
SOLAR180

# SOLAR TRACKING

## THE FUTURE IS BRIGHT

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# INTRODUCTION

**What is renewable energy?**

Renewable energy commonly referred to as 'clean energy' uses naturally produced resources or processes that never run out as they are constantly replenished. These unlimited resources such as the wind, sunlight, geothermal heat and water, power millions of homes all around the world. Of which New Zealand accounts for approximately 40% of primary energy from renewable energy sources.

**Why use renewable energy?**

Using resources such as the sun, wind and water which never run out means constant and reliable energy. By utilizing these to enhance the methods of generating electricity, it reduces the carbon emission produced when using fossil fuels. Shifting from fossil fuels which emits high levels of greenhouse gases to a more environmentally friendly energy source such as renewable energy, helps with ongoing issues like climate change and air pollution.

As the population continues to increase and technology advances, the urgency for cost-effective, dependable and everlasting energy rises.

Thousands of companies and individuals are making the big shift to a cleaner, safer and brighter future. **You can too.**

# The POWER Of The SUN



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## Solar Energy

The sun is powerful in many ways as it has been producing energy for billions of years. Ever since the invention of the photovoltaic effect, solar energy has evolved immensely since 1839 and has become one of the most popular sources energy.

Solar energy technology uses the sun's intensity to produce electricity by concentrating sunlight into a beam from a large area. This method is used to heat water and power homes as solar energy is among the very few renewable sources of energy that is promising for the future.

This freely available energy source has become a tool in the industry to develop the economic status of countries that are still undergoing development. The best option for managing long-term issues is to go solar. This is because solar power is superior in terms of efficiency, availability, cost-effectiveness and capacity. Industries that are solar based are steadily advancing due to high demands in energy as other methods are expensive and fossil fuel is limited.


**1. Solar Power is GOOD for the Environment**

It is a very known fact that Solar Energy is a clean and creates renewable power from the sun and substantially benefits the environment. Solar is a powerful way to reduce carbon footprint as well as greenhouse gases. Investing in Solar energy will help reduce these impacts on the earth.

**2. Future proof your energy source**

As the need to fix serious issues of climate change and pollution increase in urgency constantly, the likelihood of governments introducing restrictions on ways of producing energy that are not clean also increases. So by using solar energy now you not only prepare for the future but also protect your businesses reputation by being environmentally friendly.

**3. REDUCES Electricity Bills & Low Maintenance**

How much you will be able to save on your electricity bills depends on the size of the Solar system - this also means that you are in control of your own energy usage. Additionally, Solar energy systems do not require a lot of maintenance as long as they are clean - for this reason you are able to avoid power fluctuations.

**4. Solar Electricity ---> FREE Source of Energy**

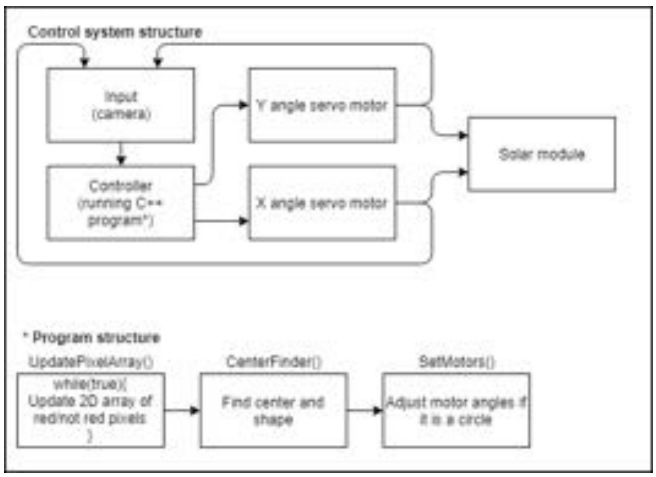
By going Off-Grid and investing into Solar Electricity, this boosts your electricity independence! This means, with the decrease in cost of solar panels, you are able to control and enjoy cheap electricity - the sun will never charge you for energy!

Solar energy is great but it can get even better with solar tracking which increases the power output of solar panels by around 40%.

