DOI: 10.38027/N72020ICCAUA316389

Practical Application of Advanced photovoltaic Cell Technology in Sustainable Urbanization field

[1*] M.Sc. **George Fawzy Sadik Younan**
[1] *College of Engineering, Zagazig University, Egypt*
E-mail[1]*: georgefawzy55@gmail.com*
[2] Dr. **Mustafa Sabry El Shanawany**
[2] *College of Engineering, Zagazig University, Egypt*
Dr. **Sherif Ahmed Sheta**
[2] *College of Engineering, Mansoura University, Egypt*
E-mail: *sheriefsheta@mans.edu.eg*

Abstract
The energy crisis is considered one of the most important concerns of the world now because it has a direct impact on the economies of countries, and the extravagance in the consumption of land resources from non-renewable energies has a negative return, whether on the environment through harmful emissions resulting from the consumption of those resources or on the scope of the consumption of natural land resources, which Resource unbalance and depletion of most of its resources. There is also a big problem facing many cities in the world, which is the phenomenon of climate changes and the phenomenon of global warming (the greenhouse) and the dangerous environmental (Baroni L, Cenci L, Tettamanti M, Berati M) effects that follow, the most important of which is the rise in the earth's temperature. Humidity and climatic fluctuations, and therefore we need many costs to face these climatic phenomena. There is an increase in electricity consumption in the field of cooling buildings to reach temperatures suitable for human life. And through scientific technological developments in the field of developing solar cells, there are unremitting efforts by scientists to reduce the cost of manufacturing solar cells as well as to reach the highest efficiency through scientific and laboratory research and experiments using nanotechnology that can achieve these goals. We also find that there are many institutions and bodies calling for The importance of relying on renewable energies and reducing dependence on non-renew energies that cause a lot of environmental damage represented by carbon emissions, air pollution and water pollution, and these damages cause many diseases affecting the population,

Keyword: energy crisis; photovoltaic Cell ; Sustainable Urbanization.

1. Introduction

Egypt is considered one of the largest countries in the world in the hours of sunshine, which can optimize the use of this energy in relation to the daily uses of individuals. Also, Egypt has vast areas of unexploited deserts that contain the finest types of sand from which photovoltaic cells are made, and they are considered the raw material for this industry, which can be obtained at the cheapest prices, and there is another factor which is the vast areas that require the placing of solar cells in them to be exposed to sunlight.

1.1 Research problem:

The main problem that the message discusses is the high costs of solar cells. Although this technology has proven successful in generating electric power, many people are reluctant to acquire them because of the high costs, and if it is possible to reach modern technology techniques to reduce the costs of making these cells, we will have achieved many goals:

- Low energy costs, which is one of the most important concerns of the world now because of its direct impact on the economies of countries (H. Steinfeld, 2006) as it is one of the most important problems facing countries, especially developing countries, as energy requires multiple fields in the areas of daily life and affected by many segments of society .
- Also, with the success of this industry, and by entering many sectors in this industry, including the governmental, private, and individual sectors, we achieve abundant job opportunities in this industry.

1.2 Research objective:

- Employing nanotechnology techniques for developing solar cells to generate electric energy to reach higher-efficiency solar cells(Kenny, 2019) at the lowest costs so that the largest segment of society benefits from it.
- How to align the integration of solar cells with buildings so that they give an aesthetic and functional value without affecting the architectural character of Arab buildings.

- Attempting to come up with a methodology for applying solar energy exploitation in the field of urbanization that aims to adopt energy sources in operating buildings on solar cells that integrate with buildings and give more than a functional, aesthetic, and economic benefit.
- Finding design and technological solutions (www.unesco.org,2012) for how to integrate solar cells with buildings..

2. Types of solar cells

- Monocrystaline solar cells- ingot are the most popular commercial because they give the most efficiency.
- Polycrystalline solar cells-Ribbon is still in the presence-proof stage, and is manufactured by automatic production of polycrystalline silicon to produce in the form of strips with high efficiency and low costs but less efficient than the previous type, ranging from 13-15% as a show in Figure 1

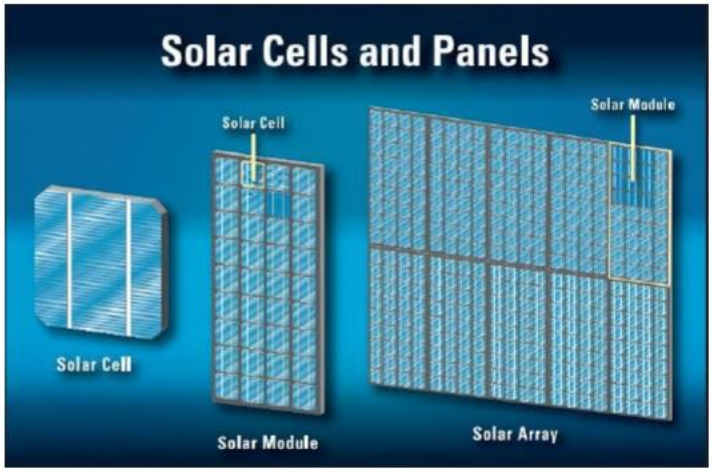

Figure 1 type solar cells and panels source el barcony 2010

- Amorphous cells - Thin Film which is one of the most advanced materials at the present time (williams s Ebhota, 2020), as it is made of Amorphous silicon, and it consists of thin layers placed on top of each of them that absorbs a limited range of sunlight. Thus, the final result is the highest conversion efficiency that can be obtained, ranging from 5-7%, and it can be made of flexible material and therefore can be used on the roofs of arched buildings.

