The Mathematics of Flux Calculations on Solar Panels

C. N. Christensen, M. Tomicic, J. S. Bach, E. L. Pedersen, K. B. Joanesarson, G. Saxe
DTU Mathematics, Technical University of Denmark

A solar power revolution

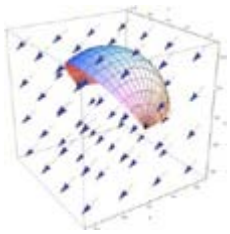
Solar power has always had a reputation for being expensive and a niche market. However in recent years developments in innovation and manufacturing mean that we could be on the threshold of a mass market breakthrough. Solar power could viably provide 20-25% of the world's electricity supplies by 2050 according to a report published by the International Energy Agency in 2010 [1]. Back in May 2011 Mark M. Little, global research director for General Electric Co., said that solar power may be cheaper than electricity generated by fossil fuels and nuclear reactors within three to five years because of innovations [2]. And perhaps most importantly, fresh figures from Bloomberg New Energy Finance show that the price of solar panels fell by almost 50 percent in 2011 – and they are now almost a quarter of what they were in 2008 [3]. In fact, solar power is now the fastest growing industry in America [4]. Being a clean, safe, sustainable energy source, this all makes solar power a technology that can hardly be ignored by all the nations and organizations that has set ambitious goals for green energy.

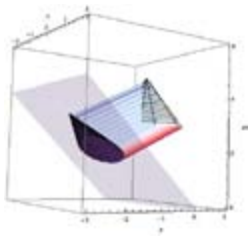
The future of solar power may be curved and 3-dimensional

In 2011 MIT Engineering Professor Jeffrey Grossman and his team set out to investigate the potential of 3D solar panels, inspired by the way trees spread their leaves [5]. Using a computer algorithm the research team "evolved" 3D solar panels all designed to take up the same base area [6]. The efficiency of these dynamic shapes was greater and much less affected by cloudy weather than regular flat panels using the same amount of ground space. And ubiquitous, 3D solar panels are exactly what the maturing industry of thin-film solar cells may be making possible.

Mathematical model, optimization and methods of flux calculation

Our presentation is based on a 3-week project from the 1st-year introductory course in "Advanced Engineering Mathematics" (Mat1). For a given configuration of curvilinear solar panels (perhaps on a building), which will be the optimal orientation for gathering solar energy over day cycle? What is the total energy absorption over a whole day? What problems exist in calculating the flux of energy in a solar panels and which methods exists for different types of surfaces? In designing a curved solar panel, what is the relationship between the curvatures and the efficiency? What things matter and doesn't matter? We have addressed questions of these kinds in our project by using a simplified model of energy absorption on a limited set of surfaces, namely planar surfaces, convex single-curved surfaces and convex surfaces of revolution, represented by parametric equations. We have investigated several methods, some of which are very specific to certain kinds of surfaces and lead to analytic expressions that yield mathematical insight, and some of which are more numerically inclined but generally applicable to a wider class of surfaces.





References

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