Propose a Checklist to Evaluate the Triple Zero Buildings

Marwa Ahmed Mostafa, Prof. Dr. Ehab Mahmoud Okba, Dr. Rabab Salah Mohammed
Architecture Department, Fayoum University/ Faculty of Engineering

***Abstract*— The enormous growth and human societies development were always synchronized with some buildings activities that lead to compelled the mutual influence between architecture and other specialties, on the other hand, the mandatory consequence to development and growth was the increase in worldwide energy consumption& waste and emissions of greenhouse gases arising from burning of fossil fuels to generate energy that leads to climate change and global warming. The concept of nature friendly buildings idea arose with efficient buildings energy wise, the negative designs, Zero Energy, zero Carbon, zero waste buildings and green buildings are different definitions but all have common dominator which is the establishment of new designs and construction techniques with high consideration to environmental and economic challenges that affected life in different topics at current time.**

Consequently, this research aimed to obtain local standards for design treatments applicable in Triple Zero Buildings with applications of high flexibility leading to architectural composition to consume the minimum possible energy with integrated effective systems, lower carbon emissions and lower production of waste. And measuring how close the building is to real Triple Zero Building.

***Keywords*— Triple Zero, Zero-energy, Zero-carbon, Zero Waste, Autonomous systems, Effective Systems, Eco-Materials.**

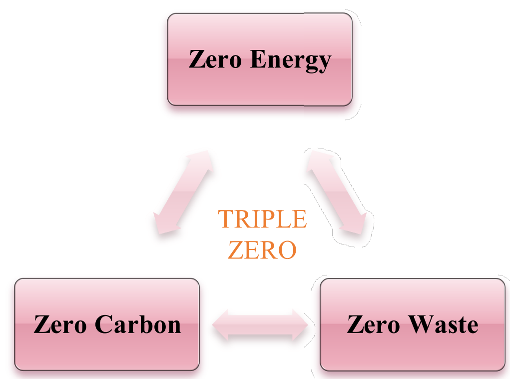
I. INTRODUCTION

One of the most important needs in modern life is housing. The increasing population in Egypt, which is the largest in the Middle East, has resulted in the continuing expansion of the construction and the building industry. The construction industry, which is among the major actors in the economic evolution in Egypt, is expected to be a top leader and influencer in the Egyptian economy in the succeeding age. Consequently, this will (a) necessitate more building materials, (b) generate more waste (c) have a negative impact on the environment (through climate change, ozone depletion, human toxicity, acidification, and so forth); and (d) require more energy and water resources. Therefore, the construction industry of any country has a strong correlation with its sustainable development. [1]

Developing countries are facing several environmental problems such as global warming, climate change and the increasing levels of CO_2 emissions. This is clearly depicted in the report conducted by the World Bank (2013) which shows that the CO_2 emissions in Egypt have been continuously increasing from 1.82 tons/capita in 2002 to 2.7 tons/capita in 2010 (World Bank). Furthermore, due to the lack of green building codes and regulations in Egypt, this has negatively affected the country's environmental conditions and therefore, its social and economic conditions. [2]

2. Triple Zero Challenge:

The Triple Zero is a major aim of sustainability Achieving the Triple Zero Concept involves a series of procedures, such as employing renewable energy sources, the use of solar cells on roofs to reduce the ecological effect of buildings, and using smart systems. These actions result in a great reduction in carbon emissions. [3]



2.1The main principles of Triple Zero:

1. ZERO ENERGY
2. ZERO CARBON
3. ZERO WASTE.

By achieving zero energy strategies, zero carbon and zero waste, we can reach the main research goal of triple zero, Zero energy strategies are self-systems (optimal design - thermal insulation - self-cooling systems) and effective systems (renewable sources of energy such as solar panels and wind), as well as zero carbon strategies of good water management and the use of renewable energy and the use of green building materials and finally achieve waste strategies Reducing the source and recycling of solid waste such as plastic, glass, paper, etc., and the strategy of reusing usable materials and using organic waste in compost production for plant and tree cultivation. Finally, the provision of safe and healthy landfills suitable for the burial of the remaining waste so as not to harm the surrounding environment and thus the complete disposal of waste through the strategies mentioned above.

