

Solar Electric Race Car Built by Maine High School Students

By Richard Komp

The Maine Solar Energy Association has been working with the Mount Blue High School students in Farmington, Maine to help them build a solar electric race car. This three wheeled vehicle, which is an outgrowth of the Electrothon race program, has a carbon fiber composite body with an array of 148 photovoltaic cells molded right into the curved, aerodynamic body shell, instead of simply mounted as modules on the body. On Sunday and Monday the 2nd and 3rd of November, Richard Komp of MESEA worked with the students to finish up the wiring of the PV array and connect the charge controller and two batteries to the 24 volt system. This project is part of the Foster Technology Center composite program run by John McDonald at Mt Blue High School.

The group also had a solar air heater workshop where they built three solar thermosiphon air heater collectors following the plans in MESEA's Maine Solar Primer and using mostly salvaged materials. The only things which were bought new were two by fours, 3/8" CDX plywood and foam insulation. The collectors, which cost less than \$75 each, will be installed on the south wall of a shop building.

Below is a photo of the students testing the electrical output of the race car body shell.



Using Solar Energy in Maine

By Richard Komp

*This article was first written for the upcoming issue of **Maine Policy Review**. The editors rejected it as "too practical" so I wrote another one for them and decided to put it in the **Maine Sun**. They also complained about the new article having too much information on solar energy, even after I cut all the "practical" parts and wrote it all in the passive voice. I will be interested in seeing what the final version looks like when the magazine comes out in January and is sent to the Legislature.*

First of all, there is a lot of usable solar energy in Maine. In the dead of winter, Maine has more sunshine than Boston, for example. We also have cleaner air, which allows more of the sunshine to reach us. I live in a solar home and have no furnace or thermostat. I also have no power lines run to my home and haven't paid a heating or electric bill for more than 20 years. It is possible to use solar energy in your life here in Maine and in the following sections I will outline some of the ways you can use Maine's sunshine in your own life.

Passive Solar Architecture

The basic ideas of passive solar architecture go back thousands of years and are easy to understand. They are also inexpensive to implement: If you or your builder knows what you are doing, you can build a passive solar home **cheaper** than a conventional home or at the very least for no extra money. The three essential elements are as follows:

1. Design the windows and the overhangs of the home so that the sun is allowed to come in when you need it during the late fall, winter and early spring; and to keep the sun out when you don't need any heat during the summer. The trick is to keep yourself warm three seasons of the year and cool in the summer, with proper ventilation from opening windows. Air conditioners are an admission of architectural failure in Maine.
2. Use **lots** of insulation to trap the heat in the home or building. You cannot have too much insulation. My home has R40 wall and R60 roof insulation and I also have window insulators I put in on winter nights.
3. Have a way of storing the heat that comes in during the day, for nighttime heating. This can be something as simple as direct gain thermal mass: masonry walls and tile floors (a "mud job" with the floor tiles set right into a massive concrete floor) are good examples. I have an indirect thermal mass in the form of a "hypocaust" (this is a Latin word for the systems the Romans used to store heat 2000 years ago) with floor air chambers. **Pg 4**

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From Page 1 Attached sunspaces and solar air heaters can be added to existing homes to retrofit them for some solar gain. The attached sunspaces can be used as an extension to your living area, as a greenhouse to grow plants out of season or start plants earlier in “mud season” to give a longer growing season, or as a way to heat your home by solar energy. Since you can’t do all three equally well, you would have to decide which of the three functions is 1st priority, which is 2nd and which you pretty much have decided is not important to you. The three priorities can be in any order and plans for working sunspaces are in our Maine Solar Primer.

The Primer also has plans for solar air heaters, solar food driers and cookers and a whole section giving the basics of passive solar architecture, as well as information on PV and PV-Solar hot water Hybrid systems. It is available from MESEA for \$10 including postage. *Look at the ad on page 7.*

Backup heating can be something as simple as my wood stove in the kitchen (which takes one cord of wood to heat my home when I am there all winter). Radiant heat in the floor works as a very good backup system. While my present home has the hypocaust radiant air system, in past homes I have always put water tubing in the floor for the radiant heat from a backup heating system. I did the first of these with my father in 1951 when I was eleven. Back then we had to use copper tubing in the concrete floor, but nowadays there is very good plastic tubing available for this purpose. The source of the backup heat can be wood, oil gas or even ground source heat pumps (sometimes mistakenly called “geothermal heat” in this part of the world).