2.1 Conversion efficiency in solar cells: (Nijs j, 1997)

The conversion efficiency of solar cells depends on the type of cell used and the type of material made from it. The main substance in most cells is silicon, of which there are three types: as a Figure 2

- Amorphous silicon (brown)
- Monocrystalline Silicon [Dark Blue - Black - Solid Gray]
- Polycrystalline Silicone (Blue)

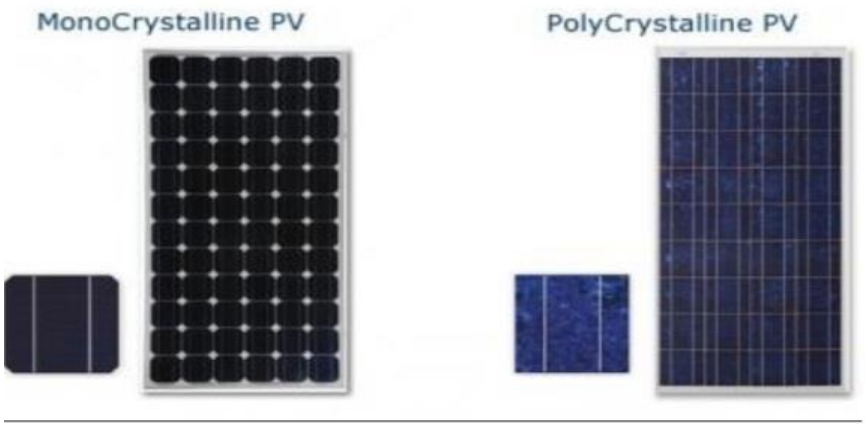

Figure 2. Monocrystalline and poly crystalline pv source(snyder). 2014.

From the theoretical point of view, the conversion efficiency of solar cells is up to 30%. However, the areas of deficiency in the material mean that the efficiency of the photovoltaic cell is somewhat small.

The electric energy generated by the solar cell on the surface area of the cell with the intensity of radiation and solar lighting is expressed in watts, usually every area of 1 m2 produces 1000 watts, and here the cell temperature is within 25 degrees, with an efficiency loss of about 0.5% for every degree Celsius increased by temperature.

2.2 Building Energy Design Techniques: (cc HUANG, 2015)

The integrated energy design in buildings is an important part of the building's integrated design process, which is defined as the process of purposeful, engineering and successive grouping of building designs in order to produce buildings with a high impact and integrated in their energy performance and low in the initial cost and when operating and with an environmentally low impact 10 This integrated design view must be taken by all members of the building design team. Energy design strategies include traditional design standards such as site layout, building shape, functionality, performance, and cost, as well as improving energy efficiency. The first step of the design process begins with the previous stages of the design process, which are the early definition of building performance goals and the performance requirements for systems in the building and its components. (kATO K Murata A, 1988)

The process of designing the integrated energy of the building must include the following activities besides the traditional architectural design and construction stages:

- Integrated design of the building through commitment and cooperation planned by the building and owner design, with a clear goal setting for the building design and project cost.
- Simulating the building energy performance through electronic systems to help the designer to take better solutions about the properties and components of the building's outer shell
- Learn about the efficiency of using the largest energy technologies in the building to give options and opportunities for the designer to design energy efficiency strategies for the building.
- Understanding the general climate of the project site, which helps to design the climatic environment of the building to be responsive to the general climate, which helps to rationalize energy consumption in the building.
- Efficient distribution and integration of the mechanical system in the building.
- Integrated design of the building's ventilation and lighting, especially natural ventilation and lighting through the upper openings of the building's roof
- Comprehensive study of similar projects and getting acquainted with previous experiences in this field. Using computer programs that help simulate and analyze energy use technologies in the building.15

Figure 3 install cells from the front facade building source developed by auther

C- Open walls, which are open systems that install cells from the front of the facade or as part of the second layer of the facade. In this system, ventilation is often not problematic.

2- Ceilings: A- Flat roofs and we find that photovoltaic systems are installed on roofs at an angle between 0 ° -10 °

1.3 The method of forming pitched roofs is divided into:

- Cells on slate roofs. In this case, we find that cells are installed on the ceiling in the traditional way and are impermeable to water
- Tile roofs, and here we find that half of the roof is covered with tiles and the rest is installed photovoltaic cells. Tiles can be in a color close to the cells
- Ceilings that are wide or installed on them and are very useful in homes, as they are sufficient for ventilation.
- Integration over water impermeable (horizontal) layers, which is a fixed system with horizontal forms installed on bricks or others.
- Integration over the impermeable (vertical) water layers, which is a fixed system with vertical forms installed on bricks or others.

