

*Self-Sufficient,
Hurricane-Combatable
Living Module*

A TECHNOLOGY TO ADDRESS THE REALITY
OF COASTAL HABITATION IN THE
21ST CENTURY

**Designed
By
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NOTE

The design of the “self sufficient” module could be accomplished because the technologies recommended already exist on the market. Those considered important for the adequate functioning of the module and described herein are:

- 1) Reverse Osmosis (RO) potable water system.**
- 2) Photovoltaic solar panels.**
- 3) Wind turbine.**
- 4) Deep cycling batteries, inverters, and charge controllers.**
- 5) Waste water sewage treatment system.**

The descriptions of the recommended equipment for use in the module were obtained from several public sources and are those given by the vendors of the technologies mentioned. The objective of this report is to present a general in-house guide for the construction of the module and not intended for publication.

SUMMARY

Self-sufficient, Hurricane-Combatale Living Module for Coastal Regions

Materials and Size

The module can be constructed of prefabricated cement walls, floor and roof (Emme Due-M2 Advanced Building design) that can be painted any color. It has five windows and two doors. The dimensions of this model are: 30 feet (10 meters) wide, 30 feet (10 meters) long and 8 feet (2.5 meters) high. The furniture (tables, chairs, bunk beds) is made of wood and is fastened to the structure. Based on the location code, the module can be placed on concrete pilings or treated wood pilings and elevated 7 to 10 feet (2.5-3 meters) above the ground. A 6 foot (2 meters) wide porch will form part of the elevated structure. This size can house two people comfortably. Larger sizes can be constructed.

Approximate Cost: \$ 20,000

Potable Water System

It consists of a small reverse osmosis desalination plant that can treat 260 to 525 gallons (1000 – 2000 liters) of seawater per day.

Approximate Cost: \$5000

Electrical System

This consists of a hybrid system that includes photovoltaic solar panels on the roof of the module and a 1.5 kW wind turbine that can be mounted on a 30 feet (9 meter) tower near the module. It is a stand-alone system that will generate sufficient power to handle a load of 400 – 500 kW hours per month. It is designed to meet the needs of six points of light, a refrigerator, an electric stove with four burners, an air-conditioner and minor kitchen appliances.

Approximate Cost: \$4000

Wastewater/Sewage Treatment System

Aerobic biological sewage treatment systems are available on the market and designed to handle from 50 to 10,000 gallons per day. It is estimated that a system that can treat 50 to 300 gallons per day is adequate for this living module. The system under consideration contains a tough, corrosion resistant coating which makes it ideal for tropical coasts.