Solar air heaters

These simple devices can be built into a passive solar home to gain more heat using walls where you don’t wish to put windows. The four thermosiphon solar heaters on the south wall of my home actually cost less than the wall area they replaced, and the Maine Solar Energy Association (MESEA) has been having a series of weekend workshops where we build solar air heaters that are designed to be added to an existing home. Recycling scrap glass and old tin roofing, we have managed to keep the cost of the collectors very low but still build good looking, efficient solar air heaters.

Solar water heating

The cheapest way to heat your domestic hot water is to install a solar water heater, and in the State of Maine they have a rebate program that will pay for a good part of your installed system. MESEA has been having a series of weekend workshops where you can come and help build solar water heater collectors and one or two of the

participants can even take a finished collector home for the cost of about \$150 or less. The Maine Solar Primer, a 32 page booklet printed by MESEA has all the plans for these solar water heaters, and all the materials needed can be bought at Home Depot, or better yet, at your local hardware and building supply store. While this solar hot water system is not certified and thus not eligible for the Maine State rebates; the idea is to have a system so inexpensive that it is cheaper without the rebates than the commercial systems are with them, but almost as efficient in operation.

It is difficult to justify the cost of a large solar water heating system for your entire home, because when you need the heat most in the winter time, the sun most likely won’t be there. However there are two ways to incorporate active solar water heating into a hydronic home heating system:

First, you can use the new evacuated tube solar collectors being made by the millions in China and coming down in price. These devices are so efficient that they will make very hot water, even on a cloudy day. If you can barely make out the bright spot where the sun is, they will make hot water.

Second, you can use a solar water heater (even our homemade workshop ones) as an efficient preheater for ground source “geothermal” heat pumps. Warming the ground water in Maine in the winter just a few degrees to about 65° to 70° F will increase the coefficient of performance of the heat pump considerably, make the whole system “greener” and save you electricity. A conventional ground source heat pump is only as green as the electricity that runs the compressor motor, which is 30% green here in Maine, unless you buy special green electricity, then your system is 100% renewable.

Photovoltaic (PV) systems

Photovoltaic systems are my special area of expertise. I have worked as a scientist developing new types of thin film, nanomaterial and organic semiconductor PV cell materials since 1960 and have written one of the most popular books on the subject: **Practical Photovoltaic’s**, which is now in its Revised 3rd Edition.

If you are living off the grid, PV systems are the cheapest way to get your electricity, far cheaper and more convenient than small gas or diesel generators. We estimate that there are more than two thousand people in Maine living without power lines who are doing this already. I won’t go into all the physics of PV cells here but wish to point out that PV cells have no moving parts, never wear out and nothing gets used up when they are quietly making electricity from sunlight. On my house, I

have PV modules which are more than 25 years old which are still producing power with the same efficiency as when I installed them 20 years ago.

Grid connected PV systems can take advantage Maine's net billing laws to use the local power line as your storage system; pumping electricity back into the grid on sunny days when you are not using as much electricity as the sun is producing, then drawing on the credits from that time in those cold winter times when there is no sun. The Maine solar rebates are also available for grid connected PV systems, but the pot of money is way too small and there is a multi-year waiting list of people waiting to take advantage of this system. Also, you must have certified PV modules installed by a certified "expert" to qualify for the rebates.

While there are "new" thin film, nanomaterial PV cells on the horizon, the crystalline silicon PV cells and modules dominate the industry and are continuously getting more efficient and less costly so they are a moving target for the alternative materials. Waiting till the price comes down before installing a PV system is like waiting for the price of computers to finish dropping before buying a computer and getting on the Internet; While you are waiting for them to get cheaper, you are missing out on a whole lot, and they will continue to get cheaper for the foreseeable future.

