Thin-film PV in Israel – Simulation vs. Reality

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In the drive for grid parity, the thin-film technologies seem to be in the driver's seat. Recent drops in the price of crystalline silicone panels would seem to counter indicate this statement; however the crystalline pricing is heavily affected by a market fueled by subsidies and other unnatural influences including dumping panels on the market at submarket prices. Any reasonable analytical comparison of the manufacturing process for these two technologies will conclude that a thin-film panel must come off less expensive than the energy intensive, multistage process required to produce crystalline silicon panels.

Indeed, financial calculations made using thin-film technologies seem to show grid parity arriving quicker with a greater probability of being correct then any calculation based on the volatile crystalline market. Any financial equation basically has two sides, the cost of the system vs. the income from the system. When dealing with the income from the system, the financial calculation depends on input from a solar simulation program that can accurately project what a given PV array will output to the grid.

Over the years, PV engineers have learned to trust these programs after finding that the simulation results match the final results delivered after a simulated array has been built and run for a year. The accumulated experience of the market over the last 40 years is dominated by crystalline silicon technology. Thin-film technologies are relatively new, as such, experience with simulating PV arrays built of these technologies is also relatively new.

Typically, a thin-film panel is less efficient in converting solar radiation into power than a crystalline silicon (Csi) panel, thereby requiring more surface area for the same power rating. Greater surface area requires more land and more balance of system costs. Thin-film marketing forces make the statement that these higher costs for BOS are offset by the lower price of the panel and the higher energy yield for the same power rating.

The thin-film marketing in Europe and the USA claim that for the same installed power (kWp), thin-film will produce more energy (kWh) over the same time frame. This factor, along with the lower price, makes the financial argument for using thin-film technologies.

The Israeli experience in PV begun only a few years ago; importing all products, engineering and experience from the European market, primarily Germany and Spain. Market experience from these countries indicated that thin-film should reign supreme in the hot dry Israeli climate, citing the lower temperature coefficient along with the higher kWh/kWp. Many Israeli contractors installed thin-film technologies for these reasons and found that the end result was not as predicted. The overwhelming majority of those who have installed thin-film in Israel are disappointed with the yield of their plants.

The only exception to this statement is by those who installed thin-film products of amorphous silicon, incidentally the oldest, most mature of the thin-film technologies.

The problem is not that these technologies are producing less than the same installed power of cSi, the problem is that the simulation programs seem to predict only what the marketing forces are saying, and not what is actually happening.

To quantify the problem I present a case study based on a commercial 50kWp array comprised of 22kWp thin-film and 28kWp of cSi. The array under scrutiny is shown in Figure 1.

Figure 1: A commercial 50kWp array comprised of both thin-film and cSi technologies

The thin-film technology used is Cadmium Telluride (CdTe), the cSi is a polysilicon product. The same series of inverters are used for both sides of the array, a 9kW for the Csi and an 8kW for the CdTe. The time frame for the study is from July to December, presenting a 6 month cycle indicative of all solar paths over a twelve month period. In order to compare the output as technologically driven, the data was normalized to kWh/kWp/day.

The results of the simulation of the two technologies are shown in Figure 2. It is clear that according to the simulation, CdTe is performing better than the cSi.

The results from the field of the two installations are shown in Figure 3. It is clear that the cSi is performing better the CdTe.

