

Applications of in-situ I-V measurement



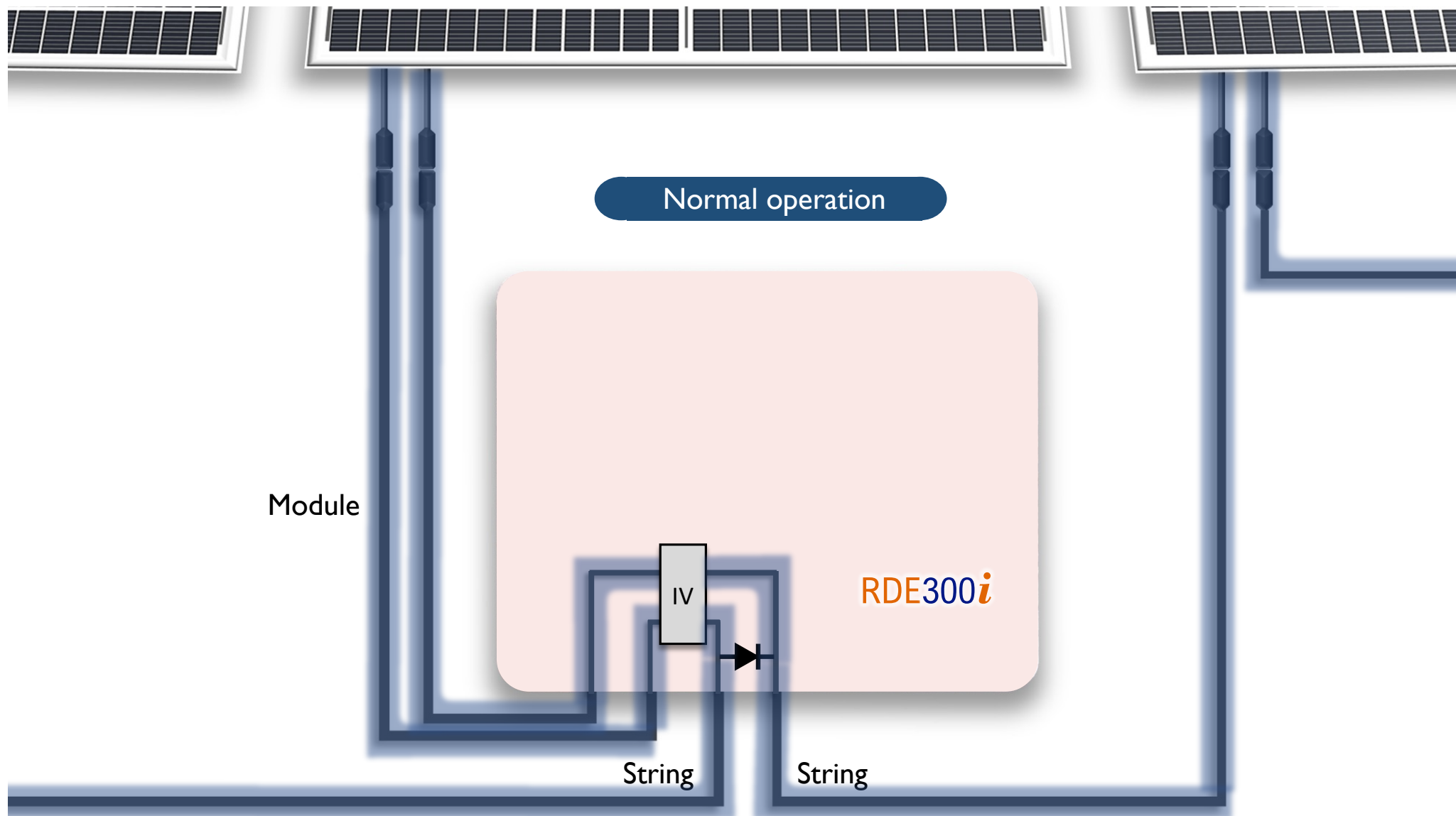
Michael Gostein, PVPMC May 2023

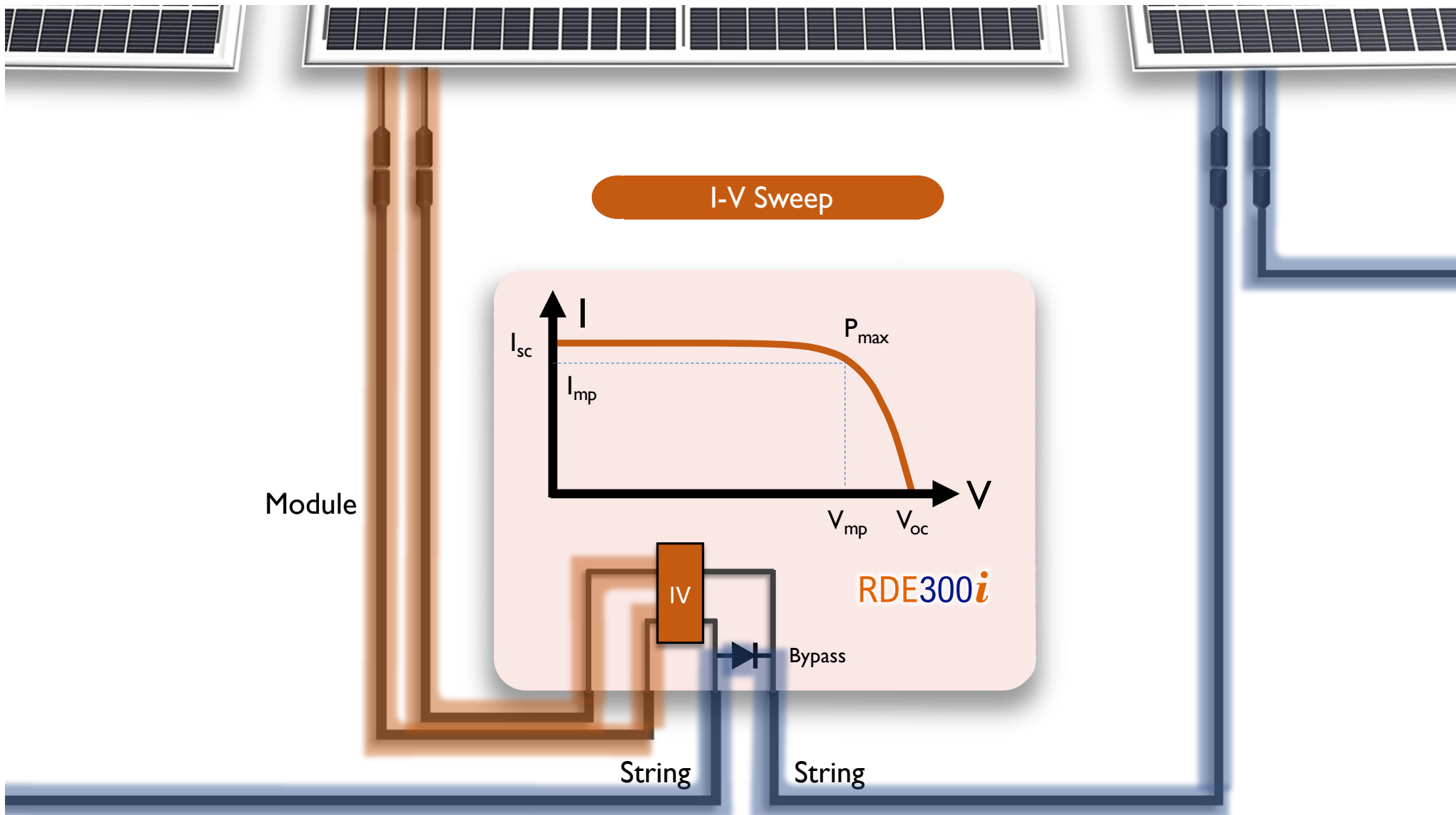


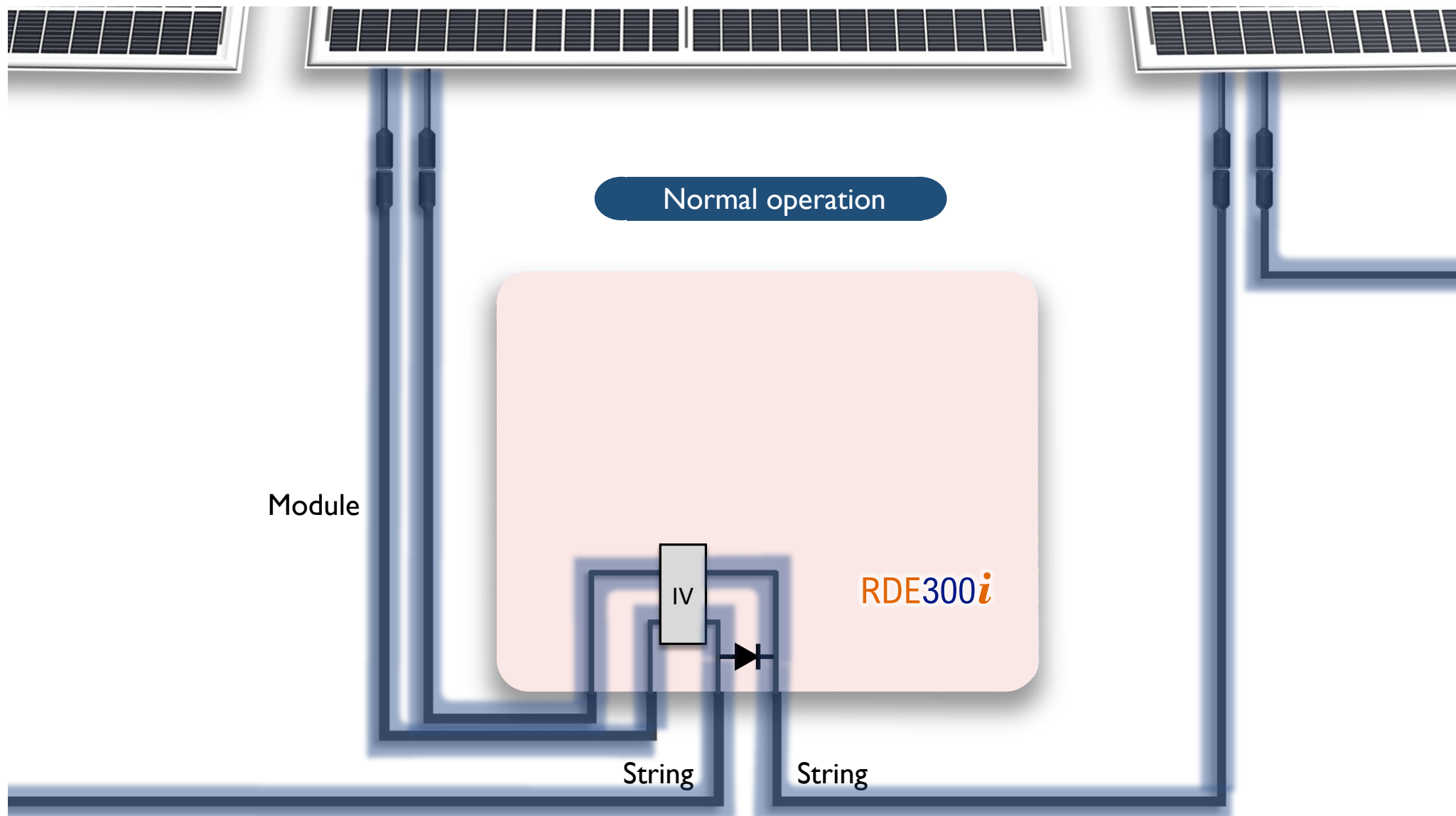
In-situ IV