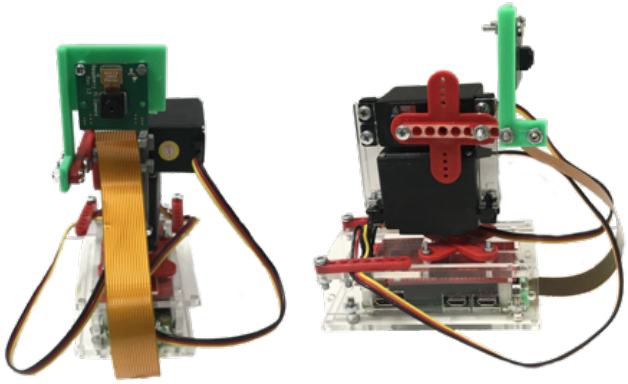
Solar trackers adjust the direction that a solar panel is facing according to the position of the Sun in the sky. The angle of incidence remains perpendicular to the Sun's rays. By keeping the panel perpendicular to the Sun, more sunlight strikes the solar panel, less light is reflected, and more energy is absorbed.

A solar panel that is exactly perpendicular to the Sun produces more power than a solar panel that is not perpendicular.

The use of solar trackers can increase electricity production by around a third, and some claim by as much as 40% in some regions, compared with modules at a fixed angle




## Model Images



# Prototype: Janice

**How does it work?**

Janice stays perpendicular to the sun throughout the day by running a program on the controller written with C++. The program works by taking a picture from the direction the solar panel is facing by going through every pixel in the image and determining which of the pixels are red and which are not red.

Each pixel contains a value from 0-255 for red, green and blue. If the percentage of red is above 50% it is considered a red pixel and placed into a 2D array with dimensions the size of the camera. The 2D array is then analysed to find the longest red row and column in the array, with these values it finds the center of the red shape.

With these values the solar tracker checks rows above and below to determine whether or not the object is a circle or a half circle and therefore, the sun. If the object is a circle/half circle the an error value is calculated and the servo motors adjust until the error value is below a certain threshold (to avoid oscillations therefore avoid wasting energy). If the object is not a circle and there are no other objects that are circles/half circles the the program sets the servo motors to an angle that is estimated to align the solar panel perpendicularly to where the sun will rise.

In order to be more efficient the program has a delay in every cycle to save energy and avoid being counterproductive.



# Solar Trackers

**Solar Tracking vs Fixed Panel**

The most common solar tracking systems are the Fixed Panel trackers or [5] Single-Axis trackers. However, Dual Axis-Tracked solar panels' energy production has a 5-10% increase in comparison with Single-Axis trackers. [6] Annually, dual-axis solar trackers can produce as much energy up to 45%.

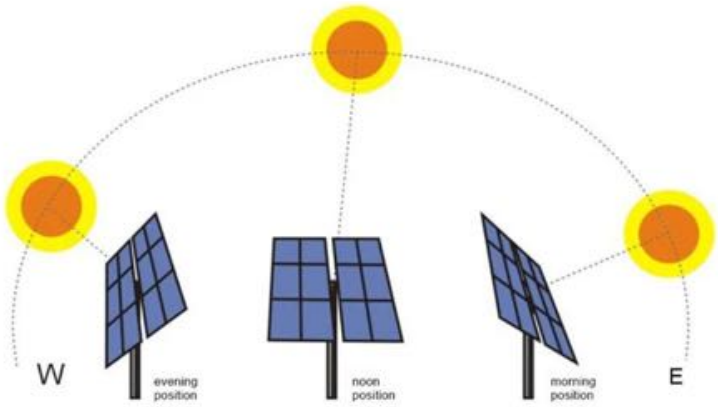
Due to the ability of axis trackers to follow the sun, it provides a larger possibility for a greater electricity generation and income. As fixed/single-axis trackers will only be able to generate maximum energy for a certain amount of hours, however dual-axis trackers will be able to maintain the power throughout the day.

In terms of investment and production, the more energy a solar tracker system produces then the easier the upfront investment will be, this can be done by specifically using only the dual-axis trackers as it produces the highest amount of power.

**Mechanical Construction**

The Solar Tracker will consist of two 12V direct current servo motors, with a 5 degree resolution, one servo for the altitude and the other for longitude. The prototype tracker, Janice, tested in the lab, was constructed using RPI, motor driving shield, a video camera.

