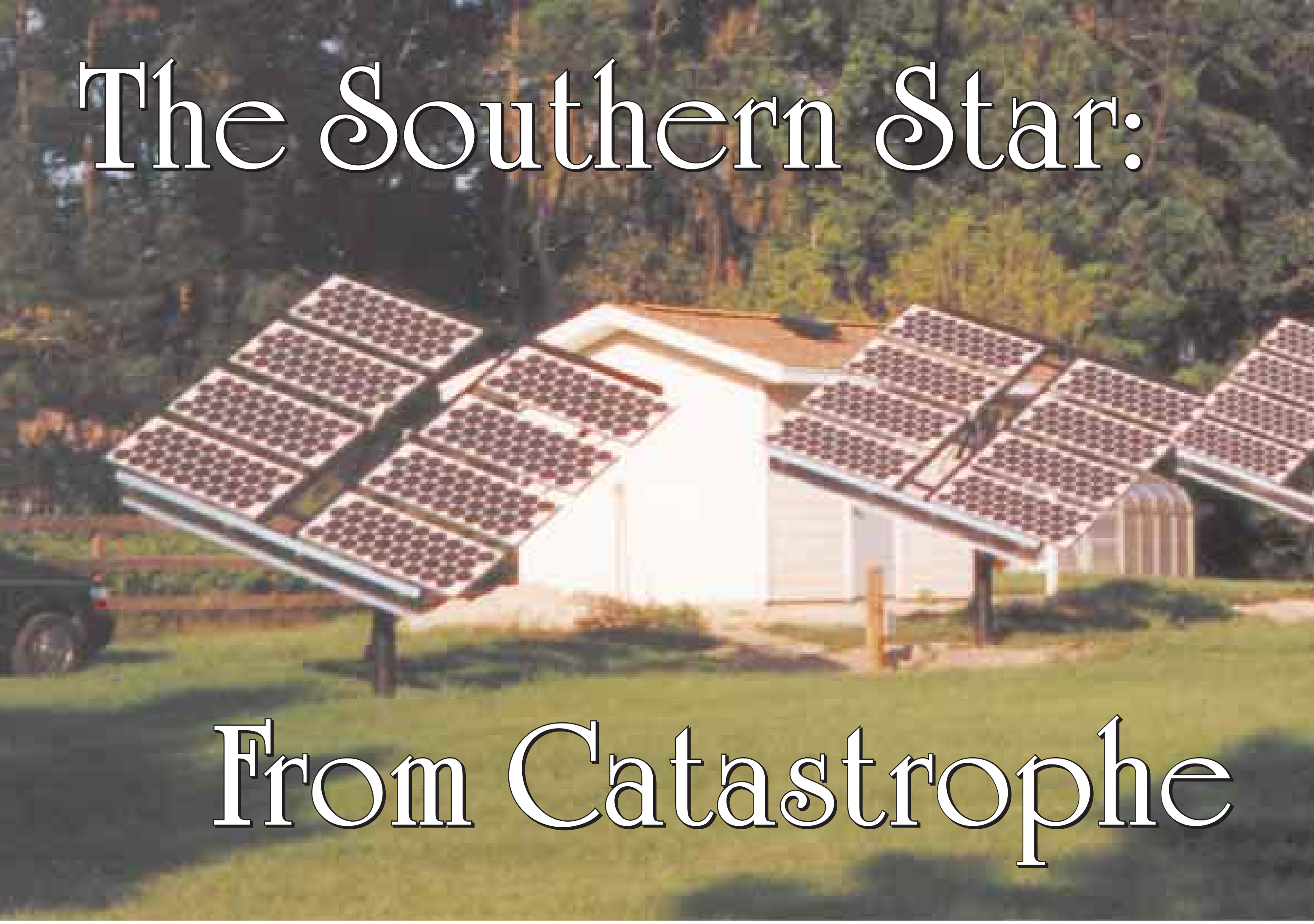
The Southern Star: From Catastrophe



Above: Six Zomeworks trackers hold eight 100 watt Siemens SR100 watt panels each for 4,800 watts at 48 volts.