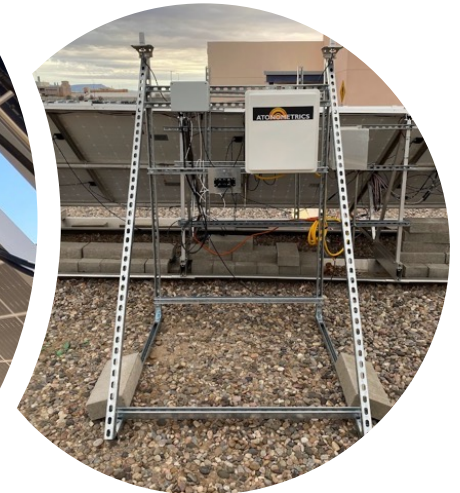


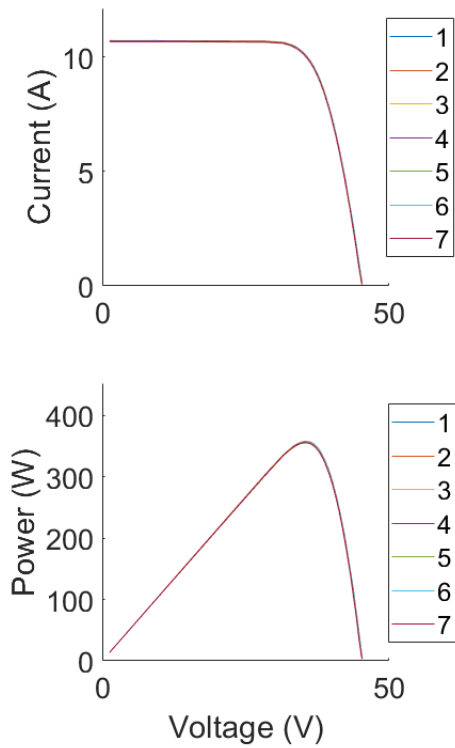
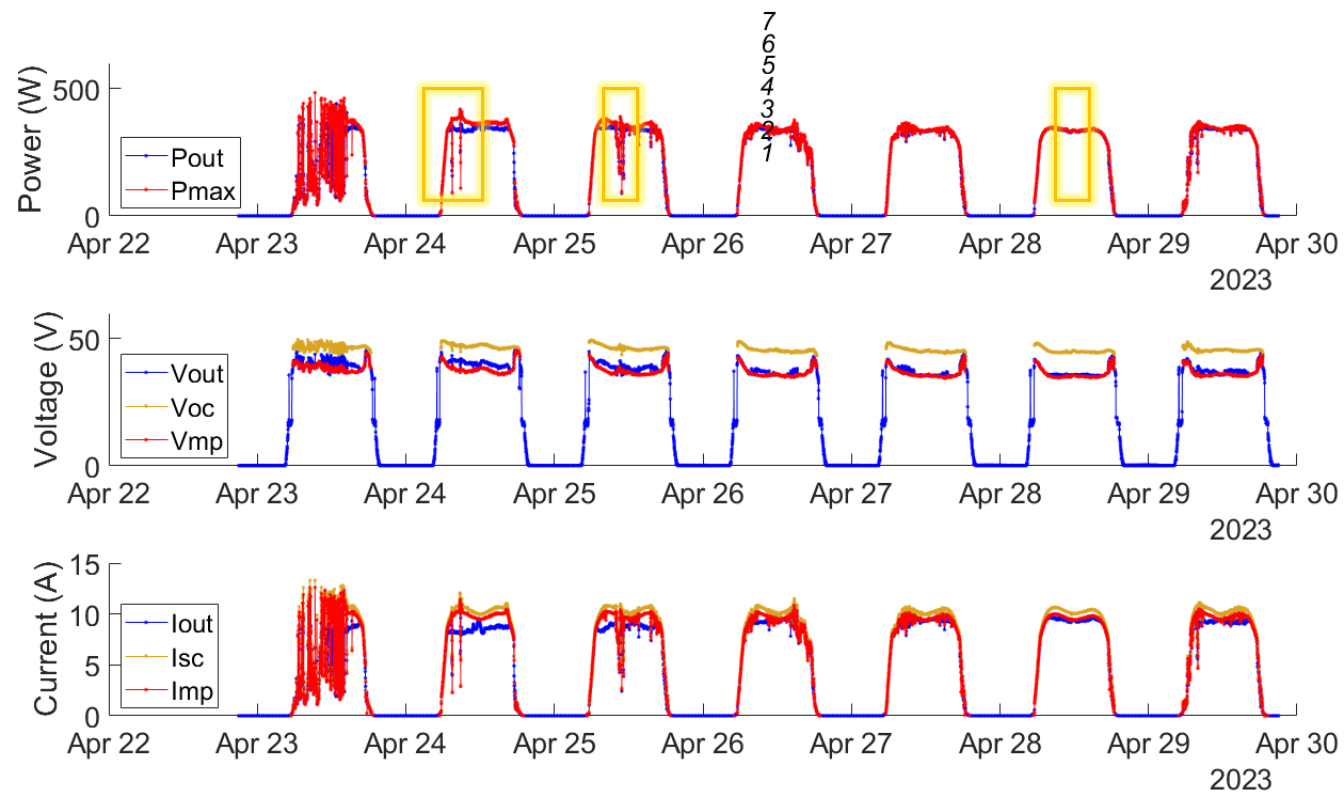


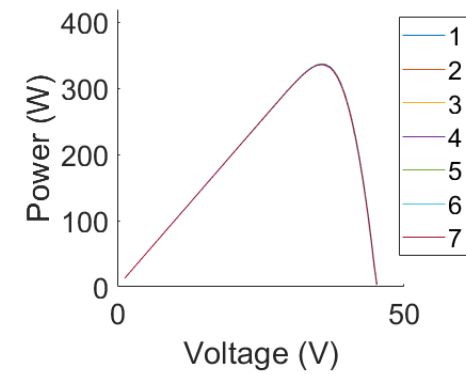
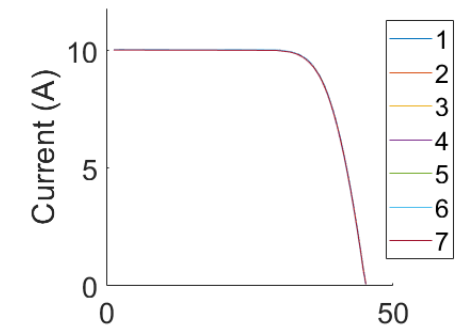
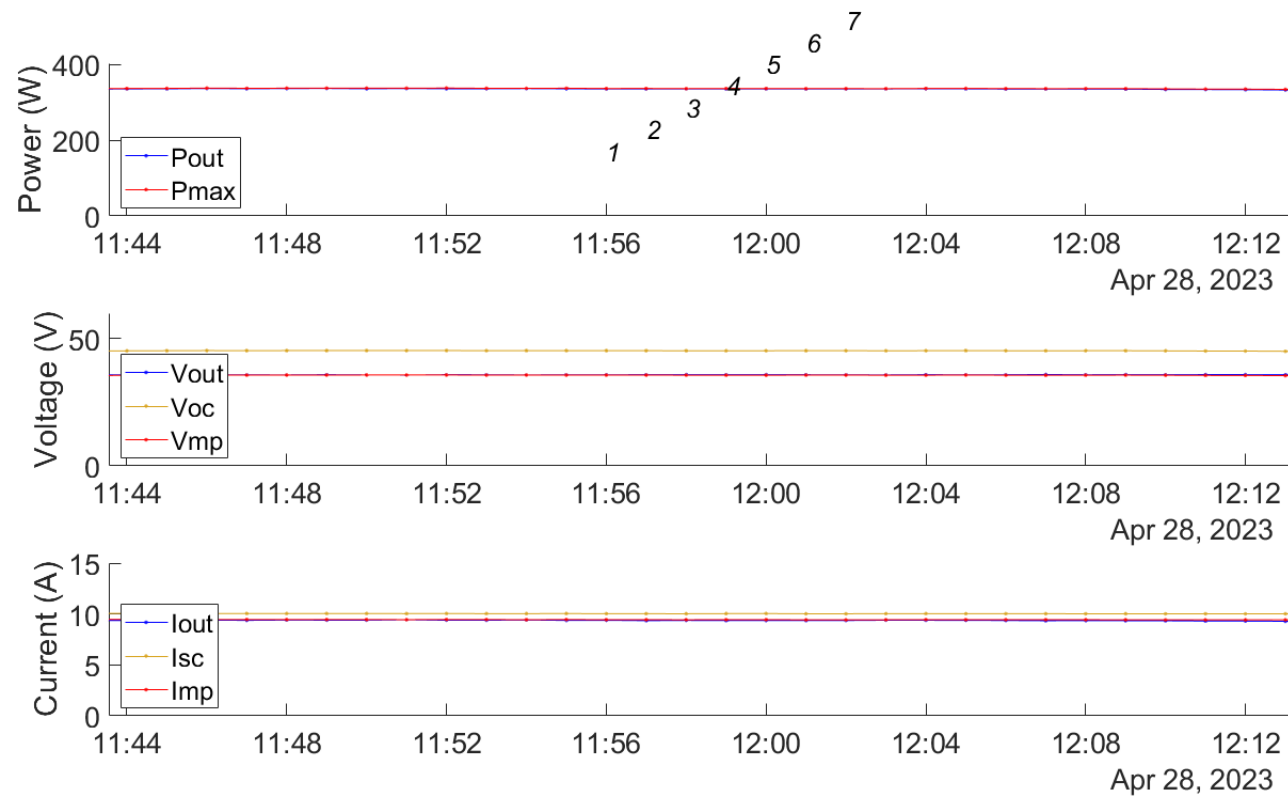


