**AJ's Technical Tips:**
**Performance Results for Amorphous Silicon Solar Modules Sold in Kenya**

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Long time readers of Solarnet will remember that some of my colleagues and I reported on the performance of amorphous silicon (a-Si) solar modules back in 2000 (see Solarnet volume 2, number 2, October 2000). That study was based on field tests of 147 PV modules in Kenya in 1999. At that time, we found that a-Si modules made by two companies (Free Energy Europe and Koncar[1]) performed reasonably well, while modules manufactured by the third main company (Intersolar) performed far below their advertised levels. These results showed that the high performing brands of a-Si modules were an effective, low cost alternative to crystalline solar PV modules. However, the poor performance of the Intersolar modules (which were sold under the "Phoenix Gold" brand name) was a serious problem, as many people purchased solar modules that did not give them good results. This was a hardship for those who were unlucky enough to have bought this low quality product, and it also caused reputation problems for the solar industry as a whole.

After our study was released in 2000, Intersolar responded by working to improve the quality if its modules. In 2003, Intersolar's factory in the UK was purchased by ICP-Solar, a Canadian based company. ICP-Solar made additional investments to improve quality, and the final result – as I will explain below – is a good product. As I see it, this is an important success story, as the low performing Intersolar modules of the 1990s have been replaced with the current generation of high performing ICP-Solar a-Si modules.

However, while the improvements made by Intersolar and ICP-Solar are very encouraging, these gains have not eliminated quality problems with a-Si technology in the Kenya solar market. That is, even while the ICP-Solar brand has achieved a level of performance that appears to be comparable to Free Energy Europe and Solar Cells a-Si modules, a study that I led in 2004-05 confirms that another low performing a-Si module brand has entered the market.

## Testing Amorphous Silicon Solar Modules in Kenya in 2004 and 2005

The results that I present in this article are based on tests of five different brands of a-Si solar PV modules sold in Kenya. These tests were carried out at Humboldt State University (HSU) and the University of California at Berkeley (UCB) between September of 2004 and March of 2005.

In implementing this project, we worked in conjunction with the Kenyan Renewable Energy Association (KEREA), as well as Kenyan based import companies who sell the various brands of amorphous silicon (a-Si) modules included in the study. In particular, KEREA coordinated a series of discussions within the Kenyan solar energy industry

[1] Koncar modules are now sold in Kenya under the brand name "Solar Cells"

about solar module quality, while the solar import companies contributed funds to cover the costs of buying the modules and shipping them to the USA.

Researchers from HSU and UCB coordinated all of the field activities related to selecting and purchasing the solar modules from retail shops in Kenya. We were assisted in this work by Maina Mumbi of Off-Grid Energy Alternative Technologies. HSU and UCB jointly covered all of the costs associated with solar module testing for the project. We thank the Schatz Energy Research Center and the Energy Foundation of San Francisco for their generous support.

## Selecting Solar Modules for Testing

We selected four modules for each of the five brands of a-Si modules in this study by purchasing them from retail shops in Kenya. See Table 1 for information about the five brands included in the study. After selection, representatives from each of the import companies were given an opportunity to inspect the modules. All of the modules included in the tests were carefully inspected and were found to be free from visible physical defects. According to the labels on the modules, all of the brands are nominally rated at 14 Watts. You will note that there were two lines of Shenzen Topray modules included in the study. Both of these lines come from the same manufacturer in China, but were sold under different brand names in Kenya.

**Table 1. Brands of a-Si Solar Modules Included in the 2004/05 Study**

| a-Si Module Brand | Kenyan Import Company | Country of Origin |
|---|---|---|
| Free Energy Europe | Chloride Exide, Telesales | France |
| ICP-Solar | Sollatek | U.K. (Wales) |
| Shenzhen Topray #1 (eSolar) | Kenital | China |
| Shenzhen Topray #2 (SunLink) | Electric Link | China |
| Solar Cells | Bhatt Electronics | Croatia |

## Solar Module Measurement Method

The solar module performance measurements reported in this study were made using an outdoor testing method that has an estimated accuracy of ±10%. This measurement method was developed, tested, and used in our earlier 1999 study. The tests involve measuring current-voltage (IV) curves for each module on a clear, sunny day. The results for each curve are normalized to standard test conditions (STC = 1000 W/m$^2$ and 25°C) using widely accepted equations. We use these normalized curves to estimate the maximum power output for each module for standard test conditions.

