DYNAMIC SHADE

Workshop DYNAMO | Josco Kester

TKI URBAN ENERGY
Topsector Energy

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WHAT IS DYNAMIC SHADE?

- Duration of shade
  - Less than 10 s
- Area of shade – full module or partial?
- Direction of shade – portrait or landscape, straight, curved?
- Frequency – is it repeating or random?
- Depth – hard, dark shade or lighter shading?

INTEGRATED PV IN THE NETHERLANDS

Stijn Verkuilen
Innovation manager
Heijmans Infra

- Solar Noise Barriers (2014-2016)
- Solar Highways (2017-2020)
- Rolling Solar (2018-2021)

BAYARDS® BUILD

Als wereldwijd opererend team van specialisten ontwikkelen we duurzame Aluminium oplossingen. Onze missie is met het combineren van creativiteit, engineering, vakmanschap, innovatie en state-of-the-art technologie hoogwaardige producten en projecten te leveren van Aluminium.

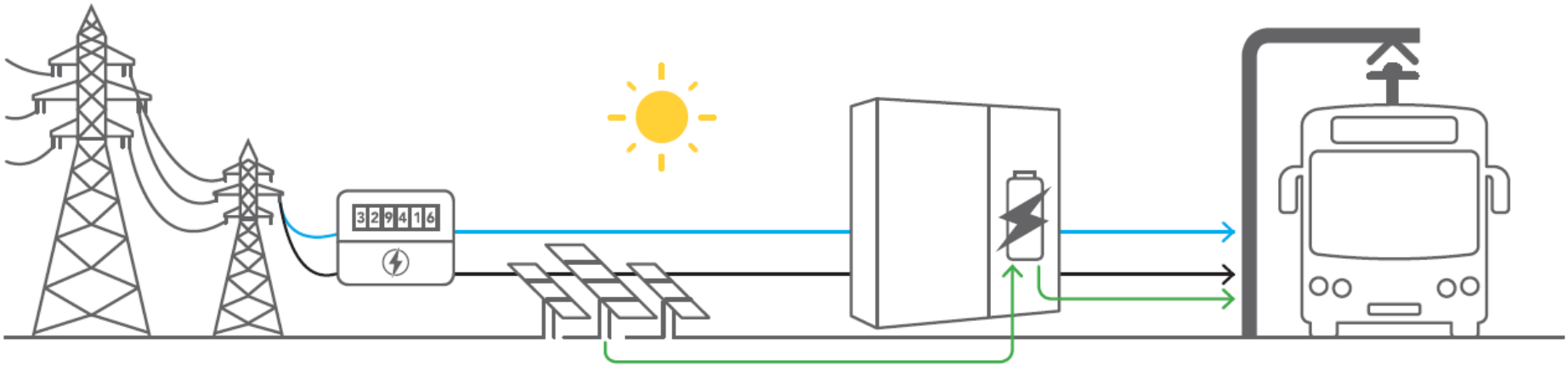
BAYARDS

solutions in aluminium

Dynamic shade

heliox

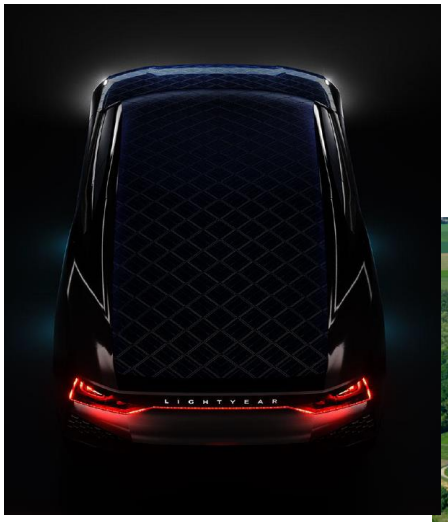
SprintCharge™
Development Battery buffered Opportunity Charger