The goal of triple zero is therefore to achieve a comprehensive integrated vision of the concept of sustainability and the definition of sustainable buildings to employ them in reaching the principles of environmental buildings, protecting the environment, energy conservation, and reducing emissions. [4]

2.2 Definition Triple Zero Building:

is a residential or commercial building that significantly reduces its energy needs by utilizing the most efficient design, and the energy needs of renewable energy technologies, as well as zero CO2 emissions and zero waste over the operation of the building to achieve A comfortable environment for human use without harming the external environment; the strategies and design treatments of triple zero buildings varies according to the different climatic conditions of the different countries. Most of the countries of the world go to this type of building. The research is concerned with the possibility of achieving triple zero building (zero energy- zero carbon- zero waste) in Egypt and suitable for our climate. [5]

2.3 Extraction of the most efficient design treatments for triple zero buildings:

The following variables can be used as a basis for measuring and modeling the triple zero buildings suitable for the local environment:

1) Zero Energy strategy:

A. Optimal design: (steering, window design, solar breakers, reflective color surfaces, landscaping). [6]
B. Thermal insulation: (multi-layered windows and walls, high insulation materials, green roofs, sealing doors and windows). [7]
C. Heating and cooling systems: (natural ventilation with openings). [8]
D. Energy production: (Renewable energy resources). [9]
E. Efficient devices: (efficient lamps, efficient home appliances and electric induction cooker).

2) Zero carbon strategy:

A. Renewable Energy Resources: (solar panels, Wind energy, Biomass…. etc.). [10]
B. Water Management: (Grey Water Systems, water capture technology, water-efficient plumbing fixtures, Design for dual plumbing, re-circulating systems, low-demand landscaping, and Reduce water pressure). [11]
C. Eco-Materials (Green Material): (Recycled Materials, Renewable Materials, Material for Efficiency, Materials for waste treatment). [12]
D. Indoor Environmental Quality: (Thermal comfort, Acoustic comfort, Day lighting, Natural ventilation, capacity of a building to absorb future functions). [13]
E. Waste Management: (Reduction, Reuse, Recycling, Landfill)

3) Zero waste:

(Source Reduction, Reuse, Recycling, Landfill, Thermal treatment, Biological treatment). [14]

2.4 Design Treatments of Triple Zero:

After reviewing the most important design treatments to achieve zero energy building, emissions and waste can be grouped together to create a triple zero building (energy building, emissions and zero waste), this is the goal of the search reach to the triple zero building by achieving strategies for zero energy, zero carbon emissions and zero waste. [15]

All of these strategies will be integrated into a comprehensive table of all design treatments to reach a Triple-zero building. These design treatments will be used to analyze examples of zero buildings and observe the extent to which these treatments are implemented in buildings and then measure the impact of these treatments through a computer program software in the subsequent chapters to develop uniform standards for triple zero building.

Table. 1 Triple Zero Check List

Design Treatments		
Zero Energy	Optimal Design	Building Orientation
		landscaping
		Openings Orientation
		Size of opening
		Window shading
		Exterior building paints
	Thermal insulation	insulating materials
		Insulating walls
		Insulating roof
		green roofs
	Autonomous cooling systems	cooling by convection
		cooling by Radiation
		cooling by evaporation
		Systems of exchange Ground
		Cooling by natural ventilation
	Energy efficient devices and equipment	Lighting devices
		solar heater
		Air conditioning applications
		electrical appliances
		Evaporative Coolers
	Renewable Energy Resources	Solar energy
		Wind energy

	Renewable Energy Resources	Solar energy
		Wind energy
		Biomass
		Biogas
		Nuclear energy
	Water Management	Grey Water Systems
		water capture technology(Collecting rainwater)
		Design for dual plumbing to use recycled water for toilet flushing or a gray water system
		water-efficient plumbing fixtures
		Employ re-circulating systems for centralized hot water distribution
		Designing low-demand landscaping
		Reduce water pressure
	Eco-Materials	Recycled Materials
		Renewable Materials
		Material for Efficiency
		Materials for waste treatment
	Indoor Environmental Quality	Thermal comfort
		Acoustic comfort
		Day lighting
		Natural ventilation
		capacity of a building to absorb future functions
	Waste Management	Reuse/ Recycling
Zero Waste	Source Reduction	
	Reuse	
	Recycling	
	Landfill	Sanitary/secure landfills
		Controlled dumps
	Waste treatment	Thermal treatment (Waste to Energy)
		Biological treatment (Compost)

