Off Shore & Off Grid

Island Life Unplugged

John McNicholas

Keewaydin Island is located in the Gulf of Mexico, just off the coast of southwest Florida. It is the longest unbridged barrier island left in the state, with pristine beaches that stretch for almost 8 miles (13 km). There are no full-time residents, no roads, no utilities, and access is by boat only. It is home to abundant wildlife, a shell-encrusted beach, the sound of the surf, and beautiful sunsets. Against this breathtaking natural backdrop, fifteen homes dot the landscape, ranging from extremely rustic cottages to lap-of-luxury, estate-style getaways. What they all have in common is their reliance on off-grid electrical systems.

Living off the grid, with style—Monica and Jack McVicker mix environmentally friendly energy sources with luxury living at their island getaway.

It is here that Monica and Jack McVicker decided to build their dream beach house. They wanted a retreat from their mainland home, a place for their kids to roam and experience nature. They wanted to build in style, with a tennis court on the beach. Of course, central air conditioning is required to cool down after a match, and a hot tub on the roof eases those sore muscles. Kitchen amenities include a Viking propane range, KitchenAid refrigerator, dishwasher, garbage disposal, and microwave. And to kick back on a Sunday afternoon with a football game, a satellite TV system was installed.

"When we first saw Keewaydin Island, we knew it was for us," said Monica and Jack. "The idea of building a self-supporting island getaway within 20 minutes of our home was an opportunity we just couldn't believe existed. Our goal was to create a natural playground for our kids and friends, and to take advantage of the unique concepts in building a 'green' house, but with creature comforts. Thanks to the great team that put it all together, we couldn't be happier with the outcome!"

I was brought in during the design phase by Barnett Design Studio. Marie Barnett has a Bachelor of Architecture degree with special emphasis on environmental design. Since moving to Florida in 1989, she has specialized in the design of unique, custom homes. Marie has designed other houses on the island, and is adept at blending the owner's vision with the special requirements of off-grid homes.

Seaside solar electricity—twelve RWE Schott 300-watt photovoltaic modules provide most of the electricity for a full-function home in this private paradise.

Marie says, "I feel that Keewaydin Island is unique and special. All of the homes that I design must work integrally with the site elements. The design of a Keewaydin Island home is very different from a house in town. The energy systems, water collection, and access to the site all become essential design elements from the initial design phase. A house that is built on the mainland would typically integrate these elements later in the design process. The self-sustaining nature of these island homes ensures that they do not interfere with the beauty and environment of Keewaydin Island. The construction of the McVicker home demonstrates that you can build a house with renewable energy systems and still have comfort!"

Continental Construction was chosen to be the general contractor and builder for the project. They were involved in construction on the north end of the island, and were already equipped with the barge necessary to move all the materials to the site. John Cecil, project manager, was excited about the challenge. "Barrier island construction is demanding and requires a lot of forethought. With the McVicker home nearly a 12-mile (19 km) round trip, you can't just run back to the marina because a subcontractor was late or you forgot the bug spray. Working with Jack and Monica on an almost daily basis during construction proved essential. With the addition to an already well-thought-out design of

Elevated to second-story level, the McVickers' house is designed to catch cool ocean breezes. Deep roof overhangs shade the windows and help their home keep cool.

things like the widow's walk on the roof, the McVickers' retreat is one of the signature homes on the island."

Technical Design

For my role, designing a photovoltaic system to power a 2,200-square-foot (204 m^2) house that has a hot tub, central air conditioning, and a boat lift was interesting indeed. In designing a system for a setting such as this, I have found that you must consider it likely that the guests will somehow find a way to use every electrical appliance at once. Forget the idea of house rules governing which appliances can be used simultaneously!

So you must provide support for maximum power draws. The catch is to make all this work within an acceptable budget. Jack understood the limitations of inverter-based systems, and was open to intelligent trade-offs in search of a balance between cost and function.