Approximate Cost: \$5000

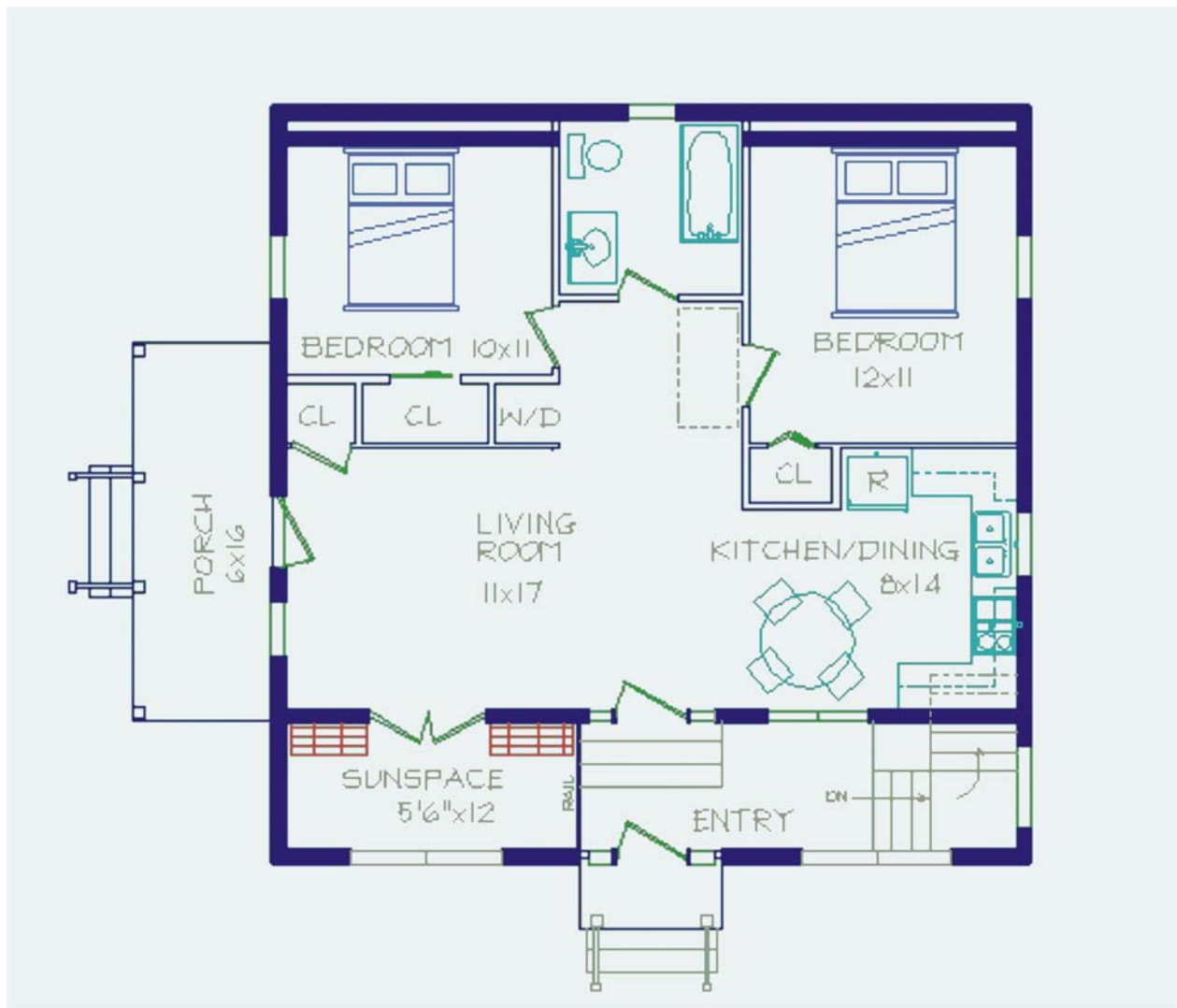
Uses For the Self-Sufficient Module (Total Cost: \$34,000)

This type of living facility can be used in the following situations:

- ◆ In coastal zones far from basic facilities where national park personnel can live for extended periods.
- ◆ On islands or deserted coastal zones where naval or coast guard personnel need to be stationed for extended periods of time.
- ◆ For those who wish to retire in coastal zones away from basic facilities or for those who wish to have a vacation retreat.
- ◆ For fisherman who need temporary living quarters on remote islands or coastal zones during fishing season.

Materials and Size of the Module

The module is hurricane resistant and constructed of prefabricated cement walls, floor and roof (M2 Advanced Building design of Metairie, Louisiana) that can be painted any color. It has five windows and two doors. One of the doors opens to a six foot wide porch. The module itself is 30 feet (10 meters) wide, 30 feet (10 meters) long and 8 feet (2.5 meters) high. The furniture (tables, chairs, bunk beds) is made of wood and is fastened to the structure. It is recommended that the modules near the coast be elevated. Therefore, based on the location code, the module can be placed on concrete pilings or treated wood pilings elevated 7 to 10 feet (2.5-3 meters) above the ground. A 6 foot (2 meters) wide porch, also constructed prefabricated cement will form part of the elevated structure. The unit is divided into the following three areas: 1) a kitchen/dining area, 2) two bedrooms and 3) a bathroom area. The sunspace area can be used for housing the water treatment plant and deep cycling battery bank that provides electricity to the appliances (see the floor plan below).



Potable Water System

Reverse osmosis, seawater desalination is the separation process that will be used to reduce the dissolved salt content of saline water to a usable level. It involves the handling of seawater that is separated into the two output streams: the low-salinity product water and very saline concentrate streams. The product water of the desalination process is generally water with less than 500 mg/1-dissolved solids, which is suitable for most domestic uses. A by-product of desalination is brine, a concentrated salt solution (with more than 35 000 mg/1 dissolved solids) that must be disposed of (after it is diluted with treated effluent) in open space areas or back into the sea where it does no harm. The water requirements for this living module will be in the range of 200 to 450 gallons per day.

Technical Description

There are two types of membrane process used for desalination: reverse osmosis (RO) and electrodialysis (ED). In the RO process, water from a pressurized saline solution is separated from the dissolved salts by flowing through a water-permeable membrane. The permeate, the liquid moving through the membrane, flows by the pressure differential created between the pressurized feed water and the product water, which is at near-atmospheric pressure. The remaining feed water continues through the pressurized side of the reactor as brine. No heating or phase change takes place. The major energy requirement is for the initial pressurization of the seawater from 800 to 1000 psi.

