1B: Materials Selection
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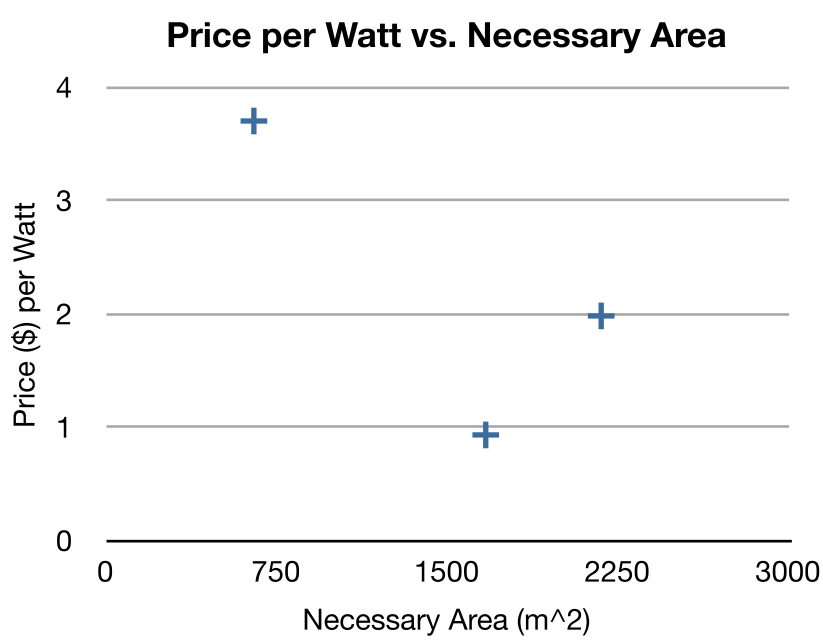
Necessary for a significant integration of solar energy into U.S. energy usage is a solar cell materials selection that considers materials availability, technological progress, sustainability, and economic and social constraints:

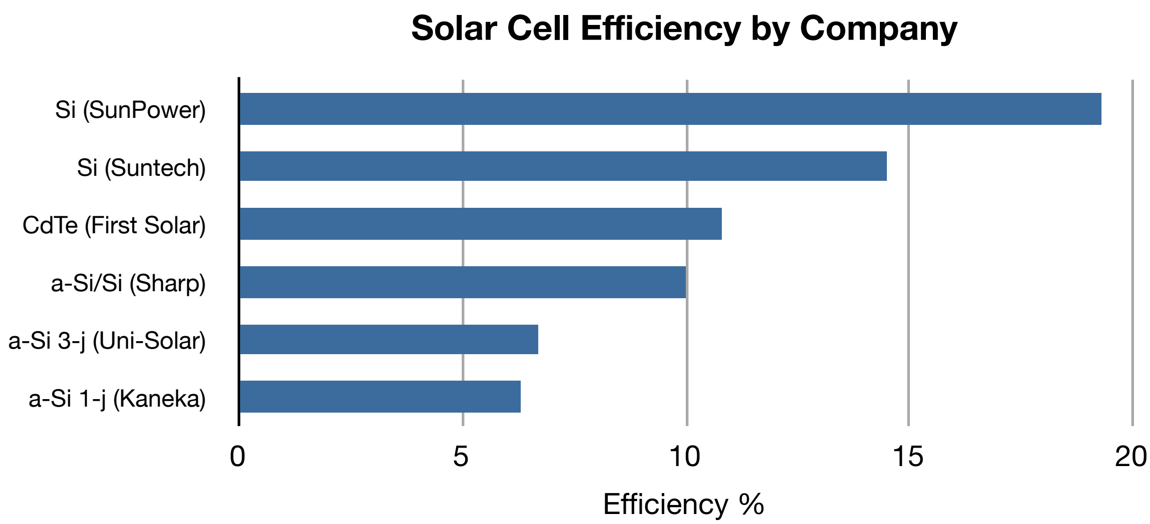
Solar cells generate electricity beginning with the absorption of photons of light by the semiconductor. This photon energy promotes electrons from the valence band to the conduction band, creating free negative charges in the conduction band and floating positive holes in the valence band. The output of the solar cell, its voltage, is generated by the movement of these charges. The doping of a material can increase these free charge carriers, and, therefore, increase the voltage. To further maximize a solar cell's output, the semiconductor material should effectively trap light by having high absorbance and low reflectance, which can be achieved with an anti-reflective coating, and should have as high a band gap as possible.

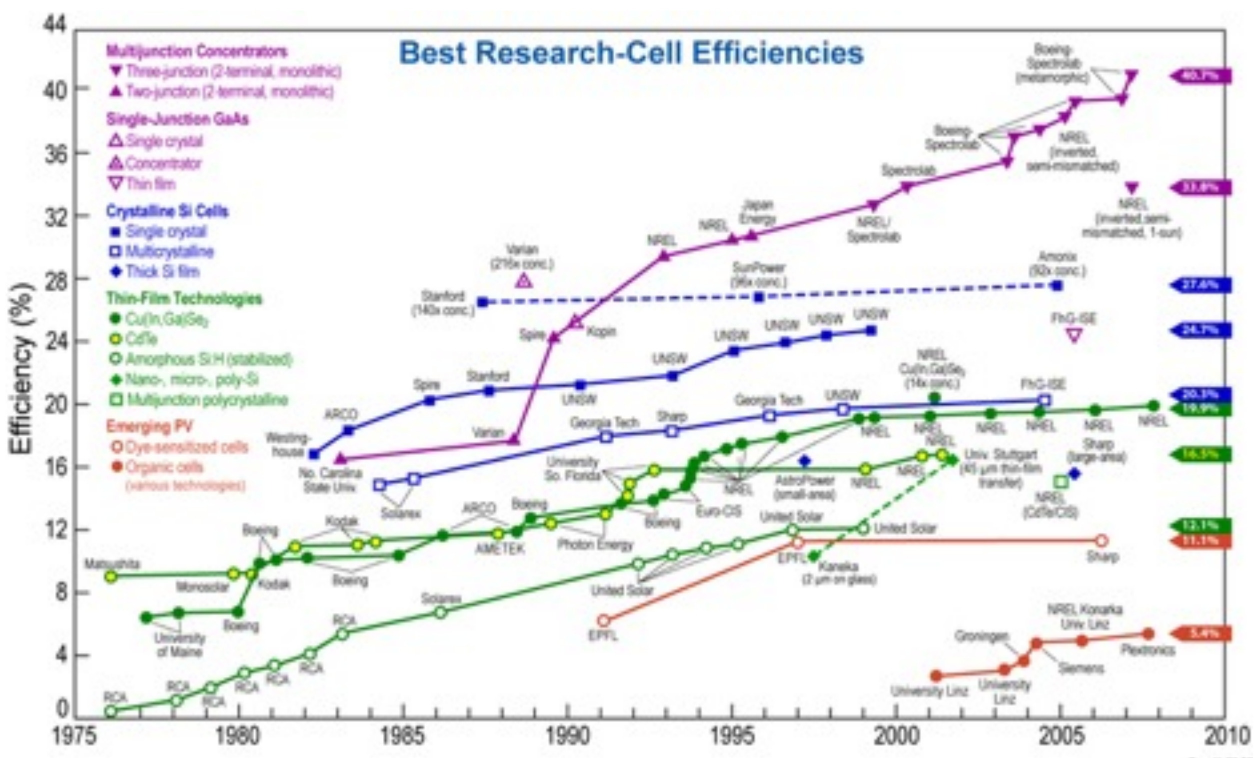
An analysis of the current solar cell market shows three basic categories of commercial solar cells: crystalline silicon, thin film amorphous silicon, and thin film cadmium telluride, all with various efficiencies. Working based on values of 725,000 MW and 600,000 MW for the peak and base loads, respectively:

	W/m^2	area (km^2)	$/W
Si (Sun Power)	193	648	3.7
CdTe (First Solar)	75	1667	0.93
a-Si (EPV Solar)	57.5	2174	1.98



Because silicon cell technologies are more developed, commercial silicon cells have higher efficiencies, and converting to solar energy using crystalline silicon panels require less energy for equivalent outputs. But, the costs to create these cells is significantly larger than the cost to create thin films, because of the larger volumes of semiconductor material needed. Because cadmium telluride thin films cost significantly less, even though their efficiencies are also less, to effectively move the US towards solar energy would be best done with CdTe films. The future of solar is within thin films because, even though efficiencies are about 10% less than traditional crystalline silicon, current technological research and progress are continuously increasing these values.





CdTe photovoltaic cells generate energy similar to silicon with a p-n junction (and, therefore, voltage) created by adding CdS. Because it's band gap is 1.44 eV compared to silicon's 1.12 eV, CdTe cells are more effective at converting light energy to electrical energy and are more suited to the solar spectrum. There exist concerns about the toxicity of cadmium, but cadmium's solubility in water is low, and proper encapsulation and recycling programs inhibit the introduction of cadmium into the environment. In fact, isolation in solar cells maybe an efficient way to deal with cadmium produced as a byproduct in manufacturing. In terms of materials availability, the supply of silicon is extremely large (silicon is the second most abundant element in the Earth's crust), the supply of cadmium is relatively moderate, but the supply of tellurium is perceived as low. The reason for this low supply is the lack of use of tellurium: silicon is widely used the electronics industry, and cadmium is used in the creation of certain batteries, and so their supplies have been explored and expanded. Tellurium has only recently been investigated, and so its supply is naturally less. Based on the data above, though, an area of 1667 m^2 is needed whose value corresponds to 16.7 m^3 which equals 97500 kg of CdTe necessary. Since CdTe is 53% tellurium, 51675 kg are needed. According to the US Geological Survey, the US has 9000 metric tons of tellurium in reserves or reserve bases, more than enough to cover the tellurium needed of this industry.

For a solar cell material that is relatively abundant, has a sustainable life cycle, continues to progress technologically, and is best suited for the economic constraints of our time, cadmium telluride is the best choice of semiconductor material.

Sources

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