Faculty of Engineering
School of Photovoltaic and Renewable Energy Engineering

Independent outdoor testing of commercial perovskite & tandem modules

ACAP Workshop 2026, UNSW Sydney

25/03/2026

Jessica Yajie Jiang, Angus Gentle, Mark Keevers, Zibo Zhou, Alison Ciesla, Martin Green

Partner institutions: Jae Sung Yun (University of Surrey), Chris Fell (CSIRO), Klaus Weber (ANU), Jacek Jasieniak (Monash), Anita Ho-Baillie (University of Sydney), Hellen Hui & Paul Shaw (UQ)



Australian Government
Australian Renewable Energy Agency

ARENA

Reduced Solar Module Temperature

$1.76m
Funded by ARENA

$5.8m
Total project cost

Project overview

Lead Organisation
University of New South Wales

Location
Sydney, New South Wales

ARENA Program
Addressing Solar PV End-of-Life Issues and Lowering Solar PV Cost

Start date
18 September 2020

End date
10 July 2023

Project Partners
5B Australia, YCGC, 3M Electrical Markets Division, Flat Grass Group, Canadian Solar, JA Solar, Jinko Solar, Longi Solar Technology

UNSW SYDNEY

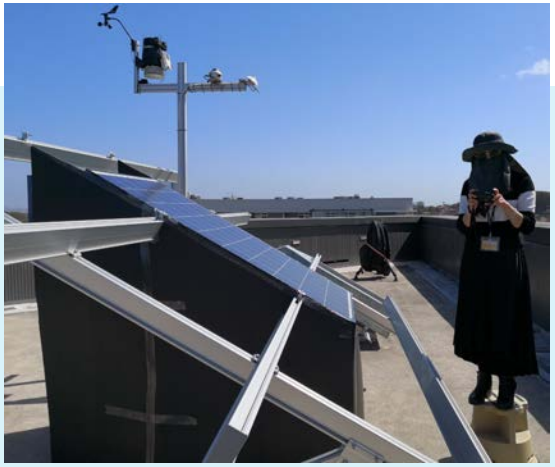
Australian Government
Australian Renewable Energy Agency

ARENA

Reduced Solar Module Temperature

$1.76m
Funded by ARENA

$5.8m
Total project cost





Project overview

Lead Organisation
University of New South Wales

Location
Sydney, New South Wales

ARENA Program
Addressing Solar PV End-of-Life Issues and Lowering Solar PV Cost

Start date
18 September 2020

End date
10 July 2023

Project Partners
5B Australia, YCGC, 3M Electrical Markets Division, Flat Grass Group, Canadian Solar, JA Solar, Jinko Solar, Longi Solar Technology

UNSW SYDNEY

Then everything changed - Perovskite modules going commercial



Then everything changed - Perovskite modules going commercial

Chinese developer switches on world's largest perovskite-based PV plant

MicroQuanta, a Chinese perovskite solar specialist, has commissioned a 8.2 MW PV facility based on its 90 W perovskite panels in eastern China.

DECEMBER 9, 2024 VINCENT SHAW

MODULES & UPSTREAM MANUFACTURING | TECHNOLOGY AND R&D | UTILITY SCALE PV | CHINA



MicroQuanta's PV plant in China's Zhejiang province

Image: MicroQuanta



UNSW SYDNEY

Then everything changed - Perovskite modules going commercial

Chinese developer switches on world's largest perovskite-based PV plant

MicroQuanta, a Chinese perovskite solar specialist, has commissioned a 8.2 MW PV facility based on its 90 W perovskite panels in eastern China.

DECEMBER 9, 2024 VINCENT SHAW

MODULES & UPSTREAM MANUFACTURING | TECHNOLOGY AND R&D | UTILITY SCALE PV | CHINA



MicroQuanta's PV plant in China's Zhejiang province

Image: MicroQuanta

Chinese PV Industry Brief: UtmoLight starts perosvkite module production

UtmoLight says it has launched the world's first gigawatt-scale perovskite solar module production line at a facility in Wuxi, China. The plant will annually produce 1.8 million panels, with a target of achieving 20% efficiency in mass production by 2025.

FEBRUARY 7, 2025 VINCENT SHAW

MARKETS | MODULES & UPSTREAM MANUFACTURING | TECHNOLOGY AND R&D | CHINA



UtmoLight's production line

Image: UtmoLight

UNSW SYDNEY

Then eve

KEY PLAYERS IN CHINA'S PEROVSKITE SOLAR INDUSTRY

Renshine Solar

Technology: Roll-to-roll compatible coating process for large-area perovskite film formation; vacuum deposition for charge transport layers

Commercial status: 10 MW R&D center and 150 MW mass production line; planning a gigawatt capacity line

Founded: 2021

Wonder Solar

Technology: Solution-phase printing methods

Commercial status: Two 200 MW capacity plants operational; one up to 3 GW plant under construction. Products will be commercially available in late 2025.