Figure 4 . Tile roofs , source(sinaps, donker) 2013

3. Designing a photovoltaic cell system

- Calculate the amount of solar radiation incident.
- The total number of hours of sunshine daily and annually and the rate of change of the angle of inclination of the sun from summer to winter Expected weather conditions (rain - wind - clouds)
- The conditions surrounding the site in terms of the presence of surrounding mountains, trees or buildings that may cause shading over the cells, which leads to a decrease in the capacity of the cells.
- Calculating the load resulting from the system and the proportionality of the resulting load directly with the amount of incident radiation, which varies from summer to winter.
- Calculating the required electricity load and through it the size of the system was determined. The number of operating hours of devices determines the storage system.
- Study the application of design that is concerned with energy or an energy efficiency measure to reduce building energy requirements.
- The choice between the building's interactive photovoltaic cell system and the independent photovoltaic cell system.
- Providing adequate ventilation, as the conversion efficiency of cells decreases as the operating temperature rises.

Photovoltaic cell applications:

There are many areas of photovoltaic application, (Alsema ae, 1998) especially in remote places that do not have public electrical networks, and these applications include the use of photovoltaic systems in home applications, communication networks, the integration of photovoltaic cells with buildings, in street lighting, as a source of electricity to protect environmental spaces and natural reserves, in machine administrations, In health and medical applications, in transport, in the agricultural field, in water treatment systems.

Characteristics of using photovoltaic cells:

- With a long life expectancy of up to 20 years.
- It is used directly without the need for transmission or distribution lines.
- Do not use mechanical parts that require complicated maintenance operations.
- A reliable and highly reliable energy source.
- It can be designed with any required size, and the cell system can be increased in size by adding units for each period of time while increasing the need

Obstacles to the use of photovoltaic cells :(pv – tech Power Archive,2020)

- High prices and costs of these systems.
- Difficulty storing at a low economic cost.
- Increasing the percentage of lost solar cells during manufacture, as some stages of manufacturing depend on manual methods, and the silicon slices are subject to breakage due to their extreme delicacy.

These points are discussed in the message and are trying to find technological solutions that overcome the high costs of solar cell manufacture.

4. Design Process

Design considerations that should be taken into account when integrating solar cells with the building:

Designers will have a major role in expressing photovoltaic systems, introducing an entirely new language into architectural and technological expression, and providing new opportunities for manufacturers' markets.

Technological solutions for integrating photovoltaic cells with the building:

Here comes the role of the architect, and its capabilities are shown in how these cells merge with the building Science provides him with new materials, with high technologies that did not exist before, so the shape of the building will be different, so we find that there is a breakthrough in modernizing building materials through scientific and laboratory research in the field of developing solar cells that increase their efficiency and reduce their costs. The role of the accomplished architect is to search for what is new in the field of building materials. These are the tools that he uses in designing his projects and what are the new technologies that increase the building's effectiveness.

And an encouragement is energy efficient and does not result in any environmental damaging effects (Shaoqing chen, 2020). These tools can be likened to an artist who holds the palette of colors in which he paints his painting in order to appear in the most beautiful picture.

Figure 5. an example of integrating photovoltaic cells with buildings, source developed by author

The role of the architect in integrating solar cells with the building:

Here, the designer faces one of two options, the first in the case of the presence of the building in nature and the need to integrate solar cells in separate places of the building and the other option is that the building is still in the design scope here, the engineer's view and design solutions differ from the first case. There are many options and more freedom in choosing places where solar cells can be integrated with the building.

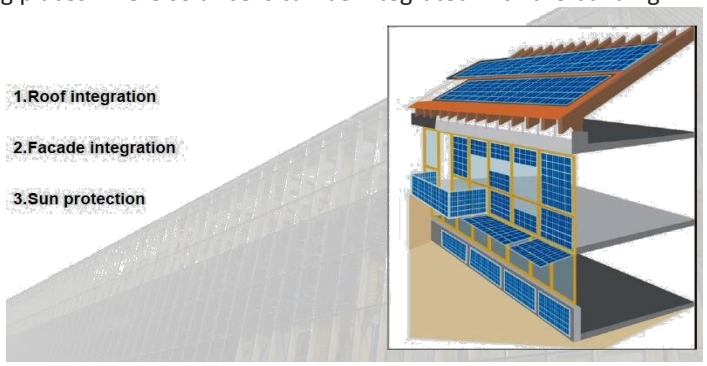

Figure 6. integrating solar cells with building , (shaybani, 2016)

Figure 7. integrating solar cell with building (shaybani,2016)

Although this technology has not been implemented, but it can be reached through nanotechnology techniques As for tilting ceilings, roof tendencies should be studied and the cells can be installed on them, and whether cells are installed over the entire roof area or parts of it and the appropriate places to install cells in

Examine the building's facades:

Solar cells can be combined with the building's outer shell as an essential part of the structure. They can also be considered as a component of building building materials. - It can also be combined with the architectural units of the exterior cover of the building, and through modern products of solar cells, it accepts to replace the building components (roofs - facades - glass surfaces) and performs multiple functions as a sun screen as Figure 8.9

Figure 8. integrating solar cell with the building (scheuten, 2019)

Figure 9. pv as a aesthetic elements ,(developed by auther)

As architectural elements, luxuries, terraces, or fences, or as aesthetic elements, such as merging them with umbrellas, and also can be combined with urban design elements. As umbrellas for pedestrian walkways and parking lots are considered design, functional, aesthetic and technological as well we find that (the integration of the building with solar cells, which is Known as the term (BIPV) multifunctional Technological and in the forefront as an element of electric power generation and there are several functions:

- Protection against climate fluctuations.
- Thermally insulating element.
- Noise Isolation Element.
- A component of light rays To control the amount of light entering the building using modern, automated technologies that regulate the entry of appropriate lighting in the building.

