Solar Work in Colombia 2011

By Richard Komp

At the American Solar Energy Society (ASES) Annual Conference in Phoenix, Arizona in May of 2010, John Burke and I gave a paper on the new methods the Grupo Fenix developed to encapsulate photovoltaic (PV) modules without an expensive laminating machine. The paper, which showed the work in 3rd World countries all over the world, was well received and afterwards we had a number of people came up to discuss the possibility of doing this kind of work in their country.

One of these people was Julian Lustig Gonzalez for Colombia, South America. During our box lunch together, I outlined to Julian just what would be required to start such a cottage PV industry in the part of Colombia where he lived. I explained that the first visit costs about $6000 for the materials and travel and living expenses. For work in 3rd World countries, I don't charge any honorarium, since the people I will be working with live on less than $2 a day.

The First Trip – March 2011

Julian stayed in touch with me and he and his mother (a language professor at Smith College) saved up the money for the first trip, which I made in March of 2011. I flew from Nicaragua, by way of Miami to Barranquilla, on the Caribbean coast of Colombia, where Julian was waiting to pick me up. I had brought the PV cells and he had the silicone encapsulant but we spent two days shopping for the rest of the parts (like the glass and aluminum frame material) that we would use to build the first PV modules assembled in Colombia. We also spent time swimming at the beautiful Caribbean beaches walking distance from his mother's new home.

Resting at Patricia's after a hard day walking the beach and swimming in the Caribbean

We are working with the local Juaruco Native Americans, who have a village walking distance from the new group of homes being built overlooking the Caribbean. In fact most of the Juarucos work

building the homes and then later become gardeners and maids, maintaining and cleaning the homes. Julian and his mother felt that they could do better things with their lives.

On the Monday after I go to Colombia I started the course on how to build PV modules and we quickly graduated from making tiny four cell solar battery chargers to bigger modules as they picked right up on the techniques of soldering and cutting the boxes of Evergreen Solar cells I had brought in my luggage from Nicaragua.

Learning how to sort and cut the Evergreen solar cells.

We took the cracked and broken PV cells and cut them into different size pieces to make the most efficient use of these cells. Some we cut exactly in half to make 32 watt modules, while others were cut into quarters for the solar cell phone chargers, which proved to be very popular. I spent some extra time teaching them how to make very flat solder joints so that when we went to encapsulate the PV cells into modules, perfectly flat modules would result and less of the expensive two part silicone would be needed.

During the course, I gave lectures on how PV cells work, how they are made and how to design PV modules for different purposes. I would mix up the working sessions with these lectures and sessions on how PV modules are used for powering homes, pumping water and as backup systems for businesses. This information is important since they will not only be building PV modules abut they also have to know how to design, install, maintain and repair PV systems. I also taught them some electricity theory like the meaning of power in watts and Ohm's law, and how to use millimeters to measure the voltage and currant outputs of the modules that are building Later in the course, we would go around to some of the fancy homes in the neighborhood, working out how to plan and install backup power systems for these vacation homes. This made some of the elite homeowners nervous, since while they are used to having the natives coming in and cleaning their homes, having them come as experts offering advice on how to get reliable electric power was a new thing for "los ricos".

Soldering strings of whole PV cells to make a 65 watt PV module

Testing the strings of a solar cell phone charger that is ready for encapsulation. Another string waits in the foreground.

The first home we wired up for backup solar electricity was Julian's mother Patricia's. Since several of my students worked on the tile roofs, it was easy for them to work out a system to mount the PV module on the roof without making any leaks or cracking any of the tiles. We put in a 65 watt module and four 11 watt 12 volt compact fluorescent lamps in the kitchen hall and bedrooms, and hooked everything up to a 12 volt battery in the laundry room. Once this was finished, we rarely ever used the home's regular 120 volt lights.

Checking the 65 watt PV module before installation on the roof

Finishing the installation

Installing a 32 watt PV module on a home in the Juaruco village

The PV modules finished after the first week, in front of the village school

After installing two PV modules and finishing a number of cell phone chargers, we then went on a troubleshooting job in a remote home site, to fix an existing PV system that wasn't working properly. We found that the modules were facing the wrong way, north instead of south; and after repositioning the modules and cleaning them, the electrical output of the system was doubled. The homeowner was very happy and the students learned how to do this kind of work. As one of the last things we did during the first trip, the students designed a PV system for their village school. We designed two systems: one

without and the other with PV power for a proposed air conditioner for the computer center the government promises for the school. The air conditioner uses up as much electricity as there rest of the entire school put together, doubling the system size.