Founded: 2016

UtmoLight

Technology: Vacuum deposition and then a solution process for the perovskite layer; physical vapor deposition for electron transport materials

Commercial status: 150 MW pilot line; 1 GW plant already operational at 25% capacity

Founded: 2020

GCL Optoelectronic Materials

Technology: Solution coating and then crystallization for the perovskite layer; physical vapor deposition for electron transport materials

Commercial status: 100 MW pilot line operational since 2021, mainly R&D focused; building complete for a 1 GW line, with equipment due to be operational by end of 2025

Founded: 2010

Microquanta Semiconductor

Technology: Solution-based roll-to-roll compatible coating for perovskite layer

Commercial status: 100 MW plant in operation since 2023; planning a gigawatt-scale plant

Founded: 2015

Chinese deve
largest perov

MicroQuanta, a Chinese pe
facility based on its 90 W p

DECEMBER 9, 2024 VINCENT

MODULES & UPSTREAM MANUFACTURING



MicroQuanta's PV plant in Chi

Image: MicroQuanta

tmoLight
oduction

e perovskite solar
will annually produce
n mass production by



UNSW SYDNEY

But how stable are they? The literature tells us very little outdoors

Most stability studies → small cells, indoors

The overwhelming majority of published stability data comes from laboratory devices (< 1 cm²) under controlled conditions. These fail to capture interconnection, lamination, and module-level degradation.

Mini-modules dominate outdoor tests

Published outdoor studies are mostly on research-scale mini-modules, not full commercial products. Module size and encapsulation approach are critical variables that are absent from these datasets.

Manufacturer data is not independent

Companies have outdoor test installations and make stability claims, but this data is proprietary, not independently verified, and covers insufficient time periods and climate diversity.

Field testing shows perovskite solar modules can retain 78% of their initial efficiency after one year

Researchers from Belgium and the University of Cyprus have completed outdoor stability tests of perovskite solar mini-modules providing two-years of data on stability performance. The tests showed that the modules' performance loss rates during the burn-in period of perovskites ranged between 7% and 8% per month.

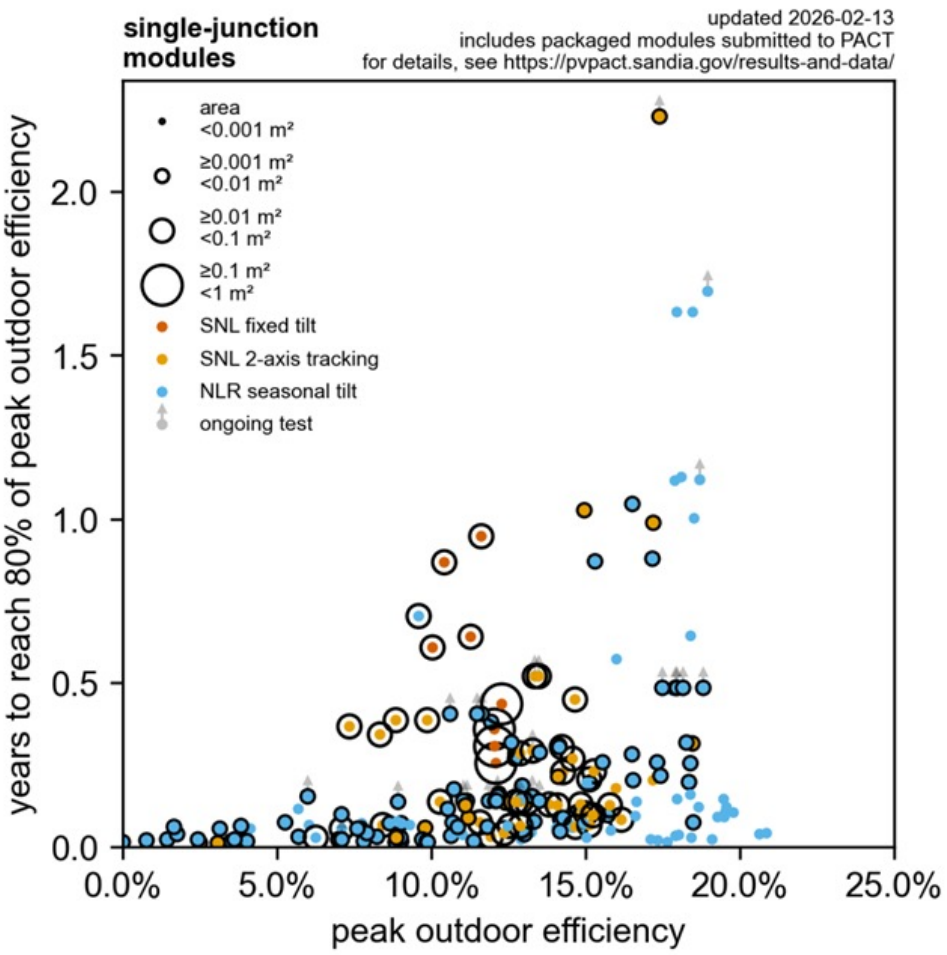
JANUARY 10, 2025 VALERIE THOMPSON

MODULES & UPSTREAM MANUFACTURING | TECHNOLOGY AND R&D | BELGIUM | CYPRUS



Image: Imec

PACT is the most visible program, while but modules are still small





Partners

As of June 2025, PACT has received over 680 perovskite PV modules for testing from nine companies and seven research institutes. Some of these partners have agreed to be identified below. Partnerships with all of our partners allow PACT to test a wide range of perovskite and other emerging module technologies.