2.5 Evaluation of the Relative Weights of Triple Zero Checklist (TZB):

The relative weights of the proposed checklist were also extracted after comparisons were made between the global systems included in the research and draw the relative weights of the proposed checklist for the triple zero, where the relative weights come according to the importance of each element in achieving the lowest energy consumption and the lowest carbon emissions and the least waste to achieve the main objective of the research is to achieve zero triple and the measurements are as follows:

Where we find that the triple zero consists of zero energy and zero carbon and zero waste and each element will be evaluated by 100% and within each element several treatments will be divided grades according to the importance of each element in the checklist and its importance for the country where it is, the division of grades is as follows:

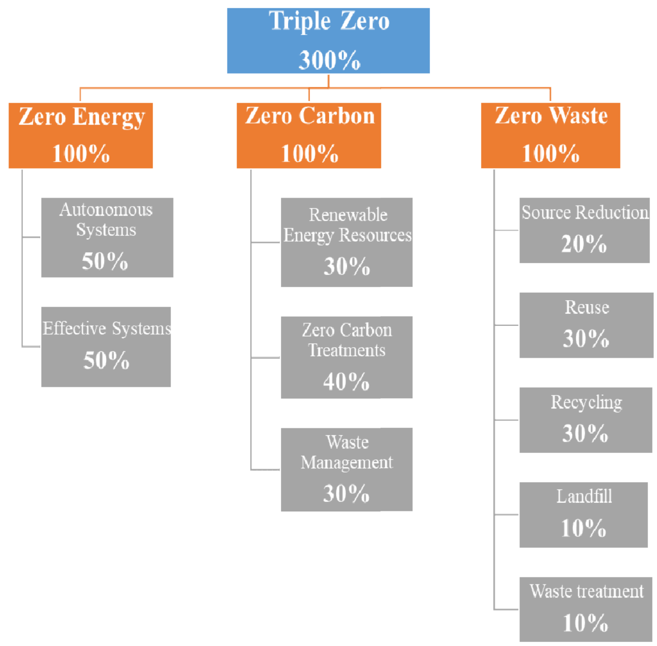


Fig. 1 Diagram shows The method of calculating the relative weight of Triple Zero Checklist

Source: Author

The relative weight of some sub-treatments was obtained by calculating the average relative weights of the elements of the global evaluation systems as follows:

Table.2 Comparison of relative weights in global assessment systems

GREEN BUILDING RATING SYSTEM	International rating systems						Egypt rating systems
	BREEAM UK 2014	LEED BD+C v4	PRS for ESTIDAMA v1.0	GSAS Typologies v2.0	CASEBEE BD (NC) 2014	EDGE Homes v1.1	GPRS Public review 2011
WATER	6%	20%	23%		2.250%	20% efficiency	30%
MATERIALS	12.5%	14%	11%	8%	12.750%	20% efficiency	10%
INDOOR ENVIRONMENTAL QUALITY	15%	15%	23%	16%	25.000%	0	10%

Eco material = (12.5 + 14 + 11+ 8 + 12.75 + 20 + 10) /7= 12

Water Management= (6+ 20+ 23+ 2.25+ 20 + 30) /7= 14

Indoor Environmental Quality= (15+15+23+16+25+10)/7= 14

The rest of the elements were calculated based on their importance in the checklist as well as the importance of treatment to achieve triple zero.

