TRANSOLA

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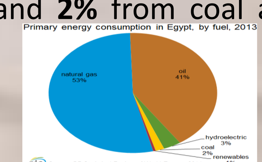
Abstract

No one can deny that Egypt encounters a hazardous energy crisis that jeopardizes all of its economic, environmental, and social aspects. This grand challenge was caused by a state of energy overconsumption due to the population explosion in Egypt in addition to relying on nonrenewable resources in energy production. As a clue, the British Petroleum company (BP) made a research and found out that Egypt produces 53% of its energy from natural gas, 41% from oil and 2% from coal. A study was made to select the best solution, and solar energy was chosen to be the most effective one. A prototype of the LSC (Luminescent Solar Concentrator) was constructed according to specific design requirements which are decreasing the energy consumption by increasing the efficiency of energy production. The prototype was made by using simple, affordable, and eco-friendly materials. The successful test plan along with the astonishing results proved the project's capability to applied in real life.

Introduction

- The **energy crisis** symbolizes a critical trouble in Egypt which contribute negatively to many other aspects – environmental, social, and economic. Egypt depends ultimately on nonrenewable resources of energy such as fossil fuels. As an evidence, a study from the BP (British Petroleum) company was made to detect that Egypt produces **53%** of its energy from natural gas, **41%** from oil and **2%** from coal as shown in **Chart (1).**



Chart(1) Shows the primary consumption of energy

- Therefore we have constructed our project to serve as a solution for the energy crisis in Egypt and this by depending on a renewable source of energy which is the solar energy - as Egypt is well-known for its hot climate in the deserts and these vast areas can be used to harvest the **solar energy**. and increasing the efficiency of using it in order to be a reliable source of energy that Egypt can depend on when applying on a large scale. Depending on a study made to select the best solution of producing energy, and the solar energy was chosen to be the most effective source of energy we can rely on. We chose our prototype to be the LSC (Luminescent Solar Concentrator) that we constructed according to specific testable design requirements whose most important one is increasing the efficiency of using the renewable solar energy along with minimizing the cost as much as possible so as to be able to be afforded by Egypt. The test plan has proven the prototype capability to be applied in real life.

Background research

A study was made in order to dominate over the energy overconsumption in Egypt. Hence, the solar energy was picked out to be the most effective one.

Luminescent Solar Concentrator:

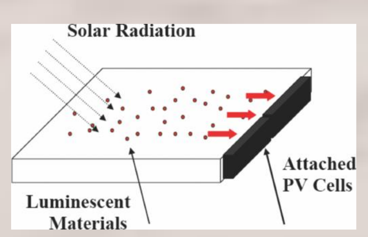
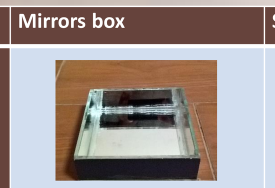
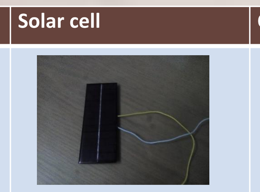


Figure (1) shows the Luminescent solar concentrator.

The basic structure of the luminescent solar concentrator is a glass/plastic plate coated with luminophores (dyes or phosphors) that absorb and emit sunlight at longer wavelengths. A part of the light is trapped by total internal reflection and guided to the concentrator edges where it is absorbed by photovoltaic (PV) cells. A variety of dye molecules are sprayed onto a glass sheet. The combination of the plastic/glass and dyes works as a waveguide; it is any device that traps light and moves it to the solar cells. The researchers at Massachusetts Institute of Technology (MIT) made a few changes to the traditional design to make it more efficient and less expensive. First, they traded in the plastic for glass. Glass is easier to manufacture, and it opens up new possibilities in terms of applications. They also added a type of aluminum called tris(8-hydroxyquinoline) that eliminates the loss of energy to re-absorption. These aluminum molecules cause the dyes to emit light waves at a frequency the dyes can't absorb. In this way, no light is lost to re-absorption as it makes its way to the solar cells at the concentrator edges.

