

# Solar Panels and Their Energy Output

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## What is the relationship between different solar panels - monocrystalline, polycrystalline, and thin film - and the amount of energy output?

### Purpose:

My study will examine the energy output from different types of solar panels – monocrystalline, polycrystalline, and thin film – to help the Palo Alto Airport become 100% solar energy sustainable.

### Background & Significance Research:

Solar panels are links of photovoltaic cells made of semiconductive materials (silicon) used as a circuit field to convert sunlight into energy.

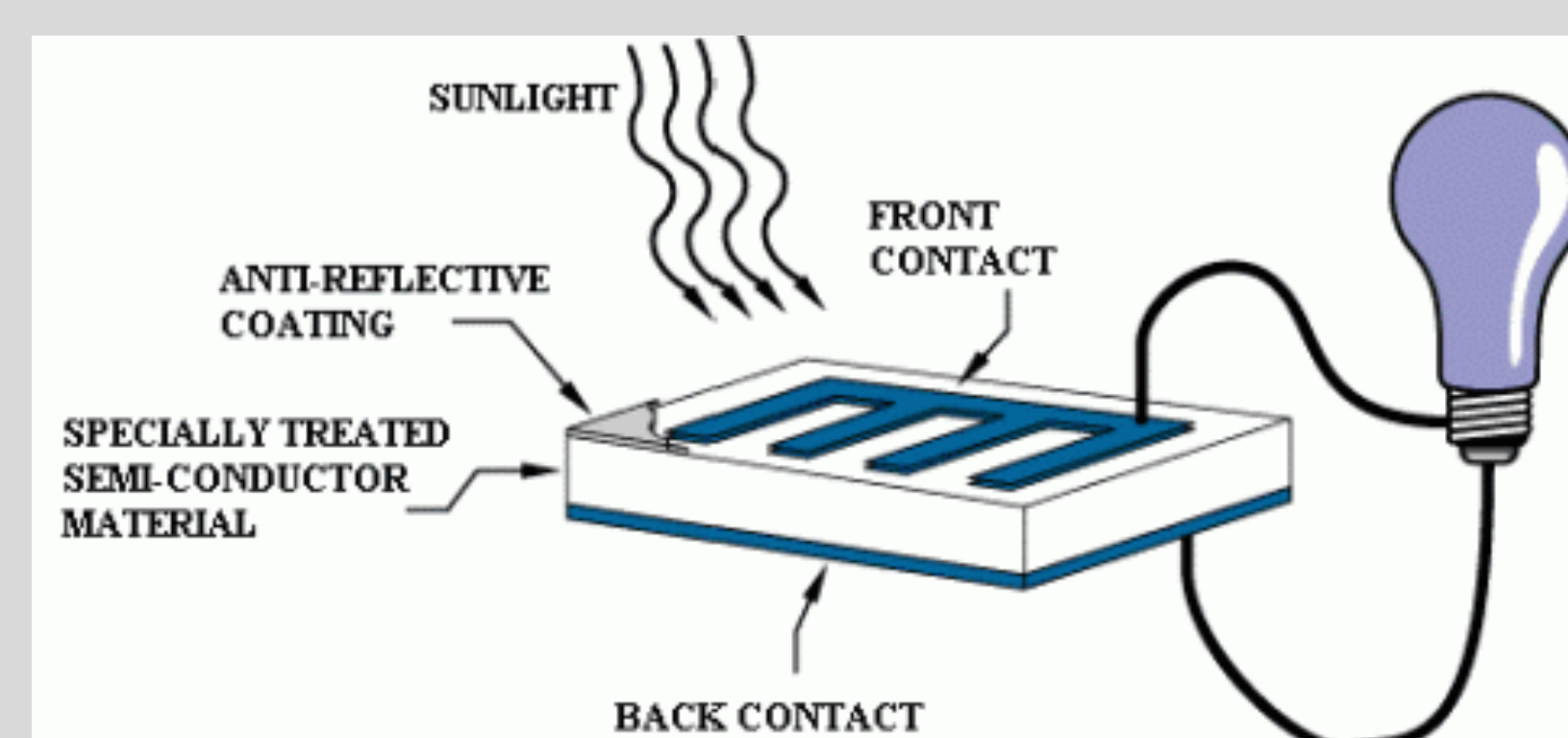


Fig 1. This diagram shows how a solar panel works.

Monocrystalline	Polycrystalline	Thin Film
High efficiency rate Long life span Expensive Not recyclable	Less expensive Low heat tolerance Lower efficiency	Mass produce Requires space

Fig 2. A table that contains pictures of the three different types of solar panels and their pros and cons.

Researchers use transparent conductive oxides in coding thin-film silicon to create high optical transparency, high electrical conductivity, and a rough surface to scatter light. Panels help to create a healthy environment and help reduce electricity costs.

