IEREK PRESS
Academic Research Community
CrossMark
http://www.press.ierek.com
ESSD
ISSN (Print: 2357-0849, online: 2357-0857)
International Journal on:
Environmental Science and Sustainable Development
DOI: 10.21625/essd.v3iss1.278

Nanotechnology: Towards Sustainable Solar Cells

Haitham E. Morsy[1], Magdy M. Qasem[2], Wael S. moustafa[3]

[1] *Architecture Department, Lecturer assistant in Faculty of Engineering, October 6 University*

[2] *Associate Professor in Architecture Department, Faculty of Engineering, Mansoura University*

[3] *Istituto di Ricerca e Promozione delle Aree Interne della Sicilia, Caltanissetta, Italy*

Abstract

In recent years, the technology of constructions witnessed such a development in building materials that assures the sustainability of buildings. Due to the negative effects on the environmental zone, the sustainability of buildings may not be achieved. Nanotechnology is not a technology with certain specifications but it is the unification of different fields of ultrafine units which is measured by a nanometer.

The applications of this technology will appear in the near future in different fields such as: bio-medicine, computers, and energy and building materials. This research focuses here on the ways, materials and techniques through which nanotechnology is used to have perfect buildings and to save energy, these cells produce 108.261 m.w.h compared to normal cells, which produce 96.174 m.w.h. Nanotechnology will also make these solar cells more efficient, longer and environmentally preferable. They will maintain their production of electrical energy over the long term compared to normal cells that produce less than 10% annually. Moreover, the research paper aims to encourage the utilization of solar cells through which the solar energy can produce clean electrical energy. This electrical energy is produced from the materials made by nanotechnology, which make the cells live longer and more sufficient.

Keywords

Sustainable Design; Nanotechnology; Solar Cells

1. Introduction

Architecture is a reflection of the civilization of people and the spirit of the times and is now witnessing an era of ideological shifts in the field of architecture influenced by the revolution of technology and information that imposed itself on the scientific and architectural arenas. Even though the continuation of this technological development is strong, it began to negatively impact society in the following ways:

1. The increasing of the phenomenon of sick buildings and polluting the environment
2. There are multiple variations of new architectural models that utilize modern technology, but they negatively impact the environment

3. A lot of renewable resources, which contribute to the environmental efficiency of buildings, such as solar energy in Egypt are not utilized because people do not understand how to use them optimally so they, therefore, employ weak usage techniques.

Architectural creativity has not stopped from the traditional methods of design in terms of aesthetics of proportions and function. However, contemporary creativity has joined the integration of modern technology and technology in architecture whether at the level of design, construction or execution or in building materials, which aim to achieve the best products that seek the benefit and well-being of the building using environmentally friendly methods that ensure the sustainability of its resources. Solar energy in Egypt is one of the most important sources of alternative and renewable energy. Solar cells have witnessed wide applications in all aspects of our daily lives. This is because we have a huge amount of solar energy in our Arab countries. Despite the steady expansion in the areas of its use, it still faces some obstacles and difficulties, the most important being its inefficiency and high price. In the long term, many researchers are now using the latest nanotechnology to try to develop solar cells that are more sustainable, efficient and less expensive.

Here are questions that come to mind:

• Can solar cells be developed through nanotechnology making them more sustainable?

• Can nanomaterials be compatible with the architecture of the future, which takes into account the highest environmental conservation standards?

2. Sustainable Design

The concept of sustainable design can be summed up as a design that seeks to reduce the negative impacts on the environment, ensure health and comfort for the occupants of the building, and thereby improving the building's performance and achieving the basic objectives of sustainability such as reducing the consumption of non-renewable resources (Figure 1) (Eid, 2010). There are several factors needed to reach sustainable design:

• Integration of planning and design: The design is self-running compared to traditional design

• The design depends on sun light and natural cooling as energy resources

• Sustainable design depends on a structural philosophy rather than particular, familiar forms.

• Sustainable buildings are assumed to be expensive during implementation but are economic in operation.

• Consider rationalization and consumption of energy and improve the health of the user of the elements of the design, followed by other elements, the trends of modern design must be directed to the forms of energy conservation and the integration of technology and the preservation of humans and the environment (Ashby & Schodek, 2009).

