ARCHITECTURE SUSTAINABILITY AND ENERGY EFFICIENCY

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ABSTRACT

High technology in the field of renewable energy has dominated various aspects of life in this era, especially architecture, by exploiting its potential to produce clean energy. It is a photovoltaic (PV) material that is used to replace traditional building materials in some parts of external buildings, such as the roof, skylights, or facades. It is increasingly used in the construction of new buildings as a main or additional source of electrical power generation to make the buildings self-sufficient in energy supply and thus reducing the costs of materials in external cladding of buildings and constitute an aesthetic design from other. One of the advantages of integrated solar power units, unlike non-integrated systems, is that they are the most common, are an integral part of the design, and are generally a better and more aesthetic combination than other solar options. These advantages led to the rapid development of sustainable sectors of the PV industry. The past decade has opened the door to countless solar photovoltaic (BIPV) buildings and other construction revolutions. In both new projects and renovations, BIPV has proven to be an energy-saving technology for use in residential, commercial, and industrial buildings as well as healthy buildings, and the harmony between sustainable design and nanotechnology assures promising future prospects for the construction industry to achieve sustainable buildings for a better built environment.

Keywords: changing materials, energy efficiency, energy performance, innovative aesthetic values, solar photovoltaic (BIPV), sustainable facades

1 INTRODUCTION

Energy is a basic human need. The degree of its abundance and the diversity of its sources determine the way of life of a society and its level of progress. Without energy, there is no development. During the past decade, the construction of energy-efficient buildings has centered around two strategies [1].

First, by installing highly efficient energy recovery systems and, second, by using passive design solutions to improve the efficiency of building facades and make them smart and sustainable destinations; building-integrated photovoltaic (PV) panels provide one or more building electronic functions, in accordance with the international standard IEC63092-1 issued by the International Electro Technical Commission. Therefore, the panels used in integrated photovoltaic systems in multifunctional buildings have the function of generating electricity [2], in addition to its function as a component of the building envelope and changing the role of the building envelope from protection only to energy storage and thus have a very significant impact in reducing the elements of some construction materials in buildings in terms of finishing and building materials for facades and roofs and the separation between the external and internal environment of the building. [3]

2 SOLAR PHOTOVOLTAIC (BIPV)

Building-integrated photovoltaics (BIPV) can be installed in many places in the building envelope, which can provide one or more building envelope functions. And in these places,

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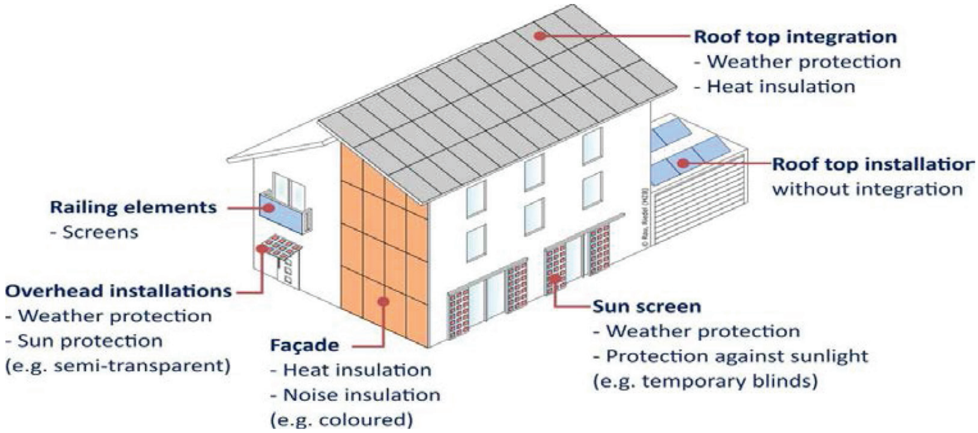

Figure 1: Helmholtz Association of the German Research Center shows the installation sites of integrated photovoltaic projects with buildings [4].

building facades provide thermal insulation and noise insulation. Like umbrellas protecting people from the sun and rain in the skylights [4], integrating these BIPV with the building surface provides thermal insulation, protection from ambient weather conditions and sun, safety, and fall protection systems for balconies and rooftops.

