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Towards Zero-Energy Housing in Egypt

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Abstract

As the Egyptian population is increasing at a huge rate, the yearly housing demand is increasing in an equivalent rate. In addition, the whole world is suffering from an energy crises caused by the rapidly increasing consumption of world's traditional energy resources, so the obvious solution is to go green, and depend much more on renewable energy resources.

According to the statistical data available in Egyptian governmental authorities, the accumulated housing demand till 2014 was about 2,400,000 units. On the other hand, the yearly housing supply from private and public sectors is about 150,000 to 200,000 unit, Egyptian authorities declared that at summer 2010 air-conditioning devices increased to reach 3.000.000 (three million) devices all over Egypt, mostly working from early mornings till 2 am next day to adjust temperatures that reach up to (45°C) and more outside buildings to reach (25 °C) or less inside. This behavior increased electricity consumption rapidly. Consequently, the electricity consumption rate in Egypt had increased by 13% more than 2009, which exceeds the maximum capacity power of the high dam by 7% to 8%, ministry of electricity announcements declared that to fill that gab we need 3000 megawatts at peak hours which costs the electricity sector up to 16.000.000.000 I.E.

Accordingly, a new architectural design concept is proposed (Zero-Energy Housing Unit) to rely on the surrounding environmental conditions and new Green Architecture Techniques in order to provide human comfort based on renewable energy sources, provided that the common current governmental energy sources will be a backup system for the meanwhile.

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Keywords

energy crises ;zero-energy houses;renewable energy.

1. Introduction

In the late seventies and early eighties appeared some articles containing the phrase " Zero Energy House ", due to the world energy crises, it was the time when the consequences of the oil crises become noticeable, and the issue of the fossil fuels sources and the energy use started to be discussed.(Marszal & Heiselberg 2012)

Most articles and papers discussed energy efficient technologies and passive solutions implemented in the building, as architects we need to do more, we need to develop housing models adopting green architecture concepts, passive heating and cooling systems, the use of Pv cells, water recycling, and energy efficiency controlling methods either generating sustainable energy or storing generated energy; these housing models are what we call "Zero Energy House " or " near Zero Energy House "

Actually ZEB in general and specially in housing sector in Egypt is a completely new direction , Egyptian architects still putting together the strategies and fundamentals of ” Zero Energy Buildings and Houses ” in Egypt , this paper is an attempt to lay down some design strategies to reach a ” near Zero Energy House Model ” 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

2. Energy consumption pattern in Egypt

In 2014, residential buildings in Egypt were the major consumer of energy recording 52% of the total electrical energy produced in Egypt that year, Fig 1(EEHC,2015) . Furthermore, electricity consumption of residential buildings is expected to grow every year because of temperature rising due to global warming, and the rapid growth of housing sector in Egypt. Moreover, energy consumption of several residential buildings was examined which revealed that cooling energy is the major required load in buildings, achieving 67% of the total energy consumption of the housing unit.(Atwa,2016)

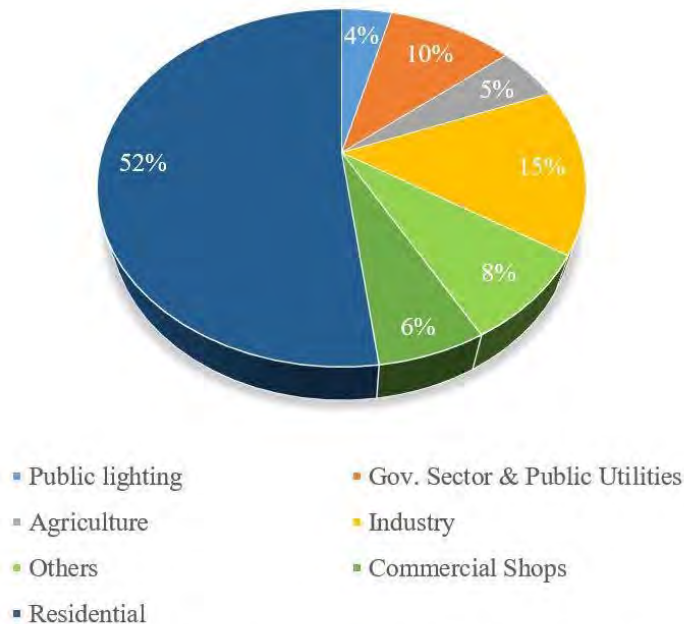


Figure 1. Electrical energy consumption distribution for 2014/2015
Source (Electric Energy Holding Company, 2015)