Figure 2: Simulated data normalized to kWh/kWp/day

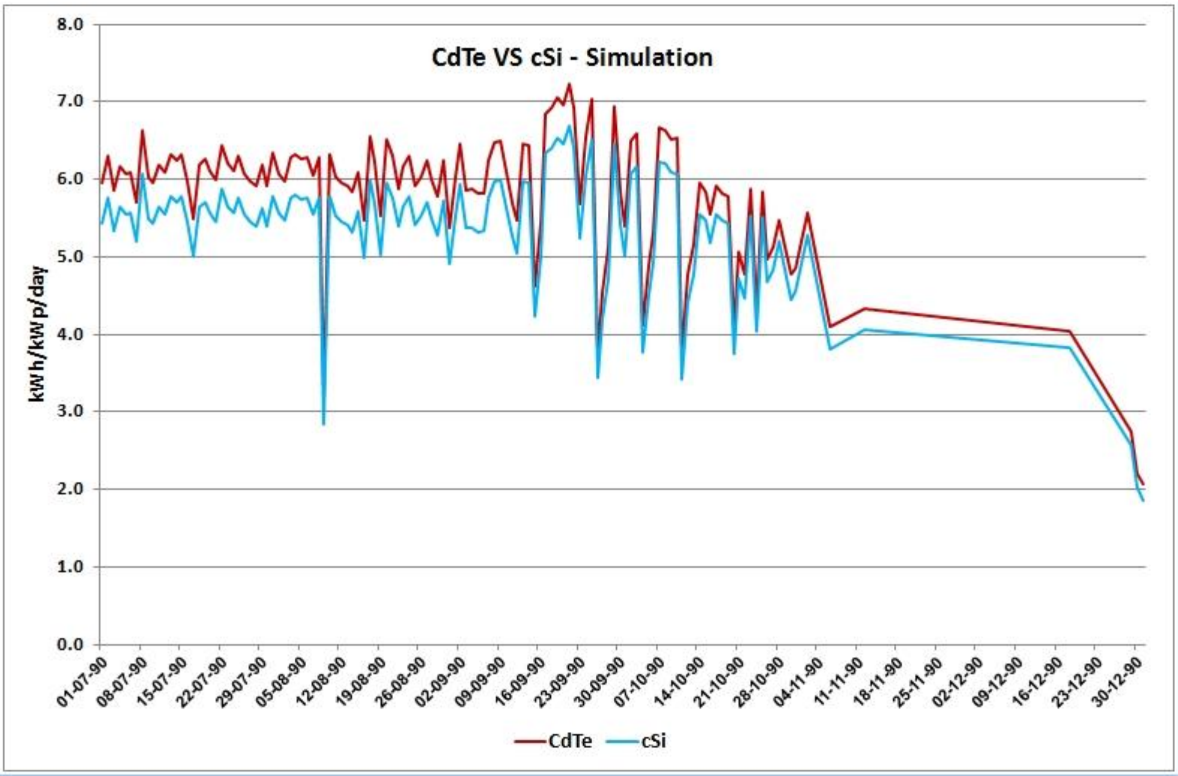
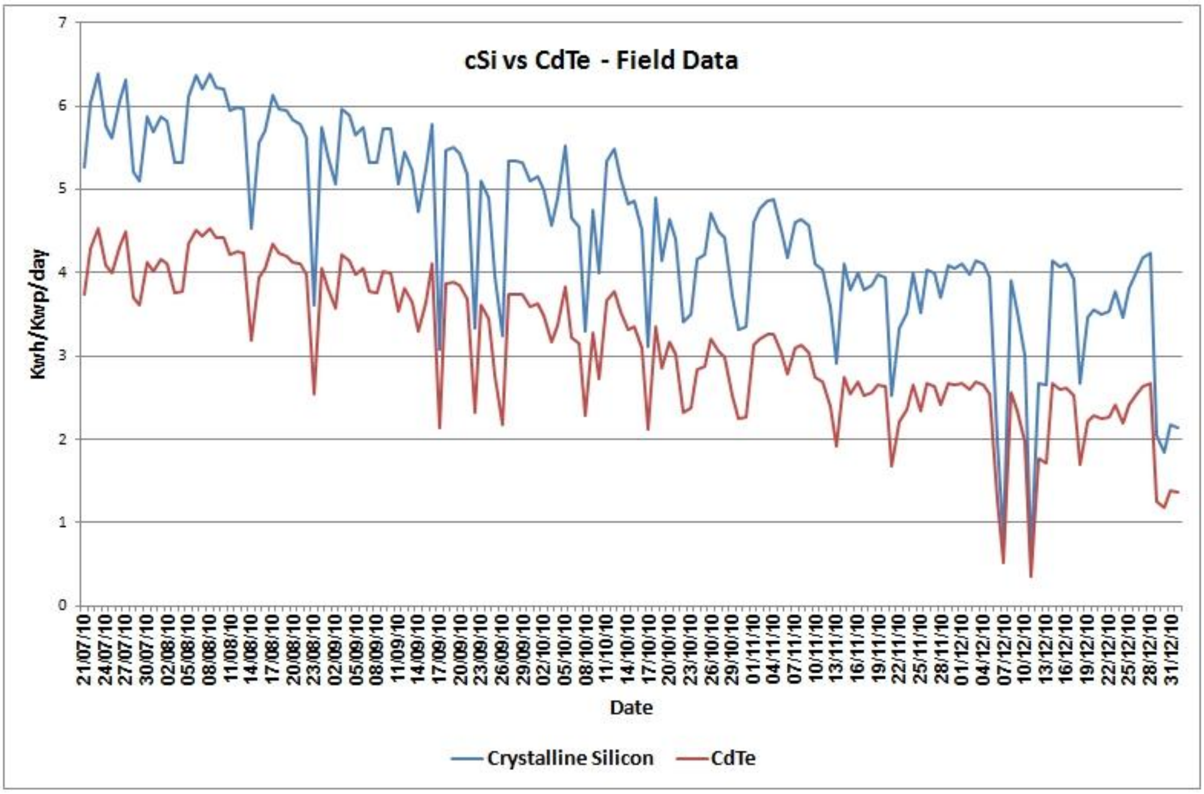