In practice, the feed water is pumped into a closed container, against the membrane, to pressurize it. As the product water passes through the membrane, the concentration of remaining feed water and brine solution increases. To reduce the concentration of dissolved salts remaining, a portion of this concentrated feedwater-brine solution is withdrawn from the container. A reverse osmosis system consists of four major components/processes: (1) pretreatment, (2) pressurization, (3) membrane separation, and (4) post-treatment stabilization. The figure below illustrates the basic components of a reverse osmosis system.

Pretreatment: The incoming seawater is pretreated to be compatible with the membranes by removing suspended solids, adjusting the pH, and adding a threshold inhibitor to control scaling caused by constituents such as calcium sulphate.

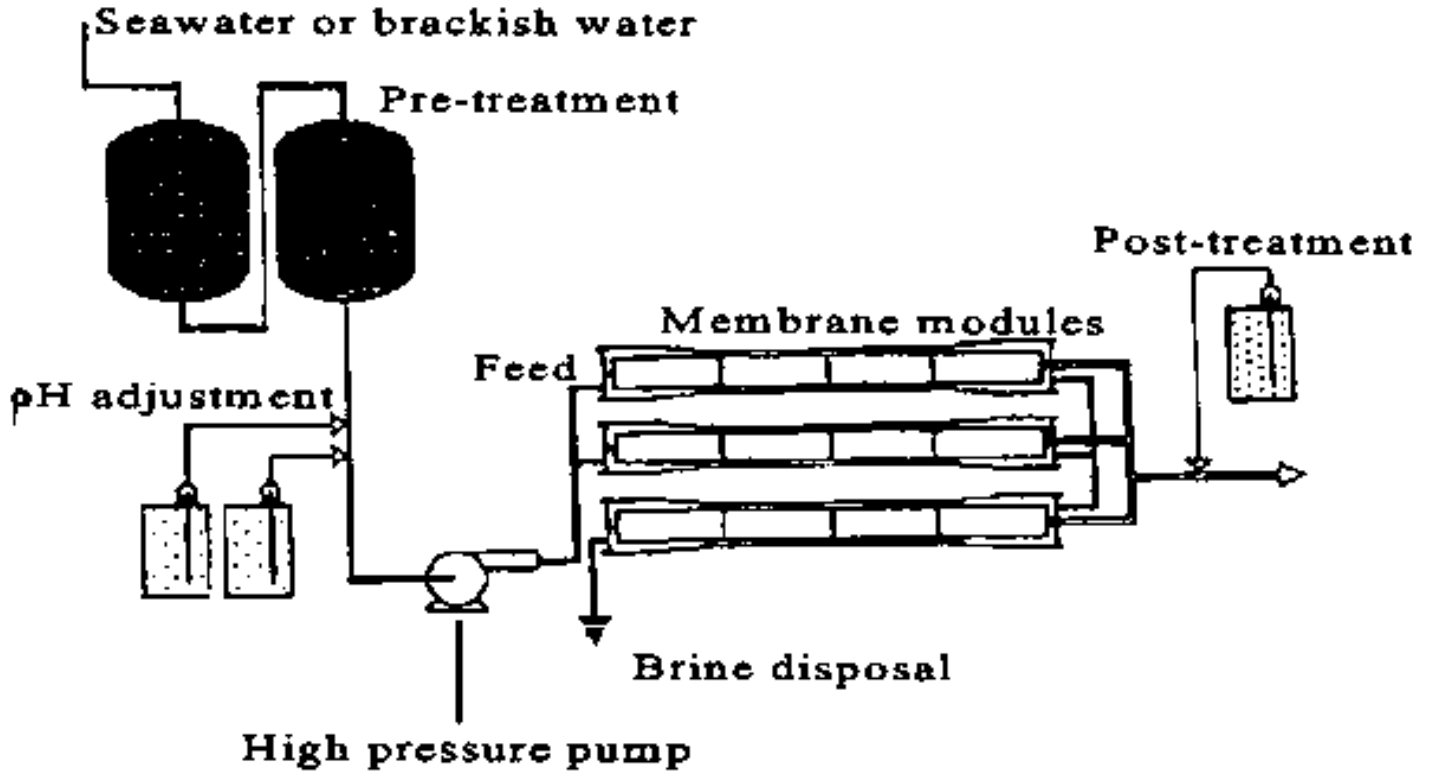
Pressurization: The pump raises the pressure of the pretreated seawater to an operating pressure appropriate for the membrane and the salinity of the seawater.