Our results include measurements of the power output of new modules, as well as the performance of these same modules after a number of months of exposure to solar radiation. The performance of a-Si modules decreases during the first few months of exposure to the sun before stabilizing. Because of this, it is important to base

comparisons of a-Si modules on their final, stabilized performance after three to six months of exposure to the sun.

**Performance Test Results**

The final, stabilized average maximum power output for each of the brands is given in Figure 1. These results indicate that the performance of three of the brands (Free Energy Europe, Solar Cells, and ICP-Solar) is consistent with what one would expect from high performing 12 Watt solar PV modules. The performance of the remaining two brands (eSolar and SunLink), both of which are purchased from the same manufacturer in China, is well below their advertised level of performance.

The data in Table 2 provide additional information about the relative performance of the five brands of a-Si modules. In the case of the high performing brands, all three began the process with a maximum power output that exceeded the nominal 14 Watt rating on their nameplate. As expected, the performance of all of the brands dropped over the first few months of exposure to the sun, and the final performance for the three top brands is consistent with the performance of modules that have a maximum power rating at standard test conditions of 12 Watts.

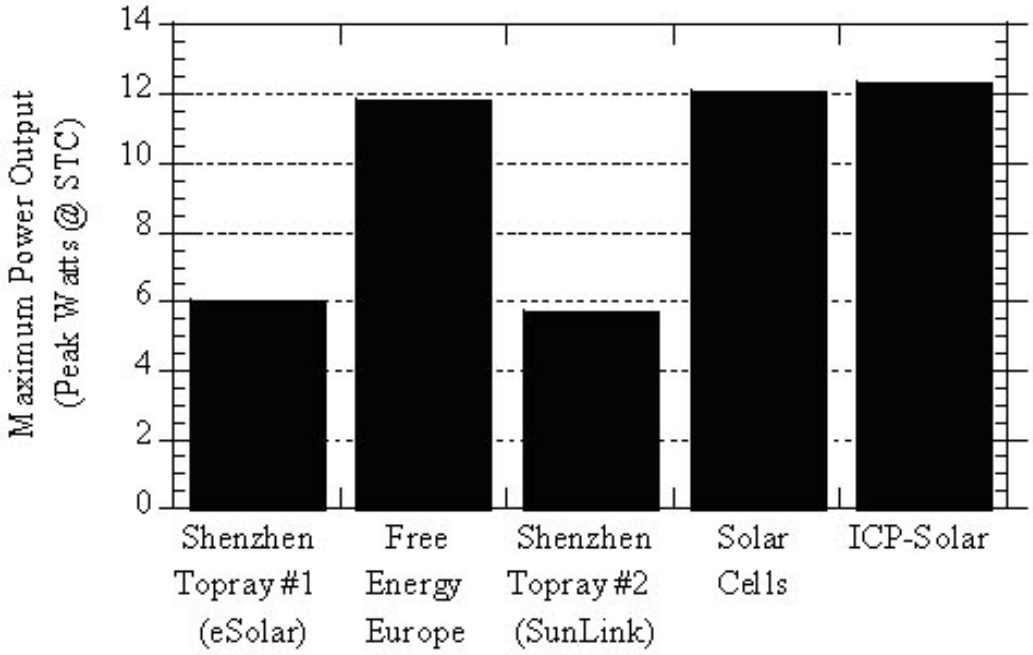


**Figure 1. Average Stabilized Maximum Power Output for Five Brands of Amorphous Silicon Solar Modules Sold in Kenya**

It is important to note that the relative performance of all three of these brands is statistically identical. In other words, although the average performance of the four ICP-Solar modules tested in the study (12.3 Watts) was slightly higher than the performance of the Solar Cells (12.1 Watts) and the Free Energy Europe (11.8 Watts) modules, these differences are well within the margin of error of the measurements methods used in the

study. Therefore, we cannot be certain, based on the tests carried out in this study, which of the brands has the highest performance. We would need to test more modules in order to determine which brand gives the highest power output.

