Design and Analysis of Concentrator Photovoltaic Systems

by

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ABSTRACT

Solar electricity is one of the most promising technologies for future electricity supply. It has been determined that if fossil fuels are continuously burnt at the rate they are today, the supply will be drastically diminished within one hundred years. If an alternative method of electricity generation is not created, the increased fuel prices, due to oil and gas companies trying to compensate for the loss, will be astronomical. However, even though these disastrous events might occur, it is important to take proper steps today in order to ensure a smooth transfer from fossil fuels to a renewable energy source.

There are many competing technologies which uses different methods and materials to convert solar energy into electricity. In order to provide sustainable and clean energy for terrestrial applications it is important to design low cost systems. For example, by using low cost concentrators, it is possible to reduce the overall cost of photovoltaic (PV) systems. This thesis discusses some of the design principles and strategies of concentrator type systems (CPV) for photovoltaic applications. By using plane mirrors and lenses it has been shown that one could increase the collection of solar flux incident on earth to the solar cells. It has been shown experimentally that by using two mirrors (1.5 times concentration level) the power output from a standard Silicon cell increases by 36%. In this work, we have designed a CPV system using Fresnel lenses and Compound Hyperbolic concentrators. This system need not track the sun to focus the light onto the PV device. Our study shows it is possible to achieve a concentration ratio of 400 and above using such systems which will require considerably smaller sized PV device, thereby lowering the cost of the overall PV system. A comparison of various light collection geometries have been presented in this thesis.