Innovative Floating Bifacial Photovoltaic Solutions for Inland Water Areas

Hesan Ziar, Bjorn Prudon, Fen-Yu (Vicky) Lin, Bart Roeffen, Dennis Heijkoop, Tim Stark, Elias Garcia Goma, Julen Garro Extebarria, Ignacio Narvaez Alavez, Daniel van Tilborg, Hein van Laar, Rudi Santbergen, and Olindo Isabella

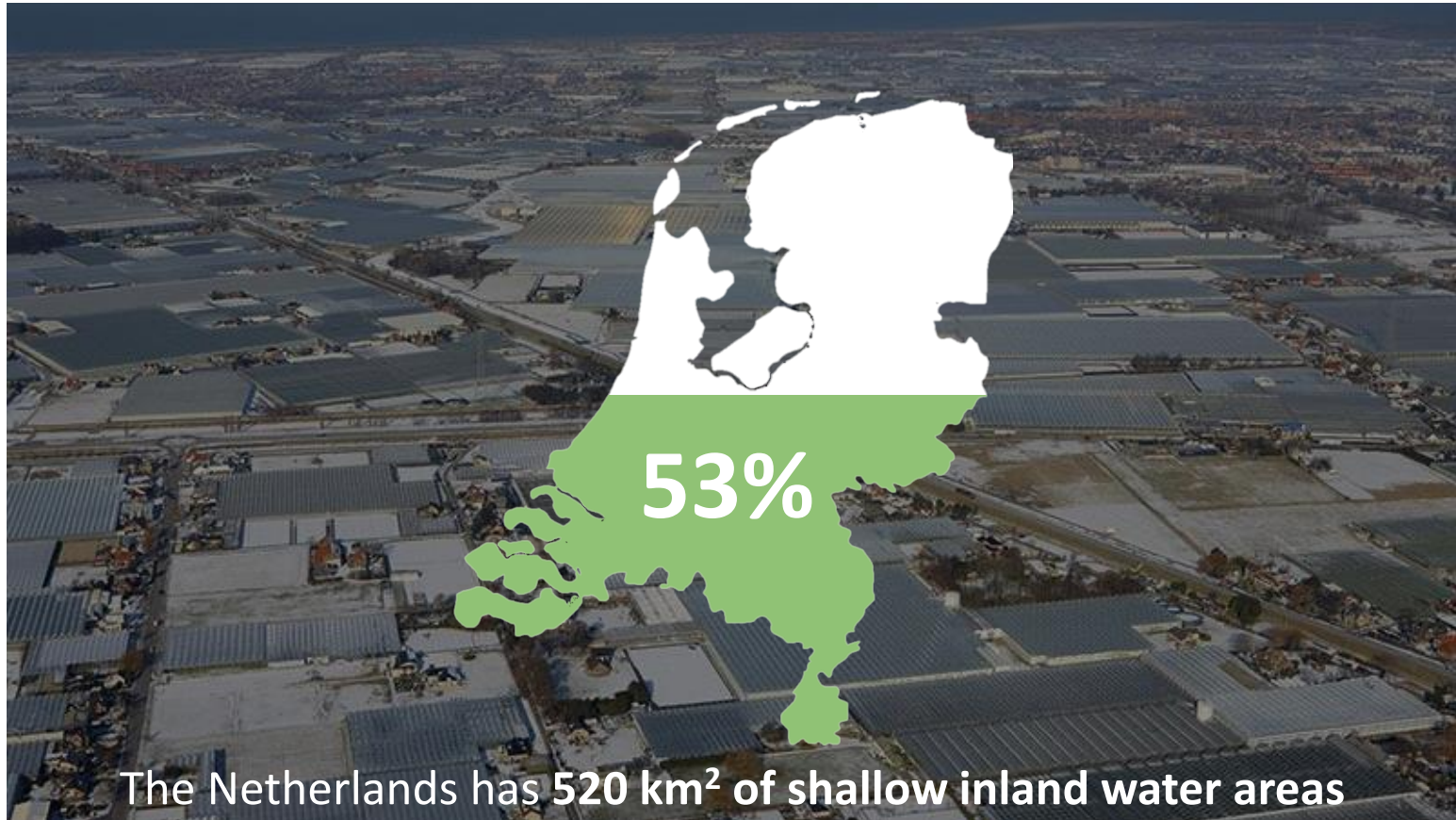**10th of September 2020**

EU PVSEC, Online

Motivation

https://www.careersatcatalyze.com

https://news.cornell.edu

Motivation

https://www.careersatcatalyze.com
https://news.cornell.edu

Motivation

Bifacial PV

Floating PV

https://vulcanpost.com
https://sunpower.github.io/pvfactors/theory

Motivation

53%

The Netherlands has **520 km²** of shallow inland water areas

CBS: 'Minder landbouw, meer natuur' (2016)

Objective

INNOZOWA: INNOvatieve **ZO**n-pv op **WA**ter

🎯 *to model, realize, and monitor **innovative on-shore floating PV concepts***

Model Realize Monitor
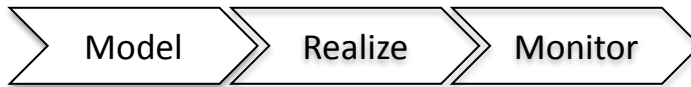
Concerns and Questions

Enable mowing activities

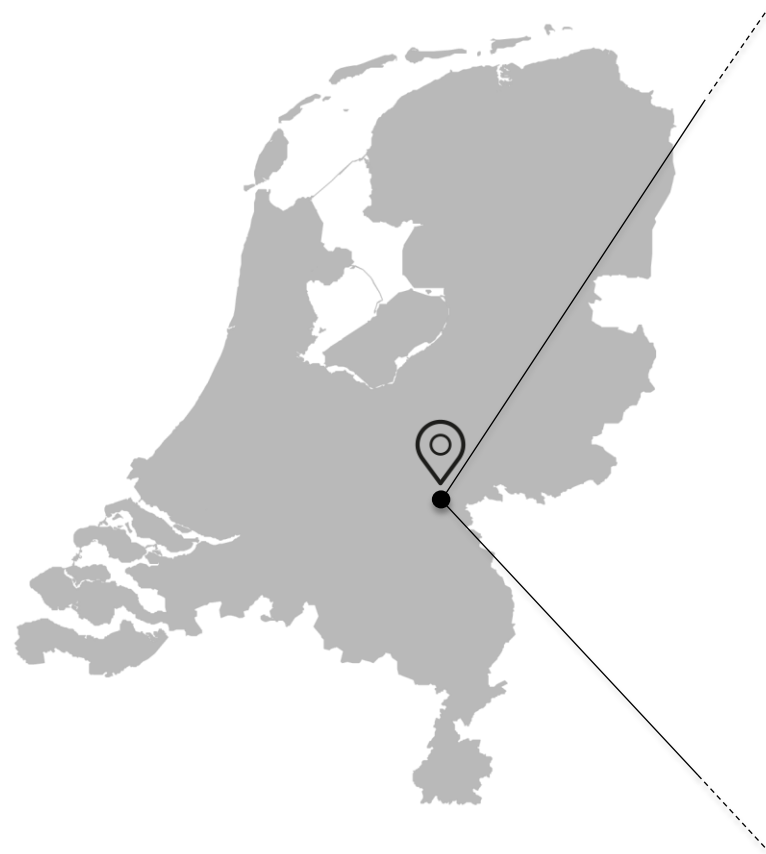**Reflection from water**

Cooling effects of the water?