Photovoltaic-Thermal Hybrid systems

The principle of the PV-Thermal hybrid system is very simple: If you use reflectors to double the amount of light hitting a solar cell, you will double the electric current from the PV cell. However, the cell will overheat and lower its efficiency (heating a PV cell does no permanent damage to the cell, however). Here in Maine, MESEA has been offering workshops for years where we build a hybrid PV solar water collector that I invented back in 1975. The Passamaquoddy Indian Nation is now discussing manufacturing this collector design commercially. There is a PV-hot water hybrid being developed here in Maine by Ascendent Energy but it misses the essential part of the reason for doing hybrids, having no concentrators built in. It also is quite inefficient in its heat transfer design so it will be very expensive for the output power it will deliver.

Policy suggestions

The first thing that should be done to encourage the use of solar is to increase the pot of money available for the solar rebates. Virtually all of this money comes from the Public Benefits Charge on electric utility bills, although a small portion comes from the Federal DoE. Even though about 30% of the Public Benefits Charge comes from utility payments by people below the poverty level, the large corporate users are getting the biggest share

of the limited pot. The working poor should get back in conservation and renewable energy benefits at least as much as they put in, but even more would be desirable since they are not normally in a financial position to install solar systems. The mix of the distribution should be reconsidered since the large corporate users have access to other financial resources and accountants who can calculate the sometimes very favorable cost-benefit ratios. Another possible way to increase the pot of money would be to increase the cost per watt to ratepayers to keep up with inflation.

A second idea which did exist in Maine until about 15 years ago is to offer low interest loans for the construction and installation of solar systems. These could be solar water or air heaters, or PV systems. The idea is to have a loan payback period set so that the monthly payment on the loan averages less than the saving on user's electric or heating bill. Since this is a loan rather than a grant, the requirements for getting the loan can be less stringent than those for the State solar rebate program. If an uncertified person builds his own solar water heater and it isn't as efficient as predicted, he still has to pay off the loan so the State still gets the money back to be used by another client. This program should not be available for new passive solar homes (since they don't cost anything extra to build) but could be available for insulation or passive sunspaces to be added to an older existing home.

Remember, the sun is a peaceful and just source of energy that is delivered free almost every day here in Maine. We should make better use of this bounty.

Photovoltaic Projections

The cost of photovoltaic electricity is due to plummet in 2009, according to the second issue of New Energy Finance's quarterly "Silicon and Wafer Price Index." It shows average silicon contract prices falling by over 30% in 2009, compared with 2008. With thin-film PV module manufacturing costs approaching the US\$1/Watt mark, crystalline silicon-based PV will come under severe competition for larger projects, resulting in margins shrinking throughout the silicon value chain, as the company argues in a recent exclusive report – "Through Thick and Thin". At the 2008 contracted silicon price of US\$165/kg, silicon contributes an estimated US\$1.52/W to the current crystalline silicon module price of around US\$4/Watt – or just under 40%. A silicon cost reduction to US\$113/kg in 2009 would therefore lower module prices for the majority of the market volume that uses contracted silicon by 12%. This lower price plus the new government plans to support the use of renewable should lead to a large expansion in the photovoltaic industry.

Innovations in photovoltaics

By Richard Komp

Last November I was asked as a consultant by an investment firm to discuss the new innovations in PV. Here are some of my answers:

There are a number of new innovations in the photovoltaics (PV) industry. Several of these are,

1. New thin film crystalline silicon PV cells where a layer of only 20 microns of polycrystalline silicon is deposited on a flexible substrate. The usual crystalline silicon PV cell is 200 to 300 microns thick. This new process uses the expensive polysilicon far more efficiently.
2. Organic semiconductor PV cells deposited on inexpensive, flexible polymer substrates. These can even be built into clothing or sailboat sails.
3. Nano tubes or layers that also can be painted on flexible substrates to build inexpensive, efficient PV cells

Some of the companies involved in this work are start-ups whose work is still proprietary but some of the ones who have public information are:

1. The thin film crystalline silicon PV cells which were being developed by Astropower were only 20 micron thick on a flexible substrate; but when Astropower was taken over by GE, work was stopped on this process. However, I have heard that GE has again started to make these in a pilot plant.
2. Konarka is the company farthest advanced in the flexible organic semiconductor PV cell field. They have actually been making flexible PV cells printed onto T-shirts and soldier's uniforms. They have been making solar lanterns using roll-up PV chargers and testing them in the Andes in Peru.
3. All the nanomaterial PV cells are still in the R&D stage but companies like Sharp and Sanyo in Japan are quite a way along.

