Issue 142

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Park your solar
Australia's largest solar car park

A solar car park just makes sense, particularly at a university campus where it can be used for research and education. A recent ATA branch meeting heard about the largest one in Australia, recently installed at USQ. Branch convenor Mark Tranter and USQ's Andreas Helwig and Alicia Logan explain.

↑ Making good use of a car park space: the largest solar car park in Australia—3842 panels and over 1MW!—is now operating at USQ's Toowoomba campus, providing energy and shading.

IT'S inspiring to see renewable energy projects springing up in Queensland even in areas of significant fossil fuel production. One such example is Australia's largest integrated solar car park, which is now operating at the University of Southern Queensland (USQ) in Toowoomba in the Darling Downs. This is a rich agricultural region that is also home to coal mining, coal seam gas production and two of the country's youngest coal-fuelled power stations, alongside large solar (2GW) and wind farm (500MW) proposals—a region with very diverse business interests.

The solar car park is part of a bigger project at USQ, the Sustainable Energy Solution, which involves installation of significant PV arrays around the university: a 1MW car park solar array at the Toowoomba campus, 196kW of rooftop PV at Ipswich, 205kW of rooftop PV in Springfield and another 506kW of rooftop PV in Toowoomba. Quite a feast of solar!

The solar project is intended as a feast for research as well. Andreas Helwig, a sustainable energy researcher from the school of mechanical and electrical engineering, is undertaking several research projects using the resulting "100km virtual aperture" (i.e. modelled like 100km of solar panels!) to investigate the "secret life" of solar panels. With PV across three locations, the research will investigate how solar cell performance is affected by transient clouds, varying levels of relative humidity and different types of airborne dust (including coal dust). All of these can degrade the PV output, reduce the cooling benefit of inverter heat sinks and exacerbate PV manufacturing faults.

Andreas notes, "A big question—and an expensive one—is when is it necessary to clean and maintain the surfaces of the arrays and the inverter heat sinks?" Research projects are also using infrared photometry to identify PV faults, whether from manufacturing or degradation over time.

Solar car park design

Using the 1.45 hectare car park at the Toowoomba campus (equivalent to the size of a football field) yielded some benefits—large PV capacity and sheltered parking for cars—and some challenges, such as the need for a structure to support the PV panels.

The panels are mounted on specially designed stands, engineered to withstand the rated wind zone for this part of Toowoomba, and orientated 30° west of north and tilted at 23° off the horizontal. The orientation for parking bays is now aligned both for better solar generation and to provide maximum shade and protection to cars.

After tenders were analysed, Autonomous Energy was chosen as principal contractor. Table 1 shows all three stages of the project and variations in panel wattage/technology as the project progresses.

The guaranteed minimum annual generation from the car park array is 1.826GWh—enough to power about 250 homes. Since commissioning in June 2017, the output has averaged 4MWh per day in winter, currently climbing in spring to around 6MWh per day. There is zero export of energy allowed from the car park array, but partial

Stage	Project array	Specs
Stage 1: Toowoomba campus solar car park online 26 June 2017	1.09 MW PV, zero export	3842 x 285 W Jinko panels 19 x 60 kW SMA inverters Min energy guarantee 1.83 GWh/year
Stage 1: Toowoomba engineering block, roof-mounted array, small system to emulate a domestic installation for research	5 kW PV with 10 kWh battery	17 x 285 W Jinko panels 5 kW SMA inverter 10 kWh LG Chem battery
Stage 2: Ipswich campus, roof-mounted array, heritage permission required, online 28 November 2017	197 kW PV, partial export up to 51 kW	678 x 290 W Jinko panels 7 x 25 kW SMA inverters Min energy guarantee 287 MWh/year
Stage 2: Springfield campus, roof-mounted array, higher efficiency panels for smaller roof, online 11 December 2017	205 kW PV, full export capability	520 x 395 W LG Neon panels 4 x 25 kW, 5 x 20 kW SMA inverters Min energy guarantee 300 MWh/year
Stage 3: Toowoomba campus, roof-mounted array over multiple buildings, online from December 2017 to January 2018	506 kW PV, zero export	1430 x 290 W Jinko, 232 x 395 W LG Neon panels 18 x 25 kW, 2 x 20 kW SMA inverters Min energy guarantee 739 MWh/year

↑ Table 1: USQ's sustainable energy solution is being implemented in three stages to provide a total capacity of around 2 MW. Technology improvements are included as the project rolls out.

and full export capability is available for the Ipswich and Springfield projects.

The cost of all three stages over the three campuses for solar PV, with a total rated capacity of 2 MW, is $6.1 m. With an expected payback of nine years, the projection is for additional savings of $3.51 m (net present value) over the 25 year life of the system.

