

The Power of Renewable Energy



**SCHOOL OF ENGINEERING SYSTEMS
QUEENSLAND UNIVERSITY OF TECHNOLOGY**





Acknowledgements

This project material is part of an experimental kit containing a solar-powered water pump. It has been designed for activities in Year 9 and Year 10 Science in Queensland although it is suitable for more advanced activities in other years.

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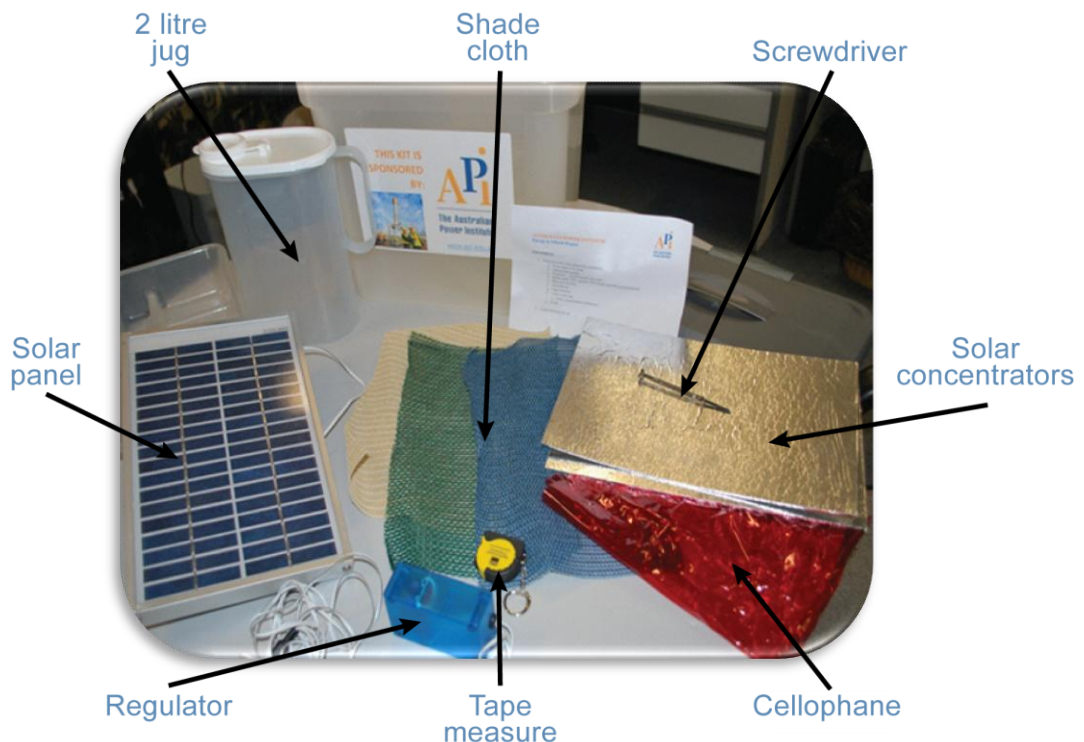
The solar-powered water pump kit



The kits contain:

- 1 Student Workbook (+ Teacher's Resource handed to teacher)
- 1 x 5w 20v solar panel
- 1 submersible water pump
- 1 regulator
- 1 small screwdriver (for altering the output voltage of the regulator)
- 3 shade cloth panels — 50% (green), 70% (blue) and 90% (cream) density
- Red and blue cellophane for light experiments
- 1 tape measure
- 1 jug (1.5-litre capacity)
- 1 wipe cloth (to ensure kit is kept dry and free from mould)
- 2 x solar concentrators (reflectors)

All leads have been manufactured to ensure safety and to avoid students connecting components of the kits incorrectly.



The container, when emptied, becomes the source for water that is then pumped into the measuring jug. This has rather coarse gradations so a tape measure is provided so that students can measure more accurately how much water they have pumped over a given time in a classroom competition. The screwdriver is provided to enable students to modify the output voltage by turning the pot (10 turns capacity).

Background

You graduated in 2005 with a B.Eng (Elec). You are a Power Engineer with a special interest in electronics. You have been successful in installing state-of-the-art systems in many modern situations.

You are a member of RedR Australia, a humanitarian organisation that provides technical expertise to United Nations agencies, including the United Nations High Commissioner for Refugees (UNHCR) in emergency relief situations.

RedR, Australia's Standby Register of technical experts, allows humanitarian agencies to access skilled workers quickly in a humanitarian crisis.

RedR Australia provides emergency assistance to communities devastated by conflict or major natural disasters by selecting, training and providing competent and effective personnel to humanitarian relief programs worldwide (see www.redr.org.au).