This three-bedroom, three-bath home is powered by two Xantrex 4,000-watt, 24-volt, sine wave inverters (SW4024s) serial stacked together, and a third SW4024 connected to a pair of OutBack FX2024 inverters with the new OutBack MIG2 product (see sidebar on page 18). RWE Schott (formerly ASE) 300-watt photovoltaic panels charge the batteries through Trace C40 controllers and a GFPI for ground fault protection. Two OutBack PSPV combiner boxes are mounted in a panel in the lookout landing.

All the comforts of town at a private oceanfront retreat—quiet luxury made possible by solar electricity.

To provide enough storage capacity, four HuP Solar-One, 1,270 amp-hour batteries were installed, wired in series and parallel to provide close to 50 KWH of storage at 24 VDC, at 80 percent depth of discharge (DOD), the extreme. We chose a large, propane-fueled Onan 20 KW generator for battery charging and backup purposes. This provided us with the extra capacity to handle large loads, such as supporting the central air conditioning unit plus the two inverters in charger mode at the same time.

To free the inverters from the start-up surge required by the 240-volt, 10,000-pound rated, boat-lift motors, we connected the lift to the generator and installed a remote starting switch

with a timer at the dock. The hot tub has a 6 KW heater in it, which would have used the capacity of one set of inverters, so it too was connected to the generator. When the heater is called for, the generator is automatically started. To maintain the automatic water filter cycling, we designed that portion of the tub to run from the inverters.

Because the humidity on the island is brutal during the summer months, the owners had a design requirement for air conditioning capability, even when the house is unoccupied. The thermostat circuit is powered from the inverters. We tag off the thermostat's 24-volt AC output, which controls the compressor, to a contactor that remotely starts the generator. We found an efficient Trane central air conditioning unit with a two-speed compressor that starts up on slow speed. A hard-start kit was added (basically just a capacitor).

With this arrangement, we can even run the unit directly on one set of the inverters! Since the house is not regularly used during the summer months, this gave us the opportunity to dedicate the two inverters to the air conditioning unit, reducing expensive run time on the generator. A Square D, four-pole switch was installed to allow the McVickers to choose either means of support. With some testing and tweaking, a balance has been found between the humidity level in the house and the minimal use of the generator, with the 3,600 rated watts of photovoltaic panels supplying most of the energy.

McVicker House Loads*

Description	Watts	Daily Run Hours	KWH
Refrigerator	180	10.0	1.80
Living room loads	1,440	3.0	4.32
Master bedroom loads	1,320	2.0	2.64
Kitchen lighting	600	4.0	2.40
Bedroom #2 loads	400	2.0	0.80
Breezeway lighting	750	1.0	0.75
Living room receptacles	360	2.0	0.72
Bedroom #3 loads	400	1.0	0.40
Bedroom #4 loads	400	1.0	0.40
Garbage disposal	600	0.5	0.30
Gas range	300	1.0	0.30
Master bath	300	0.5	0.15
Guest bath #2	300	0.5	0.15
Exterior lights	600	3.0	1.80
Gas dryer	780	1.0	0.78
Clothes washer	1,440	0.5	0.72
Pressure water pump #1	1,200	0.5	0.60
Pressure water pump #2	1,200	0.5	0.60
Hot tub filtering	240	2.0	0.48
Microwave	1,320	0.3	0.40
Dishwasher	780	0.5	0.39
Kitchen receptacles, east	1,500	0.2	0.30
Kitchen receptacles, west	1,500	0.2	0.30
AC controls #1	120	1.0	0.12
AC controls #2	120	1.0	0.12
Laundry room	240	0.5	0.12
Generator shed lighting	240	0.1	0.02
Solar room loads	240	0.1	0.02
		Total Daily KWH	21.90

*Worst-case scenario loads

A modern kitchen requires a modern power source—solar.