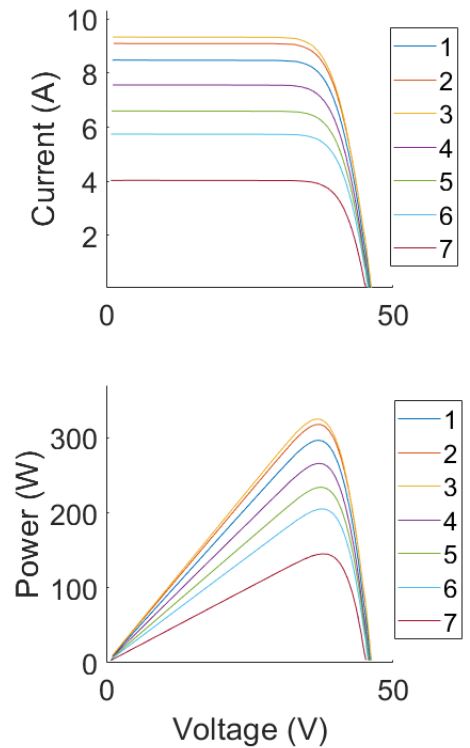
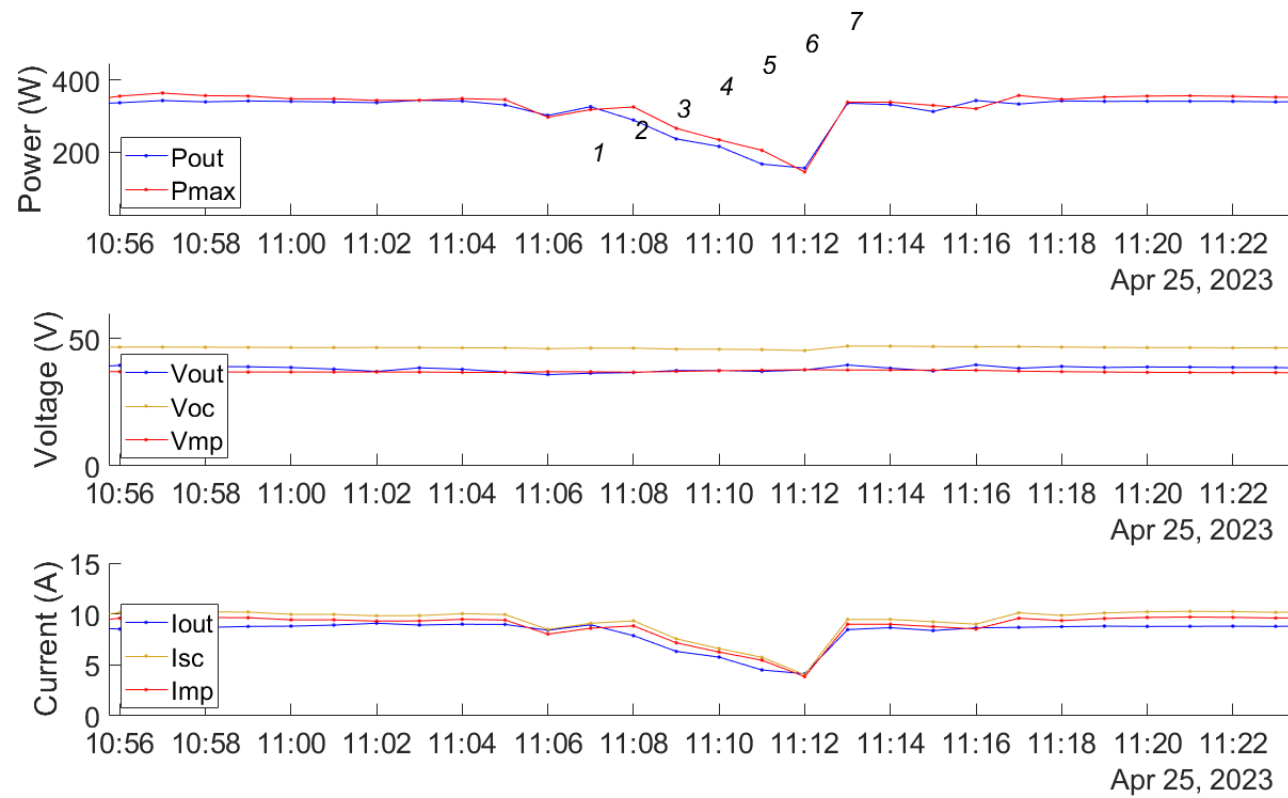


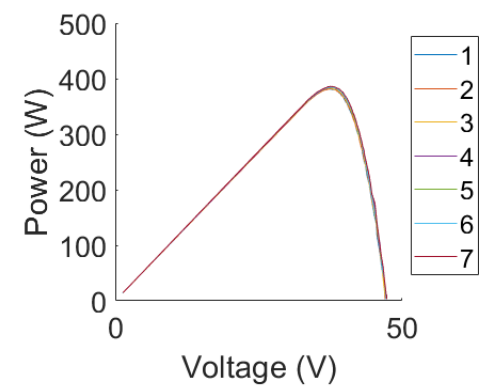
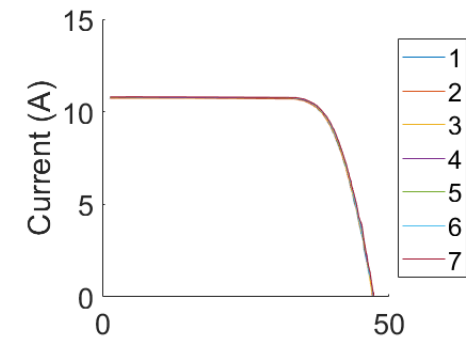
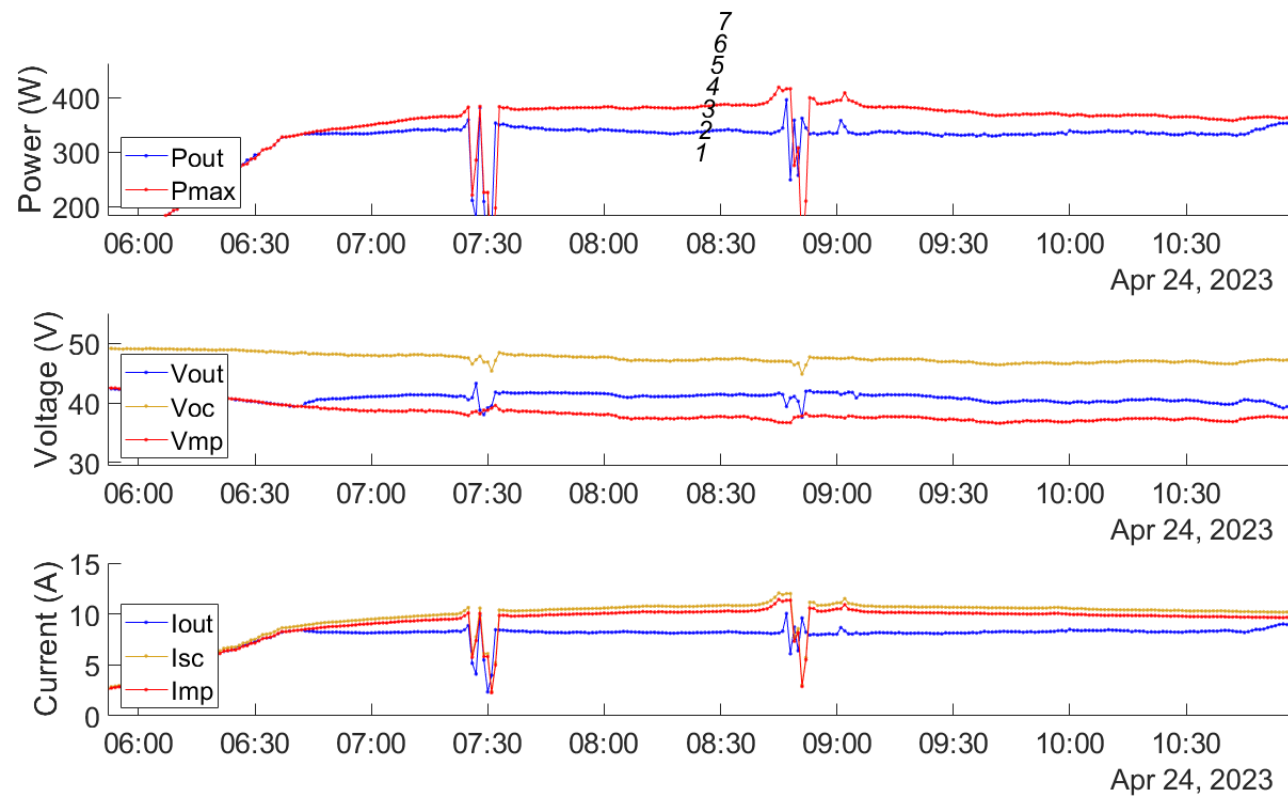