Figure 3: Actual data from the field normalized to kWh/kWp/day



The fact that the cSi is outperforming the CdTe, or that the CdTe is underperforming the cSi is not the issue. The issue is that the simulation program, while quite accurately rendering the performance of the cSi, erring on the conservative side, the

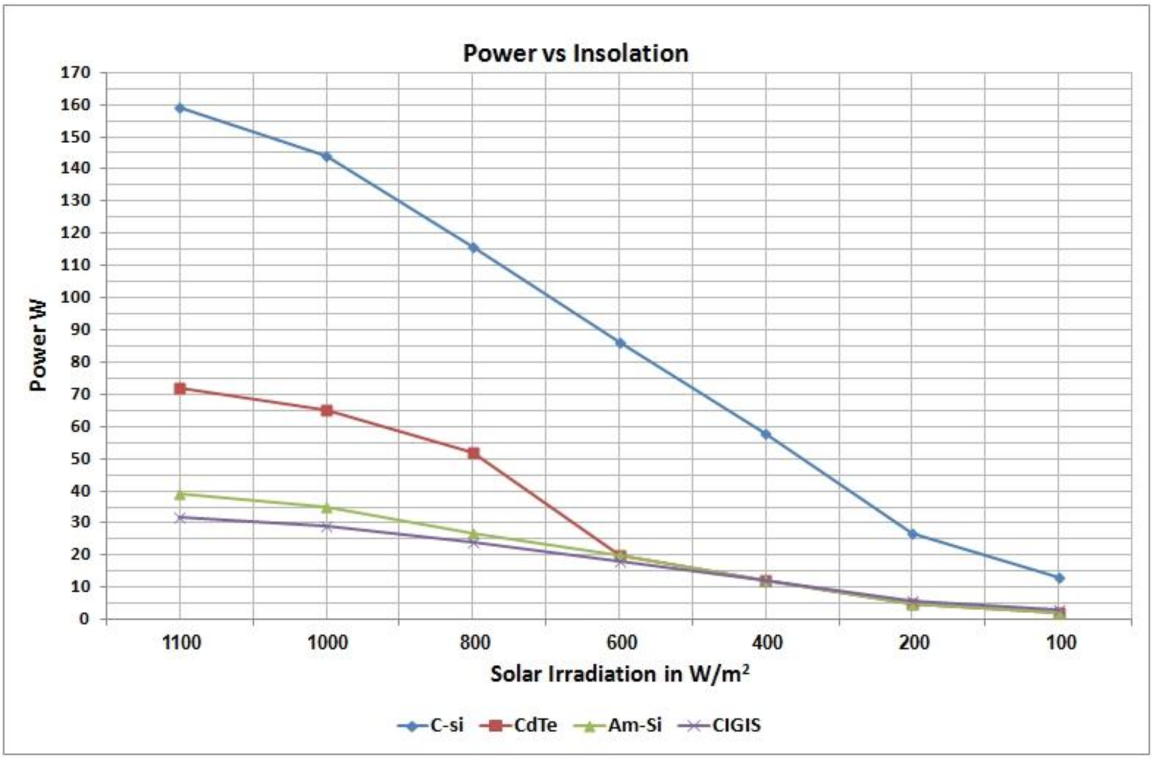
CdTe is rendered almost 50% higher than the field data. No developer would complain if his PV array produces more than his economic forecast predicted, under producing, on the other hand is a serious problem.

How can we account for this anomaly? Why are the simulation programs erring? Ongoing discussions within task 13 of the IEA-PVPS reveal that the thin-film technologies are still developing. Both the technologies themselves and the production process for producing the end product are still developing. That owners of amorphous silicon thin-film are not party to the dissatisfaction in this market can possibly be partly attributed to the relative maturity of this particular technology.

The term "thin-film" is a general term for all PV panels produced by applying a thin-film of photovoltaic material on a substrate, as opposed to the older mature method of producing crystalline silicon wafer cells, then arranging these cells in a frame for installation. It is not intuitive, therefore, that the thin-film technologies are very different one from the other.

It is instructive to see how the different technologies relate to solar irradiation of different intensity. Figure 4 is a graph built from the data supplied in a research paper prepared by the University of Arizona attempting to validate the IEC-6183 standard for PV performance in natural light conditions. The graph presents three leading thin-film technologies as they relate to the base line cSi. The power difference is not as relevant to our discussion as is the shape of the curve.

Figure 4: Thin-film Technologies – power vs irradiation for a single panel



It is clearly evident that the CdTe relates to sunlight very differently than does the cSi. The rate of change over the rising irradiation is by no means parallel.

