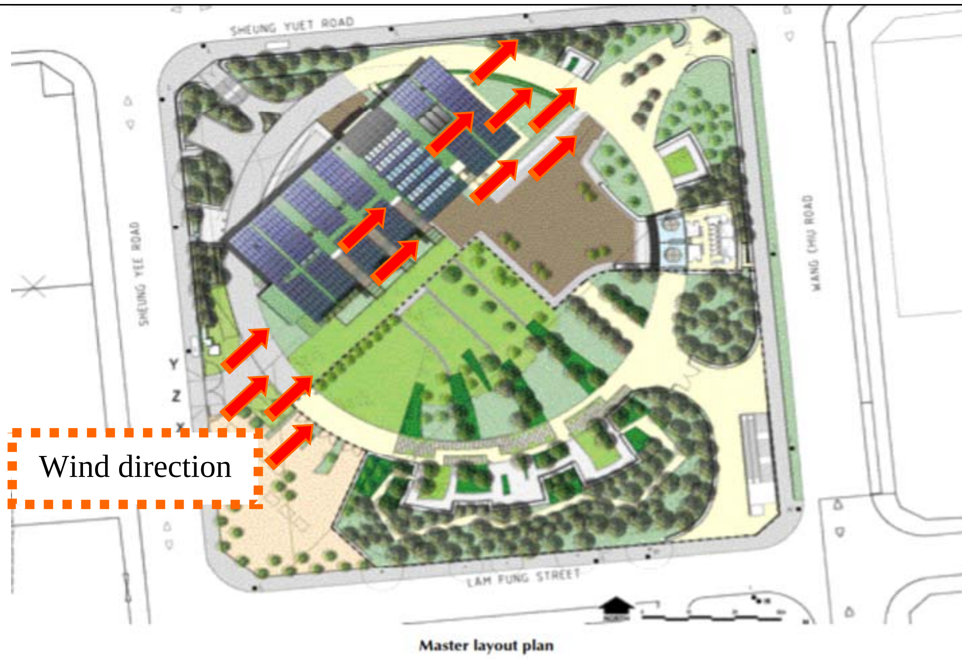


Fig (4-7) Ventilation layout
Ref:the first zero carbon building in Hong Kong, This article was published in BUILDING JOURNAL Hong Kong July 2012,
http://www.building.com.hk/feature/2012_0813zcb.pdf

-- High-performance envelope and external shading glazing produce an ultra-low overall thermal transfer value (OTTV) of the building at 11 W/m2 (greater than 80% less than current max. value required).

-- The second goal for green active systems is energy conservation, achieving 25 per cent energy savings.

-- High-volume-low-speed ceiling (HVLS) fans are designed to improve air flow and reduce air conditioning requirements.

--Underfloor displacement cooling efficiently cools the resident area at a higher supply air temperature (5 degrees Celsius over standard air conditioning).

-- Radiant cooling is used to cool the occupants by chilled projector.

-- Photovoltaic panels (three different types: poly-crystalline, Building-Integrated thin-film and cylindrical CIGS) generating approximately 87MWh annually; the primary roof tends to maximize solar irradiance on PV panels; Solar thermal provides hot water for eco-cafes.

	Design for Hybrid Ventilation: -- Natural ventilation designs for 30 % of the year (January to April) include: -- Automatic high window control with manual mode and manual low window control with window links connected to the Building Management System. Supported ventilation systems (March to June, October to December) by using HVLS ventilators to improve air flow. -Under-floor displaced cooling operating for 8 months of the year and radiant and cooling operating under the automatic control of the BMS (Building Management System) for the hottest period of 5 to 6 months.  Fig (4-8) Low carbon materials and construction Ref: the first zero carbon building in Hong Kong, This article was published in BUILDING JOURNAL Hong Kong July 2012, http://www.building.com.hk/feature/2012_0813zcb.pdf **Building and low carbon emissions components** -Application of reinforced concrete frame with a greater ratio or percentage (25 up to 35%) of pulverized fuel ash (PFA); balanced cutting and filling construction for excavation and filling of basements in urban native forests. -Lean building strategy with a focus on resource management with less material and less waste (e.g., fair-faced concrete, unpainted metalwork). -Construction of gabion walls using demolition on-site concrete, use of regional components (e.g. eco-pavers, elevated floor systems). -The usage of carbon free components (e.g. zinc signage panels).
Included renewable energy technologies:	The building produces renewable energy on site more than operating requirements, from photovoltaic panels and a tri-generation network for biodiesel.

Final energy use	Estimated energy use 116MWh/year Estimated energy use of the landscape area and others 15MWh/year Estimated output from biodiesel tri-generation system 143MWh/year. Estimated output from PV panels 87MWh/year. **estimated surplus energy export 99MWh/year**
Renewable energy contribution ratio:	Increasing the energy consumption of ion by 75 % in the efficient output of renewable energy compared to traditional grid electricity Bio-diesel Tri-generation produces more than 143 MWh per year.
Improvement compared to national requirements:	30% compared to Reference CO2 Emission
Experiences/ lessons learned:	- Applying ZCA principal to reduce energy consumption. - The design of the landscape improves the effect of cooling It is approximated that the temperature of the air is decreased by up to 1 degree Celsius.
Costs:	: HK$260m
Awards:	Grand Award in New Building Category (Building under Construction) of The Green Building Award 2012. • Innovation Award of the Year of Hong Kong Property Awards 2013, Royal Institution of Chartered Surveyors; • Platinum Rating of Building Environmental Assessment Method • The Champion Award of The Innovative Award for the Engineering Industry 2012/2013, • Future Arc Green Leadership Award, 2013.
Links to further information:	the first zero carbon building in Hong Kong, This article was published in BUILDING JOURNAL Hong Kong July 2012, http://www.building.com.hk/feature/2012_0813zcb.pdf Guiyi LI. (2013). Achieving Zero Carbon for Buildings in a Densely Populated City and a Subtropical Climate. https://www.hkgbc.org.hk/sb13-upload/presentationpdf/4.-dr-guiyi-li.pdf access (2018)

4-3-4 DEWA to build the largest zero energy building UAE (Dubai)

A Nearly Zero Energy Building (NZEB) in the UAE can be recognized as a large efficient energy building with an EUI site of less than 90 kWh/m2/year, covering a significant percentage of its total energy consumption from on-site or off-site renewable energy sources in a year[1].

Table (4-4) DEWA to build the largest zero energy building (Al-Sheraa, which means sail in Arabic).[2]	
Author(s):	**Dubai Electricity and Water Authority**
Illustration:	 Fig (4-9) Al-Sheraa in Dubai Ref: Construction week. (2017).DEWA to build the tallest zero energy building. http://www.constructionweekonline.com/article-42413-dewa-to-build-the-tallest-zero-energy-building,2018
Project aim:	In order to secure the right of future generations to live on a clean, balanced and sustainable scale, the project aims to strike a balance between growth and the environment.
Building address:	This building under construction in Dubai, It will be at The Cultural Village in Al Jadaf.
Building type:	Public (**Dubai Electricity and Water Authority's (DEWA) new headquarters)**
Building size:	The DEWA new Zero Energy Construction Network (ZEB) will be the world's tallest, biggest and smartest headquarters.

[1] Majd Fayyad, Jason John, defining nearly zero energy building in the UAE-2017 EmiratesGBC Report,p 4
[2] Construction week. (2017).DEWA to build the tallest zero energy building. http://www.constructionweekonline.com/article-42413-dewa-to-build-the-tallest-zero-energy-building,2018

	-- Al-Sheraa's overall construction area will be more than 1.5 million square meters -- The building is to consist of 15 floors, a cellar and 4 parking floors.
Building envelope construction:	- The building envelope will be curtain walls. - The ceiling are made of reinforced concrete structure - Includes 16,500 m2 of photovoltaic solar panels for the source of power.
Building service systems:	— It is a creative, green building which uses solar energy to meet the energy demand. —Al-Shera was built in accordance with the typical UAE housing, which overlooks an open courtyard with enclosed spaces. — The courtyard is the focal point and building's most outstanding feature. The architecture of the sail is used to provide shaded areas to mitigate the heat in the open courtyard. — Natural light passes through some openings in the sail during the day and provides ample Light with no accompanying heat. —The construction will be using the newest technologies such as the Internet of Things (IoT), large information, and the Artificial Intelligence technology (AI). For cleaning and security services, robot systems will be used.
Included renewable energy technologies:	1-Annual average building produced renewable energy shall exceed 5 400 MW / h. 2- In order to manufacture more than 3500 kilowatt-hours (kW / h), the building would have over 16,500 square meters of solar panels. 3- The building will produce approximately 10,000 square meters of integrated photovoltaic (BIPV) with an output of over 1,100 kWh. 4- The building's overall renewable energy is over 7,000 megawatt hours (MW / h) a year. 5- An annual energy usage (EUI) of 70 kW / m2 would take place in this building.
Final use of energy:	The amount of energy consumed in the housing complex through 1-year is equal or less than generated on site in same year.
Improvement in comparison	--The corporate building of DEWA will now be the world's biggest and most intelligent Zero Energy Building (ZEB).

to national needs:	--DEWA recorded 2.6 minutes for lost customer minutes, the lowest in the world when compared to 15 minutes documented by largest European Union utility companies. --DEWA reduced power distribution network financial loss to 3.3% when compared to 6% to 7& in Europe and USA. --Water network financial loss in North America reduced to 8%, when compared to 15%.
Experiences/ lessons learned:	-Close to 50% of the construction area would be open spaces. -The corporate building of DEWA will be connected by a bridge to Al Jadaf Railway Station. -Such activities help the Council to improve cooperation among UAE and all federal and local institutions, services and departments. -Now this will contribute providing UAE with special services in line with the country strategy.
Costs:	Utility sponsor will focus on its mega $13.63 billion
Awards:	"According to the 2018 Doing Business Report of the World Bank, the UAE, represented by DEWA, was world leader in electricity. -DEWA has also been awarded the highest reward in the European Excellence Model Foundation (EFQM). -DEWA is the first outside Europe company to earn this international prize as first nominee and is now listed in the Platinum category. Regarding results.
Links to further information:	https://cxm.world/dewas-new-building-worlds-largest-smartest-net-zero-energy-building/ Construction week. (2017).DEWA to build the tallest zero energy building. http://www.constructionweekonline.com/article-42413-dewa-to-build-the-tallest-zero-energy-building,2018 https://www.dewa.gov.ae/en/about-dewa/news-and-media/press-and-news/latest-news/2016/11/dewas-new-headquarters-in-al-jadaf Dubai Electricity and Water Authority. (2018). FNC benchmarks DEWA as role model for services to Emiratis. https://www.dewa.gov.ae/en/about-dewa/news-and-media/press-and-news/latest-news/2018/01/fnc-benchmarks-dewa-as-role-model-for-services-to-emiratis access 2019.

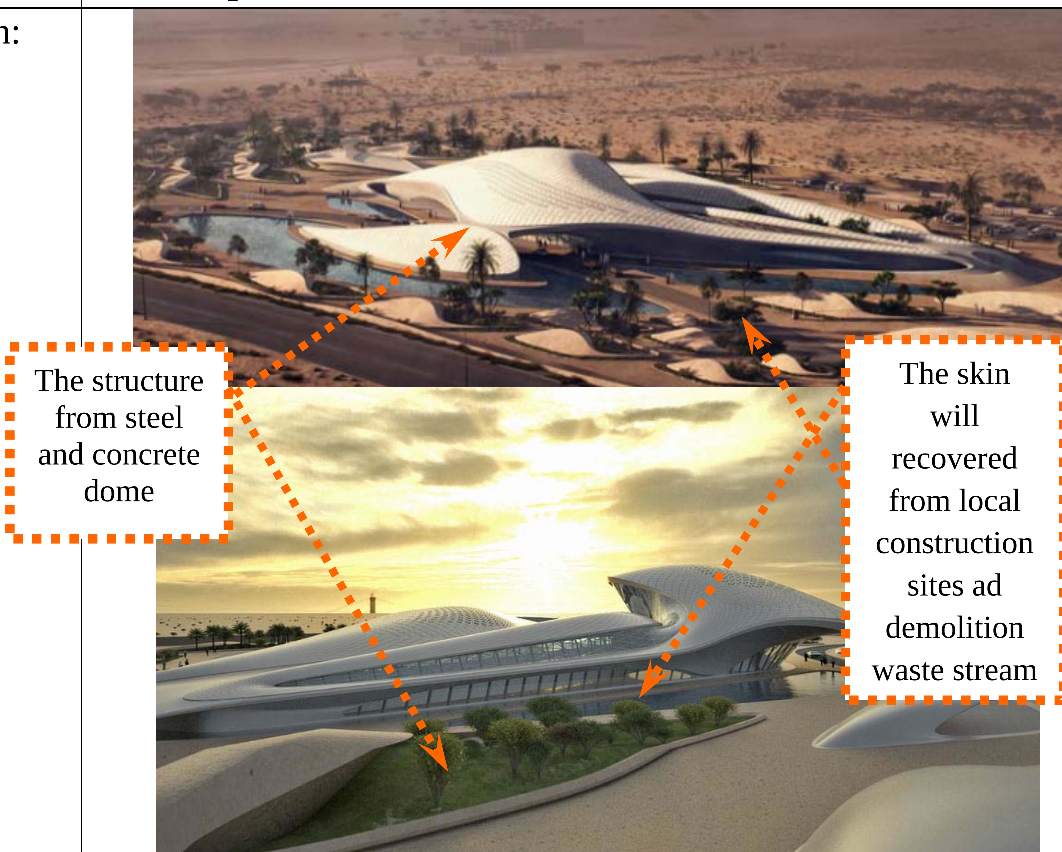
4-3-5 Credit Agricole new headquarters Egypt:

Table (4-5) First LEED Platinum project in Egypt and Africa finally got platinum certificate from USGBC Credit Agricole new headquarters	
Author(s):	Atelier Tom Sheehan & Partenaires
Illustration:	 Fig (4-10)Credit Agricole new headquarters in Egypt Ref: Skyscraper city. (2010). CAIRO ,Crédit Agricole Egypt Headquarters .http://www.skyscrapercity.com/showthread.php?t=1150463,access 2018Atelier
Project aim:	Provide CAE with a high-quality head office building enjoying a strong identity and prestigious image; and fulfill banking requirements with respect to functionality, modularity and versatility.

	It involves the construction of a "Green Building" certified LEED building.
Building address:	This building has been implemented recently in Egypt (the 5th Settlement of New Cairo, Egypt)
Building type:	Administrative building.
Building size:	A gross floor area of 24,655 m2. The building consists of two basements, garden level, and ground floor.
Building envelope construction:	-The building has brick walls -The ceiling made of reinforced concrete -(PV) power station on the roof - The courtyard and the garden level also arrange the building into a "U" shape, centered through an island of palm trees and large boulders.
Building service systems:	-Shading system -High efficient façade -Low-emitting materials and finishes -Highly effective lighting -Daylight sensors
Included renewable energy technologies:	Instead of using expensive or over-sophisticated mechanical materials, The designer put up passive strategies such as:- Building direction, -The roof overhangs, -Deep windows, -High inertia facades and so on... The use of domestically made goods, low maintenance and/or recyclable materials is a necessity and particular attention has been paid to the use and managing of buildings to encourage energy conservation and enhance quality conditions for workers.
Final energy use:	(PV) Power Plant With a capacity of 201,135 kw, the station provides 7percent of total of its energy consumption in a year
Improvement compared to national requirements:	The building achieved a 60% reduction in energy compared to the baseline result of a combination of passive and active methods, energy-efficiency measures and highly efficient construction facilities. Highly effective lighting fitting has been built, and automated systems minimize input power by at least 50 percent between 11 pm and 5 am.

Experiences/ lessons learned:	The new head office of the bank was built to: Save money, Use less water. Produce less waste Provide a higher level of quality and comfort indoors. This building's design and construction are based on taking into account the triple bottom line: PEOPLE, PLANET and PROFIT.
Costs:	$50mn
Awards:	**LEED for New Construction 2009 Platinum certified** on 03/21/2016
Links to further information:	Skyscraper city. (2010). CAIRO ,Crédit Agricole Egypt Headquarters .http://www.skyscrapercity.com/showthread.php?t=1150463,access 2018Atelier Tom Sheehan & Partenaires. (2016). Crédit Agricole Egypt Headquarters http://www.ongreening.com/en/Projects/credit-agricole-egypt-headquarters-1211, access 2018 Crédit Agricole Egypt. (2017). CREDIT AGRICOLE EGYPT TAKES PART IN SUSTAINABLE CITY BUSINESS FORUM. https://www.ca-egypt.com/en/news/credit-agricole-egypt-takes-part-sustainable-city-business-forum/?bank_segment=personal-bankingaccess 6/2020 Sara Khalifa.(2018).Credit Agricole Egypt New Head Office .https://www.researchgate.net/figure/Credit-Agricole-Egypt-New-Head-Office_fig3_323604656 access 6/2020

4-3-6 sand dune-shaped Bee'ah headquarters in Sharjah, UAE:

Table (4-6) Sand dune-shaped architecture in Sharjah to be completed in 2018 The headquarters of Middle Eastern environmental company Bee'ah.	
Author(s):	**The Iraqi-British architect Zaha Hadid**
Illustration:	 Fig (4-11) Sand dune in Sharjah Ref: Technical review middle east. (2018). Sand dune-shaped architecture in Sharjah to be completed in 2018.
Project aim:	-It has been designed to have zero net energy consumption -The dune-like architecture of the Bee'ah headquarters was intended to fit in with the landscape of the local desert. -It is expected to serve an environmental waste management company in the Middle East, and is expected to be certified for LEED platinum.
Building address:	This building under construction in Sharjah, United Arab Emirates Will opening soon at the end of 2019
Building type:	Administrative building
Building size:	7,000-square-metre

Building envelope construction:	-The structure from steel and concrete dome - The items of the head office surface can be retrieved from regional building sites and from the construction of waste streams.
Building service systems:	-Recycled construction materials are used to finalize the house. -The aim is to ensure that no waste from buildings reaches the landfill. -The building is designed to use the prevailing breeze for natural cooling and once complete, energy and water-saving equipment such as LED lighting, low-flow taps and toilets are required to be used.
Included renewable energy technologies:	-Headquarters of Bee'ah will get all of its energy from the sun. Solar panels will be attached to the Power pack battery system from Tesla, providing a total capacity of 1,890 kWh. -Gray water will also be reused and the landscaping will feature native vegetation needing little irrigation -This building powered by renewable energy, including passive solar power and wind power.
Final energy use:	PV system providing a total capacity of 16.3296 kW by year.
Improvement compared to national requirements:	This project would set a standard for all potential green projects in the Gulf area with an ultra-low carbon emissions, reduced water and energy usage and effective recycling of building materials.
Experiences/ lessons learned:	-Using Recycled building materials. -Getting electricity from the sun. -Using water-saving fixtures
Awards:	Is expected to receive a LEED Platinum (a green building standard) certification.
Links to further information:	Technical review middle east. (2018). Sand dune-shaped architecture in Sharjah to be completed in 2018. http://www.technicalreviewmiddleeast.com/construction/buildings/zaha-hadid-s-sand-dune-shaped-architect-in-sharjah-to-be-completed-in-2018 Emy Frearson. (2014) Zaha Hadid designs dune-inspired headquarters for environmental firm. https://www.dezeen.com/2014/12/18/zaha-hadid-sand-dune-inspired-headquarters-environment-firm-sharjah-uae-bee-ah/access 2019. tps://www.designboom.com/architecture/zaha-hadid-beeah-headquarters-sharjah-uae-12-18-2014/ Adam Williams. (2017). Zaha Hadid's sustainable "sand dune" emerges from the desert. https://newatlas.com/beeah-hq-under-construction/52699/access 2018 Mubasher. (2019). Zaha Hadid-designed new HQ to open in summer - Bee'ah. https://www.zawya.com/uae/en/business/story/Zaha_Hadiddesigned_new_HQ_to_open_in_summer__Beeah-SNG_135234947/access 6/2020

4-3-7 ABB's first carbon neutral factory in Lüdenscheid, Germany:

Table (4-7) **ABB's first carbon neutral factory in Lüdenscheid, Germany**	
Author(s):	**ABB Group in Zurich, Switzerland**
Illustration:	Fig (4-12) ABB's factory in Germany Ref: Zurich, Switzerland. (2019). ABB's first carbon neutral factory of the future delivers on its promise. https://resources.news.e.abb.com/attachments/published/41199/en-US/A636170BDC32/Ludenscheid_Mission_to_Zero.PNG,access 10/20
Project aim:	-this project aims to save a 630 tones of CO2 per annum. - to be the first carbon neutral industrial building
Building address:	in Lüdenscheid, Germany
Building type:	Industrial building
Building size:	More than 7,300 square meters
Building envelope construction:	-The structure from steel and concrete - brick walls and the ceiling made of reinforced concrete -The parking be covered by PV solar system

Building service systems:	- The flexible energy management system OPTIMAX ® from ABB AbilityTM Energie Management for Sites is the technical centerpiece of the entire Lüdenscheid system. -The digital solution enables continuous monitoring and efficient monitoring of energy output, use and storage. Based on predictive data, this learning system determines the optimal energy flow and offset deviations in real time. - In Lüdenscheid, ABB has not only installed a new photovoltaic and power management system, but also has implemented other ABB technologies, such as a 200 kW battery power storage (BESS) with a capacity of 275 kWh and ABB charging points, where personnel and visitors can free charge their electric cars which adds to the regional green balance of the plant. - A smart power delivery switch is used to complete this one-source energy management solution.
Included renewable energy technologies:	- The Lüdenscheid plant is powered by a set of solar panels covering approx. photovoltaics. On roofs which cover the on-site parking lot, 7,300m2 and – to save space – are installed. -The Lüdenscheid plant can together produce about 14% more energy on site than it requires. Any surplus electricity is fed into public grid that contributes to region's sustainable energy supply.
Final energy use:	PV system is expected to supply approx. 1,100 MWh of climate-neutral solar power a year, equivalent to 340 private households' annual demand.
Improvement compared to national requirements:	ABB technology is installed and can produce ample power to operate the entire factory and even feed the grid electricity. If on site solutions cannot meet a high demand for electricity, MVV Energy AG is responsible for supplying additional green energy, which ensures a 100 percent CO2 neutral production.
Experiences/ lessons learned:	- Reducing carbon emission - Getting electricity from the sun. - ABB provides goods & services that play a decisive role in enhancing business sustainability. More than half of ABB's global revenues come from technologies which tackle climate change causes.
Links to further information:	Zurich, Switzerland. (2019). ABB's first carbon neutral factory of the future delivers on its promise. https://resources.news.e.abb.com/attachments/published/41199/en-US/A636170BDC32/Ludenscheid_Mission_to_Zero.PNG,access 10/20

4-4 Measuring carbon and energy in the building:

After analyzing these examples, it was found that there are several programs to measure carbon emissions and energy efficiency in buildings, and that there is something new every day in these programs, including:
1-Efficiency house plus calculator is Calculation tool, The standardized calculations for an Efficiency House can be carried out using free online software (www.effzienzhaus-plus-rechner.de) [1].
2- The Soft-Landing Program is aimed to provide prospective businesses with a low-risk entry option into the Canadian market. The program allows business owners to explore opportunities within the North American ecosystem without having to incur heavy costs. The program functions as a trial period where international businesses can get a sense of what it is like to operate in the Canadian landscape2.
3- AIAU, the building sector is the single largest consumer of energy and producer of greenhouse gas emissions. This 10-course series, available on AIAU, will inspire architects to meet the 2030 Challenge through design strategies, efficient technologies and systems, and applying renewable energy resources.
4- The 2030 Palette is a free online resource for the design of zero-net-carbon, adaptable, and resilient built environments worldwide. The database contains sustainable strategies for all scales of design, from building scale to regional scale.
5- The Carbon Smart Materials Palette is an immediately applicable high-impact pathway to embodied carbon reductions, providing attribute-based guidelines for designing low/no embodied carbon buildings and specifying low/no embodied carbon products
6- ZERO CODE, A national and international zero-carbon building standard that applies to commercial, institutional, and mid- to high-rise residential buildings. Designers can use the ZERO Code as a guide to design a Zero Net Carbon building.
7- Quiqsheet, To implement the effective use of EPDs, an expert stakeholder group, facilitated by Architecture 2030 and CannonDesign, has developed an open-standard EPD Quicksheet. Created by and for designers and engineers, the EPD Quicksheet aims to simplify the process of reading, comprehending, and using EPDs, increase transparency in the building products industry, and support building professionals in achieving 2030 Challenge for Products goals
8- ZERO TOOL, The Zero Tool calculates fossil fuel energy consumption for existing buildings and new building designs and normalizes a building's performance for comparison to reduction targets and other buildings[3].
In the case study we will use ZERO TOOL & ZERO CODE for ease of use.