The outer envelope is considered as the dividing line between the internal environment of the building and its external climate. It regulates the stability of air

Figure 10. bipv installation , semi-transparent facad on thin film technology (schott , 2018)

Quality inside the building from climatic changes. It prevents different air masses, as well as regulates the efficiency of air conditioning systems, and more than that it works as a buffer for rain water. It gives indoor climate comfort for the building and reduces energy consumption for the least amount possible. The exterior surfaces and ceilings are coordinated and regulated in controlling multiple functions such as:

(Daylight - Ventilation - Energy - Safety – Protection…) When solar cells incorporate in the building's cover all these elements need to be taken into consideration during the design process to meet all these requirements, in addition to that there are other aesthetic factors mentioned among them:

- Colours, appearance, size
- Wind – climate
- Resistant and Maintenance
- Electrical and mechanical connections.
- the cost
- Use of materials
- building weight.

Solar cell assembly and installation systems: (REN 21- building sustainable energy future with renewable energy , 2017)

Systems that allow the installation of units are preferred for most parts of the building, as there are standard units without a frame. These units can be installed in their entirety together to cover the outer cover of the building, where advantages are achieved in low total cost. These solutions can be applied in covering the roofs and walls of the building.

5. An introduction to Nano science:

The world has been witnessing since the previous century a remarkable and unprecedented acceleration in technical development in all areas of life, the discovery of the Egyptian scientist Dr. "Ahmed Zewail" had multiple applications, this discovery opened vast prospects for studying the properties of materials and how to benefit from them.

Why nanotechnology: morphological advantages (surface area) there are phenomena that govern the optoelectronic properties of material, (www.cns.ucsb.edu), charge transfer and transport occur at the Nano scale. This phenomena at the nanoscale are governed by the laws of quantum mechanics (www.cleanenergyministerial.org) new opportunities for controlling material properties at the macroscale (As Figure 11)

Opportunity of combining the advantages of film technology, and of subtile band gap engineering.

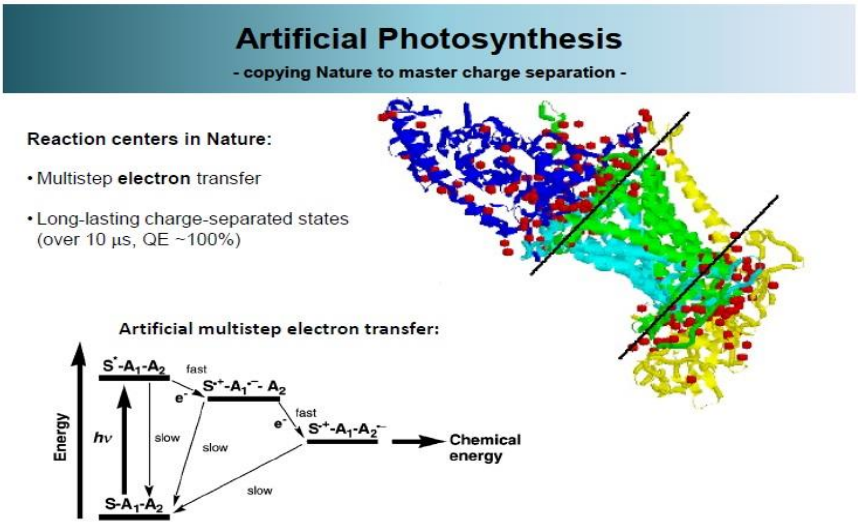

Figure 11. outlook on current nanotech approaches to pv (vanni lughi. 2017)

6. Scientific research with the aim of developing solar cells:

The world is witnessing a huge technological revolution, as a result of the availability of modern scientific devices that work with high technologies that help researchers reach important results in their research and in the field of developing solar cells. www.sciencedirect.com. In this part, we review a number of scientific researches that has reached results that benefit the message:

Available technologiesnanotechnology hot carrier solar cell :

This technique is the most challenging method since it utilizes selective energy contacts to extract light generated by " hot carriers" (HC) (electrons and holes) from semiconductor regions without transforming their extra energies to heat . this is the most novel approach for pv cell production and it allows the use of one absorber material that yields to high efficiency under concentration. The efficiency conversion factor reach a limit of 66% which is 52% higher than that of traditional si pv cell systems and 33% higher than the systems generated using qd principle

Figure 12. available technologies nanotechnology ,renwable energy applications , (irena , 2014)

Prospects for Nano- enhanced Solar Cells :

Basic research underway with the technology development required to achave the desired applications