As high as irradiation possible

Bifacial? Monofacial? Reflector?
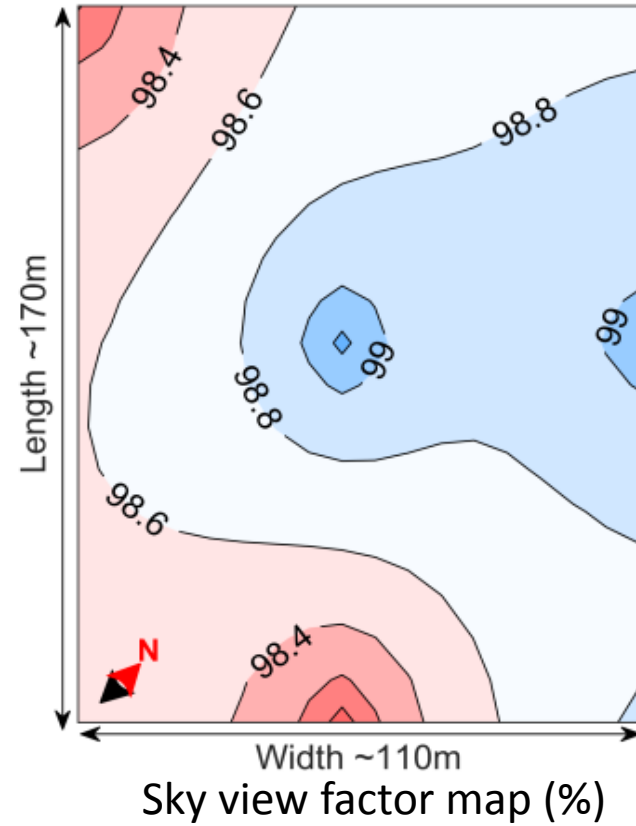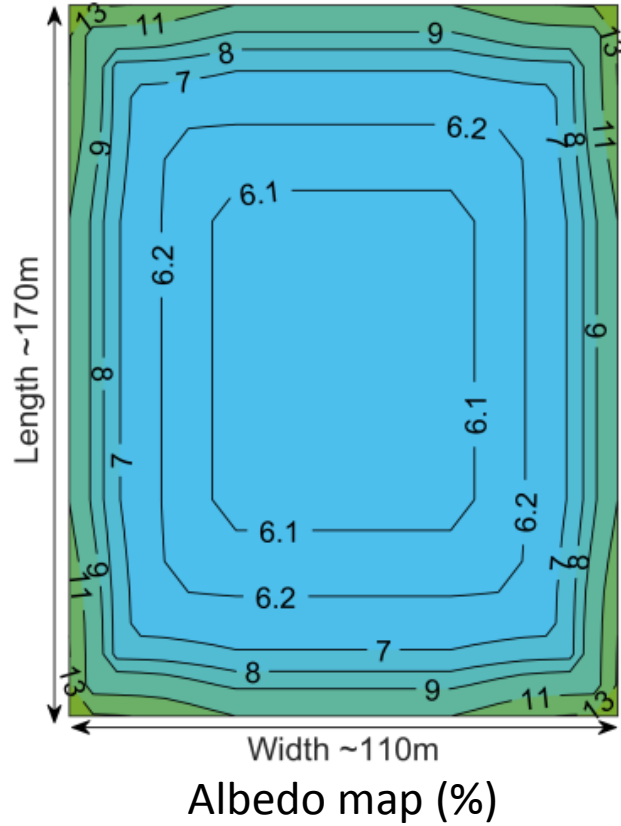
Tracking system?

Etc.

Location Survey

Model Realize Monitor
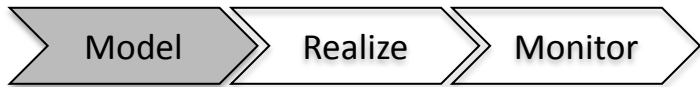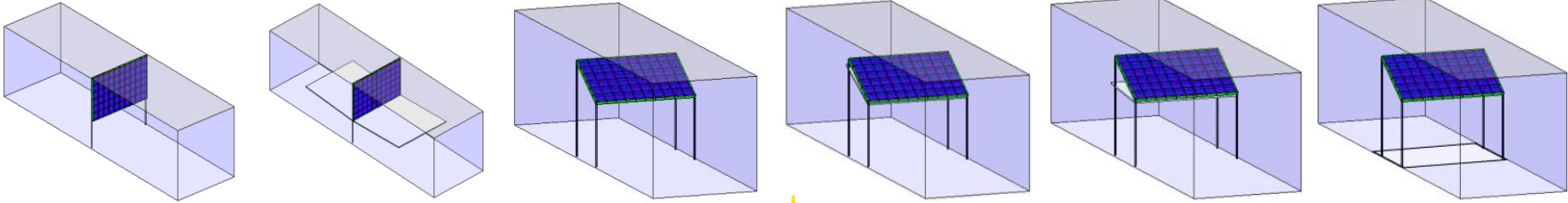
Location Survey

Albedo

Horizon

Model › Realize › Monitor

Location Survey

Albedo map (%)

Sky view factor map (%)

Model Realize Monitor

Modeling

PVMD ToolBox

Model   Realize   Monitor

R. Santbergen, et al., *IEEE J. Photovolt.*, **7**, 919-926 (2017)
R. Santbergen, et al., *Sol. Ener.* , **150**, 49-54 (2018)