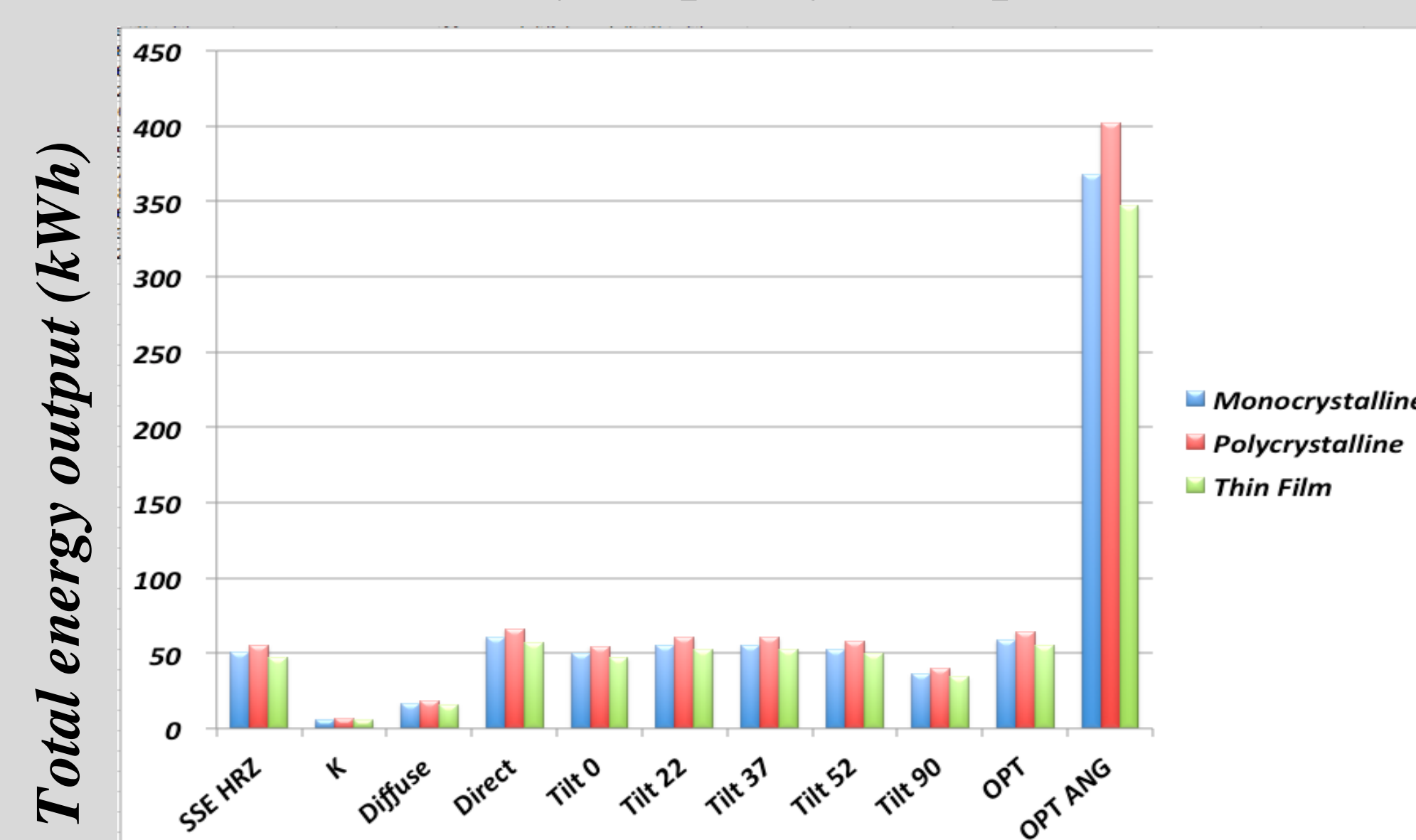
### Research Methodologies:

The equation  $E = (A)(r)(H)(PR)$  was used to calculate the total energy output of solar panels located in Palo Alto using area, solar panel efficiency, annual average solar radiation on tilted panels, and the performance ratio. NASA's website provided the annual average solar radiation on tilted panels for Palo Alto (coordinates: 37.4419° N, 122.1430° W). ENF Solar provided the percent efficiency of the solar panels. (Average efficiency: Polycrystalline - 14.76%; Monocrystalline - 16.0%; Thin film - 13.8) The default value of performance ratio, for which is 0.75.

The average annual energy consumption between 2015-2016 is 5545.417 kWh (provided by the Palo Alto Airport) over total energy output of all tilted panels for all three solar panels to receive the value for the average area of solar panels that the airport will need.