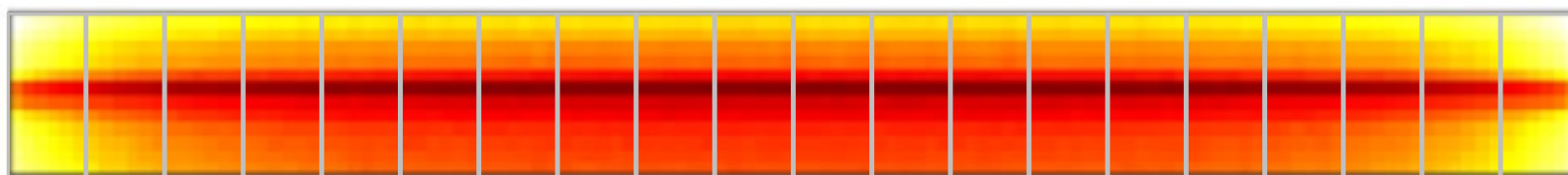




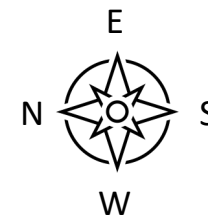


Bifacial irradiance





June 1st, 9 AM

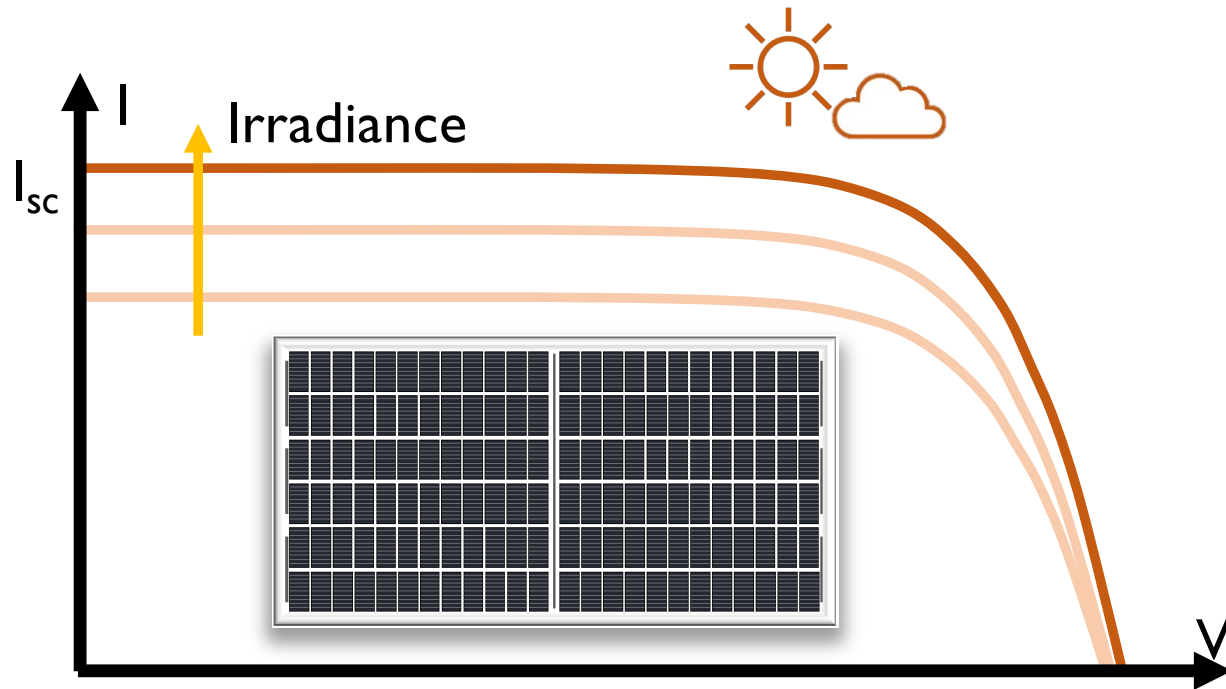


January 1st, noon

Source: Gostein, Ayala Pelaez, Deline, Habte, Hansen, Marion, Newmiller, Sengupta, Stein, Suez, “**Measuring Irradiance for Bifacial PV Systems**,” PVSC 2021

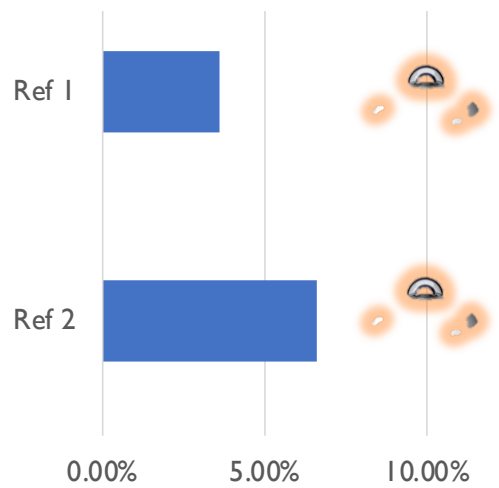


Reference: Gostein, Ayala Pelaez, Deline, Habte, Hansen, Marion, Newmiller, Sengupta, Stein, Suez, “**Measuring Irradiance for Bifacial PV Systems,**” PVSC 2021

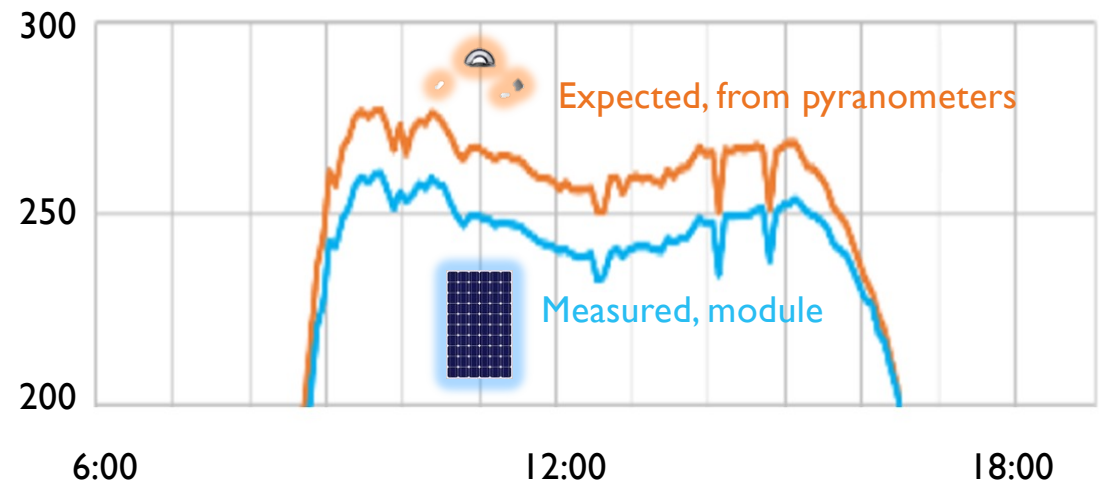


$$Irr = Irr_{ref} \cdot \frac{I_{sc} \cdot (1 - \alpha \cdot (T - T_{ref}))}{I_{sc,ref}}$$

Total Irradiance Difference vs. Module



Power (W)



Source: Ref [1]

Ref [1]: Braid, Stein, King, Raupp, Mallineni, Robinson, Knapp, **“Effective irradiance monitoring using reference modules,”** PVSC 2021

Ref [2]: Riedel-Lyngskær, Bartholomäus, Vedde, Poulsen and Spataru, **“Measuring irradiance with bifacial reference panels,”** IEEE Journal of Photovoltaics, 2022

Ref [3]: Abe, Dias, Notton, Faggianelli, Pigelet, Ouard, **“Estimation of the effective irradiance and bifacial gain for PV arrays using the maximum power current,”** IEEE Journal of Photovoltaics, 2023



Non-uniform irradiance:

1. Does module power follow average irradiance?
2. Does I_{sc} correlate with average irradiance?

Real-time plant prediction



PV plant providing grid ancillary services in Chile

Chile's National Electric Coordinator has granted approval for a new First Solar PV project to supply auxiliary grid services on a commercial basis. The installation has performed better than gas turbine technologies.

AUGUST 21, 2020 **PILAR SÁNCHEZ MOLINA**

GRIDS & INTEGRATION

UTILITY SCALE PV

CHILE



The Luz del Norte solar plant in Chile

Image: SMA / First Solar



Demonstration of Essential Reliability Services by a 300-MW Solar Photovoltaic Power Plant

Clyde Loutan, Peter Klauer, Sirajul Chowdhury, and Stephen Hall
California Independent System Operator

Mahesh Morjaria, Vladimir Chadliev, Nick Milam, and Christopher Milan
First Solar

Vahan Gevorgian
National Renewable Energy Laboratory

Flow Power claims Australian first at new smart solar farm

Renewable energy retailer Flow Power claims that the integrated technology behind a new "smart" solar farm in the town of Berri, South Australia, is the first of its kind to be switched on in Australia.