Separation: The permeable membranes inhibit the passage of dissolved salts while permitting the desalinated product water to pass through. Applying seawater to the membrane assembly results in a freshwater product stream and a concentrated brine reject stream. Because no membrane is perfect in its rejection of dissolved salts, a small percentage of salt passes through the membrane and remains in the product water. Reverse osmosis membranes come in a variety of configurations. Two of the most popular are spiral wound and hollow fine fiber membranes. They are generally made of cellulose acetate, aromatic polyamides, or, nowadays, thin film polymer composites. Both types are used for brackish water and seawater desalination, although the specific membrane and the construction of the pressure vessel vary according to the different operating pressures used for the two types of feed water.

Stabilization: The product water from the membrane assembly usually requires pH adjustment and degasification before being transferred to the distribution system for use as drinking water.

The product passes through an aeration column in which the pH is elevated from a value of approximately 5 to a value close to 7. This water is discharged to a storage cistern for later use.

Elements of the Reverse Osmosis Desalination Process



Operation and Maintenance

Operating experience with reverse osmosis technology has improved over the past 15 years. Assuming that a properly designed and constructed unit is installed, the major operational elements associated with the use of RO technology will be the day-to-day monitoring of the system and a systematic program of preventive maintenance. Preventive maintenance includes instrument calibration; pump adjustment, chemical feed inspection and adjustment, leak detection and repair, and structural repair of the system on a planned schedule.

The main operational concern related to the use of reverse osmosis units is fouling. Fouling is caused when membrane pores are clogged by salts or obstructed by suspended particulates. It limits the amount of water that can be treated before cleaning is required. Membrane fouling can be corrected by backwashing or cleaning (about every 4 months), and by replacement of the cartridge filter elements (about every 8 weeks). The lifetime of a has been reported to be 2 to 3 years, although, in the literature, higher lifespans have been reported.

Costs

The most significant costs associated with reverse osmosis plants, aside from the capital cost, are the costs of electricity, membrane replacement, and labor. All desalination techniques are energy-intensive relative to conventional technologies. The Table below gives the a few parameters for 225 and 450 gallons/day systems.

Model	DROSW-	DROSW-450
Gallon Per Day	225	450
Average Product Quality-ppm	100	100
Recovery-%	35	35
Voltage - VAC	120/240	120/240
Motor- Hp	0.5	1.0
Pre-filter Stages	3	3
Product Flow Meter	Yes	Yes
Drain Flow Meter	Yes	Yes
Re-Circulation	Yes	Yes
Low Pressure Switch	Yes	Yes
High Pressure By-Pass	Yes	Yes
Number of Pressure Gauges	3	3
Length/Width/Height-inches	30/18/24	50/18/24
Shipping Weight-Pounds	60	80
Pump Material	SS	SS
Pump Action	Hydraulic	Hydraulic
Vibration Dampening	Yes	Yes
Tank Pressure Switch	Yes	Yes

Suitability

This technology is suitable for use in tropical regions where seawater or brackish groundwater is readily available.

Advantages

- ◆ The processing system is simple; the only complicating factor is finding or producing a clean supply of feed water to minimize the need for frequent cleaning of the membrane.
- ◆ Systems may be assembled from prepackaged modules to produce a supply of product water ranging from a few liters per day to 750 000 l/day for brackish water, and to 400 000 l/day for seawater; the modular system allows for high mobility, making RO plants ideal for emergency water supply use.
- ◆ Installation costs are low.
- ◆ RO plants have a very high space/production capacity ratio, ranging from 25 000 to 60 000 l/day/m².
- ◆ Low maintenance, nonmetallic materials are used in construction.
- ◆ Energy use to process brackish water ranges from 1 to 3 kWh per 1 000l of product water.
- ◆ RO technologies can make use of use an almost unlimited and reliable water source, the sea.
- ◆ RO technologies can be used to remove organic and inorganic contaminants.
- ◆ Aside from the need to dispose of the brine, RO has a negligible environmental impact.
- ◆ The technology makes minimal use of chemicals.

Disadvantages

- ◆ The membranes are sensitive to abuse.
- ◆ The feed water usually needs to be pretreated to remove particulates (in order to prolong membrane life).
- ◆ There may be interruptions of service during stormy weather (which may increase particulate resuspension and the amount of suspended solids in the feedwater) for plants that use seawater.
- ◆ Operation of a RO plant requires a high quality standard for materials and equipment.
- ◆ There is often a need for foreign assistance to design, construct, and operate plants.
- ◆ An extensive spare parts inventory must be maintained, especially if the plants are of foreign manufacture.
- ◆ Brine must be carefully disposed of to avoid deleterious environmental impacts.
- ◆ There is a risk of bacterial contamination of the membranes; while bacteria are retained in the brine stream, bacterial growth on the membrane itself can introduce tastes and odors into the product water.
- ◆ RO technologies require a reliable energy source.