Figure 1. Electrical energy consumption distribution in Egypt for 2014/2015 (Elec. Energy HoldingCo., 2015)

Due to the pattern shown above it is obvious that the residential sector is the most important sector for architects to consider to achieve a significant reduction in energy consumption pattern in Egypt, that lead us directly to the ZEH & nZEH solutions

3. ZEB and nZEB Definition & Literature Review

There are several definitions of ZEB to be considered here is some of them

3.1. Esbensen Definition:

” With energy conservation arrangements, such as high-insulated constructions, heat-recovery equipments and a solar heating system, the Zero Energy House is dimensioned to be self-sufficient in space heating and hot water supplies during normal climatic conditions in Denmark. Energy supply for the electric installations in the house is taken from the municipal mains.”(Esbensen,1977)

This definition could be applicable for hot aired climate if we changed heating by cooling systems.

3.2. Gilijamse Definition:

” A Zero Energy House is defined here as a house in which no fossil fuels are consumed, and the annual electricity consumption equals annual electricity production, the electricity grid acts as a virtual buffer with annually balanced delivers and returns.”(Gilijamse,1995)

3.3. Iqbal Definition:

” Zero energy home is the term used for a home that optimally combines commercially available renewable energy technology with the state of the art energy efficiency construction techniques. In a zero energy home no fossil fuels are consumed and its annual electricity consumption equals annual electricity production. A zero energy home may or may not be grid connected.”(Iqbal,2003)

3.4. Torcellini, et al. Definition:

” A net zero energy building (ZEB) is a residential or commercial building with greatly reduced energy needs through efficiency gain such that the balance of energy needs can be supplied with renewable technologies.”(Torcellini,2006)

3.5. Lausten Definition:

” Zero Net Energy Buildings are buildings that over a year are natural, meaning that they deliver as much energy to the supply grids as they use from the grid. Seen in these terms they do not need any fossil fuel for heating, cooling, lighting or other energy uses although they sometimes draw energy from the grid.”(Lausten,2008)

Concluding from the above definitions that ZEB is a building generates energy from renewable resources equal to its needs, so annual energy consumed by the building equals the energy generated by it, it is better to connect the building to the grid so at emergency cases the building could take some energy from the grid, after a while buildings could supply the grid with extra electric energy generated by each building.

4. Towards Zero Energy Housing in Egypt

Housing is one of the most rapidly growing sectors in Egypt, and at the same time residential buildings are consuming more than 50% of the electric energy produced in Egypt annually and this percentage is increasing every year, so it is time that government and housing ministry must take their role and consider some guidelines and measurements to achieve a considerable reduction in electric energy consumed by housing sector, that is by using ZEH model in all new settlements to be build in Egypt in the future.

4.1. General Design Strategy for ZEH in Egypt

General design strategy for ZEH in Egypt considers three main targets:Generating the building needs of electric energy from renewable sources Fig. 2(EECDA,2015); Reducing the amount of electric energy consumed by the

building by using passive heating and cooling systems (natural ventilation,double walls, shades,double roofs. . . etc) Fig. 3(EECDA,2015), Considering the context around the housing unit using certain design criterias to plan the context also considering mass production of the housing unit to achieve most efficiency of the ZEH design.

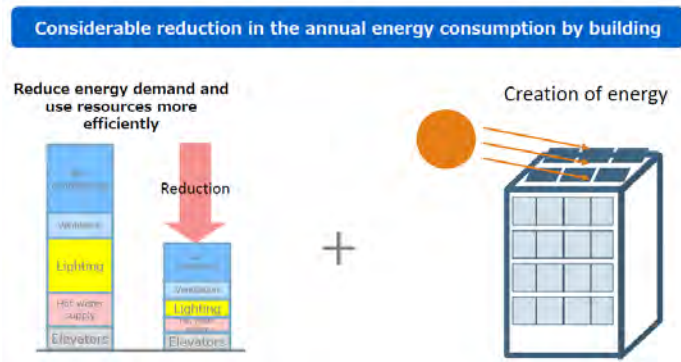


Figure 2. Generating Energy from renewable sources(EECDA,2015)

