Floatovoltaics with bifacial PV

Anna Carr[1], Teun Burgers[1], Harm Lok[2], Rob Kreiter[3], Sipco Eggink[3], Willem Vermeulen[4], William Otto[5] and Bas Van Aken[1]

Corresponding author: bas.vanaken@tno.nl

[1] ECN part of TNO - Solar Energy, Petten, NL
[2] EnTranCe, Hanze Univ. Appl. Science, NL
[3] Sunfloat B.V, Bennekom, NL
[4] Tempress B.V., Vaassen, NL
[5] MARIN, Wageningen, NL

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www.ecn.nl
P.O. Box 15
1755 ZG Petten
The Netherlands

Vertically mounted, floating PV

PV panels floating on water are a rapidly growing application in areas where **land is scarce** or where the floating PV can provide additional functionality to water bodies
Vertically mounted PV panels cause **low disturbance of the water/air** exchange and the ecosystem below the water surface. Next to oxygen, also a significant fraction of the light reaches the water.
East-west oriented, vertical bifacial panels have **more even production** of electricity over the day and **impact the grid infrastructure less** than peak production at midday. **Social acceptance** for large scale solar farms is strengthened when the solar electricity production is an **additional functionality**, instead of a competitor with recreation, nature or food production. This holds for vertical PV systems on water as well as for systems on land, e.g. agri-PV.

Conclusions

- Mounting frame, in particular front beam, cause shading around noon
- The total irradiance on the vertical faces is 10% higher for the land-based system, due to higher surface-reflected irradiance (albedo)
- Temperature data and thermal modelling shows a 1-2 K lower module temperature above water for most of the day
  - 30% because the surface-reflected irradiance is lower
  - 70% due to the natural atmospheric cooling of the water
- Even lower ambient temperature above large water bodies will yield an even lower module temperature relative to land-based systems

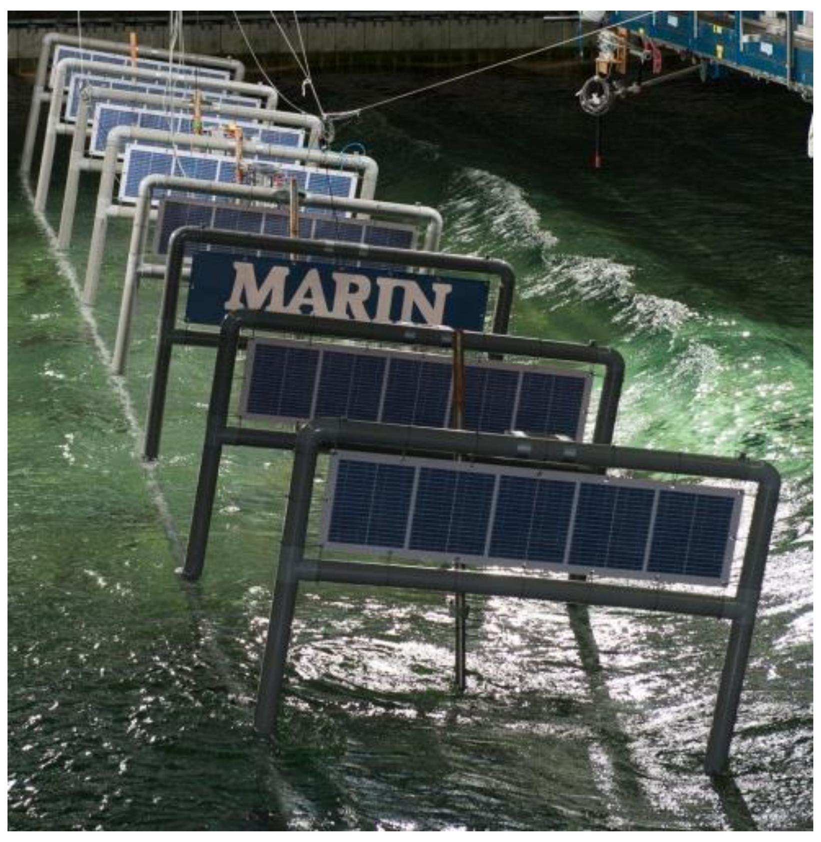
The installed set-up allows optimisation of the physical construction as well as further the understanding of the performance of vertically mounted PV on land and on water

