German University of Technology in Oman
Department of Engineering

Project Work III

Final Report

“Dual axis solar system”

Process Engineering - Group 4

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1. List of Symbols and Abbreviations

Symbol	Unit	Explanation
θ	º	Angle of incidence
W	kWh	Generation of energy
λ	candela (cd)	luminous intensity
A		Conversion factor

Abbreviation	Explanation
PV	Photovoltaic
DC	Direct current
AC	Alternative current
LDR	Light Dependant Resistor
GPS	Global Positioning System
PLC	Programmable Logic Controller

2. List of Figures

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3. Introduction

Our project is a dual-axis tracker that tracks the sun at all times like a sunflower in all directions, so it follows the sun from East to West and from North to South that's why it follows the sun horizontally and vertically so that it collects the maximum possible solar energy in order to use renewable energy from the sun, reduce the usage of nonrenewable energy, and to maximize the generation of electrical power from solar energy. We decided to have a dual-axis tracker as our project, not any other type of solar tracker, for multiple reasons, such as it has a higher degree of accuracy, especially in directions; that's why the tracker points to the spots with the maximum sun rays. Also, the dual-axis tracker has about 40% more electrical generation, unlike the not moving solar panels. In addition, it is even very flexible since the tracker on sunny days allows for higher solar energy output.

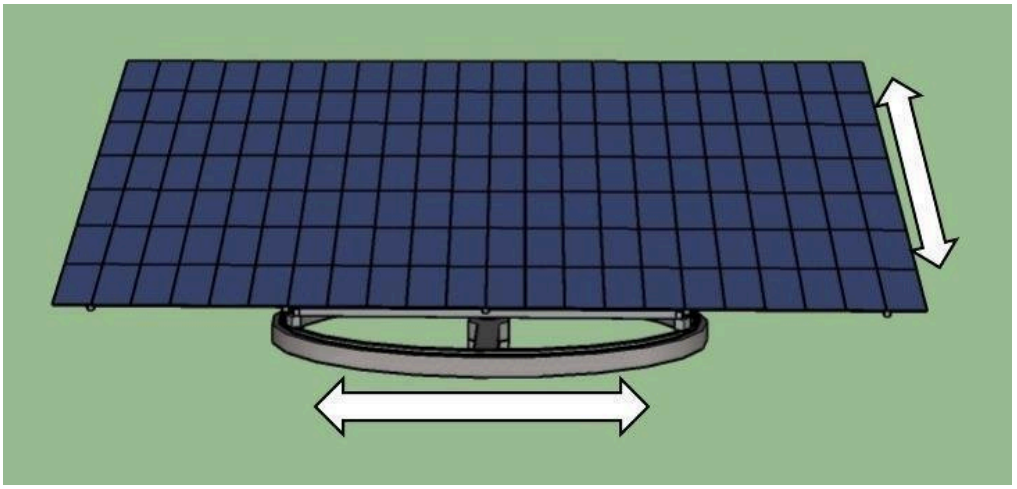


Figure 1: Dual axis solar system

4. Main Chapters

- Equipment and tools:

1- Sensors

is a sensing tool that works to detect the physical surroundings, some of which measure temperature, some of them measure pressure, some that measure radiation, and some that measure electrons or protons. Where it converts the signals falling on it into electrical impulses that can be measured or counted by a device. This enables us to know the intensity of the influence. There are also types of it that can be linked to computers and through programming it is possible to form a picture of the distribution of measurements, as is the case in magnetic resonance imaging that detects tumours in humans. There are many types of sensors depending on usage. In our project we used the type of optical sensor. The sensor determines the direction of the sun's rays so that it polarizes the vertical rays that face it.



Figure 2: LED Sensor

2- Motor

A motor is a machine that converts electrical energy into mechanical power to do work. Electric motors are used to power many machines and mechanical equipment such as washing machines, air conditioners, vacuum cleaners, hair dryers, sewing machines, electric drills, and saws. Various types of engines power mechanical tools and robots, as well as equipment that facilitates work in factories. An electric motor mainly consists of a stationary magnet and a moving conductor called a rotor. Lines of force are formed between the poles of a magnet, and when an electric current pass through a conductor, the conductor becomes another magnet. The two magnetic fields repel each other, and this repulsion causes the rotor to rotate. DC Motor Parts A common source of motor power is DC current from the battery. Because DC flows in one direction, DC motors rely on slotted-loop commutators to deliver DC current to the rotor coil. Slotted commutator rings are metal, mounted on and insulated from the axle. It