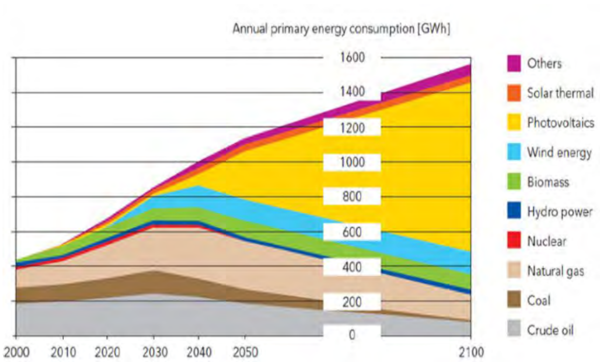

Figure 1. Global plans for demand for renewable energy resources as an alternative to fossil energy sources that face the risk of depletion over the next 100 years (Beckman, 2017)

3. The Operational Formula for Achieving Sustainability in Architecture

Many of the pioneers of sustainability in architecture and many professional and academic organizations have worked hard to develop sustainability tools (Figure 2). To make these tools available, concrete, building design should be long and play its role throughout time to be resistant to natural disasters. This means that the building achieves the maximum utilization rates of energy, water and materials regarding the following issues:

3.1. Capacity Based on self-sufficiency of Energy

1. Acceptance of the building for amendments and expansion in the future
2. The design of the building should avoid damage to health.

3.2. Building Materials

Through the optimization of materials, the use of renewable building materials, the use of durable materials and products, the selection of energy-saving materials and the promotion of the use of recyclable materials.

3.3. Site Selection

Natural validation of the site is beneficial in terms of preventing the environmental issues that can affect the supply of natural resources.

The view of the world's leading architects about the environment has changed considerably, or rather, towards sustainable architecture, and has changed many architectural concepts. But the challenge for architects today is to make this architectural approach as a design principle for the architecture of the 21st century (Eid, 2010).

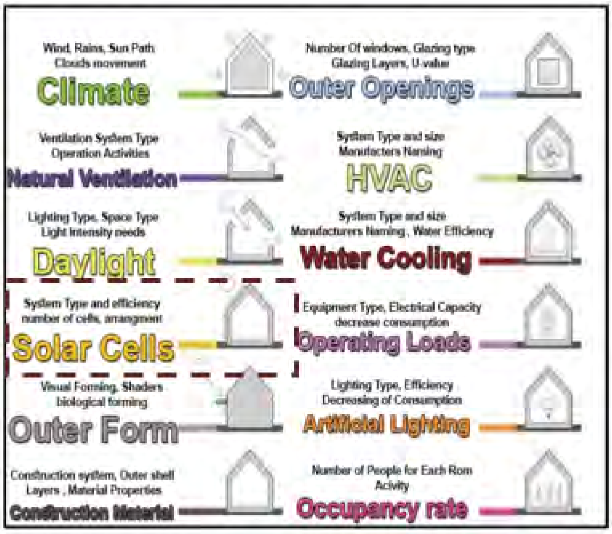

Figure 2. The most important strategiesto be upgraded to achieve sustainable design principles (Rashwan, 2014)

This research will focus on how solar energy can best be exploited by solar cells.

4. What Are Solar Cells?

Solar cells are devices that convert solar energy into electricity (fig. 3), either directly through the photovoltaic effect or indirectly by the initial conversion of solar energy to heat or chemical energy. The most common form of cells for solar energy is the photovoltaic effect so that a light emitting diode, on a two-semiconductor device, has a difference in voltage between the layers. This voltage is capable of running a current through an external circuit of this power supply (Goetzberger & Hoffmann, 2005).