Construction & Installation Details

The installation of the panels was my most challenging to date. A wooden platform was built across the forks of a forklift, which then raised us and the materials to the roof, more than three stories up. The roof is standing-seam metal, which at a roughly 30-degree pitch is exceedingly slippery, highly reflective, and just plain hot to work on. Structural aluminum angle rails 1/4-inch (6 mm) thick were used with 1/2-inch (13 mm) diameter stainless steel lag bolts into the rafters. We had our welder make a jig frame with the precise mounting holes drilled for the panels, to assist us with rail placement. Since the panels would be visible close-up from the hot tub deck, the owner requested that the long wiring runs be hidden. They were placed in conduit under the roof sheathing before the roof was closed up, making a very clean look.

The main water supply is rainwater, collected from the roof into two, 5,000-gallon (19,000 l) capacity aboveground cisterns equipped with roof washer diversion valves. Household pressure is supplied by 3/4 hp 120-volt pumps. The water flows through a carbon canister filter and then a UV filter. A shallow well was dug as a backup. A standard, propane, 40-gallon (150 l) water heater supplies hot water for domestic use.

Construction of the house took one year, since the remote location and transportation time slows progress on the island. Mother Nature always has her say too. We had to contend with some wild boars on this project, who appeared to take our presence personally. A charging boar with sharp tusks is not a pretty sight! Also, since Keewaydin Island is a barrier beach, it is a refuge for loggerhead sea turtle nesting. Special consideration had to be given to the timing and usage of large equipment. With concern for keeping any nature disturbance to a minimum, special exterior lights were chosen and approved by the Florida Department of Environmental Protection to avoid drawing hatchlings toward the house.

Off-Grid Luxury

Jack enjoys showing guests his renewable energy system. They are usually amazed that such a home can be powered in this fashion. Their interest is heightened when he mentions that the family moved to the beach house temporarily after Hurricane Charley interrupted utility service on the mainland, living there comfortably until the grid was restored after four days.

Although intended to be a weekend getaway, the more intense use of the house as a possible backup dwelling during hurricane season has made the design goal of keeping generator run time to a minimum all the more important. To deliver propane, a 2,500-gallon (9,500 l) propane truck is loaded onto a barge for topping off the

Tech Specs

System Overview

System type: Off-grid battery-based PV system

Location: Keewaydin Island, Florida

Solar resource: 5.5 average daily peak sun hours

Production: 400 AC KWH average per month

Photovoltaics

Modules: 12 RWE Schott, ASE 300-DGF/17, 300 W STC, 17.0 Vmp, 12 VDC nominal

Array: Six, two-module series strings, 3,600 W STC total, 34 Vmp, 24 VDC nominal

Array combiner box: Two OutBack PSPV, 30 A breakers

Array disconnects: 60 A breakers in DC250 and PSDC-175 enclosures

Array installation: Custom aluminum rails, SSW orientation, 30-degree tilt

Energy Storage

Batteries: Four HuP Solar-One, SO-6-85-25, 12 VDC nominal, 1,270 AH at 20-hour rate, flooded lead-acid

Battery pack: 24 VDC nominal, 2,540 AH total, 48.8 KWH total at 80% DOD

Battery/inverter disconnects: Xantrex DC250, two 250 A breakers; OutBack PSDC-175, two 175 A breakers and one 250 A breaker