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[1] Crystal Wheeler, (2014). What makes an Efficiency House Plus? - Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit - Fraunhofer IBP. https://www.readkong.com/page/what-makes-an-efficiency-house-plus-8097323, access 6/2021

[2] Toronto business development center, (2020). Soft Landing Program, https://tbdc.com/softlanding/, access 6/2021

[3] Architecture 2030. (2020). an Architecture 2030 project. https://zerotool.org/about/#toggle-id-6, access 8/2019

4-5 The questionnaire:

- The questionnaire is one of the methods for collecting information in scientific research, where data concerning the research subject is collected through the questionnaire and a form is created that contains several questions that the respondent must answer.
- Therefore, the questionnaire is used primarily in studies which explore facts concerning present practices, public opinion polls and people's tendencies, and if the people on whom the researcher wants to obtain data are far away, the questionnaire tool will allow him to reach all of these in just a little time.
- In ability to answer to the research questions, the researcher will be tried to understand the present and to forecast the future in Egypt by setting expectations and scenarios for the future, taking into account the indicators of the results of the survey.

4-5-1 Objectives of the questionnaire:

- A questionnaire aims to:

1-Know how important it is to apply the ZCA concept in Egypt 'ZCAE' to affect in architectural design and architectural thought

2-Identify an acceptable building sector to apply ZCA standards to combat climate change and to reduce energy usage or to adjust the buildings of any facility as defined by the results of the survey.

3- Prove the validity of the presented research hypotheses.

4-Add requirements generated from the views and feedback of the current study to the ZCAE inside the context of entry to the integrated criteria.

5-Measuring the level of engagement and collaboration between funders and decision-makers in upcoming projects.

4-5-2 Selection of research sample categories:

The questionnaire involved 50 architectural and energy experts as follows:

-Researchers in the area of design and specialties (urban design, architectural design) (12 specialists).

-The researchers in the area of the climate (3 specialists).

-Specialists in construction operations and funding problem (10 specialists).

-Architectural Design Academics (20 specialists).

-Decision makers (5 specialists).

4-5-3 Multiple points were considered during the questionnaire:

1 - The elements of the questionnaire were based on a theoretical and analytical study in the first and second sections.

2 -To select the sample, it is important to identify some specialties as well as diversity among them.

3 - There are a difference and variation at the ages for the research sample groups to represent as much as possible their opinions and suggestions.

4- At first, the questionnaire faced several problems which were resolved, including:

- Some terms are novel and unfamiliar; therefore a simplified definition was defined for them.
- Use the “multi choice" method which includes choosing from answers as well as a presentation of questions to know the opinions to reduce the burden and time of answer. In addition to facilitating and evaluating to get accurate and correct results.
- Use the Google site (Google forms) to work out the questionnaire and send it to reach to the largest number of specialists easily to save time and effort by emails or social media.
- Modify some questions of the questionnaire and rephrased after surveying a sample of a few specialists (Which are 10) to get accurate results.

4-5-4 The Contents and questionnaire form model:

1 - At first, an introduction which is an explanation for the purpose of the questionnaire, namely, setting standards for the “zero Carbon Architecture “in Egypt.

2 - Concepts: that include simplification and definition of idioms (terms) of (ZCA, ZCAE) as well as some notes that make information closer to the research sample to complete the questionnaire.

** Which stipulated that:

(ZCA) zero Carbon Architecture

- The building of zero carbon architecture that emits little harmful gases to the environment because of its almost equivalent production of energy.

-Some data by the Us Energy Information Administration indicates that buildings account for around half of the usage of almost 48 per cent of all energy consumption and emissions per year.

-industrial buildings and Residential account for 76% of carbon pollution, contributing to global warming.

3- Participant’s data: his or her name and specialty.

4- A set of questions: which measure the degree of participants' awareness and understanding of the phenomenon of global warming and its relationship to the principles of the ZCA, and apply to any of the types of buildings in Egypt, and the extent to which the participant agrees to this by Likert Scale –Five-point standard (Strongly agree; Agree; Neither agree nor disagree; Disagree; Strongly disagree), as well as ask some questions to display the common view of free expression in the scope of the topic and the extent of the importance of community partnership and these questions will be presented in detail later in the appendix.

4-5-5 The results of the questionnaire:

1-Architecture helps eliminate the issue of global warming by 48%.
2-The implementation of ZCA leads to the long-term solution of, environmental, global warming issues by 62%.
3-The application of ZCA in Egypt has a powerful influence on engineering and energy by 40% (In other words, there is no complete awareness of ZCA importance).
4-Application to ZCE has a massive cost by 56%.
5-Applaying ZCAE is expensive in the longer term by 64%.
6-Many syllabuses must be advanced to educate architecture students admitted the concepts of ZCA by 70 %.
7-A strategy must be developed to control and enhance ZCA in collaboration with government institutions and major world powers by 40%.
8-Based on the current Stimulation (ZCE), the components of the structure must be customized by 58%.
9-The ZCA usage will generate a special architecture value in the long run and image of the city will indeed be transformed by 52%.
10 – At first, ZCE must be applied to new buildings by 86%.
11 – Beginning with the application of ZCAE in the industrial buildings by 46%, then in residential buildings, followed by academic and administrative buildings.
12- To implement ZCE, engineers should be recognized and educated on the concepts of ZCA via courses workshops, explanatory seminars, training, scientific conferences and development of university architectural education and Post University education by 76%.
Specialists have also added:
-Acquiring certificates in the ZCA.
-Field visits to models of the buildings used and dissemination of knowledge of the findings.
-Application of a scheme for the production and repair of technical requirements for buildings in compliance with the principles of the ZCA.
13- The environmental viability of the implementation of the ZCA is followed by economic feasibility by 42%.
14- The establishment of an administrative system for the management and operation of ZCAE is a special feature of:
-Activation of the ZCA as part of the approval of the building license.

-Management, follow-up and development to reform the building and project requirements and raise awareness of the ZCA definition.

-Developing legislation, tracking implementation and assessment.

-supervise and Support

-Coordination between this facility and other state agencies specializing in construction and electricity.

-Protecting the environment and managing natural resources.

-Development of modern applications to conform to the essence of the Egyptian climate.

15- The following should be used to activate ZCA in Egypt:

1-To spread knowledge of the value of the implementation of ZCA at all levels and to raise awareness and cultural values.

2-Enable the environmental specifications of the building and apply the aspects of sustainable architecture.

3-Link the building license to an acceptable standard of environmental efficiency.

4 – The experimental operation of certain buildings and the inventory and interpretation of the findings.

5 – The Government and society, the major institutions, have adopted this idea.

6-Promote a relationship with the private sector and even the initiatives introduced by ZCA.

7-Take advantage of global expertise on the subject.

8-Provide advanced research labs to study the environment in order to establish architectural solutions.

9-Coordination with other ZCA-activated organizations.

10-To try to coordinate between the concepts of ZCA and the feature of Egyptian architecture in order to achieve a satisfactory level of performance.

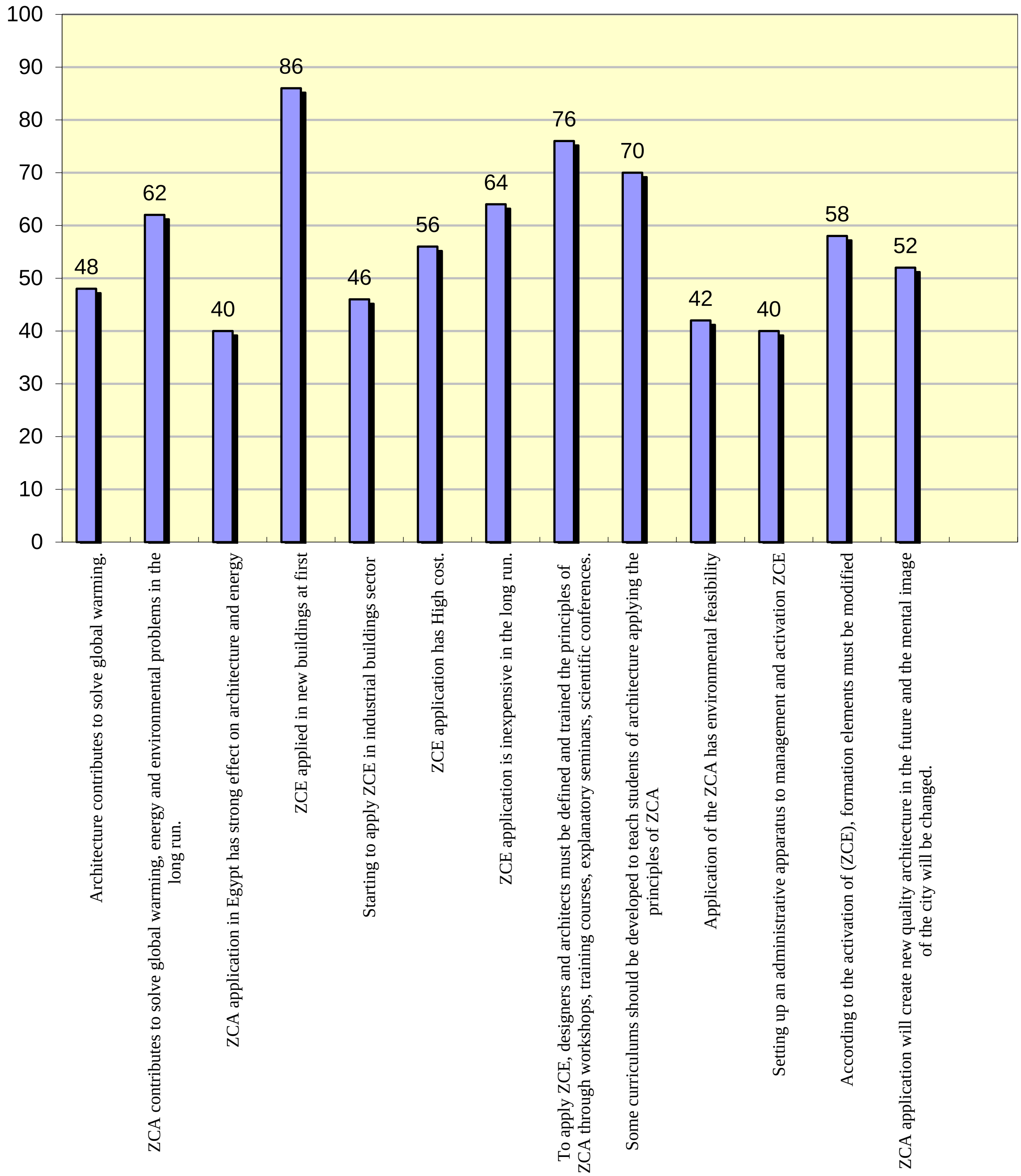


Fig (4-13) presents the questionnaire result By Researcher

4-6 Conclusions:

Zero carbon building achieves zero net carbon emissions through maximizing energy efficiency, comprehensive architectural design, resource recycling and green land.

So this chapter analyzed contemporary paradigms of zero carbon building around the world including an example from Egypt.

This study included project aim, descriptions of the building including building envelop uses of Nano technologies for an approach to zero carbon architecture, measurement of energy efficient, building cost and it's awarded.

So there is a network of efficient buildings that has the same rate of energy efficiency.

Such buildings proofs that extra costs when compared to new buildings can be reduced.

That questionnaire was concluded that:

ZCA leads in long-term to solve of global warming; it has a strong impact on architecture.

A process for managing and applying of ZCA, in collaboration with state institutions and major powers, must be created.

In the future, the ZCA design will create a new quality architecture.

ZCAE first applied to new buildings in the industrial buildings

In order to apply ZCAE, designers and architects must identify and train the concepts of ZCA through workshops, training courses, explanatory seminars, conferences.

Implementation of the ZCA shall have environmental viability followed by economic feasibility.

Make a certificate for ZCAE .

Distribute the value of ZCA application at all levels and spread awareness and community culture development.

At the end of this chapter, the lack of a ZCA industrial building was noticed as the only one noticed after extensive research into reducing carbon emissions is the mentioned one.

Therefore, research calls for application to factories as a case study at the outset to reduce the proportion of carbon emissions in the implementation of the Paris Agreement, as the factories are at the top.

Therefore, there is a research gap as a case study for applying the principles of ZCA to an industrial building and taking this into account in the applied part of the research.

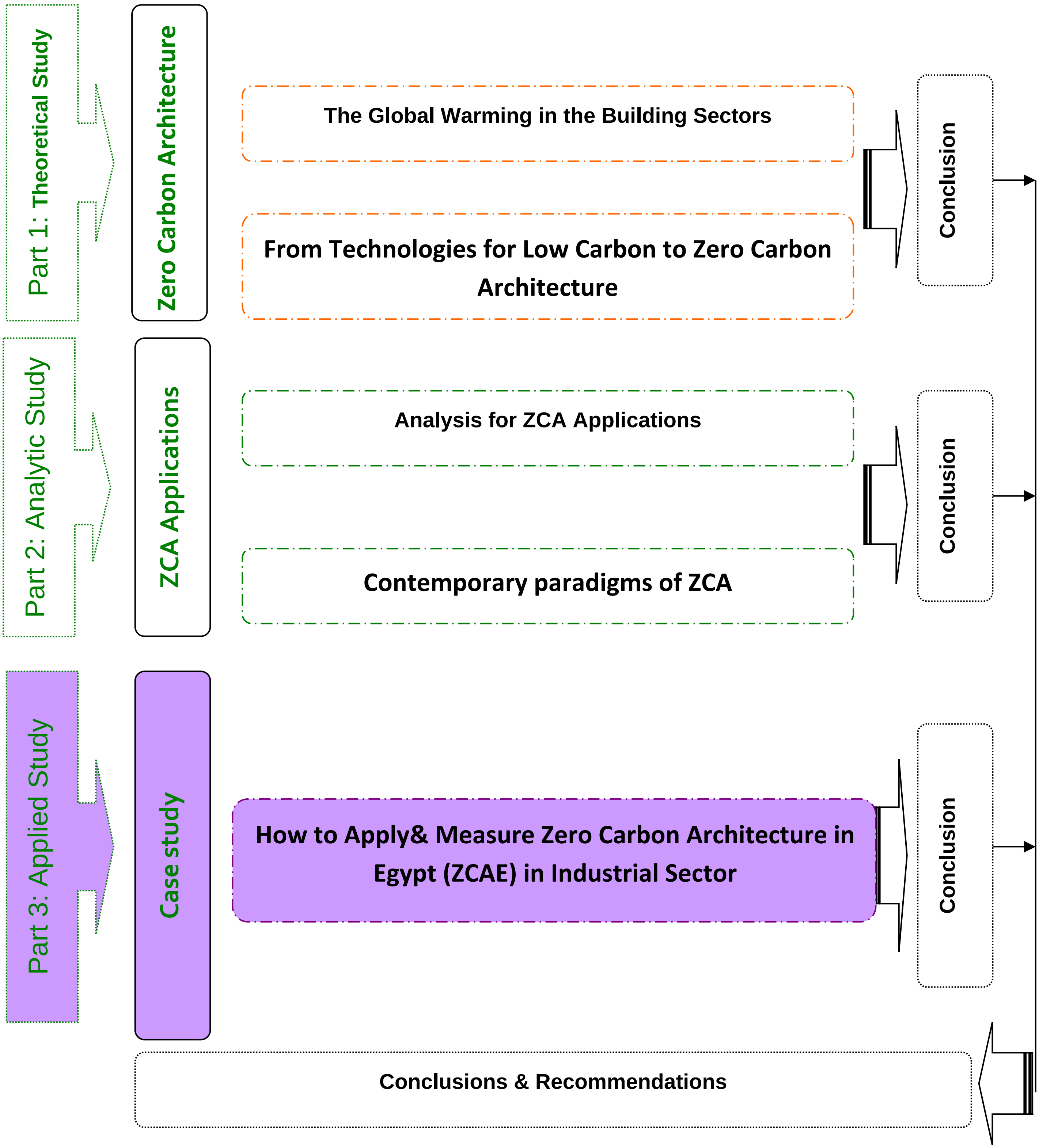
Conclusions on the Analytic study

At the end of the analytic part of the study and after analyzing the applications of ZCA and some models for contemporary buildings that apply the principles of ZCA, the research reached the validity of the first hypothesis of the research, which is that global warming can be reduced by applying the principles of ZCA, as well as the research reached some conclusions or criteria that will be used in the case study in the applied part of the research as follows:

- The outcome of the theoretical and analytic study in the previous parts, which recommends the beginning of the application of **ZCA in industrial buildings for a research gap mentioned before.**
- Application is recommended to start with buildings that consume more energy than others as the industrial ones, benefit from energy saving economically, environmentally and urbanely, but the question still arises Will the application first on a short-term or long-term factories, another question Will the work of the study of traditional feasibility or sustainable feasibility study?
- We can decrease the carbon consumption in the building sector especially industrial building.
- We can Measure and make certification for ZCA in Egypt.

Part 3: Applied Study

How to Apply& Measure
Zero Carbon Architecture in Egypt (ZCAE)
In Industrial Sector A Case Study


Part 1: Theoretical Study
Zero Carbon Architecture
The Global Warming in the Building Sectors
From Technologies for Low Carbon to Zero Carbon Architecture
Conclusion
Part 2: Analytic Study
ZCA Applications
Analysis for ZCA Applications
Contemporary paradigms of ZCA
Conclusion
Part 3: Applied Study
Case study
How to Apply& Measure Zero Carbon Architecture in Egypt (ZCAE) in Industrial Sector
Conclusion
Conclusions & Recommendations

Contents

INTRODUCTION

Many engineers in Egypt think about the sustainability and energy efficiency of buildings, however, no building in Egypt realized the ZCA. This differs from other energy efficiency programs that care about the climate as the most important aspect of its assessment but do not recognize green aspects like LEED.
So from the beginning of the research, the goal was to reach a model for ZCA for application in Egypt (ZCAE) to reach to the applied study that was built on the outcome of the previous theoretical and analytical studies.
So, this chapter is a case study of a model of an industrial building applied to the principles and thought of ZCA Likewise, how to measure ZCA using the ZERO TOOL app.
Therefore, this chapter will create a future scenario for carbonless engineering in Egypt ZCAE, and this will be achieved by adapting the existing building to follow the principles of ZCA to reach zero net carbon emissions at the urban level in the industrial zone.

5-1 Zero carbon architecture in Egypt (ZCAE):

As previously stated in the theoretical section of the study, the word "zero" applies to houses, which are either zero energy or zero emissions, representing an annual energy efficiency balance with renewable energy services. Researchers estimate hundreds of zero commercial buildings and thousands of zero homes around the world today[1].

The key aspect considered at the **ZCA** is **the climate with all its branches**; this makes it different from other tools for energy efficiency.
So in common figure (5-1) ZCA buildings appear to have a certain set of features and technologies[2].

[1] Architecture 2030 org .(2016) .ADVANCING NET ZERO WORLDWIDE .https://architecture2030.org/advancing-net-zero-worldwide/access 7/2019.

[2] New building instatue.2016 .p5

Fig (5-1) ZCA certain suite of features and technologies in Europe
Ref: New building instatue.2016

Even though Egyptian National Energy Plan has no relation to the Zero-Carbon Architecture, no research offers any information on the current ZCA in Egypt, and only a limited number of studies address the problem in industrial buildings, so the ZCA proposal seems to work well.

So ZCAE can use these keys above to apply principles of Zero Carbon Architecture in Egypt Especially since it suits the current and future waves of new cities in the map of urban (Urban Development Plan) trends in Egypt to obtain a life that may seem more developed and in line with the technological development that the world is now witnessing; maybe this is what the fourth generation cities that the Egyptian state is now implementing are achieving Fig (5-2).

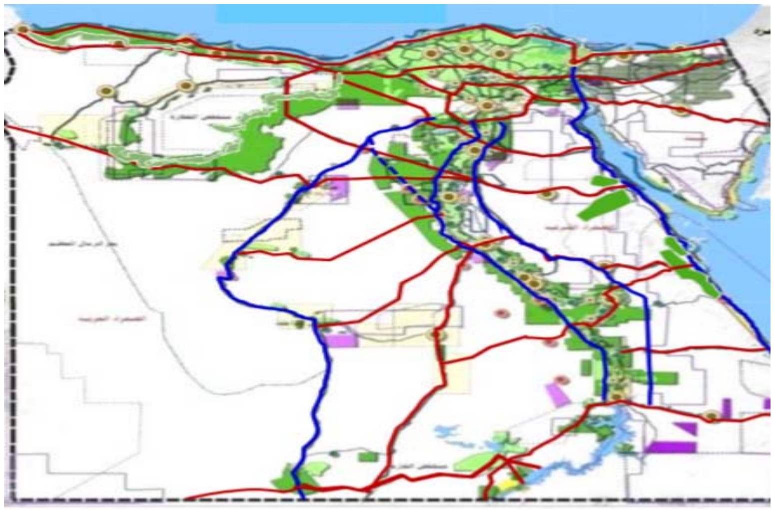


Fig (5-2) the National Strategist Plan for Egypt 2052 (Urban Development Plan)
Ref: Gopp.gov.eg. (2017). the National Strategist Plan for Egypt 2052.http://gopp.gov.eg/wp-content/uploads/2017/12.pdf. Access 6/2020

There is no doubt that cities have witnessed a varied and different boom in terms of the structure of their establishment and implementation, so that it becomes more compatible with the changes taking place in the global technology environment; whereas these cities are a developed model of cities in their network systems, activities that support university knowledge economy, and internships

There is no question that over the last five years the new cities have witnessed considerable interest from the state in engaging with the private sector; this gave it great strategic importance.