Partial Water Soaking
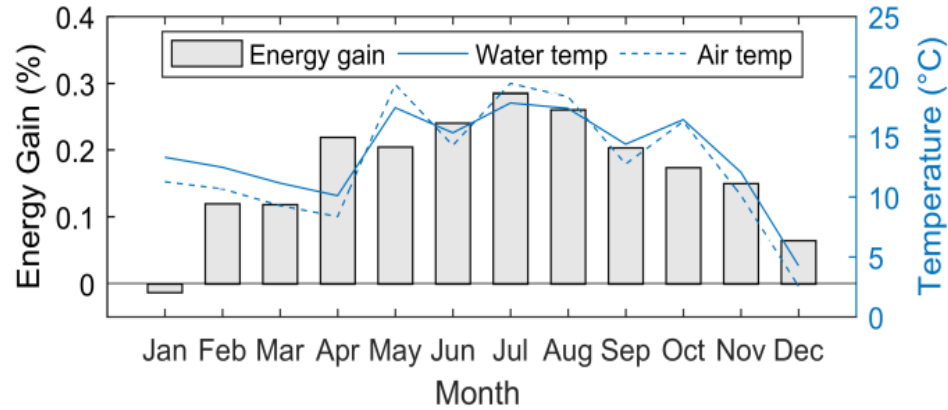
Total yearly gain by bottom frame water soaking:
0.17%
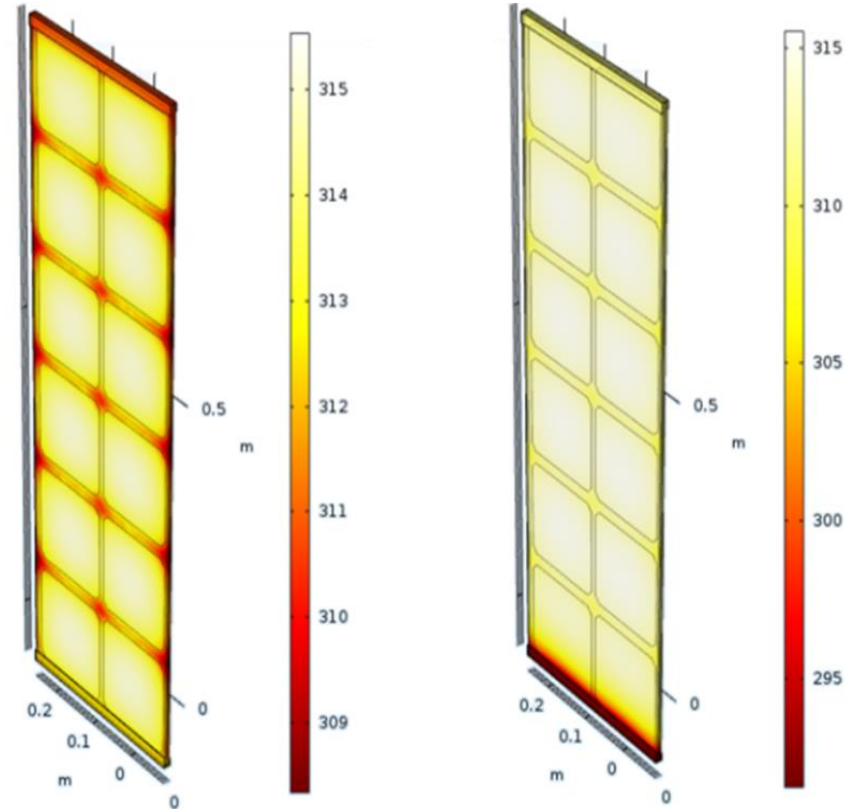
no contact with water

bottom frame in contact with water
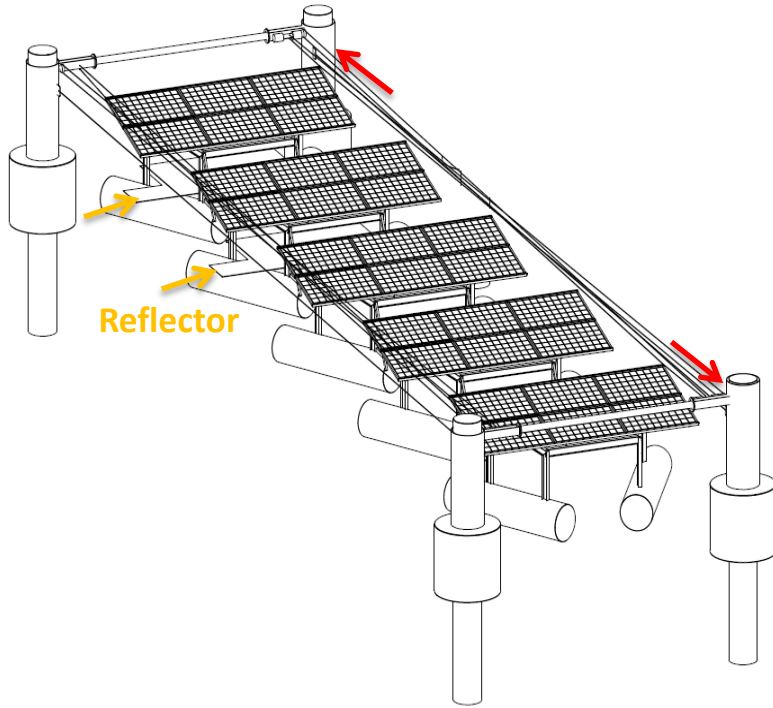
Model > Realize > Monitor
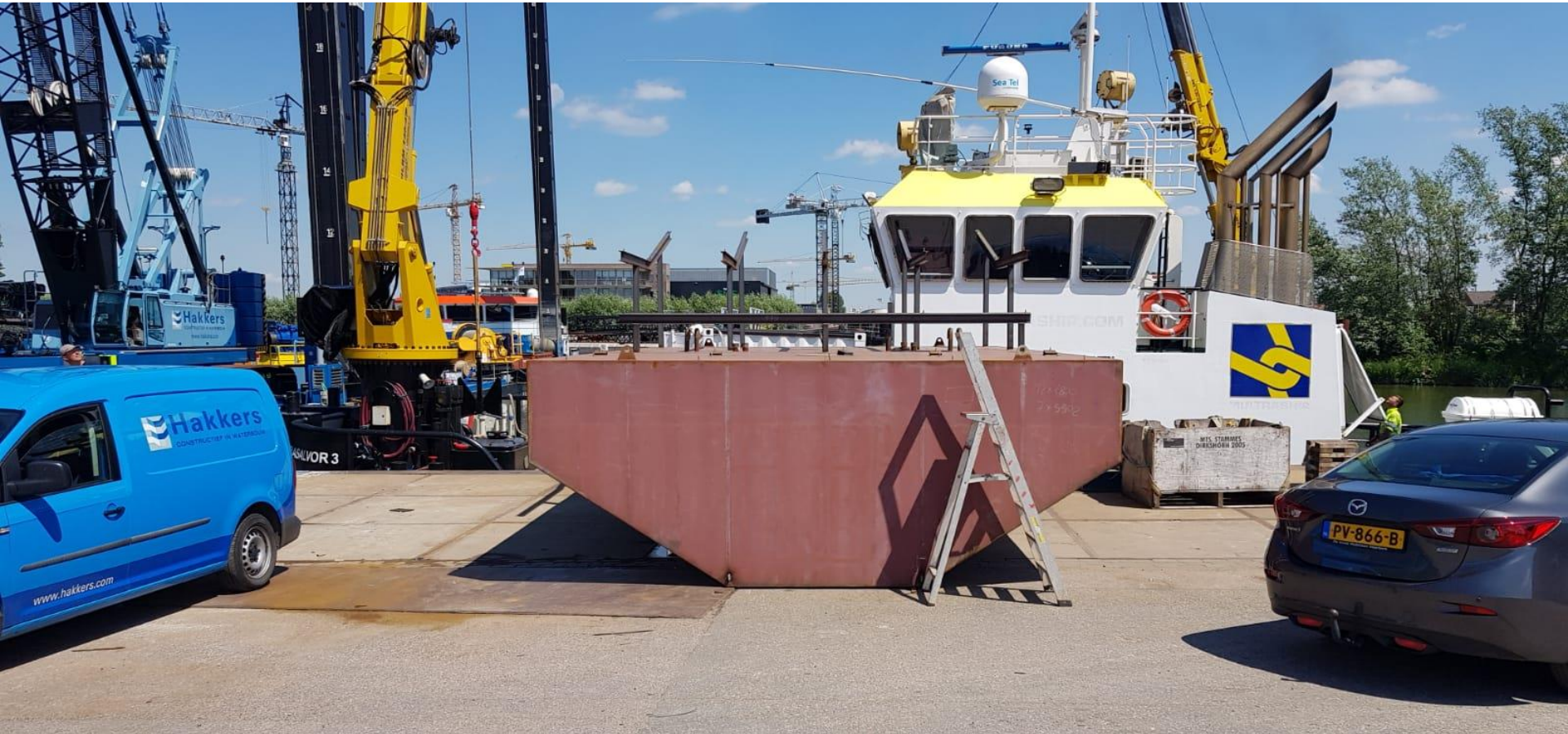
Designs