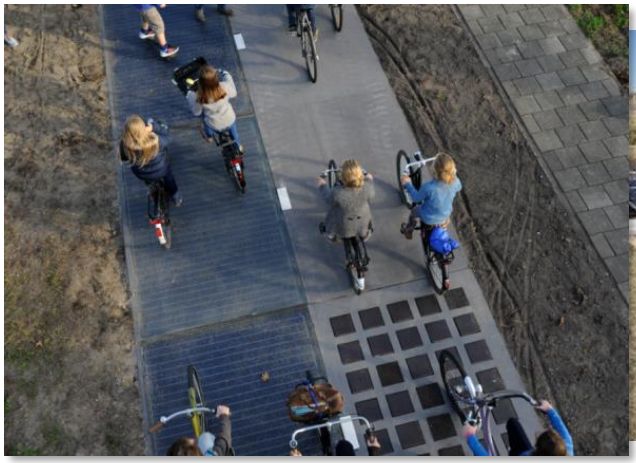


Innovative & Futureproof

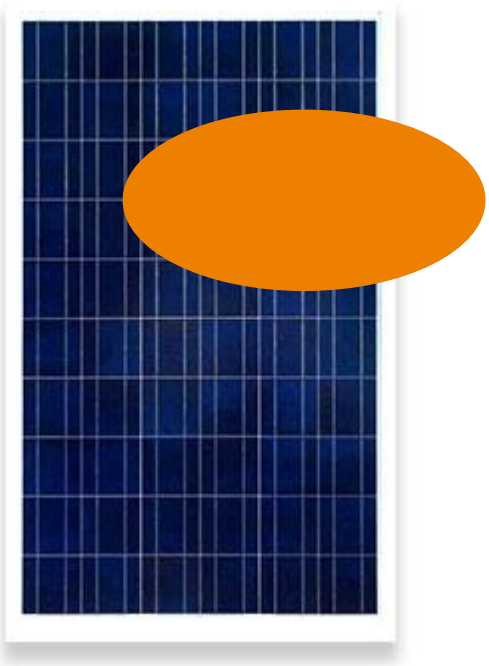
Dynamic shade

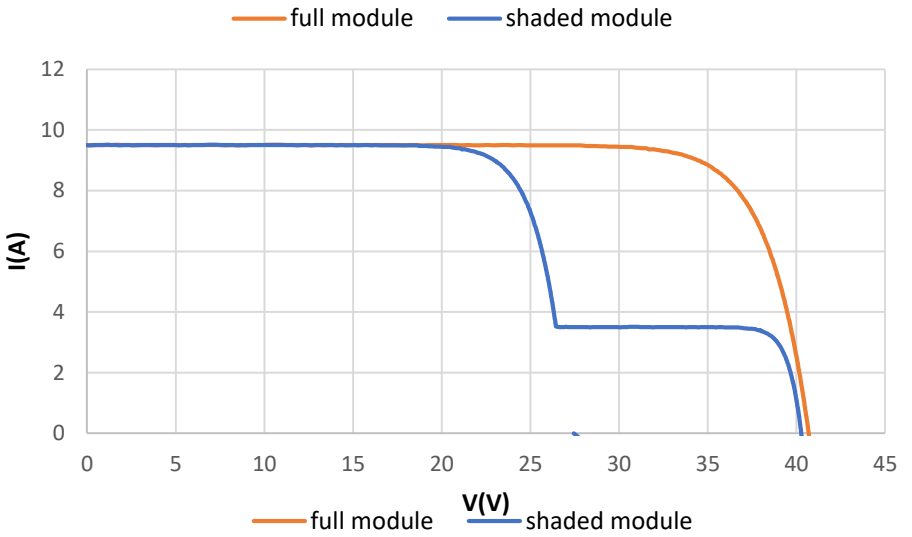
DYNAMIC SHADE IN INTEGRATED PV

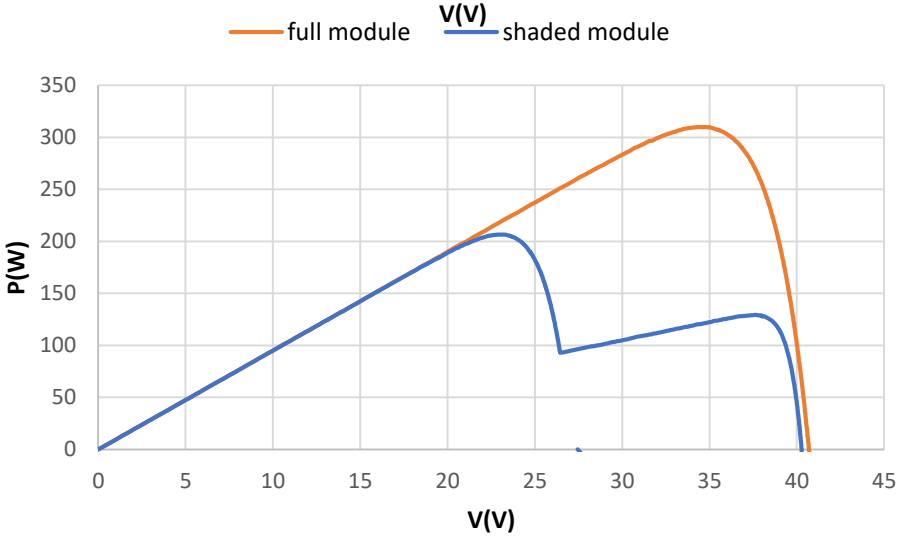




PARTIAL SHADE



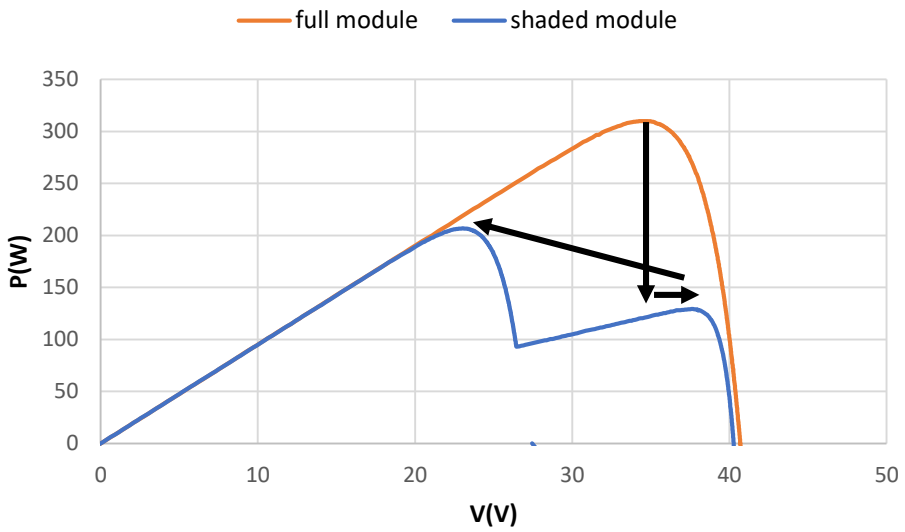




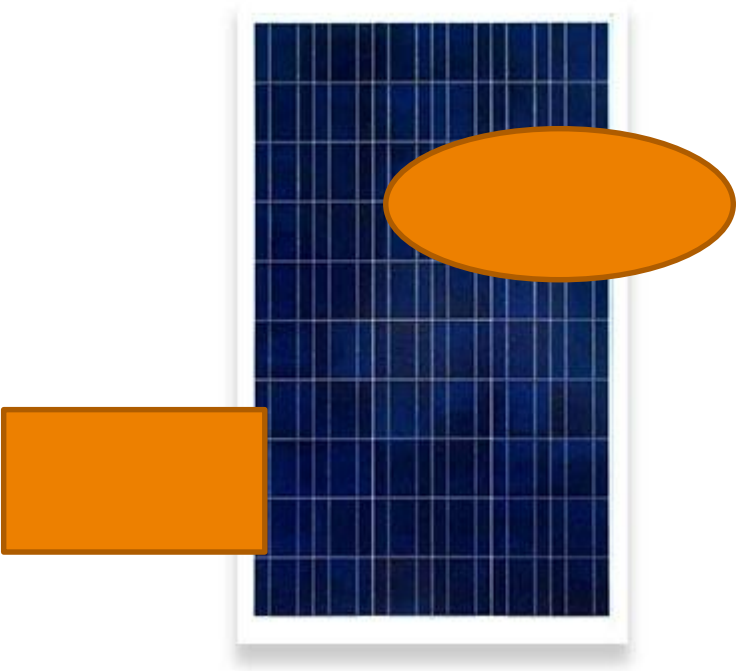
- Electronics are important
  - Bypass diodes
  - Power optimizers

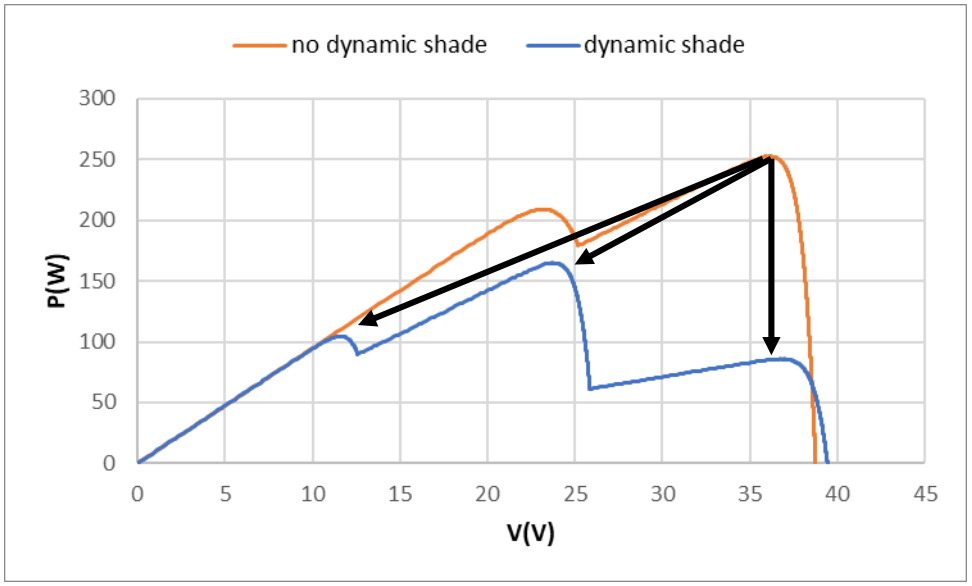
OPTIMIZER ALGORITHM

- Changes voltage to find:
  - Local MPPT (0.05 – 1 Hz) – ‘hill climbing’ to find local maximum
  - Global MPPT (every 5 – 10 minutes) – sweeps (0 - Voc+) to find global maximum



DYNAMIC SHADE WITH PARTIAL SHADE

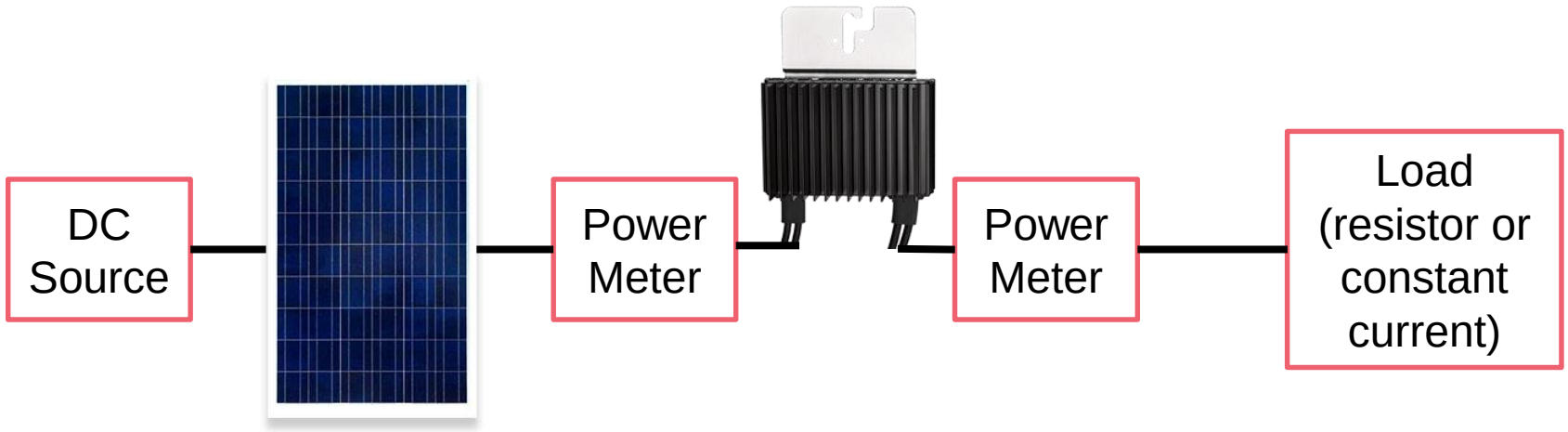




DYNAMIC SHADE CHARACTERIZATION TOOLS

1. Indoor testing of dynamic shade over full module
2. Indoor testing of partial dynamic shade
3. Outdoor testing of systems
4. Simulation of shading situations with BIGEYE
5. Power component algorithms for simulation