Electrical System

- **4 Siemens SR-100 solar panels (total 400 watt Photovoltaic)**
- **1 Air 403 wind generator**
- **6 Trojan L-16 batteries (Deep Cycling)**
- **1 Trace SW4024 inverter (110 volt)**
- **1 Trace C-40 charge controller**

Lighting and appliances

- Low voltage or florescent lighting (six points). Outside Solar sensor light
- Small refrigerator
- Four burner electric stove
- Microwave oven
- Small air conditioner

Solar Electric Panels

Photovoltaic (PV) panels, which use sunlight to produce electricity, are very efficient for their purpose. They are also useful in all climates. While the manufacturing process and the mechanism by which they work is more technical than solar thermal, they are much simpler to install and maintain in actual use.

How PV Panels Are Used

Solar electric panels are probably one of the simplest alternative energy sources to use. They can be mounted on a rooftop or a freestanding solar array rack. Once mounted, a wire needs to be run from the solar panel to a solar charge controller, and a wire needs to be run from the charge controller to a deep cycle battery bank. If the building's electrical system runs on DC power, the battery bank can be wired directly into the system.

Multiple solar panels increase the wiring complexity a bit, and of course, the homes will use 120-volt AC power in combination with DC power. AC power system will require the use of an inverter to convert the DC battery power into useable 120VAC power, and other details can be added, expanded and customized from there.

However, the fundamentals of using solar power remain simple. The solar panels turn sunlight into electricity, and that power is stored in a battery bank for household use. The household power needs are drawn out of the stored battery power, and the solar panels recharge the batteries when their charge drops below a certain level

How PV Panels Work

Solar electric panels are composed mainly of silicon. Silicon is used because it naturally releases electrons (electrical energy) when hit with a photon (light source). Most solar panels consist of a clear protective top layer, two layers of specially treated silicon with collecting circuitry attached to the top layer, and a tough polymer backing layer. From there, the panel can be framed (adds durability) or unframed (reduces weight), and in some cases the layers are even comprised of flexible materials. The vast majority of PV panels work in the same way:

The top layer of silicon is treated to give it an electrically negative character. The back layer is treated to make it electrically positive. Due to these treatments and added elements, the top layer is rich in electrons, and the back layer is relatively electron poor. These two layers are separated by an electrically charged junction, which allows electrons to flow from back to front, but not the other way around. When light strikes the PV panel, the silicon layers absorb some of the photons. The photons cause electrons to be released from the silicon crystal, and those electrons "wander around" looking for somewhere to attach themselves. Some of the electrons are freed from the bottom layer, and they find their way through the junction into the top (electron rich) layer. Some of the electrons are freed from the top layer, and since they cannot travel to the bottom (electron poor) layer, and are being "crowded" by new electrons from the bottom layer, they are left free to be collected by electrical contacts on the surface of the top layer.

Those collected electrons are routed through an external circuit, providing power to the electrical system attached to the panels. The circuit is completed when the electrons return to the bottom layer of the PV panel, find "resting spots" in the electron poor bottom layer, and wait for the next photon to shake them loose.

There are no moving parts in the PV panel, so maintenance is limited to keeping the junction boxes and wiring free from moisture and corrosion, and keeping the surface of the panel clean enough to allow light through to the silicon layers.

Wind Turbine

The new 403 AIR that will be installed has become the best selling wind turbine in the world. Still priced about the same as a photovoltaic module, an AIR is capable of producing more than seven times the energy. Maintenance-free performance, easy installation, and high output make it ideal for virtually any remote battery charging application.

- It is designed for use in combination with photovoltaic modules to balance system energy output during times of seasonal fluctuations. If there is no room for a tower, the AIR's compact design makes it ideal for rooftop mounting if necessary.

Features:

- ◆ **Simple rooftop installation; no tower necessary**
- ◆ **Variable pitch Aerolastic carbon matrix blades**
- ◆ **Aircraft quality aluminum alloy castings**
- ◆ **Exclusive Brush-less neodymium cubic curve alternator**
- ◆ **Sophisticated internal battery charge regulator**
- ◆ **Safety protection electronics controls voltage and rotor RPM**
- ◆ **Maintenance-free - Only two moving parts**
- ◆ **Exclusive Auto-brake-feature that slows the *AIR* to a silent spin when the batteries are charged thus extending bearing life and reducing noise.**

Specifications

Rotor Diameter:	46" (1.14 meters)
Weight:	13 lbs (6 kg)
Start up wind speed:	7 mph (3 m/s)
Voltage:	12, 24 and 48 volts (Inquire for others.)
Output:	400 watts at 28 mph (12.5 m/s)

Features

BLADES: The *AIR's* blades are made of a carbon fiber reinforced composite that twists as the turbine reaches its rated output. This twisting effect changes the shape of the blade, causing it to stall, limiting the RPM of the alternator protecting the *AIR* from damage in high winds.