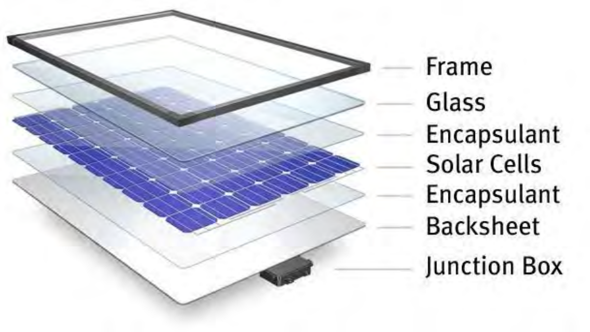

Figure 3. solarcell components (”Australian Business Council for Sustainability Energy”, 2004)

5. Nanotechnology

Many definitions of nanotechnology are presented by experts and researchers. Most of these definitions are similar in terms of content, concept, and/or their private and public status. They can be summarized in the following concept: ”It is the search, control or control of the internal matter environment at the atomic or molecular scale by restructuring and arranging atoms their component molecules, deal with structures of sizes between 1 and 100 nm in the design, production, characterization and application of unique materials, structures and systems” (Ashby & Schodek, 2009).

Nanomaterials have many terms for many international organizations:

Table 1. Multiple Terms from Different Nanomaterials (World Health Organization (”World Health Organization”, n.d.)

ISO standard	Materials with an external dimension of nanometers or with internal or surface nanometers.
European Union Scientific Committee on Emerging and Detected Health Risks	Materials with one or more external dimensions or internal structures may exhibit new properties compared to the same materials without nanometric properties or a form of material consisting of separate parts of a function, many of which have one or more scales of 100 nm or less.
EU Re-enactment of the New Food Law	Any material manufactured with one or more external dimensions of 100 nm or less or consisting of separate internal or surface functional parts having one or more dimensions of 100 nm or less including the environment, blocks and compounds of a size exceeding 100 nm but retaining the characteristics of the nanometer.
American Council of Chemistry (ACC)	Engineered nanomaterial is any material made of a single, binary or three-dimensional size between 100 nm in the normal way. It is noted that a nanometer or 100 nm is not a line error and the data available for materials outside this range may be the value. Spherical fullerenes are involved in this range although their size is less than 1 nm.

Continued on next page

Table 1 continued

Through these previous terms, we find that they all agree that nanomaterials are materials with one external dimension on the nanometer scale 1-100 nm)

6. Case Study

Figure 4. A map showing the study area and the case studyRaya Plaza Building (Beckman, 2017)

The 6^{th} of October city will be highlighted as follows:

6.1. Climate Profile of the City

The 6^{th} of October is located in the average solar radiation area in Egypt. Therefore, the general climate characterization of the city is categorized by the large daily thermal range and the increase in solar radiation (fig. 5). The amount of horizontal solar radiation is about 6 kwh/m^2/day, the average number of solar daylight hours per day is estimated to be10.825 hours, which is also high for cities in the world. Of course, this average increases in the summer and is less in the winter (fig. 6) (El-Shimy, 2009).

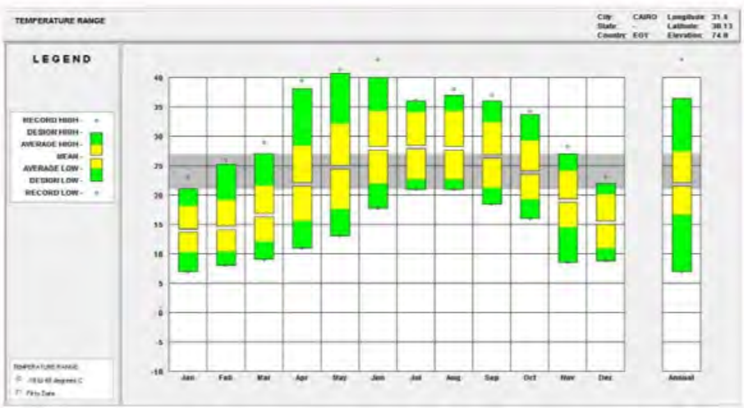

Figure 5. Climate profile of the 6^{th} of October city using the climate (consultant5.5) (10)