Balance of System

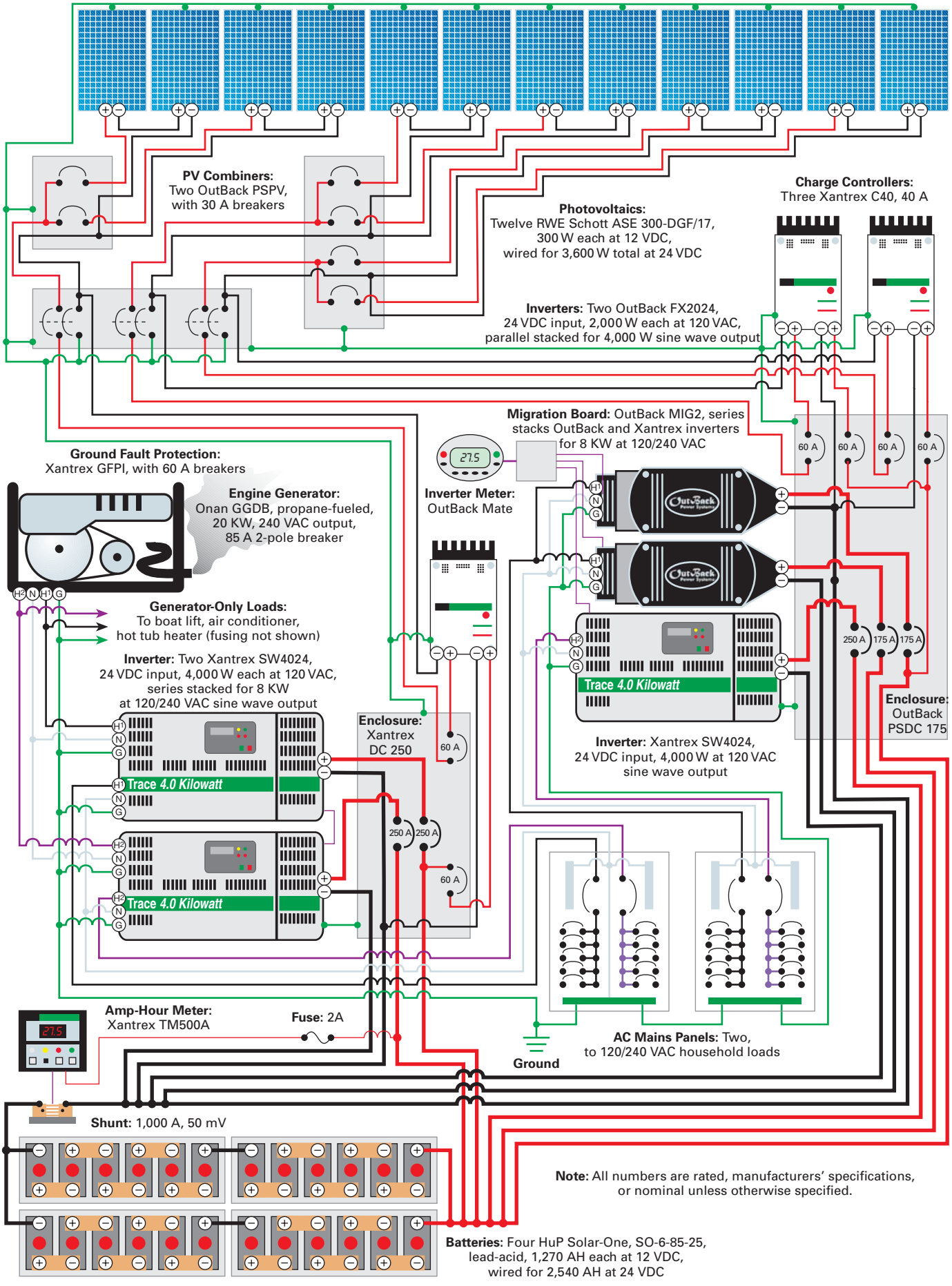
Charge controllers: Three Xantrex C40s, 40 A, PWM

Inverters: Two Xantrex SW4024, 4,000 W each, 8,000 W total, 24 VDC nominal input, series stacked for 120/240 VAC output; one Trace SW4024, 4,000 W, 24 VDC nominal input, and two OutBack FX2024, 2,000 W each, 8,000 W total, 24 VDC nominal input, series stacked for 120/240 VAC output

Engine generator: Onan GGDB 20 KW water-cooled, propane-fired, remote electric start, 240 VAC output; average yearly run time is 200 to 300 hours

System performance metering: Xantrex TM500A AH Meter, OutBack MATE, PC with RightHand Engineering software

Left: Four large, industrial quality, deep-cycle batteries provide energy storage for the island home.


PV Combiners:
Two OutBack PSPV,
with 30 A breakers
Photovoltaics:
Twelve RWE Schott ASE 300-DGF/17,
300 W each at 12 VDC,
wired for 3,600 W total at 24 VDC
Charge Controllers:
Three Xantrex C40, 40 A
Inverters: Two OutBack FX2024,
24 VDC input, 2,000 W each at 120 VAC,
parallel stacked for 4,000 W sine wave output
Migration Board: OutBack MIG2, series
stacks OutBack and Xantrex inverters
for 8 KW at 120/240 VAC
Ground Fault Protection:
Xantrex GFPI, with 60 A breakers
Engine Generator:
Onan GGDB, propane-fueled,
20 KW, 240 VAC output,
85 A 2-pole breaker
Inverter Meter:
OutBack Mate
Generator-Only Loads:
To boat lift, air conditioner,
hot tub heater (fusing not shown)
Inverter: Two Xantrex SW4024,
24 VDC input, 4,000 W each at 120 VAC,
series stacked for 8 KW
at 120/240 VAC sine wave output
Trace 4.0 Kilowatt
Enclosure:
Xantrex
DC 250
Inverter: Xantrex SW4024,
24 VDC input, 4,000 W at 120 VAC
sine wave output
Enclosure:
OutBack
PSDC 175
60 A
250 A
175 A
Amp-Hour Meter:
Xantrex TM500A
Fuse: 2A
Ground
AC Mains Panels: Two,
to 120/240 VAC household loads
Shunt: 1,000 A, 50 mV
Note: All numbers are rated, manufacturers' specifications,
or nominal unless otherwise specified.
Batteries: Four HuP Solar-One, SO-6-85-25,
lead-acid, 1,270 AH each at 12 VDC,
wired for 2,540 AH at 24 VDC

Inverter Migration Board

As a solar energy contractor in coastal Florida, I have installed and maintain more than 50 Xantrex SW-series inverters. The houses that these systems power are directly on the beach, and the extreme salt conditions constantly play havoc with electrical equipment. If the salt weren't enough, lizards, spiders, and all kinds of miniature creatures like to make inverters their homes. Wanting a permanent solution to this issue is what first brought the new OutBack Power Systems line of sealed inverters to my attention.

Most of my installations use the Xantrex serial-stacking feature, which synchronizes the output of two separate inverters to supply 120/240-volt output. The OutBack product line also provides this capability, but of course only when using two (or more) of their inverters. In October 2003, after eleven months of operation, one of the McVickers' inverters failed, leaving the system with one inverter stranded. This was a used inverter that was about three years old, and out of warranty.

OutBack to the Rescue

I called OutBack and spoke with the tech honchos about my dilemma. I wanted to use a pair of their inverters to replace one Xantrex inverter, but keep the second functioning Xantrex inverter and stack the three of them together. What we needed was a migration path to allow OutBack and Xantrex inverters to work together properly in a stacking configuration.

OutBack liked the concept and the technical challenge. A few weeks later, engineer Bob Gudgel called me and said he had the first "migration board" up and running! How soon could I install one for testing?

I planned to replace the failed inverter with two OutBack FX2024, 2,000-watt, sealed units. The parallel output from them would then be synchronized with the remaining 4 KW unit by using the new migration board, which is a modified OutBack Stack-4 communications manager. Monitoring was provided by OutBack's Mate product. The installation was a breeze. OutBack inverters are roughly 60 pounds (27 kg) each, so they are manageable by one person. The inverters connect to the migration board with supplied CAT5 cabling. I installed the board in a sealed Carlon J-box to protect it.

Phase Loss Management

The one caveat is that the board doesn't protect against the loss of phase. If either the OutBack or Xantrex stacked inverters shut down, the other will stay running, providing only 120 volts. The OutBack folks had a simple answer to prevent this issue from affecting equipment. They pointed me to a phase-loss protector device, model CV240AFN, which you can buy for US$85 from Automatic Timing and Controls. Plug the 240-volt device into it, and the moment it detects a phase loss, it shuts off the electricity to the equipment.

Happy Camper

So how does it work? It has worked very well so far, after fourteen months of operation. Equipment that requires 240 volts seems quite happy. OutBack has dubbed the migration board the "MIG2" and added it to their product line at a retail price of US$139.