### Data:

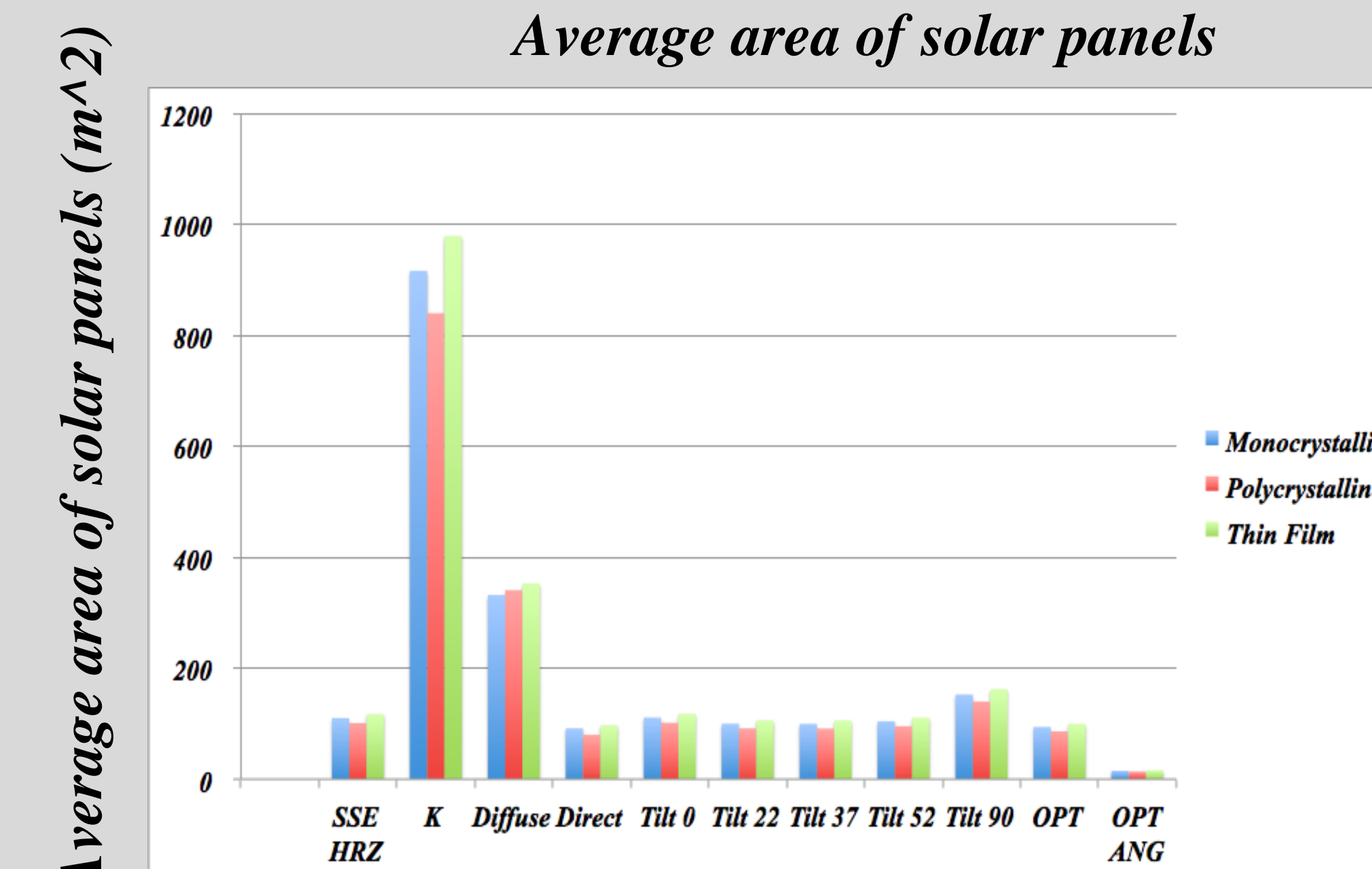
Annual average solar radiation on tilted panels vs. Total energy output of solar panels



Annual average solar radiation on tilted panels

Fig 3. A graph comparing the annual average solar radiation on tilted panels and the total energy output of monocrystalline, polycrystalline, and thin film solar panels.

Annual average solar radiation on tilted panels vs. Average area of solar panels



Annual average solar radiation on tilted panels

Fig 4. A graph comparing the annual average solar radiation on tilted panels and the average area of solar panels that the airport need for the three types of solar panels in order to equal the average annual energy consumption.

### Analysis:

The graph, figure 3, compares the annual average solar radiation on titled panels and the total energy output. It shows that polycrystalline has the highest energy output, and thin film has the lowest energy output. It also shows the result that the tilt that generates the highest amount of energy is OPT ANG, and the tilt that generates lowest amount of energy is K.

The graph, figure 4, compares the annual average solar radiation on tilted panels and the average area of solar panels that the airport need to generate energy equal to the average annual energy consumption. It shows that the tilt OPT ANG requires the least amount of area, and the tilt K requires the greatest amount of area.

### Conclusion:

Polycrystalline solar panels at OPT ANG are the best to help the Palo Alto Airport to be 100% sustained by solar energy because it generates the highest amount of energy and it requires the least amount of space.

- It can generate 402 kWh amount of total energy
- It requires 13.79 m<sup>2</sup> of the Palo Alto Airport Area

### Credits:

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4. Photovoltaic Software. "How to Calculate the Annual Solar Energy Output of a Photovoltaic System?" How to Calculate the Output Energy or Power of a Solar Photovoltaic System, Excel PV Calculator to Estimate Solar Electricity Output. Photovoltaic Software, n.d. Web. 26 Feb. 2017.

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