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EVALUATING THE EFFICIENCY OF THE SUSTAINABLE AND GREEN BUILDINGS WITH AN APPROACH TO ENERGY SYSTEMS

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ABSTRACT

Globally, the high energy consumption leads to environmental crisis climate changes, global warming, lack of energy resources, the available problems in the field of energy, and the destruction of Ozone layer. Therefore, the analysis of energy consumption levels in the buildings, and devising new strategies for achieving sustainability in creating the environments is essential. The evaluation of the definitions of the sustainable buildings shows that still there are many problems in defining the sustainability of the created environment. Accordingly, by the view of extending a general landscape based on the available theoretical stands, and applications, tools, the evaluator systems, and simulation systems for the efficiency of the sustainable buildings compatible with the ecology in the field of energy efficiency is provided. In this study, it has been attempted to discuss the concepts and factors of creating sustainability in the field of energy efficiency and buildings, and their evaluation strategies. To provide a more comprehensive view, and a better understanding of the infrastructures, and the main points, the studies, though briefly, on the evaluation and efficiency of the energy in the green buildings, and its usability, and the residents' satisfaction will be attended to. As a result, our objective is to evaluate qualitatively, and quantitatively the indices of the sustainability in the energy efficiency, and the buildings efficiency by using the suggested methods of the energy efficiency, and the reduction of wasted energy in the buildings.

Keywords: Green buildings, energy consumption, sustainability, energy systems, BEMS

1- INTRODUCTION:

In the recent years, sustainable planning has been an effective reaction to the global environmental crisis; which, its main concern is to create places, productions, and services in such a way that the use of non-renewable resources is reduced, and the environment is kept healthy, and the people are encouraged to return to the nature. The holders of sustainable planning believe that the crisis in large part of the life is due to the traditional planning, and the industrial activities which ignore the environmental risks and side effects of the goods and services. The energy consumption and waste in most of the buildings is beyond the limit; which, this is due to the un compliance with the existing laws, and the professional codes. Almost all the present buildings in the countries use the fossil fuels to overcome the heat or cold during different seasons; which, this amounts to a half of the total energy and raw materials used world widely; and, the awesome demand of energy which is provided by using limited fossil energy resources such as coal, petroleum, and gas, all over the world creates some difficulties of the environmental problems, and the emission of the greenhouse gases; but, synchronously, the building construction sector provides the potential for decreasing the emission of the greenhouse gases. Therefore, the sustainable architecture, and the green planning have become one of the widest fields of concentrating the scientific studies on creating the healthy environment, and improving the urban citizens' life quality.

The aim of planning green or sustainable buildings is to reduce the damages on the environment, the energy resources, and the nature, which includes the rules of; the reduction of consuming non-renewable resources, the development of the environment, and the removal of the reduction of consuming toxic or harmful substances in the building construction industry [1].

2- REVIEW OF THE LITERATURE AND PREVIOUS WORKS

The sustainability means to keep in existence over a long period. The sustainability of the sustainable events derives from the pattern, procedure, or the system of the events over a long period, i.e. in such a case, the event itself with its all material and non-material attributes does not sustain; rather, in every period it repeats according to the unique and durable pattern, and in this way, it sustains; and, through this frequent repeating, it modifies itself; and, in every period it tries

much the more to accord itself to the surrounding conditions [2].

As says Broman "in the sustainable development debate, no unique solution is suggested for the entire world. There is no international and similar model; rather, each country in the framework of its culture, ecology, and the other local attributes seek its own appropriate development on the bedroom of sustainability" [3].

The sustainability is a set of conditions which sustain over time; and, the sustainability is a strategy for selecting the present activities which will create the future problems. In fact, the sustainability is an invitation for creating a dynamic balance between the several effective variables, such as the social, cultural, and economical variables required by the mankind, and the necessity of protecting the natural environment which the humanity is only a part of it.

