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# Criteria for Evaluating the Saving and Production of Energy in Hospitals "Nursing Units"

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**Abstract**

Hospitals are one of the important buildings which consume a lot of energy to run all over their life cycle starting from design, construction and ending with operation and maintenance. They operate for 24 hours with a need to always ensure thermal comfort, air quality, visual comfort and hygienic regulation in order to have a healing effect on patients but on the expense of energy. Hospital buildings consume about 4-6% of energy consumption in the construction sector. As we know that the operation cost of these buildings represents 25 to 60% of public health expenditure.

Hospitals are daily exposed to a large amount of renewable energy as solar, wind and human energy which are not fully considered in hospital designs .This paper focuses on nursing units considering energy consumption and production as they implement a big area of the total area of any hospital which thus can have a big influence on energy efficiency in hospitals.

This research enumerates and assesses the basic energy influencing parameters to be an input data for evaluating hospitals from an architecture point of view and a proposed design for a nursing unit is herein introduced.

**Keywords:** Hospitals design, energy saving parameters, energy efficiency in hospitals, energy conservation, zero energy hospitals.

## 1. INTRODUCTION

In the last few decades, a great deal of attention has been given to energy saving and production in numerous disciplines. Buildings have shown to be one of predominant consumers of energy [1]. However, during the building life cycle, the highest energy consumption occurs during the operating stage. This is because this period is much longer in duration compared to the other stages and working efficiency need to be provided at this stage [2]. Most of the researches are directed towards applying the principles of green architecture for saving energy [3]. Recently, there are some proposed measures to calculate energy efficiency in buildings with a special concern regarding hospitals [4].

The problems that face architects regarding energy in hospitals can be categorized in three main interrelated groups, namely: exact definition of energy inputs and outputs, identification and assessment of energy contributing parameters and finally a means to select optimum design out of alternatives satisfying the basic energy requirements.

The methodological approach proposed, as shown in Fig.1, It is based on collecting all the items involved in energy consumption in hospitals, analysing them, producing architectural design parameters related to energy saving and production to be used to evaluate hospitals' designs and applying them in the design of a nursing unit.

## 2. HOSPITALS AND ENERGY CONSUMPTION:

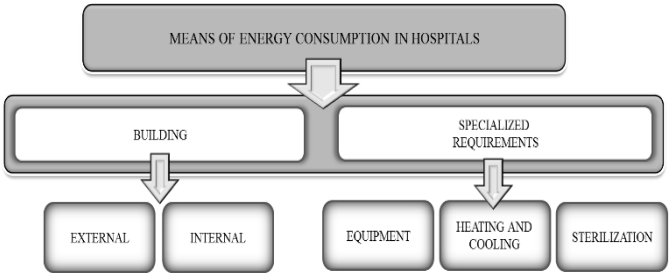


**Fig. 1:** Applied methodology

The main two items responsible for energy consumption are the building itself and all the specialized requirements within it, Fig.2.

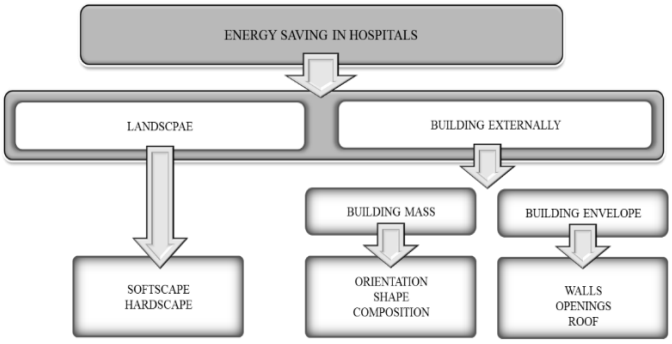


**Fig.2:**Means of energy consumption in hospitals.

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## 3. ENERGY EFFICIENCY IN HOSPITALS

Energy Efficiency in Hospitals is a scale by which the energy utilization in a hospital can be evaluated. The energy efficiency is calculated by considering the total energy used (output energy) compared with the total energy input. Minimizing the energy loss would eventually increase the efficiency.

Producing an energy efficient hospital consists of two synergistic issues:

1. Energy conservation by implementing energy efficiency systems and relying on natural and renewable energy resources.
2. Energy production by depending on new eco-technologies.

We need to study all the parameters associated with both previous issues.

## 4. PARAMETERS FOR ENERGY SAVING IN HOSPITALS.

More than 70per cent of the total energy consumed in hospitals is attributable to lighting and HVAC (heating, ventilation and air conditioning) needs [5]. Energy saving parameters in hospitals are enormous and belong to different engineering disciplines. The following is an attempt to classify, identify and describe these basic parameters that play a role in dictating the energy efficiencies and are liable for energy saving programs.

These parameters can be categorized as such:

### 4.1. Landscape

A well-designed landscape can not only add beauty to the building, but it can also reduce our need for cooling or heating by providing shading either by trees or sheds ,it can deflect winter winds and can tunnel summer breezes towards building.

### 4.2. Building mass

Building mass has an impact on day lighting, solar heat gain or loss, air movement, indoor environmental quality and hence energy consumption. The main items representing building mass are building orientation, shape and composition.

#### *4.2.1.Building orientation*

The most effective and least expensive way to reduce energy demand is by planning the orientation of the building. Orientation is the positioning of a building in relation to seasonal variations in the sun's path as well as prevailing wind patterns. Good orientation can help reduce or even eliminate the need for auxiliary heating and cooling [6].

#### *4.2.2.Building shape*

The shape factor of a building is a measure of the building compactness and expresses the ratio between the buildings thermal envelope area and its volume [7]. Buildings with higher shape factor are less compact and therefore are liable to larger heat gain, It is preferable to be a hospital in square shape because it is the least forms of shadowsas shown in fig (3).

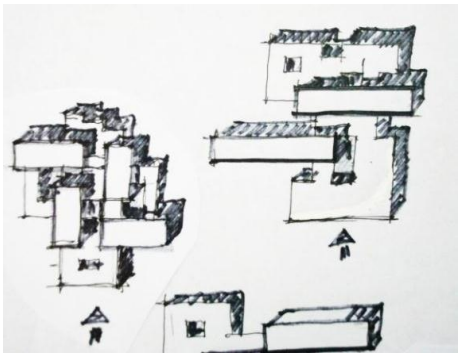


**Fig. 3:** Proposed sketches of hospital design in square form.
*Ref.: Architect Essam Safi El Din, 2013*

#### *4.2.3.Building composition*

It is the assembly of buildings parts in a way to reduce the exposure of external surfaces to solar radiation and the ability to produce shading parts.

### 4.3. Building Envelope:

The building envelope forms the outer shelter of the building and consists of the walls, openings and roofs. The building envelope protects the interior environment from less desirable exterior conditions. It is an important aspect in determining how much energy will be needed to heat or cool, light and ventilates the building.A well-designed building envelope will require less energy.Integrating passive systems that exploit natural forces as wind, sun and the use of environmentally sustainable materials in buildings is important [8].As shown in fig. (4).

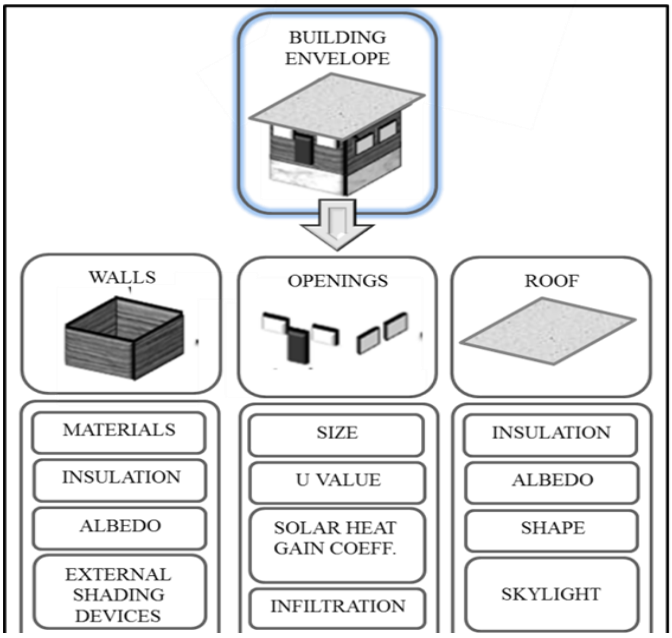



**Fig4.**shows the main parameters of building envelope involved in energy saving in hospitals

#### *4.3.1. Walls:*

Walls are usually taken as a main element in building envelope. Walls beside their major and fundamental function of forming the structure of the hospital should be selected with a view to their materials, insulation, albedo and incorporated shading devices as all these elements can affect energy performance in hospitals.

**a) Materials**

Green materials that fit most harmoniously with ecosystem processes are preferred. A great concern must be paid for embodied energy (energy required to extract, manufacture, transport, install and dispose of building material). Materials with a low embodied energy are recommended.

**b) Insulation**

Through insulation, we can reduce heat loss in buildings in cold climate and reduce heat gain in hot climate.By considering the thermal mass of the walls; this can affect indoor temperature fluctuations and overall heating and cooling requirements.

**c) Albedo**

Albedo is a measure of surface's reflectance. The higher the surface's reflectance , the lower its emissivity. Surface roughness and color have an impact as rough darker surfaces have low albedo [9].

**d) External shading devices**

External shading devices in the form of screens, movable curtains such as blinds or wooden pergolas can be used in elevations according to the surrounding climate.

#### *4.3.2. Openings:*

Openings are another factor to affect the design of building envelope. They can affect natural ventilation, natural lighting and indoor environment, hence, energy performance in hospitals. By considering the design of openings and the type of glass whether single or double, we can reduce mechanical ventilation, artificial lighting and air conditioning requirements.

The following factors must be considered in openings:

**a) Size**

The most important factor regarding window design includes the amount of sunshine that enters the building which depends on the size chosen for the window.as shown in fig (7). A clear example to control the size of openings according to the sun radiation and the desire of the patient

**b) U value**

U value is a measure of heat transmission through a material. The lower the U-value, the lower its heat transmission, the more energy efficient the window [10].

**c) Solar heat gain coefficient**

It shows how much of the solar energy striking a window is permitted to enter [10].

**d) Infiltration**

Infiltration results from leakage between the sash and the frame and can lead to increased heating or cooling loads [10].

#### *4.3.3. Roofs:*

Roofs are also a member of the building envelope to affect energy saving .The main parameters concerned with the building roof are insulation, albedo, shape and skylight.

**a) Insulation**

A well-insulated roof can reduce the need for mechanical systems and will reduce heating and cooling needs. Many forms of insulation can be used either by using heat insulation material on the concrete slab for the surface, using water sprinklers on the roof to reduce the ceiling temperature through evaporation or by cultivation on roof.

**b) Albedo**

The top surface of the roof can be covered with a reflective material to the sun to decrease the amount of heat transmitted to the interiorspace. An example is the use of cool roof.

**c) Shape**

Roof shape seither flat, shed and in some cases, gable roofs are responsible for the amount of heat gained through the building.

**d) Skylight**

Sky lighting types include open, fixed unit and operable skylight. They are used for day lighting to allow direct and/or indirect sunlight and ventilation for passive cooling and fresh air exchange [11].as shown in fig (5).A clear example to take fresh air by incorporating natural ventilation ,light and outdoor views in Rey Juan Carlos Hospital, Móstoles, Madrid, Spain[12].

**Fig. 5:** The use of large surfaces of openings in Rey Juan Carlos Hospital,Móstoles, Madrid, Spain

#### *5.1.2. Solar PV parking structure*

Installing solar systems above surface of car parks is becoming increasingly popular. The area above a car park is an unexploited site that can be used to generate renewable energy [15].By using the solar power shading structure we are not only able to make more use of the land but we can power our cars and hospital when the sun is shining.

## 5. PARAMETERS FOR ENERGY PRODUCTION IN HOSPITALS.

They include the landscape and the building both internally and externally.

### 5.1. Landscape

Many studies agree that for meeting energy demand, we can generate some of the electric power need from within the building boundaries [13].

#### *5.1.1. Roads with solar panels:*

A new technology, solar roadways , has emerged that has the potential for producing energy. The solar roadway is a series of structurally-engineered solar panels that are driven upon. They collect energy to be used by our buildings. The renewable energy generated by solar road panels will replace the current need for fossil fuel which is used for generation of electricity[14].as shown in fig (6,7,8).

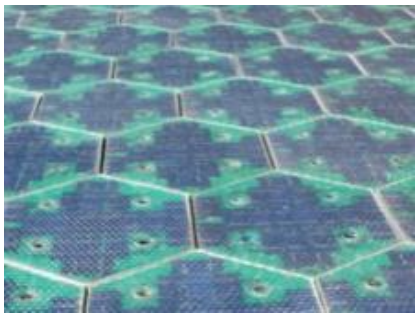


**Fig.6:** Detail of the shape of tiles

**Fig. 7:** Units as they arise, road stores energy during the day, then glows during the night

**Fig. 8:** highway

#### *5.1.3. Wind and solar powered hybrid street lamp*

The innovative wind and solar powered hybrid street lamp concept can produce light by using renewable energy. They are raised light sources which are powered by photovoltaic panels generally mounted on the lighting structure .The photovoltaic panels chargerechargeable battery, which powers a fluorescent or led lamp during the night [16].

#### *5.1.4. Artificial wind tree*

Energy harvesting trees are multi-functional, efficient and renewable energy system. They are formed of artificial trees with nana-leaves and stems which are considered one of the emerging nanotechnologies related to renewable energy. They are considered power generators as they harness the sun and wind and convert them to electrical energy [17].as shown in fig (9).

**Fig.9:**Artificial Wind Tree

### 5.2. The Building Externally

#### *5.2.1. Photovoltaic glass technology*

Photovoltaic (PV) glass uses the same basic principle as solar panels that is seen on roofs, but it is transparent[18].Photovoltaic cells are stored in glass panels. They store the solar energy in the day and at night use this stored energy.

#### *5.2.2. Photovoltaic cells*

The application of PV systems can be a substantial part of the energy needs of a building[8].The building's facades and surfaces can be supported by photovoltaic units to transform solar energy into electrical energy and can be placed on the hospital buildings in a decent manner providing aesthetic areas.

#### *5.2.3. Wind turbines*

Wind turbines can be integrated with the building either in facades or on roofs. They can be cost effective and efficient if they are placed in the correct places. They are used to generate electrical power from wind[19]. They can be designed to merge with the hospital to become a part not a part of the building.as shown in fig (10).

**Fig. 10:** (OklahomaMedical Research) ,VengerWindUnveils World's Largest Rooftop Wind Farm in Oklahoma City

*http://www.405magazine.com/September-2012/*

### 5.3. The Building Internally

#### *5.3.1. Tiles for energy production*

It is floor capable of producing electrical energy when there is movement on them. It converts the kinetic energy into electric energy and is stored in the units under the tile to be used in various activities inside the building .One step produces 5-7 watts.

They have low electricity consumption as each square meter consumes 1 kW (± 5% every five hours). They can be placed under the floors of traffic routes in hospitals to work on heating patient wards. This means that each kilowatt of the slides gives from 1015 - 1075 kcal. [20].as shown in fig (11).

**Fig. 11:**Distribution of tiles inside in one of the main tracks

#### 5.3.2. Sound absorbing panels

The hospital is one of the buildings that must be calm. Therefore, it requires sound insulation. A special insulation is used where the acoustic energy is converted to heat energy. They are used for cladding walls to reduce noise within the vacuum and can be freely used within the architectural vacuum [20]. It is recommended to place them in the main corridors of the hospital in 1/3 of the upper wall because the sound density increases in the highest vacuum.

## 6. ENVIRONMENTAL CONSIDERATIONS IN NURSING UNIT

Quality of care is directly related to the quality of the healthcare interior design, The physical environment of the buildings must provide a space that simultaneously addresses the varied needs of individual patients their families and a diverse team of health care professionals and volunteers.

The main aim should be the optimal care of individual patients and their families in a warm friendly and affirming environment. [21] We create healthcare environments that complement and enhance our patients.

Many environmental considerations must be taken into account when designing nursing units Chart (12).

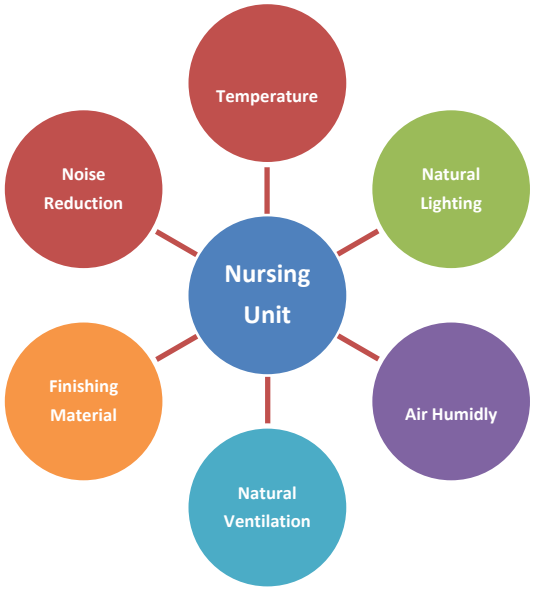



**Chart 12:** Environmental considerations in nursing unit

### 6.1. Natural lighting in nursing unit:

Light is a healing force. It regulates the body's circadian rhythm, which controls sleep-wake cycles and has a role in emotional health, heart function, body temperatures and other functions necessary for healing. At the same time natural lighting reduces the need for mechanical lighting which has an enormous impact on energy consumption in hospitals as shown in fig. (13). When designing health care spaces, the most important factors regarding window design include the

amount of sunshine that enters a room, the view, and patient privacy. [22]

**Fig. 13:** Different shots to natural lighting through the ceiling and wall in Ng Teng Fong General Hospital in in the South East Asia Region.

### 6.2. Natural Ventilation in nursing unit:

Purpose-built openings include windows, doors, solar chimneys, wind towers and trickle ventilators. This natural ventilation of buildings depends on climate, building design and human behavior as shown in fig. (14).

If well installed and maintained, there are several advantages of a natural ventilation system, compared with mechanical ventilation systems.

- Natural ventilation can generally provide a high ventilation rate more economically, due to the use of natural forces and large openings.
- Natural ventilation can be more energy efficient, particularly if heating is not required.
- Well-designed natural ventilation could be used to access higher levels of daylight.

**Fig. 14:** The ward rooms improves natural ventilation by 200% and gives every patient their own window close to their bed with a view to a garden from which to take fresh air in Ng Teng Fong General Hospital in in the South East Asia Region.

### 6.3. Noise reduction in nursing unit:

One of the most common patient complaints about hospitals is the noise with multiple sources include ( Bath rooms ,Devices ,The patients , Activities of employees Public spaces / traffic paths / lifts ).

Noise reduction is achieved by Choosing special materials that reduce noise and these materials can at the same time produce energy/.

A noisy hospital environment is not only aggravating for patients, To reduce hospital noise, U-M Hospitals and Health Centers are using several strategies intended to enhance the patient care experience and also improve working conditions for employees. As shown in fig. (15).


**Fig. 15:** Finishing materials for corridors inside the nursing unit so that they are soundproofed

### 6.4. Finishing Material in nursing unit:

Interior finishes play a vital role in a healthcare facility, because proper wall treatments can contribute to the creation and maintenance of a positive therapeutic environment for patients.

A major portion (32%) of the initial construction cost of a healthcare facility is consumed. In interior finishing and interior construction. Health Care design has traditionally concentrated on the functional efficiency of hospitals, resulting in a stressful healthcare environment that may be harmful for patient healing, also suggest that interior finishes contribute greatly to maintain a clean and infection-free atmosphere in a hospital.

### 6.5. Air Humidly in nursing unit:

Maintaining hospital humidity at between 40-60%RH will reduce the spread of airborne viruses by inhibiting their ability to initially become airborne and the length of time they can survive once in the atmosphere.

Steam is a very popular solution in hospitals as it ensures the moisture being introduced is 100% safe and also due to the fact that there is often a ready supply of steam being used for sterilizing purposes.

### 6.6. Temperature in nursing unit:

Temperature can be a particularly important measure in the built environment when considering the thermal comfort of occupants and in the design of building services systems. As a consequence, many of the measures of temperature are intended to represent the thermal comfort of people, or some component of their thermal comfort. Thermal comfort is a complex science in its own right.

A Passive hospital is a building standard that is truly energy efficient, comfortable, affordable and ecological at the same time. 1t is allow for heating and cooling related energy savings of up to 90% compared with typical building stock and over 75% compared with average new builds.

## 7. DESIGN PROPOSAL FOR A NURSING UNITTOWER IN EGYPT

Hospital patient rooms operate 24 hours per day year round, require extremely high demand for space heating and cooling since they need strict requirements for controlling the indoor environment [23]. A proposed design for a nursing unit is herein cited. It incorporates the previous principles of energy saving and production .given in Fig.16. It is designed with respect to the climate of Egypt and regarding the economical aspect. It is presented in Fig.17 which shows how an architect can incorporate all the previous parameters in his designs. The nursing unit can be a complementary part of a general hospital. It is designed to contain 150 beds with an area of 1100m2.It contains four floors .Each floor has 12 rooms (single and double rooms), 2wards, 2 intensive care units, nursing station, waiting area, 2 doctors' rooms, 2 nursing rooms, an office, detection and treatment rooms, 2rooms for medical supply and a room for general services.

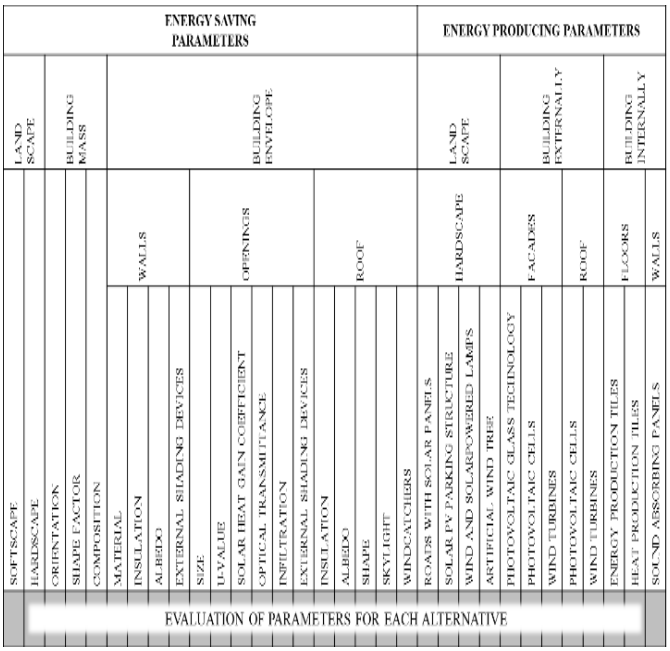



**Fig. 16:** Parameters for energy saving and production

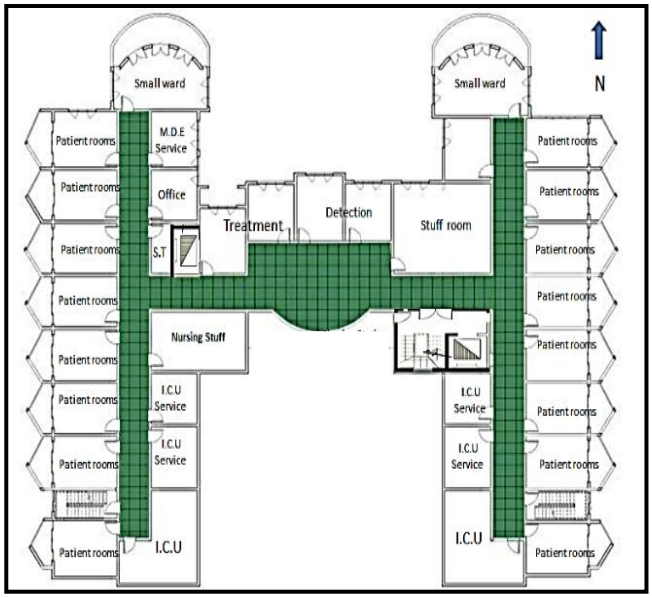



**Fig. 17:** Proposed plan of a hospital regarding energy and economic issues

The incorporated parameters considered in the design are gathered in Fig. 18 which indicates the used parameters in the landscape and in the building envelope.

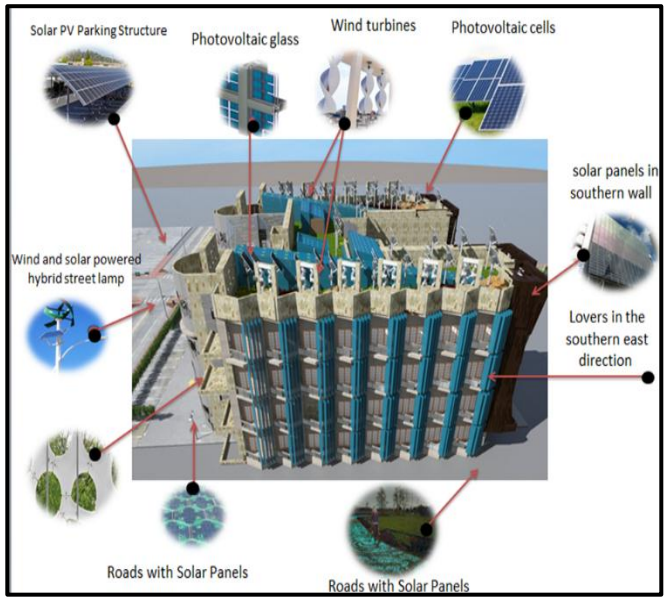
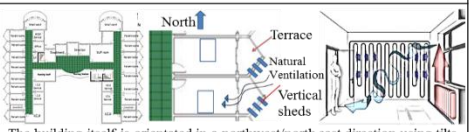
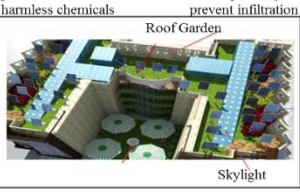



**Fig. 18:** Incorporated parameters regarding energy in the proposed design

### 7.1. Parameters Regarding Energy Saving

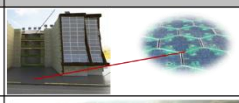
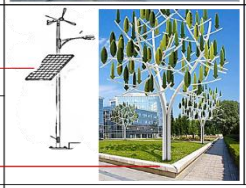
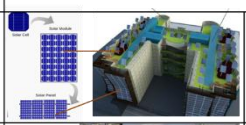
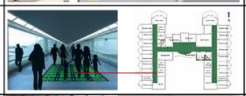
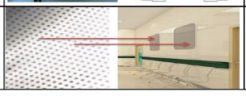
An analysis for all the parameters incorporated in the design regarding energy saving is clear in Table 1.

**Table 1.** Energy saving parameters in the proposed design

| | PARAMETER | | DESCRIPTION |
|---|---|---|---|
| LANDSCAPE | SOFTSCAPE | | Trees are used for shading the southern façade and for directing the prevailing wind in the northern façade. |
| | HARDSCAPE | | Fountains are used in the northern façade to add humidity for the air. |
| BUILDING EXTERNALLY | BUILDING MASS | ORIENTATION<br>SHAPE<br>COMPOSITION |  <br>The building itself is orientated in a northwest/north east direction using tilts in terraces to maximize exposure to prevailing winds, and at the same time minimizing exposure to intense solar heat by using vertical sheds. |
| | BUILDING ENVELOPE | WALLS<br>▪ Materials<br>▪ Insulation<br>▪ Albedo<br>▪ External Shading Devices |  <br>The walls are made of green materials with low embodied energy. The walls on the southern façade are double for insulation with white color to increase their reflectance to sun rays and they have vertical sheds on the southern east and west facades. |
| | | OPENINGS<br>▪ Size<br>▪ U value<br>▪ Solar Heat Gain Coef.<br>▪ Infiltration<br>▪ External Shading Devices |  <br>Windows have low U value and low solar heat gain coefficient. The southern facade has no openings but it has solar panels. |
| | | ROOF<br>▪ Insulation<br>▪ Albedo<br>▪ Shape<br>▪ Skylight |  <br>The roof is covered by roof garden and is well insulated and it has skylights tilted towards the north for lighting and admitting fresh air. |

### 7.2. Parameters Regarding Energy Production

**Table 2.**Energy producing parameters in the proposed design

| | PARAMETER | DESCRIPTION | |
|---|---|---|---|
| LANDSCAPE | ROADS WITH SOLAR PANELS |  | Solar panels in the roads surrounding the hospital are incorporated . They collect energy to be used by the hospital. |
| | SOLAR PV PARKING STRUCTURE |  | It forms a solar power shading structure for cars by which we can power our hospital when the sun is shinning. |
| | WIND AND SOLAR POWERED HYBRID STREET LAMP<br>ARTIFICIAL WIND TREE |  | Special street lamps are used where a wind turbine and photovoltaic panel are integrated to contribute to power generation. The energy is collected by a power conversion equipment along with a storage device to ensures lighting also during windless nights. Also the landscape contains artificial wind trees to convert the kinetic energy from the rustling of tree to electric energy. |
| BUILDING EXTERNALLY | PHOTOVOLTAIC GLASS TECHNOLOGY | Photovoltaic cells are used in glass panels of windows and skylight .They store the solar energy in the day and at night use the energy stored on them | |
| | PHOTOVOLTAIC CELLS |  | Photovoltaic cells are used on roof being exposed to direct sun and are also used in the southern façade to convert sun energy to electrical energy to be used in the hospital. |
| | WIND TURBINES |  | Wind turbines are used with an integration with the building either in facades or on roofs. |
| BUILDING INTERNALLY | TILES FOR ENERGY PRODUCTION |  | These tiles are used in the corridors of the nursing unit .They produce electrical energy when there is a movement on them. |
| | SOUND ABSORBING PANELS |  | The panels form a cladding to the walls of the corridors of the nursing unit to absorb sound and convert this acoustic energy to heat energy. |

## 8. CONCLUSION

The architect is responsible for selecting the optimum hospital design out of different alternatives.

The main objective in this choice is focused on ensuring high building efficiencies; efficiency regarding energy saving and efficiency regarding applying renewable energy and green architecture concepts.

The parameters to be under compromise are enormous; of which, are building mass, building Envelope, openings, and finishing. Parameters should be evaluated for final decision.

## 9. RECOMMENDATIONS:

By applying an energy conservation program and rationalizing the use of energy, the efficiency increases with a contributing save in energy. Meanwhile, energy efficiency is not the only important element in hospitals. As a recommendation, it is worth introducing all parameters regarding other important aspects in hospitals as medial requirements, aesthetics, and other aspects and implement them all to achieve a highly functioning and energy saving and producing hospital.

The possibility of transforming existing hospitals into energy producers through the cultivation of solar cell surfaces, the use of wind turbines, solar-powered glass, energy-producing floors and landscape can be easily achieved from the preliminary stages of design as shown in the proposed design.

## REFERENCES

[1] Allouhi , A., El Fouih , Y., Kousksou , T., Jamil , A., Zeraouli , Y.,Mourad ,Y., "Energy Consumption and Efficiency in Buildings: Current Status and Future Trends", Journal of Cleaner Production, 2015, Volume 109, Pages 118-130

[2] Yüksek, I., and Karadayi, T., "Energy-Efficient Building Design in the Context of Building Life Cycle",2017,https://www.intechopen.com/books/energy-efficient-buildings.

[3] Bauer,M., Mösle,P., Schwarz, M., "Green Building: Guidebook for Sustainable Architecture", Springer, Verlag, Berlin, Heidelberg, 2010

[4] Kolokotsa ,D., Tsoutsos, T., and Papantoniou, S.," Energy conservation techniques for hospital buildings ", Advances in Building Energy Research, Volume 6, 2012

[5] Commercial Building Energy Consumption Survey, U.S. Department of Energy,2003.

[6] McGee, C.,Reardon, C., Clarke, D.,"Passive designOrientation", Updated by ChrisReardon,2013,http://www.yourhome.gov.au/sites/prod.yourhome.gov.au/files/pdf/YOURHOME (accessed on 12/2018)

[7] Danielski, I.,Froling, M., Joelsson, Anna.,"The Impact of the Shape Factor on Final Energy Demand in

Residential Buildings in Nordic Climates" ,Mid Sweden University, 2012.

[8] Prasad,D.,Snow,M.,"Designing with Solar Power: A Source Book For Building Integrated Photovoltaics (BiPV), The Images Publishing Group Pty Ltd, Australia, 2005.

[9] Kreith, F.,West,R.,CRC Handbook of Energy Efficiency, CRC Press, NewYork, 1997.

[10] Chiras, D.,"The Solar House:Passive Heating and Cooling", Chelsea Green Publishing Company, White River Junction, Vermont, 2002.

[11] http://en.wikipidia.org/wiki/skylight (accessed on 12/2018)

[12] J Tart,World architecture 6 , Hospital building ,2012,P 92 .

[13] Amado, M.; Poggi, F. Solar energy integration in urban planning: GUUD model. Energy Procedia 2014, 50, 277–284.

[14] Alark A. Kulkarni, "Solar Roadways" – Rebuilding our Infrastructure and Economy, International Journal of Engineering Research and Applications (IJERA), May-Jun 2013.

[15] Jackson, C., " Solar car parks: A guide for owners and developers", BRE National Solar Centre, 2016, https://www.r-e-a.net/upload/rea-bre_solar-carpark-guide (accessed 12/2018).

[16] https://en.wikipedia.org/wiki/Solar_street_light (accessed on 12/2018)

[17] Singh, M., "Energy Harvesting Trees", IRF International Conference, India, 2014

[18] Dodgson, L., " Solar windows: the future of zero-carbon buildings",May 2016,

[19] https://www.power-technology.com (accessed 12/2018).

[20] Ahmed,S., "Wind Energy: Theory and Practice", PHI Learning Private Limited, Delhi, 2016.

[21] Mohamed, N., "Smart Technologies Used in The Rationalization of Energy Within The Spaces of Movement in Mall, The Smart Mall", Master of Science, Architectural Engineering, Faculty of Engineering, Cairo University,Giza, Egypt, 20140.

[22] Haimantibanerji, creation of a universally stimulating and responsive environment within hospitals ,Quality of life A vision towards better future,2 th international conference , mti. university, cairo, Egypt , 2012. P.81.

[23] https://www.naturebright.com/research-news/using-natural-light-in-hospital-interior-design/

[24] American Society of Heating, Refrigerating and Air-Conditioning Engineers ,"Advanced Energy Design Guide for Large Hospitals: Achieving 50% Energy Savings ,Toward a Net Zero Energy Building ", Atlanta: ASHRAE; 2012.