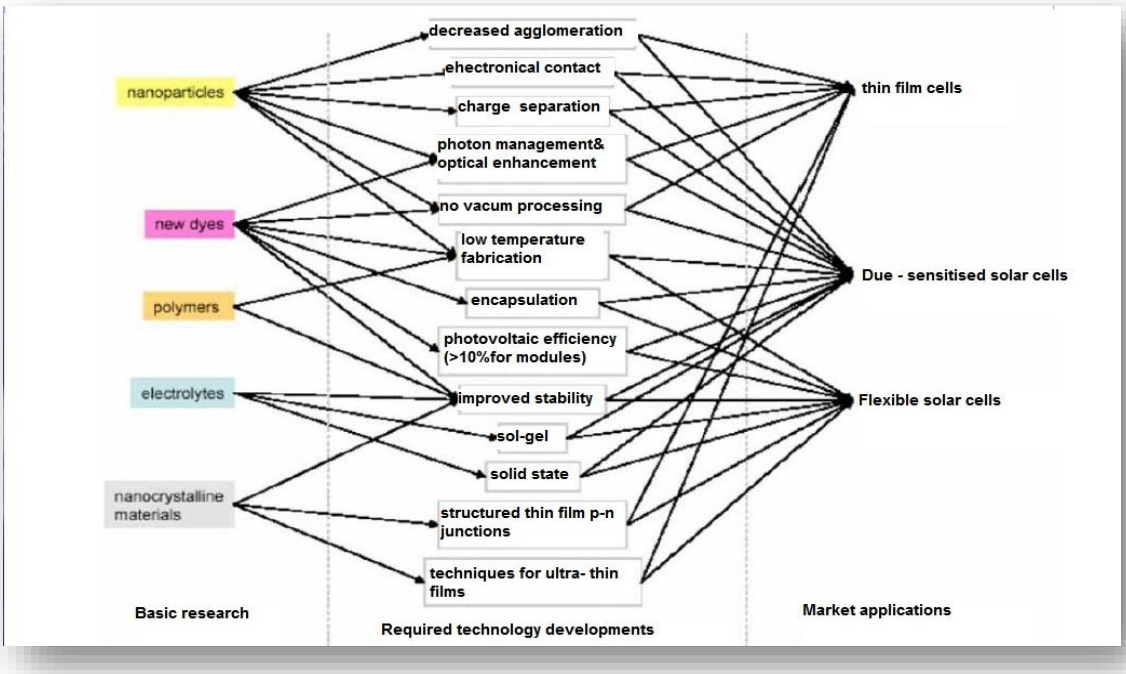

Figure 13. Nano - enhanced solar cells , developed by auther.

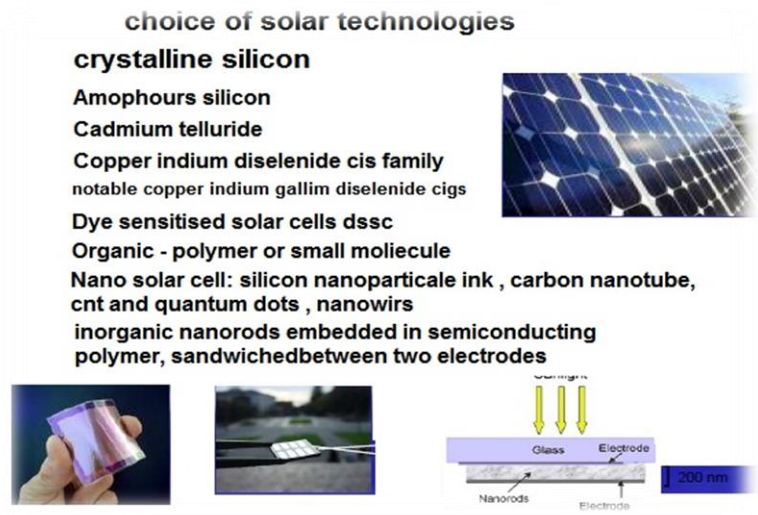

Figure 14. new materials and nanoscience developed by auther.

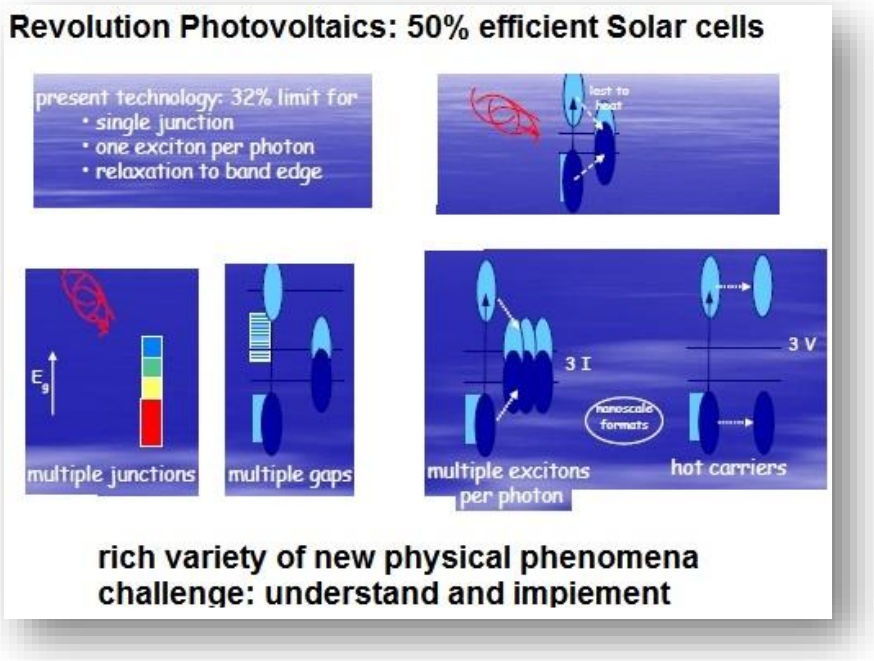

Figure 15. new materials and nanoscience,source developed by auther.