Generally, the green buildings are those buildings which show the least conflicts with their surrounding natural environment. The conflicts can take the from of high energy consumption, the reduced quality of the inner air, the high water consumption, the noise, the foul odor, the consumption of chemical pollutants, and the destruction of the surrounding ecosystem. Over ally, the green buildings planners attempt to design such

constructs that can provide the economic, social, and natural demands, and by appropriate use of the energy and natural resources, conformity with the environment and avoiding the air pollution contribute greatly to the sustainable development [4]. The buildings are the central places for the human activities, and they represent considerable participants who use energy, and consequently, make the emission of the greenhouse gases. Due to the risks of climate change, and the increased uncertainty about the future energy prices, the energy efficiency has again been back in the front line of the political debates in many countries [5].

According to the studies by Marija and Todouri, the analysis of the energy consumption level in the buildings, and devising new strategies for achieving the sustainability in creating the environments becomes essential. The strategies for evaluating the sustainability often consist of a series of the economic, social, and environmental indices which together and separately are evaluated regardless of efficiency, the material efficiency and the resources sustainability [6].

The study by Jeldou regards the effect of the green buildings on the declined use of the energy, and its side effects on the

environment, has basic guidelines such as the reduced energy demand, and it increases the energy efficiency by using the passive design techniques; similarly, appropriate penetrating building packet saves more than half of the energy distribution tabulated in the building [7].

In another study by Thai Kim and et al, they suggest using the combined methods of renewable energy, and heating, ventilating, and air condition (HVAC). The renewable energies are based on high tech. When touching upon the high technologies of saving the energy consumption, they will be able to meet all the environmental needs, and to protect the climate [8].

In another study by Sajad Zadeh and et al, they analyzed the function of the energy consumption efficiency in the green and intelligent buildings. The good control of the building services can make a considerable amount of saving. The installation of appropriate control equipment will often back price in two years or less. It is important to consider the equipment and control systems energy efficiency in the planning and installation stages. Building Energy Management Systems (BEMS) are the systems based on the computer, which automatically monitor and control the

building services such as heating, are conditioning, air boilers, and lighting [9].

The study by Pahlavan examines the building construction techniques in order to provide the integrated quality regarding the economic, social, and environmental aspects. The reasonable use of the natural resources and the appropriate management of the building construction contribute to the conservation of the limited natural resources, and the reduction of energy use, and improve the environmental quality. The quality forms the basis of the sustainable planning [1].

According to the studies by Hamzeh Lou and Khameh, another one of the elements of the sustainable planning in the modern ecological design is the green roof which can be used to increase the per capita green space, to improve the environment quality, and the urban sustainable development [10].

In another research by Moradi, he studies how the human moves towards sustainability, and greening the passage on the way of the modern global society to its present climax, and he provides a clear image of the future development, and positive effects of such developments, and he states that how greening becomes identical with the climate, being economical, and building the future. Here, one of the main modern origins is achieved, i.e. multi-functionalism [11].

The studies by Heydarian and Adeli have analyzed the green walls to improve the mechanisms of energy consumption in the buildings. Also, they investigate the role of this system in the visual beauty of the urban spaces to achieve the objectives of the sustainable development [12].

The research by Dehnad and et al introduces the concept of the green building and its benefits. As to reduce the energy consumption, each element of the building can in a way provide the construct efficiency; some roles of the building elements are encountered. Also, the globalization of the green buildings has been described, and the infrastructures and capabilities of Iran in the implementation of such buildings have been demonstrated [13].

3- METHODOLOGY

The building performance simulation (BPS) has proved to be a strong model of predicting the dynamical behavior of the building, and the building energy efficiency, the optimization of merging the renewable energy resources in the buildings with the building environmental technologies, and the synchronization of the inherent criteria in the building sustainability. The synchronous implementation of BPS, the energy efficiency, and the renewable energy resources is a reliable way of identifying the green buildings, and achieving the stable zero-energy building [6].