Investment in infrastructure and technology networks is one of the most important areas where economic and social benefits are maximized

That's why the Egyptian government tended to put infrastructure investor incentives at higher rates in design and operation with their projects than national rates, such as; environmental and technological rates to monitor their project networks and facilities; because these incentives and facilities would reduce production costs.

This means that the current and new construction will not represent different bodies in the policies and that the success of both would have a positive impact on the achievement of the national development objectives.[1]

[1] https://www.youm7.com/story/2019/11/3 , access 6/2020

5-2 Scope of the study:

Looking closely at this study, we will find that ZCA can be applied in all sectors of buildings, like residential, industrial, commercial and administrative buildings, etc. But this study is concerned with the application of ZCA starting from industrial buildings for several reasons:

1- The outcome of the theoretical and analytic study in the previous parts , which recommends the beginning of the application of **ZCA in industrial buildings first**, and these results were as follows:

- Application is recommended to start with buildings that consume more energy than others as the industrial ones, benefit from energy saving economically, environmentally and urbanely, but the question still arises Will the application first on a short-term or long-term factories, another question Will the work of the study of traditional feasibility or sustainable feasibility study?
- Decrease the carbon consumption in the building sector especially industrial building.
- Measure ZCAE by Zero Tool application.

2- The selection of the ZCA application was approved on the industrial buildings of the pillars group:

- Urbanism, such as reducing carbon emissions from the urban sector, the adoption of ZCA solutions to energy problems in the urban sector , also for the sustainability of construction and the use of materials that protect the environment, save energy and improve energy efficiency
- Environmental as reducing carbon emissions.
- Economic as large as projects Are these for large and small projects?
- Political as providing the state budget.

5-3-1 ZCAE General Methodology

There are certain criteria or concepts to serve as a consistent methodology for model and measure ZCAE in general and special **in industrial buildings at first in new cities**:

- Take into account inclusiveness and flexibility.
- Avoid complexity.

- Good knowledge about the existing situation with reformulates reality in the future.
- Design & Retrofitting the building in a futuristic way that simulates the reality.
- One of the most important reasons for choosing this building is the ability to monitor all data, as well as the fact that the factory has light loads on the environment.
- Creating an innovative targeted scenario with a reference vision based on a sustainable feasibility study.
- The scenario should be holistic by considering all the following aspects; the economic, environmental, and aesthetic aspects with documenting the environmental performance of the building.
- So there are the six main building design aspects (or six scenarios) of ZEB design must be mention first[1]:

1. Metric:	There are several definitions for NZEBs that are based on energy, environmental or economic balance. Therefore, a NZEB simulation tool must allow the variation of the balance metric.
2. Comfort Level and Climate:	The net zero energy definition and design strategies are very sensitive to climate. Consequentially, designing NZEBs depends on the thermal comfort level. Different comfort models, e.g. static model and the adaptive model, can influence the 'net zero' objective.
3.Passive Strategies:	Passive strategies are very fundamental in the design of NZEB including daylighting, natural ventilation, thermal mass and shading.
4.Energy Efficiency:	By definition, a NZEB must be a very efficient building. This implies complying with energy efficiency codes and standards and considering the building envelope performance, low infiltration rates, and reduce artificial lighting and plug loads.
5.Renewable Energy Systems (RES):	RES are an integral part of NZEB that needs to be addressed early on in relation to building form. For example solar systems, require addressing the panels' area, mounting position, row spacing and inclination.
6. Innovative Solutions and Technologies:	The aggressive nature of 'net zero' objective requires in most cases implementing innovative and new solutions. This includes low-tech and high-tech technologies.

Table (5-1): The six main aspects of ZEB
Ref: Attia, S., Gratia, E., De Herde, A & Hensen, J.L.M. (2013)

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[1] Attia, S., Gratia, E., De Herde, A & Hensen, J.L.M. (2013) Achieving informed decision-making for net zero energy buildings design using building performance simulation tools, Building Simulation, Vol 6-1, P 3-21, http://dx.doi.org/10.1007/s12273-013-0105-z.,8/2019, p39.

So, there are three basic steps to be followed to obtain a model for ZCAE industrial buildings that will apply to the industrial zone in new cities:

1. Data Collection and Analysis:
first move toward ZCAE is to collect and analyses local climate data and the energy system design in the house.

2. Energy Performance Enhancement:
The second stage will concentrate on improving the building's energy efficiency and evaluating the effects using the Zero Tool application software techniques.

3. Renewable Energy Systems:
Different programming may be used for simulating the power demand and generation, the exact number of PV arrays in addition to the scheme of linking the renewable energy to the grid should be calculated based upon climate analytical knowledge and software techniques.

Basic steps to obtain a model for ZCAE

- **Data Collection , Analysis**
- **Energy Performance**
- **Energy Systems**

Fig (5-3): Basic steps to obtain a model for ZCAE ,By researcher

5-3-2 Methodology of the scenario:

-The scenario of retrofitting the existing building will start by the specification of the field of the study and **choosing the type of the building to be used in the study.**

-The energy consumption data for the building and environmental data indoors and outdoors such as air temperature , air moisture, CO_2, luminance, noise level will be gathered after the description of the building type, Since these elements strongly impact the thermal comfort as well as the ecological quality of the air within the structural complex.

-Then these data will be **analyzed to find out the building's desired energy performance** according to the ZCAE general methodology.

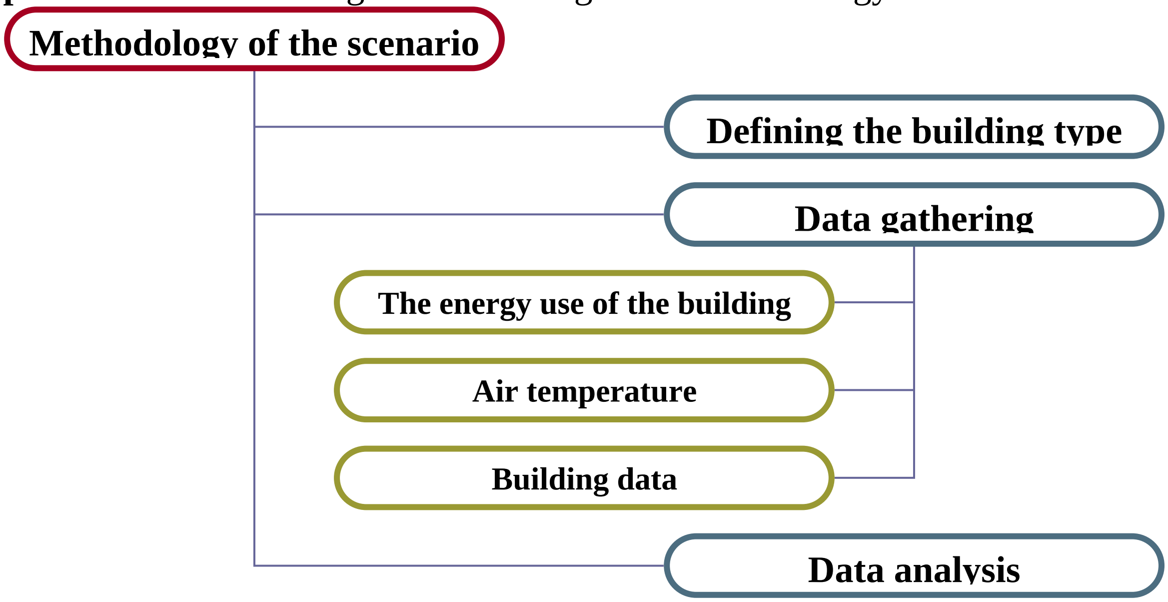

Fig (5-4): Methodology of the scenario, By researcher

Thus, the application of a theoretical thesis on an ongoing project allowed the Researcher the ability to evolve from an empirical research to a practical experience study.

The scenario will Using the actual industrial building in the New Damietta City area as a case study. The building has a certain level of energy efficiency and requires a certain amount of electricity to be used. If the energy efficiency could be improved and the power could be produced by Pv system, the building could be a zero-energy building, then this model could be used in the industrial zone.

Then measure ZCAE by using the international application Zero tool, the energy intensity use performance of the industrial building will be documented, and the amount of energy needs to be generated from the building will be calculated.

Nasr solar website will be used to determine the solar panels needed, their area, mounting position, row spacing, and inclination, in addition to design recommendations, then evaluate it by **Zero Code** application.

The study will give the building with an optimal design approach for the position of the panel, its quantity and prices from the Egyptian market. The usage of the energy simulation programme would calculate the amount of energy saved by the remodel behavior and compare it to the actual rates in order to validate the technique proposed.

5-4 Measuring ZCAE by Zero Tool App:

The study will depend on **Zero tool** scale to measure ZCAE , evaluate the industrial building and its environmental performance,then proposing and applying this tool as certificate for ZCAE in Egypt[1].

Zero tool is an application developed by Architecture 2030 for building sector professionals.

In **Zero Tool** there is A Zero Score[2] which A value allocated to the building is aimed to assist team members recognize the energy efficiency of the building and the move towards Zero Net Carbon. Zero Score is a relative value measure that can be used to evaluate buildings throughout all sites, categories, and area.

The baseline, the Zero Score of 100, is a standard modern building with an energy usage pattern; the Zero Score of zero is a Zero Net Energy house. All results between are shown horizontally.

The present or target Zero Score of a building should be measured by dividing the real or goal level of energy use (EUI) of the building by its EUI baseline.
The Zero Score calculation is compatible with the Zero Energy Efficiency Index (ZEPI) approach and the Home Energy Rating System (HERS) dataset.

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[1] Architecture 2030. (2020). an Architecture 2030 project https://zerotool.org/about/#toggle-id-6, access 8/2019.
[2] Architecture 2030. (2020). an Architecture 2030 project https://zerotool.org/about/#toggle-id-6, access 8/2019,op.cit.

Zero Tool also provide other important services including clear, simple graphic results to envision the existing building performance, or the building design goals and baselines[1].

Zero Scale is designed to assist project professionals understand the energy conservation goal needs and to envision efforts to achieve Zero Net Emissions. The scale indicates Zero Score values ranging from 100 to zero, with three indications linked to the project: BASELINE, TARGET and YOUR BUILDING fig (5-5).

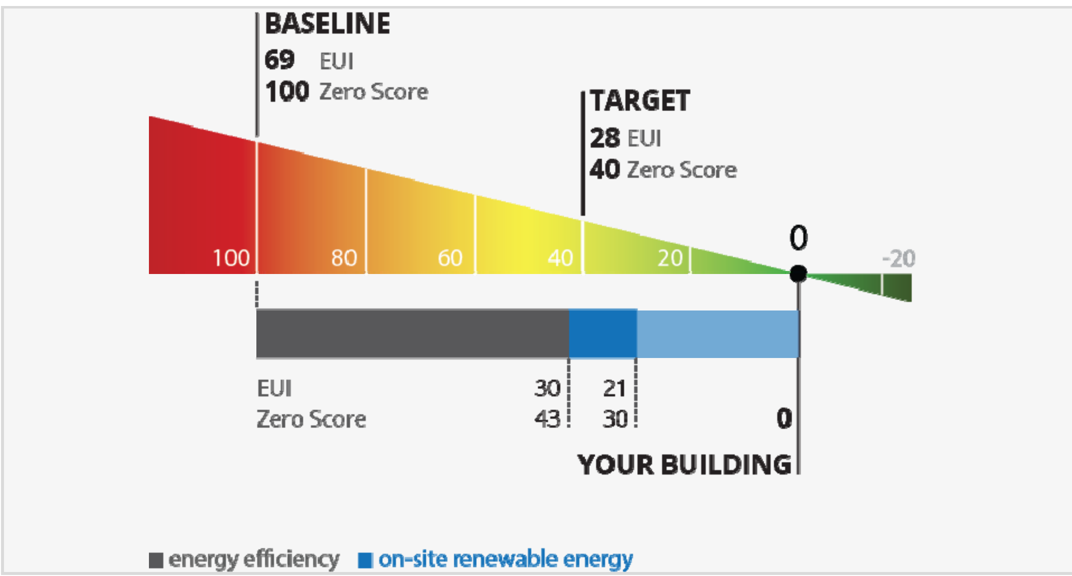


Fig (5-5) Zero tool scale showing the evaluation of the building Linked to the goal and to the baseline. Ref: Architecture 2030. (2020). an Architecture 2030 project https://zerotool.org/about/#toggle-id-6, access 8/2019.

The BASELINE indication tells energy use intensity (EUI) and Zero Score for a standard new building that is climate controlled, building type, building size, capacity, and plan.

The TARGET indication tells the EUI and Zero Score that the building should aim to accomplish this on the basis of the target submitted in the Energy Reduction Goal input field. TARGET values are determined on the basis of a linear scale or a

[1] Architecture 2030. (2020). an Architecture 2030 project https://zerotool.org/about/#toggle-id-6, access 8/2019. op.cit.

considerable reduction from the BASELINE values.

The YOUR BUILDING indication tells the EUI and Zero Score for the building built on real energy consumption.

The applications calculate these input values are placed in the Annual Energy Purchased and Annual Energy Generated input failed. Exponential EUIs and Zero Scores are also seen, describing building efficiency with no generation of renewable energy or with on-site or off-site generation of renewable energy[1].

5-5 Application of the scenario:

In order to apply and measure the ZCA in Egypt (ZCAE) to industrial buildings in new cities, a scenario was built to retrofit an existing modern building that was generated using the Zero Tool application after collecting data and information on the building in terms of energy used to run the building for the current building, the building area, the location, and its importance to know the weather to determine and measure ZCA.

Here are the steps to apply the scenario:

5-5-1 Weather data
5-5-2 Building data gathering
5-5-3 Building data analysis
5-5-4 Zero tool evaluation / Results

5-5-1 Weather data:

Weather study is necessary since the use of renewable energy would rely on the capacity of the area. A scope of this research will include one type of renewable energies: pv Systems, not only because solar power is Egypt's most available renewable source of energy, but also it is the simplest type to be used and applied by people without the need for state massive super initiatives.

[1] Architecture 2030. (2020). an Architecture 2030 project https://zerotool.org/about/#toggle-id-6, access 8/2019. op.cit.

The building is in New Damietta, Egypt, the city has no considerable continuous rainfall throughout the year, average temperature throughout the year is 20.1 degree Celsius, and about 111 mm of rain falls annually Fig (5-6), Table (5-2).[1]

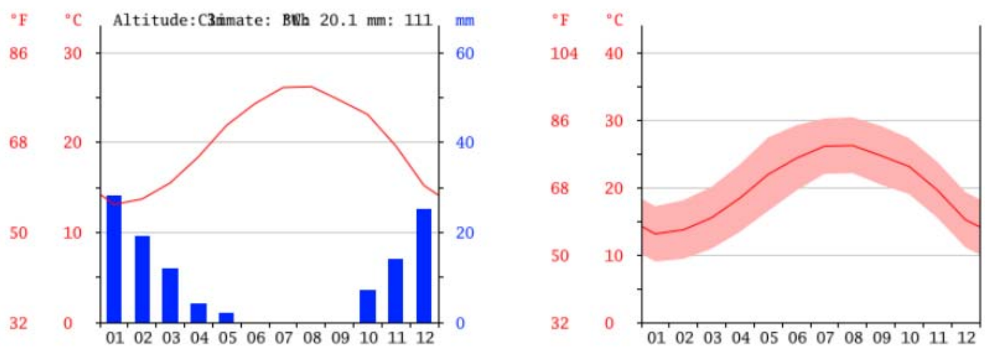


Fig (5-6) climate graph about new Damietta. The driest month is July with 0 mm of rainfall. The most rainy month is January with 28 mm of rainfall, the second graph is Temperature graph about new Damietta. The warmest month annually is August with average temperature of 26.2 degree Celsius. The coolest month is January with average temperature 13.1 degree Celsius.
Ref: Climate data .org.(2019).CLIMATE DATA FOR CITIES WORLDWIDE .https://ar.climate-data.org/location/5090/ ,access 8/2019.

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	13.1	13.7	15.5	18.4	21.9	24.3	26.1	26.2	24.7	23.1	19.6	15.2
Min. Temperature (°C)	9	9.4	10.9	13.4	16.5	19.5	22	22.1	20.4	19	15.5	11.1
Max. Temperature (°C)	17.2	18.1	20.1	23.4	27.4	29.2	30.2	30.4	29.1	27.3	23.8	19.3
Precipitation / Rainfall (mm)	28	19	12	4	2	0	0	0	0	7	14	25

Table (5-2) climate table about new Damietta. Difference between rainfall in the rainiest month and the least one is 28 mm, and the average temperature ranges annually by 13 degree Celsius.
Ref: Climate data .org.(2019).CLIMATE DATA FOR CITIES WORLDWIDE .https://ar.climate-data.org/location/5090/ ,access 8/2019.

In order to be able to use the Zero tool, the postal code of an American city should be entered before the evaluation, for the application to include all the climate date of the city.

If a country is not included in the Zero Tool, the degreedays.net website can be used to measure the day of the heating degree and the day of the cooling degree

[1] Climate data .org. (2019). CLIMATE DATA FOR CITIES WORLDWIDE .https://ar.climate-data.org/location/5090/ ,access 8/2019.

(HDD/CDD) information to be registered in the Zero Tool or even in the postal code. It is important to enter the total heating and cooling degree days for one year or the average yearly total for numerous years.
The American Institute of Architects has also created a global site for the United States. Relative Zip Code chart, from which locations in similar climate zones can be connected to the U.S. zip code.
Users of Zero Tool may replace location data of their project with U.S. equivalent data from that table.
According to the American Institute of Architects, the most equivalent US city in the climate zone to Damietta is Phoenix, Arizona with zip code of 85004fig (5-7). [1]

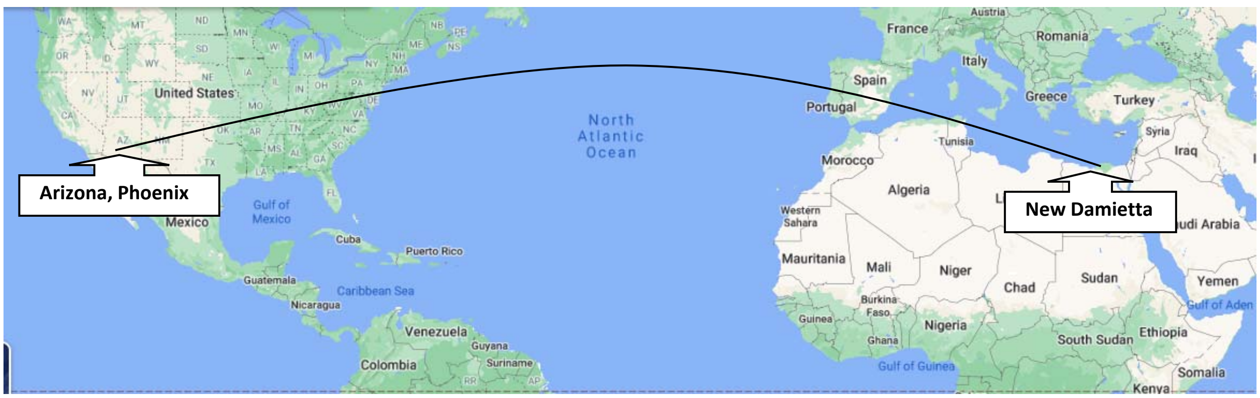


Fig (5-7) A map showing the locations of New Damietta City and Arizona, Phoenix
Ref: Google maps https://www.google.com/maps/@30.1657037,-38.5618094,3z ,access 6/2021.

5-5-2 Building data gathering:

In order to decide on the required remodel steps, the present situation of the building must be measured, so the data-gathering phase must come first.
The case study is Food Industries Factory, a 3-story industrial building each with an area of 465 m2 and the approximate total gross area is **1395m2**.
(Source: the researcher)
The total surface area of the land is 1519 m2. The building has one staircase and one elevator, the typical floor plan, and the building view is seen in fig (5-8) and (5-9).

Fig (5-8) the Current building view

[1] Degree days,(2019), Degree Days Calculated Accurately for Locations Worldwide, https://www.degreedays.net/, access 8/2019.

The location in the industrial area in New Damietta, fig (5-10).

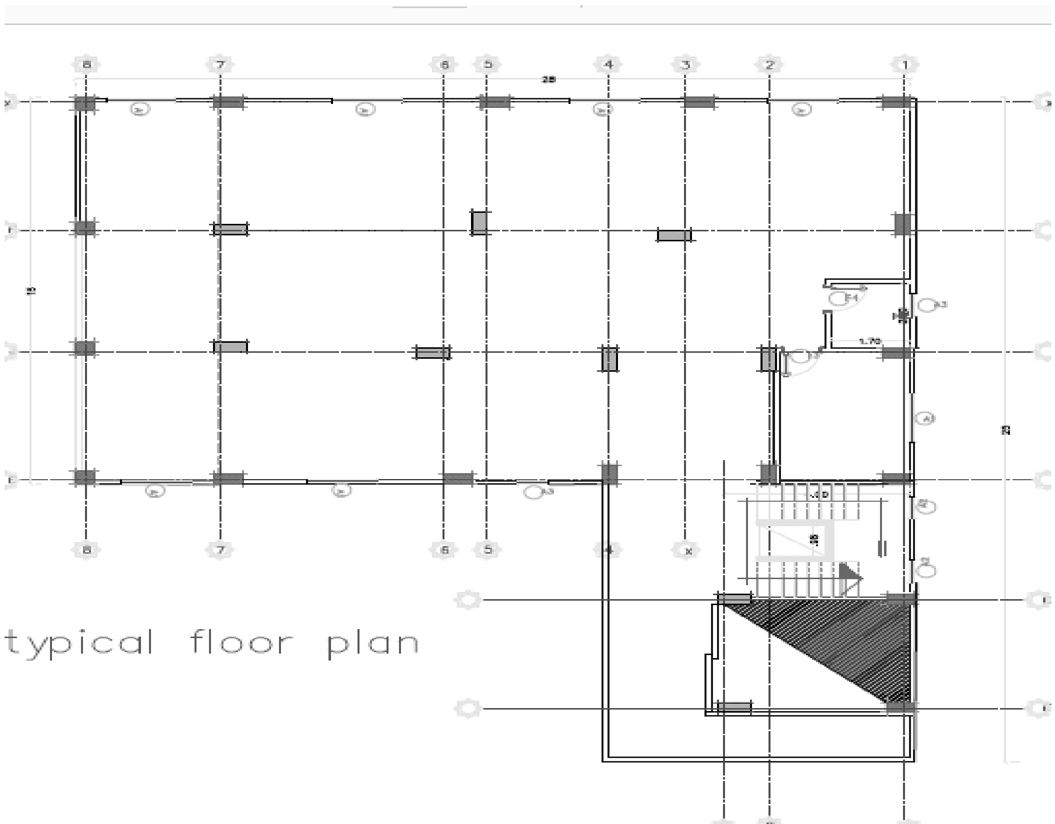


Fig (5-9) the typical floor plan By researcher

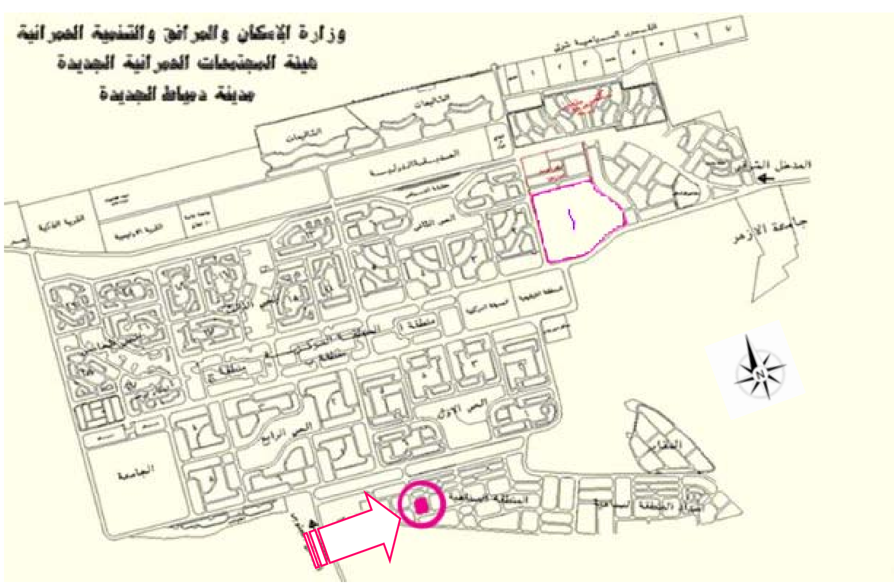


Fig (5-10) the location of the industrial building in New Damietta. Ref::New urban communities' authority. (2011). NEW DAMETTA CITY MAP .http://www.newcities.gov.eg,access 2019).