While I was there, the Juaruco natives took me o their sacred place to show me all the very ancient rock carvings. They told me that no archeologist has studied them yet, but I took lots of photographs.

The Juaruco rock carvings, some of them have been filled in with chalk

Talking with a local wild parrot friend

The Second trip – September 2011

Julian, Patricia and I stayed in touch after the first trip and while we were together at the next ASES annual conference in Raleigh in 2011, we planned for my next trip back to Colombia. At the ASES conference, I gave a well received paper on using ethylene-vinyl-acetate (EVA) sheets for encapsulating PV modules instead of the expensive silicone we have been using. We decided to teach the Colombians how to use the EVA; but because that material is cured at above the boiling point of water, we would have to have some way to heat the modules during the curing process. A pizza oven would work, but since we will be working in a remote village (without pizza ovens), we decided that special solar ovens should be built like the ones we use in Nicaragua.

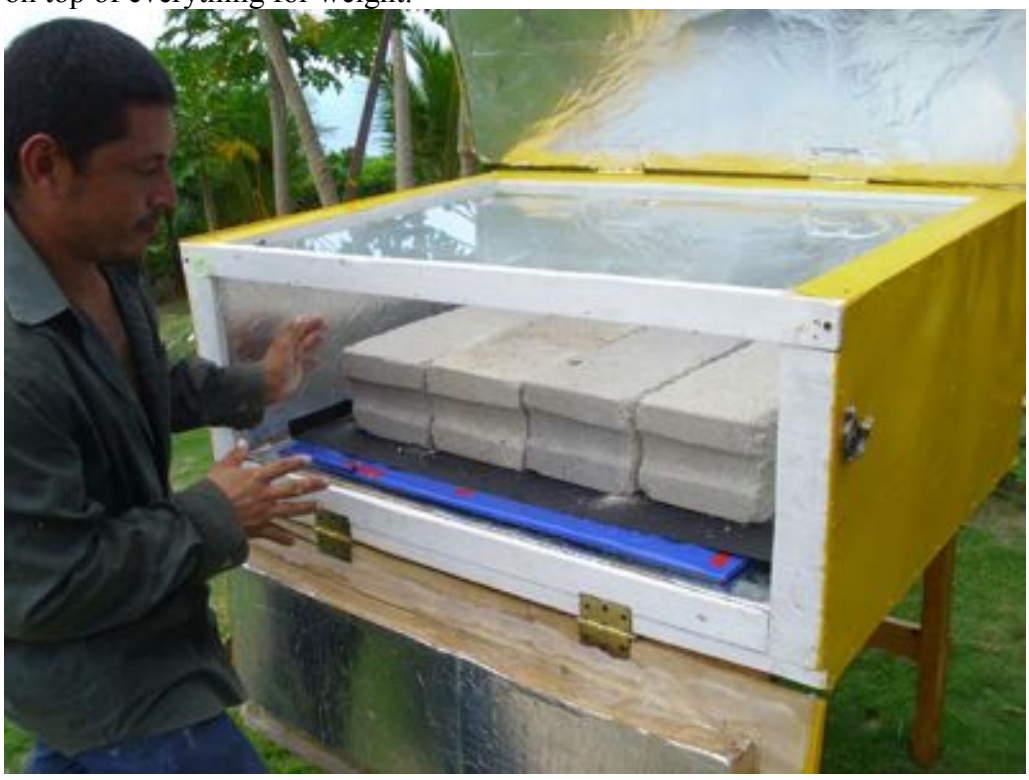
Therefore, Patricia and I arranged for Nimia, a young compesina (peasant woman) from the Grupo Fenix in Nicaragua would come in August to give her workshop on building and using solar ovens. Nimia has already given this workshop to compesinas in Peru and the Dominican Republic as well as in Nicaragua and is very good at teaching the workshop.

Nimia (in the grey T-shirt) with her students and the four solar ovens they built.