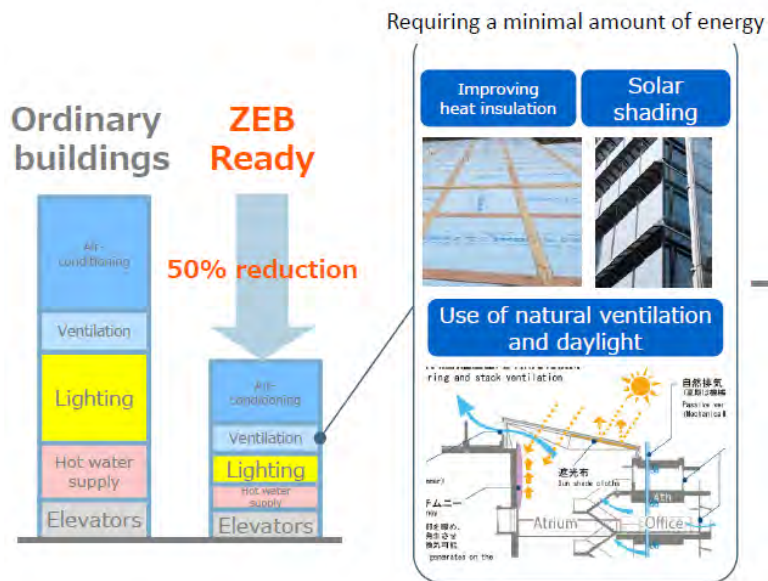


Figure 3. Reducing Energy consumption by using passive heating and cooling systems (EECDA,2015)

5. Zero Energy House Model Design Guide

We are considering here low rise housing units around 4 floors because laws in most new settlements restrict building height to 4 floors, There are some recommendations and guide lines to use while designing a ZEH model such as:

5.1. Natural Ventilation

Natural ventilation could be achieved through more than one method such as:

- Cross Ventilation for single loaded corridor design.Fig. 4(St.Clair,2009)
- Courtyards. Fig.5(St. Clair,2009)
- Malqaff or Wind Towers, a proposal of an electronic smart Malqaff is shown in Fig 6(a), 6(b), 6(c) (Mohamed,2012), or simply a traditional wind tower Fig.7(a) , 7(b) (Catnaps.org)

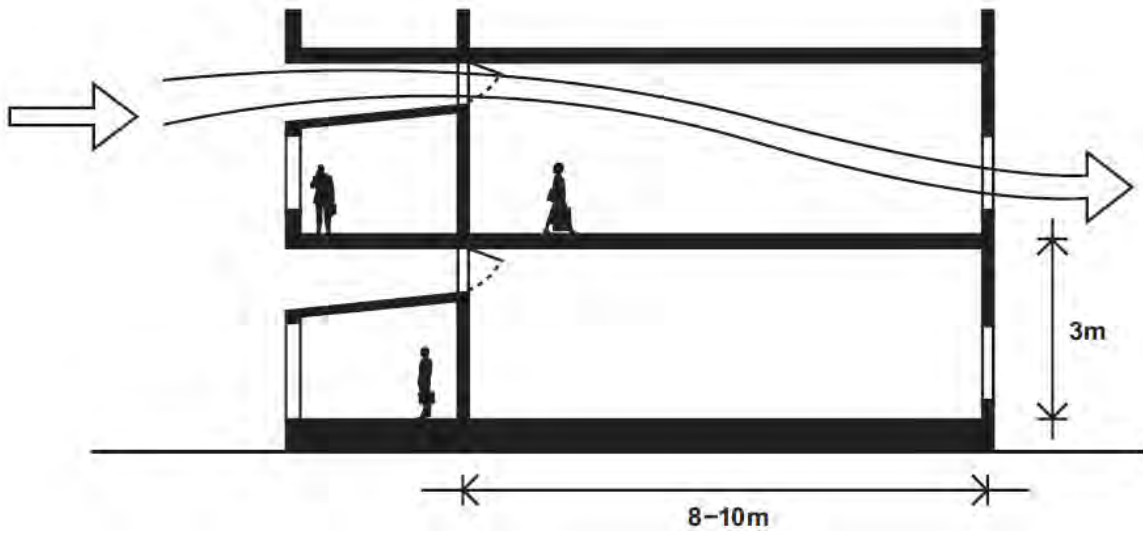


Figure 4. Cross ventilation for single loaded corridor design (St. Clair,2009)