2.1 Catalysts for Building-Integrated Solar Photovoltaic (BIPV) Projects

1. Legislation in some countries for systems of zero-energy buildings and NZEB, which are buildings whose total annual energy consumption is equal to the total annual production of energy through renewable energy sources [5].
2. In some countries, such as Japan, most of the available spaces on the roofs of buildings and land near the load points have been used. Therefore, solar photovoltaic projects integrated with buildings (BIPV) represent an opportunity to increase the size of the installation of solar energy projects in those countries [3, 5].
3. In the towers, there are not enough areas on the roofs to install traditional solar photovoltaic (BAPV) projects.
4. Building project owners and developers say that BIPV-integrated solar photovoltaic (PV) projects are aesthetically better than traditional rooftop PV projects (these are called rooftop solar PV projects).
5. It is possible to use this type of project in the marketing aspects of companies and institutions, directing them towards the use of sustainable green energy [3].

2.2 Exterior paint

Nanotechnology has bought a tremendous change in the world of architecture, from the early stages, considering finishing cladding materials, especially the right choice of materials. This not only reflects the design, but also greatly affects the methodology of thinking in designs based on the many new offerings that offer nanotechnology in the field of cladding materials [6, 7].

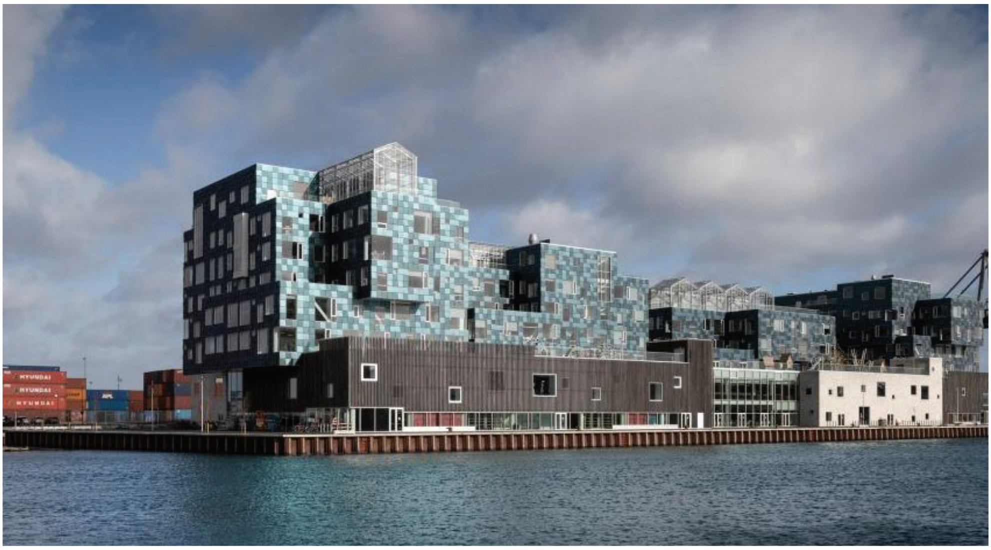

Figure 2: Photo of a photovoltaic solar energy project integrated with buildings (BAPV) at the International School of Copenhagen in Denmark [3].

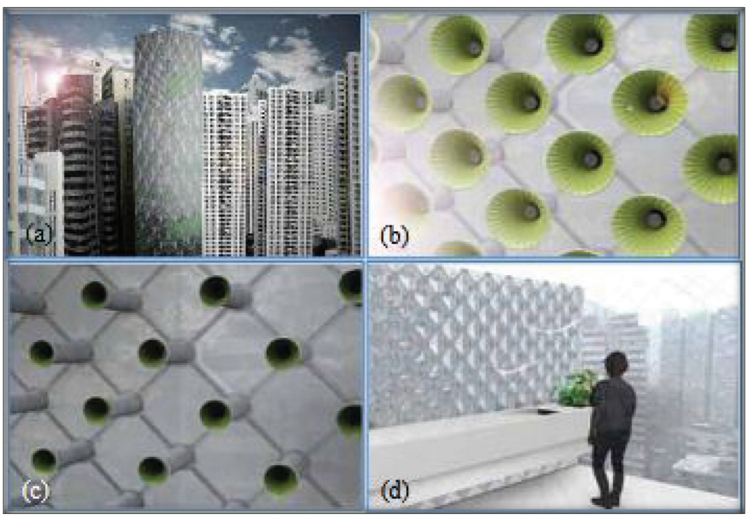

Figure 3: Off the Grid: Sustainable Habitat 2020 [7].