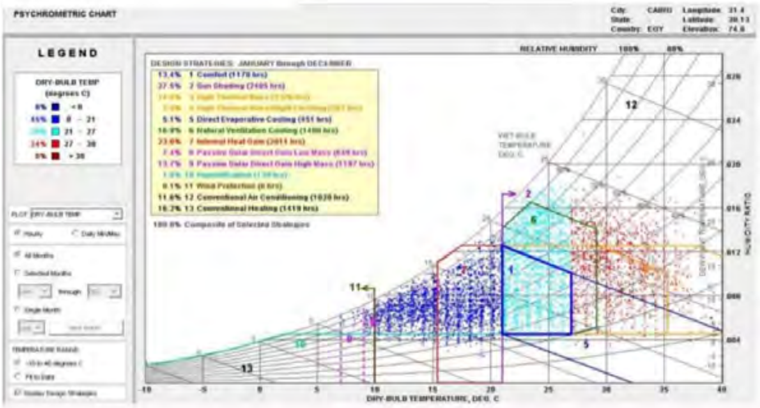

Figure 6. The thermal survey ofthe study area using the Climate 5.5 program (Beckman, 2017)

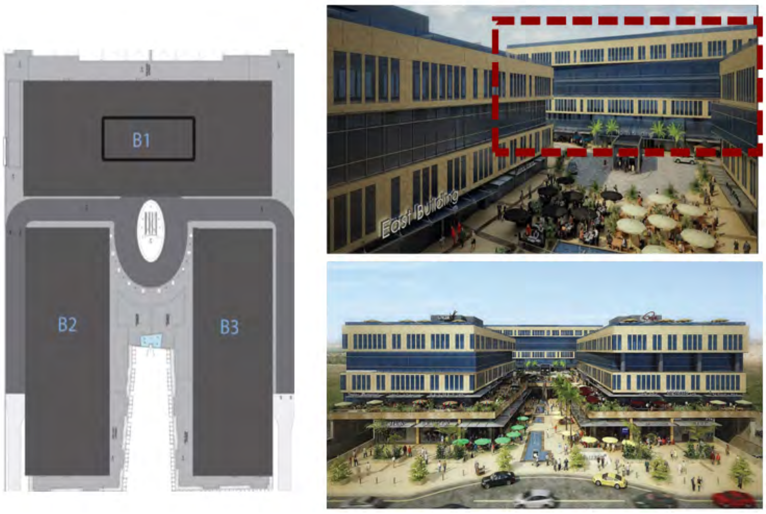

Figure 7. A mapshowing the study area and the study status of Raya Plaza Building ("Engineering Department of Raya Plaza Building", 2017)

6.2. Case Study: Raya Plaza Building (6th October City, Giza)

The Banner Plaza building was chosen for the following reasons:

1. Based on the certificate of LEED and, therefore, its objectives to improve the efficiency of energy use
2. It is classified as intelligent through its use of the elements of smart architecture.
3. A modern building used in technology nanotechnology as a user in the glass facades, thus, the research objectives can be achieved through the application of the photovoltaic cell system for use in the building, which is processed by nanotechnology in an attempt to increase and improve the efficiency of the building and reduce its energy consumption and this will be the objective of the research as shown in (fig. 7) (Engineering Department of Raya Plaza Building, 2017).

7. RET Screen Expert Program

RET is the program used in our research, which was developed by the Natural Resources Academy of Canada, and the first version of the program was published in 1996 (RET Screen V.1), which was developed by the Academy until 2007 to reach the fourth issue (RET Screen V.4). It was also developed in 2014 to its latest release, RET Screen Expert (Fig. 8), the latest version can be downloaded from the Academy website (Renewable Energy Technologies Screen).

Figure 8. Program's main interface ("Renewable Energy Technologies Screen", n.d.)

7.1. Solar Cells Used in the Case Study (Normal Cells and Cells Manufactured by Nanotechnology)

Two types of solar cells (Fig. 9) were used,

One of which was normal cells and the other a nanotechnology plant as shown in (Table 2).

Normal cells and cells designed using nanotechnology

Table 2. Applying the vocabulary of the appropriate photo voltaic system of the study model (Shaded vocabulary is the vocabulary to be weighted) ("Renewable Energy Technologies Screen", n.d.)

Company	The name of the board	Capacity (w)	Efficiency (%)	The area of the board (m2)	Capacity per square meter (w/m2)	
solaxess	PERC	310	26.2	1.2	280	Normal cells
Sanyo	Mono Si Hip 205BA3	205	17.5	1.2	173.7	Nano cells
	Mono Si Hip 200BA3	200	17	1.18	169.4	
	Mono Si Hip J50BI3	180	15.2	1.18	125.5	

The characteristics of the selected photo voltaic system were determined and the system was distributed as shown in Fig (10).