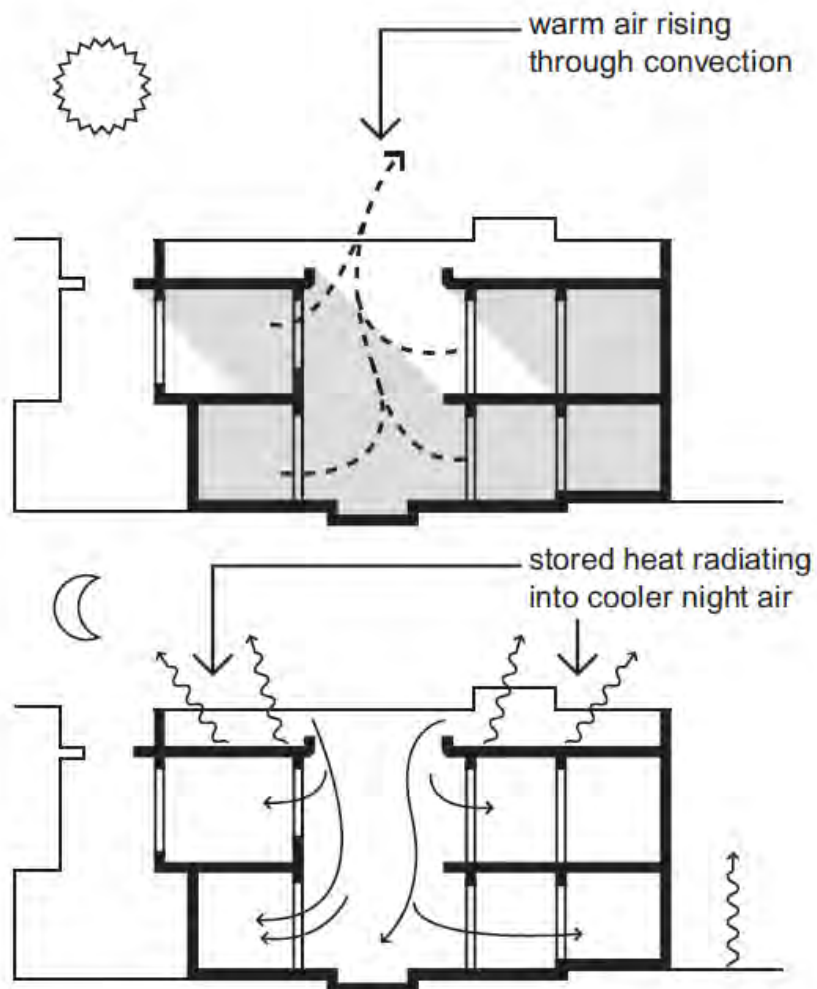


Figure 5. Courtyards(St.Clair,2009)