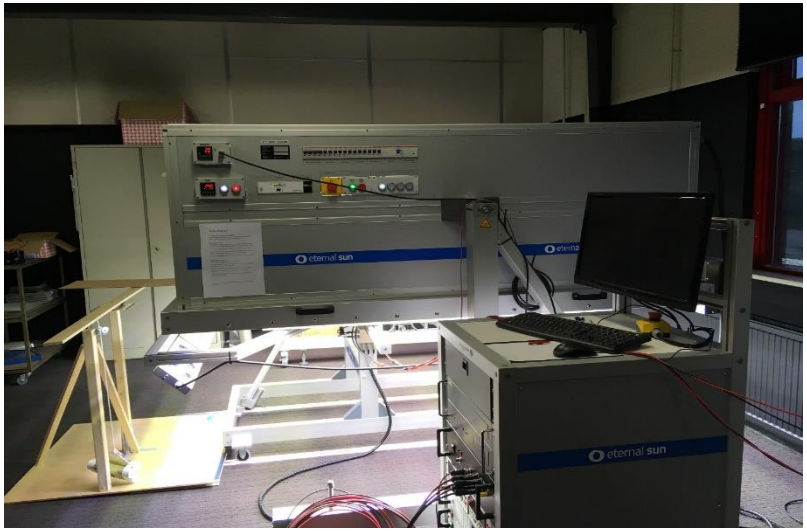
FULL MODULE SHADING

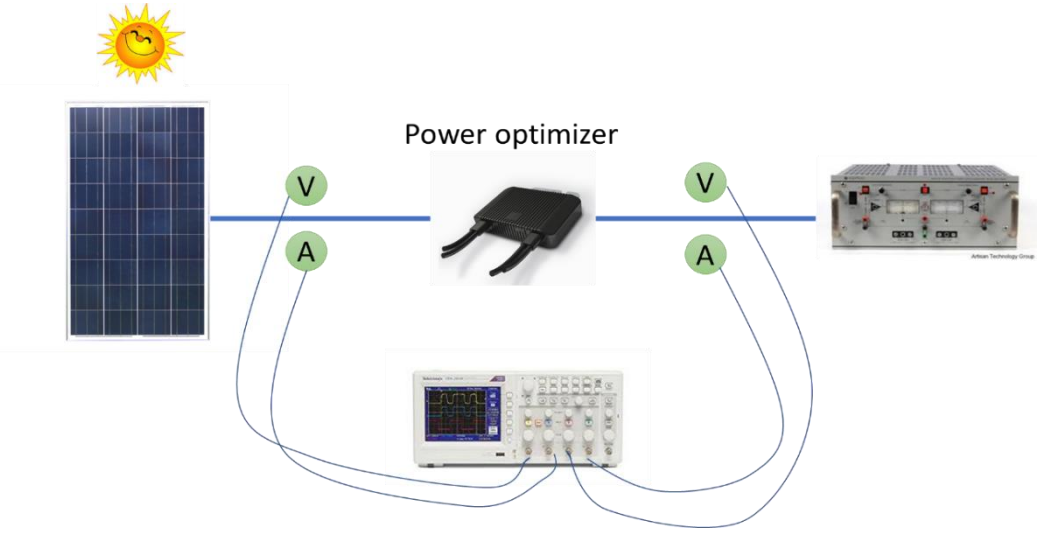


- Duration
- Depth
- Power component
- Frequency

- Type of module
- Load

PARTIAL SHADE TESTING





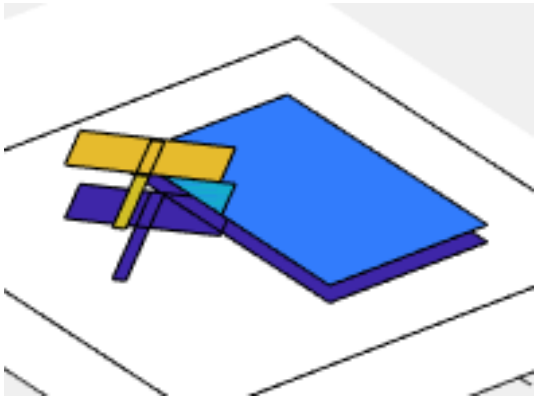
- Direction
- Area
- Depth
- Power component
- Frequency
- Type of module
- Load

OUTDOOR TEST SETUP

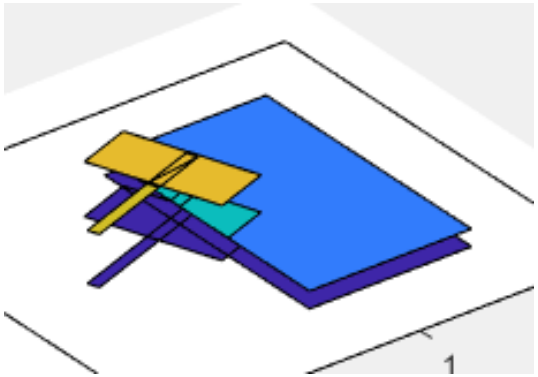
BIGEYE: SIMULATION OF ROTATING SHADE

- Landscape
- Portrait

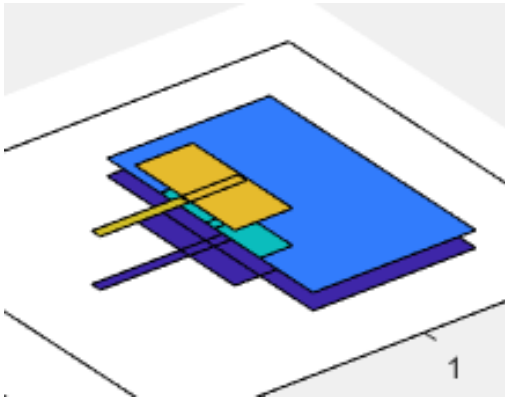
φ=50º

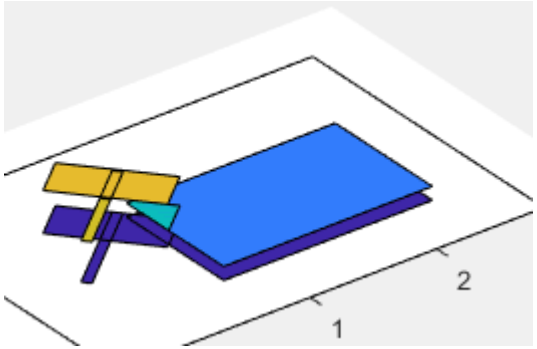


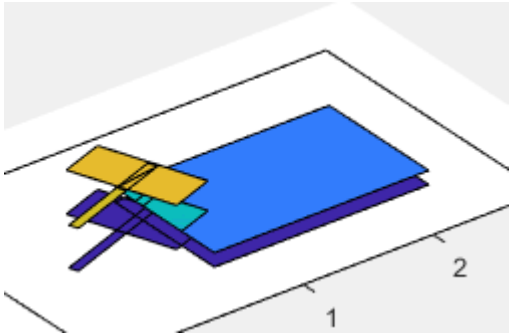
φ= 70º

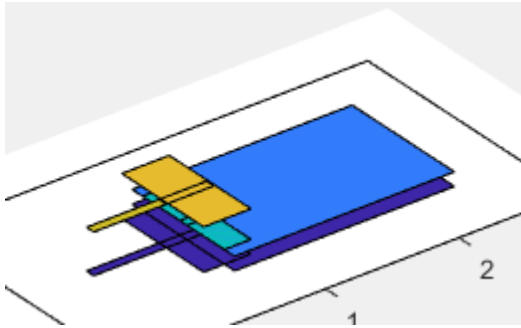


φ= 90º



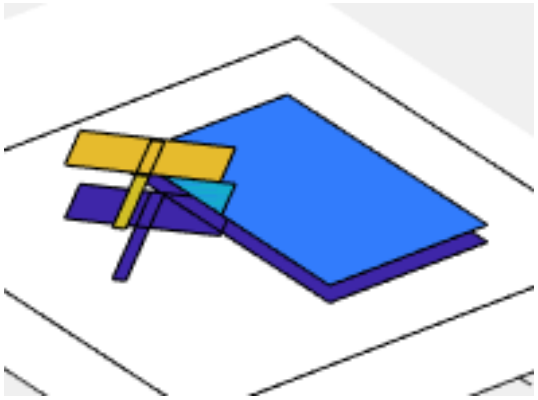






FULL I-V CURVES: LANDSCAPE

φ=50º



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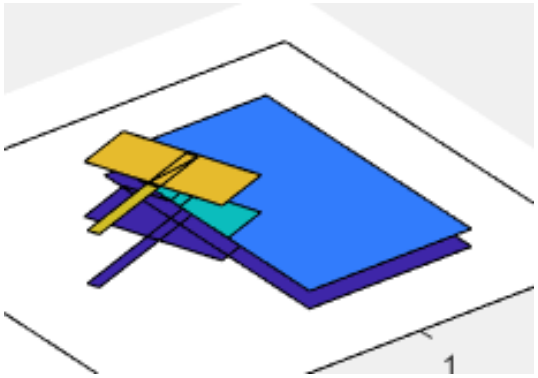

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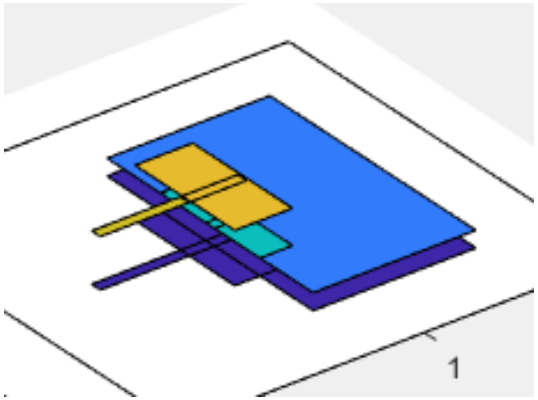
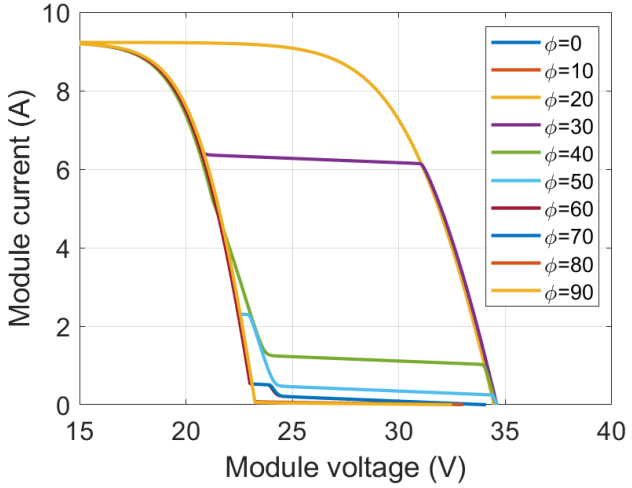
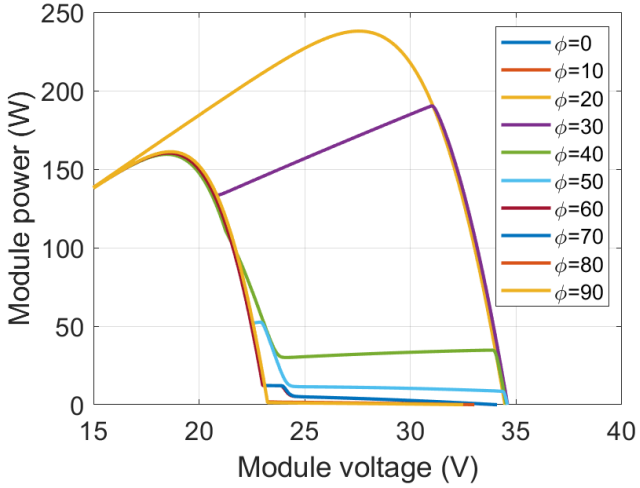
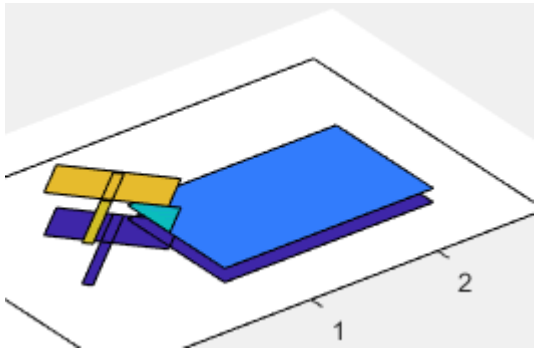






