Renewable Energy can be cheap!

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This paper provides an outline of some projects that can mainly be constructed from readily available materials. It is based on the practical component of a "renewable energy" segment of the Geography Teachers Association of SA 2005 Conference, so the PowerPoint Presentation provides some background material. You may find it useful to combine with science and/or technology teachers to gain more benefit from some of theses suggestions.

Solar Hot Water

This unit can be constructed from some poly pipe (as used for garden irrigation), some fittings and a bucket. You will also need a thermometer.

Warning – you may get quite hot water, so be wary!

Just measuring the panel inlet and outlet temperatures shows that heating is occurring.

If you measure the temperature of the water at the start and end of a time period (after mixing) the energy collected can be calculated by

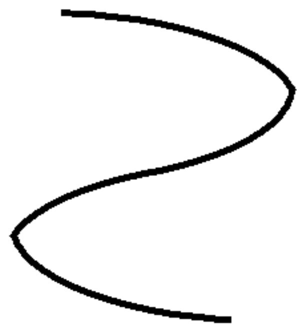
Energy = Mass of water in Unit*Specific Heat of Water*Temperature Rise
(kJ) (kg) (kJ/kg/°C) (°C)

and the Specific Heat of Water is 4.2 kJ/kg/°C. The power of the panel is then the energy collected in J divided by the time period in seconds and you can calculate power per square metre if you measure the length and width of the collector. You can use the "Solar" spreadsheet to estimate incoming solar radiation for the situation (by going to the "Direct Radiation" sheet) and then calculate panel efficiency.

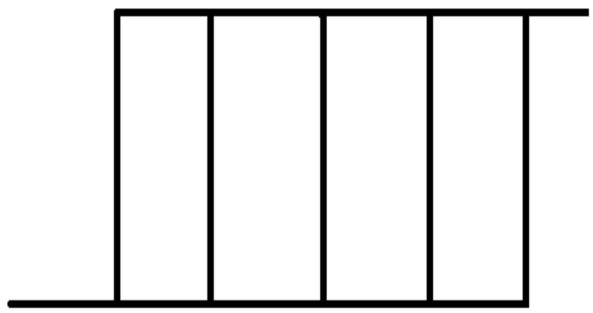
Eg 15 litres (ie. 15 kg) of water was warmed from 18C to 25C between 1 pm and 4 pm on Friday, May 13, 2005. The collector was 2.6 m of 14 mm OD black poly pipe and incoming direct radiation ranged from 821 Wm^{-2} to 268 Wm^{-2} on May 9.

	Energy to Water	= 15 * 4.2 * 7
		= 441 kJ
	Power to Water	= 441 / (3 * 60 * 60)
		= 0.0408 kW or 40.8 watts
	Collector Area	= 2.6 * 0.014
		= 0.0364 m^2
so	Collector Power	= 40.8 / 0.0364
		= 1122 Wm^{-2} (possibly a bit high, or we collected a lot of diffuse radiation)

The "collector" can be simply a single tube but commercial panels usually have several tubes in parallel to give better performance, so one task could be to compare the two collector configurations.



Single path collector



Multiple Path Collector

Other improvements are to place some insulation behind the collector to reduce heat loss and to use a glass cover to seal the unit. The effectiveness of a silver foil backing plate (with a space to the tubes) could be compared to a black metal plate with the tubes in contact.

The effect of the height of the tank base above the top of the “panel” and the consequences of dips or peaks in the inlet and outlet pipes could also be looked at.

Anaerobic Digestion

You need two containers that fit one inside the other, some plastic tube, silicon sealant and a burner. The burner can be made from 12 mm dia tube with a 1mm (or 1/16”) diameter “jet” at one end. You will also need a weight to develop burner pressure, some waste to digest and possibly some manure or sludge from another digester to get the right bacteria in the digester. Matches or a lighter will also be useful.

Warning – you are handling waste, so hygiene is important, and producing flammable gas, so no smoking!