Research opportunities

As all three stages of installation are commissioned, there will be excellent opportunities for both research and student education. The intention is to develop models to understand, predict, compare and test long-term energy production and maintenance costs for each array. This is of particular relevance to eastern Australia as renewable energy penetration increases, as well as for isolated island communities depending heavily on solar energy.

PV MANUFACTURING FAULTS

Early detection of faults in large arrays allows for planned maintenance to replace faulty panels or repair connections during non daylight hours to maintain peak performance of the array throughout its lifetime.

Possible manufacturing faults include minor leaks in a panel's hermetic seals which can lead to internal corrosion; minor fractures in the outer edges of individual cells which can develop into cracks with daily thermal cycling; incomplete metal current collectors on the front of cells; and poor panel junction box and inter-panel connections.

Several projects are looking at how infrared photometry can be used to detect changing or abnormal characteristics of PV panels and inverters (see Figure 1). With the solar car park array, infrared images can be taken from underneath the array—both easier and cheaper than using a drone or climbing onto a roof to take the images. USQ is also planning to compare the use of output monitoring versus infrared indicators to detect PV faults.

DUST, MOISTURE AND HEAT IMPACTS

All solar panels and their cells will suffer reduced output due to the impacts of heat, water vapour from humidity, and airborne dust and pollution. As humidity increases, solar irradiance decreases (Figure 2); studies will compare output from the different array locations which experience different humidity levels.

Dust is a double whammy: it can downgrade the PV output both due to shading of the cells and increased cell temperature (see Figure 3). USQ will be looking at the impacts of a range of airborne particles on different solar cell types.

For example, Toowoomba's red soil absorbs the shorter blue spectrum wavelengths and reflects and transmits the longer red wavelengths. A broad spectrum PV array such as one made from Ga-As cells would experience an energy production drop due to both shading and a loss of the spectrum used for energy production. However, the same red soil dust on a conventional monocrystalline cell will suffer the shading loss, but, as the spectrum it uses is towards the lower end of the red range (they don't absorb blue light, which is why these cells look blue), the impact is less. Black soil or soot, however, would affect the generation for both types of solar cell.

This leads onto the issue of cleaning

USQ's commitment to sustainable energy wins awards

USQ's 2MW solar array project—the Sustainable Energy Solution—actively demonstrates the university's commitment to its social responsibilities and to improving environmental performance. Over the years the university has successfully implemented projects to reduce its energy, waste and water consumption. In 2011, the university began to implement a carbon-reduction strategy including both energy efficiency upgrades and the campus-wide Sustainable Energy Solution. The project represents a significant investment into the three communities USQ is part of, providing a 'real-world experience' that delivers a measurable reduction in long-term energy-related emissions and costs, as well as an enhanced platform for research, learning and teaching.

And this commitment is winning awards. The Sustainable Energy Solution was recently recognised at the Clean Energy Council Solar Design and Installation awards, with Autonomous Energy taking out the 'Over 240kW' category for the solar car park project. The university also won the Continuous Improvement—Institutional Change category at the 2017 Green Gown Australasia awards, which recognise sustainability best-practice in the tertiary education sector. USQ will now progress to the international Green Gown Awards, representing Australasia in Europe next year. Well done, USQ!