During the lab, the team tested the prototype on its movements and direction, and its placement. Janice is able to move from the west to east direction, 180 degrees, and from the north to south direction, approximately 30 degrees. In terms of the position, the solar tracker should be mounted flat with a 90 degree placement towards the sun. This placement results in a great energy power production.

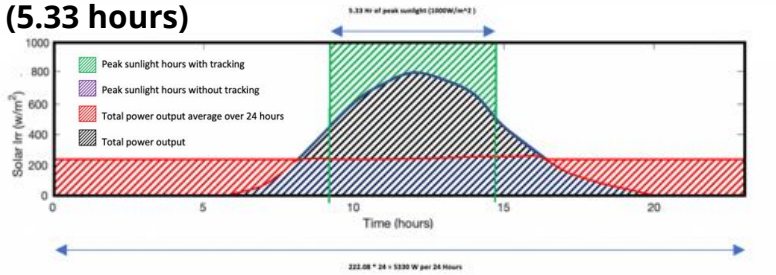


# Solar Calculations

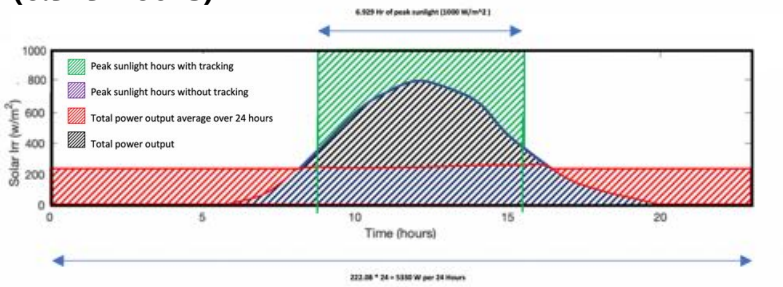
## Scaled Version

Solar180 has tested the use and functionality of the Solar Tracker by using a smaller panel. However, the scaled version which the team would design will be the size of a 300W panel. The team will need investments to be able to make the plan work.

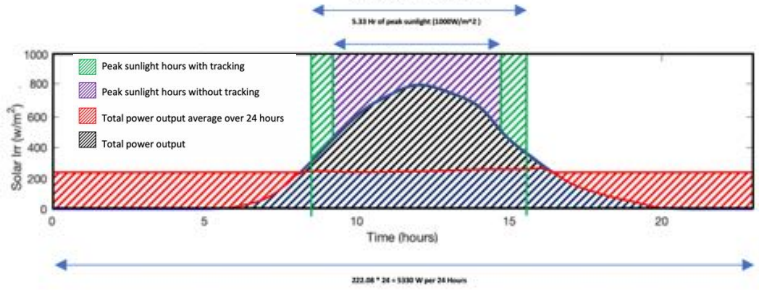
## Peak sunlight hours without tracking (5.33 hours)




## Peak sunlight hours with tracking (6.929 hours)




## Comparison between tracking and non-tracking peak sunlight hours




**Power increase:**

A solar panel with a tilt of 41° and only an efficiency of 70% will have an estimated cumulative power gained of 5.33 kW-hr/m^2 on a Summer solstice day. A solar tracker increases this number to 100% efficiency (an extra 30%) which is to 5.33 x 1.3 = 6.93 kW-hr/m^2 as the solar panel is perpendicular to the sun for longer time.

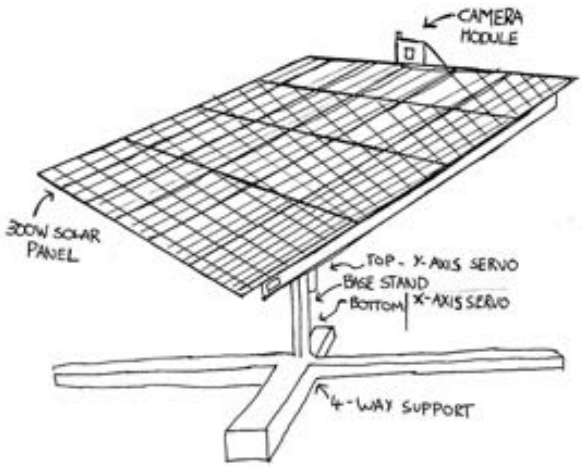
This means a panel rated for 300 W (meaning 300 W will be collected in 1 kW-hr/m^2 and in 25° C conditions) will receive:
300 x 5.33 = 1599 W - Without tracking
and,
300 x 6.93 = 2079 W - With tracking