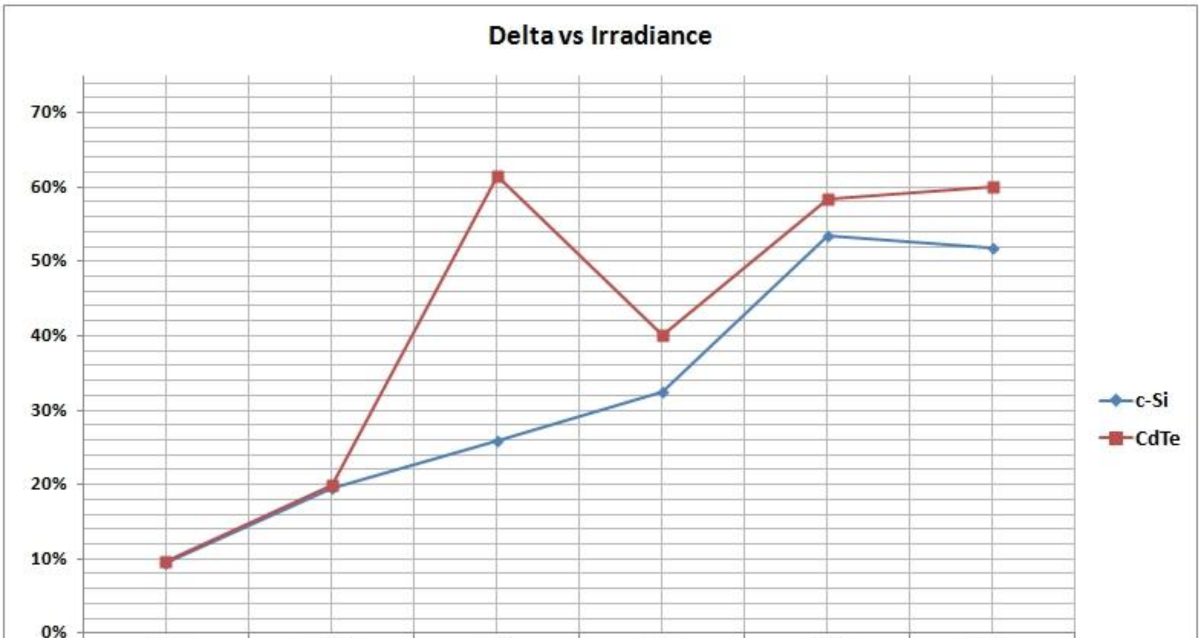
It is important to note that this test was done in Arizona, an area known for clear skies. Here in the Middle East, we are part of what is known as the “African Dust Belt”. The dust in the atmosphere must have an effect on the spectral response of the irradiance as opposed to in Arizona.

The spectral absorbance of the thin-film panels is different for each technology and from that of crystalline silicon. Our atmosphere produces a spectrum different from that in Europe and the western deserts of the USA.

Figure 5 presents the par between the power of the cSi module and the CdTe module as they experience greater irradiance. It is interesting to note that the largest difference between the power production of these panels occurs in the range of 600 – 1000 w/m^2 .

As opposed to Europe, this range accounts for 45% of the sun hours in Israel. It is likely that in Europe, this range does not enjoy such prominence. Once again, this data is from Arizona, land of clear skies.

Figure 5: Power delta between cSi & CdTe with rising irradiance



	1100	1000	800	600	400	200
c-Si	9%	19%	26%	33%	53%	52%
CdTe	10%	20%	62%	40%	58%	60%

Solar Irradiance W/m²

We have defined the problem; we have taken a small look at the technologies. The question now is how we can validate the use of thin-film technologies in Israel. The answer is obvious; when the simulations reflect the production.

The IEA-PVPS task 13 is currently studying thin-film technologies as they pertain to the efficiency and reliability of PV systems. Subtask 1.3 is dealing with failure analysis and will include a study of thin-film PV arrays in operation in much the same way as the case study brought above, while subtask 3.1 will provide the status of ability to measure power rating of thin-film PV modules and compare module performance data from modules deployed in a variety of climates to identify patterns of behaviour. Subtask 3.2 will provide information on module performance and failures in the laboratory and in the field in order to learn more about real module failures and failure statistics.

In order to successfully bring about a change in the testing and simulating of thin-film systems, we must study as many systems as possible in Israel, in order to ascertain to what extent and for what reasons the Israeli experience is so negative.

All owners of thin-film systems are encouraged to contact the author in order to arrange to have the system defined for simulation and then monitored for a period of time such that a data base of thin-film use in Israel can be developed. This study together with the activities of subtask 3 with data from Israel included alongside that of other countries will lead to enough information to feed the developers of simulation programs with the data necessary to make simulation of thin-film in Israel as useful as the simulations currently used for crystalline silicon panels.