APRIL 6, 2023 **DAVID CARROLL**

TECHNOLOGY AND R&D

UTILITY SCALE PV

AUSTRALIA



Two groups challenge grid operator rules that restrict renewable energy

Earthjustice filed a complaint with FERC on behalf of SEIA that challenges a MISO rule that prohibits renewable energy resources from providing ancillary services.

FEBRUARY 1, 2023 **ANNE FISCHER**

MARKETS

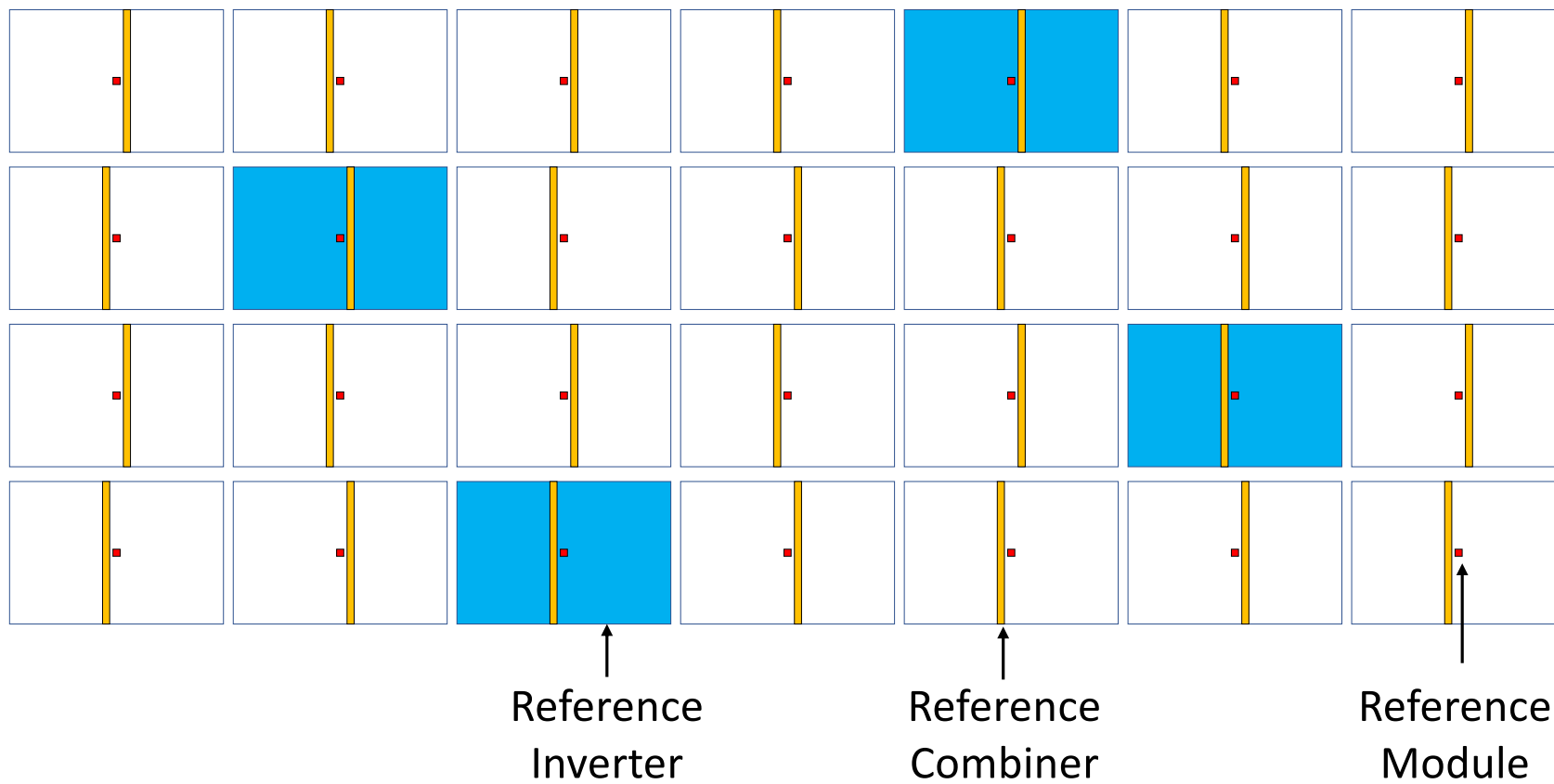