Materials & Methods

Materials name	Mirrors box	Solar cell	Convex lens	Multi meter
Picture				
Description	17*17*7 cm 1 side glass & the rest sides are mirrors	17*7 cm	Focal length is 6 cm.	----------------

Table(1) shows the used materials for constructing the prototype

Methods

In order to build the prototype successfully, several procedures and methods were followed as followed:

A mirror box with the dimensions of 17*17*7 cm was made as in Figure (1).

One PV solar cell with the dimensions of 16.5*6.5 cm was stuck at one of the lateral sides of the box.

The mirror box was covered with a mirror on the top with a little space for the light to enter the box as in Figure (3).

A convex lens is placed near the box to collect and concentrate the light before entering the mirror box.

Figure(1) shows the used mirrors box in the prototype

Figure(3) shows the used mirrors box with the top on its surface.

The **design requirements** for the project are decreasing the energy consumption by increasing the efficiency of energy production and using low-cost, eco-friendly materials.

To attain these requirements, the prototype was subjected to a test plan illustrated in the following steps:

1. Measure the volt and the ampere of the normal solar cell without the mirror box as shown in **Figure (6)** and **Figure (7).**
2. Calculate the watt by multiplying the volt and the ampere.
3. Repeat Step 1 but with the mirror box and calculate the produced watt.

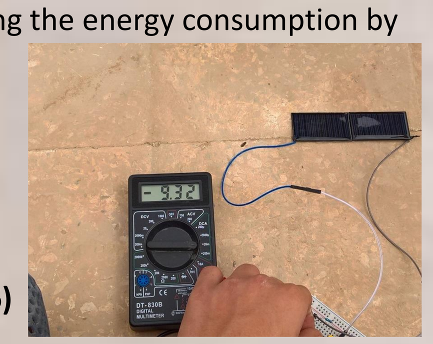


Figure (6) shows measuring the current intensity.

We used the 3D blinder program to design a 3D model of the prototype as illustrated in **Figure (8).**

Figure (7) shows measuring the voltage.

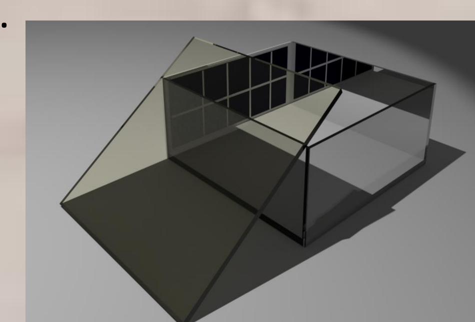


Figure (8) shows the 3D design of the prototype.