Two of the solar ovens were built to an extra large size big enough to take the glass sheet for a 65 watt PV module. One of these ended up as a solar cooker for a restaurant on the beach while the second was used for our work making PV modules. There is about $90 worth of materials in each big cooker. Nimia and I got to spend only two days working together as she had to go back to Nicaragua shortly after I came, but we worked together designing a lightweight, portable solar oven that folds down and can be carried on the back of a llama for the compesinos on the top of the Andes in Peru, or on the back of a camel for the nomads in the Sahara desert in Niger. Both places have no trees for firewood. When I get to Nicaragua in December, we will start working together on the prototype.

The big solar cooker at the beach restaurant on the Caribbean

I brought a roll of the EVA with me so we could start making PV modules using the new method. While I was gone, the students made about 25 of the 65 watt PV modules using the silicone but they were looking forward to using this new method. We put together the sandwich of the PV cells between two sheets of the EVA with a sheet of glass on the bottom (we build these modules upside down) and the vinyl backing sheet on the top and slid it into the solar oven with a sheet steel plate and concrete blocks on top of everything for weight.



The EVA PV module sandwich in the solar cooker ready for baking at 120º C

Hugo and I with the successfully encapsulated 65 watt PV module right out of the oven. You can see the grain of the polycrystalline silicon Evergreen solar cells. The module works perfectly.

This experiment worked very well, even though the oven temperature only got to 115º C and we had to finish the encapsulation the next day when clouds came over the first afternoon. This is the first time anybody in the world has made a full size PV module this way so we have a lot of details to learn, but this method can replace the half-million dollar automated laminating machine that normally does his work.

The University course in Bucaramanga

On Friday of the first week I was in Colombia this time, the rector (president) and head of the engineering school of the Universitaria de Investigacion y Desarillo (UDi) in Bucaramanga came to visit us in Barrenquilla. They wanted me to come to their university and teach a short course on solar energy for the faculty and visiting engineers. They arranged to fly us there on the Sunday of the following week after we had finished the work with the Juaruco natives.

Hugo, one of the natives went with Julian and me to help teach the short course. I gave the lectures (in Spanish with Julian's help) and Hugo gave the hands-on workshops on how to build the PV modules. The university put us up in the three bedroom UDi downtown condominium so we had pretty palatial living quarters on the 9th floor. The elevator didn't work all the time so I got lots of exercise but they arranged for us to eat at a small restaurant near the university so we also ate well.

The course was lectures from 8 am till noon every day, then hands-on work from 2 until 5 in the afternoon. Since this was to be a higher lever course, I included the quantum physics of semiconductors and gave a lot of the equations I usually skip to not intimidate the students. Hard work in Spanish for me but Hugo did very well holding up his end considering he is a campesino with about a fourth grade education, teaching university professors.

Hugo (in the blue T-shirt) showing the university people how to test the PV cell strings prior to encapsulation.

We had split the 24 students into three groups and by the end of the week, they had made six 65 watt PV modules and about 8 solar cell phone chargers. We also went over the methods of designing PV systems with several examples; and I gave lectures on solar thermal systems including solar air conditioning.

This latter was important since one of the reasons why they wanted me to come was to help them design a the story addition to the university hat they wished to be a "zero energy" building with all the electricity, hot water and air conditioning being accomplished completely by solar energy.

Hugo and I checking out the "zero energy" 10 story building already under construction

Discussing the Zero energy building design with the architect

After the week long course, we spent Saturday going around the building with the Cuban architecture professor who is in charge of designing and building the building. He was already well versed in solar design and had included proper shading and solar daylighting to keep the heating and lighting load of the building to a minimum, so the PV array needed was about 144 of the 65 watt modules. We designed a lithium bromide absorption air conditioner that ran from heat from an array of 150 evacuated solar water heater tubes. The only electricity the air conditioner will need is to run the pumps and fans since the heat furnishes all the energy needed to produce the chilled water, which will be stored in large insulated tanks for use when cooling is need at night or cloudy days. All the hot water needed (and then some) will be from the waste heat from the air conditioner system.

The building will be connected to the university power grid and when it is producing more electricity than the building needs, the excess will go to other building in the university. Probably none of the electricity will end up in the national utility grid, which is not yet set up for anything like net billing. There is a lot of social and political work needed in Colombia to get to that point.

The plans are for me to come back as a consultant as needed during the construction of this system, but the $100,000+ price tag of the system has the university administration a bit scared and I have not heard from them since I left in October. We will see if this project comes to pass.