Discard the first gas collected (it will be mainly nitrogen and carbon dioxide), then observe the blue methane flame from subsequent gas collected. If you can collect enough gas you could heat some water and estimate energy and power as in the Solar Hot Water project.

Students could investigate the effect of operating temperature, the suitability of different types of waste for anaerobic digestion and how much effluent can be added per day/week before the digester fails.

If you are interested in a 200litre size digester I am in the process of organising a DIY kit.

Gasifier

The gasifier is constructed from a tin can and a larger diameter can provides the base as well as the billy (with a fencing wire handle). Wood chips/twigs, paper and matches complete the kit.

Warning – the cans get hot and carbon monoxide can be released, so use in well ventilated areas only!

The temperature gain of an amount of water can be used to estimate energy and power, as with the Solar Hot Water unit.

The effect of different air inlet/outlet areas, sizes of wood chips and types of wood used could be compared.

Solar Electricity

For this project you will need a PV cell and a couple of multimeters (available from electronics outlets) along with some low power light globes, sockets to suit and some electrical wire for connecting up the system.

Set one multimeter to measure voltage and attach it across the panel outlet wires, this gives the "open circuit" or maximum voltage. Look at the effect of panel orientation and shading on the voltage reading.

Now connect a light globe to the panel, using the other multimeter as a current meter. You can now see the voltage and current produced for different orientations and shading as well as for different loads if you connect more globes. The power from the panel and its area are given by

Power = Voltage * Current
Area = length * width

Eg On Friday, May 13, 2005 we measured 10.8 volts when the current was 0.13 amps from a panel 29cm by 29cm.

	Power to Globes	= 10.8 * 0.13
		= 1.404 watts
	Panel Area	= 0.29 * 0.29
		= $0.0841 m^2$
so	Panel Output	= 1.404 / 0.0841
		= $16.69 Wm^{-2}$

The globes I used were a bit big for the panel I used (rated at 5 W, giving 0.33 amps at 15 V), so I connected them in series to get a range of loads where normally you use a parallel connection if you can run several globes off the panel (check on the size of panel, as bigger panels will run more globes easily).

Savonius Windmill

A large can, a shaft with some means of supporting it, a couple of nuts and bolts, bluetack (or similar, for balancing weight) some string and some small weights are required to assemble a Savonius rotor. Then you need some wind!

Usually the Savonius Rotor has the half drums overlapping a bit, but for simplicity I just attached them to the shaft by bolts – students could look at the effect of different amounts of overlap on performance. The unit will also have to be balanced by adding small weights to the light section (you may use bluetack if that is convenient) - hold the shaft horizontal (out of the wind) so that it is free to rotate and wait for the heavy section to settle on the bottom.

The Savonius rotor is usually used with the shaft vertical, but to simplify estimating load hold the shaft horizontal and face the unit so the wind blows across the shaft. The power is estimated by timing how long the rotor takes to raise a known weight a given distance, preferably letting the rotor get going before starting timing.

Energy (work) = force * distance
= mass * acceleration of gravity * distance
where acceleration of gravity = 9.8 ms^{-2}

and Power (Watts) = energy / time

Attach the string to the rotating shaft, so it winds up and lifts the weights. The power for different amounts of weight on the string and at different wind speeds could be looked at.

Water Wheel

Construct a wheel by placing a number (at least 12) paddles between a couple of discs about half a metre in diameter. You will then need to arrange a channel for water to flow down and have the wheel supported in the channel. A string and some weights provide the load, as in the Savonius Windmill.

Look at power for different loads and a range of water flow rates.

Further Information

I have put some information (including the PowerPoint presentation) on a web site at http://www.ees.adelaide.edu.au/pharris/RenewableEnergy/welcome.html but there are plenty of other websites.

The book "Integrated Renewable Energy for Rural Communities", by Bassam, N. El, and Maegaard, P., published by Elesvier in 2004, also provides extra information, it is quite detailed in some areas but a bit superficial in others.