The situation

A severe earthquake disaster has struck the impoverished country of Haiti in the Caribbean. You have received the phone call stating you will join with other engineers from RedR Australia on a mission to restore water supply. You find yourself on a C-17 Globemaster with tonnes of supplies and 45 other specialist personnel heading to the Caribbean — they wouldn't let you take your surfboard!



In engineering, a realistic approach to problem solving is the PIST method:

- **P**roblem
- **I**mpact
- **S**olution
- **T**iming.

These are presented as follows.

The problem

- Two million people are left with no power station, hence no electricity.
- Two million people are in a hot country unable to pump water from their wells.

The impact

(You are to complete this section)

The solution

- Submersible pumps to pump the water out of the small diameter wells that are available across the country.
- Solar electricity panels to provide the electrical power to do the work in raising water to the surface. Sunlight near the equator is not a problem!

The timing

- Immediately and urgently. Water is a vital resource for sustaining life.

Your mission:

to restore water to the victims of the earthquake

To do this with the solar powered water pump, you will need to work out the best set voltage for pumping to give the greatest amount of water in a day, from sunrise to sunset.

Your task

To determine the **best operating voltage** to operate a solar water pump so as to **give the maximum flow rate** of water in a day from sunrise to sunset.

1. Assemble the solar pump kit under the guidance of your group's supervisor.
2. Test a range of variables to determine which conditions provide the maximum volume of water in a day.

Work out the best option:

1. High voltages, high flow rate for a short time.
2. Low voltages, low flow rate for a longer time.
3. Somewhere in between — but where, to get the maximum amount of water in the shortest time?

The solar panels in the earthquake zone have an electronic voltage regulator to preset the best operating voltage for the pumps so as to give the maximum volume of water per day.

The investigation

What is the optimum voltage to produce the best flow rate of water and how can this be produced?

Independent Variables

1. Angle of the solar panel to the sun
2. Light intensity falling on the solar panel
3. Light frequency (colour of light) falling on the solar panel

Dependent variables:

1. Voltage
2. Flow rate of water

Results:

Independent variable	Conditions	Voltage	Volume of water moved in 2 minutes
Angle of the solar panel above the horizontal	15°		
	30°		
	45°		
Light intensity (Shade cloth filter)	Light (green) 50%		
	Medium (blue) 70%		
	Heavy (cream) 90%		
Light frequency (colour of light determine by coloured cellophane)	White		
	Red		
	blue		

Conclusion:

Light Intensity

One way to increase the intensity of sunlight is to tilt the solar panel to face the sun so that the sun's rays hit the panel at 90°. Another is to concentrate the sun's energy by use of mirrors.



Do not reflect the sun directly into the face of other students as this can cause eye damage

You have two 'mirrors' about the same size as the solar cell. Can you think of another way to increase the sun's intensity falling on the solar panel?

Mirrors are used in real world situations to increase the intensity of sunlight falling on solar panels. Mirrors are permanently set up so as to reflect some extra sunlight. Check out YouTube, Solar PV mirror concentrators.

TEST THIS

With the back of the panel facing the Sun, use one mirror to reflect the Sun onto the solar panel. Record the panel voltage _____ v.

Now using the two mirrors, reflect the Sun onto the solar panel. Record the voltage. _____ v.

Is this the result you expected? _____

Can you explain the result? _____

With the front of the panel facing the Sun, record the panel voltage _____ v.

In order to reflect Sun onto the panel, you will have to work out how to use the two mirrors, being careful not to cast a shadow over the panel.

Record the panel voltage _____ v.

How solar panels convert sunlight to energy

Solar panels convert sunlight directly into electricity. Solar panels consist of several cells made up of at least two layers of semiconductor material. One layer is positive P type silicon (Si), the other layer is negative N type Si. When light energy enters the cells making up the solar panel, the energy from some of the photons from the light are absorbed by the semiconductor atoms, freeing electrons from the cell's negative layer (N type) to flow through an external circuit and back into the positive (P type) layer.

The electrons are made to move through a conducting wire connecting the P type Si to the N type Si. This flow of electrons produces electric current. The electrons on their way through the conducting wire can be made to do work (for example, pump water) before they return to the P layer. The electrons return to the N type through the PN junction to get energised by light and start the process all over again.

When two solar panels are wired together in series (**don't try this yourself!**), their voltage is doubled while the current stays constant. When two solar panels are wired in parallel, their current is doubled while the voltage stays constant. To achieve the desired voltage, solar panels are wired in series and parallel into what is called an 'array'. Through a mixture of different series and parallel combinations, any desired voltage can be achieved.