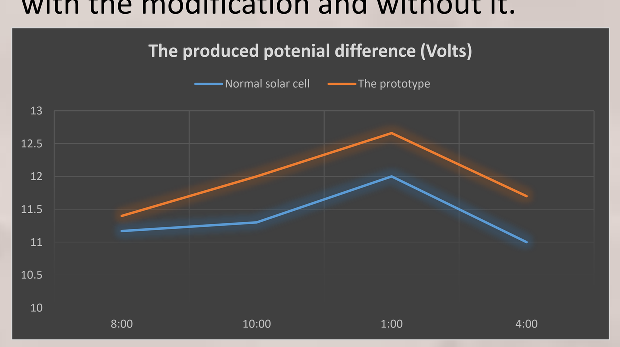
Results

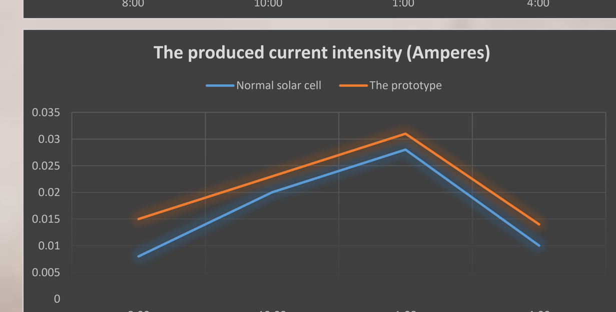
After finishing the test plan, it's found that the prototype had accomplished the design requirements perfectly. The ratio of the power produced by the prototype to the solar cell is **(2)**. The maximum electric power obtained from the prototype is **(0.4)** watt **(errors of ±0.2 volt, ±0.2 ampere).** This reading was at **1:00 pm** which is the best time for the solar cell to get its optimum efficiency.

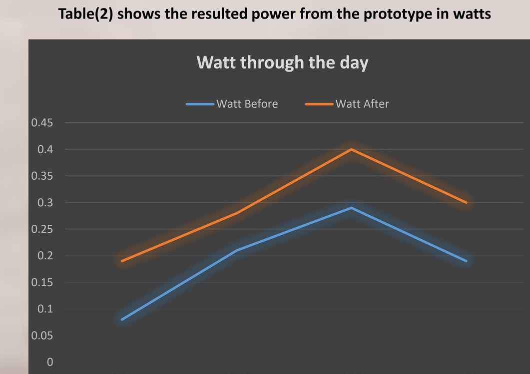
Table(2) demonstrate the resulted power from the prototype. **Graph (1)** illustrates the produced power in watt from the prototype with the modification and without it.

Time	Potential difference (volt)	Current intensity (ampere)	Electric power (watt)
8:00 Am.	11.40 Volt	0.015 Ampere	0.26 Watt
1:00 Pm.	12.66 Volt	0.031 Ampere	0.4 Watt
4:00 Pm.	11.7 Volt	0.014 Ampere	0.24 watt

Table(2) shows the resulted power from the prototype in watts







Graph(1) shows the relation between the prototype with and without the modification

Analysis

Energy of a photon:

To know the output energy, the equation is shown in **Figure(2)** is followed. Where **h** is Plank's constant **(6.63*10^-34)**, **C** is the speed of light **(3*10^8)**, and λ is the wavelength.

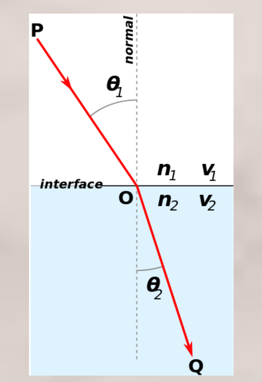
$$E_{\text{photon}} = h\nu = \frac{hc}{\lambda}$$

Figure(5) shows the Equation of energy of photons

To calculate the input energy, the λ will be = **490 nm** (the absorption of the coumarin) and to get the output one, it will be = **650 nm** (the emission of the coumarin). It's found that the input = **2.222*10^-28**, and the output = **1.675*10^-28**. As a result, the energy input will be greater than the output by **13%** approximately.

Snell's law:

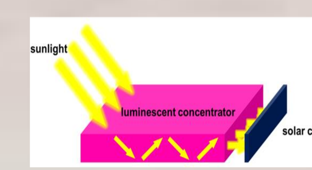
That law states that the ratio of the angles' sines of incidence and refraction of a wave are constant when it passes between two given media as shown in **Figure(9)**. When the light moves from one state of matter to another, it considered to be refracted. The relation between the angle of incidence and angle of refraction is $\mathbf{n_2 \sin \Theta_2 = n_1 \sin \Theta_1}$ where n_1 is the refractive index of air and equals **1.00029** and n_2 is the refractive index of glass slide which equals **1.52**. The light beam comes from the air to enter the glass slide which has a critical angle of **41.1˚** by using this equation: $\mathbf{\sin^{-1} \Theta = (1 / n)}$. It's found that $\mathbf{\sin^{-1} \Theta_2 = n_1 \sin \Theta_1 \backslash n_2}$. As the light's angle changes during the day. By supposing some specific angles and substitute them in the equation, Θ_2 will be concluded. If the incidence angle is **30˚**, the refractive one will equal **19.21**. If the incidence angle is **60˚**, the refractive one will equal **34.7˚**. If the angle is **90˚**, Θ_2 will equal **41.1˚**. The angle of refraction of light that passes from air to the upper surface of glass equals to the angle of incidence of the light that falls on the lower surface of glass to the air inside the box.