After surviving the devastation of Hurricane Andrew, Al Ford moved his family from southern Florida to the rolling hills of northern Florida's Alachua County. Living through the aftermath of the hurricane—months of no running water, flush toilets, air conditioning, or fans during the heart of a tropical summer—Ford developed a clear awareness of the fragile nature of grid-connected power.

Because of his experience, Mr. Ford asked Energy Conservation Services of North Florida (ECS) to develop a solar power system to back up his new home's diesel generator. Mr. Ford wanted to develop a solar electric system not only for personal comfort and reliability, but also to inspire others. He wanted to show that solar technology is not only economically viable, but the best socially conscious power choice today.

Set an Example

Ford believes that environmental consciousness should motivate both decisions and actions. He wanted his system choice to set a sterling example of how southern shelters could be upgraded cost-effectively, while still protecting Florida's fragile environment.

The total cost of the system was $69,000, including the battery house and all controls. The system design was meant to encourage two groups of new homeowners to consider solar—affluent southern homeowners who often spend $25,000 to $100,000 to upgrade their bathrooms and kitchens, and a wider range of southerners who could afford to choose smaller, affordable, off-the-shelf solar backup systems.

The Al Ford solar electric system was given the name "Southern Star" because it was meant to be an example that any licensed solar contractor or electrician could easily duplicate. The design goal was long term reliability in the hot humid subtropical climate, with little in the way of homeowner maintenance and monitoring. Mr. Ford did not want to be technically involved with his power system any more than a typical homeowner wants to be involved with his HVAC system.

to Inspiration

Tom Lane and Linda Tozer

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Space between panels and tie-down loops on the corners of the trackers provide protection from hurricanes.

Plug into the Sun

We hope this article will help readers realize how easy it can be to “plug into” the sun. After twenty-two years of solar contracting, we can easily appreciate the autonomy and design of Trace’s new Power Panel. The grid-connected homeowner does not want to own a unique system that requires daily involvement. The typical off-grid system designed today for people in remote homes is not autonomous enough to meet the needs of most people. The future of our industry in the South, if solar is to become a part of the mainstream in grid-connected homes, is simplicity, reliability, and autonomy.

To overcome past design dilemmas and create a system that would have long-term reliability in a humid subtropical climate, we tried to design a uniformly balanced system that could be assembled quickly and checked easily for system malfunctions during and after installation. These design hurdles have been a stumbling block to local electrical contractors. They generally choose simple stand-alone generators over the environmentally and technically superior inverters with battery chargers and solar electric backup.

System Design

The Fords’ solar electric system uses a Trace Power Panel that includes two SW4048 sine wave inverters, producing both 120 and 240 volt AC power. This Power Panel delivers 8 KW, with a surge capability of 18.7 KW, to power a 1.5 horsepower well pump and every electrical circuit in the home except the air conditioning circuits.

The system includes two 40 amp Trace C-40 charge controllers, each with digital meters and LCD displays. These meters allow all wire connections from the solar arrays to the power panel to be checked individually.

The photovoltaic array contains 48 SR100 Siemens modules. They were configured individually as 6 volt modules at 12 amps each. These 100 watt modules, mounted in eight panel arrays on six trackers, were then wired as eight panels in series to create 48 volt arrays at 12 amps. This wiring scheme is not advisable if shading is a problem, but these trackers are in full sun for more than eight hours a day. Wiring this way was greatly simplified—only one #8 (8.4 mm^2) flexible wire run exits each tracker.

Above: The Ford house has a solar hot water system with panels on the roof.

The two rows of three Zomeworks Universal Track Rack trackers were wired and fused as two parallel subarrays, each at 48 volts and 36 amps, in a lightning-protected combiner box. Every combiner has a separate wiring run of #2 (33.6 mm^2) wire to one of the two C-40 controllers. The digital voltage and amperage meters on each controller enabled ECS' technical crews to fine tune the trackers and the wire connectors, producing nearly identical amperage and voltage readings from each subset of three trackers. The Siemens SR100 modules consistently delivered higher than claimed amperage and voltage to the power panel.