ALTERNATOR: The *AIR's* brush-less alternator is optimized to match as close as possible to the cubic energy in the wind. It is constructed with Neodymium Iron Boron permanent magnets for superior performance and maintenance-free operation.

Battery Type Needed for Solar Panel/Wind Turbine Use

Deep-cycle solar batteries such as the Trojan L-16H are the most common choice for remote power systems. Originally designed for industrial floor sweepers, but very well suited to remote power use. This is a 6-volt battery with a 5-6 year life expectancy. **Advantages:** good service life, fairly resistant to occasional abuse, reasonable cost. **Disadvantages:** not as resistant to abuse as industrial cells.

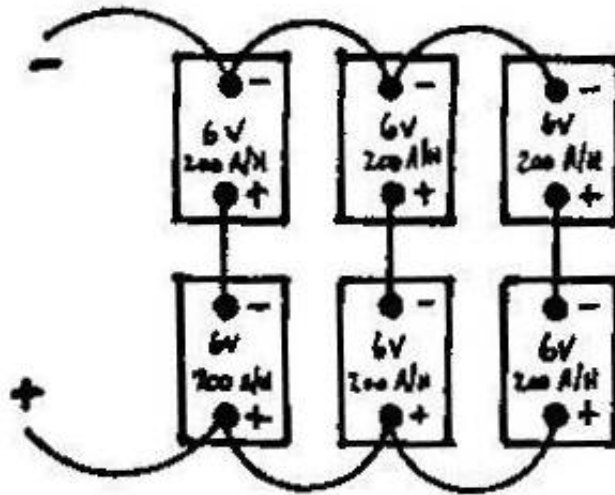
Deep cycle batteries like the Trojan L-16 are designed to be discharged down as much as 80% time after time, and have much thicker plates. **The major difference between a true deep cycle battery and others is that the plates are SOLID Lead plates - not sponge.** The popular golf cart battery is generally a "semi" deep cycle - better than any starting battery, **better than most marine, but not as good as a true deep cycle solid Lead plate, such as the L-16 or industrial type.** However, because the golf cart (T-105, US-2200, GC-4 etc) batteries are so common, they are usually quite economical for small to medium systems, but these types of batteries are not recommended for this system.

Many **Marine** batteries are usually actually a "hybrid", and fall between the starting and deep-cycle batteries, while a few (Rolls-Surrette, Concorde, Trojan L-16) are true deep cycle. In the hybrid, the plates may be composed of Lead sponge, but it is coarser and heavier than that used in starting batteries. It is often hard to tell what you are getting in a "marine" battery, but most are a hybrid. "Hybrid" types should not be discharged more than 50%. Starting batteries are usually rated at "CCA", or cold cranking amps, or "MCA", Marine cranking amps - the same as "CA". Any battery with the capacity shown in CA or MCA may not be a true deep-cycle battery. It is sometimes hard to tell, as the terms marine and deep cycle are sometimes overused. CA and MCA ratings are at 32 degrees F, while CCA is at zero degree F.

Plate Thickness

Plate thickness (of the Positive plate) matters because of a factor called "**positive grid corrosion**". This ranks among the top 3 reasons for battery failure. The positive (+) plate is what gets eaten away gradually over time, so eventually there is nothing left - it all falls to the bottom as sediment. Thicker plates are directly related to longer life, so other things being equal, the battery with the thickest plates will last the longest. Automotive batteries typically have plates about .040" (40/1000") thick, **while forklift batteries may have plates more than 1/4" (.265" for example in the Rolls-Surrette) thick - almost 7 times as thick as auto batteries. The typical golf cart will have plates that are around .07 to .11" thick. The Concorde AGM's are .115", The Rolls-Surrette L-16 type (CH460) is .150", and the US Battery and Trojan L-16 types are .090".** Most industrial deep-cycle batteries use Lead-Antimony plates rather than the Lead-Calcium used in AGM or gelled deep-cycle batteries. The Antimony increases plate life and strength, but increases gassing and water loss. This is why most industrial batteries have to be checked often for water level if you do not have Hydrocaps.