Retractable System
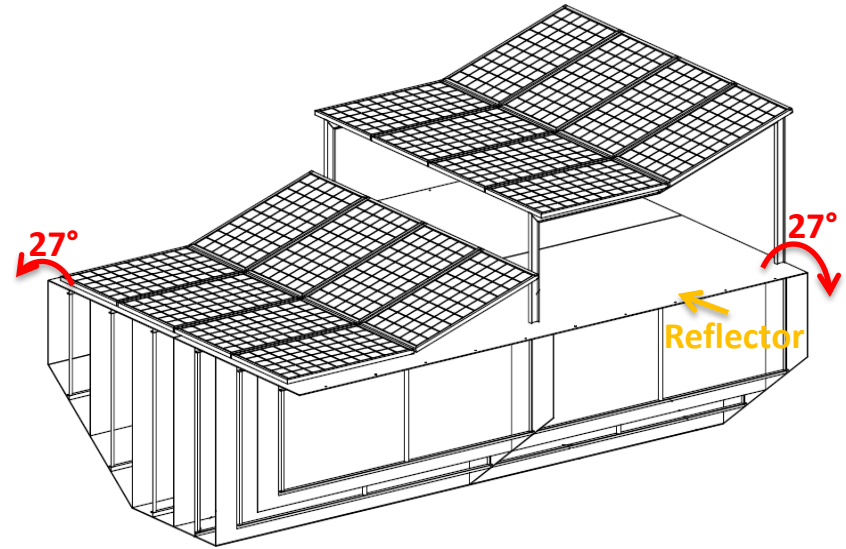
27°   27°

Reflector

Floating Island [1]

Model   Realize   Monitor

Floating island, patent pending.

Construction

Model Realize Monitor

Construction

Model Realize Monitor

Installation

Model   Realize   Monitor

Testing the Systems

Model > Realize > Monitor

Installed Systems

Model Realize Monitor

Pilot Systems (on water)

Tracking bifacial (0°) + reflector

Tracking bifacial (15°) + reflector

Tracking mono-facial (0°)

Tracking mono-facial (15°)

Fixed bifacial (15°) + reflector

Fixed bifacial (15°)

Fixed mono-facial (15°)

Model Realize Monitor

Pilot Systems (on land)

Fixed bifacial (15°) + reflector

Fixed mono-facial (15°)

Model　Realize　Monitor

Observations

Model > Realize > Monitor
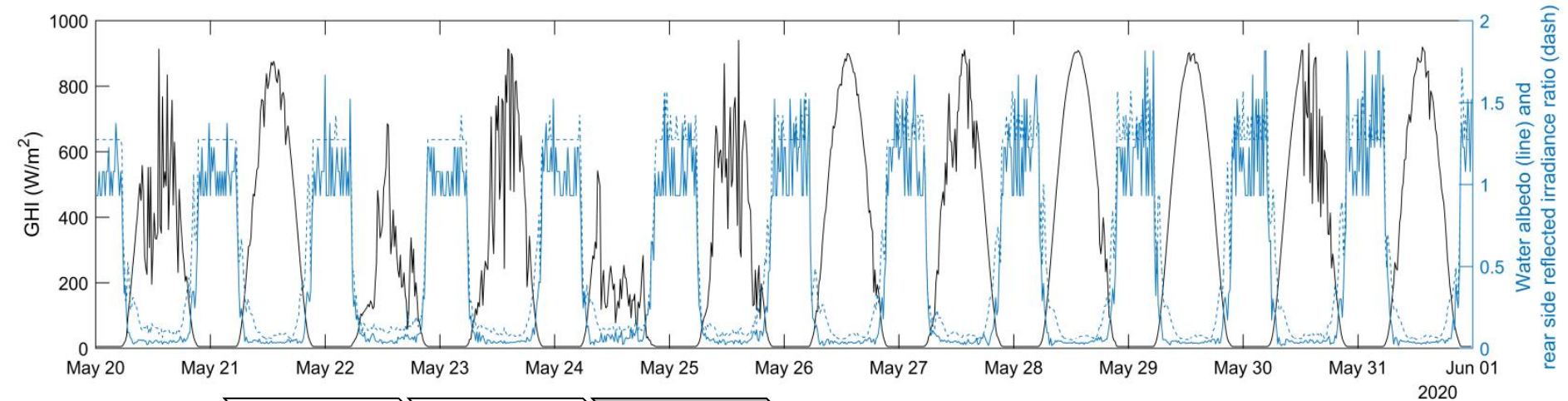
Observations

Model ⟩ Realize ⟩ Monitor
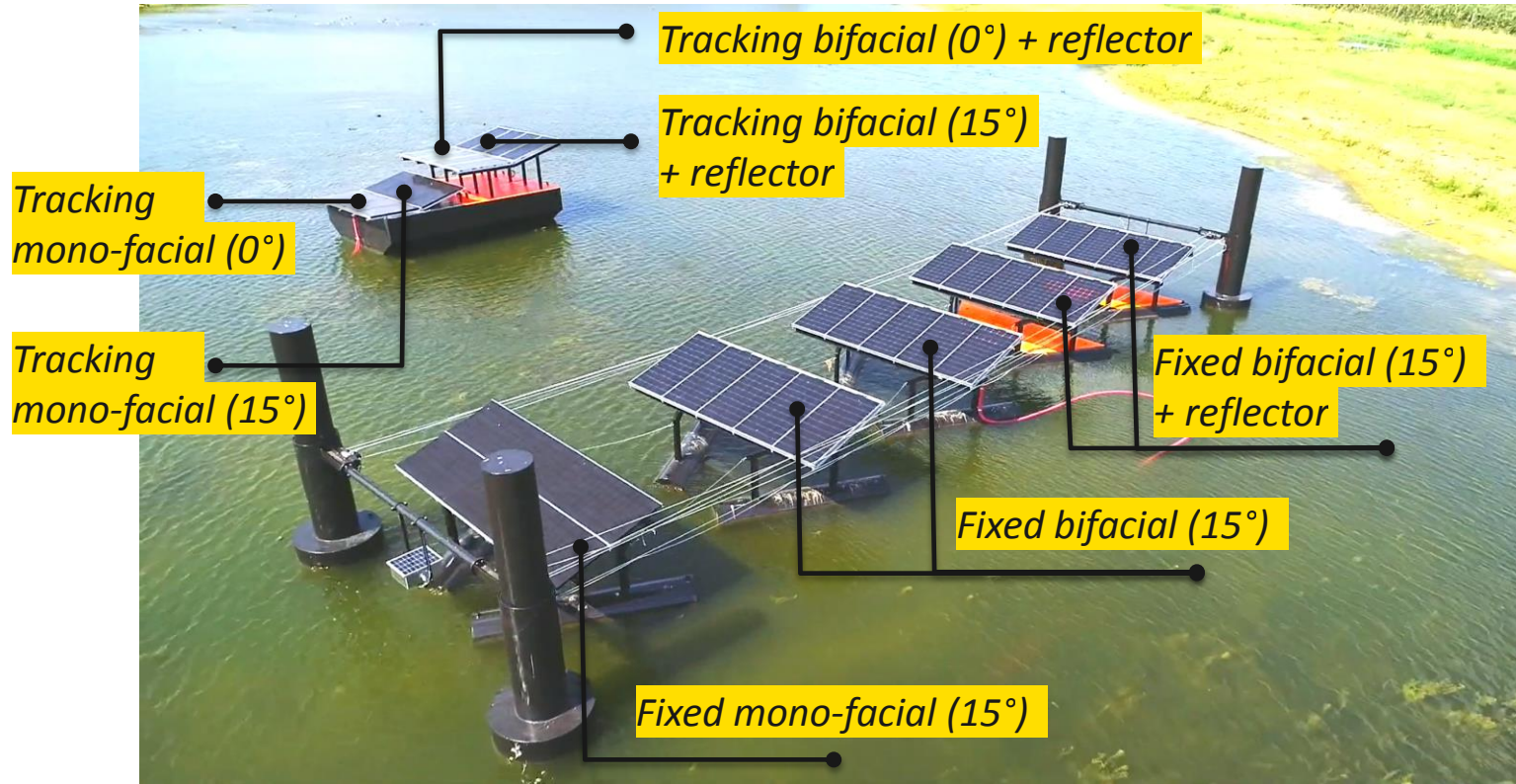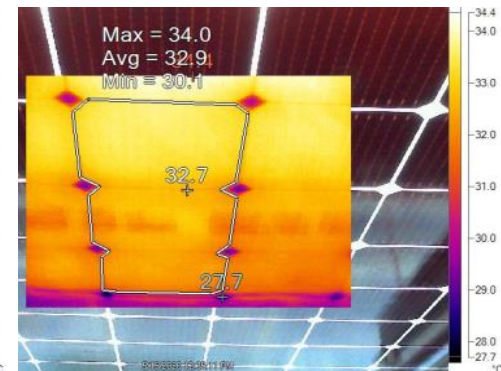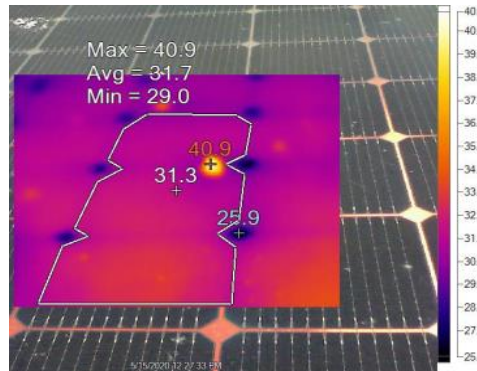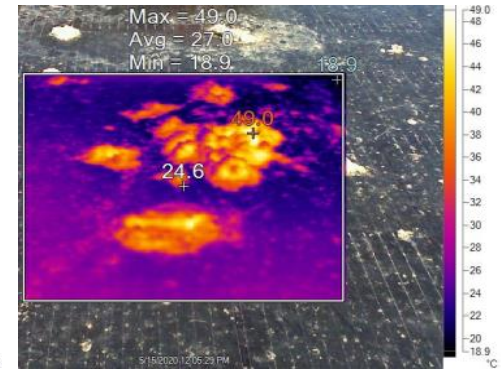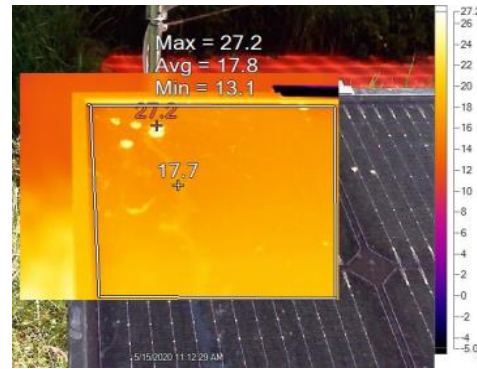
Reflected Irradiance Monitoring

Average day-time albedo
~11.6%

Average day-tiem rear-side irradiance ratio
~23.4%

Model > Realize > Monitor

# Reflected Irradiance Monitoring

Water albedo
~5%
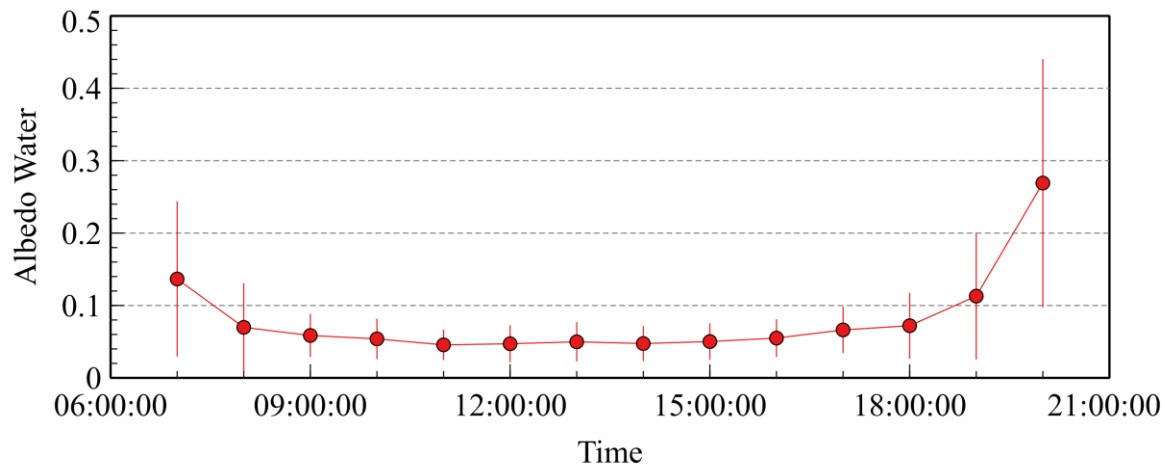
Model | Realize | Monitor

