

# The solar lifecycle test

Does it take more energy to produce photovoltaic panels than they're worth?  
Andrew Moore investigates the life cycle of a solar photovoltaic system.

**A**re we doing a good thing for the environment by installing solar panels? People often ask if photovoltaic (PV) solar panels generate sufficient power to outweigh that consumed in their production, transport and installation. To answer this, we carried out a life cycle assessment for a complete grid-connected PV solar system.

## What is a life cycle assessment?

A life cycle assessment (LCA) looks at the environmental impacts of each stage during the whole life cycle of a product, from the mining of the raw materials, processing, production, product use, through to recycling or final disposal of the product. Here we conducted an LCA for complete PV solar systems that were manufactured in Germany and shipped to where they were installed in each Australian capital city.

We traced the full life cycle of all the components of the solar system, right back to the mining of the quartzite rock and production of silicon wafers. The manufacture of all components of a complete 1kW (1000W) PV solar system was examined in the study, including the monocrystalline PV modules, inverter, aluminium roof mounts, wiring, right down to the nuts and bolts. The study examined the environmental impacts of each step in the life cycle including the greenhouse gas emissions, energy consumed, and importantly, the energy produced.

We included the impact of transport as this is often considered a significant contributor to a product's environmen-

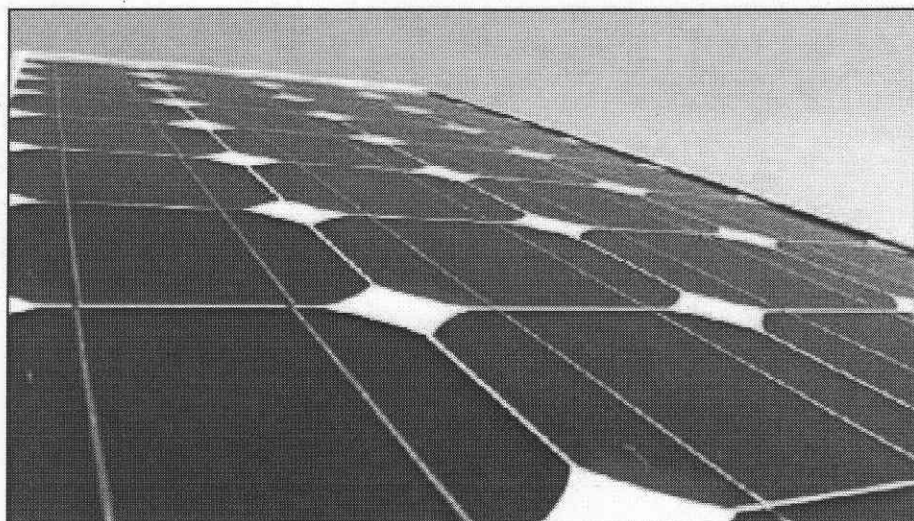


Photo: Andrew Moore

tal footprint. Transport during all parts of the journey was included: raw material to processing, components to assemblage factories, parts to dock in Germany, shipping to Australia, dock to warehouse, to installer and finally to a home. A sensitivity analysis took out the influence of distance variation between installer and homes.

## Hasn't an LCA been done on solar before?

Other studies have looked at the life cycle of PV solar systems before, but this one was unique in that it considered systems installed in every capital city in Australia. It analysed the details for each capital city including the solar resource, the transport of the system and the greenhouse gas emission factors of the local electricity grid. Sensitivity analyses were also conducted to gauge the impacts of PV module output degrading over time, and transport within Australia.

## How is a solar cell made?

Monocrystalline silicon cells, used in

traditional solar modules, start their life as a piece of quartzite rock. This rock is changed into pure silicon metal, which is then further purified to a silane gas that is deposited as polycrystalline ingot. The polycrystalline ingot is melted, and from this melt a single crystal (monocrystalline) is drawn which is then sliced and coated to produce your solar cell. As well as the silicon solar cells, each solar module requires low iron glass, aluminium for the frame, solders, copper wire, silicon rubber and various types of plastics.

## Where do the emissions come from during production?

For a 1kW PV solar system to be produced it creates just over two tonnes of greenhouse gases. Almost 85% of this is in the manufacture of the solar modules themselves, and almost all of which is emitted during the silicon wafer production. The rest of the greenhouse gas emissions are due to the inverter production (7%) and roof frame and wiring (4%).

