

# Is the Sunshine going to Waste? Harnessing Solar Radiation in Singapore

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The growing concern about global warming has led to a renewed interest in developing green technologies to better exploit alternative sources of energy. Owing to geographical limitations, many renewable energy sources like hydroelectricity, wind and geothermal energy are not accessible in Singapore. What is abundantly available, however, is solar energy. At 1.17° north of the equator, Singapore receives at least 11½ hours of daylight and more than 4 peak solar hours daily (1), totalling 1635kWh/m<sup>2</sup> of annual solar radiation (2). This is considerably more than that available to countries like Japan and Germany, two of the world's largest solar energy consumers, particularly during winter months (3). Not only does solar power reduce carbon emissions, it is also Singapore's best option towards fuel self-sufficiency and energy security (1).

Despite its potential, solar power accounts for a negligible proportion of the electricity generated in Singapore (4). The reasons cited for this are the high investment and running costs, long periods of delayed financial return, and the substantial cloud cover experienced locally (1,2,5). Solar power can be harnessed using solar heating panels, which are for the sole purpose of heating water, or photovoltaic cells, which convert solar energy into electrical energy.

Solar heating panels are sporadically located on the roofs of private homes and buildings and, on a larger scale, on the roofs of the Changi International Airport. Photovoltaic cells, which can be used within a single building or linked to grid lines, are found even less widely, in an exiguous number of test projects and buildings, so at the moment, painfully little of the plentiful sunshine of Singapore is being tapped.

Singapore is not the only country reluctant to employ solar energy on a large scale. The solar radiation that Earth receives from the sun has the potential to generate enough electricity to meet the world's energy requirements (3), but hesitation remains, mainly because of the high costs of manufacturing solar panels or photovoltaic cells and their low conversion efficiencies. In addition, while solar panels have a heating efficiency of up to 60%, current photovoltaic technology gives a maximum solar-to-electric efficiency of only 30%. Nevertheless, this is a big improvement from 10 years ago, when PV cells could only be made with 12–18% conversion efficiency (6). While rigorous research and development in the field has produced cells with increasing efficiency at

decreasing costs, with the promise of continuing progress in the years to come, solar-generated electricity still costs two to five times more than the current regular power supply from fossil fuel. Thus, at the moment solar power is generally viewed as being most useful only in remote areas where regular power lines are expensive to build (2,7).

However, there are countries that have successfully implemented the use of solar power on a relatively large scale. To offset the high initial costs, countries such as Germany, Spain, Italy, America and South Korea offer incentives like financial rebates to citizens and corporations who purchase and use photovoltaic cells (3,8). In Israel, the annual solar irradiance of nearly 2000 kWh/m<sup>2</sup> has been put to good use since 1980, when the 'Solar Law' mandated the installation of solar water heaters in all new buildings. Currently, solar panels are fitted on more than 80% of all Israeli households, and solar energy is extensively used in agricultural and commercial industries. As a result, even as the country's researchers pursue technology with higher efficiencies, solar energy now accounts for almost 5.2% of Israel's national energy consumption (4).

Even without financial incentives, places including Japan, Hawaii and Northern California boast low costs of



Another wasted day?

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subscribing to solar power, which can be as competitive as local grid power supplies (7). This is because research in the development of solar technology has advanced rapidly in the past decade—literally 'green' cells are being developed to mimic photosynthesis for the production of valuable bio-fuel. Boeing-Spectrolab has unveiled a solar concentrator cell which has a solar-to-electric conversion efficiency of 40.7%, and can produce electricity at a cost of 16–20 cents per kilowatt hour (kWh) (9). Photovoltaic 'balloons' are also expected to debut in 2010 at \$3.40 apiece, harvesting solar energy at 3.4 cents per kWh (10). This is vastly different from the current levels of conversion efficiency that led to the

trepidation of economic inefficiency. Even after taking into consideration initial installation costs, the price tag is also not much more expensive than the current cost of 21.15 cents per kWh that domestic users now pay for fossil-fuel generated electricity in Singapore (11). The economic viability of solar power is also likely to increase as oil prices climb.

The development of solar technology holds an unmistakable promise for environmental and economic sustainability, given the rapidly rising demand for solar power (12) in the wake of mounting concerns over the effect of carbon emissions on global warming and a growing consumer conscience. The potential for economic returns has only recently become sufficient to tip local decision in favour of solar

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photovoltaic cell research and development (13). However, it is still insufficient to favour the actual use of solar cells. Singapore's earliest plans for photovoltaic cells in a new shopping mall and public housing are for 2009 and 2011 respectively (14,15), and no further action towards encouraging a more widespread use of solar panels have been reported.

It is uncertain how far the solar power movement will progress while its main support comes from the environmental conscience of individual consumers and corporations. It is therefore necessary to disseminate consumer-friendly information easing fears about the costs and efficiency of solar power. Providing financial assistance or recognition would also help to further promote its widespread use (16). To date, the only incentive in Singapore is the Building and Construction Authority's Green Mark Scheme, which was launched in January 2005 to move the construction industry towards more environmentally friendly buildings, in both retrofitting and new construction projects. However this policy does not guarantee that the use of solar power in particular will increase (17).

The meticulous research that has been planned and proudly announced in the media will undoubtedly help to enhance the conversion efficiency and lower the cost of photovoltaic cells, but the existing solar heating panels and photovoltaic cells merit some attention, and could be more extensively advocated. Research may help to optimize and capitalize the technology that is finally used on rooftops, but also wastes a good many years of potentially useful solar energy during the time-consuming research phase.

In the meantime, another device that can harness solar radiation is the chloroplast. At present, roof gardens are more popular than solar cells because of their aesthetic value and lower cost. They can also contribute positively to the local environment, and are a good substitute for the ground cleared to make way for buildings. Roof gardens exploit not only light, but also heat, and in an urban setting have been found to be beneficial for the thermal environment, as they help to keep the surroundings cool (18). Growing food crops that require warm temperatures and long hours of sunlight on rooftops is thus an effective way to help channel both light and heat from solar radiation to good use, with potential financial rewards and greater crop self-sufficiency (19). Successful projects have been carried out in countries

such as Singapore and Australia, and the encouraging results should pave the way for filling more rooftops with plants. While roof gardens are increasingly being incorporated into new building designs, however, old buildings are not refurbished to make way for them, leaving most Singapore rooftops barren.

Although recent government efforts have addressed a wide spectrum of environmental issues including recycling water, with the aim to be self-sufficient by 2061 (20), and increasing the efficiency of electrical appliances, Singapore's most abundant natural resource should not be left idle any longer. Singapore has prided itself on being a garden city, but the density of plants does not compensate for the ever-increasing density of rooftops. It is only logical to take steps that would contribute to a successful economy, but given the urgent environmental agenda, greater deference to environmental concerns might help yield a more favourable blend of economic and environmental benefits, particularly since sunlight can be harvested in more than just one way.

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