Specific Yield Comparison

10 months of monitoring: from Oct 2019 to July 2020

Model ⟩ Realize ⟩ Monitor

Specific Yield Comparison

10 months of monitoring: from Oct 2019 to July 2020

Model Realize Monitor

Specific Yield Comparison
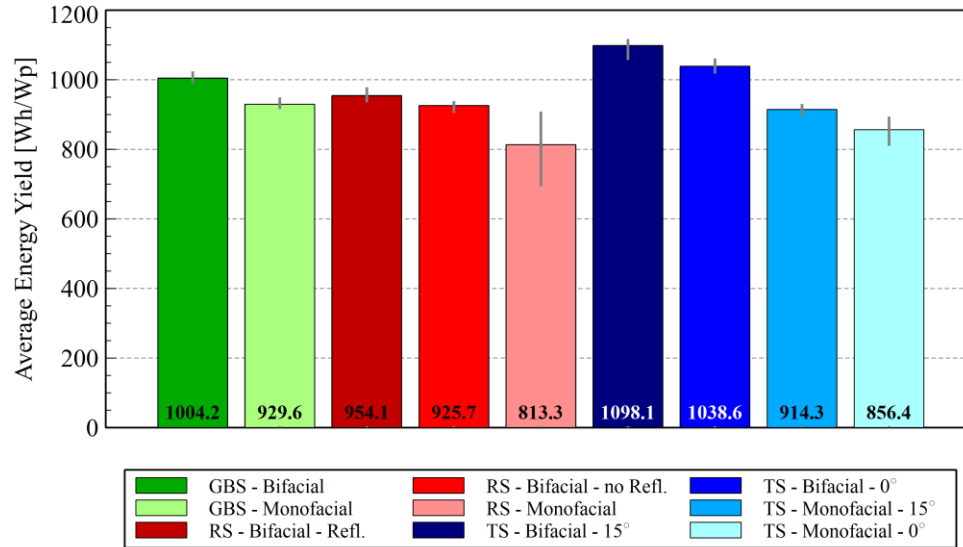
10 months of monitoring: from Oct 2019 to July 2020

Model > Realize > Monitor
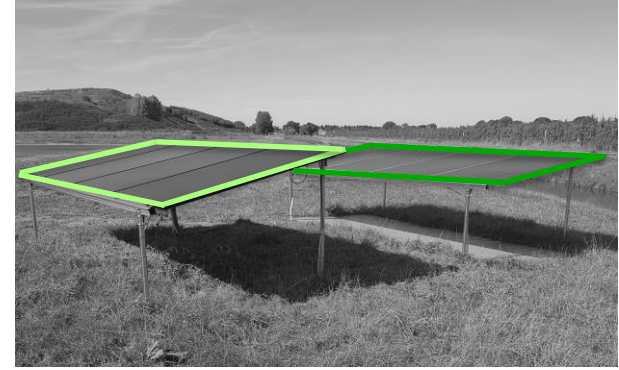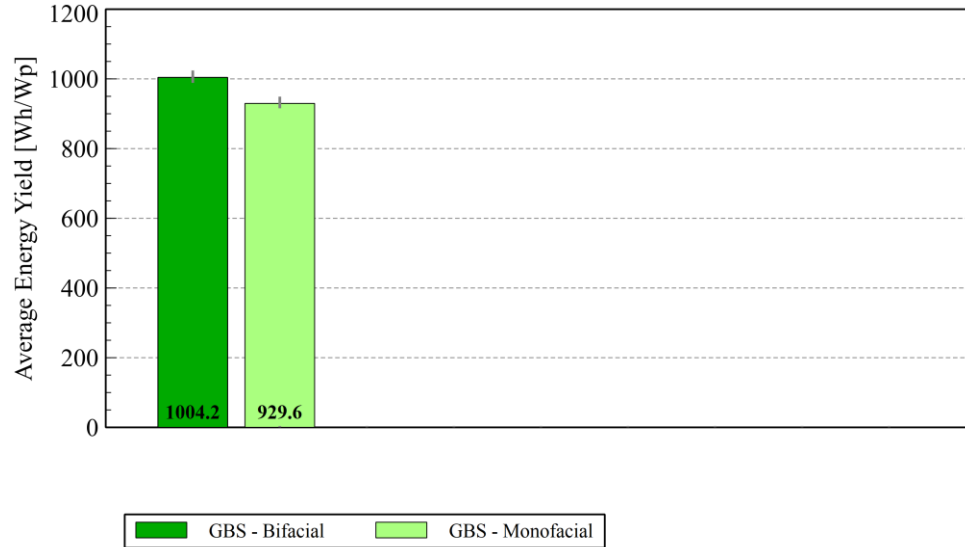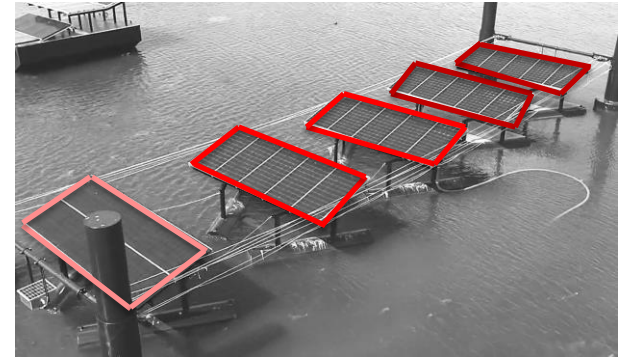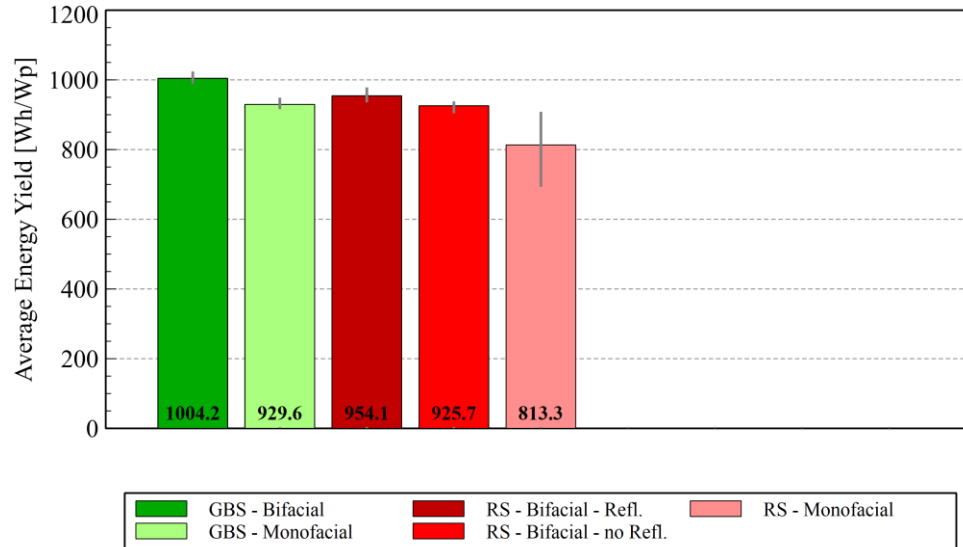
Specific Yield Comparison

10 months of monitoring: from Oct 2019 to July 2020
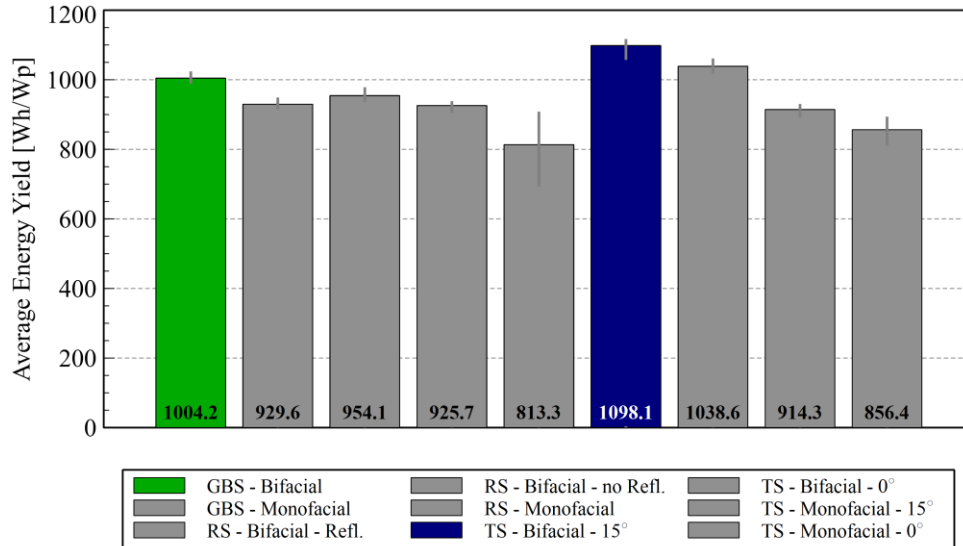
Outperforms the on-land bifacial by:
9%

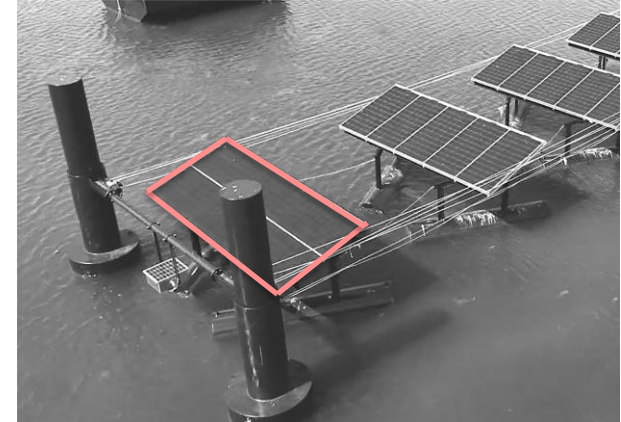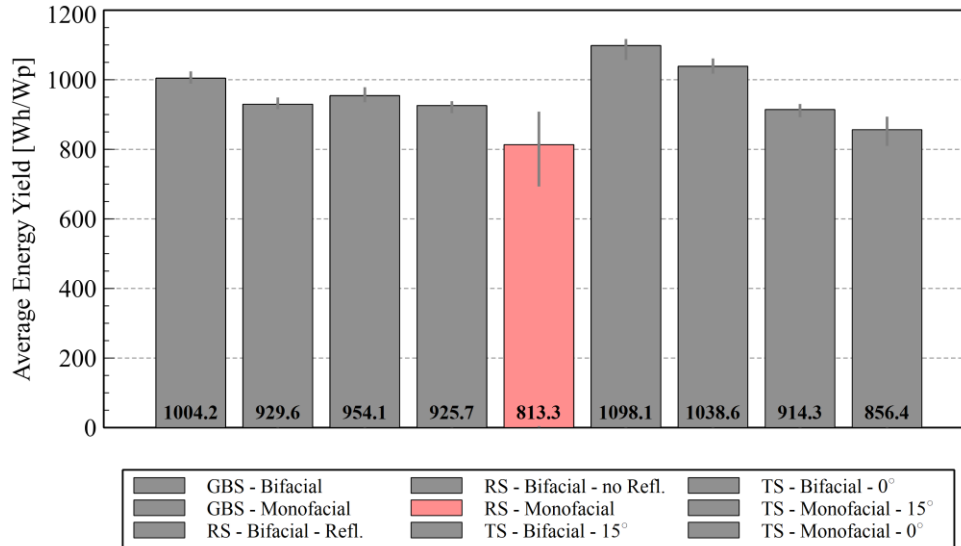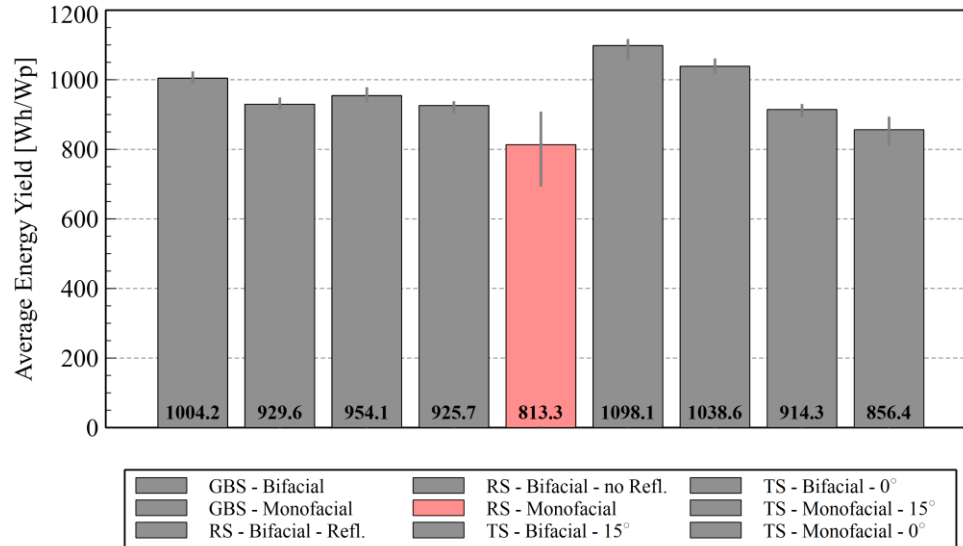Internal consumption for tracking:
<1%