7.2. Distribution of the Components of the System (Normal and Nano-photovoltaic Cells) on the Building

The required components can be distributed in a separate private electricity room or at least distributed by the technical engineer in the main electrical panel at the entrance of the model. The arrays can be distributed to the ceiling. The space can be increased by no more than 1 m^2 as needed in order to reach the maximum amount of electrical energy that can be generated by comparing cases. The requirements for the distribution of matrices on the surface, such as the distances to avoid self-shadowing, are taken into account.

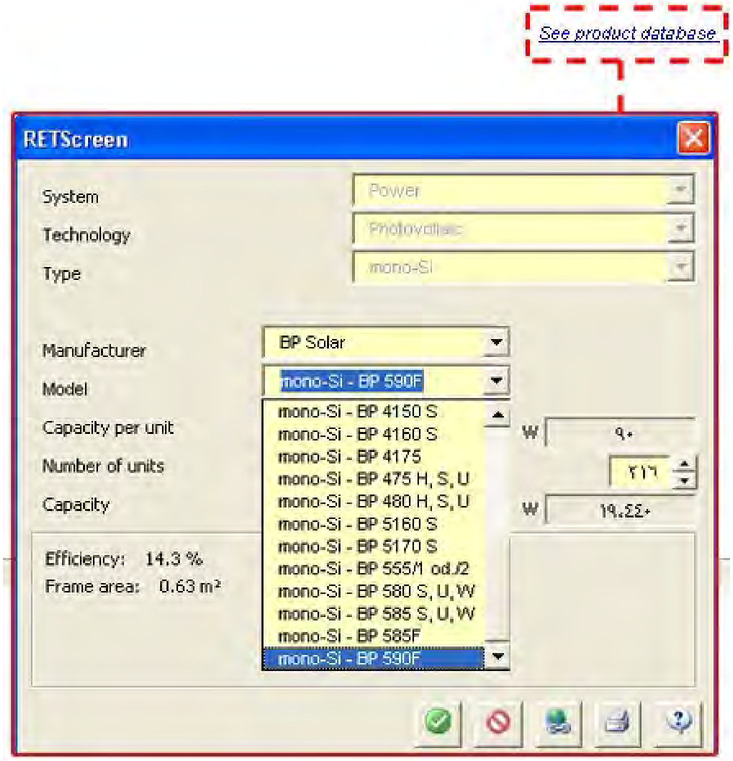

Figure 9. The panel data window which will be used ("Renewable Energy Technologies Screen", n.d.)

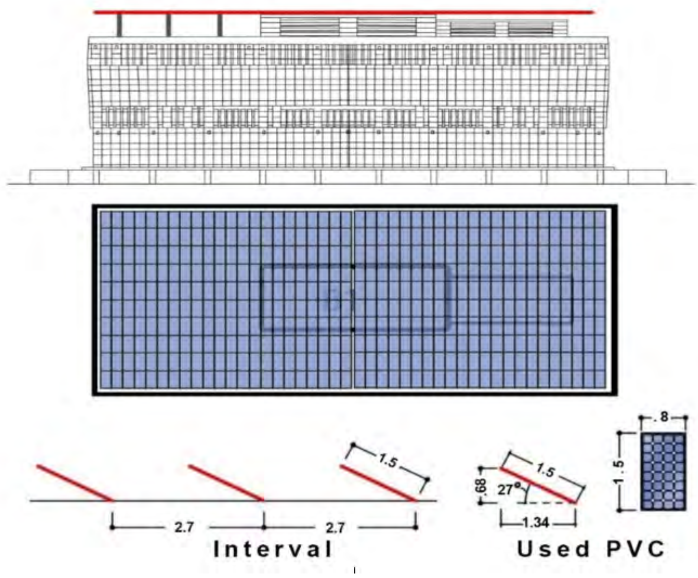

Figure 10. Distribution of photovoltaic matrices in astatic routing method and an open assembly

In this case, matrices should be distributed on the surface with an open assembly method and a fixed orientation with ideal inclination. The dimensions of the proposed board are 1.50 m x 0.80 m, with an ideal slope of 27º. This should be carried out in an open distribution mode after leaving the required inter-ports, which are calculated according to the distance between the matrices and the length of the matrix, which is estimated in the city of 6^{th} October to be about 1.8 as shown in (Fig.11), (Fig.12).