## What about transport?

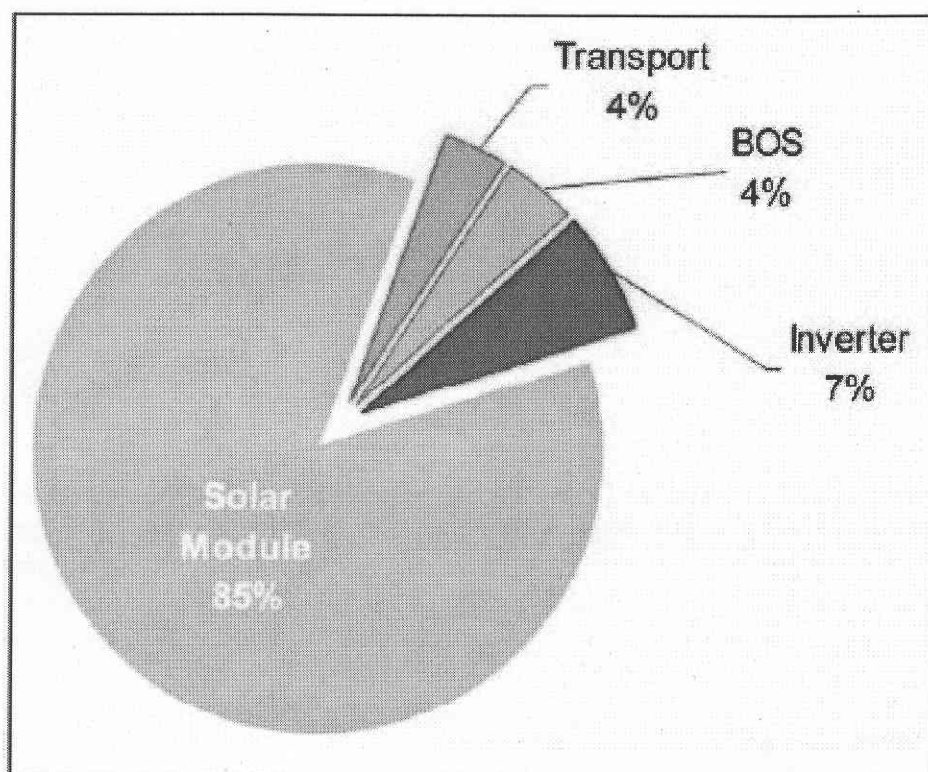
Transport of the PV solar system is very efficient, producing only 4% of the greenhouse gas associated with the system. Transport of the solar system from Germany to Australia by ship is only responsible for 2% of the total greenhouse gas emissions as each container ship is loaded with thousands of tonnes of cargo (23,000t on an average container ship [1]) making it a low greenhouse gas emissions mode of transport for bulk goods. As for the distance from the warehouse to your house; if your installer got lost along the way they would have to drive all the way around Australia 12 times (168,000km) before producing the same amount of greenhouse gases that your solar system will save over its lifetime (assumes installation location is Perth).

## What is the energy payback period?

Energy payback period is the amount of time that it takes the solar system to generate the same amount of energy consumed in making the system in the first place. It is a common myth that it takes more energy to produce a solar system than the system would generate over its lifetime. The truth, however, is that it only takes between 1.7 (for Perth and Darwin) and 2.3 years (Hobart) for the solar system to pay back the energy consumed during its life cycle. Assumptions for the study were: the solar module life is 30 years (most come with a 25 year warranty), inverter life 15 years (after which it is replaced with a new one), solar modules are mounted on roof facing north at a 20 degree angle (i.e. flat on the average roof), and there is no shade from local trees.

## What is the greenhouse gas payback period?

The greenhouse gas payback period is the time it takes for the solar system to 'pay back' the amount of greenhouse



Greenhouse gas emissions associated with the production of the PV solar system.

gases that were produced during its life cycle.

By producing electricity from solar you consume less electricity from conventional grid sources which produce greenhouse gases.

With the exception of Hobart, the greenhouse gas payback period for solar systems installed in Australia is less than 1.6 years (Hobart is still respectable at seven years greenhouse gas payback period considering that the system should last 30 years). After that time the system has paid off its greenhouse footprint and from then on it is savings all the way.

## What are the greenhouse gas savings?

A 1kW solar system installed in Australia will save between 37 and 49 tonnes of greenhouse gas emissions over its lifetime. The exception is Hobart where the savings are around 7 tonnes as it receives less solar energy and the local electricity grid is already mostly powered by renewable energy (hydro).

Surprisingly, the city where install-

ing a PV solar system results in the greatest greenhouse gas savings is Melbourne. Rather than being due to the amount of sun it receives, this high savings is due to the fact that their state's grid power produces the highest amount of greenhouse gases, which solar beats hands down. On a per unit of electricity (kWh) basis, grid power in Victoria produces 1350g CO<sub>2</sub>-e [2] (full fuel cycle emissions) whereas solar is only 55g CO<sub>2</sub>-e when looking at the whole life cycle. So, when considering PV solar for your home, not only do you need to look at how sunny your location is, you also have to consider the greenhouse gas emissions coming from the local electricity grid.