Wave and wind resistance testing

scale model 1:2.5 at MARIN
- wave and wind conditions
- “real” wave heights >1 m

- relatively small wave induced motions
- mooring line tension depend on depth of floaters
- first and last racks larger dynamic response

system suitable for larger water bodies like lake IJsselmeer



Comparison of water and land-based modules

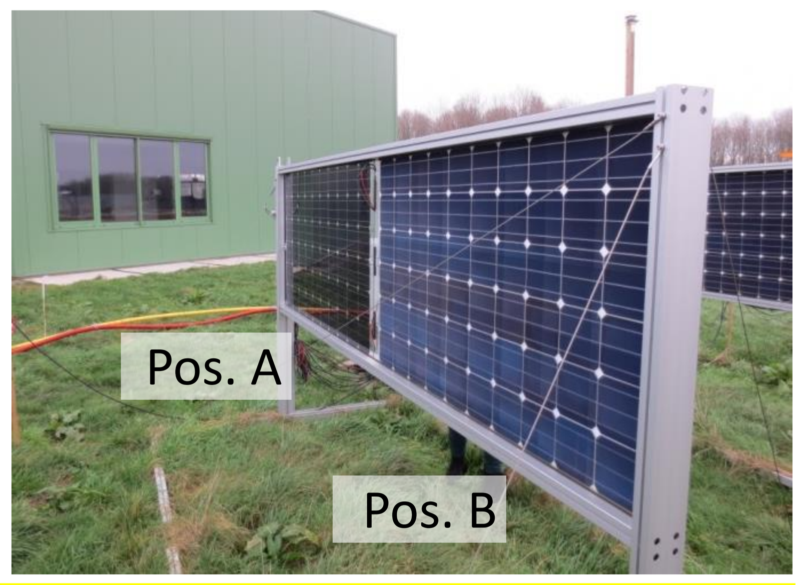
two identical systems
- on land and on water

four vertical racks
- east-west
- spacing ~3.5 m
- two bifacial modules
- mounted landscape

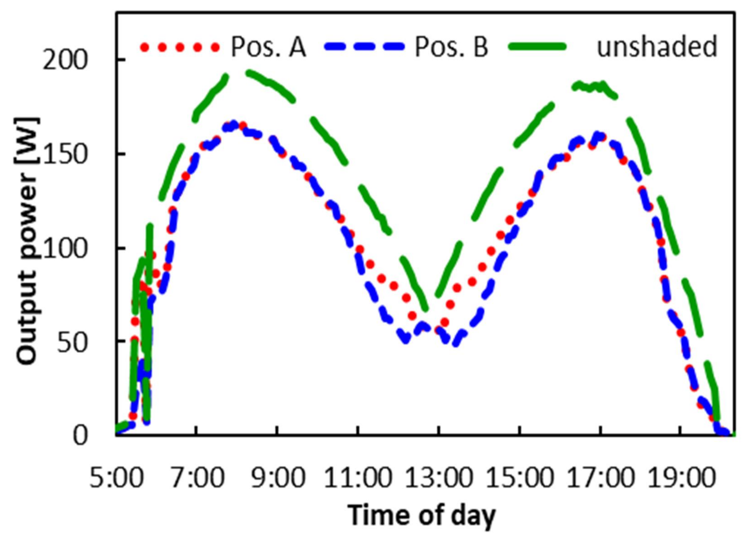
wide mounting frame

sensors:
- plane of array irradiance
- east and west; water and land
- ambient temperature
- module temperature

module measurements:
- voltage
- current
- power



Measured power: shade effects



period with low power around noon
- more pronounced for pos. B the south side of shed

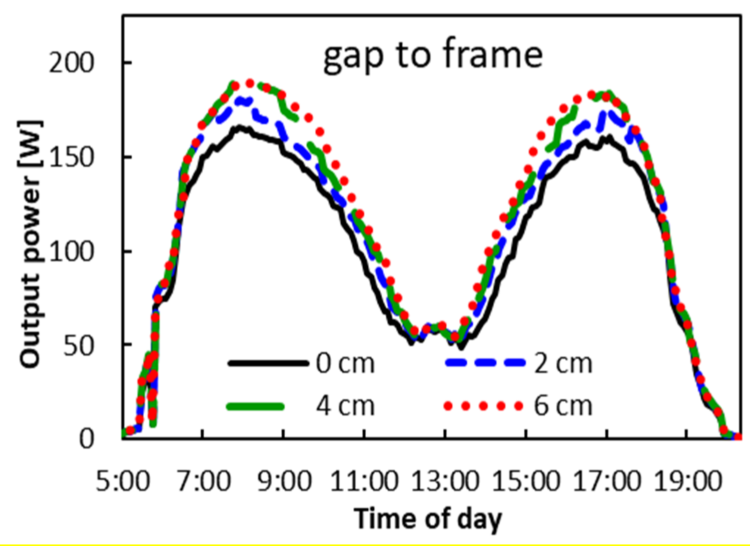
reduced power morning/afternoon
- both modules same power profile