First Solar · Caelux · The University of Toledo · CUBIC PV · The University of North Carolina at Chapel Hill · imec · Singfilm · SwiftSolar

UNSW SYDNEY

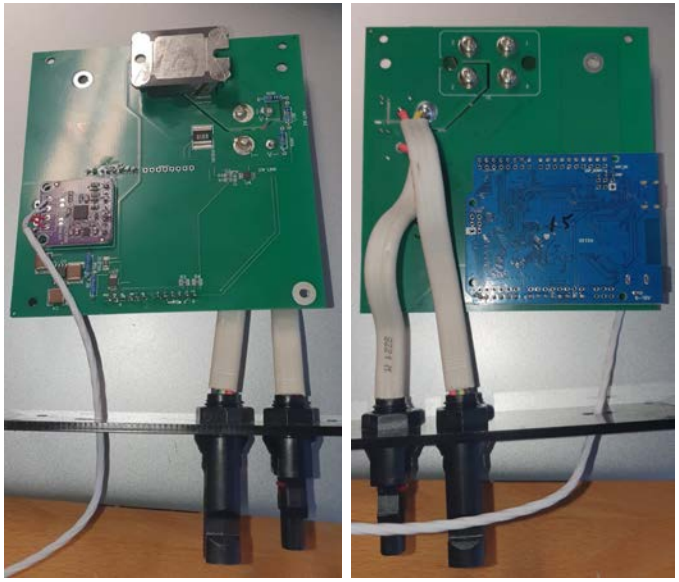
Our Initiative - Independent outdoor testing of commercial perovskite modules



Continuous monitoring:

IV sweeps (1/hr) MPP tracking Spectral irradiance UV dosimetry Temperature/humidity Wind PL imaging Thermal imaging

Custom low-cost DC Loads (powered by 12V)



PCB board (Front & Back)



Aluminium enclosure with fan cooling



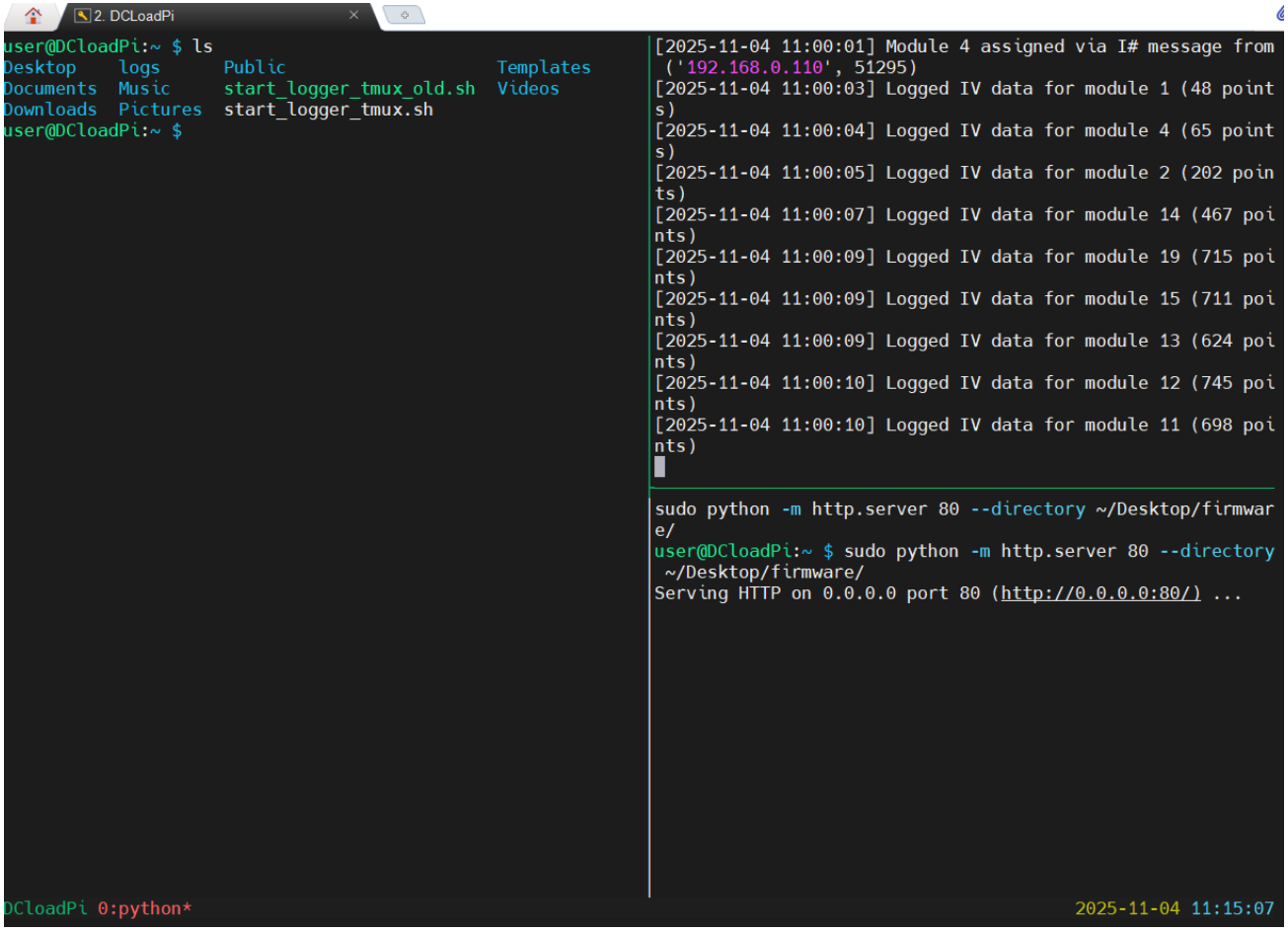
Deployed under modules at Kensington

Modes: MPP, V_{OC}, I_{SC}, IV Sweep

Scalable: mW minimodules through to full-size commercial modules (100s of W)