We used a special flat black, high temperature coating to weatherproof and rustproof the racks for the humid southern climate. For installation anywhere near the ocean in Florida, I don't recommend the painted mild steel typically used in manufactured racks. Only anodized aluminum, stainless steel, or pressure treated wood should be used in a mounting system that will be in the salt air of coastal environments.

We encountered wet, sticky, southern "gumbo clay" while digging the six holes for the tracker poles. Fortunately, we subcontracted to a local tree planting company whose power spades made quick work of digging the holes. Six inch (15 cm) schedule 40 black iron poles were heavily duct taped where they were surrounded by concrete in the ground and sprayed with an automotive rubberized black bumper coating above ground. A post hole digger was used to round out a one foot deep, six inch wide (30 by 15 cm) hole at each hole's center to drop the bare tracker pole into the earth below the pole's concrete collar. This helped to ground the pole to the earth for lightning protection.

Tracker Features

Several unique installation features for southern sites were incorporated into the installation of the Zomeworks trackers. Each tracker had four D-rings welded onto its corners. This will enable us to level out and strap down the corners to earth anchors within minutes if a hurricane approaches. The SR100 modules were spaced a few inches apart, moderating the dangerous sail effect of a solid, massive array in a hurricane.

The new universal Zomeworks tracker, which comes knocked down in pieces, made it easy to bring all six trackers to the site for assembly using one trailer. The universal tracker is a design breakthrough that costs only $175 more than a fixed pole mount rack. Trackers are definitely cost effective below 34° latitude if you ground mount more than 600 watts per array and get full sun for at least seven hours a day.

Below: ECS crew members (from left) Jamie Dempsey, Shirley Lane, Tom Lane, and John Ault in the custom built power shed which houses the Trace Power Panel and thirty-two Trojan L-16 HCs.

Above: An aerial view from the south makes the huge array seem small.

Batteries

The battery bank consists of thirty-two high capacity 6 volt 395 amp-hour Trojan L-16 batteries. The L-16 HCs are a bargain in that they cost only $12 to $15 more per battery than the standard 350 amp-hour L-16s. These batteries, besides having an extra 45 amp-hours per battery, have dual positive and negative terminals. The extra stud terminal made it easy to make the fourteen connections between the eight batteries in series. Four strings of eight batteries resulted in a 1,580 amp-hour bank at 48 volts.

Our battery suppliers made installation easy by cutting the twenty-eight series and six parallel battery cables to exact lengths in red for positive and black for negative. The cables were crimped and heat shrunk to pre-measured specifications and delivered with the batteries, ready for installation. Positive and negative battery ends and four pairs of 3/0 (85 mm^2) welding cable for the two Trace inverters were also pre-manufactured, allowing rapid assembly upon arrival.

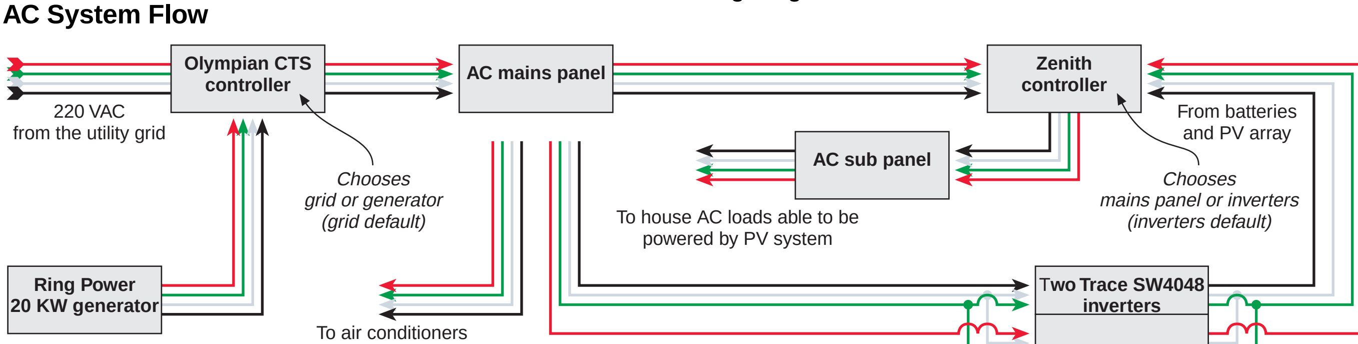
A battery box to contain the battery system was pre-built from marine grade plywood and pressure treated pine. This was fiberglassed, and then treated with rubberized bumper coating.