3 CASE STUDY

To test the credibility of the theoretical hypotheses of scientific research by analyzing the case of El-Rahmaniya Central Hospital.

3.1 Study tools

Observation using field images by the researcher.

1. Note the location.
2. Documents and engineering designs.
3. Analysis through the methodology deduced from the theoretical–analytical part.
4. Personal interviews with officials at Al-Rahmaniya Central Hospital.

3.2 Rahmaniya City

Rahmaniya belongs to the Beheira Governorate, which is located in the north of the Arab Republic of Egypt. The city of Rahmaniya is the capital of the canter. Its population, according to official statistics, was 130,457 in 2006, with an area of 120.95 thousand square meters. Its geographical location is distinguished by its presence on the Rosetta branch of the Nile River in Egypt.

3.3 General location of the hospital

It is located in the city of Rahmaniya, bordered on the north side by Princes Park, the school complex, the southern district, the Rahmaniya College Court, and the eastern and western side of streets. The building was built on an area of 2,500 square meters, which is nine architectural blocks with different medical specialties, and the blocks range from one to four floors.

3.3.1 Destination problem

As the facades are made of traditional architectural elements and are not smooth, it is difficult to clean their surfaces for bacteria and dust. Thus, there is a need to paint these facades permanently, which is costly as these are very traditional walls that do not prevent heat transfer within the space [8].

3.4 Strategies for the development of Al-Rahmaniya Central Hospital

Upgrading the Rahmaniya Central Hospital is one of the most important positive methods that prevent the deterioration of health and treatment places at that time, as the spread of diseases and epidemics is increasing and must be reduced by using nanotechnology in architecture because of traditional building materials and the great waste of energy and the use of nanotechnology in Rahmaniya Central Hospital is working to raise its efficiency and the possibility of producing and generating the energy needed to operate the entire building and to use materials and Nano products and integrate them into the existing buildings. To add new features to the building, it is necessary to upgrade the condition of the buildings and raise the efficiency of destinations with nano materials, making the building sustainability [3, 9].

3.4.1 Destination Development

The destinations are grid units divided into squares at an angle of 45 degrees surrounded by metal tubes with wires inside to transmit electricity and glass units. Purifying the air by

Figure 4: Clarifies construction materials and traditional windows.
Source: Researcher.

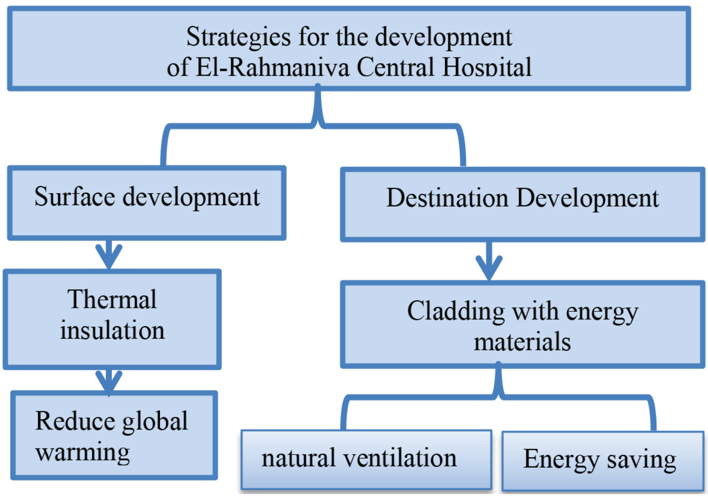

Figure 5: Explains how to develop Rahmaniya Central Hospital.
Source: Researcher

reducing the building envelope as a natural cooling device for the internal environment. It also works to draw moisture from the air and condense it into water and pass it inside the building walls to the tanks to keep it and generate the electricity needed for all the building's devices. As the energy savings that are kept during the daytime in the summer are approximately 224.32 kW from energy storage and in the winter periods, equivalent to the same percentage at a 25% discount [10].

3.4.2 The surfaces

Integrated Building Solar Cells (BIPV) are photovoltaic materials that are used to replace traditional building materials in some exterior building parts such as the roof, skylights, or facades. It is increasingly used in the construction of new buildings as a main or additional source of electric power generation, and BIPV has also been supplied to some old buildings.

Figure 6: The main entrance to the emergency department.
Source: Researcher

Figure 7: The photovoltaic panels for roofs, how they are used, and the amount of energy produced.
Source: Researcher.