Safety: PCB cutout isolation
Double-insulated wires
Isolated MOSFET
High-temp cutout
Grounded metal case

Raspberry Pi server



Data collection

- Continuously collects data from all modules.
- DC Loads transmitting data every ~2s. IV Sweep each hour.
- Synchronized Control of loads for PL (MPP - Voc Images)

Data volume: ~25 MB/module/week manageable for long-term archiving

Easy to replicate: Battery-powered can run at Manly Vale and remote sites with no mains connection

Case Study – Certain modules show spatial degradation from Day 1

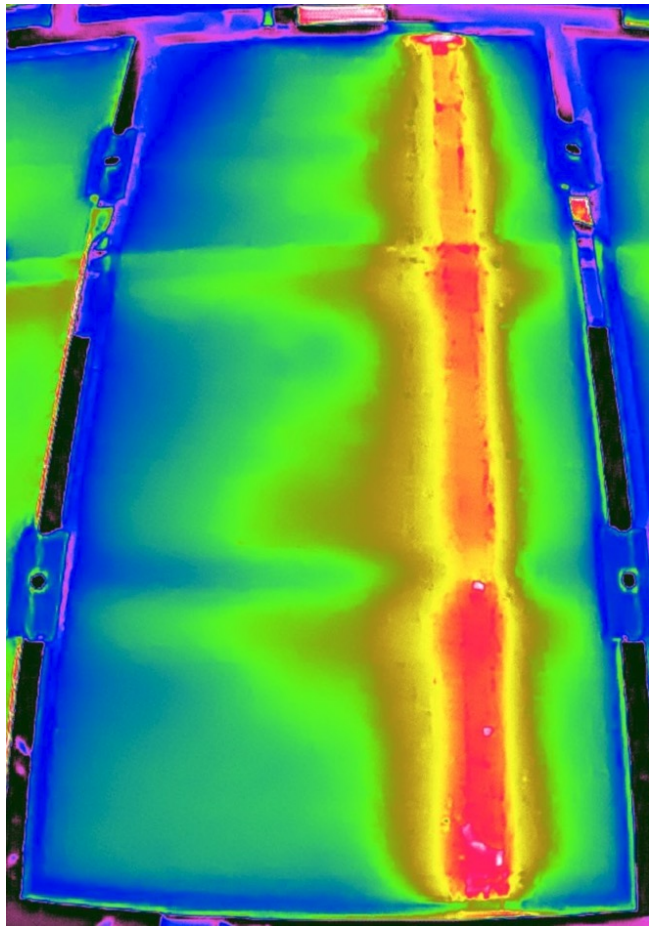


Optical

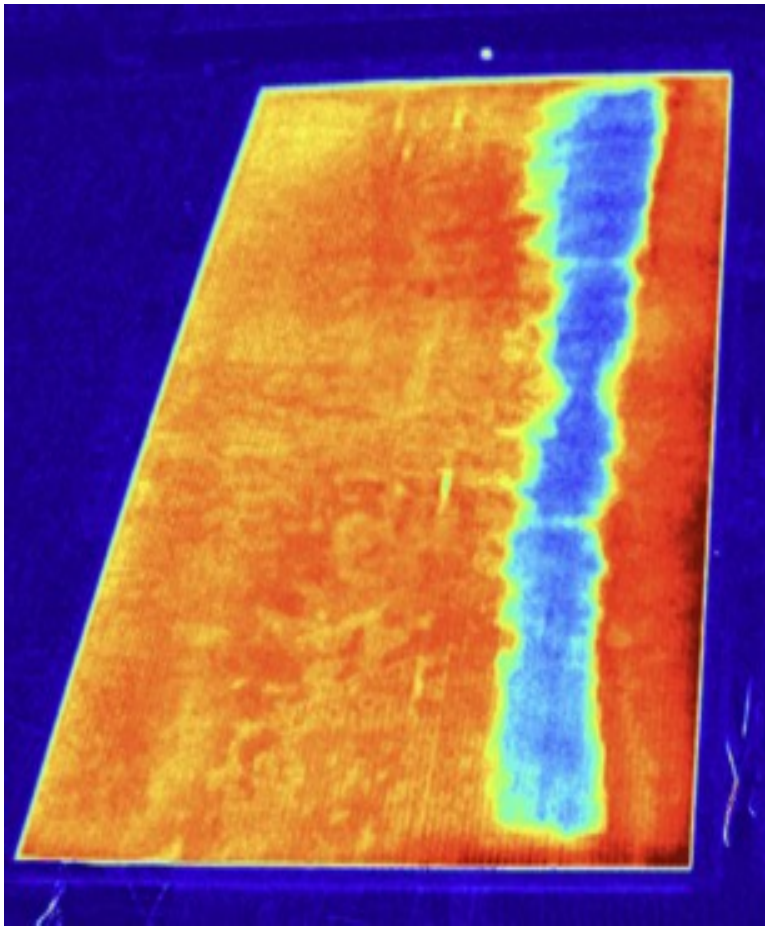
Case Study – Certain modules show spatial degradation from Day 1



