The effectiveness of using some green architecture techniques towards a zero-energy housing to reduce energy consumption in Egypt

Assist.Prof.Dr. Ahmed Salah Eldin Shiba
Associate Prof. Department of Architecture, Faculty of Engineering, Beni-Suef University, Egypt.
ashiba1979@yahoo.com
Assist.Prof.Dr. Ali Kamal Al-Tawansy
Associate Prof. Department of Architecture, Faculty of Engineering, 6 October University, Egypt.
dr.aly@hotmail.com
Dr. Hala Abdelmoez Mohamed
Assistant Prof. Dep. of Arc. Higher Technological Institute in the 10th of Ramadan - 6 October City Branch – Egypt
hala_waheed2004@hotmail.com

Abstract :

The research describes the growing electricity consumption problem with the expansion of the housing and utilities sector in Egypt as a result of the pobulation increase and the current urban boom, where the housing sector constitutes the largest proportion of electrical energy consumption in Egypt, which entails the need to provide practical and applicable architectural and urban solutions to preserve the gains that we have achieved in the energy production field in Egypt. Many studies and researches have presented solutions and proposals to rationalize or generate energy in buildings towards fully or partially implementing the concept of zero energy in the building. The research aims to identify the passive solar design applications of green architecture that are most effective, appropriate and applicable in Egypt to create low-energy housing and urban communities as a contribution to solving the problem of increasing energy consumption and achieving the Ministry of Housing sustainability strategy in Egypt. Where the research imposes that there are applications of green architecture that are more effective and influential in reducing energy consumption in residential buildings, and more applicable than others. The research follows the descriptive methodology describing the current problem of energy consumption in residential buildings in Egypt, and defining the zero energy building concept. Then follows the inductive method to prove the effectiveness, efficiency, applicability and suitability of some green architecture techniques to reduce energy consumption in residential buildings than others in Egypt, based on local and cultural experiences, economic feasibility, or its capabilities in Egypt. Therefore, the research does not present new techniques or new strategies, but identify the most effective and applicable applications towards a "zero energy house" in Egypt.

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Keywords :
energy crises; zero-energy houses; renewable energy; sustainable strategey.

Introduction:
After the end of October 6th war between Egypt and Israel with the Arabs cutting off oil from the West, the world became aware of the importance of energy as one of the most important pillars of our contemporary civilization, especially in light of the warnings of the Rome Club report in 1972, which were confirmed by the effects resulting from the crisis of oil shortage [1], which prompted the world to search for alternative energy sources in the event of the depletion of oil and fossil energy sources, to start serious research and studies on renewable energy, specifically at the end of the seventies and the beginning of the eighties, when some articles appeared containing the phrase “buildings with zero energy consumption”.
As a result of the world’s interest and as an affirmation for the occurrence of a global energy crisis, the time has come when the repercussions of the oil crises became noticeable and influential in all sectors in all countries of the world, so we can be certain that since this date the discussion of renewable energy sources has begun. [2]
Most of the studies and research papers discussed energy efficiency technologies and passive solutions implemented in the building, as architects we need to do more, we need to develop housing models that adopt green architecture concepts, passive heating and cooling systems, use of photovoltaics, water recycling, [3] and methods for controlling energy efficiency are either sustainable energy generation or storage of generated energy; These housing models are what we call a "Zero Energy House" or a "Near Zero Energy House."
In fact, ZEB in general and especially in the housing sector in Egypt is a completely new trend, Egyptian architects are still developing strategies and foundations for “zero energy buildings and homes” in Egypt, this paper is an attempt to develop some design strategies to reach a “close home model” Zero Energy Consumption" in Egypt.

"Nomenclature "

ZEB	Zero Energy Building
nZEB	nearly Zero Energy Building
ZEH	Zero Energy House
nZEH	nearly Zero Energy House
RES	Renewable Energy Sources

1- Energy consumption pattern in Egypt:
In 2014, residential buildings in Egypt were the main consumer of energy, recording 52% of the total electrical energy produced in Egypt that year, Figure No. (1) [4]. Moreover, the electricity consumption of residential buildings is expected to increase every year due to the temperature rise due to global warming, and the rapid growth of the housing sector in Egypt.