One of the advantages of integrated solar modules, as opposed to non-integrated systems, which is more common, is that the initial cost can be reduced by reducing building materials and labour used when constructing the part of the building in which BIPV modules are used. It is an energy-saving technology for use in residential, commercial, and industrial buildings as well as in health buildings [7].

After calculating the amount of energy generated from the rooftop solar panels, the general roof area of all buildings in Al-Rahmaniya Central Hospital is 991.43 m, and each 8 square meter area is 1 kW. The ceilings and this quantity suffices the needs of the building, and it overflows by 70% after consumption [10].

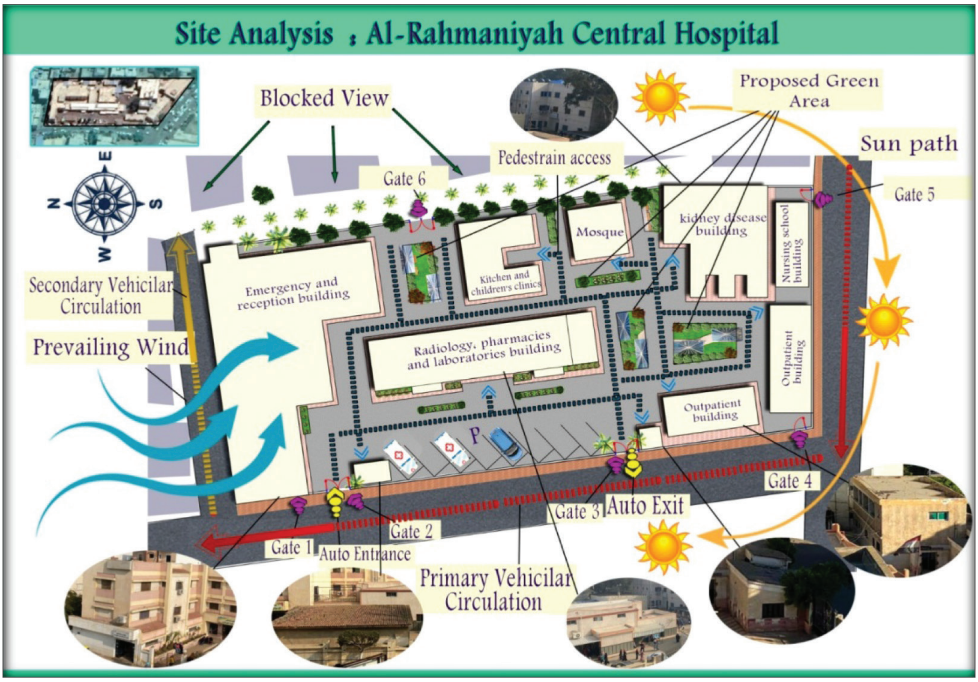

Figure 8: A study showing how the sun moves on all the buildings in the hospital during the day, with an explanation of the spaces and the paths of movement.
Source: Researcher.

3.4.3 Thermal insulation

For flat roofs, installing a thin layer of integrated solar cells for flexible polymer membrane roofing is the most widely used so far.

Solar panels are units designed to look and function like normal panels while incorporating the flexibility of thin-film cells [5, 10].

These ceilings extend the life of ordinary ceilings as they protect the insulation process as well as the membranes from ultraviolet rays and deteriorate water quality. It does this by eliminating the condensation process because dew is trapped on top of the roofing membrane [3].

4 CONCLUSIONS

The capabilities of solar systems have become beyond their function in transforming buildings from traditional buildings to energy-efficient buildings that is through the designer's ability to make it integrated as architectural elements that have an impact in the design of the building.

1. The building was adopted on nano devices to achieve the sustainability of the building in terms of reliance on the external environment and renewable natural energies for self-sufficiency of electricity, water, air, and biogas energy.
2. The building presents a new concept of architecture and its role in improving and removing environmental pollution and helping to improve the internal and external environment in the field of energy and air purification.

3. A new concept of sustainable buildings that lead to the sustainability of cities.
4. Completely dispensing with the public networks (energy–water–sewage).
5. Strengthening the architectural thought, which considers the external surfaces of the building only as a separator between the internal and external environment, so that the building envelope is a living element that works to nourish the building with lighting, water, and ventilation.
6. Develop the general site so that it is integrated with nanomaterials in terms of function and shape and makes full use of it and works to create a clean green environment from pollution.

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