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AN INTEGRATED DESIGN APPROACH TO ZERO-E UNIVERSITY BUILDINGS IN EGYPT

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Abstract

Study energy usage in the university recently due to inefficient use of energy and lack of awareness among building users has become urgent. In this context, energy conservation should be implemented to optimize energy use. This paper discusses the concept of zero energy university with a view to proposing steps to conserve energy and achieve sustainability. A review of the literature reveals that energy conservation methods can be classified into three categories: building systems and taking advantage of external influences and reducing the thermal load of the building. Within the context of these categories, using the analytical method numbers of high-impact energy conservation methods are suggested, including renewable energy, improvement of energy efficiency, energy usage management and monitoring, promotion and integration of energy concept, an improvement on energy-saving awareness and energy-use behavior. Using the applied approach, the Fayoum University model was used to ensure the effectiveness of the proposed solutions and alternatives and to make sure of the possibility of reducing electricity consumption through the suggestions presented. Based on the recommendations in this paper, universities can adopt energy conservation methods that can be in harmony with their policies and strategies.

Keywords

Zero Energy- Universities - Energy Conservation.

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1. Introduction

The rebound effect is a phenomenon that became a focus of energy economists since early 80's.this phenomenon is when demanding cheaper, more efficient produced energy cause a loss of potential technological saving. A high performance building became a major hope in achieving environmental goals.(Stela Rubínová - 2009/2010- page ii) Producing a high performance building can be achieved in case of understanding how buildings work also taking the right decision in choosing materials. (Nisson & Wilson- 2008 – page 130) This research deals with a methodology that helps to design a system to reduce energy consumption on campus in Egypt, that achieves its principles and commensurate with the nature of the situation in Egypt and addresses the problems in Egypt. it will be applied to the Egyptian university.

2. Determine the most important factors affecting the consumption of thermal energy:

The study will address setting criteria for evaluating the proposed model for evaluating the principles of energy saving on the campus in Egypt, which is the focus of the research study.

2.1 Criteria for selecting analyzed models

All selected cases Succeed in achieving Reducing energy consumption through architectural measures.

1-The universities should be in near circumstances as in Egypt

2-The universities should be executed, not projects that have not been built yet

3-applying some of energy saving principles as goal to design them.

To obtain best practices in implementing a strategy to reduce energy consumption and preserve the environment, through these parameters:

- The human need
- Learning requirements
- Low cost energy design
- Improve the condition of the existing building

2.2 Scheme of applied study for models:

In this part of the study, a light is shed on the architecture of zero energy buildings architecture at the global level, By studying the most important elements used in energy saving and thermal comfort, as well as the possibility of adapting to site conditions and using them for the benefit of the building and the exploitation of natural lighting, as well as the energy of the sun in providing the energy used for operation. "table 1 "

3. The effective design treatments for zero energy buildings:

By reviewing "table 1", analyzing them, and examining the elements that were used to transform the buildings into zero-energy or near-zero buildings, we can extract some important elements that determine the shape of the zero-energy building or contribute to its formation, which are as follows "table 2 "

"Table 2" Treatments for new and existing zero energy buildings - Source: author

serial		Elements	New building	Existing building
1	Compatible design	Orientation	√	/
		Openings (size – place-material)	√	√
		Building envelope treatments	√	√
		roofs treatments	√	√
		Afforestation of the site	√	√
		Day lighting and shading	√	√
		Rooms and spaces size	√	/
2		Thermal insulation	√	√
3		Energy generating	√	√
4		Passive technology	√	/
5		Intelligent building control systems	√	√

4. Effective alternative for zero buildings' components:

In the following table we review some of the effective alternatives, or the most important ones, which can be used in building elements and components as the external envelope, directives, external and internal treatment. " Table 3"

" Table 3" Alternative Components for new and existing zero energy buildings -Source: author

Serial	Elements		Variables
1	Compatible design	Orientation	√
		Building envelope treatments	Wall claddings
			brick cladding
			Wood cladding .
			Metal cladding.
			Ceramic cladding
			Concrete cladding
			Stone cladding
			Composite cladding