Figure(9) shows the application of Snell's law

Mirrors

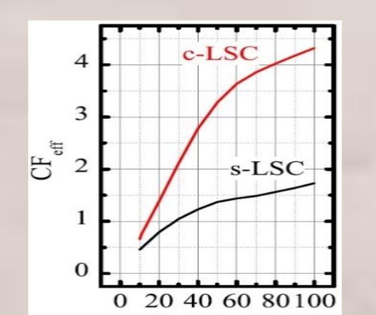
Mirrors were used in order to increase the light concentration onto the solar cell. As it's shown in **Figure(10)**, when the light strikes the box, the mirrors will reflect it till it reaches the solar cell eventually, causing a concentration of the light onto the cell that will consequently increase the current intensity (Ampere) in order to increase the efficiency of the prototype.



Figure(10) shows how light travel inside the mirrors box

Dimensions

The dimensions of the glass box are chosen to be: **17*17*7** centimeter to increase the surface area compared with the lateral area to get the highest amount of light. The width and length should be equal to distribute the light on the sides equally and the mirrors on the sides will reflect it back causing the light trapping till it reaches the solar cell eventually. Surely, the efficiency will increase simultaneously with the increase of the dimensions of the **c-LSC (center- luminescent solar concentrator)**, as proven in **Graph(3)**.



Graph(3) shows the Dimensions and the efficiency of the solar cell

Concerning the height, it's chosen to be **7 cm** specifically, because it's the actual height of the chosen solar panel, so are the length and the width. Over more, the dimensions are theoretically predicted to reach an efficiency ranges from **1:3** more times than the traditional solar cell. But, the actual world is not as accurate as the theoretical world.

Conclusion

To sum up the whole project from scratch, we had a problem to solve which is the **energy overconsumption**, so we did a research and chose a solution which is the solar energy. A prototype which is the **luminescent solar concentrator (LSC)** was assembled according to specific methods to attain the **design requirements** by simple materials. The prototype has achieved the **design requirements** magnificently through a test plan exhibiting its ability to be made as a reliable solution and an effective life application.

Future Plans

There are several improvements and enhancements that can be done in the real life in order to increase the efficiency of the prototype and here are some of them:

1- Solar tracker system:

The obstacle that encounters the efficiency of the solar cells is that they are stationary so they don't follow the movement of the sun across the day. A possible improvement for this issue is the solar tracker as shown in **Figure(11).**

Figure(11) shows the solar tracker

It tracks the sun as it moves from the beginning of the day until its end to make sure that the solar panel is perpendicular to the sun rays. The solar panel is connected by a steeper motor and two LDRs (Light Dependent Resistor) on both sides. The panel will rotate to the side of the LDR producing the higher intensity when the sunlight strikes it.

2- Coumarin 6:

Usage of Coumarin 6 is a good improvement in the **LSC** industry as they are characterized by their simple structure and ease of fabrication. Coumarin 6 dye is one of the best fluorescent dyes to be used due to its high absorption and emission rate that can be used to increase the efficiency of energy production by trapping more light. The only obstacle is its high cost.

3- Turning Windows into Solar Collectors:

By far the most amazing aspect of the product, though, comes from the use of glass. We can use the windows in our houses and offices as large solar collectors. The glass that lets sunlight into our homes and offices could also generate the power we need to run those spaces. However, the biggest obstacle to getting these solar-power windows into our homes is longevity. In fact, the LSC prototype only lasts about three months.

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For further information

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