One additional significant point is that, while the maximum power output of a solar module under standard test conditions is a key indicator of performance, other performance parameters such as durability and longevity are also important. In this area, Free Energy Europe deserves special credit for the high performance of its "C-version" a-Si module, which has passed the rigorous set of tests required for IEC certification.

**Table 2. Summary Performance Results for Five Brands of a-Si Solar Modules**

| a-Si Brand | # Modules in Original Sample | # Failed Modules (Mar 05)* | Avg. Initial Performance (Wp, STC) | Avg. Final Performance§ (Wp, STC) |
|---|---|---|---|---|
| Shenzhen Topray #1 (eSolar) | 4 | 3 | 9.1 | 6.0 |
| Free Energy Europe | 4 | 0 | 14.9 | 11.8 |
| Shenzhen Topray #2 (SunLink) | 4 | 1 | 9.1 | 5.7 |
| Solar Cells | 4 | 0 | 15.2 | 12.1 |
| ICP-Solar | 4 | 0 | 17.3 | 12.3 |

* Failed modules are defined as those with a maximum power output below 1 Watt.
§ The average final performance is based on the maximum power output of all "working" modules (i.e. modules that had failed outright were excluded from the sample for the purpose of estimating the average final performance).

As noted above, the performance of the two low performing brands is well below their advertised nameplate ratings. The average stabilized performance for both lines of Shenzhen Topray a-Si modules was approximately 6 Watts, which is well below acceptable levels for 14 Watt rated modules. The low performance of these modules may be caused by impurities introduced during production or other quality control problems in the manufacturing process.

In addition to low power output, we observed problems with module failure for both lines of Shenzhen Topray a-Si modules. In the case of the modules sold under the eSolar brand name, three of the four modules failed completely during their first few months on the test rack. One of the four modules sold under the SunLink brand name also failed during this time period. These failures appear to be caused by water intrusion that led to delamination of the active material of the a-Si modules. See Figure 2 for an illustration of this delamination.

**Figure 2. Water Intrusion Related Delamination in a Shenzhen Topray a-Si Solar Module.**

## Response to Study Results by Kenyan Companies

To its credit, Kenital – the company that marketed the Shenzhen Topray amorphous silicon modules under its eSolar brand name – has responded to the results of this study by discontinuing sales of these low performing modules. Kenital is now importing and distributing the Croatian made "Solar Cells" a-Si modules, which it markets under the eSolar brand name. It is therefore important to note that while Kenital continues to sell a-Si modules under the eSolar brand, these modules are now a high performing product.

Electric Link, the other company that has been importing Shenzhen Topray modules, has agreed to suspend imports of these modules. However, they have continued to sell their remaining stock of these modules under brand names including "SunLink" and "SunSolar." Given the extremely low performance of these modules, I strongly recommend against purchasing them, and I urge Electric Link to discontinue sales of this product. Resumption of sales of the Shenzhen Topray brand should proceed only when they achieve acceptable performance levels that are confirmed through independent tests.

## Conclusion

To summarize, in this article I present test results from 2004-05 which indicate that the majority of the brands of a-Si solar PV modules sold in Kenya perform well, and they remain a good value for their price compared to crystalline PV modules of comparable sizes. Free Energy Europe and Solar Cells brand modules deserve special mention for their long track record of producing consistently high quality goods, while ICP-Solar merits credit for significant improvements in recent years. Our measurements indicate that the power output of these three brands is now similar, with each delivering approximately 12 Watts of power under standard test conditions (STC). However, we also found that modules imported from the Shenzhen Topray Solar Company performed well below their advertised levels. This information should be made widely available to the Kenyan public so that they will know which brands perform well and which perform poorly. If this sort of performance information is not disseminated broadly, the overall

performance of the solar market as well as the interests of the Kenyan public may suffer due to the persistence of low quality brands in the market.

The results of this study also demonstrate the need for an ongoing testing program to verify the quality of solar equipment that is sold in Kenya. Such a program should include testing for solar modules as well as for other products such as batteries, charge controllers, lights, et cetera. In my view, the solar energy research laboratory under the direction of Dr. Mwamburi of the Physics Department at Moi University in Eldoret offers a promising Kenya-based site for such testing. Over the coming years, I intend to do my part to help make this center a reality.

Until next time, *kwaherini*, and remember to send me letters at my NEW email address (arne@humboldt.edu).