**Typical remote power battery bank using 6-volt batteries
(series+parallel)**



= 12 VOLTS, 600 AMP/HOURS

Battery Bank Wire Sizing

Batteries can put out a huge amount of power in a short time. It is important to use big enough wire for your series and parallel connections between the battery terminals (the interconnect wires) and to the inverter. For BATTERY INTERCONNECT wires, use #4 gauge if you have a 500-watt or smaller inverter. Use #2 gauge for an 800-watt inverter, and go with #2/0 for larger inverters. If you can afford using #2/0 welding cable, they are highly recommend for battery interconnects no matter what size inverter you have since it is so flexible. Keep in mind that welding cable may not meet NEC code, even though it is clearly the best and safest choice (because of welding cables' flexibility, it puts little strain on the connection points) for battery and inverter wiring.

Buss Bars

It often saves a lot of trouble later to install + and - buss bars directly off of your battery bank, connected with wire thicker than what you need for your inverter. These buss bars give you extra room to hook up new windmills, solar panels, meters, loads, etc. Use rectangles of at least 1/4" thick copper, drilled with extra holes. It's easy to tap threads into copper, too--this will speed your hookup time (no nuts necessary on the back side of the buss bar). If you have an amp/hour meter, it's shunt should go between the - (negative) buss bar and the battery bank so that all power collected and used is measured.

Battery Bank Care

Most battery banks need maintenance only 4 times a year or so. But after the system is first installed, check the batteries every month for a while just to make sure. If the electrolyte level gets below the plates, the batteries WILL be damaged. A good reminder is to do this by performing maintenance on the solstices and equinoxes--quite appropriate for a solar energy system!

4 times a year you should **turn off the main power switch** and:

- Check the electrolyte level. Do this when the batteries are not discharged, and wait a couple hours after charging for the hydrogen bubbles to disperse. The batteries should have full and low marks--sometimes the full mark is an inner plastic "shelf" with a hole in it to see the electrolyte level.
 - Wear safety goggles and rubber gloves
 - Fill **ONLY** with distilled water to the "full" mark
 - **DO NOT** add acid!
- Clean the battery tops with rags dipped in a baking soda and water solution. **DO NOT** let this cleaning solution get into the batteries--be careful of the vent holes in the caps on each cell, as cleaning solution can enter the battery here.
- Check for corrosion on all the battery terminals
 - If any terminals are encrusted in green "stuff" you should
 - Make **SURE** your main power switch is off. If you don't have a main switch, turn off the inverter, all load circuits, and all charging circuits.
 - Carefully disconnect wires from the dirty terminal and clean off the gunk with a wire brush. Don't breath in the dust! Wear a mask if necessary
 - Apply anti-corrosion paste to the terminal (available at any hardware store in the electrical department)
 - Reconnect the wires

Battery Safety

Batteries demand lots of caution when you work around them or move them. They are very heavy, store enough energy to start a fire, are full of dangerous sulfuric acid, and emit explosive hydrogen gas. Fun stuff, eh? Here are some safety tips for working with your batteries. Note: These safety precautions are for standard lead-acid batteries, since nickel-cadmium batteries use a base--potassium hydroxide--instead of sulfuric acid for an electrolyte. Follow the manufacturers instructions instead of these with your NiCad batteries.

- Install your batteries in a vented battery box, they emit hydrogen gas when charging
- Never install electrical equipment in the same compartment as batteries due to explosive hydrogen gas
- No smoking around batteries for the same reason
- Wrap wrench handles in electrical tape to avoid shorting between battery terminals. A 6-volt golf cart battery can turn a wrench red hot in seconds
- Wear goggles and rubber gloves to protect yourself from sulfuric acid when moving or working on batteries
- Keep a box of baking soda and a jug of water around to neutralize any spilled battery acid
- **If you get acid on your skin, flush with lots of water**
- **In case of acid in your eyes, flush with water for 15 minutes and call a doctor**

Inverters

Inverters change Direct Current (DC) to Alternating Current (AC). The stand-alone inverter, the one for this system, is used to convert DC from a battery to AC to run electronic equipment, motors, appliances, etc. However, Intertie Inverters are used to convert the DC output of a photovoltaic module, a wind generator or a fuel cell to AC power to be sold to the utility grid. This option is not contemplated here. Multifunction inverters perform both functions.