Optical

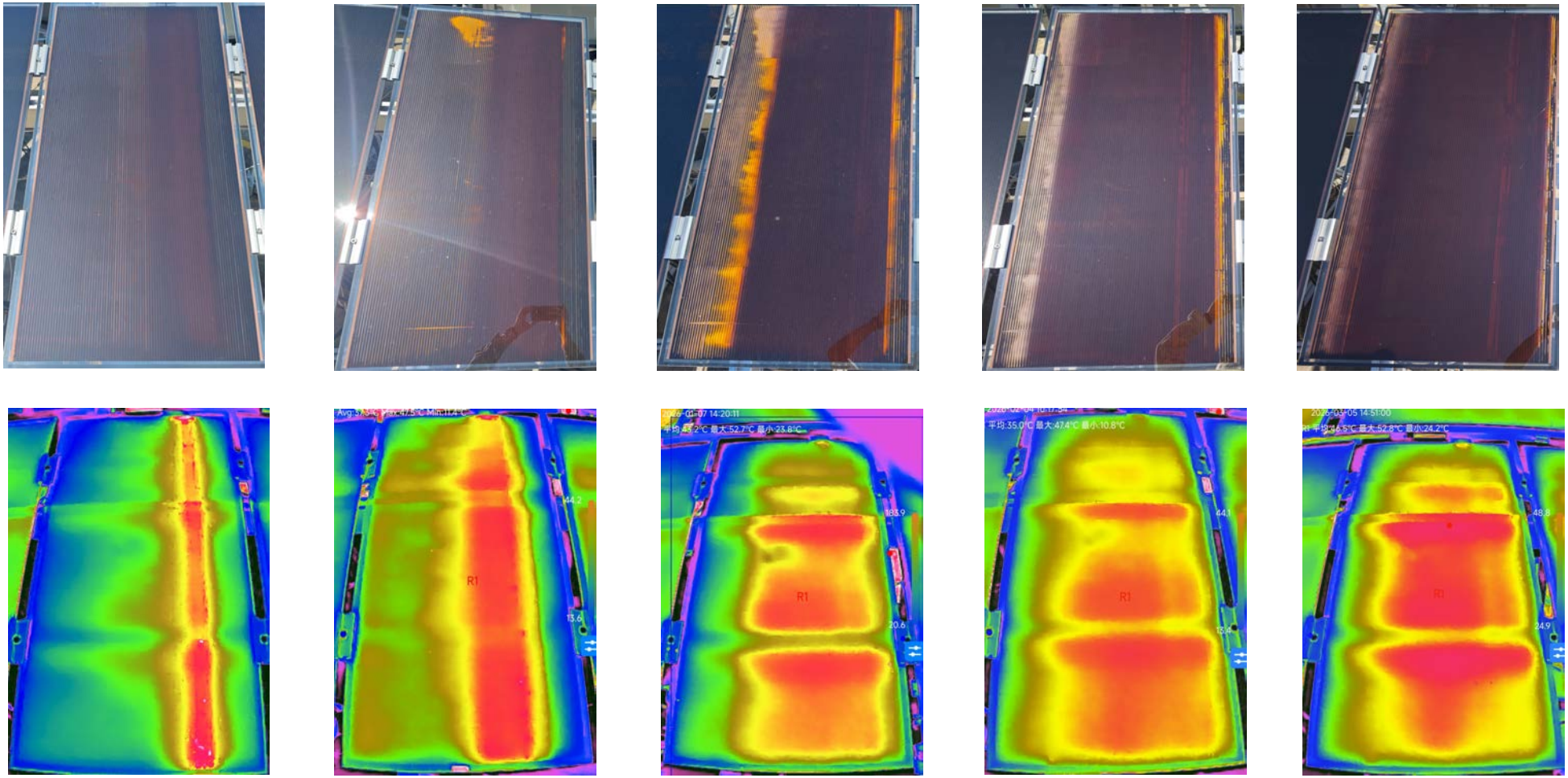


Thermal



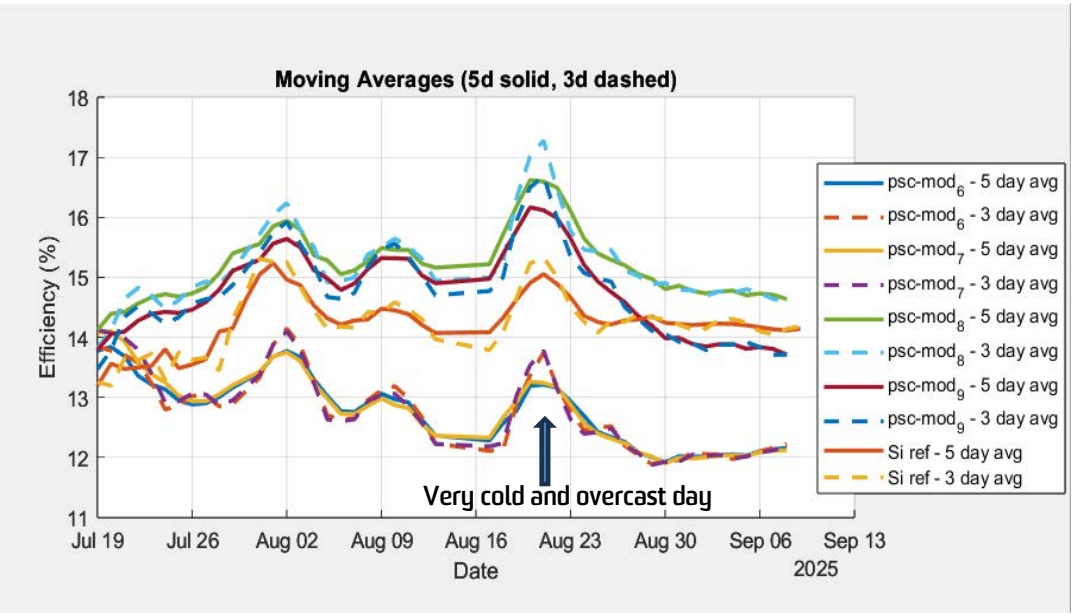
PL

Case Study – Degradation

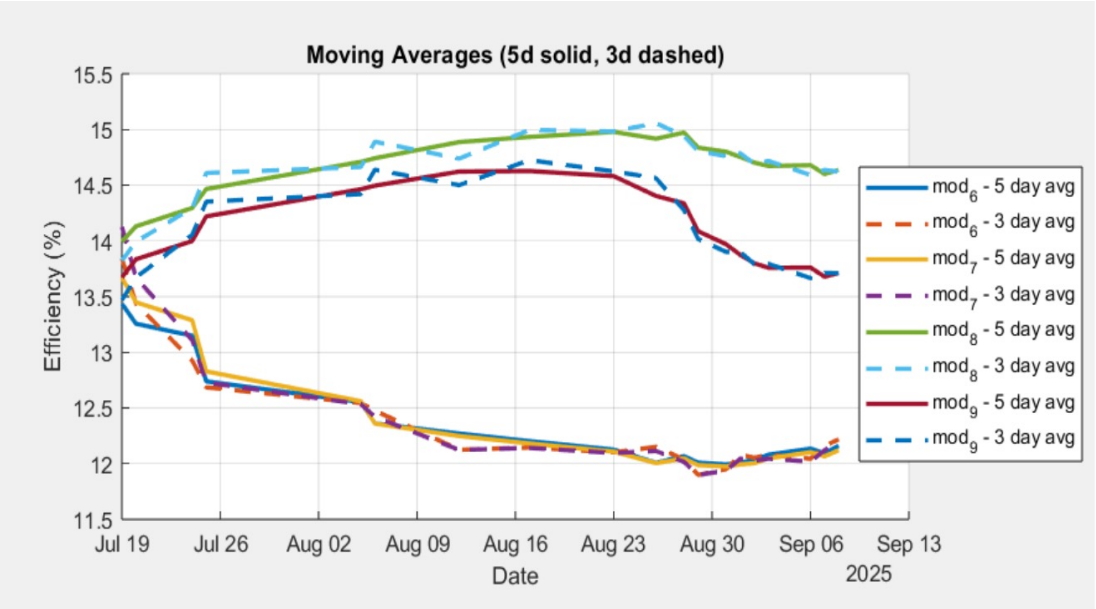


Preliminary field data

Efficiency showing all days (both sunny and cloudy)



Peak efficiency & failure calculated for (Sunny days over 4kwh/m^2/day only)