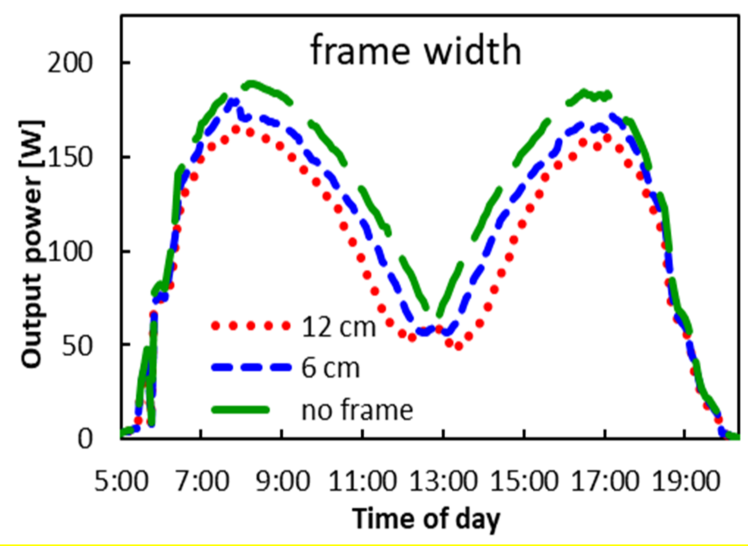
shade by frame (see photo)
- on top row
- first cell of each row (pos. B)

mitigations (modelled with BIGEYE)
- reduce width of frame
- increase gap frame to cell

Simulated effect of frame width and gap to cells

BIGEYE: Modelled system of 4 sheds with two modules
- gap between cells and frame: 0, 2, 4 and 6 cm
  - gain during morning and afternoon: 9%, 14% and 17%
- width of frame also effects duration of noon minimum
  - 6 cm or absent frame: energy gain 11% and 24%

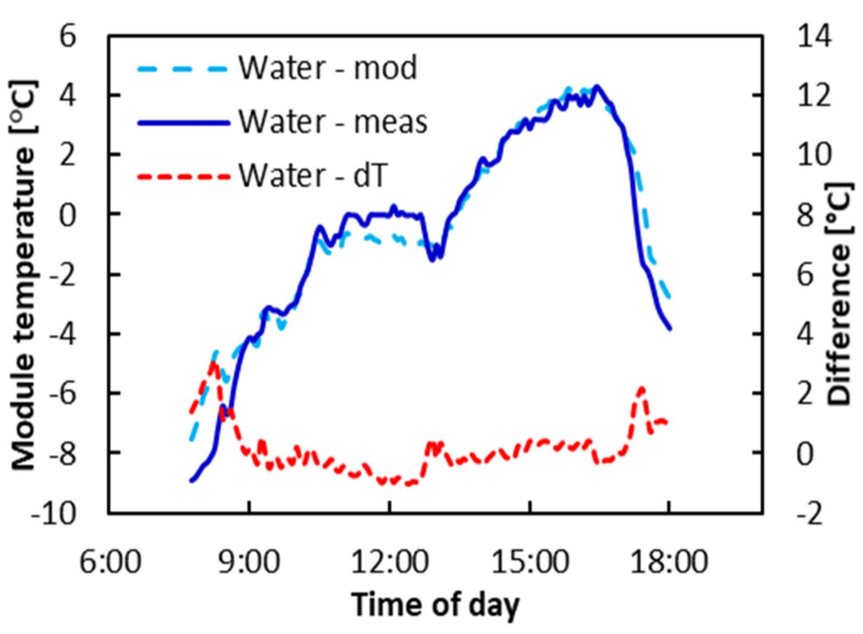




Measured and modelled module temperature

simple thermal model:
- measured ambient temperature
- total irradiance
- a single heat transfer coefficient

land and water module temperatures well-described



Modelled $\Delta T_{land\text{-}water}$ depends on T_{amb} and G_{tot}

land-based modules consistently warmer

temperature difference
- higher ambient land temperature
- higher ‘albedo’ irradiance

large water bodies
- lower ambient temperature
- larger temperature difference
- increased energy output