Accordingly, Interval between matrices = ratio (1.8) x matrix length (1.5) = 2.70 m

Using RET Screen Expert, the following results are summarized in Table (3):

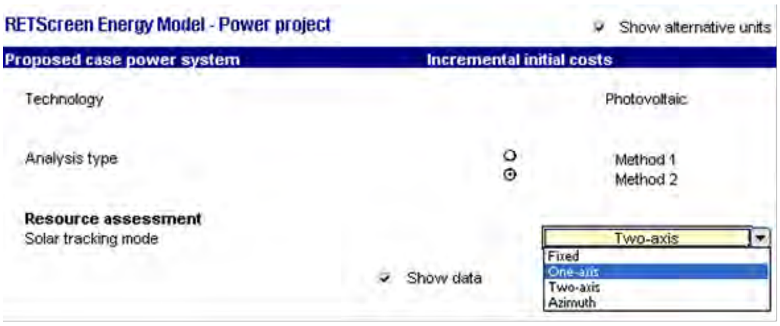

Figure 11. Data on the proposed renewable energy system Photovoltaic systems ("Renewable Energy Technologies Screen", n.d.)

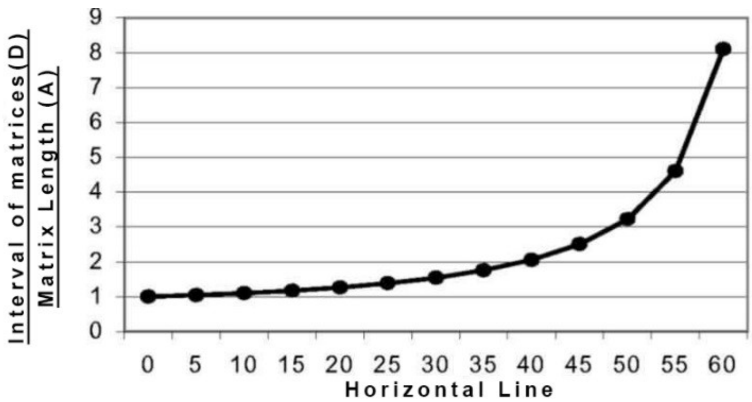

Figure 12. Relation between the fixed arrays and the citylatitude ("Top 50 Solar", n.d.)

Table 3. Calculating the amount of electrical power generated by the PV system in different design cases of the system using the RET Screen Expert program and comparing it with mathematical equations ("Renewable Energy Technologies Screen", n.d.).

		Normal photovoltaic system	The photovoltaic system is manufactured using nanotechnology
Inputs (System data) Outputs (The amount of electrical energy produced (MWS))	Climate data	6th October City Data	
	Routing method	Fixed	Fixed
	Inclination	27	27
	Number of panels	264	264
	January	6.509	7.903
	February	7.825	8.526
	March	9.115	8.622
	April	8.345	9.5277.903
	May	8.012	9.132
	June	7.913	11.118
	July	8.780	10.102
	August	8.801	9.910
	September	8.452	9.455
	October	8.256	8.396
	Nov.	7.641	8.358
	Dec	7.357	6.212
	Annually (total)	108.261	96.174

8. Production of Electrical Energy for Regular and Nanoparticle Photovoltaic Systems

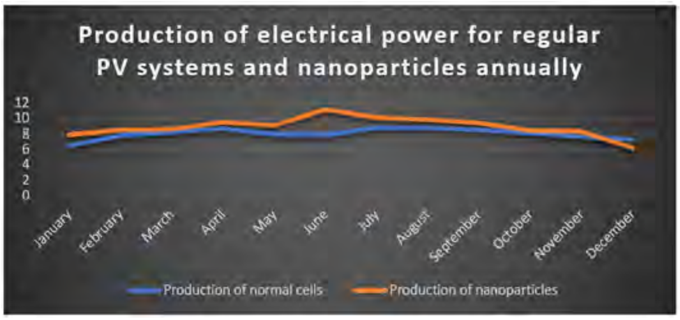

Figure 13. Economic value of solar cell sustainability inthe near term (time efficiency) ("Renewable Energy Technologies Screen", n.d.).