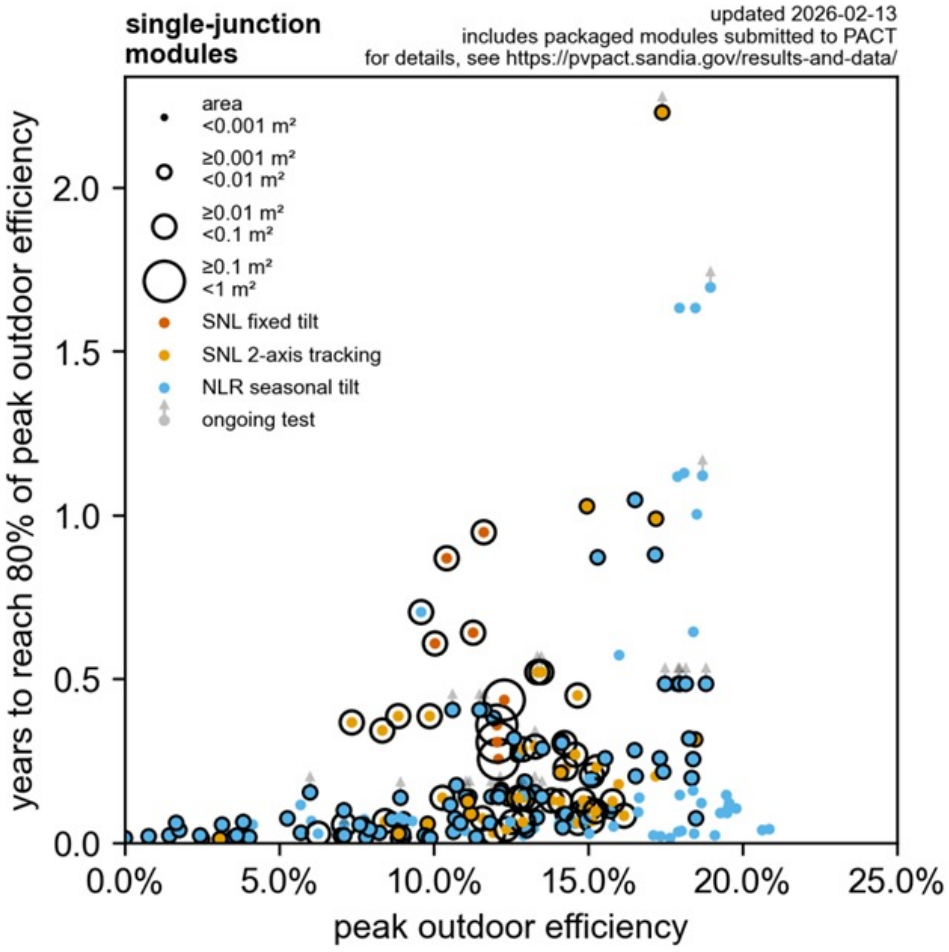


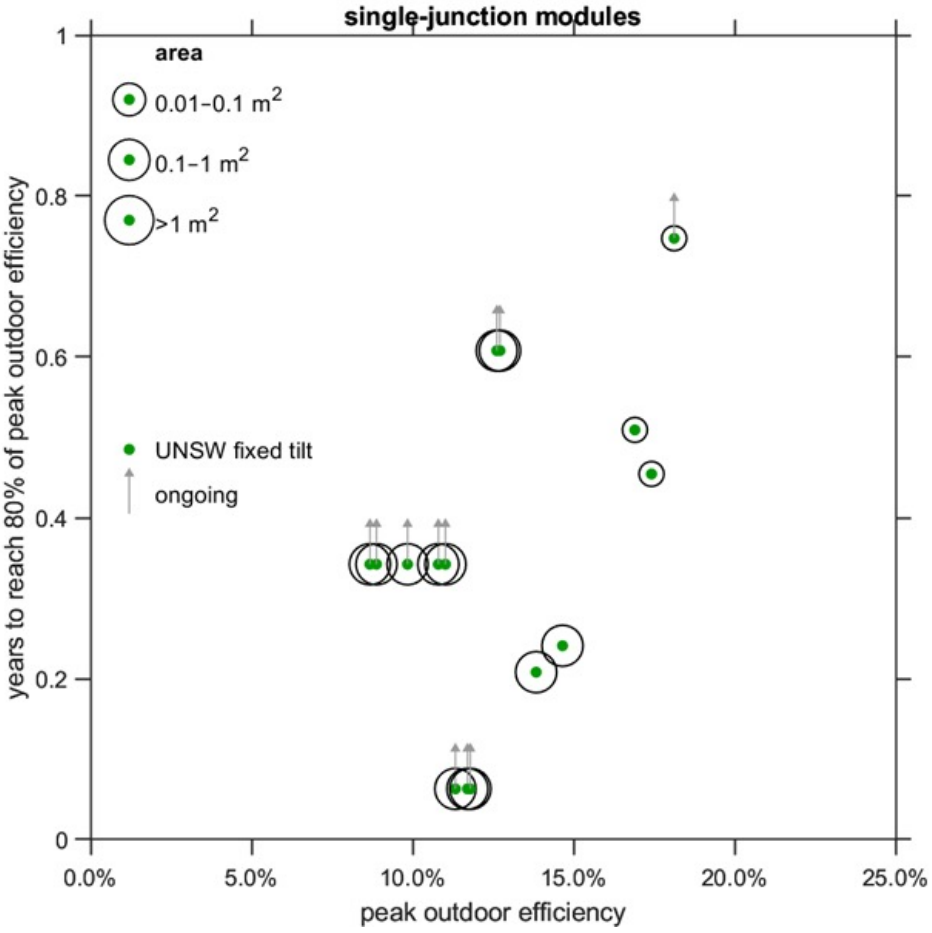
- Module-to-module variability grows over time
- there is clear summer decline and partial winter recovery

Daily Efficiency = Energy In / Energy Out over the day

UNSW SYDNEY

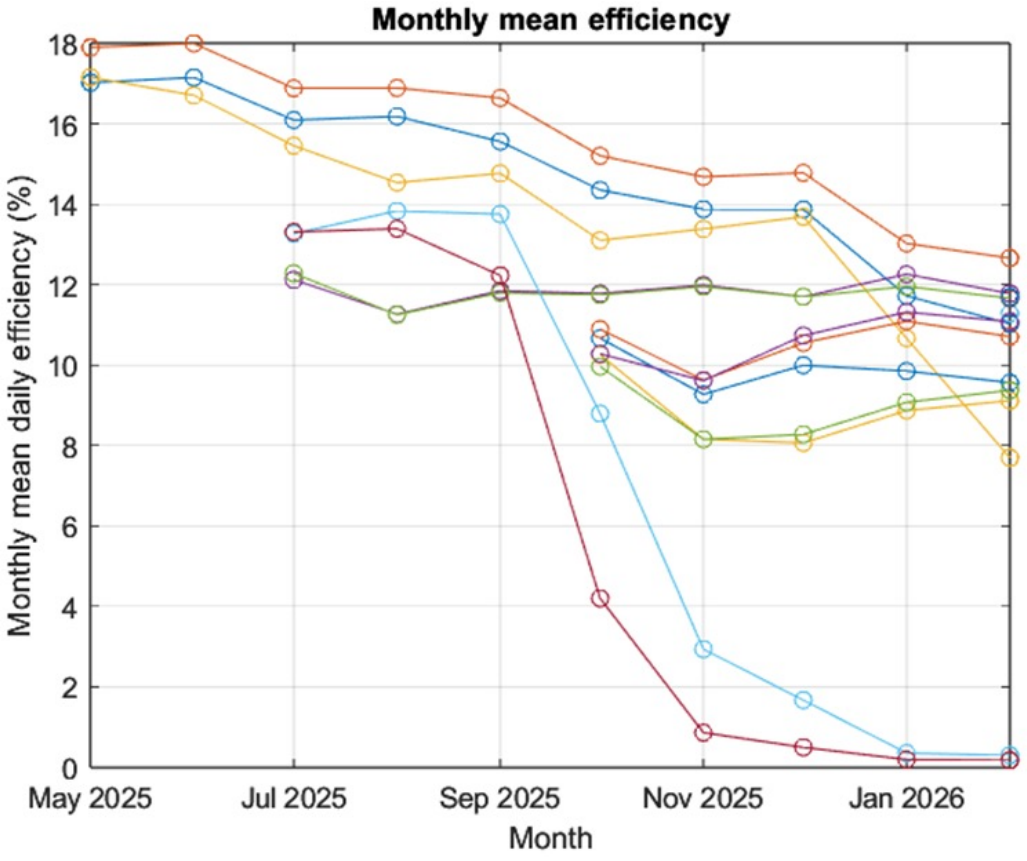
Our Bubble Chart ☺

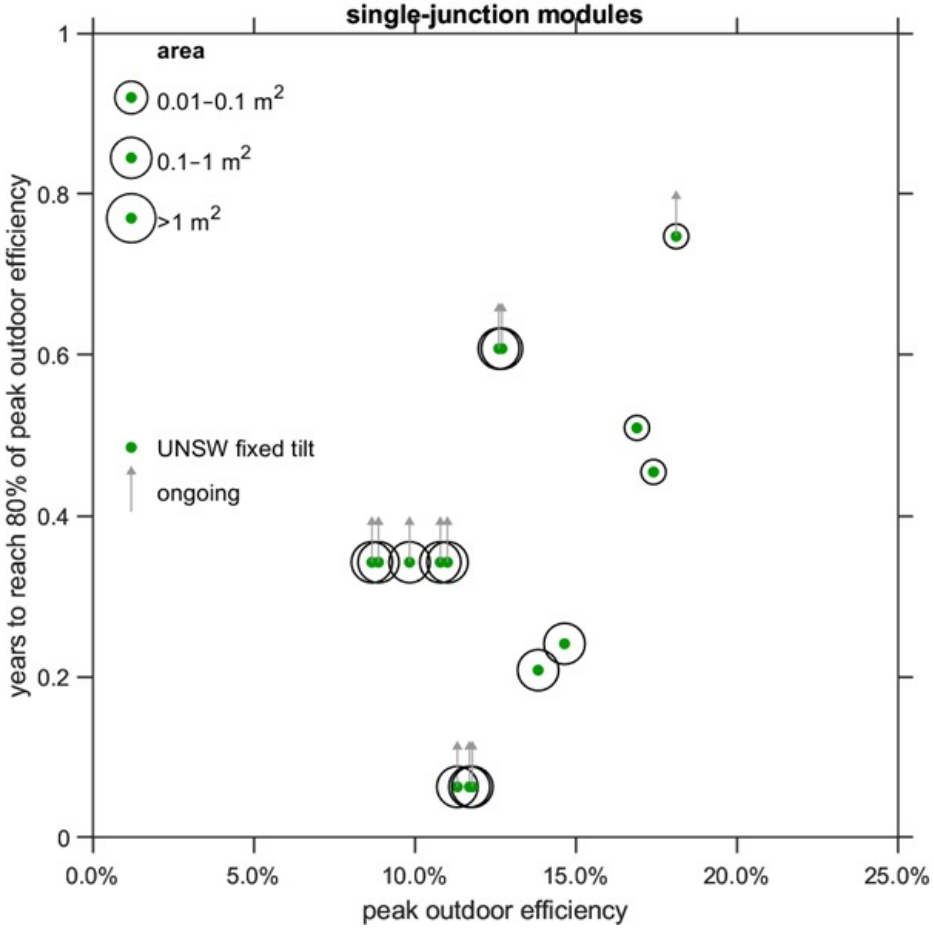




UNSW SYDNEY

Monthly mean daily efficiency (Energy Out/Incident Solar per day)





UNSW SYDNEY

Expanding to Manly Vale field testing station (25 × 25 m)



Site approved & cleared

✓ Complete

Rack procurement & installation

In progress

First modules installed & monitoring live

Year 1 milestone

Recruit additional manufacturers

Year 1 target

50+ module capacity operational

Year 1 end

Summary and next steps

- ✓ 8+ manufacturers committed across single-junction, tandem, rigid and flexible designs
- ✓ 10 commercial + 7 pre-commercial modules actively monitored at Kensington
- ✓ First data showing degradation variability, seasonal patterns, and failure modes
- ✓ ACAP funding secured to expand to Manly Vale (50+ module capacity)
- ➢ Manly Vale rack installation and commissioning (Year 1)
- ➢ Recruit additional manufacturers to expand dataset
- ➢ Detailed failure mode analysis on field-aged samples
- ➢ First quarterly database report to consortium members SOON

AUSTRALIAN CENTRE for ADVANCED PHOTOVOLTAICS (ACAP)

School of Photovoltaic & Renewable Energy Engineering, UNSW Sydney





Research Intensive School : > $100M infrastructure in PV cell fabrication & manufacturing

Unique facilities in an open university environment

ARENA

Australian Government

Australian Renewable Energy Agency

ACAP

Questions?

Jessica Yajie Jiang

yajie.jiang@unsw.edu.au