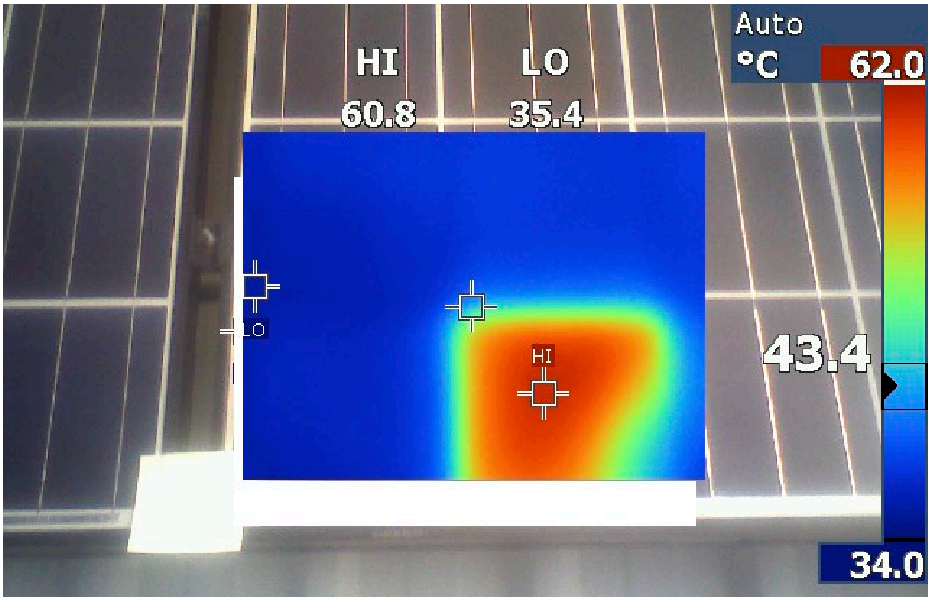

Figure 1: USQ is experimenting with using infrared thermal images to detect PV faults. This image from a USQ student's research shows how hot spots can be detected; this is made simpler in the USQ solar car park as they can be detected from underneath the structure.

PV arrays. Cleaning arrays is expensive and involves electrical safety issues, so it's important to get the balance right between cost, cleaning without degrading the PV's glass surface and maintaining the array for optimal energy output.

Inverters are also affected by heat, with many inverters now having thermal rollback protection—they reduce output to keep their electronic components below 45 °C to 50 °C. The effectiveness of cooling heat sinks is also degraded by dust accumulation. The installations enable research into how ambient temperatures and dust affect the performance and life of the inverters under different conditions.

DUAL LAND USE

The project also lends itself to consideration of agriculture under large PV arrays. The microclimate that occurs under large PV arrays offers potential for dual land use for 'protected' agriculture using dew and rainfall run-off. If USQ research is successful, this could be used to enhance agriculture in semi-arid landscapes.

A model campus

These projects across the university's three campuses have many benefits. One is as a model for other projects; for example, the USQ solar car park provides a template that can be applied across shopping centres, hospitals and other places with large open parking areas. As well as shade for the cars, with appropriate design a solar car park can pay for itself, providing payback within a decade or so. This payback period could potentially be reduced in the future if electric vehicles become more prevalent, with a solar car park able to get a return from a fee for EV charging.

"The microclimate that occurs under large PV arrays offers potential for dual land use for 'protected' agriculture using dew and rainfall run-off."

The projects also support the university's future energy needs and stand as a model of practical and cost-effective action to contribute to Australia's emission reduction goals. Further, the projects enhance regional resilience, both producing energy and developing new jobs in areas as diverse as solar energy forecasting, reliability engineering and high-value sustainable agricultural practices. You'd have to say that's a good place to park your car. ✱

This article is based on a talk at ATA's Toowoomba branch in September given by Alicia Logan (USQ's Environment Manager) and Andreas Helwig (USQ Lecturer in Electro-mechanical Engineering). For further information, see www.usq.edu.au/toowoomba/sustainable-energy

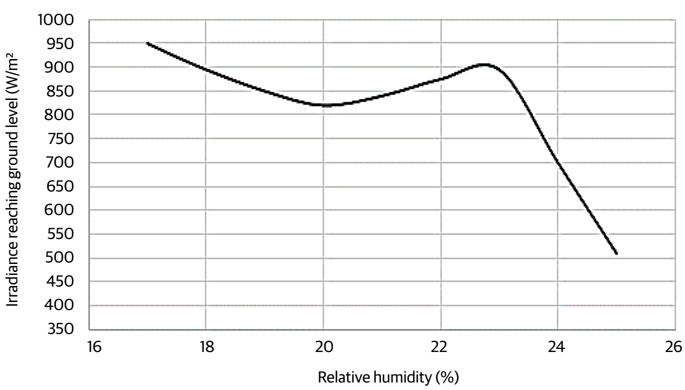

Figure 2: Typical impact of atmospheric humidity on irradiance reaching ground level in the tropics.

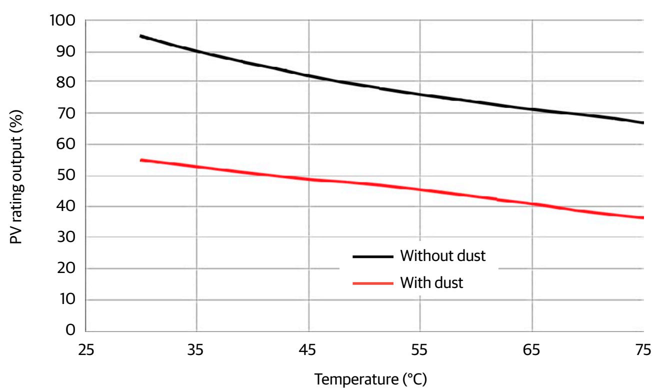

Figure 3: Typical effects of rising temperature and dust accumulation on PV panel output capacity relative to the panel's rating.