## Why solar in Australia?

Australia is in the unenviable position of having the highest greenhouse gas emissions, per unit of electricity produced of all OECD countries [3]. Thirty five percent of all its greenhouse gases are associated with electricity production [4]. The majority of this electricity is generated from coal (76%) with only

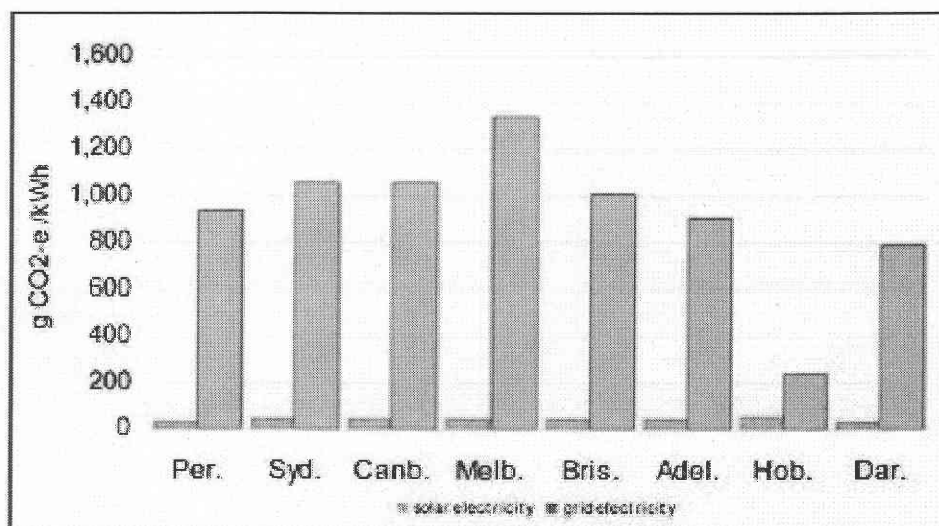
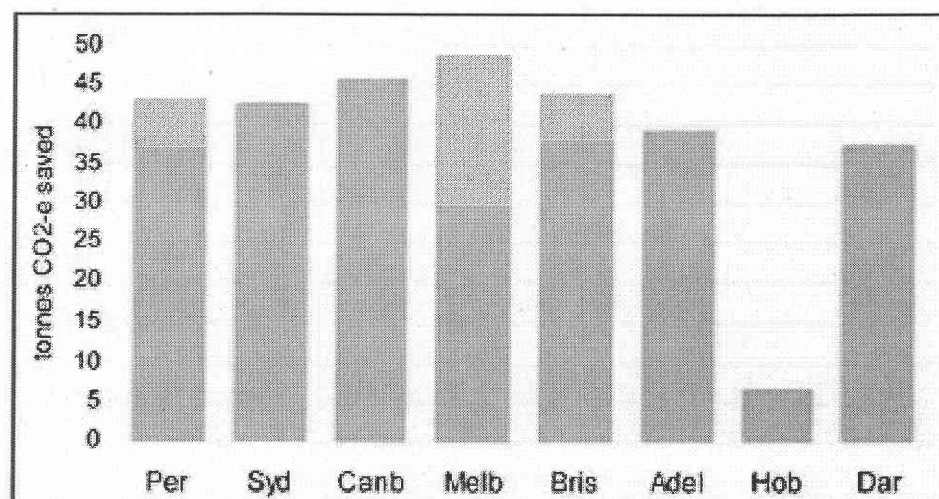


eight percent currently being supplied from renewable sources [5]. Australia has an excellent solar resource, with Perth having the best solar resource of all cities in the OECD [3]. Given the current greenhouse gas emissions of Australia and its high number of peak sun hours, there is plenty of room for more solar in Australia.

When you consider the whole life cycle of solar electricity it isn't greenhouse gas emission free, but with up to 96% less greenhouse emissions than the local grid it is a much greener option. \*

## References

- [1] EcoTransIT: Ecological Transport Information Tool, environmental methodology and data (2008), IFEU, [www.ecotransit.org](http://www.ecotransit.org).
- [2] Department of Climate Change (2009) National Greenhouse Accounts Workbook
- [3] Gaiddon B. and Jedliczka M. (2006) Compared assessment of selected environmental indicators of photovoltaic electricity in OECD cities. The compilation of this report has been supported by the French Agency for Environment and Energy Management, ADEME/IEA, Hespul, Villeurbanne, France.
- [4] Department of Climate Change (2006). National greenhouse gas inventory 2004, <http://www.greenhouse.gov> (accessed Sept 2008)
- [5] Australian Bureau of Agricultural and Resource Economics (2005), En-



Top: Greenhouse gas emissions savings compared to grid electricity (assumed 30 year lifetime). Bottom: Solar electricity versus grid electricity. Solar produces between 76% and 96% less GHG emissions per kWh than grid electricity.

ergy in Australia 2005, Canberra. Andrew Moore is a Life Cycle Consultant working with PE International. This study was completed as part of his Masters in Renewable Energy at Murdoch University in 2008. The study

was updated using Department of Climate Change national greenhouse account figures from June 2009 for this article.

For more information email [a.moore@pe-international.com](mailto:a.moore@pe-international.com).

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