
**POTENTIAL OF
BUILDING INTEGRATED PHOTOVOLTAIC (BIPV)
IN EXISTING URBAN HIGH-RISE HOUSING IN SINGAPORE**

Final Report

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EXECUTIVE SUMMARY

There is a significant potential for Building Integrated Photovoltaic (BIPV) for urban high-rise housing in Singapore for various reasons:

- The *solar radiation is very favorable* compared to countries such as Germany or even Japan, which are successfully utilizing solar energy for many years already. Singapore's annual global solar radiation is 50% higher than that in Germany. Its provision is even, whilst others suffer from under- or overprovision in winter or summer. Furthermore, the predominant diffuse nature of the solar radiation makes vertical surfaces receive high solar radiation regardless their orientation. High amount, constant and even provision and the predominately diffuse nature of solar radiation are key advantages for grid-connected BIPV. (Chapter: Solar radiation data for Singapore and 'PV' countries)
- The *selected building design and construction holds advantages* for PV integration. The building orientation is already with respect to the sun path, meaning the sun-exposed facades have fewer windows, to prevent solar heat from entering the interior. These sun-exposed solid facades are preferred for BIPV. Furthermore, the roofs are usually not used and hence available for PV installations. The buildings are made of pre-fabricated elements, with many repeated elements of the same size. As such customized PV can be efficiently applied in large numbers. (Chapter: BIPV architectural design proposals)
- The developed different BIPV designs for typical Slab and Point Blocks provide evidence that *PV can easily supply 20-30% of the total energy demand* of a building during the day. Even a modest PV installation provides an electrical power surplus if only used to power the public facilities such as lifts, pumps, and other daily loads of the building. Reasonable PV integration into the façade is able to cover 15-30% of the total energy demand of a typical Point Block and even adds an aesthetical vertical or horizontal look, which makes the buildings look less uniform.

PV elements can double up as shading devices along the facades or rain water collecting devices as butterfly roofs, and hence add additional value to a building. If applied on roofs alone, they provide for Point Blocks another 30% and for Slab Blocks up to 50% of the energy demand. The developed designs can be mixed, so that even more than 50% are possible. (Chapter: Electrical demand and PV supply for all BIPV designs)

- *Amorphous silicon performs well under Singapore's tropical hot and humid conditions.* The efficiency of around 6% does not suffer from high temperatures and the PV cells seem to prefer the predominant diffuse solar radiation. Applied as laminates on steel panels without any glazing makes them less vulnerable as other PV technologies. Crystalline cells are covered with glazing materials, which may raise security concerns if installed on vertical surfaces, and, if slightly cracked, allow humidity to spoil the whole panel. Furthermore amorphous silicon is less costly compared to 1st generation PV, and hence is likely to score well in a life cycle and cost analysis. (Chapter: PV technologies and application)

The significant potential of BIPV was not known prior to this research. Some studies conducted several years ago looked into installations of 1st generation PV on roofs only, and concluded that it was economically not viable. Today, after it has been shown that 20-30 % of the building energy demand can be easily supplied by BIPV, hopefully a new discussion will start on *the economical and environmental benefits of using Photovoltaic* as 'Solar Energy seems to have the greatest potential of renewable energies in Singapore' quoting Singapore's former Minister of State for Health Dr. Balaji Sadasivan¹.

Japan and Germany for instance, have established sustainable national energy policies to cover a certain percentage of the energy supply by renewable energies. As of 2003 the capacity of all residential BIPV is 620,000 kW_P and 370,000 kW_P in Japan and Germany respectively. Singapore, with even more solar radiation at its disposal, has a total known capacity of less than 100 kW_P.

¹ Minister of State for Health Dr. Balaji Sadasivan on the occasion of the Seminar on Efficient Use of Fossil and Renewable Energies, 11 Nov 2002, Regent Hotel, Singapore

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