MARKETS & POLICY

POLICY

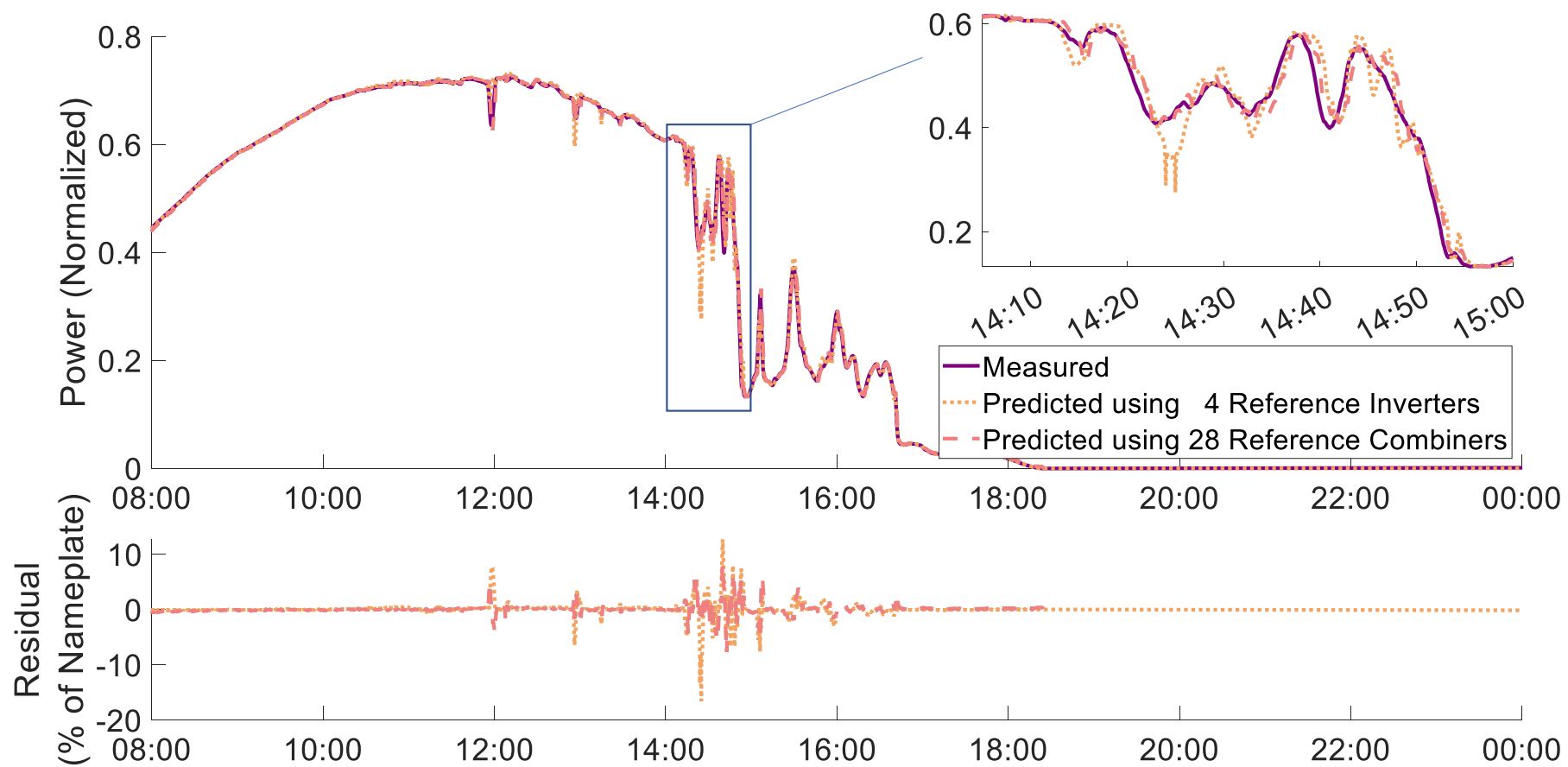
UNITED STATES



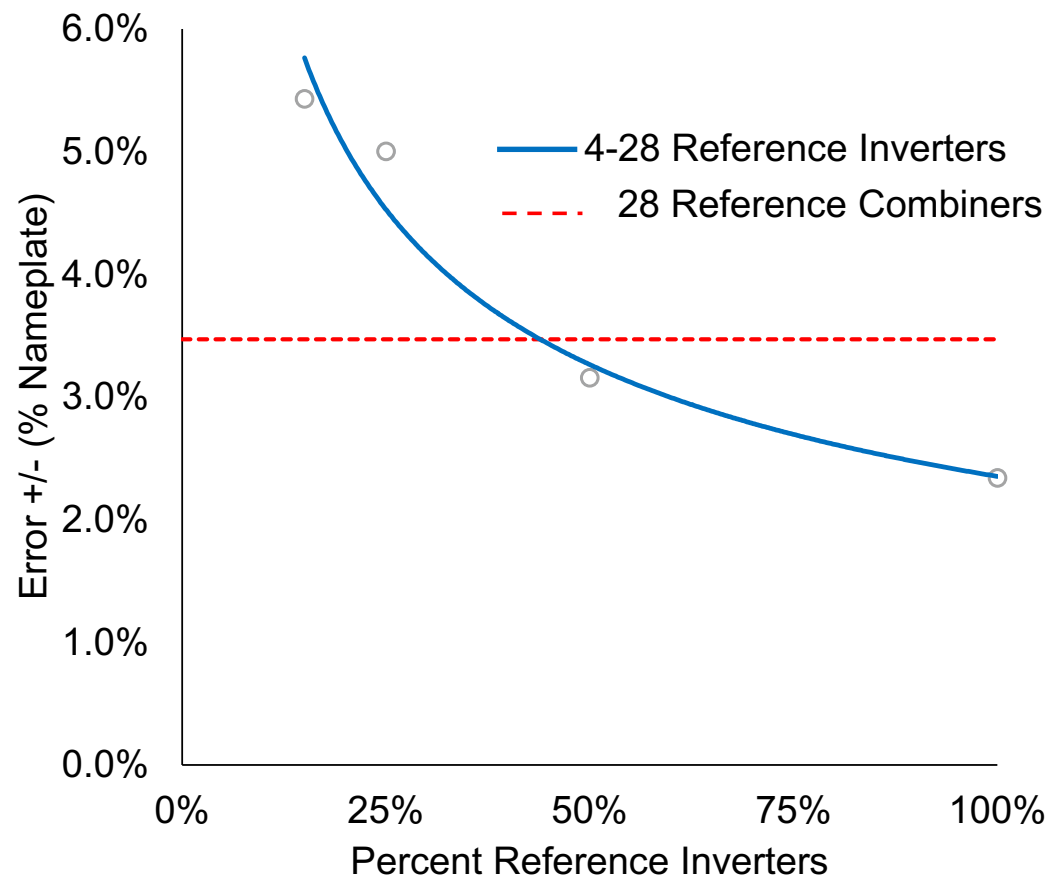




In progress: Hobbs, Gostein, PVSC 2023



In progress: Hobbs, Gostein, PVSC 2023

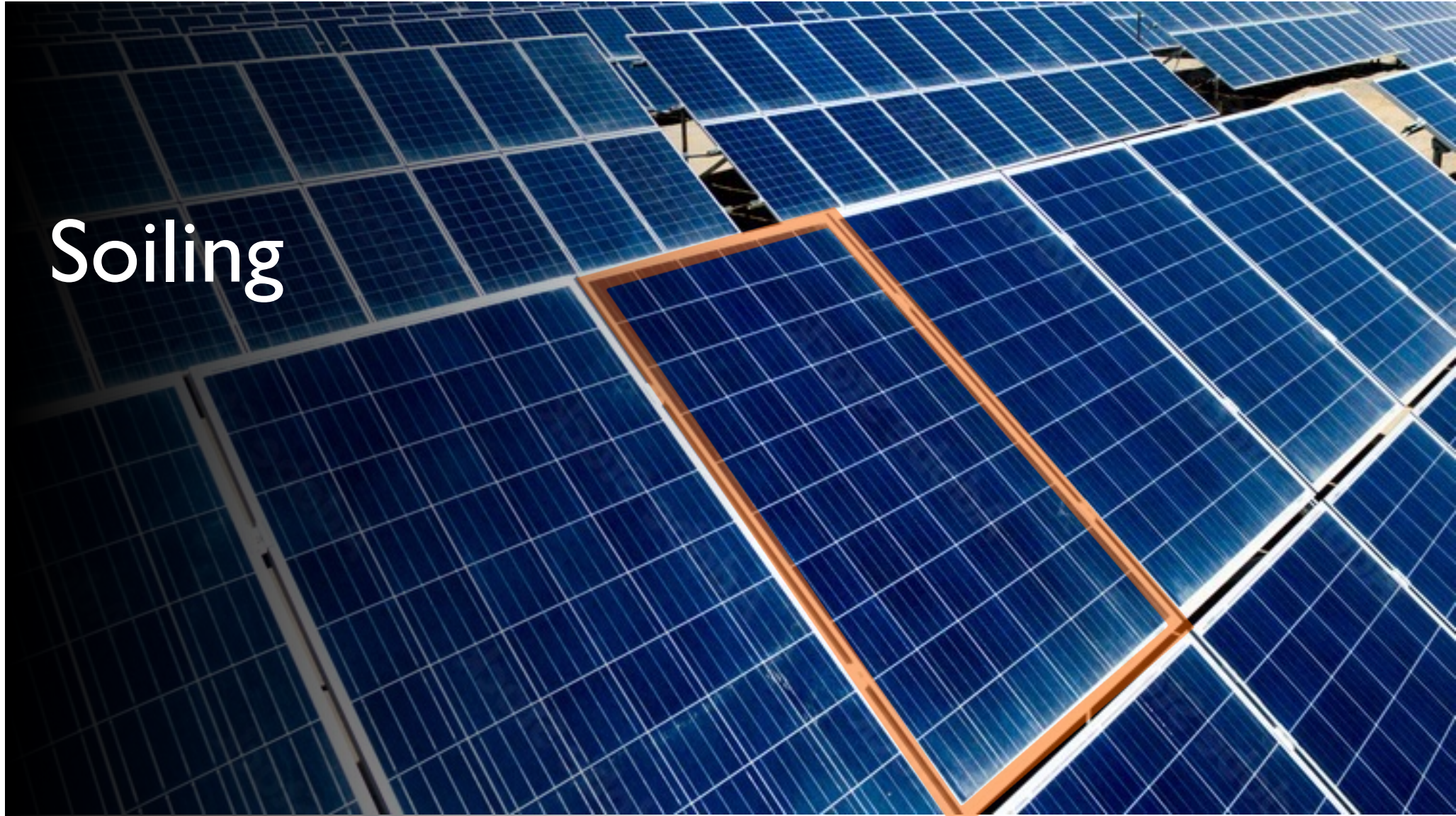


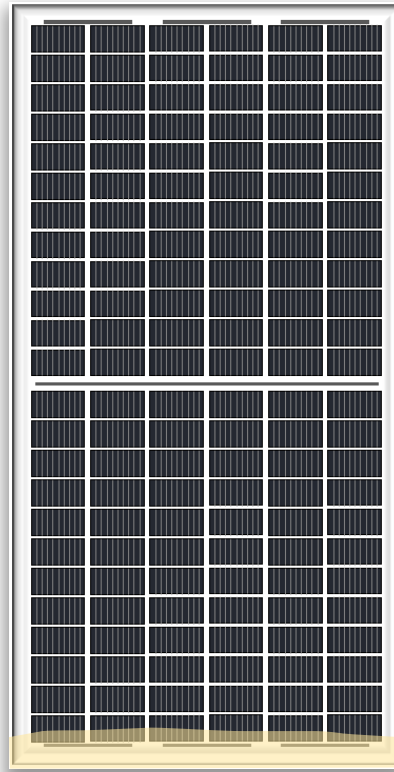
In progress: Hobbs, Gostein, PVSC 2023



In progress: Hobbs, Gostein, PVSC 2023

Soiling

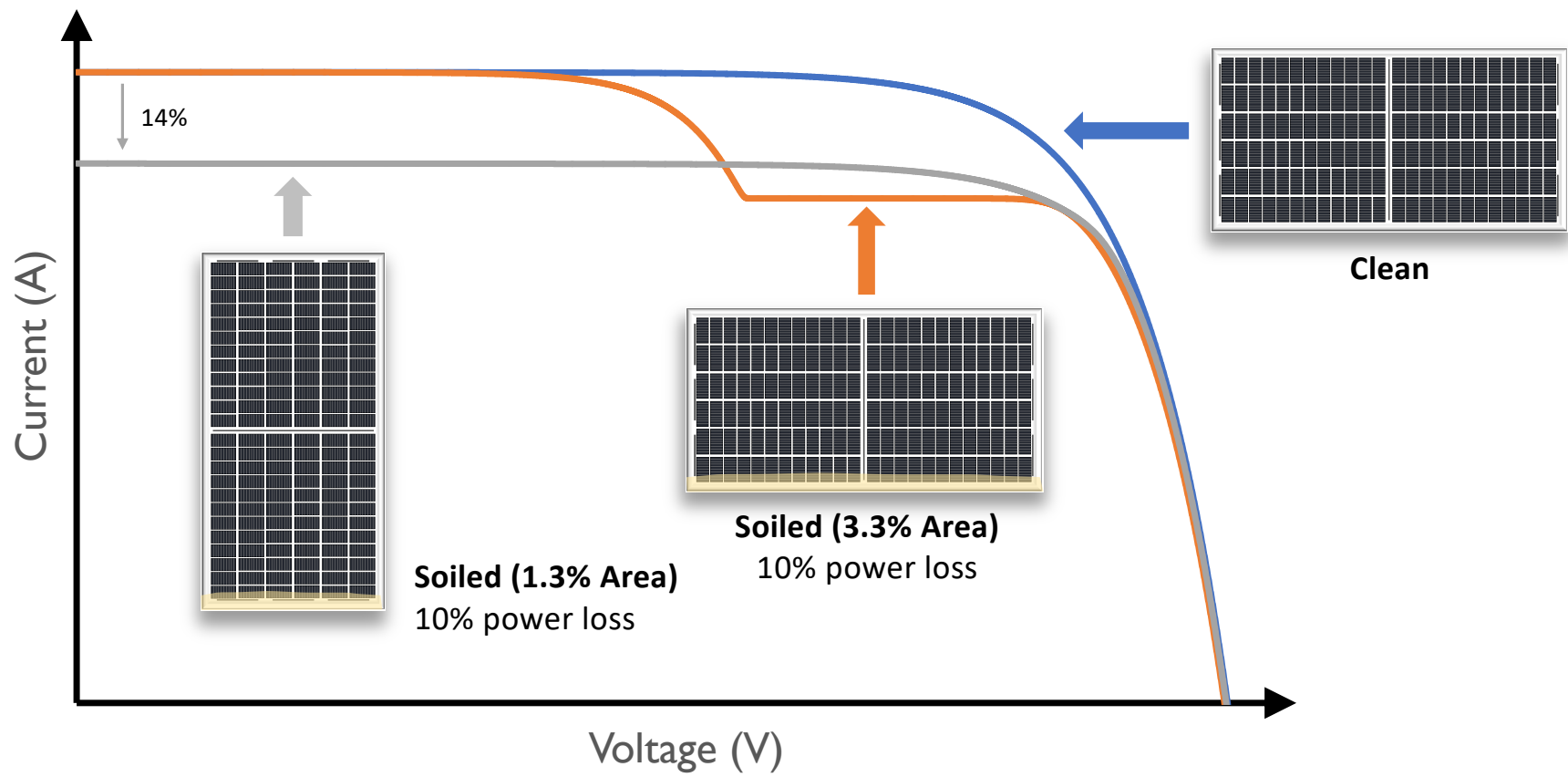