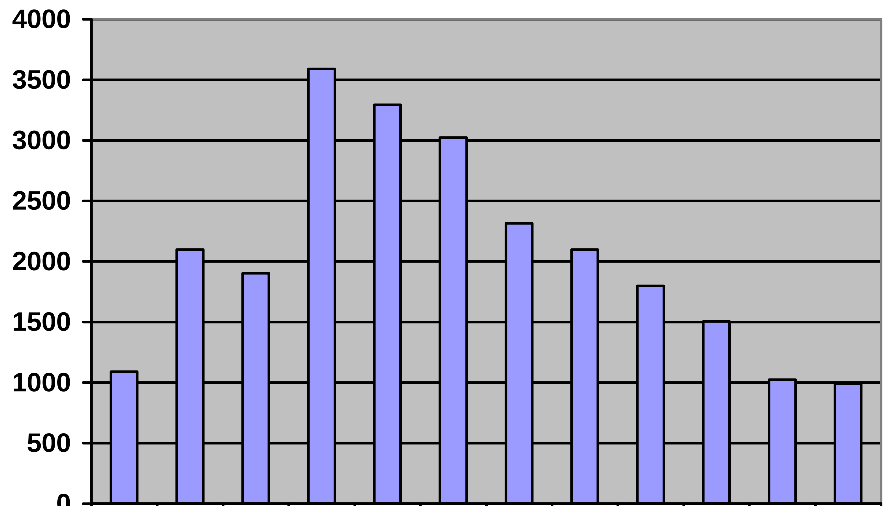
The vertical envelope of the building is a single wall of 25 cm thick bricks with aluminum framed windows. There is no padding on the exterior or inside of the envelope. The roof layers are the finishing bricks, the waterproofing membrane, the thermal insulation, and then the concrete slab covered by the pilaster from the inside. (Source: the researcher)

The building's vertical envelope will later be modified to suit ZCA's thought.

5-5-3 Building data analysis:

One of most valuable information to be regarded in this example is the information on energy usage, which has a strong effect on the amount of electricity to be saved either by redesigning or to be created by the power generation system.

The average daily consumption rate was identified as 120 kWh estimated from the monthly rates fig (5-11) from the actual electric bill (Source: the researcher)



	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
electricity consumption per Kwh	1091	2098	1901	3591	3294	3025	2315	2097	1798	1506	1023	989

Fig (5-11) Monthly **electricity consumption in the case study building – 2019 by researcher (these bills in Appendix)**

According to calculation method for onsite solar energy to be generated[1] the average total consumed energy per day should be multiplied by 1.3 (the energy lost in the system) to get the total Watt-hours per day which must be provided by the panels.

For our building: Annual Energy consumed = 120 * 365 = 43800 kWh

Annual Energy to be Generated = 43800 * 1.3 = 56,940 kWh

5-5-4 Zero tool evaluation / Results:

Zero tool[2] application was used considering all the weather and building data gathered in the previous steps, especially the building energy consumption data for energy after construction during operation.
Zero tool application was used to improve the energy baseline and energy use reduction goal for the industrial building

Energy reduction target:

First case: In 2030 Reduction goals for new building and extensive repairs are:

- 70% today
- 80% in 2020
- 90% in 2025
- Carbon-neutral in 2030 (using no fossil fuel GHG emitting energy to operate)

Second case: In 2030 Reduction goals for existing structures are:

- 20% today
- 35% in 2025
- 50% in 2030

Whereas the study building is existing, so it is supposed to reduce 20% of its energy use today and 50% in 2030(second case).

[1] Amr Mohamed. (2019). calculation method for onsite solar energy https://www.linkedin.com/pulse -amr-mohamed, access 8/2019.
[2] Architecture 2030. (2020). an Architecture 2030 project https://zerotool.org/zerotool, access 8/2019.

First; applying the data with 20%energy reduction target fig (5-12), (5-13):

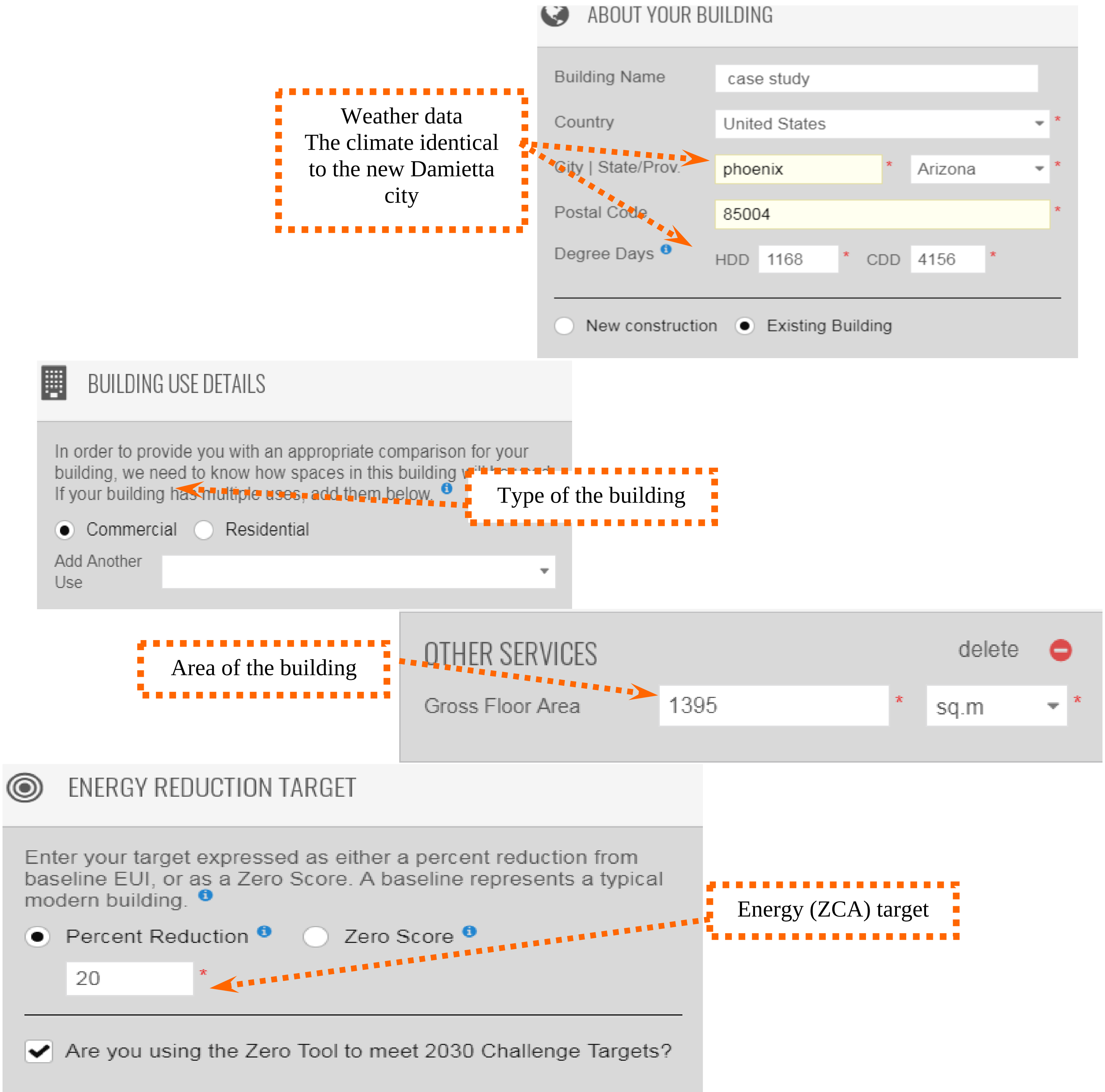


Fig (5-12) building data. Ref: Architecture 2030. (2020). an Architecture 2030 project https://zerotool.org/zerotool, access 8/2019.

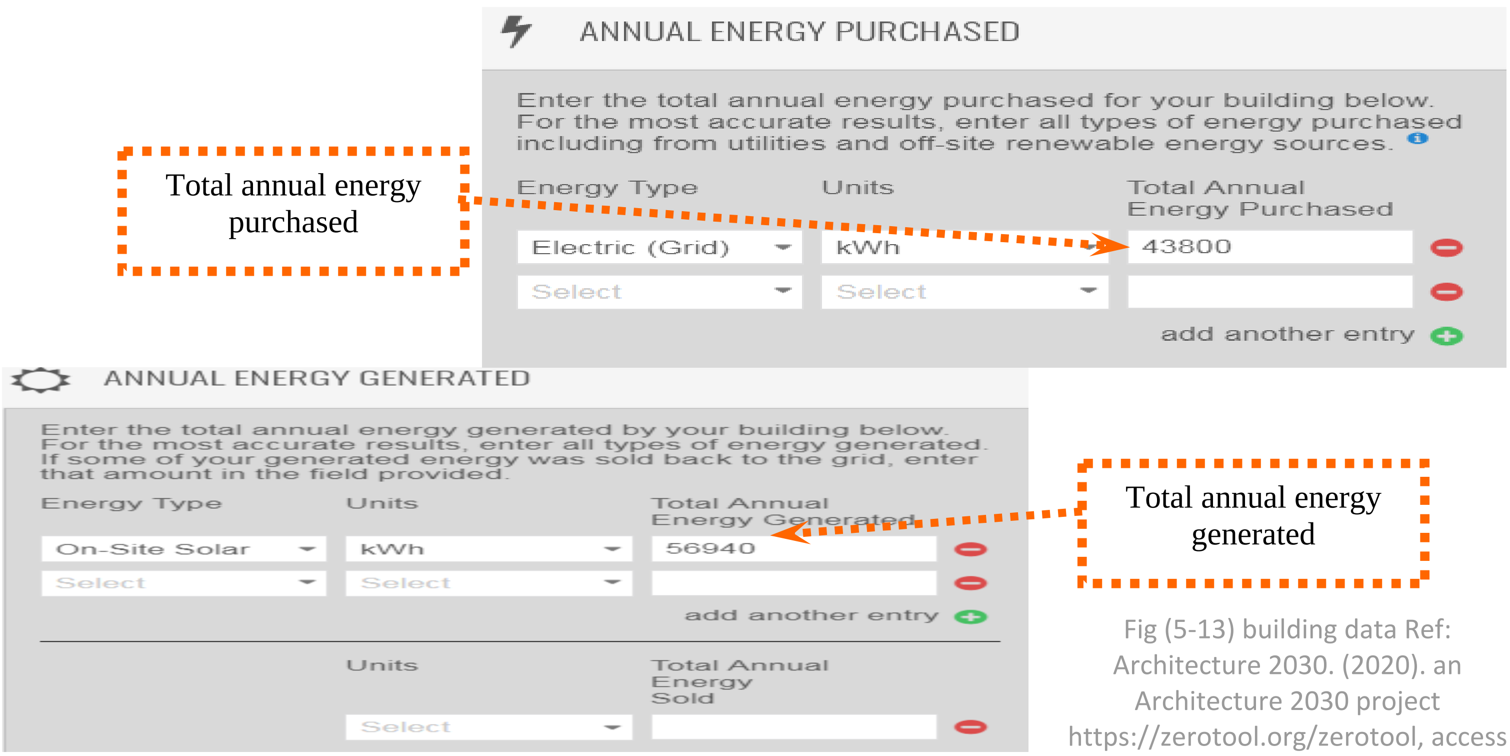


Fig (5-13) building data Ref: Architecture 2030. (2020). an Architecture 2030 project https://zerotool.org/zerotool, access 8/2019.

<u>After we input building data, the results were as the following:</u>

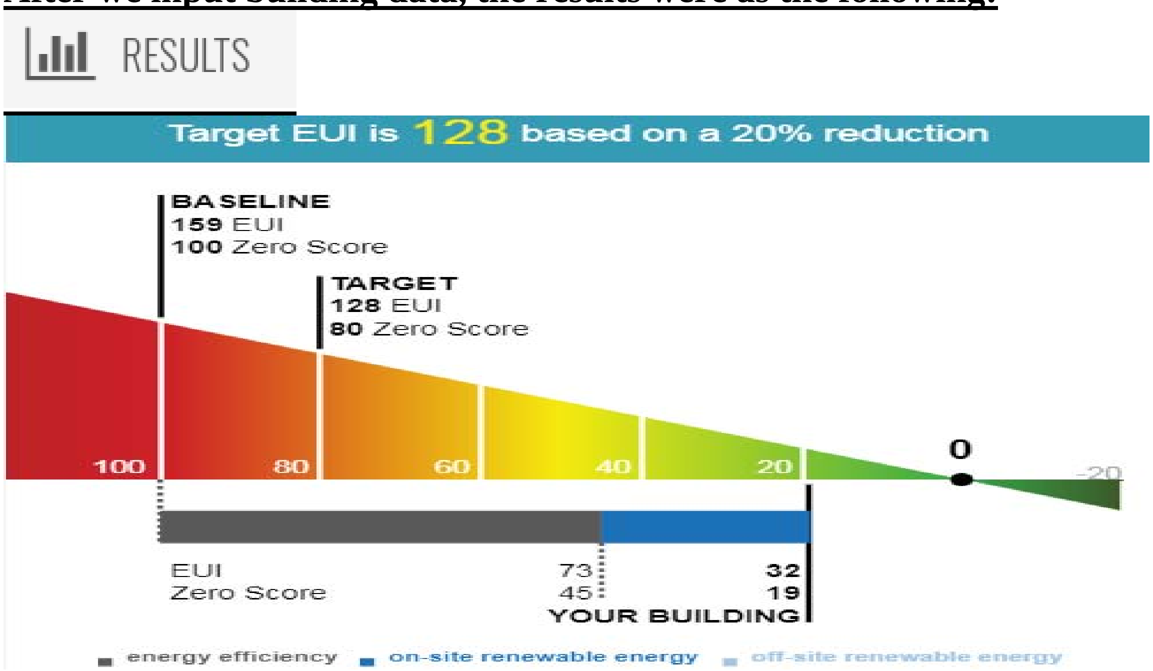


Fig (5-14) Results on the ZERO SCORE with the 20% reduction target. Ref: Architecture 2030. (2020). an Architecture 2030 project https://zerotool.org/zerotool, access 8/2019.

BUILDING SUMMARY

LOCATION	phoenix, AZ	85004
USES	Other Services	1,395 sq.m (100.0%)

RESULTS	BASELINE	TARGET	YOUR BUILDING
EUI % Reduction from Baseline	0%	20%	
EE			55%
EE w/ On-Site RE			81%
Zero Score	100	80	
EE			45
EE w/ On-Site RE			19
Site EUI (kWh/m²/yr)	159	128	
EE			73
EE w/ On-Site RE			32
Source EUI (kWh/m²/yr)	317	254	
EE			227
EE w/ On-Site RE			99
Total GHG Emissions (metric tons CO_2e/yr)	76	61	24

Fig (5-15) Results summary with the 20% reduction target. Ref: Architecture 2030. (2020). an Architecture 2030 project https://zerotool.org/zerotool, access 8/2019.

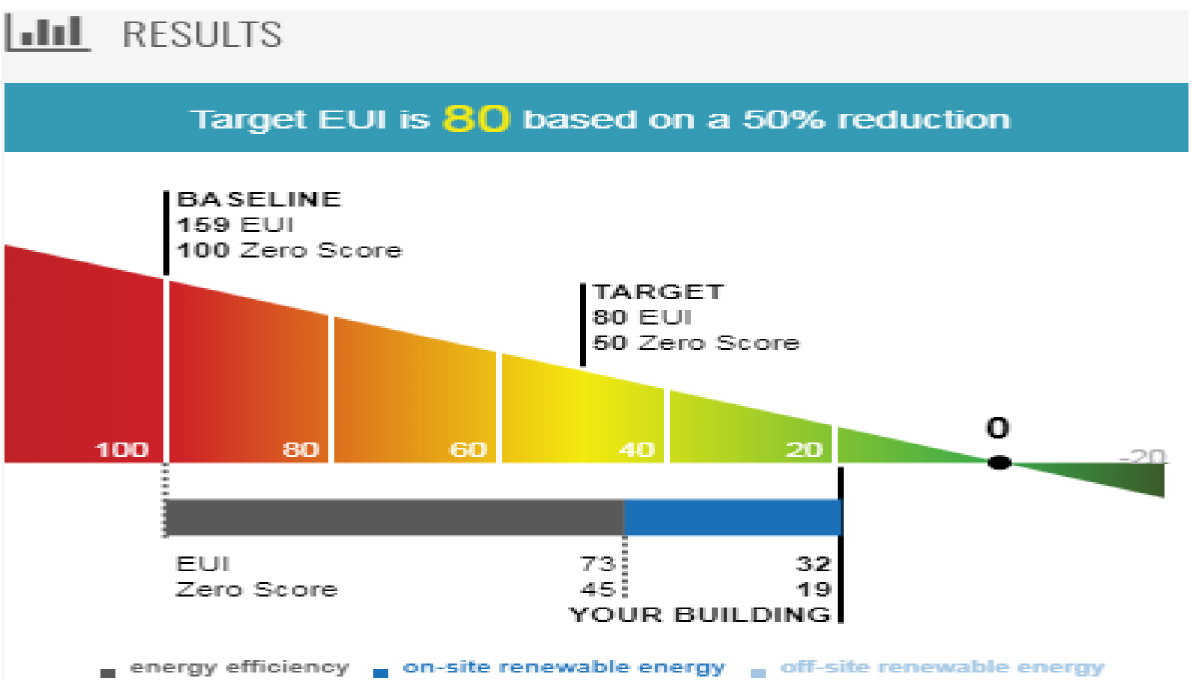


Fig (5-16) Results on the ZERO SCORE with the 50% reduction target. Ref: Architecture 2030. (2020). an Architecture 2030 project https://zerotool.org/zerotool, access 8/2019.

BUILDING SUMMARY

LOCATION	phoenix, AZ	85004
USES	Other Services	1,395 sq.m (100.0%)

RESULTS	BASELINE	TARGET	YOUR BUILDING
EUI % Reduction from Baseline	0%	50%	
EE			55%
EE w/ On-Site RE			**81%**
Zero Score	100	50	
EE			45
EE w/ On-Site RE			**19**
Site EUI (kWh/m²/yr)	159	80	
EE			73
EE w/ On-Site RE			**32**
Source EUI (kWh/m²/yr)	317	159	
EE			227
EE w/ On-Site RE			**99**
Total GHG Emissions (metric tons CO_2e/yr)	76	38	**24**

Fig (5-17) Results summary with the 20% reduction target. Ref: Architecture 2030. (2020). an Architecture 2030 project https://zerotool.org/zerotool, access 8/2019.

After analyzing the results in fig (5 - 14, 15, 16, 17), the research obtains for 20 % reduction target shows that the building performance is very good and even exceeds the target.

The target was set to be 20% reduction in the use of energy while the building scores more than 81% reduction.
The target energy use intensity is set to be 128 kWh, while the building uses only 32 kWh.
Total GHG Emissions are only 24 while the optimum is 61, ***zero score is 19***
Consequently, results with the 2050 reduction target that is set to 50% reduction are also very suitable and accepted.

The same results were obtained when using website **degreedays.net** to calculate heating and cooling degree day (HDD/CDD) data for entry into the Zero Tool instead of the postal code.

5-6 Retrofit the building (case study) to suit ZCAE:

To obtain ZCAE building (case study) apply the ZCA principles mentioned before in the research that to have a certain set of features and technologies that concentrated on the building's envelope and then we choose a power generation system that fits the building energy consumption.

5-6-1 Retrofit the building's envelope:

As shown in fig (5-18) 3D modeling for case study, the building's envelope contains several elements to become ZCA building as:

1- Using high-performance windows with high level insulation.
2- Using walls with a thickness of 25 cm with high insulation level.
3- Providing day lighting, as well as natural ventilation plus artificial ventilation.
4- Using high-grade insulation materials for roofs.
5- Use Nano materials to reduce maintenance and save energy.

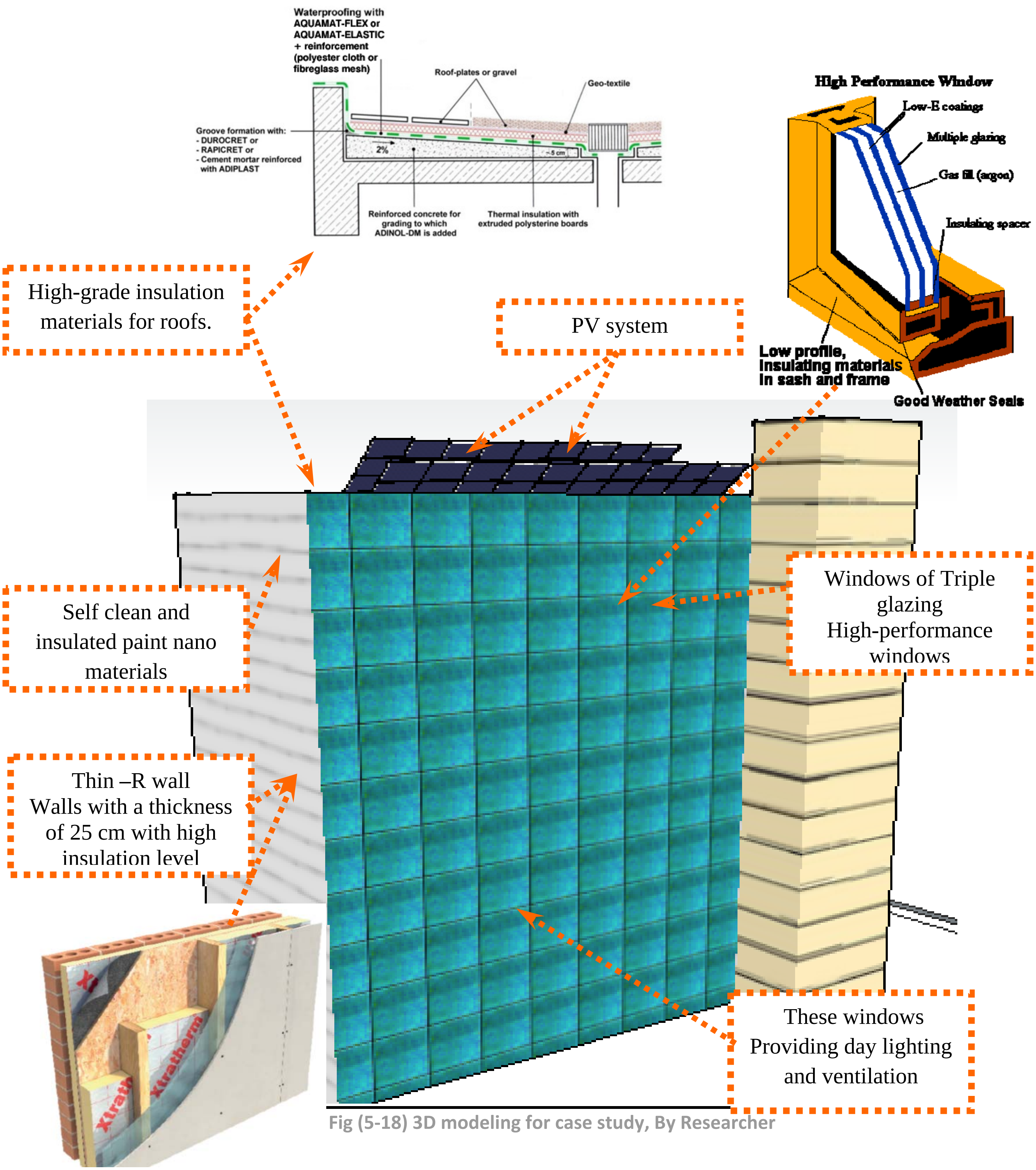


Fig (5-18) 3D modeling for case study, By Researcher

5-6-2 using Renewable Energy Technology design (solar photo-voltaic panels):

Using the data collected in the previous segment, some study will be done to decide the best angles of the PV panel and the best sort that would be suitable to the Egyptian background.

5-6-2-1 System selection:

For this research study, just one sort of solar power is expected for the research to be able to handle all elements of this method. The chosen device would be **solar photovoltaic systems.**

In order for the form of panel to be thin film, mono-crystalline or poly-crystalline would have a major impact on the amount of electricity produced;**Mono crystalline panels** will be used for better appearance and to help in the design process[1].

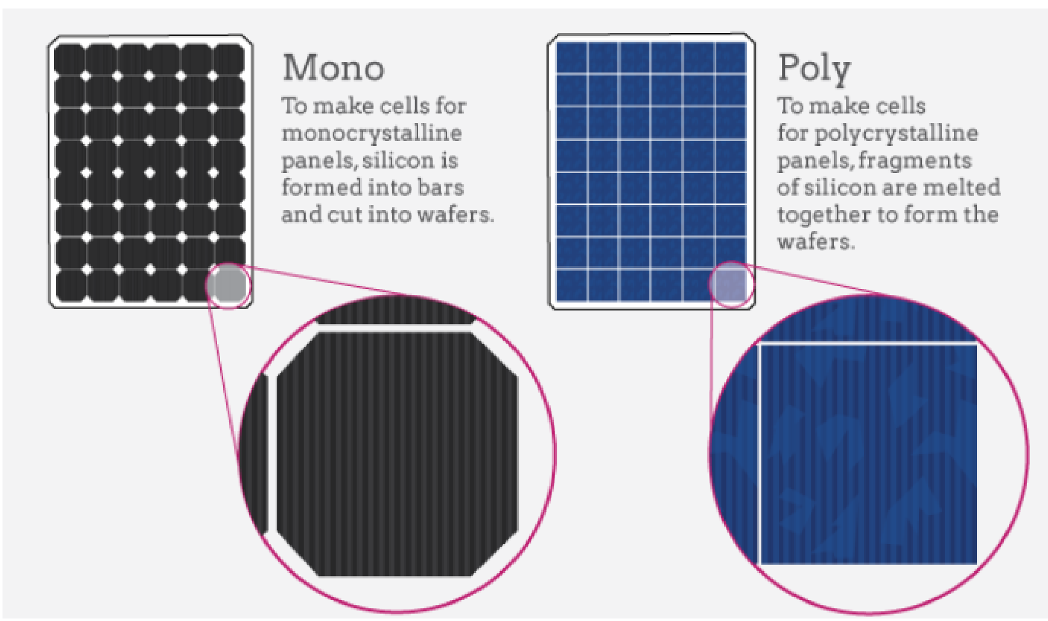


Fig (5-19) mono crystalline or poly crystalline
Ref: Electram Engineering. (2019). Monocrystalline and polycrystalline solar panels: what you need to know. https://www.energysage.com/solar/101/monocrystalline-vs-polycrystalline-solar-panels access /7/20

[1] Nasr Solar company. (2015). Application. HTTPs://nasrsolar.com/,access 8/2019.

5-6-2-2 System design:

The basic design and implementation measures will be addressed in the following section as applicable from the Naser solar site.
This site allows entering the building data in terms of the coordinates and the capacity of the solar panels in kilowatts, so it gives calculations of the potential solar radiation of the site, the number of solar panels and the distances between them and the appropriate angles to place them throughout the year.

A. site basic data:

Location: New Damietta, Egypt
Average Solar radiation rate annually: 3084 KWh/ m2
Building average consumption: 120 kW per day = 43800 KWh annually
Maximum power needed: 120 * 1.3 = 156 kWh per day = 56940 KWh annually

Solar panels power: Needed energy to be generated / solar radiation rate
56940/ 3084 **= 18.5 KWh.**

- Power of the mono crystalline solar panel = 1 KWh
- Number of needed panels: Power of panels needed / Power of one panel
18.5 / 1 = **19 panel needed.**

وحدة القياس	القيمة	العنصر
كيلووات/م2	**3084**	ألأشعاع الشمسي السنوي
شمال	31.3932	خط العرض
شرق	31.71162	خط الطول
كيلو وات	1	قدرة الألواح الشمسية

Fig (5- 20) Average Solar radiation rate annually for New Damietta, Egypt
Ref: Nasr Solar company. (2015). Application. HTTPs://nasrsolar.com/,access 8/2019.

B. Panels basic data:

- **The panels' orientation:** Panels will be built facing south on the basis of the solar statistical analysis previously given.

- **The panels' inclination angle:** 8° in the summer, 46 ° in the winter and **the best angle all over the year is 27°**.
- **Type of panels** is mono crystalline type ,it will give the best appearance and help in the design phase.
- **The spacing** between panels in order to avoid surplus shading of the panels on each other was calculated :

L1= 2.7m, L2=3.97m, **L3= 6.67m**, H=1.3m**, X=3m**, a=18.4°, fig (5-21).

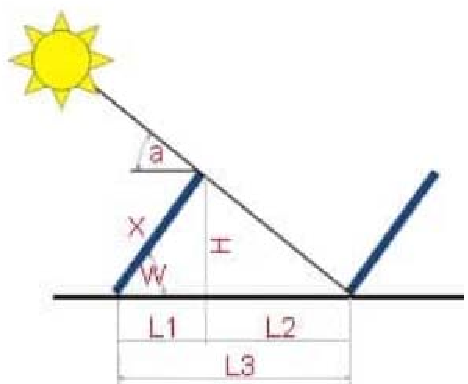


Fig (5-21) the spacing between panels
Ref: Nasr Solar company. (2015). Application. HTTPs://nasrsolar.com/,access 8/2019.

- **System used**

Net metering system will be used; this system is connected to the government nets, and uses a **Bidirectional meter fig (5-22)**.

This meter records inversely when the generated energy from the panels is more than the consumed energy and adds this difference to the client charge.

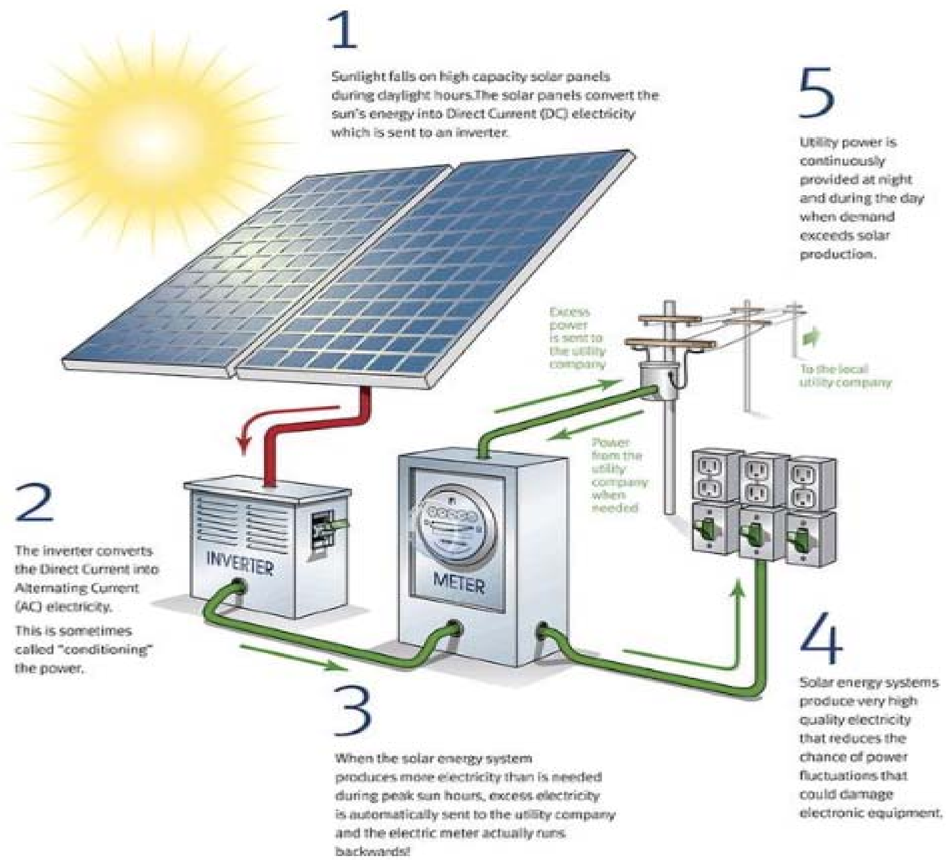


Fig (5-22) Net metering system
Ref: https://medium.com/@solar.dao/how-energy-travels-what-happens-with-pv-solar-power-16a047dbe87e ,7/20

C. Panel distribution and design:

After deciding the tilting angle, the orientation and the panel type comes the panel design phase on the roof of the building, and after the research we will use a micro inverter behind the panels (it has a small size)[1], and the panels are of different sizes, as the board consists of a group of PV cells connected to each other in one frame and connected between them.

Cells are standard 15.6 x 15.6 cm[2]

The 255-285 watt panels contain 60 cells (6 * 10) and the size is 99 * 164 cm

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[1] https://enphase.com/en-us/products-and-services/microinverters,2019

[2] Pv education.org. (2019). Module Circuit Design. https://www.pveducation.org/pvcdrom/modules-and-arrays/module-circuit-design,access 2019.

The 315-335 watt panels contain 72 cells (6 * 12) and the size is 99 * 196 cm
The 72-cell panels size 99 x 196 cm were selected fig (5-23)
so the solar panel grid will be designed in 2 rows in parallel, each row equipped with 30 PV Panels, each panel contains 72 cells (99 x 196 cm) with an electric output equal 335.3 watts.
The basic study designed with 19 PV Panels with an electric output equals 1 KW per panel; practically it is replaced by 3 PV Panels with an electric output equal 335.3 watts per panel as mentioned above.
Fig (5-24) Displays the planned panel allocation, including the highest limit of panels that could be constructed.

Fig (5-23) shows Dimensions of different solar panels

Ref: Pv education.org. (2019). Module Circuit Design. https://www.pveducation.org/pvcdrom/modules-and-arrays/module-circuit-design,access 2019.

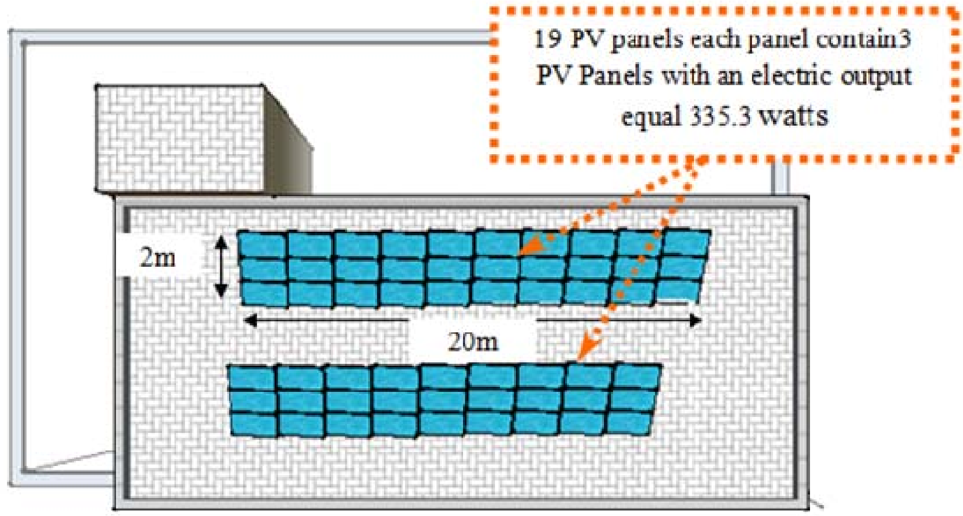

Fig (5-24)) shows the proposed panel distribution in layout. By Researcher

5-6-2-3 Zero Code evaluation:

The ZERO Code [1]– an Architecture 2030 initiative – is a national *and* international building energy standard developed for adopting jurisdictions. The ZERO Code incorporates current and cost-effective energy efficiency measures with on-site and/or off-site renewable energy resulting in zero-net-carbon buildings.

The ZERO Code software Energy Calculator currently includes weather and solar files for 2,500 cities worldwide.

When entering the data of the industrial building above (case study) to the Zero Code the results were as follows:

[1] Architecture 2030 initiatives. (2019). Zero code. https://dev-zero-code-2030.pantheonsite.io/energy-calculator/9/2019

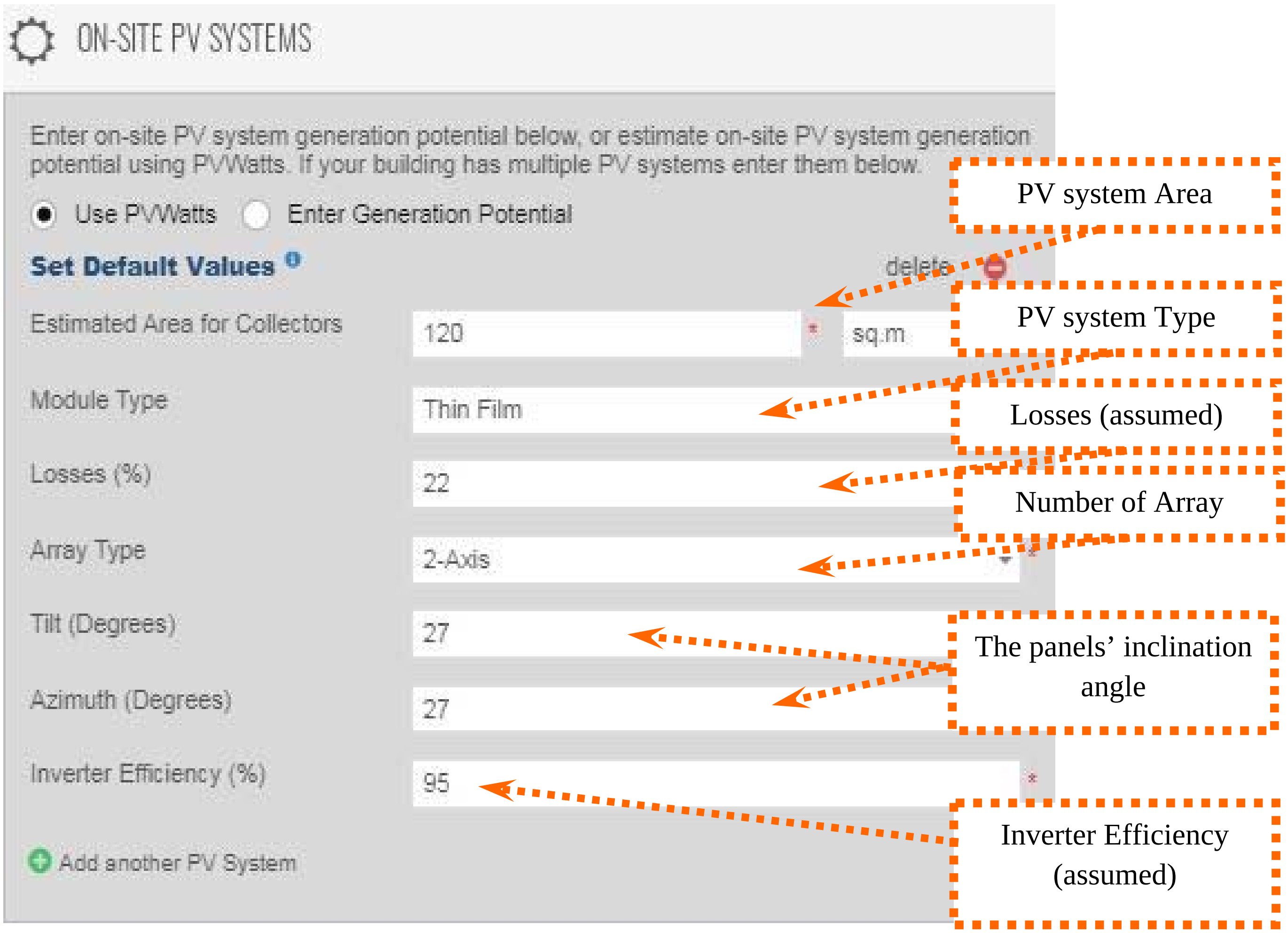

Fig (5-25) entry data
Ref: Architecture 2030 initiatives. (2019). Zero code. https://dev-zero-code-2030.pantheonsite.io/energy-calculator/9/2019

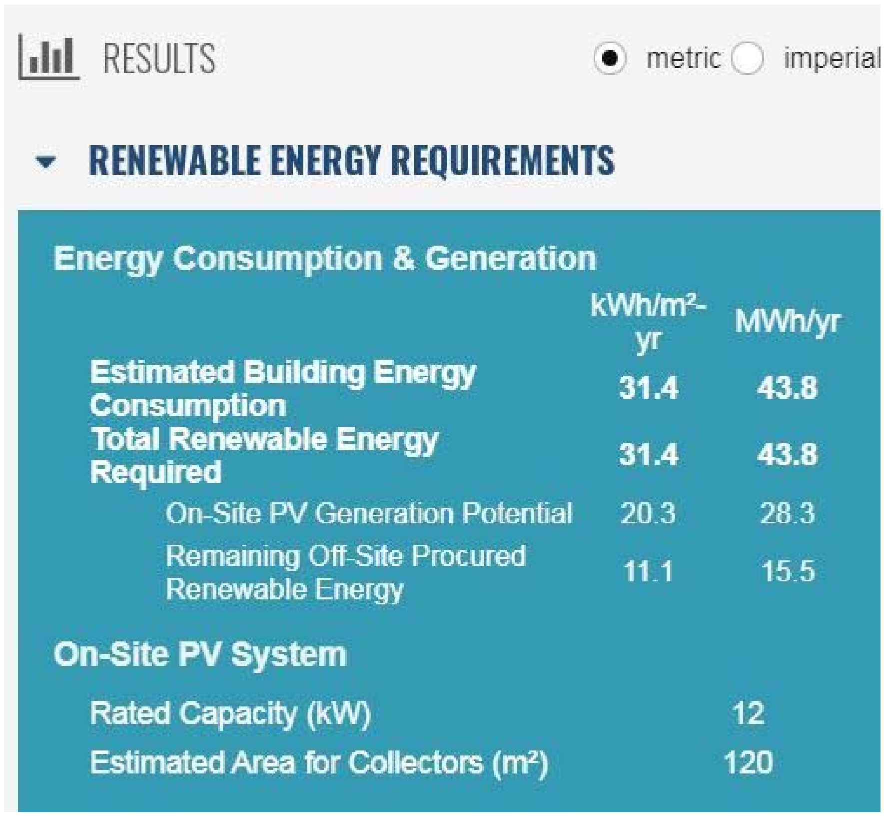

Fig (5-26) the results
Ref: Architecture 2030 initiatives. (2019). Zero code. https://dev-zero-code-2030.pantheonsite.io/energy-calculator/9/2019

So, these results in Zero code are almost similar to the results which already obtained from Zero Tool, as well as annual AC&DC production results fig (5-27).

In Zero code total energy consumption = 31.4 KWh/m2/yr

In Zero Tool EUI =32 KWh/m2/yr

FileID	23183.tm2
City	PHOENIX
State	AZ
FTE Solar Hours (hrs/yr)	2,358

	AC Production (kWh)	DC Production (kWh)
January	1,733	1,808
February	1,904	1,983
March	2,320	2,418
April	2,725	2,836
May	3,010	3,134
June	2,892	3,010
July	2,714	2,827
August	2,632	2,740
September	2,437	2,537
October	2,346	2,443
November	1,863	1,941
December	1,720	1,794
Total	**28,296**	**29,471**

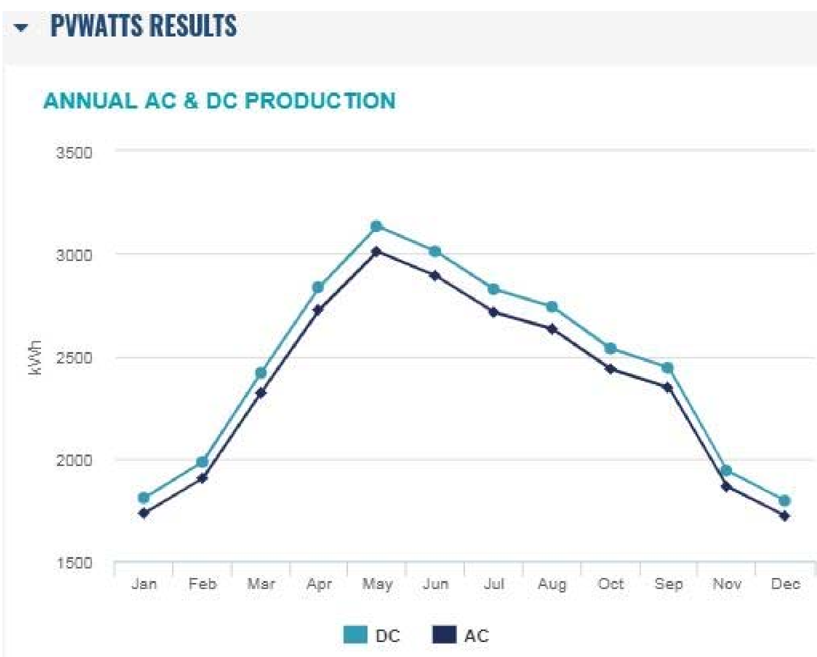

Fig (5-27) PV watts results
Ref: Architecture 2030 initiatives. (2019). Zero code. https://dev-zero-code-2030.pantheonsite.io/energy-calculator/9/2019

5-7 Industrial zone as a Case Study:

When we consider the industrial building model applicable to ZCA and apply it to the industrial zone as a whole to highlight the results economically and environmentally and optimize the benefit from it at the state level and generalize it in the industrial zone, in particular, to reduce economic burdens and support the state budget as well as to reduce pollution and CO2 emission.

Therefore, the above results will be applied to the industrial zone in the new city of Damietta as a case study, which contains approximately 75 industrial buildings as shown (5-28).

We will assume that the industrial zone consists of 75 buildings and that the factories are similar in area and energy consumption. We will apply the same model to the entire industrial area to maximize the benefit of applying ZCA principles.

Fig (5-28) layout for the industrial zone
Ref::New urban communities' authority. (2011) .NEW DAMETTA CITY MAP .http://www.newcities.gov.eg,access 2019).

By relating to long-term industrial development in order to produce the best outcomes by using a sustainable feasibility study to provide the country with positive returns for three axes fig (5-28):

1. **Economically**
2. **environmentally**
3. **"Visually" in urban areas**

1. **Economically:**

For one industrial building (case study), *the target was set to be **20%** reduction in the use of energy while the building scores more than **81%** reduction.*

The results saved 159-32= 127 KWh/m2/yr; in Site EUI.
For case study: we can save {127 *1395 m2} =**177165 KWh/yr**

For all zone {177165*75 buildings} almost produce 13287375 KWh/yr

This saved energy is estimated according to the energy prices in Egypt in 2020 for factories with heavy use (fifth tranche) **1.6 LE for 1KWh**.[1]

So the one industrial building can save {1.6 LE*177165} = **283464 LE in the year**

All zone it saves about {283464 * 75 buildings} = 21,259,800 LE in the year.

In addition to the reduction of energy consumption **(Research problem)** at the level of the country, ***<u>there are more than 21 million pounds</u>***, it can be saved for the state and used for several works

<u>Environmentally:</u>

For one industrial building (case study),
From previous results, it saves 76-24=52 metric tons CO2e/yr; from total GHG Emissions.

For all zone it saves about {52*75 buildings} = 3900 metric tons CO2e/yr

So this output will directly help **reduce carbon emissions by almost 30%** and thus reduce temperatures that contribute to the problem of **global warming** **(Research problem).**

2. **<u>Urban "Visually":</u>**

The level of urban and visually will contribute significantly to change the mental image of buildings by adding solar panels on the roof of the building or facade of

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[1] Rahma Ramadan. (2019). the energy prices in Egypt.https://www.youm7.com/story/2019, access 6/2020

the building as well as possible to create lighting poles solar energy to save more energy then to produce **Zero Carbon City** in the future.

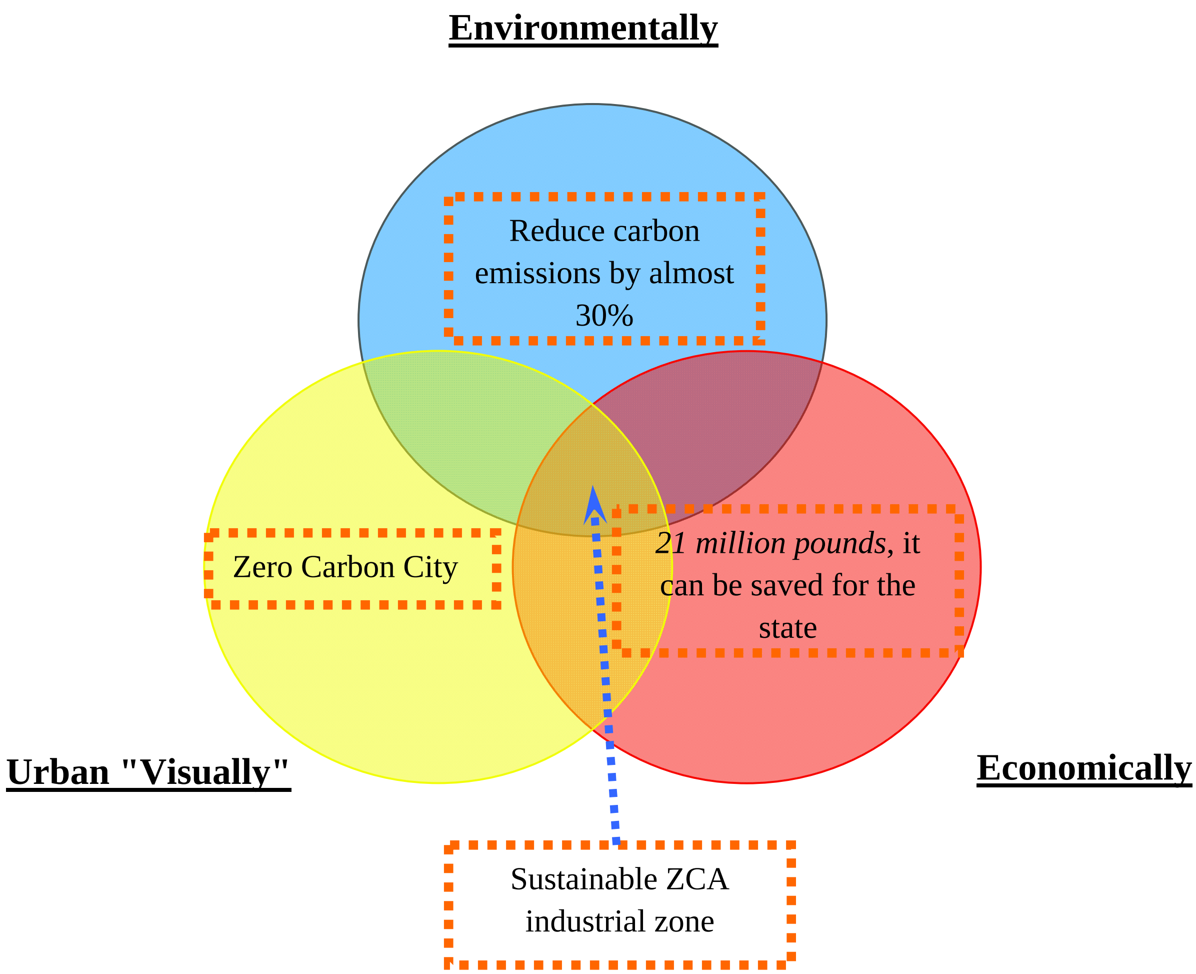


Fig (5-29) layout for the industrial zone positive returns ,By Researcher

5-8 Conclusions:

Zero energy emissions and zero carbon architecture can be realized in Egypt through definite strategies. **This chapter introduced the first prototype industrial building that meets the 2030 challenges of energy reduction, using international applications as the Zero tool and Zero Code.**

Zero Tool can be used to measure ZCAE as LEED as a certeficate for ZCAE.

The study chose an existing industrial building for the scenario based on the previous results that recommended starting retrofitting of industrial buildings then the residential ones.

This scenario uses the real industrial building in the New Damietta City area as a research study. The project has a determine degree of energy efficiency and requires a large amount of electricity to be used. If the energy efficiency could be improved and the energy could be produced by PV panels, the project could be a zero-energy building, thus introducing this model in the industrial zone.

Measuring ZCAE by using the international application **Zero Tool**, the energy intensity use performance of industrial building documented, and a total of power needs to be generated from the building calculated.
Nasr solar website used to determine the solar panels needed, their area,
Mounting position, row spacing and inclination, in addition to design recommendations, then evaluated by **Zero Code** application.

This scenario lead to a zero carbon prototype in Egypt, with Utilize in the energy saving for the state at the urban, economic and environmental levels as a scientific addition, as well as the possibility of a sustainable feasibility study of ZCAE as a future thought.

The obtained results at the industrial zone as (**Case Study**) are valuable for the state as follows:

1. <u>Economically</u>

In addition to the reduction of energy consumption **(Research problem)** at the level of the state there are more than 21 million pounds, it can be saved for the state and used for several works.

2. Environmentally:

For all zone it saves about 3900 (metric tons CO_2e/yr) from total GHG Emissions.
So this output will directly help **reduce carbon emissions by almost 30%** and thus reduce temperatures that contribute to the problem of **global warming** **(Research problem).**

3. Urban "Visually":

The level of urban and visually will contribute significantly to change the mental image of buildings to produce **Zero Carbon City** in the future.

Thus, the applied study concluded by presenting an industrial building model in the industrial zone in new cities that applies ZCA thought in Egypt (ZCAE) **(main objective).**

conclusions on the applied study

At the end of the applied part of the study, and after presenting the proposed model for an industrial building that applies ZCA principles and using ZERO TOOL to measure ZCA, the research tried to find economic, environmental and construction benefits for the state as a whole after a presentation and explanation of how to apply the principles of ZCA, starting from directing the building to the building envelope and using smart materials and technologies for smart buildings as well as the energy production and consumption system to reach ZCA.

Thus, the research reaches its main Objective, which is:

-Approaching to Zero Carbon Architecture (ZAC) in Egypt

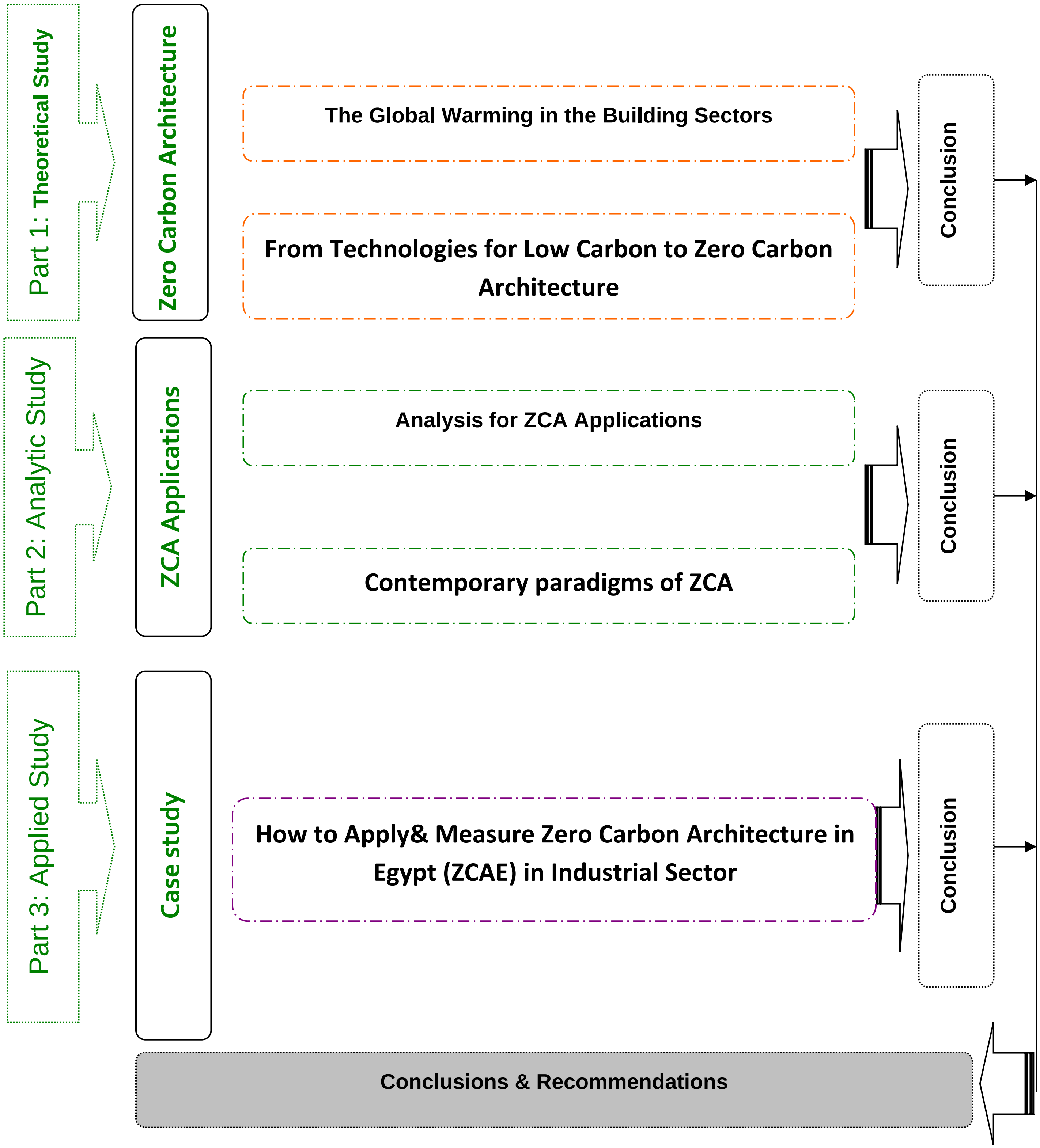
And some of the sub Objectives, namely:

- Obtaining a suitable scale for buildings in Egypt to measure the reach of building to zero carbon.
- How to reach ZCA.

At the end of this part, we can see that the second hypothesis of the research can be reached, namely:

-*Future Scenarios* for Zero Carbon Architecture will lead to long-term sustainable feasibility architecturally, urbanly, economically, environmentally and visually.

Conclusions & Recommendations


Part 1: Theoretical Study
Zero Carbon Architecture
The Global Warming in the Building Sectors
From Technologies for Low Carbon to Zero Carbon Architecture
Conclusion
Part 2: Analytic Study
ZCA Applications
Analysis for ZCA Applications
Contemporary paradigms of ZCA
Conclusion
Part 3: Applied Study
Case study
How to Apply& Measure Zero Carbon Architecture in Egypt (ZCAE) in Industrial Sector
Conclusion
Conclusions & Recommendations

Contents

➢ Conclusions :

1- First, the research concluded in the **theoretical study** to basic concepts and principles as follows:

- Global warming **(Research problem)** is the rises since mid-20th Century and its expected continuation in the average Earth temperature of near-surface air and oceans.

- Greenhouse gas emissions from buildings are expected to rise at 280 Mt by 2050.

- In the Government's strategy to combat emissions particularly under the emissions trafficking scheme, the building sector might play a major role in reducing the cost of economic reduction across the country.

- Technologies for low carbon include energy and design; these technologies considering the reduction of consumption of non- renewable energy and replace it with renewable energy.

- **Low and zero carbon technologies**; However, the requisite low-carbon skills are trained in energy efficiency, comfort and thermal performance through engineering. They should generate zero net carbon among all power consumption at building for a year.

A NEB building, is a building with zero energy consumption and zero carbon emissions each year, a building with zero energy, a NEB, or a NEB. Buildings generating surplus energy during the year can be labeled "energy-plus buildings" and "ultra-low energy" buildings that consume no more energy than they generate.

- Zero carbon architecture (ZCA) aims to increase energy efficiency and enhance smart building technology.

2- Second, conclusions of **Analytic study** as follows:

-By analysis of ZCA applications:

- In energy application:

- Energy saving technologies gives us the opportunity to move into new high value-added areas both by creating new architecture and by radically changing traditional ones.

- In design application:

- Zero and Low Carbon Buildings can make changes to the working practices by using computer simulations and image processing to reduce greenhouse gas emissions associated with the building design.

- Zero carbon architecture reaches zero carbon emissions by optimizing energy consumption, rigorous design concept, recycling of resources and green land.
- The study focused on contemporary paradigms of zero carbon building

These building are chosen from around the world Germany, UK, Hong Kong, UAE and Egypt.

These building selected upon its energy efficiency, renewable energy and awards which had got, these buildings show that the additional costs compared to a regular new building can be decreased.

3- Third, conclusions of **Applied study** as follows:

The research introduced the first prototype to retrofit industrial building that meets the 2030 challenges of energy reduction, using international applications as the Zero tool and Zero Code.

Zero Tool can be used to measure ZCAE.

The study chose the industrial zone for the scenario based on the previous results; this scenario will utilize an existing industrial building in New Damietta City area as its case study. The building has certain energy performance level and needs a certain amount of electricity to perform. If the energy performance could be enhanced and the electricity could be generated through PV panels, then the building can be a zero-energy building, accordingly applying this model at industrial zone.

Measuring ZCAE by using the international application **Zero Tool**, the energy intensity use performance of the industrial building will be documented, and the amount of energy needs to be generated from the building will be calculated.

This scenario will lead to a zero carbon prototype in Egypt, with Utilize in the energy saving for the country at the urban, architectural, economic and environmental levels as a scientific addition, as well as the possibility of a sustainable feasibility study of ZCAE as a future thought.

➢ Recommendations:

the research suggests the following recommendations generally:
1-The implementation of ZCA leads to the long-term solution of, environmental, global warming issues.
2-The application of ZCA in Egypt has a powerful influence on engineering and energy.
3- Many syllabuses must be advanced to educate architecture students admitted the concepts of ZCA.
4- A strategy must be developed to control and enhance ZCA in collaboration with government institutions and major world powers.
5- The ZCA usage will generate a special architecture value in the long run and image of the city will indeed be transformed.
6 – At first, ZCE must be applied to new buildings.
7- The following should be used to activate ZCA in Egypt:

a-To spread knowledge of the value of the implementation of ZCA at all scales and to help raise awareness and community culture.
b -Connect construction licenses to an acceptable level of environmental efficiency.
c-Promote a relationship with the private sector as well as the initiatives initiated by ZCA.
d- Take advantage of international expertise in this area.
e-Provide advanced research labs to observe the environment in order to establish design solution.
f-Coordination with several other organizations. for ZCA-activated
g-To try to coordinate between the concepts of ZCA and the feature of Egyptian architecture style in order to achieve a satisfactory level of performance.

The recommendations are distributed in detail as follows:

First, the recommendations directed at architectural education:

1- Activate the framework of the applied study conducted by the research to include all buildings, to create a database through a specialized committee, and work on its application.
2- Formulate strategic research visions in architecture and complementary fields.
3- Develop some educational curricula such as architectural design to accommodate ZCA and its principles.

Second, recommendations directed at governments and decision-makers:

1- The need for the state to encourage and sponsor scientific research for this type of research, and to hold training courses, free for all engineers working in this field.
2- After limiting the current situation to the state plan, we study industrial and logistics facilities and apply scenarios for the future and follow up.
3- Try to take advantage of the global experiences and the application locally.
4- The importance of law-making and adoption using studies and future scenarios.
5- Setting an annex to the special requirements on the environmental law.
6- The development of laws with an architectural requirement supplement rises to the required level.

Third, recommendations directed at the producing companies:

1- Develop existing projects for ZCA application to have economic, practical and environmental returns.
2- Technology solutions are at different levels of growth, and initiatives must also concentrate on both the near-market commercialization of these technologies and on study, growth and display for those further away.

Fourth, recommendations directed at engineering Syndicate and unions:

1- Supporting and implementing ZCA thinking in all establishments that will be licensed or supervised.
1-Training engineers to implement buildings that apply ZCA principles, emphasizing the importance of converting ordinary buildings into buildings that apply ZCA thinking, and providing engineers with the necessary information and technologies for that.

Fifth, creation of an administrative system for the control and operation of the ZCE of its specialties is:

1-Activation of the ZCA as one of the approvals of the building license.
2-Management, follow-up and growth to improve the building and project requirements and raise awareness of the ZCA principle.
3 – Designing regulations, tracking progress and evaluation.
4-Coordination between this facility and other government entities specializing in engineering and power.
5-Development of modern applications to conform to the nature of the Egyptian climate.

So, this research opens the way for **future studies** such as:

- Complete studies and research to achieve Zero Carbon Architecture in Egypt (ZCAE).
- Study the possibility of applying the principles of ZCA for short or long term factories.
- Study the extent of achieving community partnership with the country to reach out to ZCAE.
-The need for a study of the economic costs and budget that the state can work.
- Conducting future studies based on design criteria proposed for the current and future situation.
-In the future, it would be important to consider major technological requirements and specifics at a very early stage, such as the use of nanomaterials and insulation materials with advanced technologies to increase energy efficiency.
- Architects of the future, need new and challenging expertise concerning the design of sustainable and zero carbon buildings will be required.
- It is an opportunity we must seize, and the governments shall put in place the public goods such as a world-class science and technology base, incentives for knowledge transfer and high educational standards, to enable companies to put innovation at the center of their strategies for the development of ZCA criteria.

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Appendix (Questionnaire)

Questionnaire--

Contents

Questionnaire---

1- The questions of Questionnaire:

1 – Do you think that architecture contributes to solve the phenomenon of global warming? "Likert Scale"

While asking about the extent to which the participants agreed to this, the answers were various and the result was as follows: **strongly agree 48%, Agree 38% Neither agrees nor disagree 8%, Disagree 2%, strongly disagree 4%**

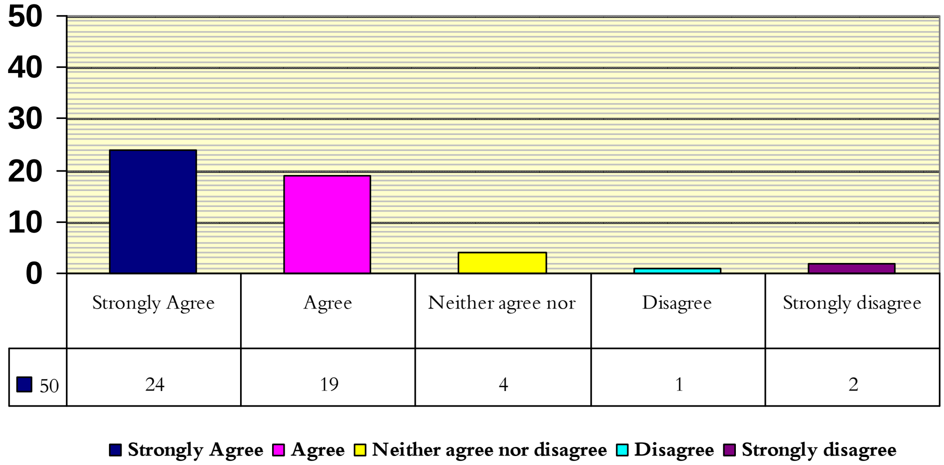

Fig a presents the result of the first Question by researcher

2– Application of ZCA leads to the resolution of global warming, energy and environmental issues (short-term – long run- I don't know).

<u>The answers were as follow:</u>

The short run … 20 %, long run … 62%, I don`t know …18%

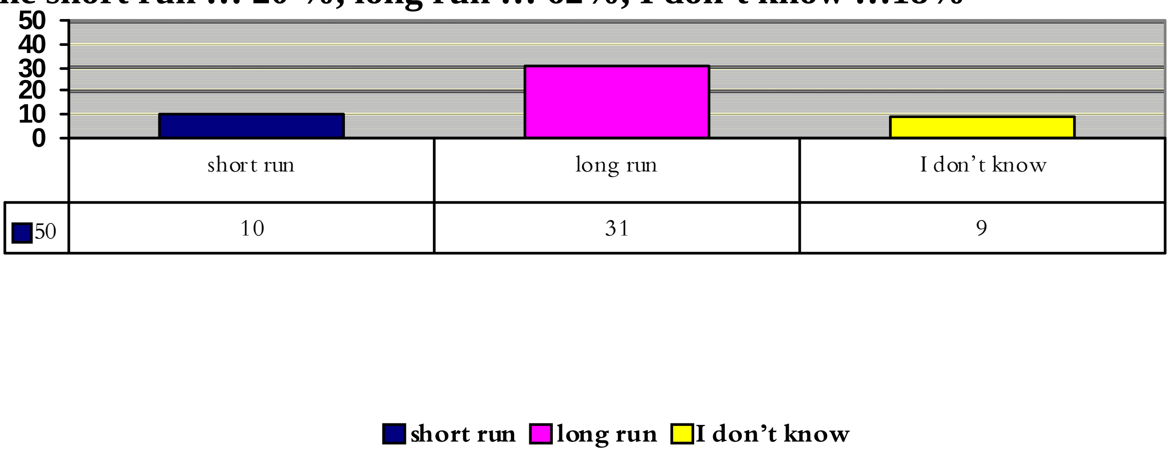

Fig b presents the result of the second Question by researcher

3 - How does the application of ZCA affect architecture and energy in Egypt? "Likert Scale"

While asking about the extent to which the participants agreed to this, the answers were various and the result was as follows: **strongly agree 18%, Agree 40% Neither agree nor disagree 22%, Disagree 18%, strongly disagree 2%**

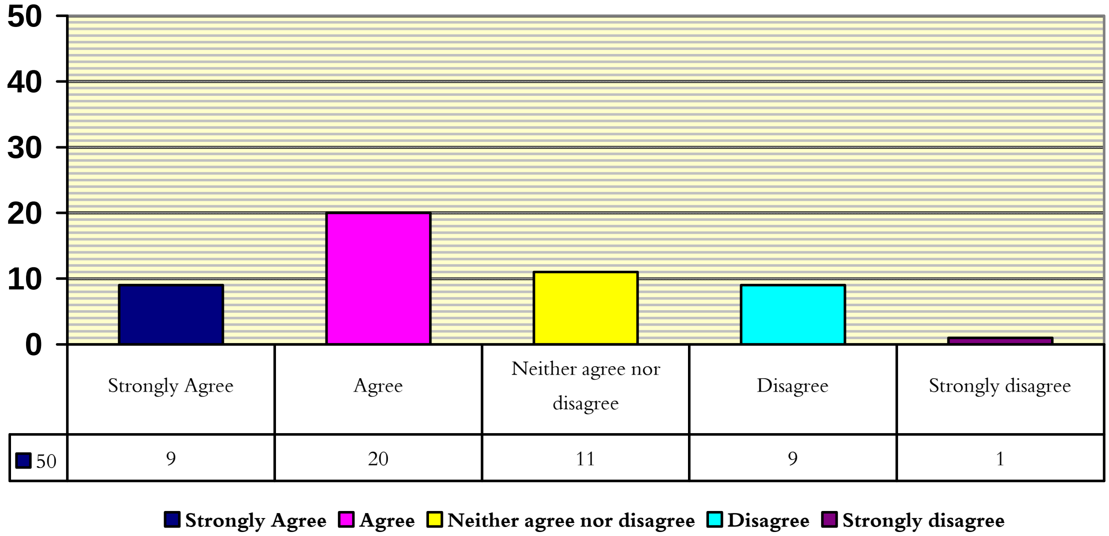

Fig c presents the result of the third Question by researcher

4- Which buildings do you support application of ZCA at first New Buildings or Old Buildings?

The result was as follows: **new Buildings 86%**, **Old Buildings 14%**

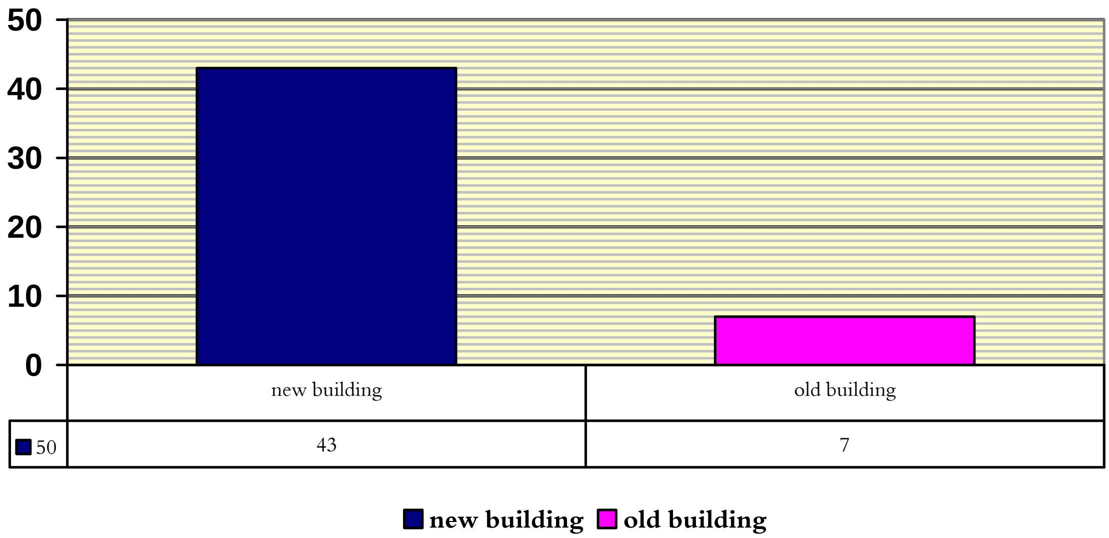

Fig d presents the result of the fourth Question by researcher

5- In which building sector shall we start to apply ZCA in Egypt?
(Residential building – industrial buildings – educational buildings - Commercial and administrative buildings).
The results were as follow:
(Residential building 44% – industrial buildings 46% – educational buildings 6% - Commercial and administrative buildings 4%).

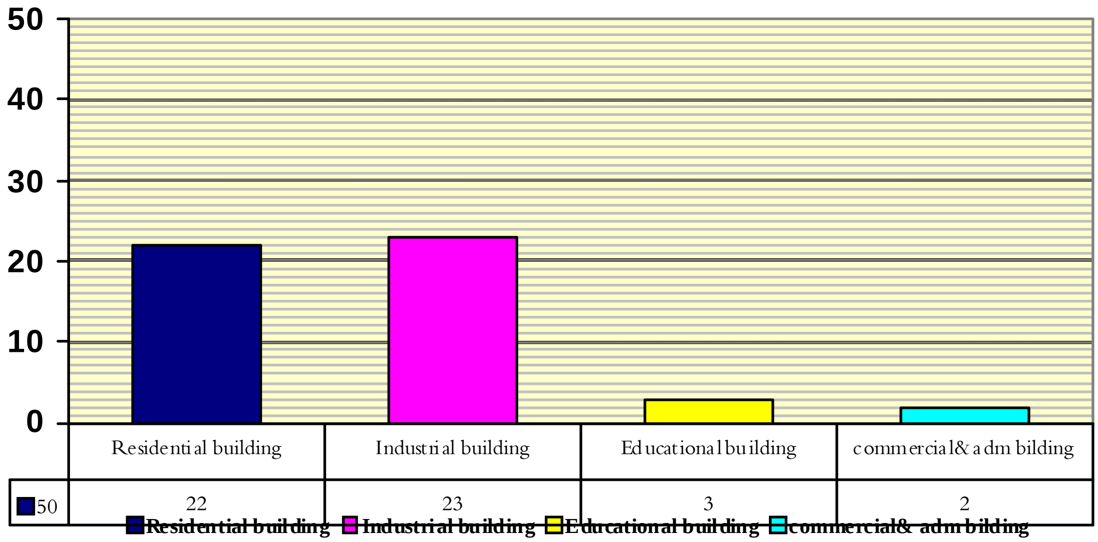

Fig e presents the result of the fifth Question by researcher

6- Do you think the application of ZCA is high cost? "Likert Scale"
The results were as follow:
strongly agree 14%, Agree 56%,Neither agree nor disagree 26%, Disagree 4%, strongly disagree 0%

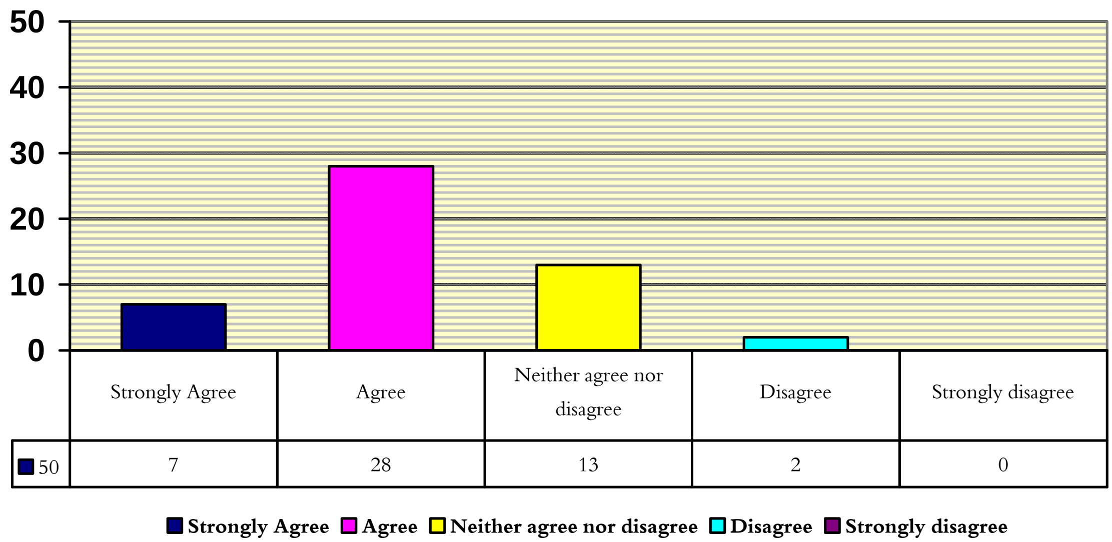

Fig f presents the result of the sixth Question by researcher

7- Do you think the application of ZCA is not expensive in the long run? "Likert Scale"

<u>*The results were as follow:</u>

strongly agree 12%, Agree 64%,Neither agree nor disagree 16%, Disagree 8%, strongly disagree 0%

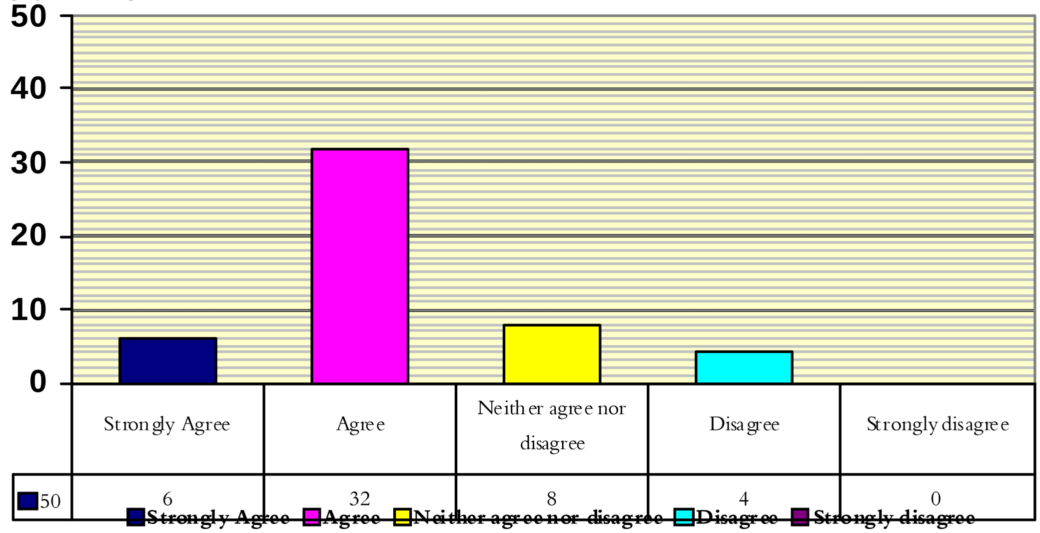

Chart g presents the result of the seventh Question by researcher

8 - In order to apply ZCAE, designers and architects must identify and train the concepts of ZCA via workshops, training courses, explanatory seminars, science conferences or all of the above.

<u>*The results were as follow:</u>

Workshops 10%, training courses 4%, explanatory seminars 8%, scientific conferences 2% or all of the above 76%.

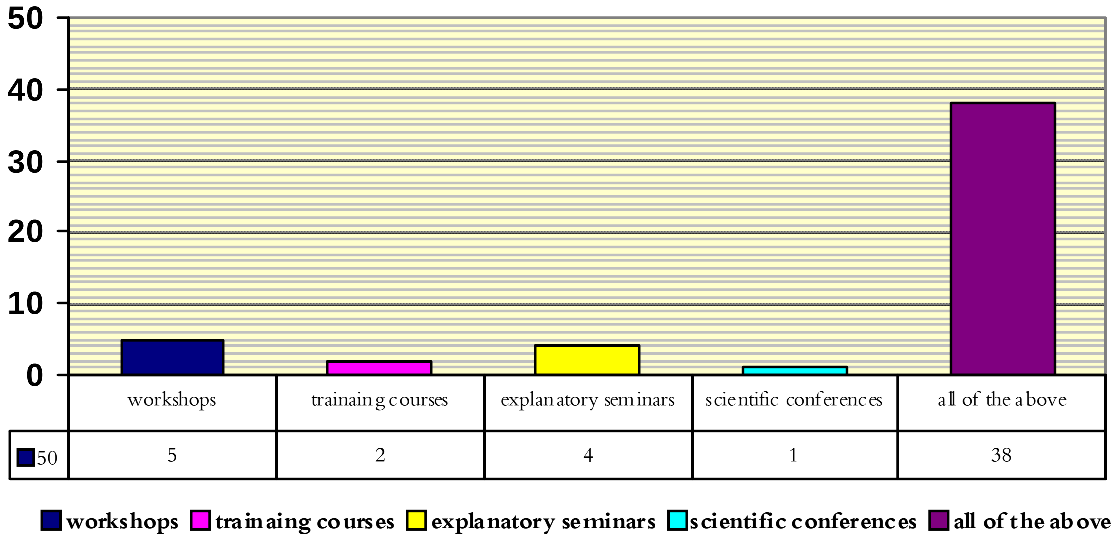

Fig h presents the result of the eighth Question by researcher

9 - If you have other suggestions, please mention them.
When I ask about the opinion of the participants, the answers were various as follow:

ZCA was applied through:

1- Architecture education and Post University education.
2- Training missions.
3- Get ZCA certificates such as LEED
4- Field visits to models of buildings used and awareness-raising of the findings.
5- Application of a framework for the production and repair of technical requirements for buildings in conformity with the standards of the ZCA

10- Some curriculums must be developed to learn students at architecture colleges activation and application of ZCA standards…."“Likert Scale”
<u>*The results were as follow:</u>
strongly agree 70%, Agree 26%,Neither agree nor disagree 4%, Disagree 0%, strongly disagree 0%

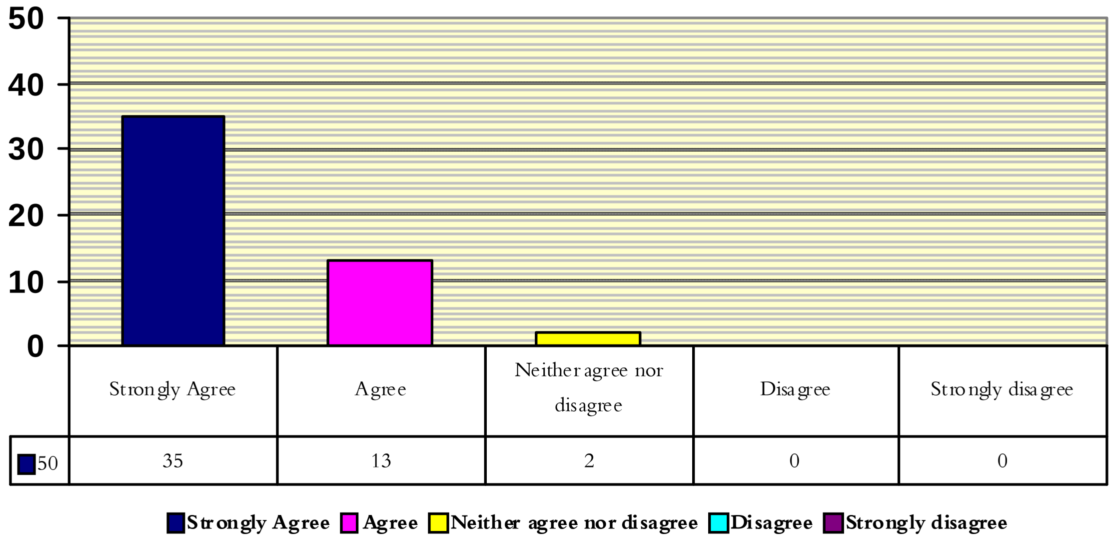

Fig i presents the result of the tenth Question by researcher

Questionnaire---

11- In your opinion, what is the feasibility of applying ZCA in Egypt?
(Economic - healthy - formative - environmental (for energy consumption).

- **The results were as follow :**
  (Economic 26% - healthy 30% - formative 2% – environmental 42%)

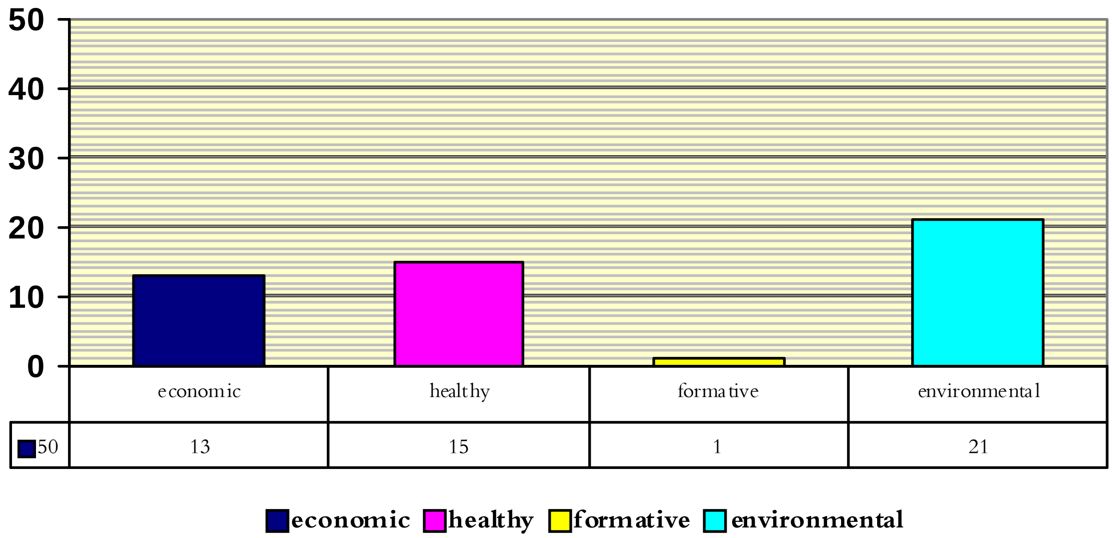

Fig j presents the result of the eleventh Question by researcher

12- A structure must be developed to control and enable the ZCAE in collaboration with government institutions and big powers? "Likert Scale"
<u>*The results were as follow:</u>
Strongly agree 40%, Agree 40%, Neither agree nor disagree 14%, Disagree 6%, strongly disagree 0%

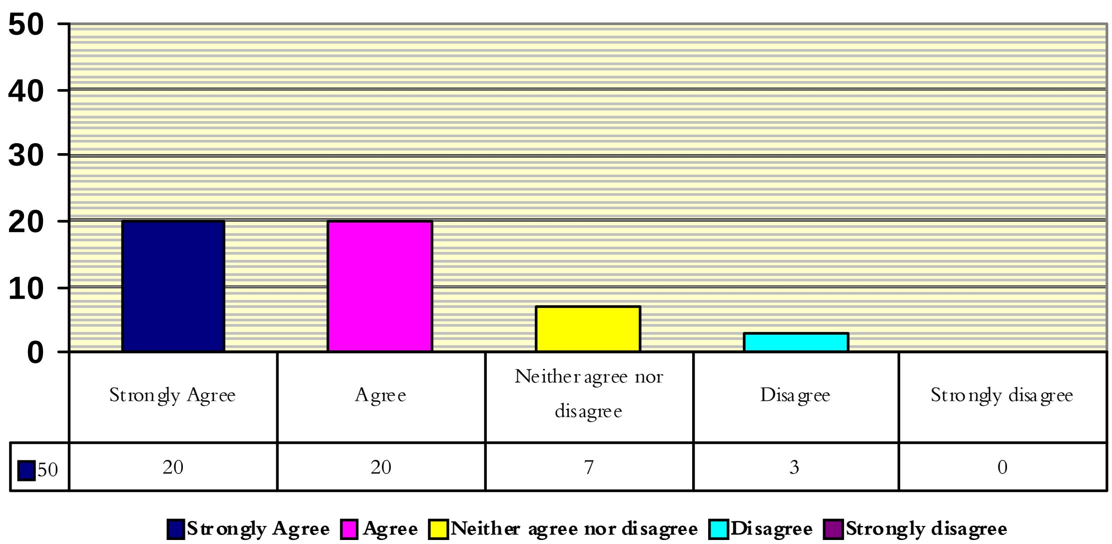

Fig k presents the result of a question number 12 by researcher

13 -If you agree with the previous question, what are the specialties of this system in your point of view?

When asking about the opinions of participants, the answers were various as follow: (Exclude some answers because is not useful)

1-Activation of the ZCA as one of the approval of the building licence.

2-Management, follow-up and growth to improve the building and project requirements and raise awareness of the ZCA principle.

3– Designing regulations, tracking progress and evaluation.

4– Assistance and supervision

5 - National and regional planning.

6-Coordination between this facility and other government entities specialising in engineering and power.

7-Protecting the environment and maintaining resources.

8-Development of modern applications to conform to the nature of the Egyptian climate.