Thin film solar cell junction structures

Homo junction: p-n junction of crystalline silicon

Hetro junction: formed by contacting two different semiconductor s cds and culnse

p-i n/ n-i-p: typically , amorphous silicon thin – film cells use a p-i- n structure , where as cdte cells use an n-i-p structure.

Multi junction: also called a cascade or tandem cell, can achieve a higher total conversion efficiency by capturing a large portion of the solar spectrum

A multijunction device is a stack of individual single – junction cells in descending ordre of bandage

The top cell captures the high – energy photons and passes the rest of the photons on to be absorbed lower – bandgap cells

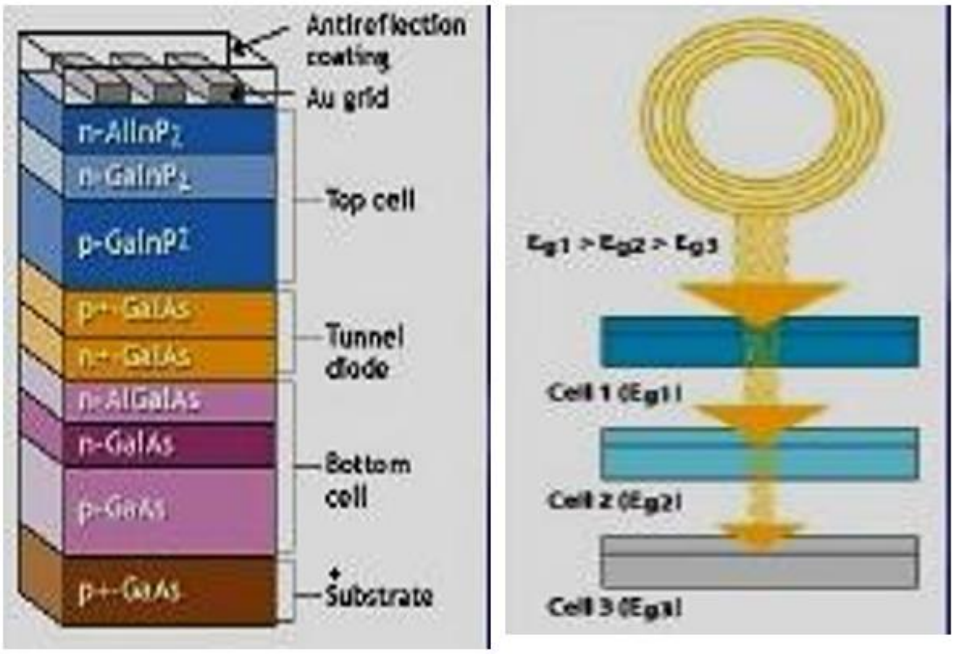

Figure 16: thin film solar cell junctions structures source developed by auther

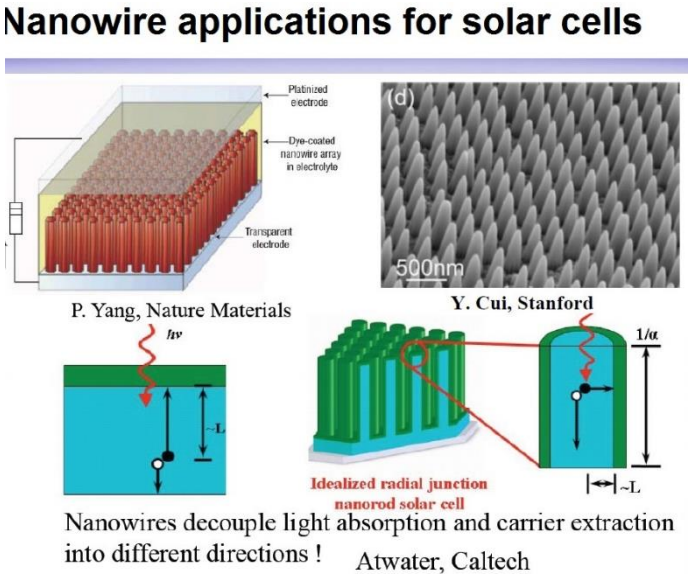

Figure 17. nanowire applications for solar cells source developed by auther.

The issue of energy and its relationship to buildings, which is known as the sustainability of the buildings discussed in the research, is not considered a manifestation of luxury, but it is a fundamental issue related to the economies of countries and their human development, and the energy issue is an urgent issue at the present time that all countries try to provide energy sufficient to meet their multiple needs of the population, and the more the number Population increased need for energy. We find that energy is based on all human activities, as it is the main nerve of contemporary life. Just as food is the fuel of human life, so electric power is the one on which people depend for all daily activities.

And with a comprehensive view of energy sources, we find that the world has tended to generate energy in previous eras on non-renewable sources, which are called UNRENWABLE ENERGY RECOUSES). On them with all their capabilities

- If we consider the work of photovoltaic cells from the generation of electrical current from natural sources, we find that they are similar to a natural process that takes place in plants in the fields and is repeated dozens of times, a process of photosynthesis that takes place in the plant at night, where the plant absorbs carbon dioxide from the atmosphere Then, the chlorophyll that is found in the leaves of plants performs photosynthesis.