Table. 3 The relative weights of triple zero checklist

	Triple Zero Elements		Percentage	Design Treatments	Degree
Triple Zero 300%	Zero Energy 100%	Autonomous systems	50%	Optimal design	24
				Thermal insulation	16
				Autonomous cooling systems	10
		Effective Systems	50%	Energy efficient devices and equipment	10
				Renewable Energy Resources	40
	Zero Carbon 100%	Renewable Energy Resources	30%		30
		Zero Carbon Treatments	40%	Water Management	14
				Eco-Materials	12
				Indoor Environmental Quality	14
		Waste Management	30%		30
	Zero Waste 100%	Source Reduction	20%		20
		Reuse	30%		30
		Recycling	30%		30
		Landfill	10%	Sanitary/secure landfills	5
				Controlled dumps	5
		Waste treatment	10%	Thermal treatment(Waste to Energy)	5
				Biological treatment(Compost)	5

These variables will be adopted to evaluate examples of global buildings and will be used to evaluate the case study used and to measure the probability of approximation of triple zero building.

2.6 Case Studies on Various Building Types:

Any building is evaluated on the triple zero checklist (energy, carbon, and waste), where the percentage of deficiencies of a building is calculated in achieving the design treatments in the checklist. If the percentage of deficiencies in achieving design treatments is greater than 50%, then the building fails to achieve triple zero. If the percentage of the building's failure to achieve design treatments is less than 50%, this means that the building has succeeded in reaching the triple zero, in other words, if the percentage of deficiencies is close to 0%, this means that the building has become a triple zero building, i.e. a building of energy, carbon, and zero waste, but if the percentage of deficiencies is close to 100%, this means the failure of the building to achieve triple zero.

2.6.1 Bird Island in Kuala Lumpur: [16]

The project won the first prize for the YTL Green Homes Competition, held in 2007 with designs from all over the world and won by Graft Lab (an architectural and urban planning company founded in 1998 in Los Angeles, California).

The house consists of light bamboo frame with fabric, glass panels and wire. Made of sustainable material, the outer crust clears and turns along the facade and changes the transparency, orientation and appearance of the external courtyard, the structure of the house is characterized by a lightness and flexibility that allows the breeze to influence through it just like the tree figure (2).

Fig. 2 Bird Island: Zero Energy Home

A. Rafflesia Flower Idea:

The design of the building looks like the flower of Rafflesia, the largest flower in the world, a flower that grows in the rainforests of Malaysia (Rafflesia was used as a national symbol in Malaysia, but was replaced by Petronas towers) Figure (3).

Fig. 3 Rafflesia flower

An integrated strategy has been implemented to develop a zero-energy house that seamlessly matches the economic and environmental advantages of environmentally friendly organisms with the needs of occupants and enhances their ability to enjoy the comfort of their time at home with the expansive availability of outdoor living spanning the entire site, the relationship between inner and outer space has been transformed, allowing comfort in a house not surrounded by walls. Extended living spaces are arranged separately from each other.

B. Home layout:

The house consists of a central courtyard circular shape around which the rooms of the house and separated by a corridor connecting all the rooms with each other, the house consists of seven basic rooms with services are once bowed once again to overlap with the outer spaces, surrounded by trees and green vegetation in all its aspects, it is like a tree that is similar to the trees around it.

Table. 4 Evaluation ofBird Island in Kuala Lumpur

TRIPLE ZERO ELEMENTS	DESIGN TREATMENTS		ACHIVE OR NOT	Degree of treatment	Percentage of deficiencies
ZERO ENERGY TREATMENTS	Optimal Design	Orientation	4	24	12%
		landscaping	4		
		Exterior color of the building (Building paints)	4		
	Thermal Isolation	Insulating walls	4	16	12%
	Heating and cooling systems	Natural Ventilation	6	10	2%
		Industrial Ventilation	2		
	Energy efficient devices and equipment		0	10	10%
	Renewable Energy Resources	Solar Panels	40	40	0%
	Total percentage of building deficiencies in achieving zero energy				36%
ZERO CARBON TREATMENTS	Renewable Energy	Solar Panels	30	30	0%
	Water Management	Grey Water Systems	2	14	10%
		water capture technology	2		
	Eco material	Recycled Materials	3	12	0%
		Renewable Materials	3		
		Material for Efficiency	3		
		Materials for waste treatment	3		
	Indoor Environmental Quality	Day lighting	3	14	8%
		Natural Ventilation	3		
	Waste Management	We will take the degree of waste management from waste zero strategies	18	30	12%
	Total percentage of building deficiencies in achieving zero carbon				30%
ZERO WASTES TREATMENTS	Reuse		30	30	40%
	Recycling		10	30	
			10		
			10		
	Total percentage of building deficiencies in achieving zero wastes				40%
Total percentage of building deficiencies in achieving evaluation elements					35% Near to Triple Zero
The building approaches the triple zero					

2.6.2 Rural House of Zero Carbon (Rural ZCD TM): [17]

The building is a model of zero-carbon rural houses located in the United States. Design by ZCD Factory The house may be single or in several adjacent houses.