14 – Depending on the activating (ZCAE), the elements of the formation must be adjusted. "Likert Scale"

<u>***The results were as follow:**</u>

Strongly agree12%, Agree 58%, Neither agree nor disagree 20%, Disagree 10%, strongly disagree 0%

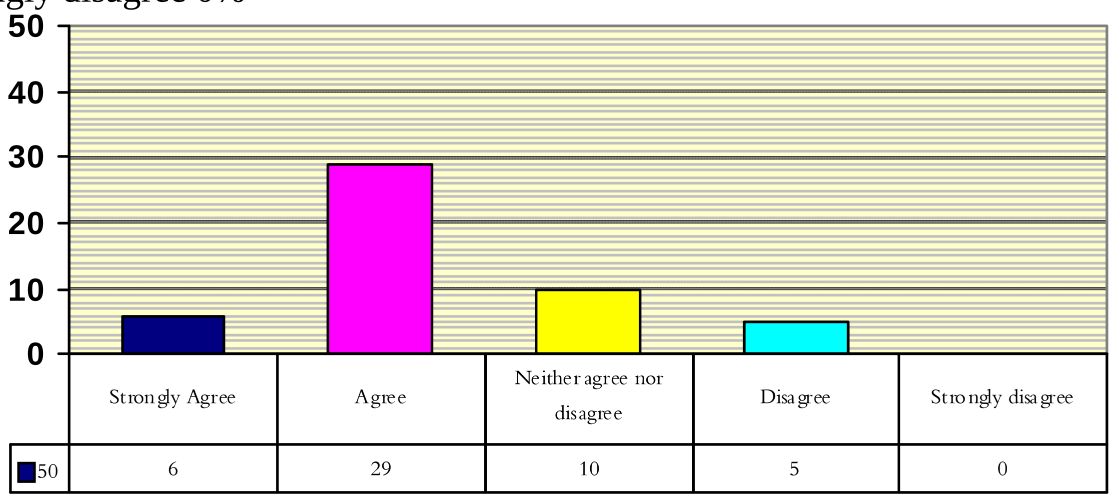

Fig l presents the result of the fourteenth Question by researcher

15 - When activating ZCA, do you think that the mental image of the city will be changed and new quality architecture will occur in the future?
“Likert Scale”
<u>*The results were as follow:</u>
Strongly agree 28%, Agree 52%, Neither agree nor disagree 16%, Disagree 4%, strongly disagree 0%

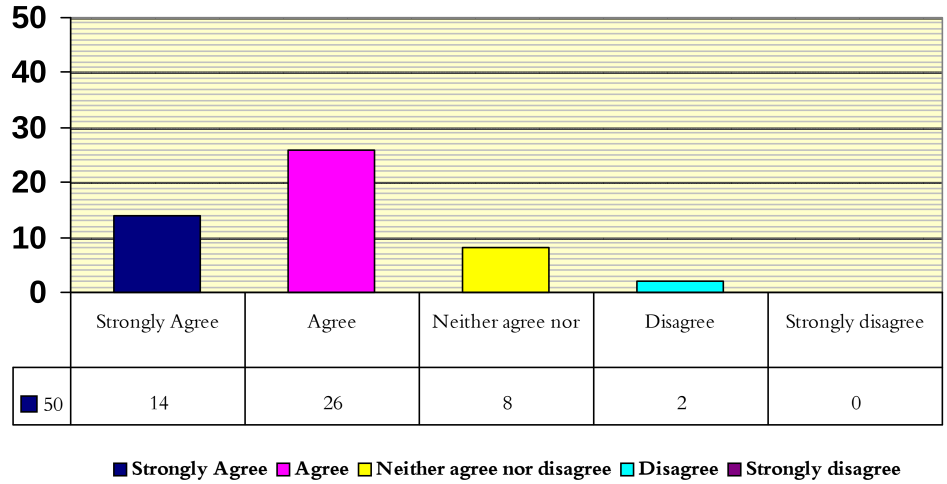

Fig m presents the result of the fifteenth Question by researcher

16 - In your opinion, what other procedures should be taken to activate the ZCA principles in Egypt (ZCAE)?

** When asking about the opinions of participants, the answers were various as follow:

1 – The awareness and education of the importance of ZCA application is not only at the level of specialists but other individuals.
2 - Activate the environmental requirements of the building.
3 - Establishment of Ministry.
4 - Coordination between building licenses and obtaining an appropriate level of environmental performance assessment.
5 - Spread awareness and community culture of ZCA function.
6 – Experimental application of some buildings and inventory and analysis of results, such as "government buildings".
7 - Explanation of financial impact.
8 - The state and society adopted this thought.
9- Application of sustainable design principles.
10 –spread awareness of the economic and environmental benefits of ZCA by activating the role of media, journalism and the Internet.

Questionnaire--

11 – To obligate state projects to apply ZCA as a leading projects , especially in the government housing models such as Social Housing and Residence of Egypt
12 - Encourage the projects which applied ZCA such as tax exemption.
13 - Encourage partnership with the private sector and banks in long run projects such as solar cells, which generate long-run returns.
14 - Impose control on non-conforming building materials.
15 – Take advantage of the international experiences at this field, especially countries which have similar environmental and economic conditions.
16 - This thought must be adopted and be an important case of study at the Department of Architecture and also be specialized.
17 - Provide specialized research laboratories to study the environment and produce suitable architectural solutions of our environment, in coordination between architects and all other disciplines.
18 - Coordinating with the specialized authorities to follow the specialized companies in the building materials as well as developing a suitable methodology to be a reference for the ZCA.
19 - Obligation large companies to support ZCA application.
20 - Trying to manage between the concepts of ZCA and the components of Egyptian architecture in order to achieve progress.

Questionnaire---

Appendix (Questionnaire)

Questionnaire---

Mansoura University

Faculty of Engineering

Department of Architectural Engineering

بيانات المشترك:

Section 1 of 2

التخصص/ *

Short answer text

Section 2 of 2

مفاهيم :

(ZCA) zero carbon architecture :

العمارة التي تنبعث منها غازات ضارة للبيئة بنسب أقل بسبب انتاجها الذي يكاد يكافئ استهلاكها للطاقة (العمارة خالية من الكربون)

(ZCE) zero carbon architecture in Egypt:

العمارة الخالية من الكربون في مصر

*توضح بيانات من إدارة معلومات الطاقة الأمريكية أن المباني مسؤولة عن نصف الاستهلاك (48٪) تقريبًا من جميع استهلاك الطاقة وانبعاثات الغازات الدفيئة سنويًا .

*يمثل قطاعي المبانى السكنية والصناعية نسبة 76% من انبعاثات الكربون التي تؤدي بدورها لظاهرة الاحتباس الحرارى .

الاسم / *

Short answer text

الأسئلة الموجهة/

Questionnaire---

* 1- هل تعتقد ان العمارة تساهم في حل ظاهرة الاحتباس الحرارى؟

- [ ] اوافق بشدة
- [ ] اوافق
- [ ] لا مع ولا ضد
- [ ] اعترض
- [ ] اعترض بشده

* 2- تطبيق (ZCA) يساهم في حل ظاهرة الاحتباس الحرارى ومشاكل الطاقة والبيئة علي المدي

- [ ] القريب
- [ ] البعيد
- [ ] لا أعرف

* 3- ما مدى تأثير تطبيق (ZCA) في مصرعلي العمارة والطاقة؟

- [ ] قوي جدا
- [ ] قوي
- [ ] لا قوى ولا ضعيف
- [ ] ضعيف
- [ ] ضعيف جدا

* 4- في أى المبانى تؤيد تطبيق (ZCE) أولا ؟

- [ ] المباني الحديثة
- [ ] المباني القديمة (القائمة)

Questionnaire---

* 5- في أي قطاع من المباني نبدأ بتطبيق (ZCA) في مصر ؟

- [ ] المباني السكنية
- [ ] المباني الصناعية
- [ ] المباني التعليمية
- [ ] المباني التجارية والادارية
- [ ] Other...

* 6- هل تعتقد ان تطبيق معايير (ZCA) عالي التكلفة ؟

- [ ] اوافق بشدة
- [ ] اوافق
- [ ] لا مع ولا ضد
- [ ] اعترض
- [ ] اعترض بشدة

* 7- هل تعتقد ان تطبيق مبادئ (ZCA) غيرمكلف علي المدي البعيد ؟

- [ ] اوافق بشدة
- [ ] اوافق
- [ ] لا مع ولا ضد
- [ ] اعترض
- [ ] اعترض بشدة

* 8- لتطبيق وتنفيذ (ZCE) يجب تعريف وتدريب المصممين والمعماريين علي مبادئ (ZCA) من خلال

- [ ] ورش عمل
- [ ] دورات تدريبية
- [ ] ندوات تعريفية
- [ ] مؤتمرات علمية
- [ ] جميع ماسبق
- [ ] Other...

Questionnaire--

* 9- إذا أجبت بغير ذلك في السؤال السابق اذكرها من فضلك

Long answer text

* 10- يجب تطوير بعض المناهج الدراسية لتعليم طلاب كليات العمارة تفعيل وتطبيق معايير (ZCA) ؟

- ☐ اوافق بشدة
- ☐ اوافق
- ☐ لا مع ولا ضد
- ☐ اعترض
- ☐ اعترض بشدة

* 11- من وجهة نظرك ما جدوي تطبيق معايير (ZCA) في مصر؟

- ☐ اقتصادية
- ☐ صحية
- ☐ تشكيلية
- ☐ بيئية (لاستهلاك الطاقة)

* 12- يجب تشكيل جهاز لإدرة وتفعيل (ZCE) بشراكه الدولة والمؤسسات الكبري؟

- ☐ أوافق بشدة
- ☐ أوافق
- ☐ لا مع ولا ضد
- ☐ أعترض
- ☐ أعترض بشده

* 13- إذا أجبت بأوافق في السؤال السابق فماهي تخصصات هذا الجهاز من وجهه نظرك؟

Long answer text

Questionnaire--

* 14- في ضوء تفعيل مبادئ (ZCE) يجب اعادة صياغة المفردات التشكيلية بروح تتناسب معها ؟

- [ ] أوافق بشدة
- [ ] أوافق
- [ ] لا مع ولا ضد
- [ ] أعترض
- [ ] أعترض بشده

* 15- عند تفعيل (ZCA) هل تعتقد أنه سيتم تغيير الصورة الذهنية للمدينة وستحدث عمارة نوعية جديدة في المستقبل؟

- [ ] أوافق بشدة
- [ ] أوافق
- [ ] لا مع ولا ضد
- [ ] أعترض
- [ ] أعترض بشده

* 16- من وجهة نظرك ما هي الإجرآت الأخرى التي ينبغي اتخاذها لتفعيل مبادئ (ZCA) في مصر؟

Long answer text

مع خالص شكري وتقديري

الباحثة

Factory electricity bills show the electricity consumption







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العمارة الخالية من الكربون وسيناريوهات المستقبل في مصر

Zero Carbon Architecture In The Future Scenarios, In Egypt

بحث مقدم من

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تحت إشراف

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2021

كلية الهندسة
قسم الهندسة المعمارية

جامعة المنصورة

المشرفون

عنوان الرسالة: **العمارة الخالية من الكربون وسيناريوهات المستقبل في مصر**

اسم الباحثة : **مديحة حامد عبد الستار عماشة**

الدرجة العلمية المطلوب الحصول عليها : دكتوراه الفلسفة في الهندسة المعمارية

لجنة الإشراف

م	الاسم	الوظيفة	التوقيع
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رئيس قسم الهندسة المعمارية — **وكيل الكلية للدراسات العليا والبحوث** — **عميد الكلية**

أ.د. أحمد الطنطاوى المعداوي عوض — **أ.د.شريف مسعود البدوي** — **أ.د.محمدعبد العظيم محمدعبد العظيم**

جامعة المنصورة

كلية الهندسة
قسم الهندسة المعمارية

أعضاء لجنة المناقشة والحكم

عنوان الرسالة: **العمارة الخالية من الكربون وسيناريوهات المستقبل في مصر**

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رئيس قسم الهندسة المعمارية	**وكيل الكلية للدراسات العليا والبحوث**	**عميد الكلية**
أ.د. أحمد الطنطاوى المعداوي عوض	**أ.د.شريف مسعود البدوي**	**أ.د.محمدعبد العظيم محمدعبد العظيم**

جامعة المنصورة
كلية الهندسة
قسم الهندسة المعمارية

إقرار

اقر انا الباحثة / **مديحة حامد عبد الستار عماشة** بالالتزام بقوانين جامعة المنصورة بأنظمتها وتعليماتها وقراراتها السارية المعمول بها والمتعلقة بإعداد رسائل الماجستير والدكتوراه عندما قمت بإعداد الرسالة العلمية الخاصة بي تحت عنوان:

العمارة الخالية من الكربون وسيناريوهات المستقبل في مصر

ولجنة الإشراف :

1– أ.د **محمد صلاح الدين سيد السيد** (أستاذ العمارة – قسم الهندسة المعمارية –كلية الهندسة – جامعة المنصورة)

2– أ.م.د **علاء محمد شمس الدين العيشي** (أستاذ مساعد –قسم الهندسة المعمارية–كلية الهندسة– جامعة المنصورة)

3– أ.م.د **أحمد الطنطاوى المعداوي عوض** (أستاذ مساعد ورئيس قسم الهندسة المعمارية–كلية الهندسة– جامعة المنصورة)

كأحد متطلبات نيل درجة **دكتوراه الفلسفة في الهندسة** تخصص **هندسة معمارية**, والإقرار بحداثة موضوع الرسالة البحثية وأنه لم يسبق تناول الموضوع والعنوان البحثي بصورته النهائية الكاملة أو النشرسابقا في أى رسائل أو أبحاث أو أى منشورات علمية وذلك بما ينسجم مع الأمانة العلمية في كتابة الرسائل والأطروحات العلمية. وتم نشر عدد (1) بحث في مجلة علمية متخصصة وبياناته كالآتي:

Zero Carbon Architecture in The Future Scenarios

(Case Study (Industrial Building at New Damietta City, Egypt

العمارة الخالية من الكربون وسيناريوهات المستقبل

دراسة حالة (المبانى الصناعية فى مدينة دمياط الجديدة بمصر)

في مجلة المنصورة للعلوم الهندسية عدد مارس 2021

وأن البحث المنشور مستخرج من الرسالة المذكورة بعاليه وأن أسماء جميع السادة المشرفين موجودة علي البحث.

وهذا إقرار مني بذلك ,,,

المقر :

م.م / مديحة حامد عبد الستار عماشه

جامعة المنصورة

الإدارة العامة للمكتبات

كلية الهندسة
قسم الهندسة المعمارية

مستخلص رسالة (25) مكتبات

الكلية	الهندسة	القسم العلمي	الهندسة المعمارية	الرقم العام	
اسم الطالبة	**مديحة حامد عبد الستار عماشة**	الدرجة العلمية	دكتوراه الفلسفة المعمارية	التاريخ	
عنوان الرسالة	**العمارة الخالية من الكربون وسيناريوهات المستقبل في مصر**				

المستخلص

تعتبر قضية الاحتباس الحرارى من أهم القضايا التي تشغل أذهان الجميع ,هذا لما تعانيه المجتمعات الحديثة من اعتماد كلي علي الطاقة الذي يتسبب بزيادة انبعاثات الكربون والغازات الدفيئة مسببة الاحتباس الحراري,وقد تبين أن المباني تمثل حوالي نصف إستهلاك الطاقة 48%سنويا (إدارة معلومات الطاقة الأمريكية), كما تحتل انبعاثات الكربون في قطاع المباني الصناعية والسكنية نسبة 76%التي تؤدي بدورها لظاهرة الاحتباس الحراري.

وتتمثل **المشكلة البحثية** فى التقليل من انبعاثات الكربون في قطاع المباني باستخدام مبادئ العمارة الخالية من انبعاثات الكربون(ZCA) للحصول علي عمارة خضراء باستخدام التقنيات الحديثة واستخدام الطاقة البديلة لتقليل استهلاك الطاقة والحصول علي مقياس للعمارة الخالية من الكربون.

ويهدف البحث إلى الوصول للعمارة الخالية من الكربون (ZAC) وقياسها في مصر ومقترحات لتعديل قانون البناء والبيئة بما يتوافق مع العمارة الخالية من الكربون في مصر ،وشرح أهمية استخدام مبادئ ZCA وقبول السوق المحلي لفكر العمارة الخالية من الكربون ، والتركيز على تأثيرها في الهندسة المعمارية والتفكير المعماري في تصميم المباني ، ثم توضيح عوائد تطبيق ZCA للبلد وسيناريوهات تطبيق ZCAفي مصر. ومن أجل تحقيق الهدف من الدراسة **اعتمد البحث على استخدام طريقة الدراسة النظرية والتحليلية ومن ثم التطبيقية** كأداة لإثبات صحة الفرضيات.

الدراسة النظرية قامت علي توضيح بعض التعريفات والمصطلحات الخاصة بالاحتباس الحراري في قطاع المباني وكذلك شرح للتقنيات ومبادئ العمارة الخالية من الكربون مرورا بتقنيات المنخفضة الكربون ، اما الدراسة التحليلية قامت علي تحليل لتطبيقات العمارة الخالية من الكربون وكذلك لمباني من العمارة الخالية من الكربون من انحاء العالم ، والدراسة التطبيقية شملت علي تطبيق للنتائج التى حصل البحث عليها ومبادئ العمارة الخالية من الكربون علي دراسة الحالة (المنطقة الصناعية في مدينة دمياط الجديدة في مصر)

وقد توصل البحث إلي أن تطبيق مبادئ العمارة الخالية من الكربون في مصر ZCAE يقلل من استهلاك الطاقة وبالتالي يقلل من انبعاثات الكربون في المباني الصناعية خاصة وتوفير عوائد اقتصادية وبيئية وحضرية وبصرية كبيرة للبلاد ، خاصة على المدى الطويل ،كما في حالة الدراسة وكذلك امكانية قياس تاثير تطبيق مبادئ العمارة الخالية من الكربون من خلال تطبيق ZreoTool ، وقد توصل البحث أيضا إلي أن الهندسة المعمارية تساهم في تقليل ظاهرة الاحتباس الحراري باستخدام مبادئ العمارة الخالية من الكربون (ZCA) وضرورة توعية المجتمع بأهمية تطبيقها واستخدامها علي قطاع المباني الصناعية أولا ونشر النتائج ورفع درجة الوعي باستخدام مبادئ فكر العمارة خالية من انبعاثات الكربون(ZCA).

رؤوس الموضوعات ذات الصلة (لاتزيد عن 10)

الاحتباس الحراري – العمارة – خالية من الكربون – الطاقة – أداة الصفر – مصر – المنطقة الصناعية – البيئة – العمران

بسم الله الرحمن الرحيم

(هُوَ أَنشَأَكُمْ مِنَ الأَرْضِ وَاسْتَعْمَرَكُمْ فِيهَا)

صدق الله العظيم

من الآية ٦١ سورة هود

إهداء

- إلى كل صاحب فضل ، وكل طالب علم .
- إلى روح جدى الحبيب رحمه الله وأسكنه فسيح جناته .
- إلي جدتى الحنونة , إلى أبى وأمى الحبيبين الغالين ،وإلي من كان دعائهم سر نجاحي أطال الله أعمارهم.
- إلى زوجى ورفيق دربي وبناتي قرة عيني بارك الله لي فيهم .
- إلي إخوتي ورفاق عمرى أحمد و فاطمة , وجميع عائلتى حفظهم الله .

شكر وتقدير

الحمد لله رب العالمين ، والصلاة والسلام على أشرف المرسلين. .

أما بعد

فلا يسعنى وأنا أتقدم برسالتى إلا أن أعترف بالفضل لأساتذتي الأجلاء أعضاء لجنة الإشراف

- **أ.د محمد صلاح الدين سيد السيد** (أستاذ العمارة – قسم الهندسة المعمارية –كلية الهندسة – جامعة المنصورة)
- **أ.م.د علاء محمد شمس الدين العيشي** (أستاذ مساعد –قسم الهندسة المعمارية–كلية الهندسة– جامعة المنصورة)
- **أ.م.د أحمد الطنطاوى المعداوي عوض** (أستاذمساعدورئيس قسم الهندسة المعمارية–كلية الهندسة– جامعة المنصورة)

كما أتقدم لهما بالشكر على ما قدموه من جهد مخلص ، فكراً وعلماً وتطبيقاً..

الباحثة

ملخص البحث

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أولاً: الدراسة النظرية

الفصل الأول: الاحتباس الحراري في قطاعات البناء

سيوضح هذا الفصل قضية الاحتباس الحراري وانبعاثات ثاني أكسيد الكربون بشكل عام ولكنه سيركز على الغازات الدفيئة المنبعثة من قطاع البناء بشكل خاص.

الفصل الثاني: بداية من التقنيات المنخفضة الخاصة بالكربون إلى الهندسة المعمارية الخالية من الكربون

سوف يشرح هذا الفصل التقنيات المنخفضة الخاصة بالكربون في قطاع البناء ، حيث يتم تصنيف هذه التقنيات على ثلاثة تصنيفات (مواد ، طاقة ، تصميم) مرورا إلى العمارة الخالية من الكربون ZCA وتعريفها.

ثانياً: الدراسة التحليلية

الفصل الثالث: تحليل لتطبيقات العمارة الخالية من الكربون ZCA

يوضح هذا الفصل تطبيقات ZCA في (الطاقة ، التصميم) ويعتبر هذا الفصل بداية للجزء التحليلي للرسالة وتم تحليل هذه التطبيقات من حيث (التعريف والاستخدام ومميزات و الخصائص وتأثيرها علي العمارة)

الفصل الرابع: نماذج معاصرة لمباني العمارة الخالية من الكربون ZCA

سيركز هذا الفصل على نماذج معاصرة لمباني العمارة الخالية من الكربون حيث تم اختيار هذه المباني من جميع أنحاء العالم ، ألمانيا ، المملكة المتحدة ، هونج كونج ، الإمارات العربية المتحدة ومصر ، تم اختيار هذه المباني بناءً على كفاءتها في استخدام الطاقة والطاقة المتجددة والجوائز التي حصلت عليها.

ثالثا: دراسة تطبيقية

الفصل الخامس:كيفية تطبيق وقياس العمارة الخالية من الكربون في مصر (ZCAE) في القطاع الصناعي ,كدراسة حالة

سيخلق هذا الفصل سيناريو مستقبلي للعمارة الخالية من الكربون في مصر ZCAE , وعمل نموذج مستقبلى في القطاع الصناعي(المنطقة الصناعية في مدينة دمياط الجديدة بمصر) ,ثم دراسة تأثير المباني التي تتحول إلى مباني خالية من الكربون (معمارياً ، حضريًا ، اقتصاديًا وبصريًا) وعائدها للدولة ، وكيفية قياس حالة المباني من ZCAE من خلال تطبيق أداة Zero Tool.

النتائج والتوصيات

في هذا القسم يستخلص النتائج من خلال الرصد والتحليل والمقارنة والتطبيق والتحقق من الفرضيات ،

وقد توصل البحث إلي أن تطبيق مبادئ العمارة الخالية من الكربون في مصر ZCAE يقلل من استهلاك الطاقة وبالتالي يقلل من انبعاثات الكربون في المباني الصناعية خاصة وتوفير عائدات اقتصادية وبيئية وحضرية وبصرية كبيرة للبلاد خاصة على المدى الطويل ، كما في الحالة الدراسة وكذلك امكانية قياس تاثير تطبيق مبادئ العمارة الخالية من الكربون من خلال تطبيق ZreoTool ، وقد توصل البحث أيضا إلي أن الهندسة المعمارية تساهم في تقليل ظاهرة الاحتباس الحراري باستخدام مبادئ العمارة الخالية من الكربون (ZCA) وضرورة توعية المجتمع بأهمية تطبيقها واستخدامها علي قطاع المباني الصناعية أولا ونشر النتائج ورفع درجة الوعي باستخدام مبادئ فكر العمارة خالية من انبعاثات الكربون(ZCA).

ثم اعداد التوصيات الحالية والمستقبلية وفتح المجال لإجراء ابحاث ودراسات مستقبلية تستكمل ماتوصل اليه البحث.