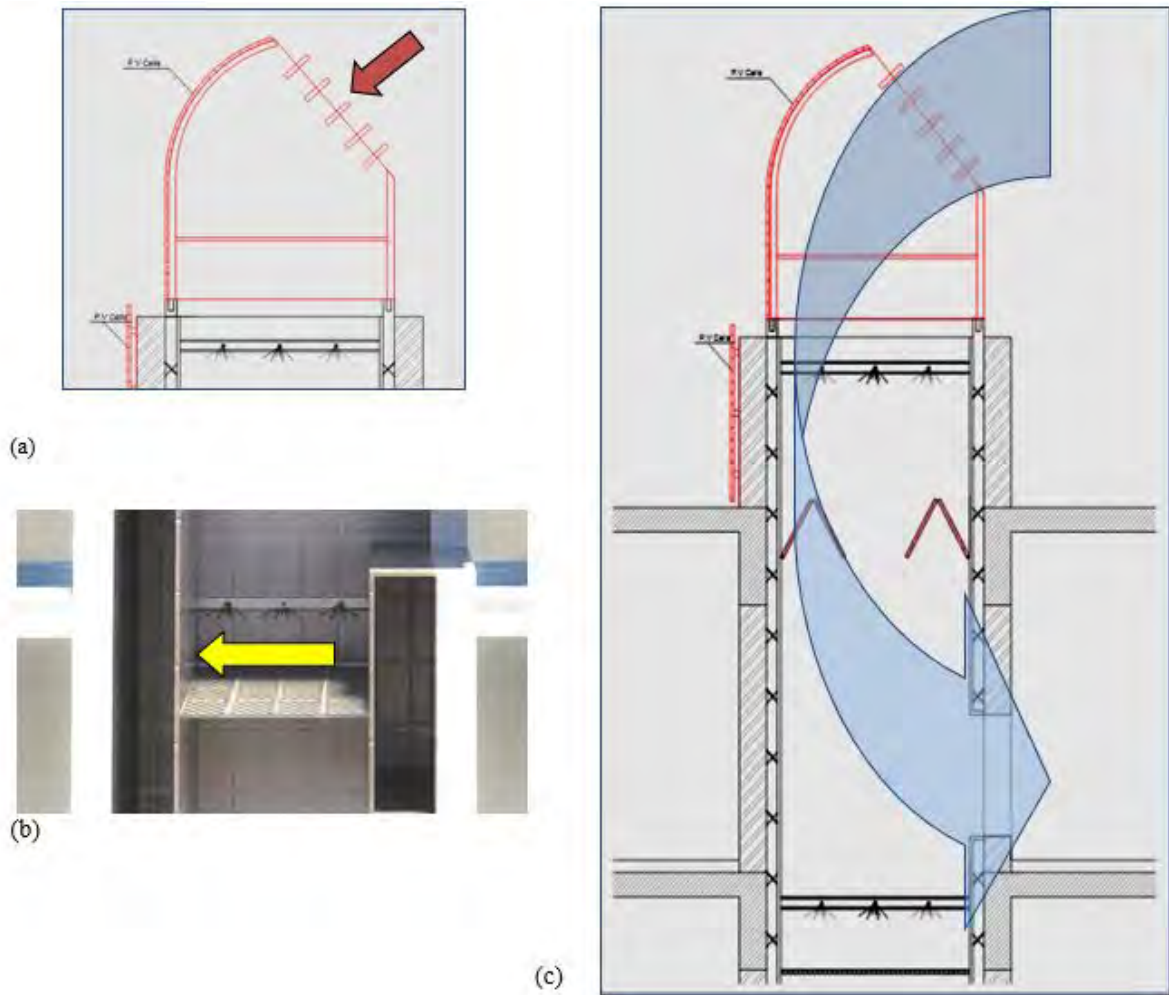


Figure 6. (a) The electronic smart Malqaff(Mohamed,2012) (b) The moving sides of the electronic Malqaff (Mohamed,2012) (c) Section of the electronic Malqaff(Mohamed,2012)