Description: The building is designed to capture the warm sunlight in the winter, and to isolate the building with a tight seal and good insulation, and the walls and nets are the basis in the process of sealing the building and prevent the leakage of heat and cold, and rely on the movement of air transit to provide clean air inside the house and heat equation, using sunlight to heat water and generate electricity. Large windows provide plenty of light and all the bulbs and appliances used are low power and efficient figure (4).

Fig. 4 A zero-carbon rural home in the United States

Table. 5 Evaluation ofRural House of Zero Carbon

TRIPLE ZERO ELEMENTS	DESIGN TREATMENTS		ACHIVE OR NOT	Degree of treatment	Percentage of deficiencies
ZERO ENERGY TREATMENTS	Optimal Design	Orientation	4	24	12%
		landscaping	4		
		Windows Shading	4		
	Thermal Isolation	Insulating walls	4	16	8%
		Green Roof	4		
	Heating and cooling systems	Air filter	6	10	4%
	Energy efficient devices and equipment		6	10	4%
	Renewable Energy Resources	Solar Panels	40	40	0%
		wind turbines			
	Total percentage of building deficiencies in achieving zero energy				28%
ZERO CARBON TREATMENTS	Renewable Energy	Solar Panels & wind turbines	30	30	0%
	Water Management	water capture technology	2	14	8%
		Dual plumbing	2		
		Designing low-demand landscaping	2		
	Eco material	Recycled Materials	3	12	6%
		Renewable Materials	3		
	Indoor Environmental Quality	Day lighting	3	14	8%
		Natural Ventilation	3		
	Waste Management	We will take the degree of waste management from waste zero strategies	15	30	15%
	Total percentage of building deficiencies in achieving zero carbon				37%
ZERO WASTES TREATMENTS	Source Reduction		20	20	50%
	Recycling		30	30	
	Total percentage of building deficiencies in achieving zero wastes				50%
Total percentage of building deficiencies in achieving evaluation elements				38% Near to Triple Zero	
The building approaches the triple zero					

2.6.3 Zero-house designed by Meditch Murphey: [18]

The home is located in Virginia, America, and the site has been chosen to be close to social services, green spaces, and public transport network.

Description: The house is designed to produce a lot of energy and is isolated from the national electricity grid using the storage system. The house was designed to demonstrate that the concept of zero energy & carbon buildings is real and can be built for a pollution-free environment and for a more sustainable future, the building envelope is tightly sealed with the use of efficient electrical appliances and the use of solar energy figure (5).

Fig.5 Zero House in Virginia, USA

Table. 6 Evaluation of Zero-house designed by Meditch Murphey

TRIPLE ZERO ELEMENTS	DESIGN TREATMENTS		ACHIVE OR NOT	Degree of treatment	Percentage of deficiencies
ZERO ENERGY TREATMENTS	Optimal Design	Orientation	4	24	8%
		landscaping	4		
		Windows Shading	4		
		Building paints	4		
	Thermal Isolation	insulating materials	4	16	8%
		Insulating walls	4		
	Heating and cooling systems	Thermal system	2	10	2%
		Natural ventilation	6		
	Energy efficient devices and equipment		10	10	0%
	Renewable Energy Resources	Solar Panels	40	40	0%
	Total percentage of building deficiencies in achieving zero energy				18%
ZERO CARBON TREATMENTS	Renewable Energy	Solar Panels	30	30	0%
	Water Management	water capture technology	2	14	8%
		Designing low-demand landscaping	2		
		Reduce water pressure	2		
	Eco material		0	12	12%
	Indoor Environmental Quality	Natural Ventilation	3	14	11%
	Waste Management	We will take the degree of waste management from waste zero strategies	0	30	30%
	Total percentage of building deficiencies in achieving zero carbon				61%
ZERO CARBO N TREAT MENTS	There is no waste management		0	100	100%
	Total percentage of building deficiencies in achieving zero wastes				100%
Total percentage of building deficiencies in achieving evaluation elements					60 % Far from Triple Zero
The building is not approaching the triple zero					