Stand-Alone inverters convert DC power stored in batteries to AC power that can be used as needed. Selection of the inverter for our power system is based on the maximum load that will be powered, the maximum surge required, output voltage required, input battery voltage and optional features needed. High quality stand-alone inverters are available in sizes from 100 watts, for powering notebook computers and fax machines from your car, to 8000 watts, for powering an entire house or small commercial operation. The size of an inverter is measured by its maximum continuous output in watts. This rating must be larger than the total wattage of all of the AC loads you plan to run at one time. The size of the inverter can be minimized if the number and size of the AC loads is kept under control. Wattage of most AC loads can be determined from a tag or label on the appliance, usually located near where the power cord enters, or from the owner's manual. If the inverter is expected to run induction motors, like the ones found in automatic washers, dryers, dishwashers and large power tools, it must be designed to surge, or deliver power many times its rating for short periods of time while these motors start.

Stand-alone inverters are available with three basic power output waveforms: square wave, modified square wave (sometimes called modified sine wave) and pure sine wave. Synchronous Inverters and Utility companies deliver a pure sine wave.

Output Voltage

Inverters should supply standard 120 Volt 60 HZ AC power, such as one gets from utility companies and fuel-powered generators. Most of them can be special ordered with other output voltages and frequencies for use anywhere in the world.

Interference

The electronic circuitry in inverters may, in some cases, cause problems with radio and television reception, noise on telephones and buzz in audio equipment. Sine wave inverters cause the least amount of interference. Locating the inverter very close to the batteries, twisting together cables that connect the inverter to the battery and locating the inverter away from appliances that are susceptible to interference can minimize interference. Inverters cause interference on AM radio.

Inverter Cable Sizing Chart

Inverter Continuous Watts	Voltage	Fuse Size in Amps	Minimum Wire Size
150	12	20	#4
250	12	40	#2
250	24	20	#4
500	12	100	#2
500	24	40	#2
800	12	110	#2
800	24	60	#2
1000	12	150	#2/0
1000	24	100	#2
1500	12	200	#2/0
1500	24	100	#2/0
2500	12	400	#4/0
2500	24	200	#2/0

Charge Controller

The charge controller that is required is a regulator that goes between the solar panels and the batteries. Regulators for solar systems are designed to keep the batteries charged at peak without overcharging. Meters for Amps (from the panels) and battery Volts are optional with most types. Some of the various brands and models that can be used are listed below.

Most of the modern controllers have automatic or manual equalization built in, and many have a LOAD output. There is no "best" controller for all applications - some systems may need the bells and whistles of the more expensive controls, others may not.

There are several charge controllers but the Trace C40 is recommended for this system based on the application, system size, and voltage. Others are:

Trace C12, C35, C40, C60
Morningstar Prostar and SunSaver (All)
Pulse
RV Power Products (Solar Boost)
Lyncom

Any of the above will almost always give better battery life and charge than "on-off" or simple shunt type regulators.

A) WASTEWATER/SEWAGE TREATMENT (Headhunter's Design)

There are several wastewater treatment systems on the market. However, for this module the one considered the most practical is Headhunter's Tidal Wave 50B treatment system (TW-50B). It is an aerobic biological sewage treatment system that has been certified by the U.S. Coast Guard as a Type II Marine Sanitation Device (MSD), and is IMO Approved for worldwide compliance. Some of the advantages of Headhunter's TW-50B system are that it is a reliable biological treatment process, it is easy to operate, it is compact, is virtually maintenance free, uses no harsh chemicals, and there are no moving parts in contact with the sewage. Systems coated with tough corrosion resistant material for handling 50-300 gallons per day are ideal for the Tropical Self Sufficient Living Module.

B) WASTEWATER/SEWAGE TREATMENT (Dr. Ralph Portier Design)

Advanced BioSystems "Boss" wastewater treatment system is considered to be the most practical. It is an aerobic biological sewage treatment system that has a reliable biological treatment process, it is easy to operate, it is compact, is virtually maintenance free, uses no harsh chemicals, and there are no moving parts in contact with the sewage. The systems are coated with a tough corrosion resistant material for handling 50-300 gallons per day are ideal for the Tropical Self Sufficient Living Module. The "BOSS" IMBR System presently being tested at Alt. On-Site Septic Technology Center at Otis AFB, a 100% funded EPA test facility owned by Mass. Health Department. Nationwide EPA permit is pending. The system is designed for application as On-Site Wastewater Treatment Plant for

residential or small commercial applications where treatment facilities are not available. Standard design is for 440 gallons per day. System is scalable. System has no pumps and uses one 10v. aerator. Meets 10 – 10 – 10 standard for on-site treatment of domestic waste with no organic waste build-up, clogging or short-circuiting. System is very stable and highly resistant to toxic chemical shock. System can also be added on to improve performance of existing septic systems.

