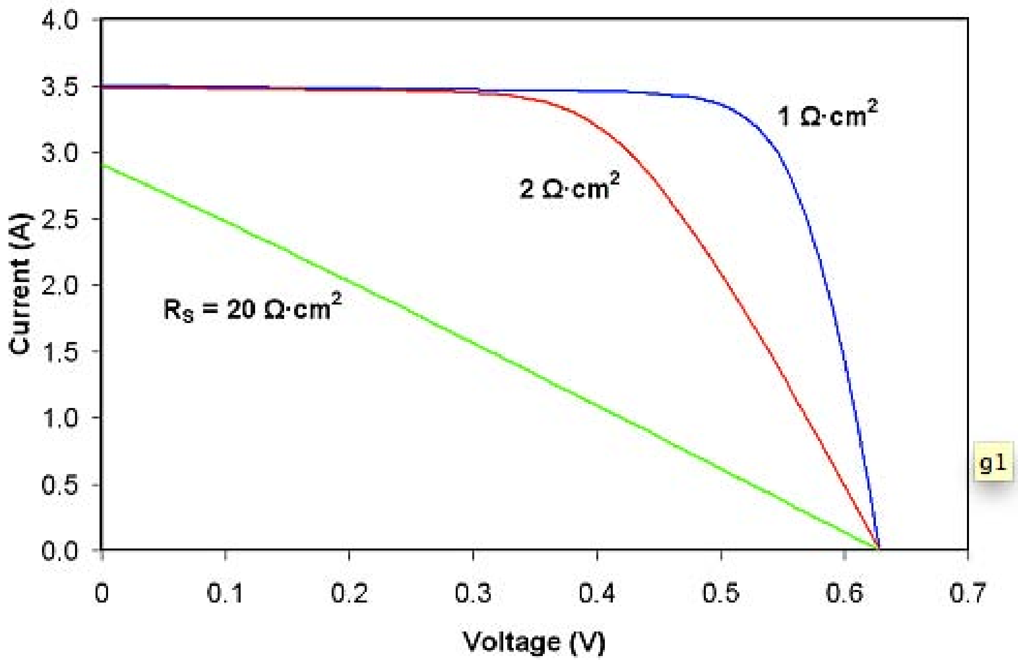
Project 1B
Student A, Student B, Student D

At a high level analysis, it is important to decide what main material to use in order to provide a 'cradle-to-grave' sustainability profile and performance to meet constraints. The materials chosen have to have various physical properties – it has to be able to handle the thermal pressures, corrosion, etc. Also, it has to have the material properties to be able to absorb light from the highest range of wavelengths and further trigger the flow of electrons to produce electricity. Looking at the properties above, silicon is usually found to be the best material to be used. It can provide a maximum efficiency of around 22% and is one of the most abundant materials in the earth's crust – it makes up 27% of the crust, therefore, its extraction is easy. For local power generation, this is a great material to use because its ability to handle various stress levels allows it to be used in obscure places in cities and it can survive on low maintenance. Silicon is also non-toxic, meaning it is safe over its entire time of deployment. In order to meet constraints specified earlier, it is necessary to have a thorough study of all the materials used. Using thin-film silicon has benefits such as lower production costs and implementation techniques (due to weight and flexibility). However, bulk has a greater efficiency and ability to absorb more light. Bulk silicon wins over thin film in absorption, charge collection (due to its thick structure), and light trapping. 85% of market share goes to bulk silicon and 15% to thin film cells, so that is experimental data that researchers worldwide have found bulk silicon to be more effective. Of course, it is possible to try a combination cell to increase the peak[i]. Current extraction and reflectance seem to be the same from my research, depending simply on other properties. To narrow down the scope a little, it is necessary to determine which sort of bulk silicon is best to use—monocrystalline silicon, polycrystalline silicon, or ribbon silicon. Ribbon silicon, which has flat films stacked together, saves cost but compromises efficiency (though it does not waste silicon). Polycrystalline cells are the most efficient, and in fact, they are also the cheapest and avoid the expensive Czochralski process. One thing to consider, however, is the efforts currently being made in the field of thin film solar cells, especially by researchers in China, driving the cost down below that of bulk silicon. This could be a factor to consider as more developments are made in the field of thin film, and it is also a strong argument for *combining* the two as suggested earlier.

Graph of silicon solar cell efficiency evolution removed due to copyright restrictions. Please see slide 118 in "Year 11 Preliminary Engineering Studies Focus Module:Photovoltaic Engineering." *Engineering Studies Package.* UNSW School of Photovoltaics & Renewable Energy Engineering, 2010.

The upward trend of silicon solar cell efficiency leads one to believe that it will be better than alternatives such as cadmium telluride, copper indium, gallium arsenide multijunction, and organic/polymer.

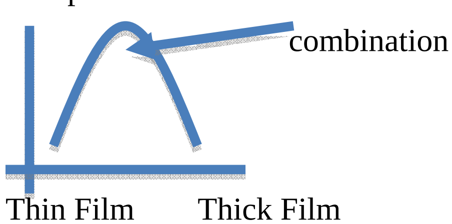
To narrow down the process it is important to consider the substrate to use. Solo Loco believes that it is advantageous to pick a substrate determined by the surroundings in each individual location. Glass is usually easy to clean, compared to plastics. However, tempered glass cannot be used with amorphous silicon cells because the temperatures are too high. These kinds of constraints will affect the choice made. However, glass (not tempered) is better than metal, while plastic is cheaper than both. In low income areas it is better to use plastic and in larger scale setups I recommend glass. The benefit Solo Loco has is its ability to customize to maximize efficiency wherever it sets up. The semiconductor will consist of a p-n junction, basically a setup matching of phosphorous doped silicon and boron doped silicon—this will create a difference in Fermi levels which will be the creator of voltage. For the AR coating, research trends have leaned towards replacing titanium dioxide by silicon nitride, since it protects the solar cell surface from carrier recombination, which would cause a loss of voltage. Vapor deposition would be used to put in a layer of silicon nitride coating, visible as a bluish tinge on the wafer. There is a newly developed option of creating a textured surface instead of a traditional antireflection coating, but that has not been researched enough yet to be represented here. In class, we got to look closely at the contact metallization on a solar cell from Evergreen Solar. This showed us how the design could be used to create electrical contacts for reading and studying voltage as well as for the final usage of the device. The E-shaped design could also be made more grid-like. A typical semiconductor absorber has a Bragg mirror in order to maximize back reflectance and thus efficiency. These require a good passivation device for the surface to increase lifetime and thus it increases the appeal for silicon nitride as the AR coating, since it increases surface passivation and decreases carrier recombination. Overall, efforts to decrease resistance should be made by taking care of detail—this will reduce energy loss of the system.



This shows that the decrease of resistance will drastically increase performance.

---

[i] Graph is as follows:



3.003 Principles of Engineering Practice
Spring 2010