FULL I-V CURVES: PORTRAIT

φ=50º



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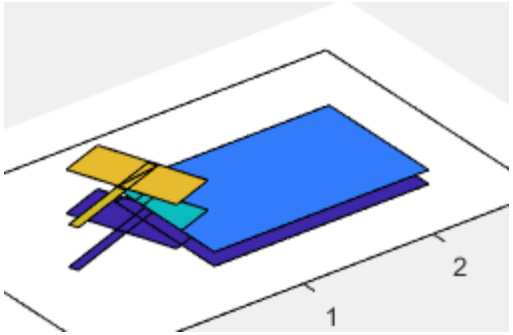

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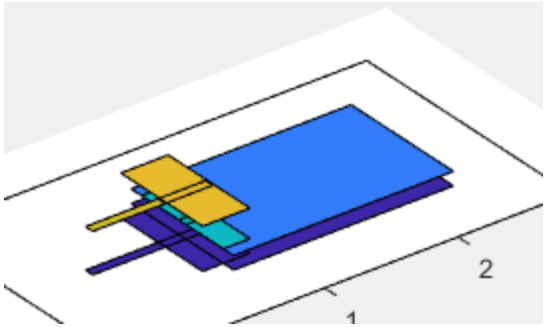

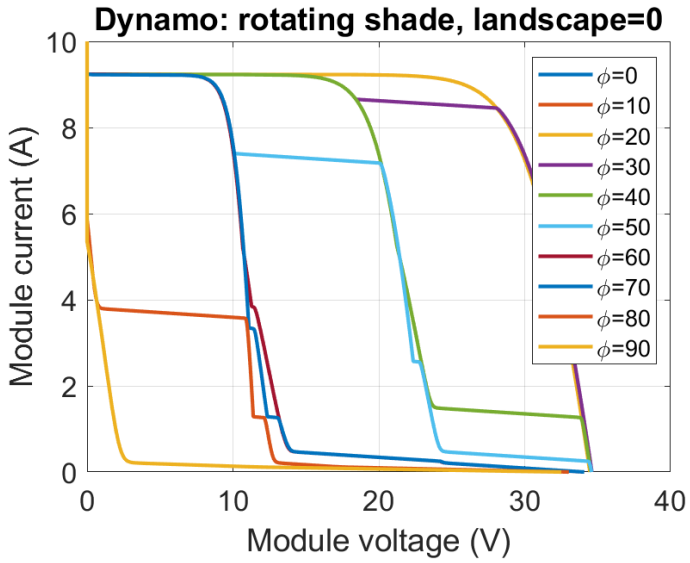

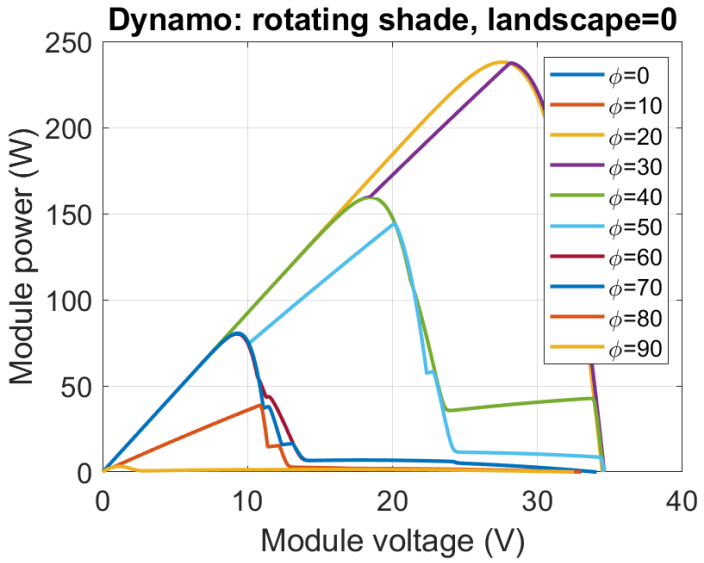

MAXIMUM POWER POINTS

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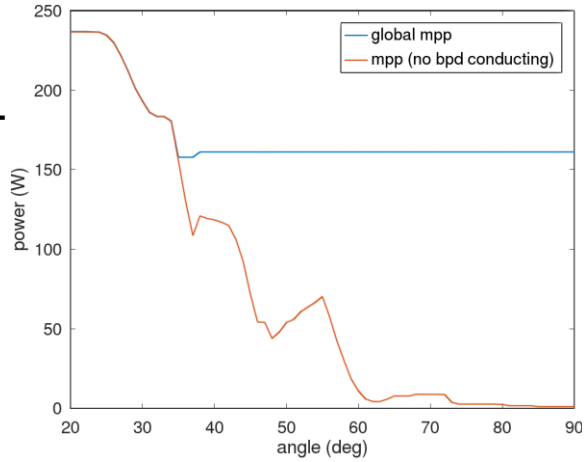
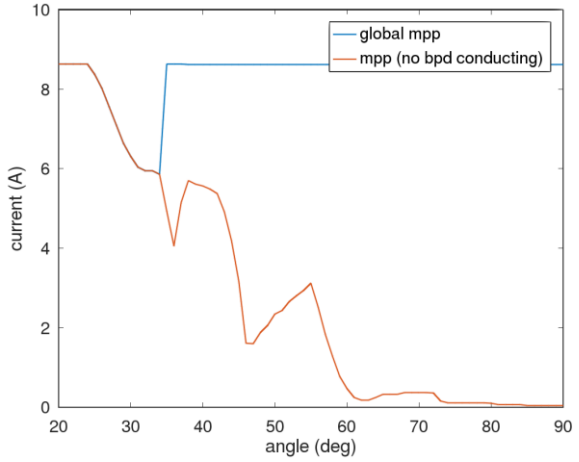
Power