The calculation model in the planning stage should meet the following requirements: firstly, the physical information of the building should be put in computer as parameters, rather then acute modeling. Secondly, the calculation of building energy consumption is rapid, and it can reflect accurately the parameters optimization, and thirdly, the out put results can directly be used to modify effectively the suggested parameters in the planning [14].

Building energy simulation is performed by the architecture planning experts, engineers, energy consultants, and others by using building planning software tools, and the energy efficiency analysis. In the present time, the building energy simulation tools are employed after many decision-makings which affect the building energy efficiency.

Comprehensive Assessment System for Building Environment Efficiency or CASBEE is a common strategy taken by the state, university, and industrial sections in Japan. The four main aspects of CABEE are: the energy efficiency, the resources efficiency, the local environment, and the inner environment. Which altogether are consisted of 80 subscales which again are classified into two main groups: Q (quality),

and L (load). To evaluate the green building sustainability CASBEE adopts the BEE (Building Environmental Efficiency) amount [15].

The equilibrium (1) shows how to calculate BEE (15):

$$BEE = \frac{Building\ Environmental\ Quality}{Building\ Environmental\ Load} \quad (1)$$

Another one of the building energy management systems (BEMS) are the computer-based systems that automatically monitor and control the building services such as heating, air condition, air boilers, and lighting. A major part of their tasks, in addition to controlling the environmental parameters, is to provide information about the energy efficiency that enables us to identify the objectives of achieving the energy saving. There are two main types of BEMS: The centralized, and the intelligent uncentralized. In the centralized systems, all the systems of the adopted center are controlled by a central computer unit. This type of BEMS is more appropriate for the commercial and industrial buildings such as hospitals with more than 500 beds, large factories, and the airports. The un centralized intelligent systems are a new achievement. This type is consisting of a number of local intelligent stations; which, each station controls a small building that is part of large

building which offers a special service. The stations send the information to a central unit in such a way that the total acquired information can be analyzed. This type of system is usually used for small to medium buildings under a common ownership such as schools, hotels, chain stores, and public stores. By the installation of BEMS, compared to individually controlling one by one of the services, the efficiency improvements from 10 to 20 percent are achieved [9]

In this study, the methodology is based on the library studies; and, the has a descriptive and analytic approach to study and evaluate the models such as BPS, BEMS, the green roof, and the green walls in order to improve the building energy consumption mechanisms.

4- Innovations in the sustainability

4-1- Energy efficiency simulation in the building

The building energy simulation is the building analysis by using computer modeling tools that express the building heat load and the energy consumption via energy and building attributes. The energy efficiency simulators are analyzing the available buildings; which as, the simulation, and analysis of the efficiency should be employed during the building planning

process to evaluate the shape, from, material, and integrated systems of the building during the design stage. The building performance simulation (BPS) has proved to be a strong model of predicting the dynamical behavior of the building, and the building energy efficiency, the optimization of merging the renewable energy resources in the buildings with the building environmental technologies, and the synchronization of the inherent criteria in the building sustainability. The synchronous implementation of BPS, the energy efficiency, and the renewable energy resources is a reliable way of identifying the green buildings, and achieving the stable zero-energy building [6].

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Building energy simulation is performed by the architecture planning experts, engineers, energy consultants, and others by using building planning software tools, and the energy efficiency analysis. Taking this strategy has the following benefits: 1- It is a strong model to study the building energy efficiency, and a tool for the evaluation of the building architecture's planning.

2- With the help from building energy simulation, we can point out the causes of the serious problems that have occurred in the building architectural planning, quantify them, and evaluate them.

3- It is a useful tool for creating a better understanding of the building energy efficiency.

4- The analyzed energy can provide better information for making capital and strategic decisions.

4-2- Building Energy Management Systems (BEMS)

At the center of BEMS, there are the computer-based systems that automatically monitor and control the building services such as heating, air condition, air boilers, and lighting. A major part of their tasks, in addition to controlling the environmental parameters, is to provide information about the energy efficiency that enables us to identify the objectives of achieving the energy saving. There are two main types of BEMS: The centralized, and the intelligent un centralized. In the centralized systems, all the systems of the adopted center are

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These factors are determined prior to the system installation [9].