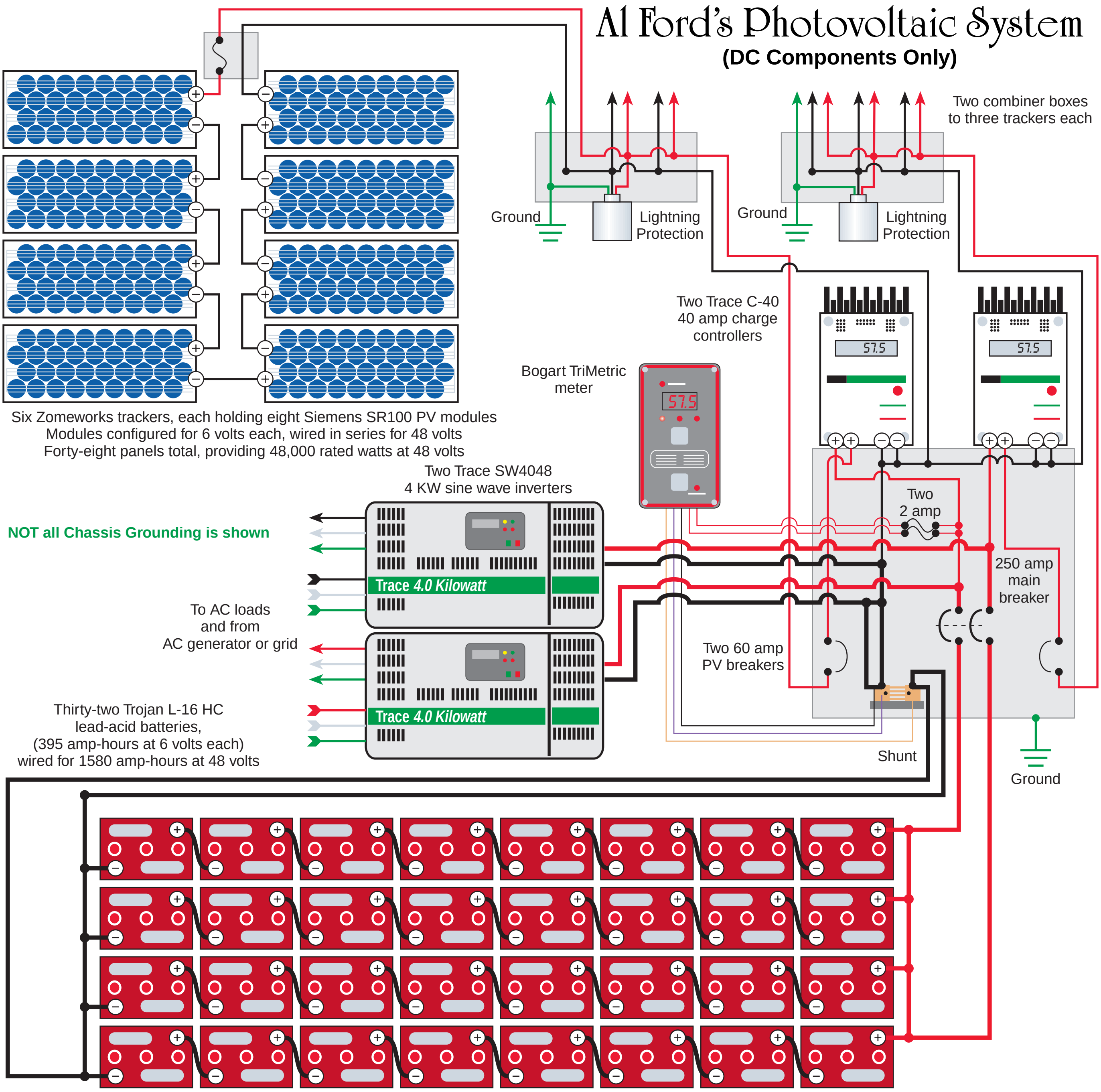
When the job permit was pulled, I asked the electrical inspector about using welding cable for battery connections. He advised me that the cables supplied by the authorized Trojan battery distributor would satisfy the National Electrical Code, and plain common sense. So, having the battery distributor manufacture the interconnect cables saved time and made it easy for the electrical inspector to approve the battery bank.

Power Room

The battery and system components room was built on a 10 by 14 foot (3 by 4.3 m) concrete slab. It was poured along with the tracker holes, saving time and money. Insulation and sheetrock were applied to the room walls, but the ceiling was left exposed. Then the ceiling, interior walls, and exterior metal door were sprayed with LO/MIT-1 radiant barrier coating. This radiant barrier paint's low emissivity and low absorptivity will help to keep the room cool in the summer and warm in the winter. The pure aluminum coating, often used in car firewalls, also provides a shield against electromagnetic pulse and other outside electronic interference. The paint's spectral reflectivity is 98 percent, helping to illuminate the room with minimal lighting.

AC System Flow





To help vent any hydrogen created by the battery bank, the roof has a continuous ridge vent combined with a direct PV-powered fan on the southern roof. Storage batteries were eventually capped with Water-miser safety vent caps. These extend watering intervals for a safer fume-free environment in the battery room. These caps will not melt down during equalization charges.

Automatic Operation

One unique aspect of this system is the automatic operation. The battery bank is protected and maintained by grid power if necessary, or by a backup diesel generator should the grid fail. The diesel generator is capable of supplying the home's entire load and has its own transfer switches which will automatically start and operate it at full speed within seconds. The inverter battery chargers were programmed to bring the battery bank to full charge with grid-connected power whenever the battery bank drops to 60 percent of its rated capacity. If the grid fails, then each inverter battery charger has generator power available for charging.

The solar input to the system passes through a Zenith automatic transfer switch connected to the sub-panel used for powering the 110 volt and some of the 240 volt loads in the Ford home. The transfer switch automatically transfers back to the grid or the generator if the solar electric system malfunctions. Upon grid failure, there is virtually seamless power generation. For the Ford's home to lose power, it would take a failure of all three systems—grid, generator, and solar.

The solar control center and battery room is locked and only accessible to ECS solar technicians and the electrical subcontractor. The Fords can monitor the battery banks, voltage, input from the solar array, and system contribution to the home's load each day by viewing the TriMetric battery monitor located on an outside wall of the battery room.

An annual maintenance contract will assure the Fords a trouble-free system. Within the next few months, we will create a modem connection to inverter ports so that the system can be monitored directly from the ECS office.

The 1.5 hp conventional well pump will be replaced by a three inch diameter Grundfos integrated variable frequency drive submersible pump which has no starting spike. This revolutionary and inexpensive AC submersible Jetsub well pump only operates on a sine wave inverter. Because it has a soft start, it makes extra inverter power capacity available.

Solar Water Heating Systems

The downstairs and upstairs water heaters in the Ford home were re-plumbed in series. Two 41 gallon (155 liter) PT-40 ProgressivTube passive batch solar water heaters were also plumbed in series with the electric water heaters. These preheat the water for both electric backup water heaters.

A small direct-drive DC pump wired to a 10 watt Siemens PV module circulates water from the bottom of the upstairs water heater through the solar water heaters to the bottom of the downstairs tank. Water then leaves the downstairs tank from the top water outlet and is delivered to the bottom of the upstairs tank. This strategy assures the homeowner of 162 gallons (613 liters) of heated water. The lower electric elements were disconnected to minimize power consumption from the grid. The backup upper elements only operate if water temperature drops below 120° F (49° C).

Future Sustainable Community

Al Ford plans to develop more than 200 acres in nearby Alachua into a sustainable solar-powered community. Part of his inspiration came from a visit to a Ford automotive manufacturing plant that uses a massive array of Siemens modules to help power the plant. The

Above: Tom Lane (left) and Al Ford celebrate the completion of the system.

sustainable building strategy for the community is to incorporate natural earth-friendly recyclable building materials into the homes. Ivor Sparks, a local builder who specializes in sustainable building with natural materials is working with Mr. Ford on the community design.

Single family homes are planned around minimal automobile use. Traffic design will make it easy to walk or bicycle to community shopping, parks, and entertainment. Potential community homeowners will be able to choose from an array of earth-friendly home building materials. Solar electric system designs will use prepackaged, preassembled components, creating a more compact and less costly system than the Fords'. This will give the community homeowner access to affordable and easily installed and maintained systems.

This community design will help others realize that solar and other environmentally friendly technologies are viable today. They are, in fact, an integral part of any sustainable 21st century community seeking to renew rather than waste the planet's resources. Jobs for some of the people living in the new sustainable community may be provided by the University of Florida's high technology Progress Center in nearby Gainesville. The Center, as planned by the University of Florida, will serve as an incubator for research and to foster new high-technology jobs.

A Long Tradition

Pioneering new energy technologies is in Al Ford's blood. Mr. Ford's great-grandfather was Henry Ford of the Ford Motor Car Company. Henry Ford had his own home power electrical generator in Dearborn, Michigan, designed by his friend Thomas Edison. This independent home electrical system is thought to have been one of the first in the nation.

The original system included hydro-electric power, a steam-powered generator, and a large battery bank for backup. The hydro-electric system was recently restored by the University of Michigan and is still providing the home with electric power. It consists of two 55 KW DC generators coupled to Leffel turbines. The eight foot high dam and special venturi system give power equivalent to that of an eighteen foot high dam.

The battery bank was removed in 1925 and the system is now tied to the grid. The steam power equipment is still on site, but not operational because of safety concerns. The Ford home is a National Historic Landmark on the University of Michigan campus in Dearborn, and is open to the public.

The friendship between Henry Ford and Thomas Edison prompted them to build homes near each other in Fort Myers, Florida. These homes and Edison's lab are still standing and are open for public viewing.

Why Florida?

Florida is the home of the Florida Solar Energy Center, the Florida Solar Energy Research and Education Foundation, the Florida Solar Energy Industry Association, and the Florida Energy Office at the Department of Community Affairs. Recent accomplishments of these organizations include the elimination of state sales tax for solar equipment, a state law preventing homeowner associations from establishing covenants which prohibit solar collectors, and builder incentives for installing solar energy equipment.

These organizations also have been instrumental in opening up new Florida housing markets and in assisting Florida companies in the export of solar equipment throughout the Caribbean Basin, Mexico, and Central and South America. Florida solar electric sales climbed dramatically in 1998, a result of these groups' efforts, a series of southern climatic catastrophes, and in response to the Y2K issue. We also expect solar electric contractor jobs to spiral up dramatically over the next few years.

Our industry association is lobbying the State Legislature to introduce a "Solar Christmas Lights Bill." This bill, initiated by Tom Lane, Technical Director of FLASEIA, and Peter DeNapoli of Siemens Solar, would allow homeowners to plug up to 600 watts of solar electric power directly into their wall sockets—just like plugging in Christmas lights. They are already allowing this in Holland, with Trace Micro Sine Inverters on the back of solar electric panels. The proposed bill would allow the homeowner to do this without permits and without utility approval. People who support green energy could give their friends a 100 watt solar panel each Christmas or on our annual state "Sun Day."

Solar Future Today

The future of solar electric power is today. The Southern Star that Al Ford built can help others realize that this technology is affordable and readily available. It is ready for the builders, architects, and real estate and banking industries to offer to the public as a real "upgrade" to basic shelter. Solar technology can power the base electrical load with only a 10 to 20 percent budget increase for most homes. This is a minor investment for most homeowners; it will not lose its equity value, and it can be expanded in the future.

Al Ford's commitment to solar energy should be celebrated as a showpiece of environmentally responsive design that can be easily copied. His Southern Star is an example and a challenge to inspire others to make solar energy a part of their lives.

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