Model → Realize → Monitor
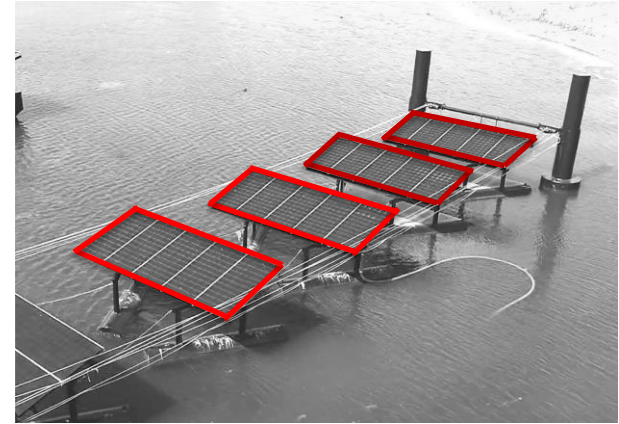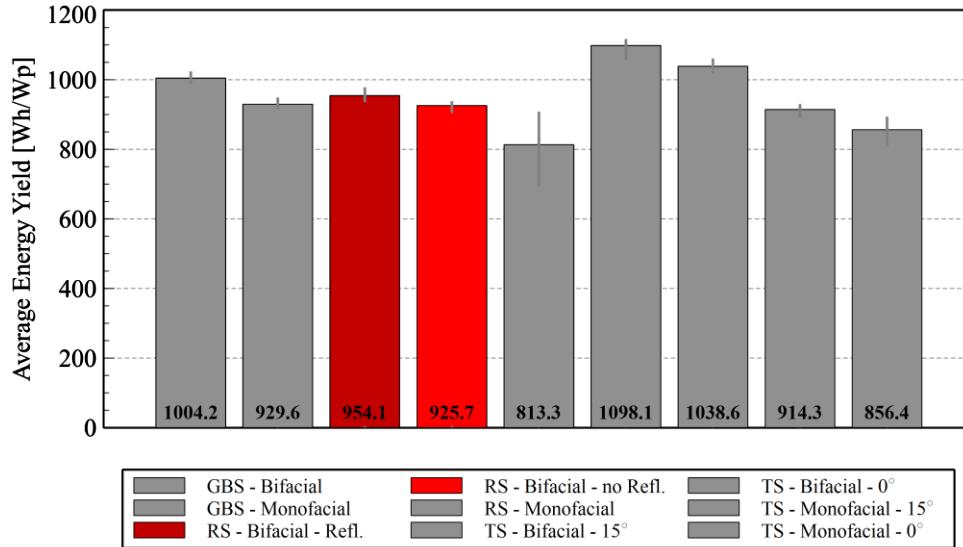
Specific Yield Comparison

10 months of monitoring: from Oct 2019 to July 2020

Model Realize Monitor

Specific Yield Comparison

10 months of monitoring: from Oct 2019 to July 2020

Shading loss:
10%

Model Realize Monitor

Specific Yield Comparison

10 months of monitoring: from Oct 2019 to July 2020

Difference with reference case:
-5%

Gain from reflector:
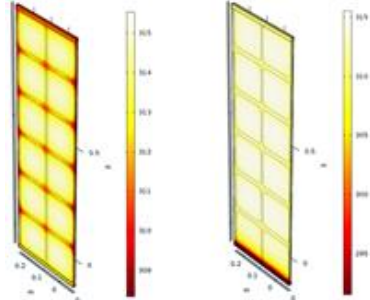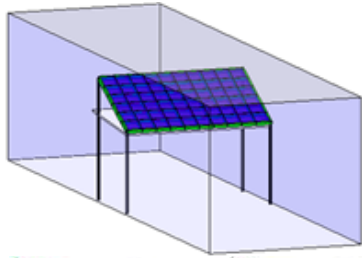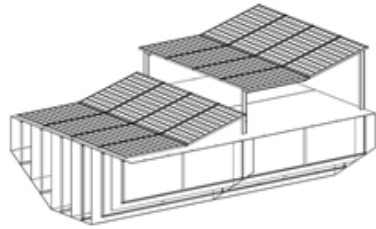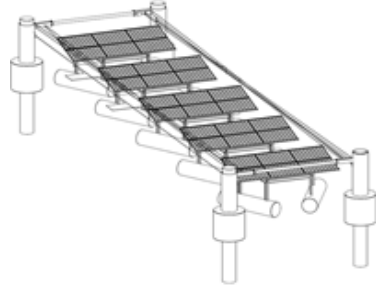**3%**

Model Realize Monitor

Summary and Highlights

Modeling/Tests	Designs/Realization	Monitoring/Analysis	Highlights

This is a presentation slide with four columns of images and text highlights.
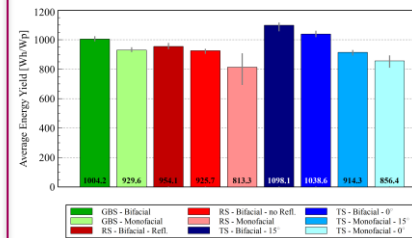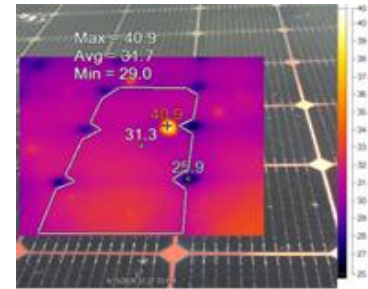
Highlights column text:
- Low water albedo, reflectors are required
- Frame water-soaking has negligible effect
- Horizontal tracking is possible for FPV
- Birds' presence has short-term effect
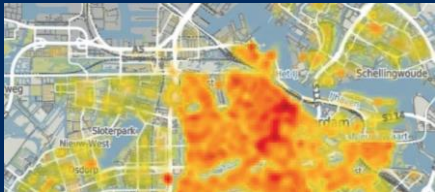- High temperature spatial variance for FPV
- Tracking FPV & reflector yield +18% extra

Thanks to

Nynke Hermelink *(Rijksdienst voor Ondernemend Nederland)***,**
Johan Bakker *(Waterschap Rivierenland)*
And all the INNOZOWA contributors

Thank you for your attention!

TU Delft Urban Energy Institute

TU Delft E-Refinery Institute

PVMD funding

Request your trial version of ASA7: **http://asa.ewi.tudelft.nl/**

PVMD web-lab: **www.tudelft.nl/dutchpvportal**

International PV Systems Summer School series: **www.tudelft.nl/pvsss**