For BEMS to effectively work in the building, the grouping of the heating, air conditioning, and lighting system should be possible in accordance with the available functions in different sections of the building. The equipment should be flexible enough be able to comply with the necessary modifications in the system. Most of the problems occur in the buildings that their function over long years has been modified without any modifications in the servicing systems. If the available equipment are not kept property, or the controls are erroneously installed, their modification at the initiation can lead to considerable saving. When this is done, with regard to the expenses, the installation of a BEMS can be ineffective. The main task of BEMS is to show that how much the building services are inappropriate. The scheme of an intelligent building is demonstrated in figure1.
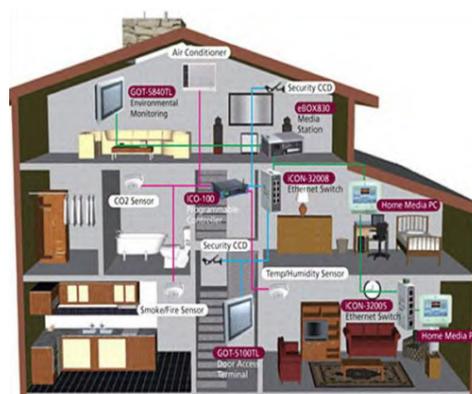

Fig1. The scheme of an intelligent building

4-3- The green roof

The green roof which is also called the plant roof or the biological roof, is a light engineering construction that facilitates the plant growth on the roof, while it protects the roof. Such spaces have different environmental and technical engineering application. In another definition of the green roof, it is a roof that in some part or in whole is covered with a growing medium [10].

Generally, the green roofs with respect to the variety of flora, the average soil thickness, and the maintenance are classified into three groups: the extensive system, the centralized system, and the modular system or Box plant. The extensive system: this system is also known as the low profile or the thin implementation. This type of the green roof is consisting on only on or two plant species, and the thin growing medium. This system is usually employed when the least weight load is considered. Typically, only the maintenance staffs are granted access to this type of the roof.

This type of roof, similar to the Norwegian grass, is built on the flat and sloping roofs. In this system, the plants usually have roots with 44 to 144 lengths. The approximate maximum load of the roof is 40 to 144 Kg/m^2 in the saturation. The word Green Roof is used for the extensive system. For the sloping roofs, in most places the recommended slope is 14% to 24%. In the maximum 34% slope, it is necessary to use worn and anti-erosion tolls.

The centralized systems: this system is also known as deep profile or garden roof. This type of roof is consisting of a green roof involving different kinds of plants; and, it is designed similar to a park. Some green roof include large trees, and water view; which, this requires the basic construction enhancement. This system often makes it essential the need of new constructions on the roof, especially for the roofs which are in public use. The word Garden Roof is used for the centralized system.

The modular system or plant box: in this system, the plant and its growing medium are kept in special boxes that cover all or almost the entire green roof. In the modular system, the growing medium consists of a continuous layer on the green roof. The garden roof classification details are very diverse and massive. This is due to the fact that each commercial corporate or company offers a fraction based on its approach to the subject.

In Table1, a comparison has been made between different kinds of green systems. The green roofs compared to the common roofs, give many benefits. For example, the aesthetical is one of the benefits of the green

roofs that give a refreshing appearance to the surrounding environment; the green spaces substitute the dull tarpaulin roofs, and can be seen from different urban landscapes.