2.6.4 Triple Zero (TZB) Rating Levels:

After evaluating the previous buildings on the triple zero checklist, a rate is given for each building on the triple zero rating system, Where the average rating within the triple zero checklist is as follows:

Evaluation depends on the percentage of deficiencies

If percentage of deficiencies >50% (Unclassified)

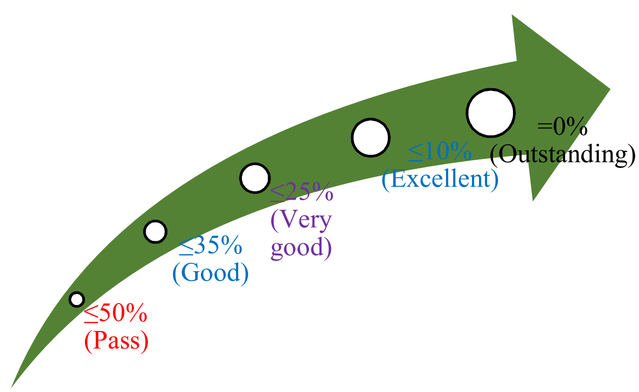
If percentage of deficiencies ≤50% (Pass)

If percentage of deficiencies ≤35% (Good)

If percentage of deficiencies ≤25% (Very good)

If percentage of deficiencies ≤10% (Excellent)

If percentage of deficiencies = 0% (Outstanding)



2.6.5 Comparison of previous examples evaluated

After the design treatments applied in the three examples of zero buildings were described. The three buildings will be compared to find out who is closest to achieving the triple zero building as follows:

Table. 7 Comparison of analytical examples and determination of their scores

Project Name	A photo of the building	Percentage of deficiencies	Rating Levels
Rural House (Rural ZCD TM)		**38%** Near to Triple Zero	Pass
Bird Island in Kuala Lumpur		**35%** Near to Triple Zero	Good
zero-house		**60%** Far from Triple Zero	Unclassified

After comparing the previous three buildings, it is clear that the building of the **Zero-house designed by Meditch Murphey** obtained 60% of the deficiencies in achieving the triple zero and this ratio is greater than 50%, which means that the building does not achieve the triple zero, the other two buildings, **Bird Island in Kuala Lumpur** and **Rural House (Rural ZCD TM)**, received 35% and 38% deficiencies. This percentage is less than 50%, which means that they are close to achieving triple zero. Any building can be evaluated on the triple zero checklist and the extent to which buildings achieve triple zero elements (zero energy, zero carbon and zero waste).

II. CONCLUSIONS

The design treatments for energy, carbon and zero waste buildings were extracted and then collected in a table as a checklist of the design treatments for triple zero and given relative weights after studies and comparisons of the global green assessment systems, Some design treatments within the triple zero checklist were the result of calculating the average relative weights in the global systems that were included in the thesis and some treatments took their relative weight by their importance in achieving the triple zero elements. Therefore, we have a complete checklist of design treatments that achieve a triple zero building. The triple zero checklist was used to evaluate three examples of zero global buildings, some zero energy, some zero carbon, others combining zero energy, zero carbon and zero wastes buildings.

The Triple Zero Checklist can be used to evaluate any existing building or before design to determine how close the building is to achieving Triple Zero and to determine the percentage of deficiencies of a building in achieving the design treatments for Triple Zero. By using triple zero strategies, any building, whether existing or not yet constructed, can easily be transformed into a building with zero energy, carbon and zero waste, thus the building becomes sustainable and environmentally friendly because of its low carbon emissions, low energy consumption, and low waste production. The checklist is easy to use and easy to apply. To evaluate any building whether residential, administrative or commercial.

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