More than that, energy consumption was examined in several residential buildings which showed that cooling energy is the main burden required in buildings, with 67% of the total energy consumption achieved for the residential unit. [5]

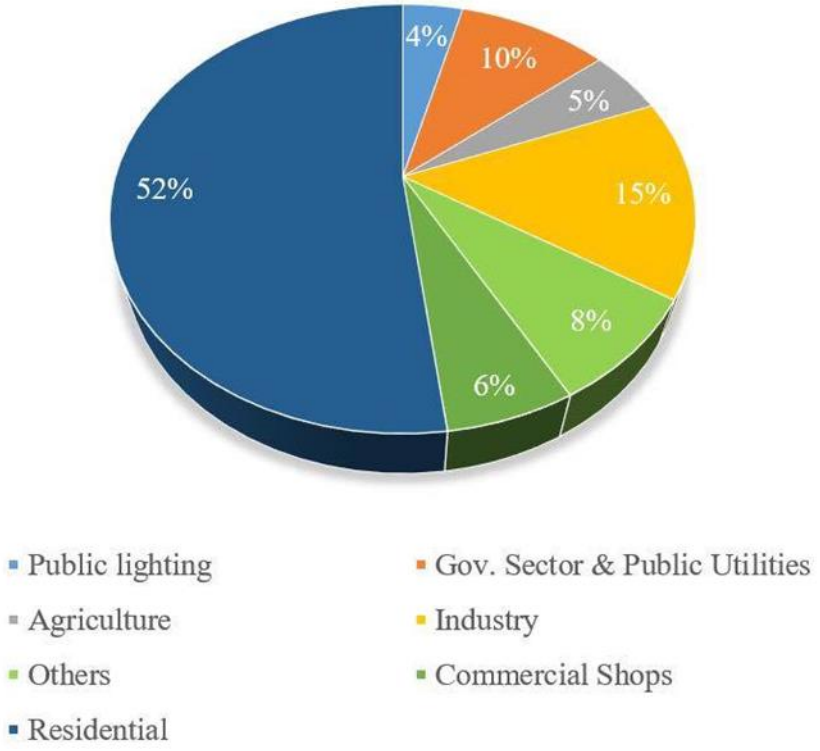

Figure No. (1) Distribution of electrical energy consumption in Egypt for the year 2014/2015 [4]

Given the pattern shown above, it is clear that the residential sector is the most important sector for architects to achieve a significant reduction in the energy consumption pattern in Egypt, which prompted us directly to ZEH & nZEH solutions.

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2- Definition ZEB and nZEB and literature review:

There are several definitions of ZEB to consider and here are some of them:

2-1 Definition of Esbensen:

"Through energy conservation arrangements, such as highly insulated constructions, heat recovery equipment and a solar heating system, the zero energy house has been dimensioned to be self-sufficient in space heating and hot water supply during normal climatic conditions in Denmark. Energy supply for electrical installations in the house be taken from municipal pipes. [6]

This definition can be applicable in a hot air climate if we alter heating by means of cooling systems.

2-2 Definition of Gilijamse:

"A zero-energy house is defined here as a house in which no fossil fuels are consumed, annual electricity consumption equals annual electricity production, and the power grid acts as a virtual store with annual balanced connections and returns." [7]

2-3 Definition of Iqbal:

"Zero-energy home is the term used for a home that optimally combines commercially available renewable energy technology with the latest energy-efficient building technology. In a zero-energy home, no fossil materials are consumed, and its annual electricity consumption equals annual electricity production. It may be that The zero-power house is connected to the grid and may not be." [8]

2-4 Definition of Torcellini et al.:

"A net zero energy building (ZEB) is a residential or commercial building with a significant reduction in energy needs by raising the efficiency of energy consumption and generation so that a balance of energy needs can be achieved through renewable energy technologies." [9]

2-5 Definition of Lausten:

"Net zero energy buildings are more natural buildings than a year, which means that they give as much energy to the supply networks as what they use from the network. Under these conditions, those buildings do not need any fossil fuels for heating, cooling, lighting or other energy uses. Although it may sometimes draw power from the grid.[10]

Concluding from the above definitions that ZEB is a building that generates energy from renewable resources equal to its needs, so the annual energy consumed by the building is equal to the energy generated by it, it is better to connect the building to the network for emergencies so that the building can draw some energy from the network, after a while buildings can supply the grid with additional electrical energy generated by each building.

