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# Renewable Energy Comes of Age

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When one discusses natural resources, one normally considers that which lies within or upon the surface of the Earth. Today, however, I am going to talk about how you can get your share of humanity's greatest untapped resource that lies 150 million kilometres away at the centre of the Solar System. Of course, I am referring to the Sun, and the vast river of electro-magnetic energy in the form of light and heat flowing outward from it in a seemingly never-ending bounty.

The spectral distribution of solar radiation that impacts upon the Earth's surface spans a range of wavelengths between 0.3 micrometres (ultra-violet) to 1.8 micrometres (infra-red), with the visible lightwaves sandwiched in between. When we look at a beautiful rainbow, the range of visible lightwaves is clearly displayed. However, our human eyes can only see one-third of the total spectrum, as we are blind to ultra-violet and infra-red frequencies.

The amount of solar radiation reaching any given point on the Earth's surface depends on the latitude, season and time of day. However, on clear conditions around noon, the approximate energy density is 1000 watts per square metre of horizontal surface. For the production of electricity via the 'photo-voltaic' effect, we utilize the ultra-violet and visible light waves with panels realizing a conversion efficiency of between 10 to 15 percent. In other words, between 100 to 150 watts of electricity can be generated per square metre area.

There are basically three types of photo-voltaic panel currently in production for the conversion of sunlight into electricity: mono-crystal; poly crystal; and thin film. For the past twenty years, it has been the mono and poly-crystal panels that have dominated the power generation market, with the thin films relegated to a minor role in small electronic products such as watches and calculators. Now, however, the tide has turned and it is the thin film panels that are set to take centre stage, due to improvements in efficiency and long term stability that have plagued this form of construction in the past.

The two overwhelming advantages of thin film panels is their low embodied energy and the ease and speed at which they can be produced, which is in a roll-to-roll

process similar to newsprint. Within three years, a thin film panel will repay its original 'energy debt' (the amount of energy embodied in its production), and the operational lifespan of the new 'UNI-SOLAR' modules is in excess of 20 years. Crystal cell solar panels, on the other hand, are far less suited to mass production, as they are made by a tedious, energy-intensive batch process that cancels out the positive environmental aspects of the first seven years of the panel's operation!

Other major advantages of thin film panels are that they can be manufactured without glass, so they are extremely durable and some are flexible; their power output is stable irrespective of temperature variation, and the Uni-solar panels that I have here on display have a parallel cell architecture so they are shadow-tolerant.

So that you can appreciate how photo-voltaic power systems operate and to give you some conception of the scale of things, let's examine a low-cost, mini lighting kit that I have designed for a tent or single room. It consists of an 11 watt, flexible, thin film solar panel, a 12 volt 80 watt-hour heavy duty deep cycle battery, a 10 watt high efficiency quartz halogen lamp and a control unit.

Theoretically, the amount of energy stored in the 80 watt-hour battery could sustain the lamp for 8 hours from a fully-charged state, but the control unit will automatically switch the lamp off after 5 hours to preserve the battery's operational lifespan. In other words, 5 hours x 10 watts = 50 watt-hours has been discharged out of a possible 80 watt-hours, and 30 watt-hours will always remain. The control unit will also switch off the solar panel once charging is complete, to protect the battery from overcharge. The system is designed to supply several hours of lighting at night by accumulating solar energy during the day.

In this particular example, the wattage rating of the solar panel and the lamp are about equal, therefore, every hour of full strength sunlight striking the panel will provide around an hour of lamp operation at night. As well as being functional, this small system is also highly educational, expandable and a quality introduction to solar power systems.

In this presentation, I will demonstrate an 'entry level' state-of-the-art power delivery system running on solar and wind energy.

The system is designed to supply basic refrigeration, lighting, entertainment and communications services to a small residence, with an average daily energy consumption of 2000 watt-hours, and is comprised of the following components: photo-voltaic (solar) panels, mini wind generator, battery bank, sinewave inverter, logic control unit and super-efficient refrigerator/freezer. These components have been carefully matched to provide high performance at an extremely realistic price.

## Photo-voltaic solar panels

The very latest triple junction amorphous (thin film) silicon solar power panels are shadow-tolerant, have a twenty-year warranty and an effective lifespan of over thirty years. Under typical Australian conditions, the 200 watt solar array will deliver an average of 1000 watt-hours of energy daily into the system.

## Mini wind generator

This fine, compact machine has a twenty-year heritage, and with a propeller diameter of only 900 mm is not much bigger than a windvane. It is quiet and unobtrusive and designed for convenient roof mounting. Power output is 90 watts in a twenty-knot wind, with a peak output of 220 watts at forty knots. A daily energy production of 1000 watt-hours is easily achieved in most areas open to the prevailing winds.

## Battery bank

A heavy-duty, 24 volt, 250 ampere-hour (6000 watt-hour) lead-acid battery bank is to store several day's energy in reserve to cater for cloudy, still weather conditions. These batteries are of the type used in electric vehicles and have a life of approximately 1000 charge/discharge cycles, equating to 3 to 5 years.

## Inverter

The inverter transforms the large pool of low voltage direct current (DC) energy stored in the battery bank into 240 volt alternating current (AC) The output waveform is pure sinewave of a quality equal or superior to the utility mains supply. The continuous rating is 500 watts, with a maximum surge rating of 2000 watts, sufficient to operate the fridge, lighting, TV/video/computer equipment, food processor, small washing machine and hand-held power tools, etc.

A larger inverter is available, if required, to operate a microwave oven, electric iron, hair dryer, vacuum cleaner, and a wider range of higher consumption appliances up to 1200 watts continuous rating and 3600 watts surge rating.

## Control unit

The 'Solar Wonderland' energy control and monitoring unit integrates the various system components, maintains the battery condition within strict operational limits and provides essential data to the users. A priority shutdown circuit automatically switches off non-essential appliances in the event of a low battery condition, effectively rendering the system foolproof.

## Refrigerator/Freezer

The super-efficient 'Enviro' refrigerator/freezer has a gross storage capacity of 140 litres and an average daily energy consumption of 1000 watt-hours. This remarkable efficiency is achieved with the latest 'green freeze' compressor and heat exchanger technology based on isopropane refrigerant. It is ideal for a small family or for preserving vital medical supplies.

## Unique advantages

The key features about this whole system which will endear it to a wide range of potential users are its ease of installation, versatility, expandability, negligible maintenance, and very importantly, its amazingly low price, which is currently around A$6000. This is truly a significant price/performance breakthrough, and for many people throughout the third world and rural Australia it heralds a quality of life and amenity often denied them.