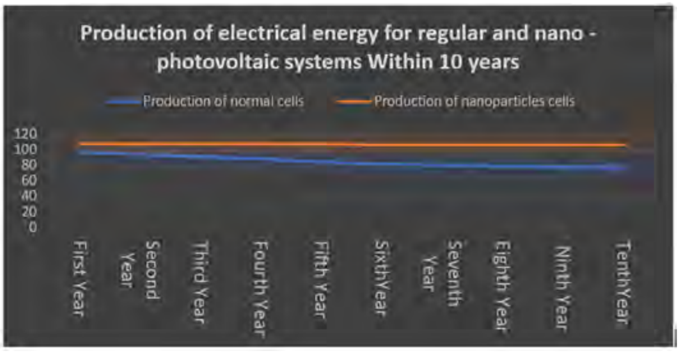

Figure 14. Economic value of long-term sustainability of solarcells (time efficiency) ("Renewable Energy Technologies Screen", n.d.)

9. Results

The research ends with the results of the case study of the Raya Plaza building in 6^{th} of October city. The photovoltaic systems manufactured by the nanotechnology industry are higher than their current counterparts which produce 108.261 m.w.h compared to normal cells, which produce 96.174 m.w.h. photovoltaic systems can achieve high performance in the generation of rate electric cells when compared to ordinary cell. This is because the cells manufactured using nanotechnology are characterized by the effectiveness of time, in the long and short run, where they are to maintain the production of electrical energy in comparison. Moreover, these photovoltaic systems may achieve proper thermal insulation for the roof by using nanoparticles during the manufacturing process of solar cells. As a result, thermal insulation is improved. Finally, a coefficient-based study found that these systems can be technically applied to the model chosen.

10. Recommendations

The paper showed the need to use nanotechnology in solar cells because of its efficiency, but at the same time, the urgent need to continue scientific research in this field to reach the best product at the lowest cost.

References

1. Ashby, M., & Schodek, D. L. (2009). *Nanomaterials, nanotechnlogies and design: An introduction for engineers and architects*. Amsterdam: Butterworth-Heinemann.

2. Australian Business Council for Sustainability Energy. (2004). *The Australian photovoltaic industry roadmap*

/ Australian Business Council for Sustainable Energy. The Council Carlto.

3. Beckman, K. (2017, September). *DNV GL's Energy Transition Outlook: for the first time in history, energy demand will peak*. Retrieved from Energy Post: http://energypost.eu/dnv-gls-energy-transition-outlook-for-the-first-time-in-history-energy-demand-will-peak/

4. Eid, E. M. (2010). Sustainability Architecture towards a Safer Future. *Technology and Sustainability Conference in Urbanization*. Saudi Arabia: College of Architecture and Planning, King Saud University, Saudi Arabia.

5. El-Shimy, M. (2009). Viability analysis of PV power plants in Egypt. *Renewable Energy, Science Direct,* 2187-2196.

6. Engineering Department of Raya Plaza Building. (2017). Architectural Designs of Raya Plaza Building.

7. Goetzberger, A., & Hoffmann, V. U. (2005). *Photovoltaic Solar Energy Generation*. Springer-Verlag Berlin Heidelberg.

8. Rashwan, A. (2014). The Role of Nanotechnology towards Designing Sustainable Future Architecture. *Master's Thesis, Department of Architecture, Faculty of Engineering, Mansoura University*. Mansoura, Egypt: Mansoura University.

9. Renewable Energy Technologies Screen. (n.d.). RET Screen.

10. Top 50 Solar. (n.d.). *B5 solar - photovoltaic and solar systems partner.* Retrieved from Top 50 Solar: https://www.top50-solar.de/de/teilnehmer/id/1636/b5-solar.de.html

11. World Health Organization (WHO). (n.d.). *Intergovernmental Forum on Chemical Safety*. Retrieved from Intergovernmental Forum on Chemical Safety: http://www.who.int/ifcs/forums/six/en/index.html