Table 1: Kinds of green roof systems [16]

	Extensive green roof	Half green roof	Condense green roof
Maintenance	Low	Periodical	High
Irrigation	No need	Periodical	Regular
Vegetation	Moss, Sodom, herbs, meadow	Meadows, herbs, bush	Perennial plants or meadow, trees
System thickness	60-200mm	120-250mm	150-400mm
Weight	kg/m2150-60 Lb/sqft	kg/m2200-120 Lb/sqft40-25	kg/m2 500-180 Lb/sqft100-35
100	40		
High	Medium	Low	cost

The reduction of the urban heat island phenomenon: The large cities, due to their extensive hard and impervious surface without vegetation absorb the sunlight heat rapidly, and they act themselves as the emitting sources of the heat energy. In such a case, a considerable difference of temperature occurs between the urban areas which is called the urban heat island phenomenon such s condition exists in the urban areas where the surfaces are covered with asphalt shingles, and the areas with vegetation.

Air purification: Like other plant masses, the green roof can purify the dust and the soot particles in the air. Compared to the common roofs that have no optimal effect on the air, the green roofs capture many particles in the air, and the urban air will kept healthy for humans and other living creatures to breathe.

Sound and heat insulation: the green roods are composed of several layers such as water proof layer, shell roof, the growing medium, and the plant elements. So, due to a big thickness, the green roofs can act as sound insulation, and reduce the infiltration of the noises from the traffic, airplanes, and other factors in to the building.

Of other benefits, it can be mentioned the following flood management, the reduction of Co_2, the maintaining of the moisture, the reduction of water absorbance, the reduction of heat transmission via building energy saving, and the economic benefits. In figure2, the resulting temperature changes on vegetation green roofs are shown. The reduction of the difference between the maximum and minimum temperatures have been observed on the roofs vegetation rather than the roofs without vegetation, that can be an important factor of decreasing wasted energy through the roof, and decreasing the environmental sub effects in the buildings.
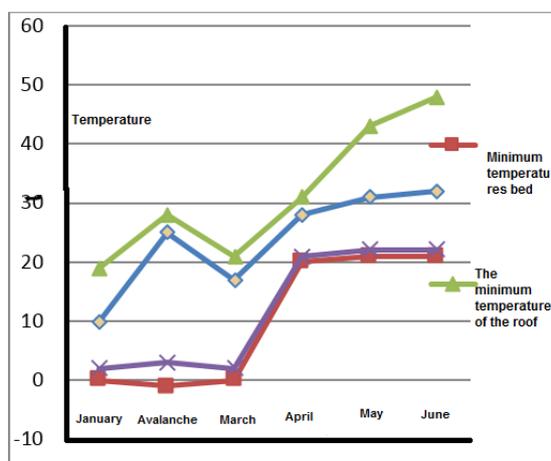
Fig.2 The resulting temperature changes on vegetation green roof [17]

4-4- Green Wall

The green wall is a living covering system with advantages similar to the green roofs. It is a new technology that nowadays smoothly gains its significance in the world metropolitans. A living green wall is a vertical arrangement of plants and other elements that naturally remove the toxic materials and the unhygienic and harmful emissions from the natural environment. In other words, the green wall helps to refine the environment. Giving wider green views in the limited constructions in comparison to the green roofs is a benefit; on the contrary, the flora variety is less than the green roofs [12].

Of the green wall benefits that can lead to achieving a sustainable environment, the following can be mentioned:

1- It improves the energy efficiency.

2- It protects the building constructions.

3- It improves the quality of inner air.

4- It reduces the urban heat island phenomenon.

5- It improves the outside urban air quality.

6- It improves the aesthetical aspects.

In figur3, the performance of the active living wall is demonstrated. In this system, the produces air by the plants is used in the building air conditioning.

Fig3. The performance of the active living wall

4-5- Measuring Energy Systems Sustainability

The researches have shown that it is possible to define a coherent collection of sustainability indexes to be used in the energy system. For this reason, four groups of indexes are identified which cover the resource, the environmental, the social, and the economic indexes [18].