3- Towards low energy consumption (zero energy) housing in Egypt:

Housing is one of the fastest growing sectors in Egypt, and at the same time, residential buildings consume more than 50% of the electric energy produced in Egypt annually and this percentage is increasing every year, so it is time for both the government and the Ministry of Housing to do their part and consider developing a number of guidelines and measures to achieve a tangible reduction in the electric energy consumed by the housing sector, by using ZEH models in all new settlements that will be built in Egypt in the future.

3-1 The General Design Strategy for Low Energy Consumption (Zero Energy) Housing (ZEH) in Egypt:

The General Design Strategy for Low Energy Housing (ZEH) in Egypt sets three main objectives:

Generating the building's electrical energy needs from renewable sources, Figure No. (2) [11]; Reducing the amount of electrical energy consumed by the building by using passive heating and cooling systems (natural ventilation, double walls, canopies, double roofs...etc). Figure (3) [11], taking into account the perimeter of the housing unit using design criteria. Specific design and planning of the surrounding urban environment also take into account the mass production of the housing unit to maximize the efficiency of the ZEH design.

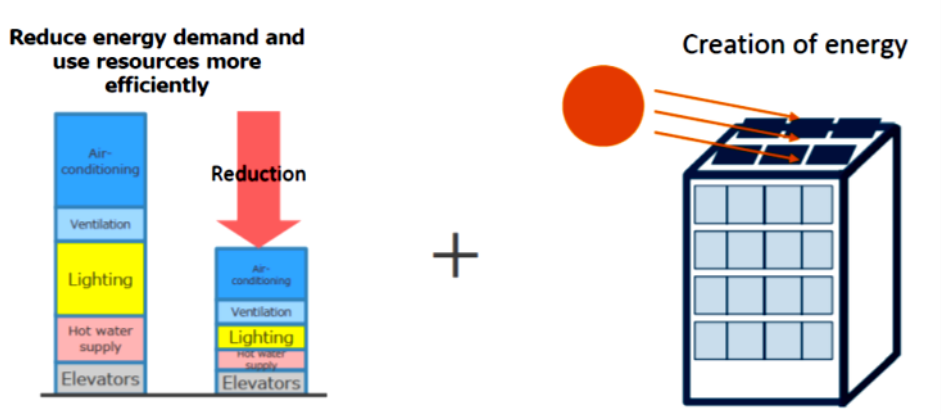

Figure No. (2): Energy generation from renewable sources [11]