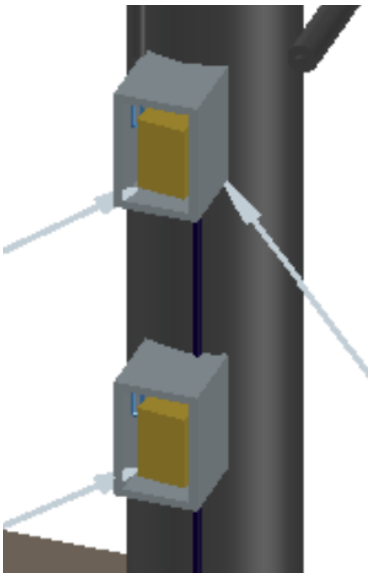


Figure 3: Motor 1 and 2

picks up the current from the battery and delivers it to the rings and thus to the rotor coil by two brushes. In our project, the motor responds to the light sensor to the direction of the sun's rays and moves the solar panels in the correct direction of the sun's rays perpendicular to it. We used two types of motors, each with a specific direction to move in,

Motor 1 (X Axis motor): It is mission is to move the solar panels in the y axis direction.

Motor 2(Y Axis motor): It moves the solar panels in the x axis direction.

3- Anemometer (wind speed sensor)

Anemometer with a pressure tube is a device used to measure wind speed, as it determines the wind speed in this device through the pressure caused by the wind on the pressure tube constantly facing the wind and transmits the effect of pressure and drag through tubes that lead to the wind speed indicator. We used in our project this sensor that measures wind speed. If the wind speed is high, the solar panels will be in the zero-angle position in order to avoid any damage that the wind may cause and may damage the device.

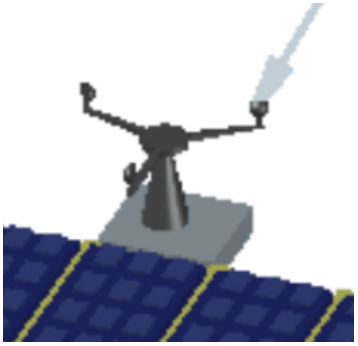


Figure 4: Anemometer

4- Solar panel and Its holder

A solar cell is a device that converts solar energy directly into electrical energy by taking advantage of the photovoltaic effect. It consists of a silicon layer to which some impurities are added to give it some electrical properties. The upper layer opposite the sun is added to the element phosphorous, to give it the property of pumping electrons when the light hits it, and this layer is called the layer N while the element boron is added to the lower layer and gives it the property of absorbing electrons and this layer is called P. Electricians

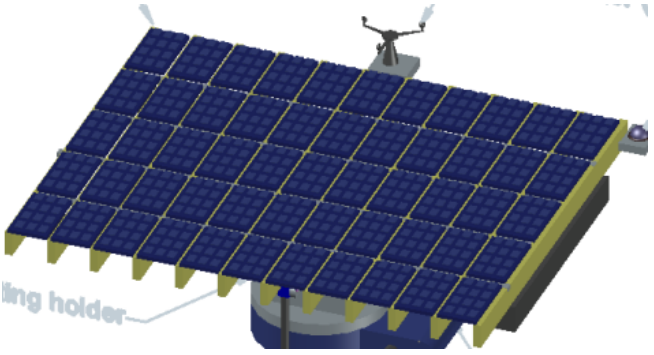


Figure 5: Solar panels

5- Fastener

A fastener is a piece of equipment that is used to connect two things. In our project, we used it to connect the cylinder and the rotary holder in order to avoid direct connection between them to avoid any future damage and to facilitate disassembly without any damage to make any required maintenance.

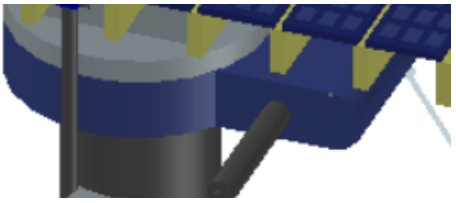


Figure 6: Fastener

6- Rotating holder

The rotary holder is a device located between the holder of the solar panel and the fastener. The motor moves it to move the holder that holds the solar panels, which as it moves the solar panels in the direction of the sun's rays.