-The result of this chemical process results in the release of oxygen gas and the release of energy from the plant. If we liken the plant to the building, the photovoltaic cells represent chlorophyll in the plant. Where the photovoltaic cells absorb the solar radiation, some atoms move from their orbits in other orbits, and this process is called induction, which results in the generation of an electric current.

Here we find the importance of studying the environment, its components and its natural processes and how to benefit from its application in other areas.

There are studies specific to the designer and the design process of buildings to apply the integration of photovoltaic cells in them. There are many factors that must be taken into account before starting the design process, the most important of which are:

The location of the building - the topography of the earth - the distances between the buildings - the heights of the buildings - the direction of the buildings - the climatic factors of the site - a study of the building's interfaces that are exposed to solar radiation - the areas where the PV cells can be placed.

The architect uses the success of the design process with multiple tools such as climate programs and the impact of climate factors on the performance of the building, as well as imaginary performance programs (SEMULATION) that show the most important facades of the building influenced by solar radiation, periods of sunshine, and so on.

By studying the entry of photovoltaic cells in the field of building materials, we find that they have multiple effects. It is an important design tool for the architect. If we likened the engineer to the artist who takes his brushes and draws his artistic painting, and there is a palette of colors, the photovoltaic cells represent a new tool that the artist can produce his painting in the best possible way from the formal and functional point of view.

Photovoltaic cells have multiple properties. They represent a source of electricity production. They are also a thermal insulator for the building, an acoustic insulator, and an insulator from the sun's rays if they integrate with glass. Finally, it is a structural factor for building facades where it is possible to provide photovoltaic in multiple colors and shapes.

Also, the planner must choose the systems that are applied at the level of city planning and which solutions are most suitable for their application. There are systems called "Grade OFF" in which the photovoltaic cells are placed directly on the buildings and the solar rays are converted into an electrical current and there is a transformer to convert the continuous current generated from the cells to Alternating current that can be used directly for multiple household appliances and excess electrical energy can be stored in special batteries located under the building to take advantage of in times of sunset.

There is another system called (Grade on), which is known as the solar fields, where a large number of photovoltaic cells are deployed over vast areas to absorb the largest amount of solar radiation to convert into electrical energy, which is reduced through special cables to transfer energy to power stations that are prepared to take advantage of these. Energy at the city level, and the stations are connected to the buildings by special networks known as the infrastructure.

As for the application of the idea of integrating the photovoltaic of buildings on a large scale, on a city scale (Macro SCALE) We find that we have two options, the first option is planning a new area and planning is done from the perspective of relying on photovoltaic to provide energy for buildings, and therefore special studies are carried out where planning decisions are made and studies of energy supply paths in the main roads of the city, which are called infrastructure studies.

As for building planning, placing photovoltaic cells on the roofs of buildings and their façades, as mentioned above, and choosing the appropriate photovoltaic cells to generate electrical energy. The second option is the presence of buildings located in the natural and these need to study each building separately as a case study and we need to determine the appropriate areas to put the photovoltaic cells on them.

The study also dealt with developing photovoltaic cells with multiple technologies. There are multiple scientific researches in the world to raise the efficiency of photovoltaic cells and reduce their production costs. - It is not possible to limit all the scientific research that was presented with the aim of developing photovoltaic cells, but it is possible to take advantage of the results of that research. We find that there are researches that have found new types of elements other than the silicon element that have the property of absorbing the light rays that can be combined with the silicon element to increase its efficiency.

There are also researches that have come to reduce the thickness of the photovoltaic cells, which can be manufactured to a very small thickness, so that its thickness does not exceed several millimeters, which is called (thin film) and has achieved high efficiency.

There are also researches to develop photovoltaic cells, and they have come to produce a multi-layer photovoltaic cell.

It was also reached to produce organic cells from natural materials. One of their advantages is to reduce their production costs, even if they are less efficient than silicon cells. - It was also reached to produce plastic photoelectric cells in the form of soft rolls and they can be placed on large areas such as roofs of buildings. It was also possible to reach the types of cells that could be merged with the glass interfaces (curtain walls) in various colors and shapes, and they became an important structural element of the building. Also, through nanotechnology techniques, it is possible to develop photovoltaic cells through green chemistry and change the properties of the materials that make photovoltaics. It is possible to raise the efficiency of photovoltaic cells, as the efficiency of silicon cells has reached about (12-14% to reach 43%)

7. Recommendations

Through the technological applications of developing solar cells and merging them with buildings, we find that there are important results, the most important of which are:

Buildings are transformed from a sector that consumes electricity into energy-saving buildings, but more than that Generating energy so that it suffices itself from the energy it needs to operate buildings of all its functional needs, such as lighting, ventilation, thermal control, electrical appliances, cooking, etc.

The buildings can generate electrical energy in excess of their need, and therefore the buildings can be connected to electrical networks connected to major stations to distribute electricity at the city level Thus, you can redistribute them to places that need electricity.

To optimize the utilization of local raw materials, which are sand, which is the primary element in the production of solar cells, and which are vastly available in the desert, and which do not represent an economic impediment to the state.

By applying these technologies, it directly contributes to reducing the environmental impacts that result from relying on non-renewable energies and thus reducing the carbon emissions that result from the combustion of these substances that pollute the environment.

· 55- By applying these policies and strategies that support a strong support to the national economy by providing large sums spent on energy subsidies, and these are among the important issues that the country suffers from and which places a burden on the state's general budget as we have previously explained in studies of the economic return from applying this technology.