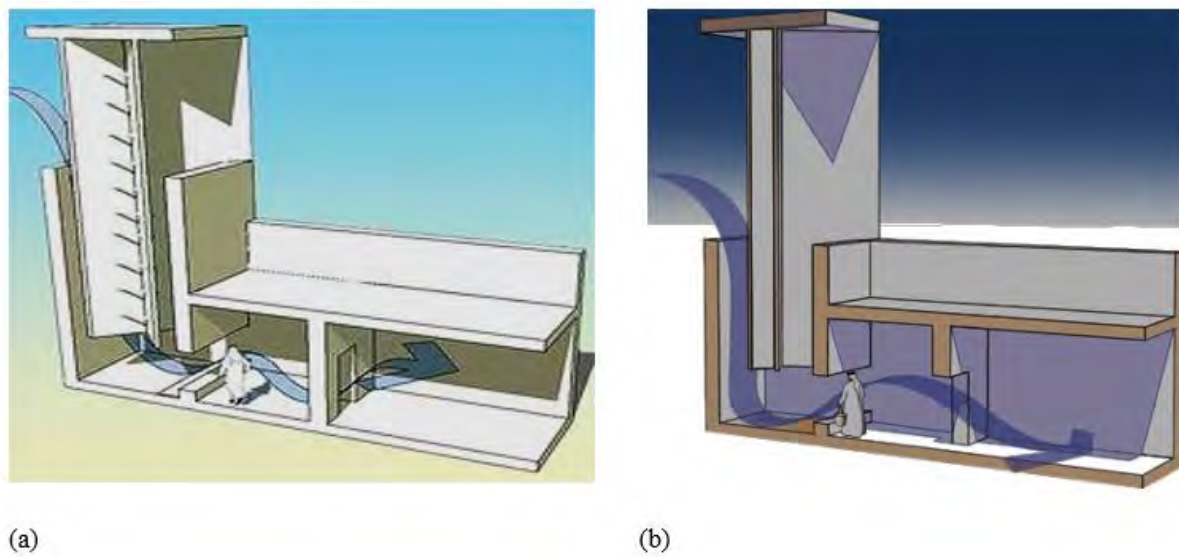


Figure 7. (a) traditional wind tower (Catnaps.org) (b) Air movement through wind tower(Catnaps.org)

5.2. Double Walls

Double wall is a technique to delay thermal transmission from outside the house to inside at daylight, and from inside to outside at night. Fig 8 (Soundproofingcompany.com)

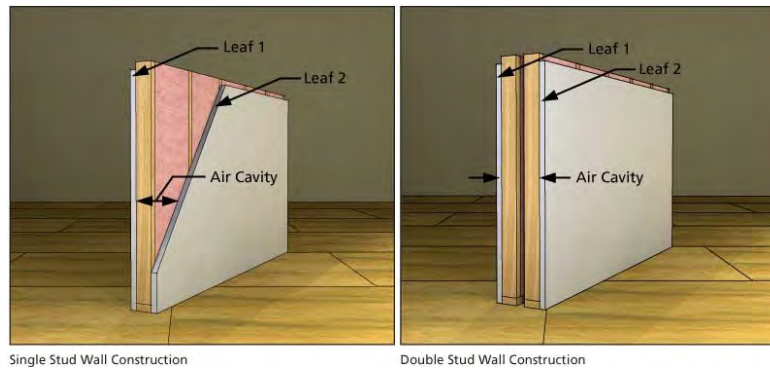


Figure 8. DoubleWall systems (soundproofingcompany.com)

The air cavity works as an insulation for both sound and thermal transmission.

5.3. Shadings and Façade Design

At hot arid regions using window shades both horizontal or verticals are important due to high levels of solar radiation, Fig.9 (payette.com), also façade design takes a good role in the overall energy performance of the building, shade and shadow designed by projecting some parts of the façade, size and placement of windows, it is preferable to use small windows in hot regions. Fig.10 (pinterest.ie)

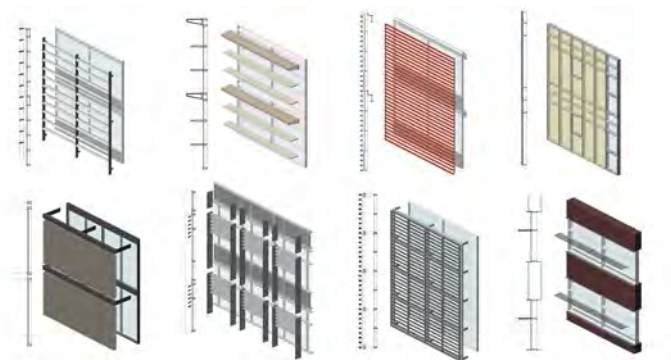


Figure 9. ShadingsTypes (payette.com)



Figure 10. Small Windows Facades (pinterest.ie)

5.4. PV cells

Merging PV cells in the ZEH model design on the rooftop or the facades is a must, so they would work as the electric energy generator which will provide the building with its needs of electric power.

There are many types of PV cells, one of them is the Flexible PV cells which are very important for architects so they can integrate the pv cells in any form into their building.Fig.11(nbamyjo.com)



Figure 11. Flexible PV cells (nbamyjo.com)

5.5. Water Recycling Systems

A simple grey water recycling system must be integrated in our ZEH model, through this system the water coming from bathroom showers and hand basins is to be recycled and reused in garden, car washing and washing machines; while the water coming from toilets and kitchen basin is directed immediately to sewer, a simple grey water recycling system is shown in Fig.12 (Pinterest.ie).