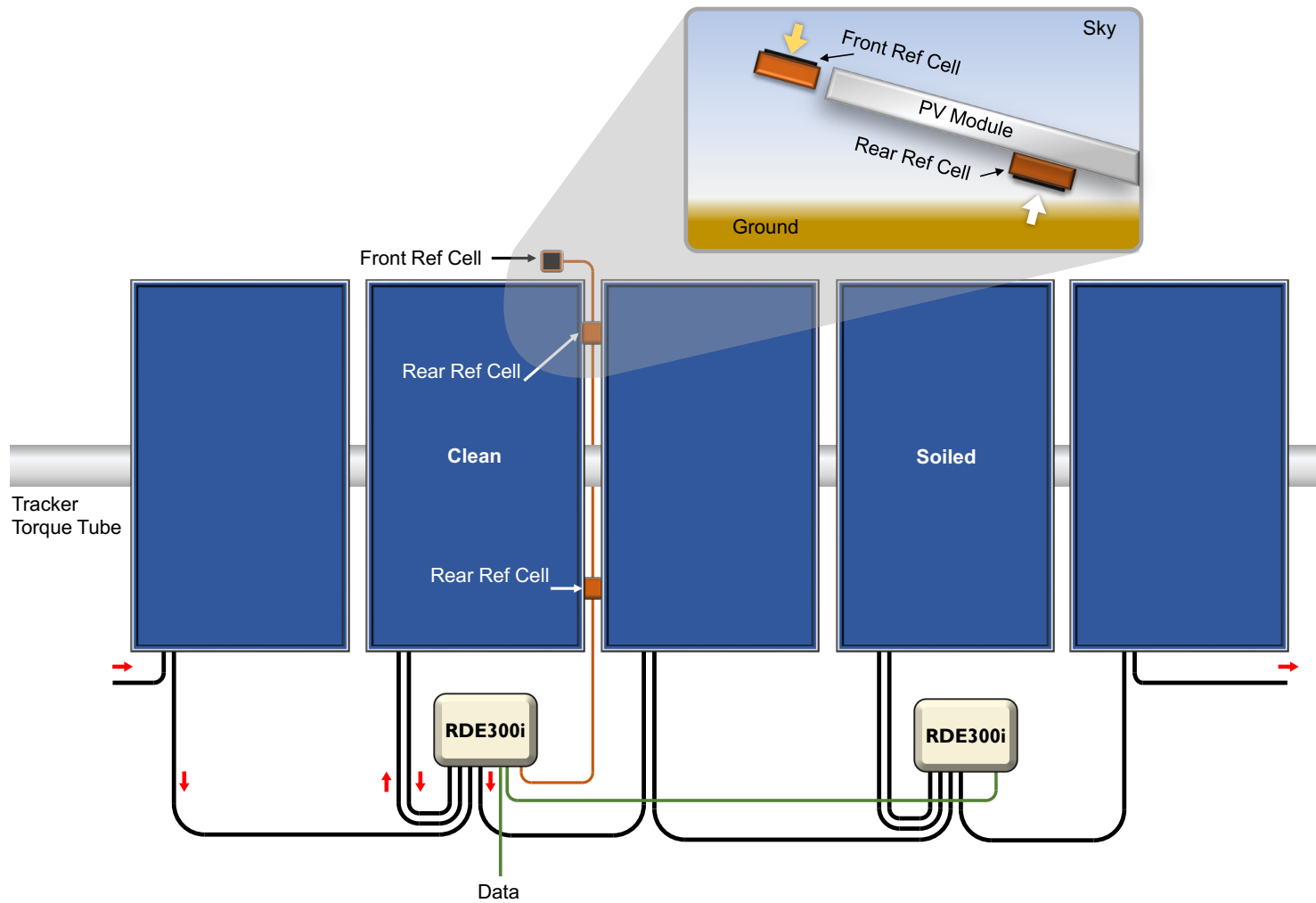
**Soiled
(1.3% of Active Area)**

Power Loss = ?

- A** 0%
- B** 1.3%
- C** 10%









In progress: Gostein, Marquis, Bila, Campbell, "Soiling and Irradiance Measurements in Bifacial PV Systems Using In-Situ I-V," PVSC 2023

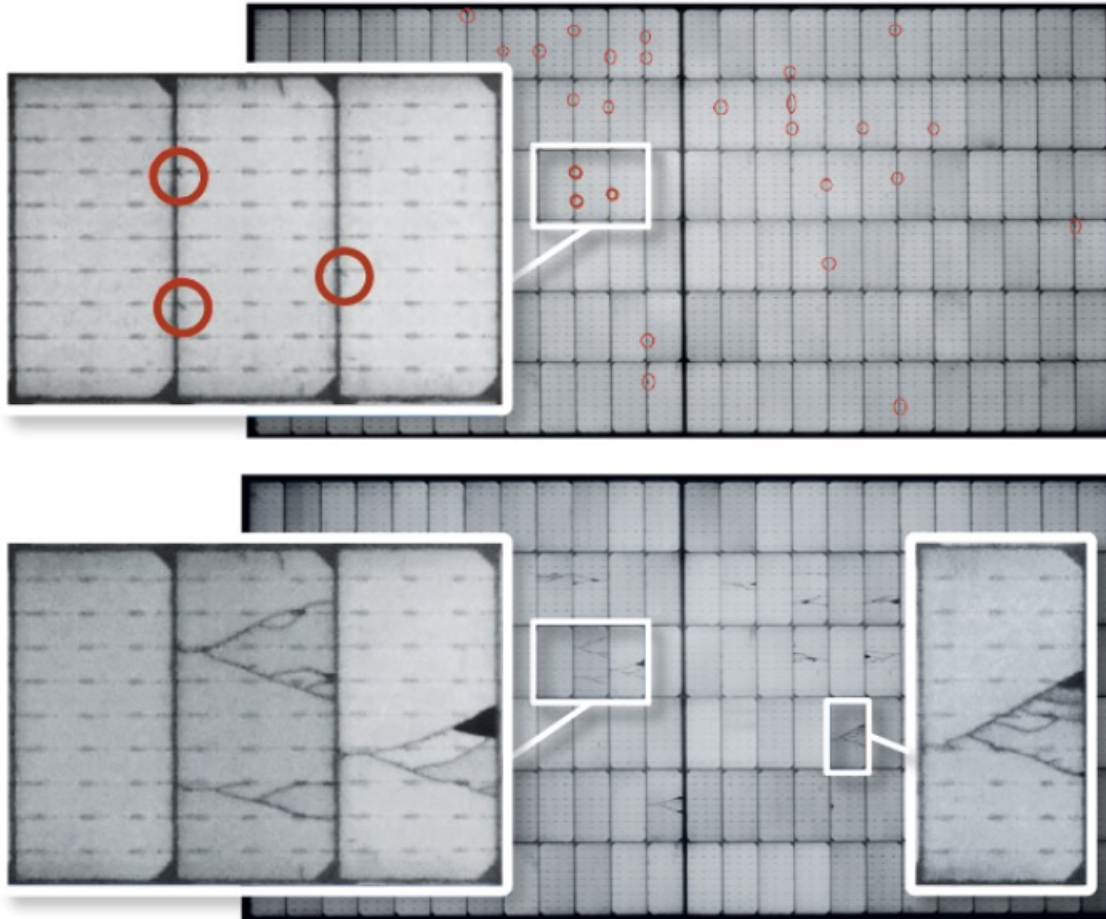
Degradation



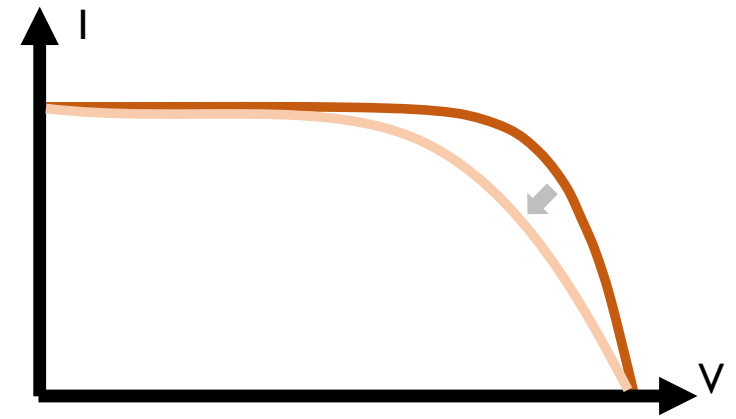
Bigger modules, bigger headaches?