7- Cylinder

The cylinder is where the wires are connected from the solar panels to the battery. It holds the solar panels to a higher level than the base. The cylinder carries two motors on the side.

8- Base

The base is the part which is responsible for the stability of the entire device, and it must be strong and solid and bear all the weight required for the device.

9- Switch

The switch is the lock that enables the device to be opened and closed.

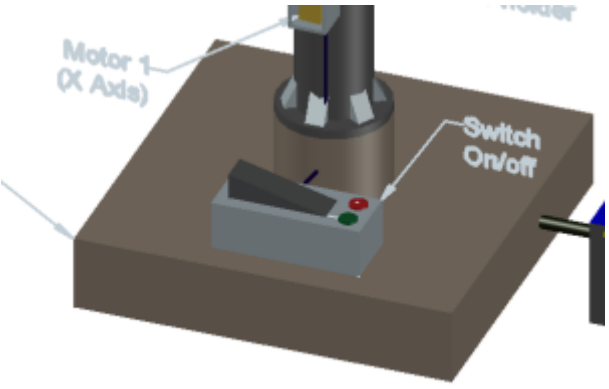


Figure 7: Base & the switch

10- Battery & Generator

A battery is a device consisting of one or more electrochemical cells with external connections to power electrical appliances. Which is work like storage.

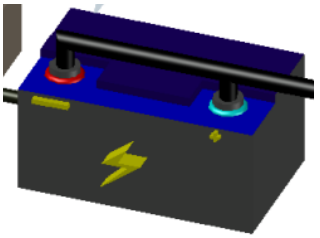


Figure 8: Battery

11- Inverter

It converts the type of continuous electric current coming from the battery into an alternating current, which is the type of current that is suitable for usage in the home and other places.

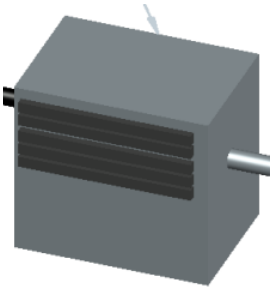


Figure 9: Inverter

- Process and Working principles:

I. Process of Hardware:
In this part the sketching till the final design of the project will be illustrated.

a. Sketch
After choosing the right project and doing a father research on how the device is going to function, considering the objectives and different forces that might affect the structure of our device. Taking into account of all the above we started sketching and Fig.1 present the primary design of our project.

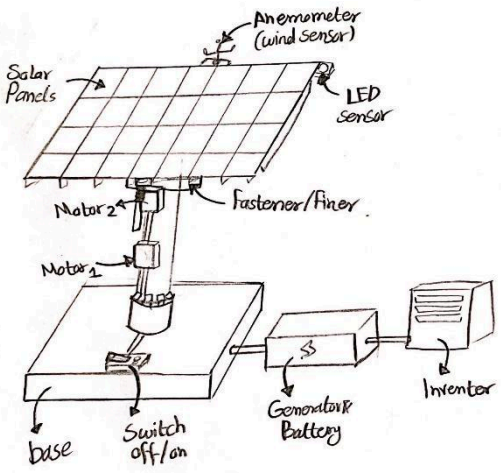


Figure 10: Sketch of dual axis solar tracker device

b. AutoCAD
Using the primary sketch, the 2D and the 3D design were implemented in the AutoCAD software application. Fig.10 shows the 2D draft and design, Fig.11 shows the 3D design.

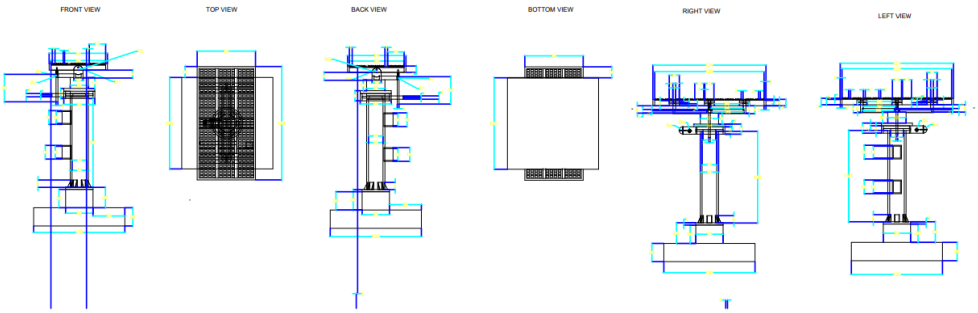


Figure 11: 2D design in the AutoCAD application

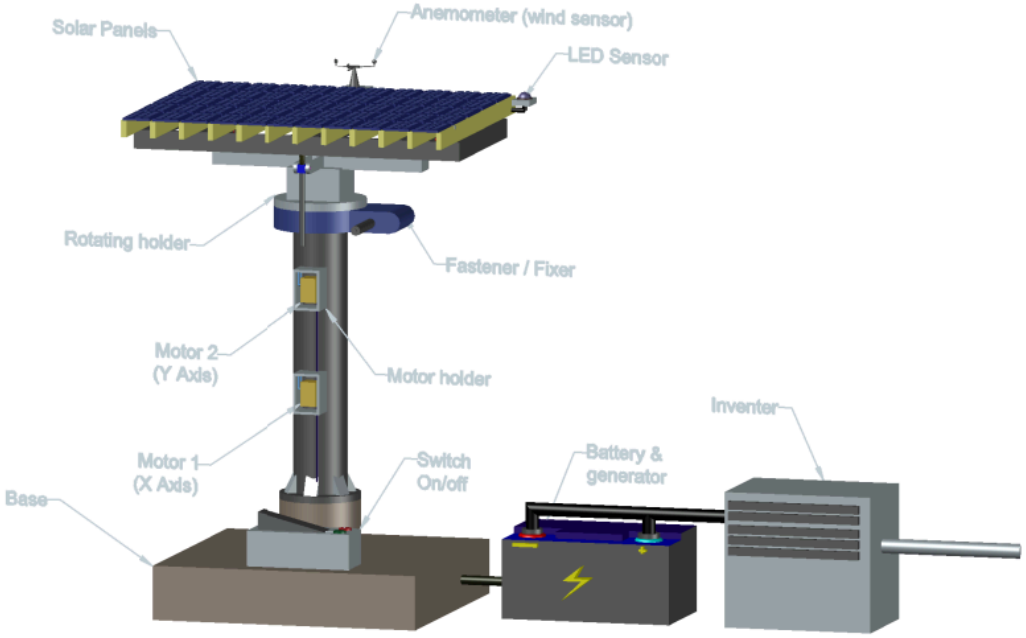


Figure 12: 3D design in the AutoCAD application

I. Calculation processes
   a. Solar energy

IN order to fully understand the fundamentals of the solar energy system starting with the solar panels. Solar panels in the tracker are build out of solar cells that either connected in series or parallel connection, The series connection of the cells increase the overall voltage, while the parallel connection increase the overall current. PV or solar cells generates DC (Direct current) type of current due to this the solar panels is considered DC current system. The current flowing will then charge the battery connected to the solar panels. However, the amount of current the solar panels generated depends on the intensity of the light falls into the solar panels. Fig.12 Shows simple illustration od the angle of incidence (θ)i :

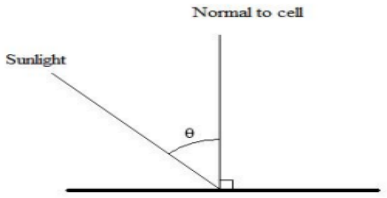


Figure 13: Angle of Incidence to PV

The generation of energy from the solar cell (W) can be calculated with respect to Fig.4 the angle between the normal to solar cell is perpendicular to it which is the angle of incidence (θ). With the assumption that the light has a constant intensity (λ) and A is conversion factor according to the structure of the panels, gives the following equation:

$$W = A \lambda \cos(\theta) \quad \textbf{eq.1} \text{ [1]}$$

The working principles of dual axis solar tracker depends mainly on the sensors since the motors dose not move unless the sensors detect the direction of the sun for the tracker to adjust its position towards the sun rays. Considering the sun, it does not only move from east to west but also north to south as its changing in height. One of the most important components in the device is LDR (Light Dependant Resistor) which has a varying resistance that changes with different intensities of light. Followed by the Anemometer (Wind speed sensor) a device that measures wind speed which is critical to have in a solar tracker at windy days the sensor will alert the system to return to its basic position stowed at 0° in order to keep the overall profile as

low as possible minimize the resistance performed by the tacker. We refer to this position as stowed position showed in Fig.13:

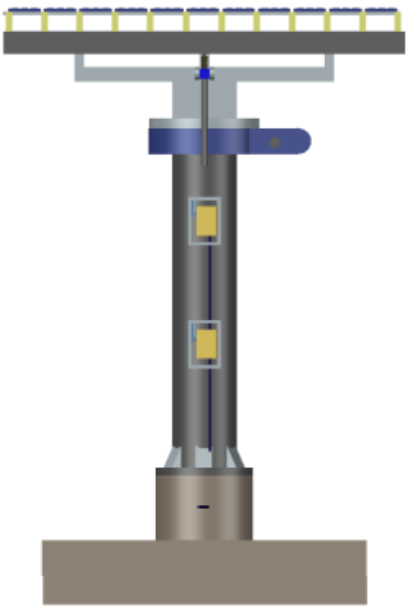


Figure 14: Stowed position

- Problems, difficulties and solutions:

In the beginning, our problem was the lack of the sharing feature in AutoCAD, in other words, that we all work on one file and one of us.
But this was not present, so we drew the shapes separately, and our problem here was not specifying the exact measurements. When we combined the shapes when we finished drawing and shaping, we noticed that many shapes have a difference in size and length, so we had to redraw some shapes Because we can't reduce it.

Our second problem was when we decided to open a meeting in Microsoft Teams, each of us opens her screen and draws in front of us and we all help her, but sometimes the two programs together are heavy on the laptop for long hours, so the two programs are suspended and then shut down Autocad and sometimes we lose our work.

As for the last problem, it was due to our lack of knowledge in this project, we initially drew and designed unnecessary equipment and devices that could cost us a lot in vain. We were wasting our time designing devices that we didn't need..

The solution that solves our previous problems is that we do a deep research for our project from scratch in order to avoid losing time and drawing and designing things we do not need, the technical solution is out of our control, but we fixed the measurements with a tool Scale in AutoCAD.

- Future plans and further developments:

To improve our solar of tracker, we included two sensors. One is anemometer sensor, which is the wind speed sensor which detects the wind speed and direction to refer to this position for changing the direction and position of the solar panel. So, for example when there is a very high-speed wind, we keep the profile of the solar tracker as low as possible in order to let the wind pass by without any losses or any other damage to the solar panels and any part in the solar tracker.
And we added another sensor which is an LDR light sensor which detects the sun rays and where the sun rays are directed and the strongest to move the solar panel accordingly towards the sun rays to get the maximum possible solar energy from the sun and to move it in a way so that the solar panel will be a perpendicular to the sun rays in order to get the maximum benefits of the solar energy.
For our solar tracker we installed two motors one is for the X-axis to move the solar panel along the X-axis and another one for the Y-axis, so we get the movement in two directions.
For our future we will include a GPS detector in order to track the sun’s position throughout the year, in all seasons and throughout the day.
We are also planning to install a mirror or a concave lens on top of the panel to increase the solar tracker’s efficiency by directing and focusing a large amount of sun rays directly on the solar panel to absorb the maximum possible solar energy.
And placing a concave lens or a mirror will also result a high optical efficiency.
For our future plans, we are also planning to add a PV robot cleaner to clean the solar panels in specific times of the day from the dust and dirt while the solar tracker is being outside most of the times. We are also planning to add a PLC control unit where we use the Ladder Diagram (LD) as programming language to program and control the solar tracker.





5. Conclusion

In conclusion, we concluded that dual solar energy tracking systems are very important and necessary for photovoltaic plants, and they are safe and permanent because they are renewable energy, they are worth the effort and effort despite facing high-cost challenges that include design, implementation, and prices of devices.

And designing the project in AutoCAD was great and somewhat tiring because day after day we discover something new and new information. But building it on a program and determining its measurements, shape and plan facilitates the rest of the work.

The project is not that difficult, and any adult can understand it and know its equipment, tasks, and parts perfectly in about 10 minutes. The task of each device in the project is very necessary to complete its function in the fullest manner, and each device is linked to the others like a circle. Moreover, each device completes the other device work, and if we missed a small device such as LED sensor, the whole project would fail and will not work.

we will work hard to develop this project and to be a source of electrical energy and many other energies because we are in a geographical area that helps this device work and receive the largest amount of solar energy.

6. Sources

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7. Statement of Authorship

I hereby confirm that I am author of this work and that all sources used are properly stated. When used, Ideas and concepts developed by others are clearly marked as such. I affirm that this work has not been submitted elsewhere for a similar purpose.

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8. Appendix

1. Formulas

$$W = A \lambda \cos(\theta) \quad (1) \quad [1]$$