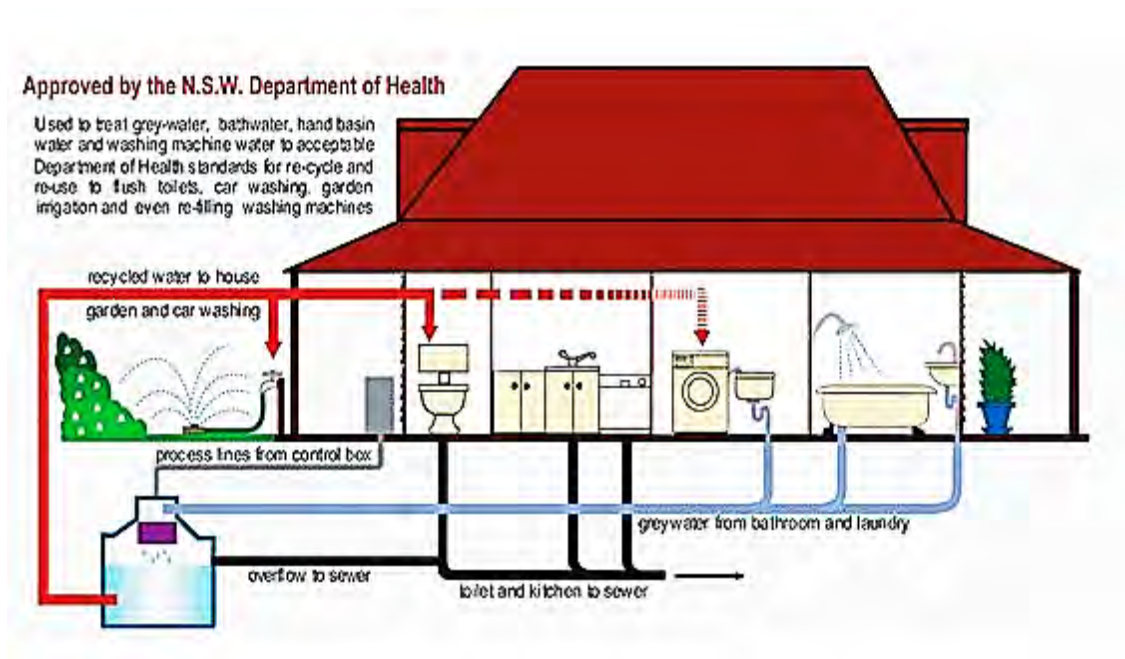


Figure 12. A Simple Grey Water Recycling System (Pinterest.ie)

6. From Zero Energy House to Zero Energy Settlement

As previously shown housing sector is one of the most growing sectors in Egypt, and residential buildings consume more than 50% of the electric energy generated in Egypt, so in all new settlements to be built we should obligate architects to stick with ZEH models guidelines, and take it more further and design Zero Energy Settlements, the efficiency of ZEH units would be much more valuable if we go mass producing for the housing units itself and for our designing concepts for the whole settlement.

6.1. Urban Strategy to use on a Zero Energy Settlement

There are two main concepts to be used on a Zero Energy Settlement:

- **Building Orientation :** Most housing units should be facing north direction to capture the preferable north wind in Egypt, and to get most benefit of natural ventilation treatments used in the housing unit design.
- **Spacing between buildings :** We must use a compatible urban pattern when designing new settlements specially in hot arid region, to get as much shadow in the settlement as we can to reduce the energy needed to cool residential units to minimum.