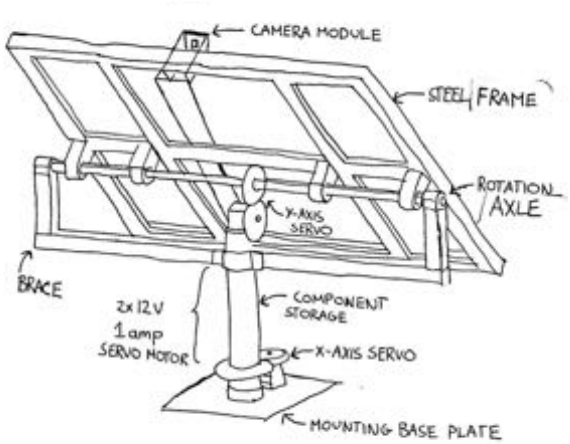
This means there is an additional 480 W collected with tracking. However, we still need to account for the energy the servos will use.

The system consists of two 5° resolution servos each uses P = 12 V x 1 A = 12 W
The servo will need to rotate 5° 72 times for a total of 360° so the panel can follow the sun for a day and then move back to the expected sunrise position. Since each rotation takes 10 seconds this means the total rotation time is 0.2 hours. This means the total power used by the horizontal servo is
P = 12 W x 0.2 s = 2.4 W.

This means the energy collection increase from solar tracking is
480 W - 2.4 W = 477.6 W
Assuming the vertical servo's energy use is negligible.

## Sketches of the scaled system



# Budget

| Things we need (maybe): | Description: | Price: | Link: |
|---|---|---|---|
| Solar Panels | 300W Panel | $679 | https://www.jaycar.co.nz/300w-premium-recreational-solar-package/p/ZM9306 |
| Servos x2 | 12V DC<br>1A Current<br>5 Degree res<br>10 seconds to rotate 5 Degrees | $216 per servo | https://www.alibaba.com/product-detail/Original-dc-servo-motor-12v-SGMAH_62108724760.html?spm=a2700.7724857.normalList.12.5c1d3f3cV3r2nL&s=p |
| Controller | Controls RPI | $42 | https://nz.rs-online.com/web/p/products/8111284?cm_mmc=NZ-PLA-DS3A-_-google-_-PLA_NZ_EN_Catch_All-_-Fusion-_-PRODUCT_GROUP&matchtype=&pla-468790558708&gclid=Cj0KCQjw5MLrBRCIARIsAPG0WGwDRiJ4gfePsRDX3rSanU0mNWGev4w2PDr_bwwFiVZP5yAm5MOpgVAaAq8CEALw_wcB&gclsrc=aw.ds |
| Labor | | $1000 per solar tracker | |
| Minor additional costs | | $200 | |

# Appendices

(n.d.). 3D CAD Model Collection: GrabCAD Community Library. Retrieved from https://grabcad.com/library/dual-axis-solar-tracker-2

(2016, September 14). Big Sun to Off Gridders: It's Time for A Dual-Axis Solar Tracker. Retrieved from http://paratusnews.com/big-sun-to-off-gridders-its-time-for-a-dual-axis-solar-tracker/

[5] (n.d.). Home. Retrieved from https://www.kiewit.com/plant-insider/current-issue/fixed-tilt-vs-axis-tracker-solar-panels/

[6] Renewables, A. E. (n.d.). Comparing the ROI of a Solar Tracker vs. Fixed Mount Solar. Retrieved from https://www.allearthrenewables.com/blog/dealers/pv-tracker-vs-pv-fixed-mount-system

[7] (2019, August 16). Solar PV Tracker vs fixed comparison. Retrieved from http://www.keremcilli.com/solar-pv-tracker-vs-fixed-comparison/