The companies who are selling the "best mousetraps" are:

1. Evergreen Solar with their string ribbon grown polycrystalline PV cells that are now only 120 microns thick. These are inexpensive to produce and use far less of the scarce polysilicon than the conventional PV cells.
2. Konarka with their flexible organic PV cells already in pilot production.
3. SunPower, with the most efficient and most elegant single crystal PV cells with back contacts which produce black-on black modules, very popular with architects installing building integrated PV into modern office buildings in Europe.

The "must have" products are:

1. The SunPower black PV modules for new office buildings in Germany and other places where being "green" is important.
2. Thin film flexible PV modules made now by Unisolar to "peel and stick" onto standing seam metal roofs for building integrated PV. I expect other companies like Sharp and Kyocera to expand their line of PV roof shingles.

The most successful "new" introductions are:

1. The First Solar CdS/CdTe PV cells and modules. While the technology they use is not new, they managed to bring it to large scale production. However, there are start-ups who have better ways to deposit the CdTe layer which use far less of the scarce and expensive Tellurium.
2. SunPower with the efficient black-on-black PV modules.
3. SunTechPower in China which are ramping up production to be one of the world's premier PV module producers with their vertically integrated production facilities.

The most important new products in the past five years are:

1. The new generation, non-silicon PV cells.
2. The thin film crystalline silicon PV cells.

In the next 5 years we will see "paint on" organic semiconductor PV modules, and high efficiency organic dye sensitized inorganic nanoparticle PV cells and modules. Possibly the thermo-photovoltaic PV cell technology will be developed.

The three companies developing the most innovative products in the PV industry are:

1. Konarka
2. Evergreen Solar
3. SunPower

The most important technical developments impacting the PV industry are:

1. The new thin film crystalline silicon PV cells
2. Thin film CdS/CdTe PV cells
3. The organic semiconductors for PV cells
4. Nanomaterials in new, creative configurations like columns with controllable band widths to "tune" the PV cells for maximum efficiency.

From Electric Light and Power Magazine:

How green will Obama be?

Renewable energy

Renewables, perhaps more than any other source of energy, seem to have the most political and legislative momentum. In the face of estimates of immense energy demand and not enough supply -- especially clean supplies -- renewable sources of energy are being looked at as part of the solution. Add to that worries about climate change, and you've got a great plank for your political platform. Here's where Obama stood:

Obama backs a renewable portfolio standard (RPS) for the country that would require 10 percent of our electricity come from sources like wind and solar by 2012. He also wants to extend the federal production tax credit (PTC) for another five years.

Plug-in hybrid vehicles (PHEVs)

Paying Euro-style prices for gas is not setting well with the nation, which will only ramp up support behind [PHEVs](#). There's some kinks to work out, like better batteries, infrastructure to support the cars and getting them to a bearable price point just to name a few. Still, PHEVs are being looked at as a source of distributed generation, a place to store energy, a way to reduce emissions and a solution to our dependence on foreign oil. With greater acceptance of PHEVs, the utility industry will be impacted for better (distributed generation is good) and for worse (PHEVs have the potential of putting more strain on an already stretched grid). In any case, here's what Obama had to say during the election about PHEVs: Obama intends to use public and private funds to develop better battery technologies for automobiles. He hopes that such an R&D push will help automakers make PHEVs available to consumers. By 2015, Obama wants to put 1 million PHEVs on the road. As an incentive for adoption, he wants to give two tax credits, one for conservation and a \$7,000 credit for "the purchase of advanced technology vehicles." Another way he'll get 1 million PHEVs on the road is by, if elected, converting the White House fleet to PHEVs and making half the cars purchased by the feds PHEVs by 2012.