6.2. Extra Useful Ideas for Zero Energy Settlement Design

- **Animal Farms :** We could build an animal farm for the whole settlement to produce beef, graze and also methane gas through special treatments for cows manure to be used for cooking and heating. Fig.14 (wordpress.com)

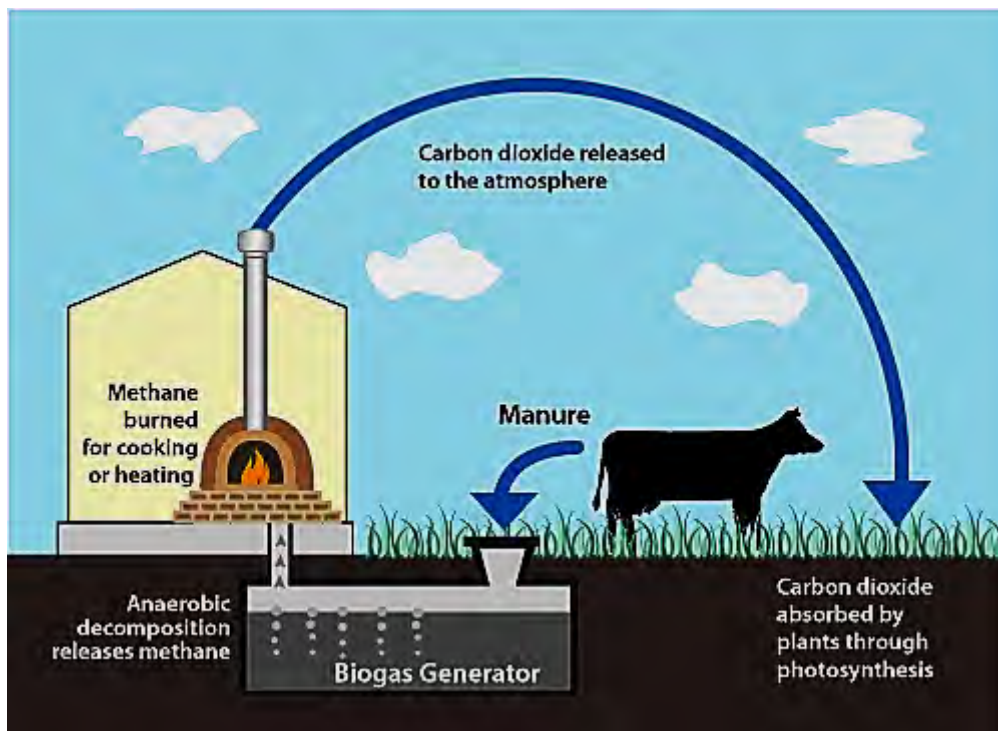


Figure 13. Using cows manure to generate methane gas for cooking and heating (wordpress.com)

- **Wind Farm :** To generate more electric energy as a reserve for the whole settlement. Fig.14 (inhabitat.com)



Figure 14. Windfarm (inhabitat.com)

7. Conclusion

- Residential buildings consume annually more than 50% of the total electrical energy produced in Egypt.
- Housing is one of the most growing sectors in Egypt, and government is planning to build a lot of new settlements in the near future.
- Government and Housing ministry should obligate architect and designers to follow certain roles and guidelines when designing housing units in the new settlements to create Zero Energy Housing models.
- ZEB is a building generates energy from renewable resources equal to its needs, so annual energy consumed by the building equals the energy generated by it, it is better to connect the building to the grid so at emergency cases the building could take some energy from the grid, after a while buildings could supply the grid with extra electric energy generated by each building.
- General design strategy for ZEH in Egypt considers three main targets:
 - Generating the building needs of electric energy from renewable sources; Reducing the amount of electric energy consumed by the building by using passive heating and cooling systems (natural ventilation,double walls, shades,double roofs. . . etc), Considering the context of the housing unit using certain design criterias to plan the context also considering mass production of the housing unit to achieve most efficiency of the ZEH design.
 - Zero Energy House Model Design Guide considers:
 - Natural ventilation through different techniques (cross ventilation,courtyards,and wind towers or Malqaf traditional or electronic); Double walls; Shadings and Façade design; PV cells; and Water recycling systems.
 - Designers should develop the idea from just a Zero Energy House to a Zero Energy Settlement.
 - There are certain urban strategy to deal with while designing a Zero Energy Settlement involving: Building orientation; and Spacing between buildings.
 - There are some extra ideas could be useful when designing a Zero Energy Settlement: Building an Animal farm to produce beef, graze and methane gas from cows manure; and building a Wind Farm to exaggerate the electrical energy generated from the settlement.

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