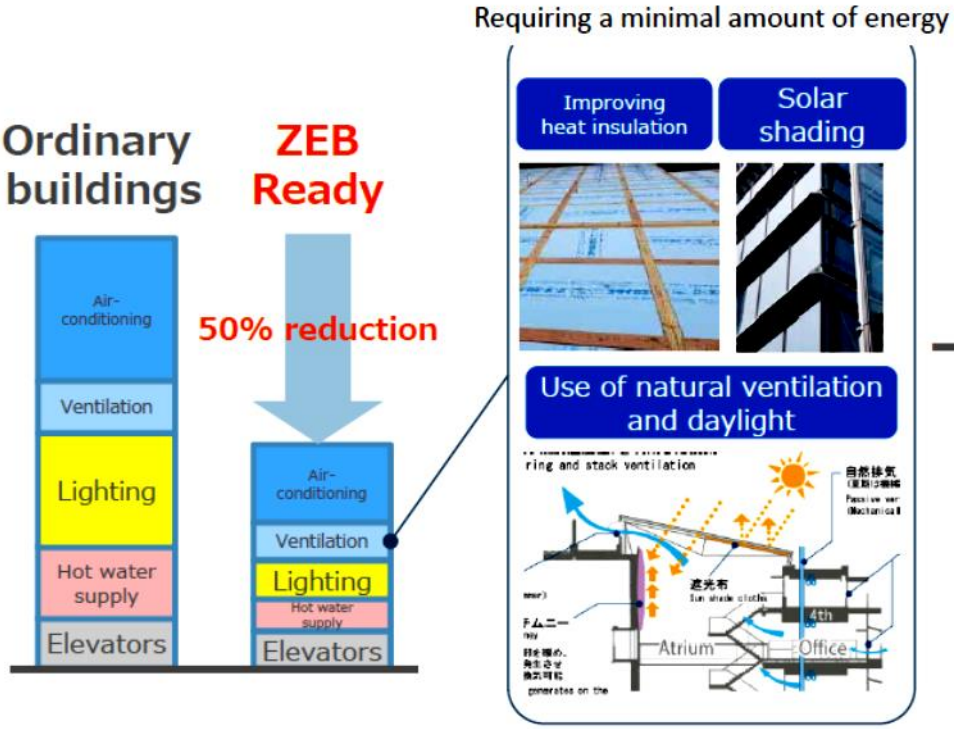

Figure (3) Reducing energy consumption using passive heating and cooling systems [11]

4. Zero Energy Home Model Design Guide:

Here we study low-rise housing units around 4 floors because laws in most new settlements restrict the height of buildings to 4 floors, and there are some architectural and urban recommendations and design guidelines to be used during the design of the ZEH model such as:

4.1 Natural ventilation:

Natural ventilation can be achieved in more than one way such as:

- Cross ventilation (opposite openings) for the design of buildings with single loading for the corridor, Figures (4) [12]
- Courtyards and internal courtyards, Figures No. (5) [12]
- A wind tower, a proposal for an electronic smart latch shown in Figures 6(a), 6(b), 6(c) [13], or simply the conventional wind tower Figures 7(a), 7(b) [14]

5- Discussion:

The trend towards green architecture applications and its use to achieve distinct designs for zero-energy housing and then zero-energy neighborhoods is the only way out of the growing crisis in energy consumption rates, especially in residential buildings, in addition to the crisis of non-renewable energy sources worldwide.Therefore, it is necessary to direct architects and planners and even oblige them, especially in new urban communities, to follow the design guidelines and laws binding on the design of zero-energy housing units and to adhere to the recommendations for designing zero-energy housing to reduce the burden on the electricity networks and achieve self-sufficiency in these houses from the electrical energy that the house needs, and even in the future supplying the grid with the surplus of electricity production from those homes, especially when the Egyptian government activates the merger with the electricity grids to reduce the use of storage batteries, which represent approximately 40% of the cost of solar energy systems, which puts these homes as an effective model to contribute to reducing energy consumption in the Egyptian Arabic Republic.

6- Findings and Recommendations:

1. Residential buildings consume annually more than 50% of the total electrical energy produced in Egypt.
2. Housing is one of the most growing sectors in Egypt, and the government is planning to build a lot of new urban communities and colonies in the near future.
3. The government and the Ministry of Housing should compel architects, designers and planners to follow certain rules and guidelines when designing housing units in new urban communities to create low-energy housing models.
4. ZEB is a building that generates energy from renewable resources equal to its needs, so the annual energy consumed by the building is equal to the energy generated from it, it is better to connect the building to the network for emergency cases so that the building can draw some energy from the network, after a while the buildings can supply the network with additional electrical energy generated by each building.
5. The General Design Strategy for Low Energy Consumption (Zero Energy) Housing (ZEH) in Egypt identifies three main objectives:
• Generating the building's electrical energy needs from renewable sources,
• Reducing the amount of electrical energy consumed by the building by using passive heating and cooling systems (natural ventilation, double walls, awnings, double roofs...etc.).
• Taking into account the scope surrounding the housing unit using specific design criteria for designing and planning the surrounding urban environment and taking into account the mass production of the housing unit to maximize the efficiency of the ZEH design.
6. The Zero Energy House model design guide considers the following:
7. Natural ventilation through various techniques (cross ventilation, courtyards, traditional or electronic wind towers or galleys); double walls, design of shading and facade systems; Photovoltaics and water recycling systems.
8. Designers should develop the idea from a zero-energy home to a zero-energy colony.
9. There are specific urban strategies to be dealt with while designing zero-energy colonies: building orientation; The spacing between buildings.

10. There are some additional ideas that can be useful when designing zero-energy colonies: building an animal farm to produce beef, dairy, and methane from cow dung; And building a wind farm to increase the electric power generated by the colonies.