Making the most of the results of scientific researches that search in the field of energy support by producing low-cost solar cells that have huge potential in electrical power generation, and thus scientific research can be linked to the local need.

Multiple projects related to this technology can be set up, such as setting up factories to produce solar cells, and international expertise in this field can be used.

Providing job opportunities for large numbers upon which these technological applications are based in the field of manufacturing, transportation, installation, maintenance, operation, and technical consultations.

By applying the incorporation of solar cells with buildings, adding a new element to the materials that enter into this industry, it performs multiple functions: it generates electrical energy, controls the amount of light transmitted to the building, makes a noise and heat insulator, and an aesthetic component of the building that integrates with the design of the building's outer cover.

References

Baroni L, Cenci L, Tettamanti M, Berati M. (2007 Feb). "Evaluating the environmental impact of various dietary patterns combined with different food production systems" (PDF). Eur J Clin Nutr. 61 (2): 279–86. doi:10.1038/sj.ejcn.1602522. PMID 17035955. http://wwwpersonal.umich.edu/~choucc/environmental_impact_of_various_dietary_patterns.pdf.

H. Steinfeld, P. G. (2006). Environmental issues andotions, shadow . In P. G. H. Steinfeld, *Environmental issues andotions, shadow* (p. 390). C.de HAAN " Livestocks long .

kATO K Murata A, S. k. (1988). Energy payback time and life - cycle co2 emission of residential PV Power system with silicon pv photovoltaic . In S. k. kATO K Murata A, *Energy payback time and life - cycle co2 emission of residential PV Power system with silicon pv photovoltaic* (pp. 105-15). vienna.

WWW.UNESCO.ORG. (2012, 9 20). Retrieved 3 15, 2020, from https://en.unesco.org/: https://en.unesco.org/

REN 21- building sustainable energy future with renewable energy. (2017, 4 2). Retrieved 2 18, 2020, from https://www.ren21.net/: https://www.ren21.net/

solar united association serving solar- united .org. (2019, 8 3). Retrieved 4 12, 2020, from https://www.solar-united.org/: https://www.solar-united.org/

PV-Tech Power Archive. (2020, 1 4). Retrieved 4 6, 2020, from https://www.pv-tech.org/pv-tech-power/list: https://www.pv-tech.org/pv-tech-power/list

Alsema ae, F. p. (1998). Energy payback time of photovoltaic energy conversion. In F. p. Alsema ae, *Energy payback time of photovoltaic energy conversio* (pp. 6-10). vienna.

cc HUANG, C. B. (2015). 12 GREEN GUIDELINES CDBCS GREEN AND SMART URBAN DEVELOPMENT GUIDELINES. In C. B. cc HUANG, *12 GREEN GUIDELINES CDBCS* (p. 69). CHINA: ZUO- KUN - VICE -PRESIDENT CHINA DEVEOPMENT BANK CAPITAL.

H. Steinfeld, P. G. (2006). Environmental issues andotions, shadow . In P. G. H. Steinfeld, *Environmental issues andotions, shadow* (p. 390). C.de HAAN " Livestocks long .

industry, s. u. (2019, 4 12). *solar united association serving solar - united .org*. Retrieved 2 4, 2020, from https://www.solar-united.org/: https://www.solar-united.org/

islam, e. (2000, 5). *fine arts*. Retrieved from uni of alexandria: www.finearts.com

kATO K Murata A, S. k. (1988). Energy payback time and life - cycle co2 emission of residential PV Power system with silicon pv photovoltaic . In S. k. kATO K Murata A, *Energy payback time and life - cycle co2 emission of residential PV Power system with silicon pv photovoltaic* (pp. 105-15). vienna.

Kenny, D. R. (2019, 5 10). *www.eupvsec-proceedings.com*. Retrieved 5 10, 2010, from https://www.photovoltaic-conference.com/: https://www.photovoltaic-conference.com/

Nijs j, M. R. (1997). Energy payback time of crystalline silicon solar modules . In M. R. Nijs j, *Energy payback time of crystalline silicon solar modules* (pp. 291-327). American : co: American solar energy socity .

Shaoqing chen, A. k. (2020). Advanced approaches and applications of energy footprints toward the promotion of global sustainablility. *applied ENERGY* , 261.

home - heriot-watt- university. (THE Golden Age University Rankings 2018). Retrieved 3 14, 2020, from https://www.hw.ac.uk/: https://www.hw.ac.uk/

The University of California Center for Nanotechnology in Society is based in the Institute for Social, B. a. (2017, 6 5). *cns.ucsb center for nanotechnology in society*. Retrieved 5 11, 2017, from http://www.cns.ucsb.edu/about/nanotechnology-society.html

williams s Ebhota, T. c. (2020). green technology . *international journal of precision engineering and manufacturing* , 97-117.

(REN 21- building sustainable energy future with renewable energy, 2017)

cc HUANG, C. B. (2015). 12 GREEN GUIDELINES CDBCS GREEN AND SMART URBAN DEVELOPMENT GUIDELINES. In C. B. cc HUANG, *12 GREEN GUIDELINES CDBCS* (p. 69). CHINA: ZUO- KUN - VICE -PRESIDENT CHINA DEVEOPMENT BANK CAPITAL.