Serial	Elements	Variables	
			Metal Mesh cladding
			Intelligent building
			Reflective coating
		roofs treatments	Planted roofs
			white roofs
			Add shade
			heat-resistant flooring
		and Afforestation of the site	Backyards planted
			Dense trees to shade around the building
			Green lands
		Daylighting shading	Sky light
			Sun screens
			Vertical and horizontal louvers
		spaces size	Small spaces and flexibility of use
2	Thermal insulation		Green walls
			Green roof
			Double Skin
			Box window
			Corridor type
			Multi story
			Nano material insulation
			Aerogel thermal insulation
			Double wall
3	Passive technology		Solar thermal energy
			solar chimney
			Ventilative cooling
			Passive ventilation
			Radiant cooling
4	Energy generating		Solar pv systems
			geothermal systems
5	Intelligent control systems		Efficient Lighting performance and reduction appliances
			Energy efficient appliances usage.
			Moving Sensors

5. The proposed system model for evaluating campus in Egypt

In this part of the study, the practical application is highlighted on an existing model which is the Faculty of Engineering of The University of Fayoum - a civil building. Take procedures to reduce the consumption of energy used in the building and even try to introduce electrical power generation units.

5.1 The objective of the applied study:

The applied study aims to try to develop a system that helps reduce energy consumption in existing buildings and create treatments aimed at improving the environmental performance of the building in order to save expenses.

5.2 Applied study curriculum:

i. About the building and building materials.

ii. Ventilation and lighting.

iii. Analysis of the current state of the building.

iv. A presentation of proposed solutions.

v. Energy efficiency as a result of the proposed adjustments

5.3 Fayoum University (faculty of engineering) as case study:

The local study sample was chosen according to the fact that it is a university building and serves a large number of students for long periods.

5.3.1 Building description:

The building consists of 3 floors ground floor and 2 typical floors. The building spaces are distributed between offices and various educational spaces. The number of users ranges from 300 students to 50 students in the amphitheater and research labs and service laboratories. Laboratories serve students and provide services to the public as well as. Also there are internal service rooms. (Bathrooms, stores and small kitchens). Figure 1

Table 1. Analysis of the selected global models

	comparison	Benefit from the natural elements of the site	Lighting at the site	Buildings' finishing materials	design strategies	
Analysis of the selected models	**Chatham University** (edenhall.chatham.edu) (aia.org)(businesswire.com) (glassonweb.com)	Photovoltaic panels, solar hot water, geothermal co-generation and micro-turbines - Using natural gas with bio-fuel equivalency. - greenhouse	using glass in the facades to get cross ventilation	The skin from the outside consists of black locus panels, eight inches of mineral fiber insulation, a vapor barrier, and a wood interior wall -solar control low-e glass	green roofs, rainwater storage and mixed-use areas and linked via a variety of public spaces and pedestrian connation's	
	Singapore University of Technology and Design (sasaki.com) (austria-architects.com) (unstudio.com) (/spaces4learning.com)	solar photovoltaic cells is used to produce renewable energy . sun loungers on the east and south elevations -Using the wind for ventilation and cooling	Use natural lighting on the site by using glass elevations	The pre-cast concrete facade system -Strata flooring and coatings-In cladding SSG® Low Emissivity Glass - Topaz Zero Silk 58903	Covered walkways, and shading of the vented façades on the basis of studies of directional and intense winds.	
	Stanford University Central Energy Facility (aia.org) (archdaily.com) (architectmagazine.com)	Solar farm An open-air plan with high ceilings, allow day lighting throughout the year	Fans and operable windows permits natural ventilation	board-formed concrete sandstone- red tile terra cotta roofs- Exposed concrete floors -wood ceilings of arcades on campus	Hot building core provide most of electricity needs - replaces a 100% fossil-fuel- electrical power—65% of which comes from renewable	
	Welcome Center at Millersville University (lancasteronline.com) (csemag.com) (aiacontracts.org/)	Solar panels are the stars of the building's energy-generating side geothermal heat pump systems	using solar glass that is photovoltaic	terra cotta rain screen system is used as the exterior cladding using solar glass that is photovoltaic ″3Thermax sheathing and Knight Wall Systems CI girt cladding support system	Geothermal heat pump system provides efficient heating and cooling. Inside, the performance of this system is indicated through interactive dashboards	

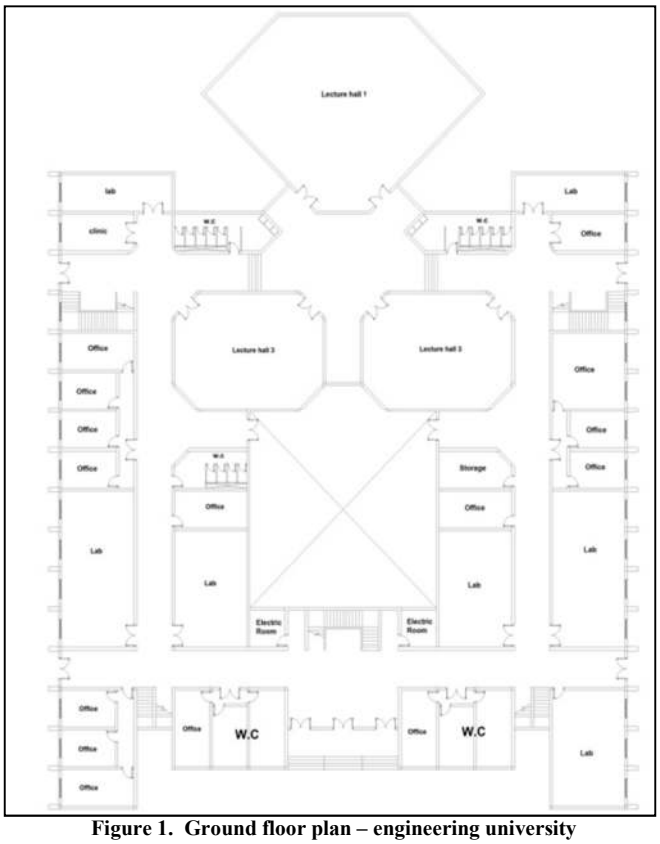

Figure 1. Ground floor plan – engineering university

5.3.1 Building materials

The building walls were constructed of bricks and normally used material in all recently constructed buildings. Interior finishes of plaster and granite which used as a durable material and to minimize temperature in corridors of the building also wood is used in lecture halls.

5.3.2 Ventilation and lighting:

All rooms in building are day lighted as the building doesn't have artificially ventilated rooms .Diffused natural daylight and the open indoors as well as improved ventilation and indoor air quality play a role for improving the building and create a healthier, more productive environment for faculty, staff, students and researchers. Figure 1

5.4 The suggested solutions for saving the energy

"Table 4" Suggested solution elements in civil engineering building

Serial	Elements		Solution
1	Compatible design	**Openings**	Using double glass (low- e) *Solarban*® 70XL solar control low-e glass
		Building envelope treatments	Reflective wall coatings
		roofs treatments	-Reflective white coating -Green roofs -Shading
		Daylighting and shading	-Exterior window shading and glassshading
2	**Thermal insulation**		-Gamma Nano Ultra-thin Thermal Insulation -double wall (gypsum board – expanded polystyrene) -Aerogel thermal insulation
3	**Energy generating**		Solar pv systems
4	**Intelligent building control systems**		Replace old system with smart one

5.5 Applying the suggested solutions to the civil engineering building:

a) Civil engineering building simulation:

Figure 2. Defining location in design builder

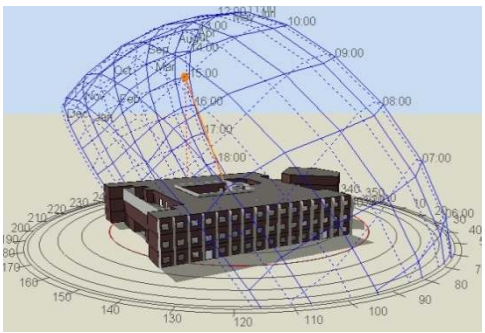

Figure 3. Building modeling in design builder

b) **Next step** was to define all known information about the building to the program:
   a. Function and building activity time.
   b. Building construction components.
   c. Building openings.
   d. Lighting system in building.
   e. HVAC systems.

c) **Before retrofit:** First, a simulation of the building in its current condition is performed to find out the value of the building's current electricity consumption. Total energy consumption: appears to consume 532.930 kW daily "Figure 4"

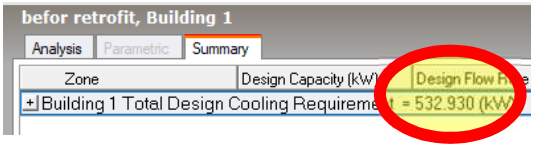

Figure 4. Before retrofit energy consumption simulation results

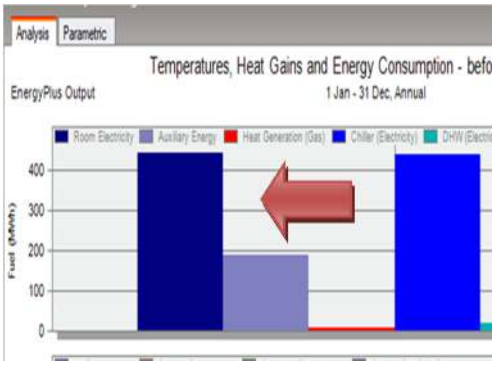

Figure 5. Before retrofit yearly energy consumption simulation results

d. **Solution systems simulation:** In this part we will analyze the building after applying the suggested solutions in (Table 4) .Each element and its effect will be tested to analyze how it will affect the energy usage in building. Finally all elements will be tested to verify the energy

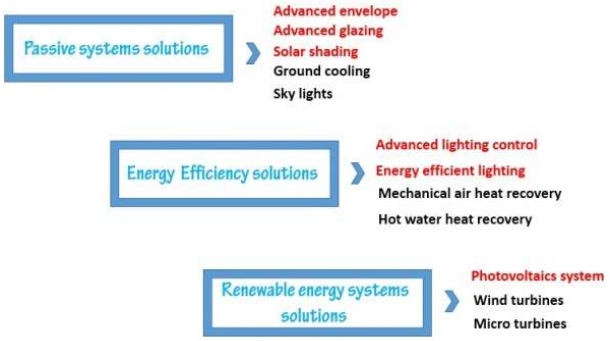

Figure 6. Suggested solution systems

The regular simulation of the current state of the building showed the strength of the effect of changing or modifying any of the proposed elements during the research on energy consumption and the possibility of effecting an effective change through the modification of some simple elements, but the results of the change are very large and saved from the electrical energy consumption budget.

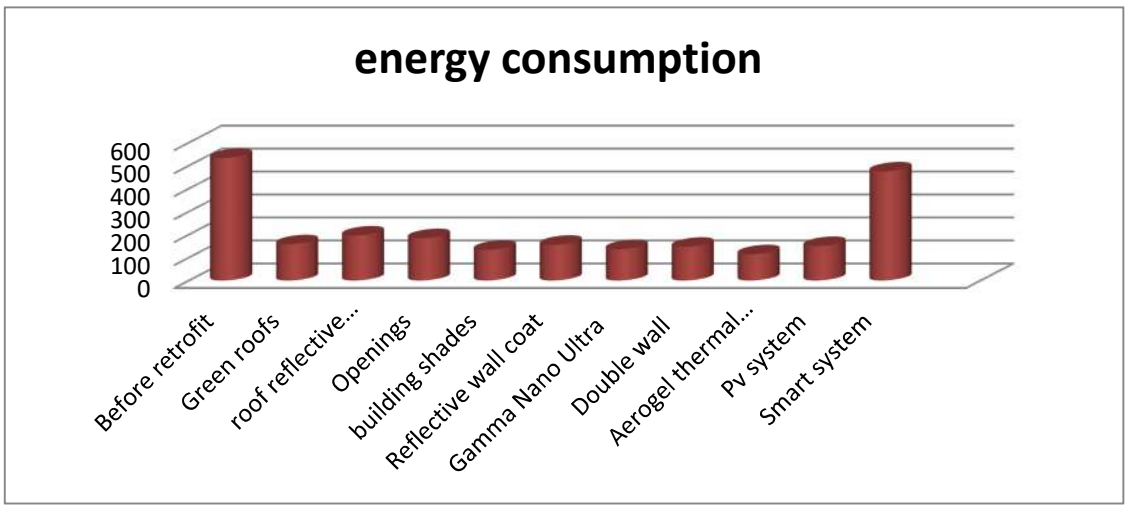

Figure 7. Energy consumption before and after retrofit.

6. Conclusions

The main objective of the study is to show that it is possible to reach the buildings near zero energy by modifying the existing university buildings taking into account the Egyptian conditions. This was proofed through the study after analyzing some global examples and extracts from it the elements that affect energy consumption and that more than one component has been tested on local building and its effect on the building's energy consumption. (fig 8) also through the study, we turned to find out that the modifications that can be applied to existing buildings are very limited modifications, especially in university buildings due to the sensitivity of the building's role and its importance. in the overall process of implementing standards, the study revealed a direct correlation between increasing the rate of implementation of standards and achieving the highest rate of energy consumption rationalization while preserving the highest rate of internal environment efficiency .

"Table 5" Energy consumption before and through the application of alternatives

Serial	Tested element	Result	Saving average
1	**Before retrofit**	532.93 KW	---
2	**Green roofs**	157.490 kW	70 %
3	**roof reflective white coating**	195.670 kW	63 %
4	**Openings**	183.900kW	65 %
5	**building shades**	133.590 KW	75 %
6	**Reflective wall coat**	155.220 KW.	71 %
7	**Gamma Nano Ultra**	136.38 kw	74 %
8	**Double wall**	146.43 kw	73 %
9	**Aerogel thermal insulation**	114 kw	79 %
10	Pv system	149.81 KW	72 %
11	Smart system	474.30 kw	11 %

To cope with the aging process and to rationalize energy use, as well as to improve the efficiency of the internal climate and the environment in General, research advancement in the field of saving energy should be pursued. It is critical to implement technology to save energy.

According to the researcher, the following factors should be considered in order to create a zero energy university

1. Research the impact of the building's envelope on thermal loads and lighting
2. The relationship between building's envelope and educational attainment rates.
3. Methodologies for working with buildings in universities.
4. A methodology for achieving zero-energy buildings in the university
5. The role of standards and the necessity to improve them in the process of reducing energy use in university buildings in order to improve the climate.
6. The role of improved materials in the process of climatic compatibility of existing building

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مدخل تصميمى متكامل لتصميم المبانى الجامعية صفرية الطاقة

دراسة استخدام الطاقة في الجامعة مؤخرًا بسبب الاستخدام غير الفعال للطاقة ونقص الوعي بين مستخدمي المبنى أصبح أمرًا ملحًا. في هذا السياق ، يجب تطبيق منظومة للحفاظ على الطاقة لتحسين الاستخدام. تناقش هذه الورقة مفهوم الجامعة صفرية بهدف اقتراح خطوات ترشيد الطاقة وتحقيق الاستدامة. من خلال القراءات المتعددة والاطلاع على الابحاث المنشورة يتضح أن طرق الحفاظ على الطاقة يمكن تصنيفها إلى ثلاث فئات: 1- أنظمة البناء 2- الاستفادة من التأثيرات الخارجية 3- تقليل الحمل الحراري للمبنى. في سياق هذه الفئات ، يُقترح باستخدام الطريقة التحليلية عددًا من طرق الحفاظ على الطاقة وتقليل الحمل الحراري للمبنى وتقيق استهلاكه من الكهرباء وهى طرق ذات تأثير فعال وقوى مثل استخدام الطاقة المتجددة ، وتحسين كفاءة الطاقة ، وإدارة استخدام الطاقة والمراقبة ، وتعزيز مفهوم الطاقة وتكامله ، وتحسين الوعي بأهمية توفير الطاقة ووترشيد سلوكيات استخداما . وكا تم من خلال البحث وطبقا لاستخدام المنهج التطبيقي استخدام نموذج جامعة الفيوم للتأكد من فاعلية الحلول والبدائل المقترحة والتأكد من إمكانية تقليل استهلاك الكهرباء من خلال الاقتراحات المقدمة. بناءً على التوصيات الواردة في هذه الورقة ، يمكن للجامعات القائمة و حتى الجديدة اعتماد طرق للحفاظ على الطاقة يمكن أن تكون متوافقة مع سياساتها واستراتيجياتها.

الكلمات المفتاحية : صفرية الطاقة، الجامعات، المحافظة على الطاقة