This was my first installation of OutBack inverters. It has been a very positive experience working with the OutBack staff and their products. The systems are very well thought out, with many features already built in that make my life easier. And with the new MIG2, you can begin to enjoy the benefits of the OutBack inverters, while preserving the investment in currently functioning equipment.

Author and system installer John McNicholas with the first stacked Xantrex/OutBack inverter system made possible by the MIG2 migration board.

McVicker System Costs

Item	Cost (US$)
12 RWE Schott ASE 300-DGF/17 PV panels	$18,000
Onan 20 KW propane generator	12,000
3 Xantrex SW4024 inverters with conduit boxes	11,500
4 HuP Solar-One S0-6-85-25 batteries	11,500
2 OutBack FX2024 inverters	3,600
Module mounts, custom	1,000
OutBack PSDC-175 enclosure with 175 A & 250 A breakers	650
3 Xantrex C40 charge controllers	477
Xantrex DC250 enclosure with 250 A breakers	450
2 OutBack PSPV combiner boxes w/ breakers	400
Xantrex PVGFP-3 ground fault interruptors	375
OutBack Mate	300
TriMetric meter	200
OutBack MIG2 migration board	139
Total	$60,591

two, 1,000-gallon (3,800 l) tanks prior to the weather season. It is an expensive proposition to say the least. So the initial capital expenditure for twelve, 300-watt solar-electric panels and a large battery bank has been well worth it.

The McVickers' tennis court has played host to local charity matches, as well as entertaining island neighbors. To provide some shade, a chickee hut (a thatched hut covered in palm fronds, native to south Florida) was built courtside, and outfitted with lights, a ceiling fan, an outdoor shower, and a water fountain. A solar-charged electric golf cart is used to shuttle the competitors out to the beach to cool off.

The house is used regularly on the weekends when the children are out of school. Leaving the cares of the world behind them as the family steps off the dock, a white shell path extends from the Intracoastal Waterway, beckoning them to the house and all it has to offer. Knowing that the sun is providing the electricity makes it all the more enjoyable.

Access

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Mark Colwell, Colwell Electric Inc., 340 Columbus Way, Marco Island, FL 34145 • Phone/Fax: 239-642-0458 • Electrician

Scott Williams, SPS Energy Solutions, 340 El Pueblo Ste. F, Santa Cruz, CA 95066 • 800-635-7497 or 831-440-9313 • Fax: 831-440-9345 • swilliams@spsenergy.com • www.spsenergy.com • Equipment supplier

RWE Schott Solar Inc., 4051 Alvis Ct. Ste. 1, Rocklin, CA 95677 • 888-457-6527 or 916-625-9033 • Fax: 916-625-9032 • rsssales@rweschottsolar.us • www.rweschottsolar.us • Equipment supplier, PVs

Northwest Energy Storage • 800-718-8816 or 941-697-1344 • Fax: 941-697-0767 • batteries@nwes.com • www.hupsolarone.com • Batteries

OutBack Power Systems, 19009 62nd Ave. NE, Arlington, WA 98223 • 360-435-6030 • Fax: 360-435-6019 • sales@outbackpower.com • www.outbackpower.com • Inverters, DC disconnect, breakers, MIG2

Xantrex Technology Inc., 5916 195th St. NE, Arlington, WA 98223 • 360-435-8826 • Fax: 360-435-3547 • info@xantrex.com • www.xantrex.com • Inverters, DC disconnect, breakers, meter

RightHand Engineering LLC, 19310 226th Ave. NE, Woodinville, WA 98077 • Phone/Fax: 425-844-1291 • info@righthandeng.com • www.righthandeng.com • WinVerter software

Cummins Southeastern Power Inc., 5910 E. Hillsborough Ave., Tampa, FL 33610 • 813-664-5833 • Fax: 813-628-4183 • randolph.m.szurma@cummins.com • www.onan.com • Generator

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Bogart Engineering (TriMetric), 19020 Two Bar Rd., Boulder Creek, CA 95006 • 831-338-0616 • Fax: 831-338-2337 • Bogart@bogartengineering.com • www.bogartengineering.com • TriMetric meter