Measuring multi criteria energy system is a way to create a measuring parameter that entails the different interactions between the system, and its surrounding environment. This may lead to the development of a way that can help us in the deep understanding of selecting energy system specific role in our life quality; like every other complicated system, the energy system is defined by some restrictions which reflect its efficiency, technology, geography, property, and capacity. There are many consequences of the performed activities to move towards sustainability in the healthy buildings. The technologies that aim to improve the internal environment quality should be evaluated for their overall environmental effects. The energy system sustainability can not be simply based on the environmental effect. It should be mentioned that the use of the renewable energy technologies can considerably be beneficial from the social,

environmental, and economic concerns. To determine the standard quantity for measuring the sustainability of each energy system planning, the indexes are defined in order to meet this need. The first step in the process of developing a sustainable energy efficiency index entails the identification of the sustainability definition and principles. The second step is the selection of problems or sustainability details in the building. There are some major problems such as energy consumption, resources tale-up, and water quality. The third step is creating indexes or a scientific method in order to answer the questions very simply. The final step has only been considered to guide the process of developing the sustainable energy efficiency index [5]. Of the indexes are the environmental index, the social index, and the economic index.

5- CONCLUSIONS

In summary, this study has analyzed the sustainable energy efficiency in the green buildings, and discusses the way of evaluating the energy system sustainability and the effect of energy efficiency on the sustainability of the green building. Most of the time, our problems are not our objectives; rather, they are the strategies taken for achieving those objectives. The findings of this study entails the strategies of evaluating

sustainability with a series of economic, social, and environmental indexes, that are synchronously and continually evaluated with energy efficiency, material efficiency, and resources sustainability. However, to realize the sustainable construction, and to create methods of evaluating sustainable building, the sustainable energy efficiency indexes should be synchronously studied; and, by a useful classification and by employing qualitative tools, and system of indexes, and a quantative tool with a LCA approach it can be fulfilled. In fact, by analyzing energy system in the planning stage, and by improving the energy efficiency in the building utilization, the sustainable architecture and green planning become of the most effective areas of building environmental evaluation that leads to that the building in a long-termed prospect improve the economic value, the environmental neutrality, the human satisfaction, and the social justice, and touch upon the urban citizens' life quality. In addition, the evaluation tool should be devised based on the local, regional, and cultural conditions along with merging the appropriate energy efficiency indexes, and take into account in a long-termed prospect the effect of the building on the physical and mental health of the residents. In other words, the qualitative and quantitative approaches should be taken for measuring the building sustainability. To extensively recognize a rating system of the green building, it is very important for system to be flexible, and adoptable with respect to the studied areas, and it can reflect an understanding of the users' demand. This strategy is achieved via research, simulation, the interdisciplinary studies, and using new technologies.

According to the present study, the following suggestions are offered on the development and implementation of the green buildings benefiting from the sustainable energy:

Creating motivations for demanding green building; considering compliance with the environment and the economic conditions; encouraging the development of employing renewable energy technologies; pricing the energy saving products and developing the sustainable energy markets; supporting the local researches on the renewable energy technologies; applied investments on energy efficiency; regulating energy cost.

Appropriate and logical evaluation and planning of the energy systems; fulfilling national energy standards of green building industry; developing sustainability indexes; warranty of project quality; expert training of the staff evaluating energy efficiency in the

building and inspecting temperature ratio; energy saving; innovation of the energy systems.

Neutralizing the environmental sub effects by considering renewable technologies; using the real experiences on the residents' satisfaction; introducing and clarifying the products market; increasing the knowledge of environmental issues; and reasonable use of energy.

Social justice; residents' satisfaction and shareholders' equity; individual's ease and health based on multi-variable analysis flexibility and adoptability of the systems; creating a mental image to increase the public knowledge about renewable energy technology.

Successful appliance of renewable technologies by employing professional staff, and construction standards; supplying useful energy saving products while decreasing the production costs; Institutional and regulatory framework to enhance energy services.

With respect to present issues and obstacles of this study, it is necessary to identify and expand useful energy strategies for green buildings to achieve sustainability. Knowledge and experience sharing will become a tool to successfully get closer to the sustainable buildings optimization, and the sustainability, in general.

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