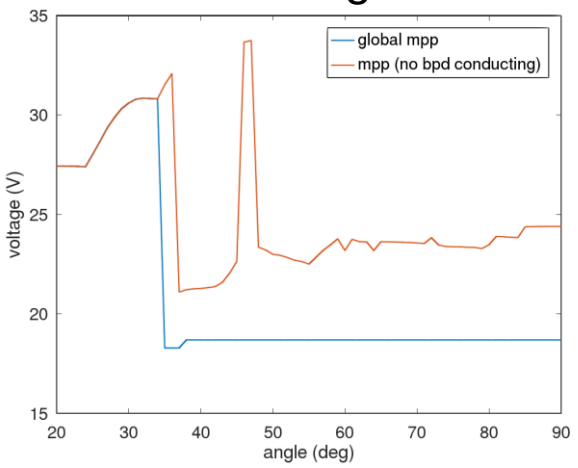
Current

Voltage

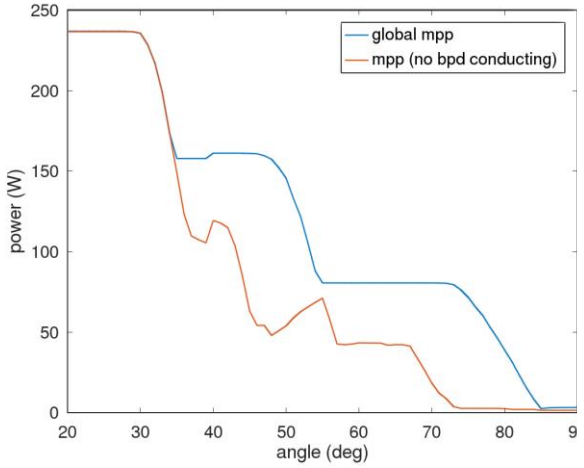
Landscape

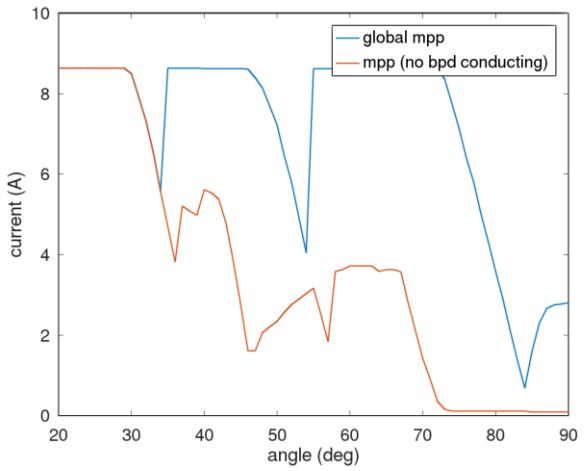


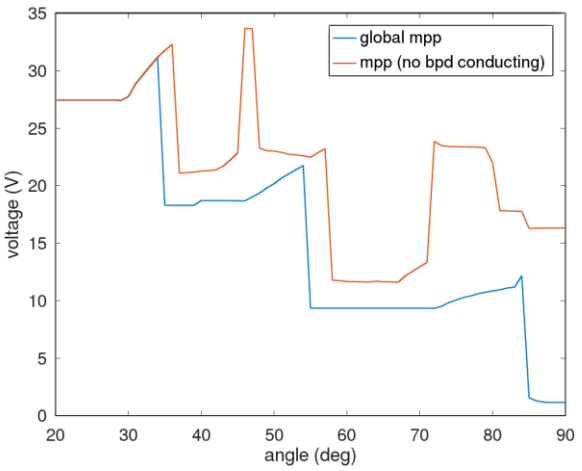




Portrait

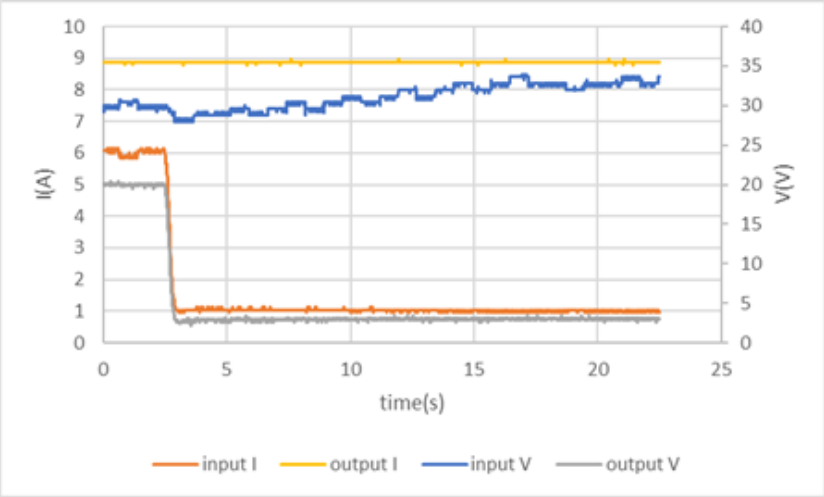




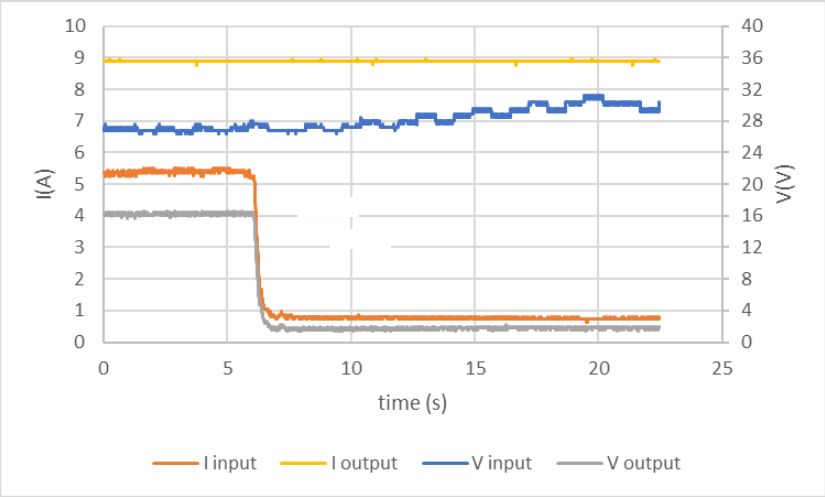


PORTRAIT VS. LANDSCAPE

Portrait



Landscape



- Same response in voltage
- Only finding local maximum, not global
- No gMPPT sweep
- Potential for significant losses (6% if with 10% shade time)

DYNAMIC SHADE

- Same shade duration

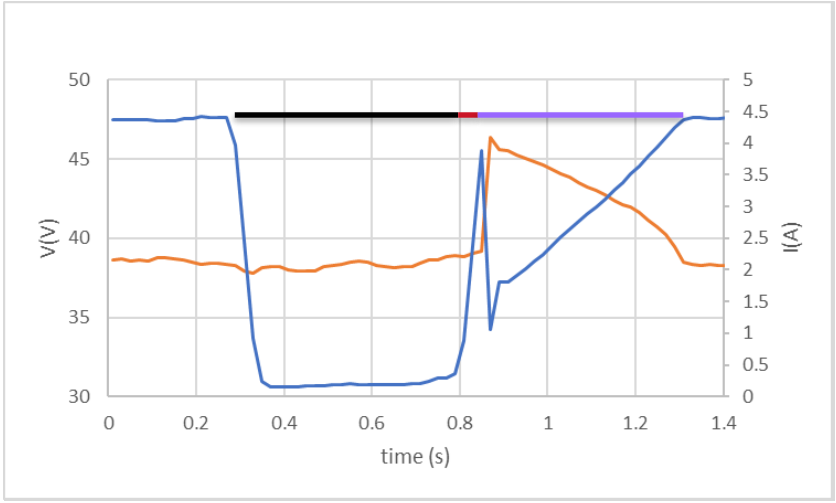
- Black bar denotes duration of shade
- Red bar denotes stabilization time
- Purple bar denotes inverter reaction

- The power optimizer coupled to an inverter takes much longer to stabilize.
  - Power optimizer itself is very swift
  - Power loss inverter: ~20 W
  - 10-25% additional loss (2-9 J)

A (optimizer)

B (optimizer)

C (micro-inverter)



CONCLUSIONS

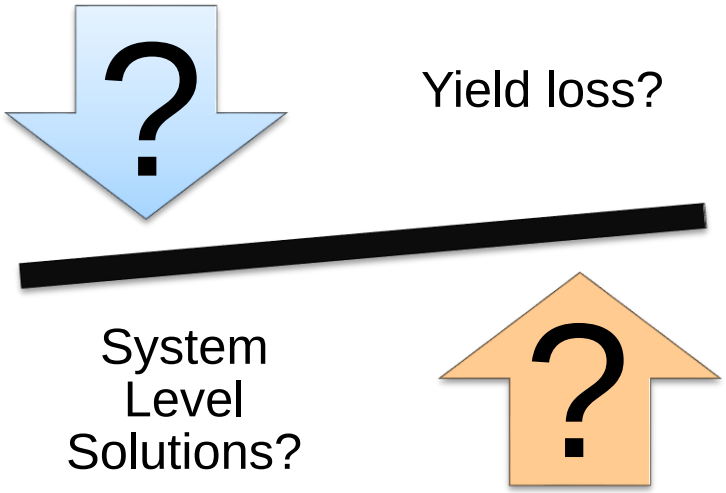
- Dynamic shade results in multiple MPPs and step changes in voltage @ global MPP
- Module design, system design and MPPT algorithms can have significant impact on
  - Energy yield
  - Stresses on power electronics (impact on lifetime?)
- Yield losses can be significant >10%
  - with wrong module and system design, power electronics
- Best choices depend on many parameters
  - shade intensity, duration, frequency, direct/diffuse irradiation, …
- Models available
  - various illumination environments
  - module design, system design, power electronics components

WHERE WE ARE…

Dynamic shade is complex!

(and cannot be generalized, yet)

We can study it in the laboratory and simulated environments for particular situations.



WE ARE CONTINUING…

- Further testing
  - Increase the number of optimizers, micro-inverters tested
  - Test for periodic and random repeated shade – methodology for understanding ‘resonance’ frequencies in the system

- Other applications
  - Floating Solar
  - Combined Solar and Wind Farms
- Models
  - Best module design, system design, power electronics components
  - Cost benefit analysis in specific situations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