APRIL 6, 2023

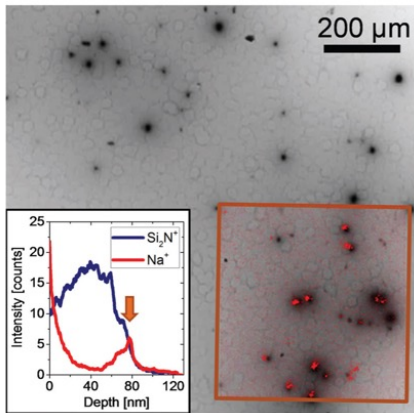
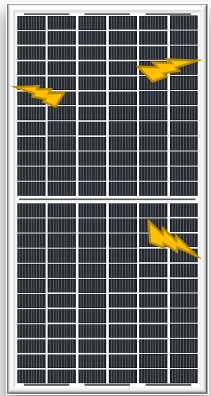
pv magazine



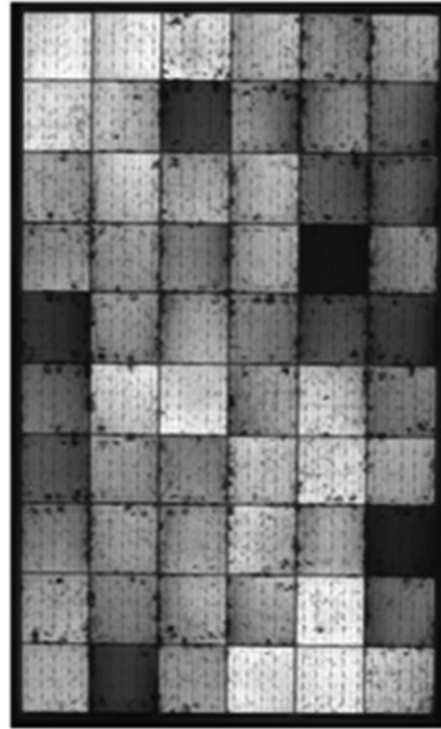
Cracks



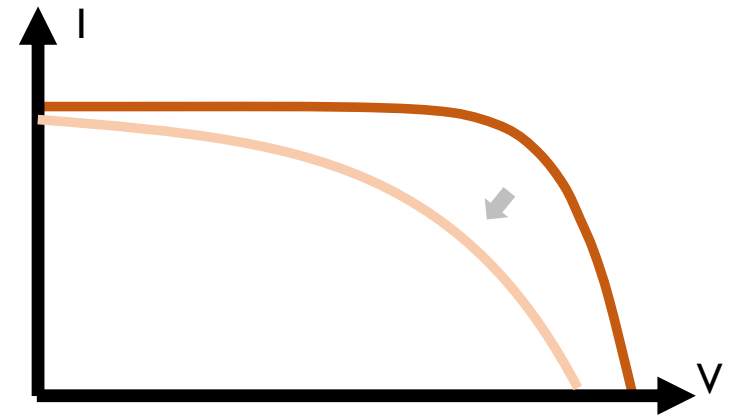
PID



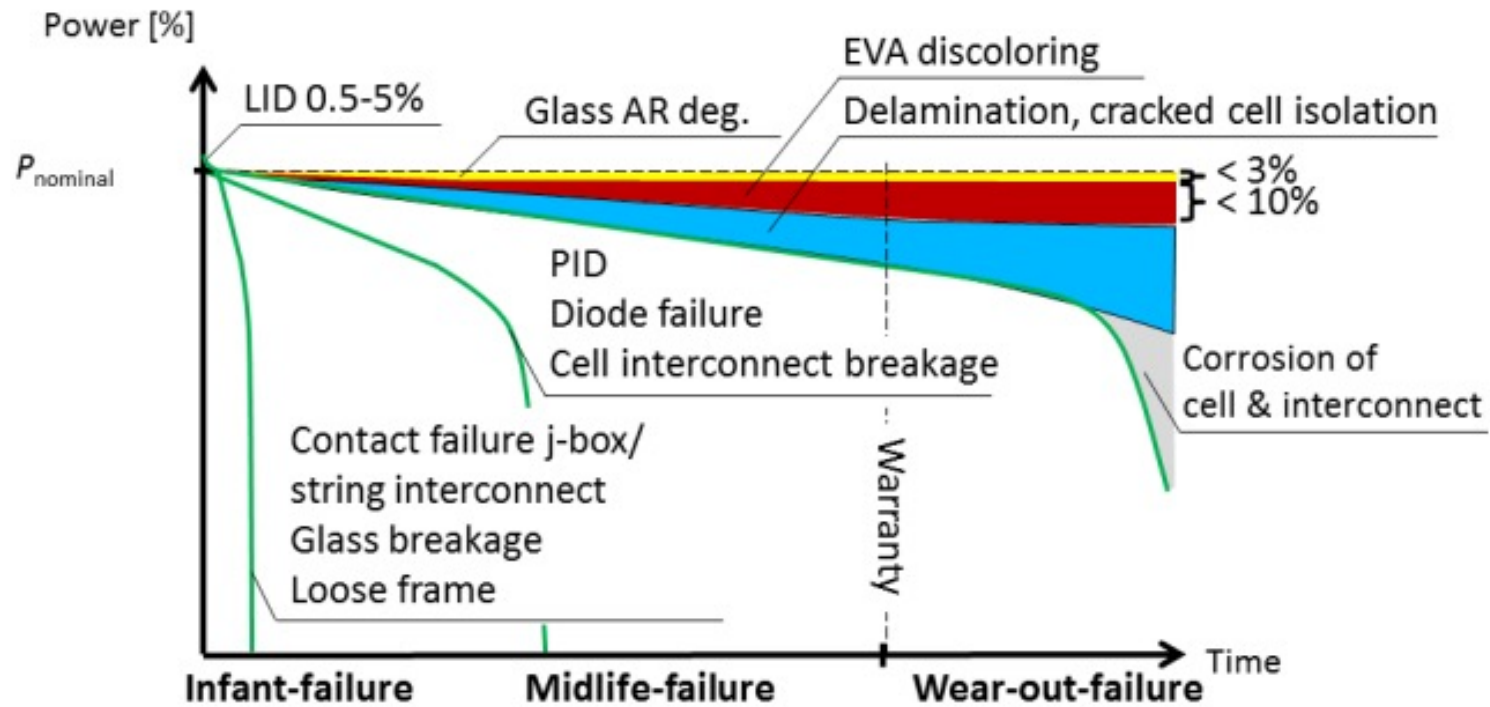
Ref. [1]



Ref. [1]



- Ref. [1]: Luo et al, "**Potential-induced degradation in photovoltaic modules: a critical review**," Energy Environ. Sci., 2017
- Ref. [2]: Schütze et al., "**Laboratory study of potential induced degradation of silicon photovoltaic modules**," PVSC, 2011



IEA-PVPS T13-01 2014 Review of Failures of Photovoltaic Modules



“Mahindra Susten Launches India's First Mobile PV Testing Lab,” PR Newsire, October 2017

Capabilities



Fast

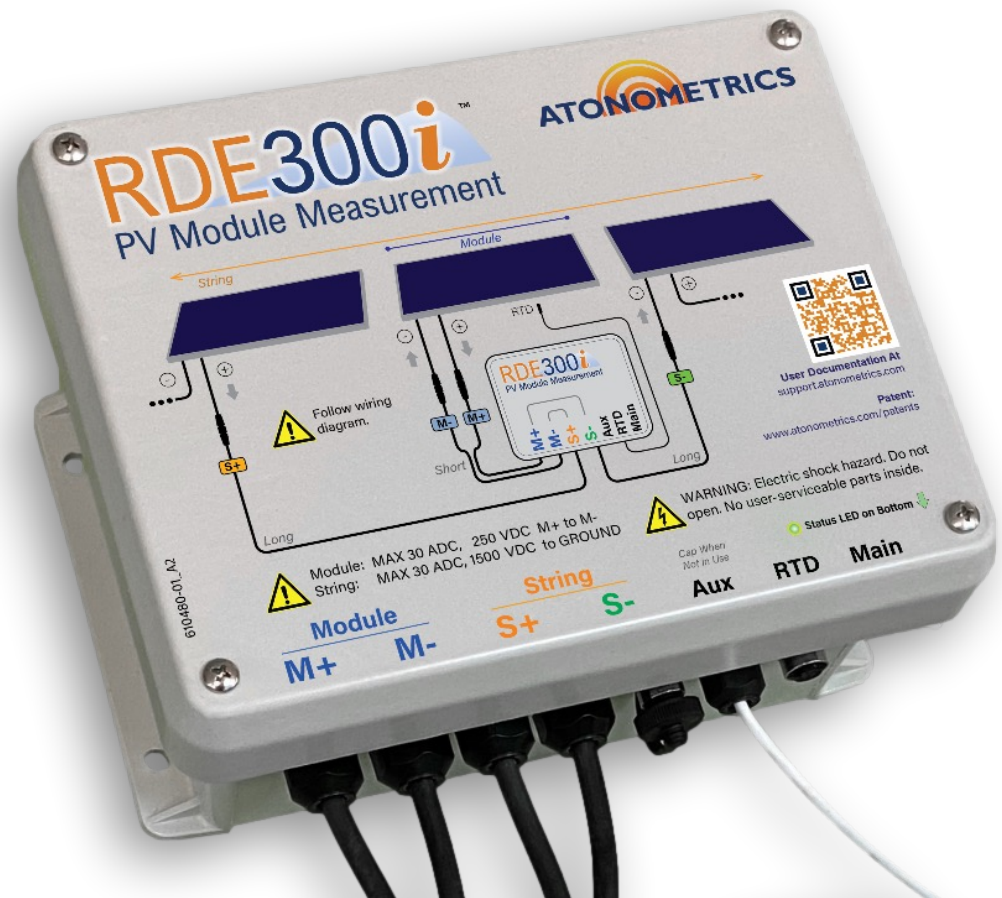
- Update every 2-60 seconds

Wide Input

- 30 A, 250 V, 1500 W

Networked

- Automatic multi-unit soiling calcs



Summary



Some applications of in-situ IV measurements:

