Solar at Sea II

Nationaal Consortium Zon op Water

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11 January 2023

Agenda

- Introduction
- Solar@Sea II
  - Concept
  - Demo Oostvoorne
  - Tests
  - Lessons learned
- Next phase
- Q&A

Please feel free to interact

Solar@Sea II Consortium

avans hogeschool

Genap waterproof solutions

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MARIN

ENDURES a TNO initiative

TNO innovation for life

Consortium lead

Solar@Sea Project Overview

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Solar@sea I	Solar@sea II	Solar@sea III
Thin film P/V on Foam structure	Thin film P/V on Inflatable floaters	Thin film P/V on Inflatable floaters
On floater in Weperpolder	2 floaters in Oostvoornse meer Brackish water	4 floaters in NSF Offshore Test Site
	Basin tests 1:1 Mechanical tests Manufacturing analysis Fouling tests Material aging tests	Basin test scaled Monitoring system linked to digital twin. Offshore installation and removal procedure.

2018 2019 2020 2021 2022 2023 2024 2025

Solar@Sea Concept - Vision

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Design from start with commercial application in mind

- Materials
- Fabrication
- Transport
- Installation
- Operation

Solar@Sea Concept - Floater

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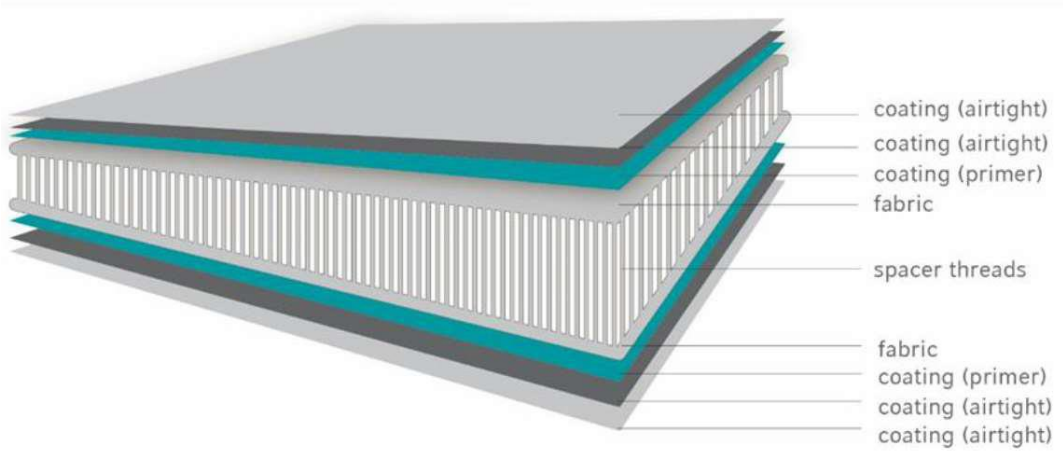
Double walled fabric drop stitch floaters

Thin film P/V panels on top

Flexible system, moving with the waves



Solar@Sea Concept - Floater

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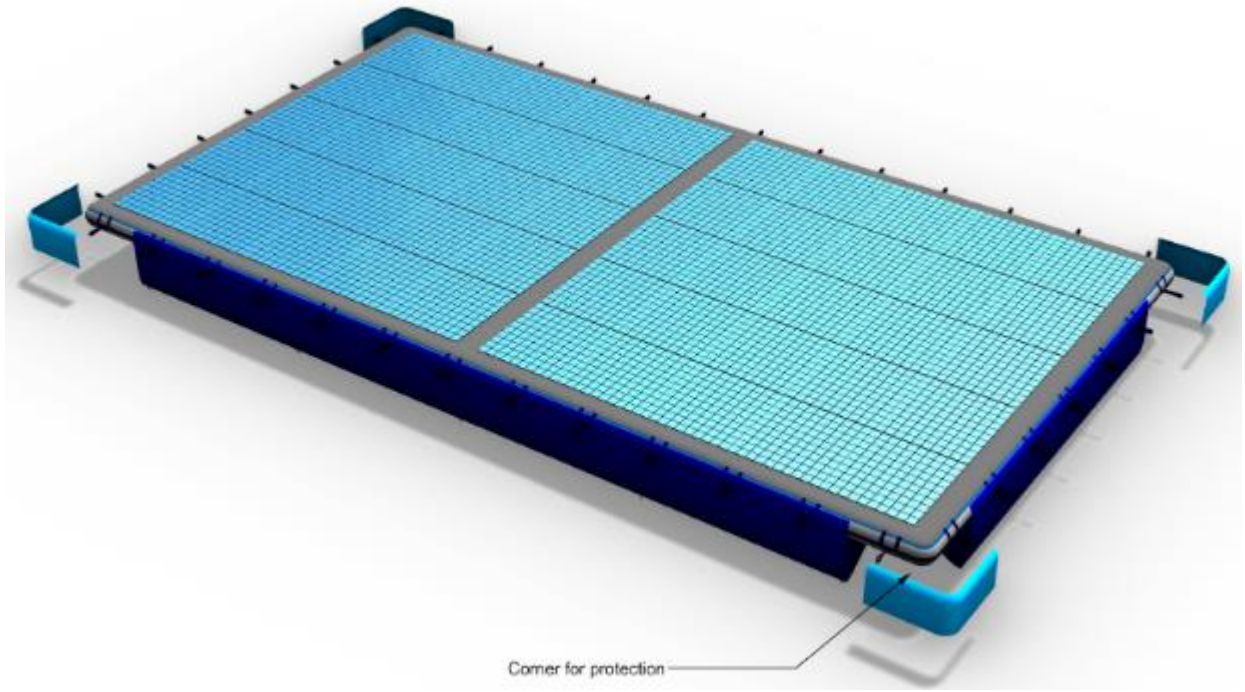

Solar@Sea Concept – Solar panels

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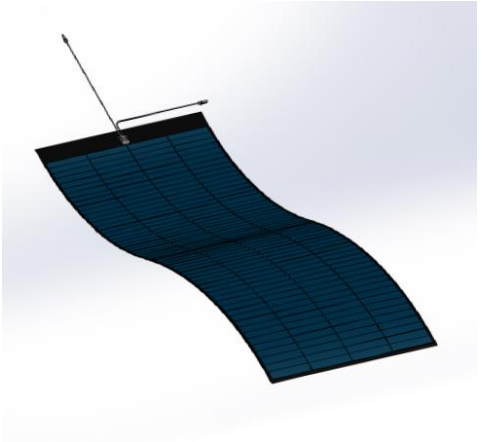
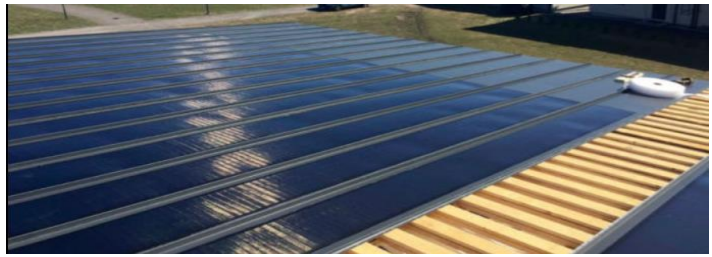
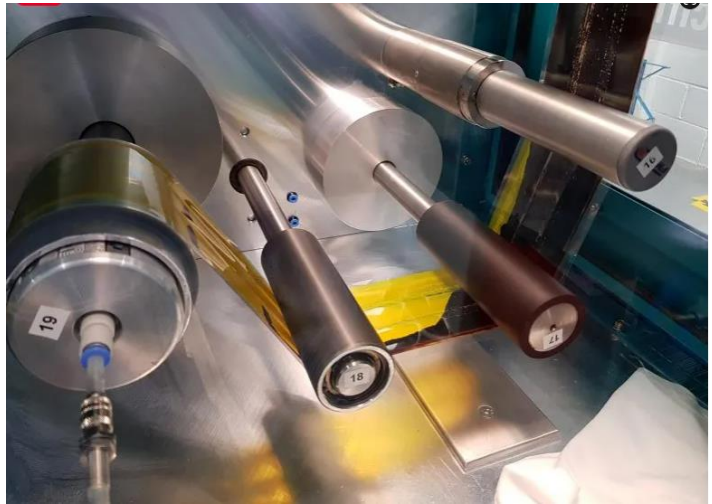
Flexible PV modules (CIGS tested)

- Light weight
- No significant degradations under frequent small deformations
- Commercially available in lengths up to 6 m
- Certified for salt spray
- Efficiency increasing every year
- Costs will drop significantly by ‘economy of scale’. Production techniques maturing.







Solar@Sea Concept - Mooring system

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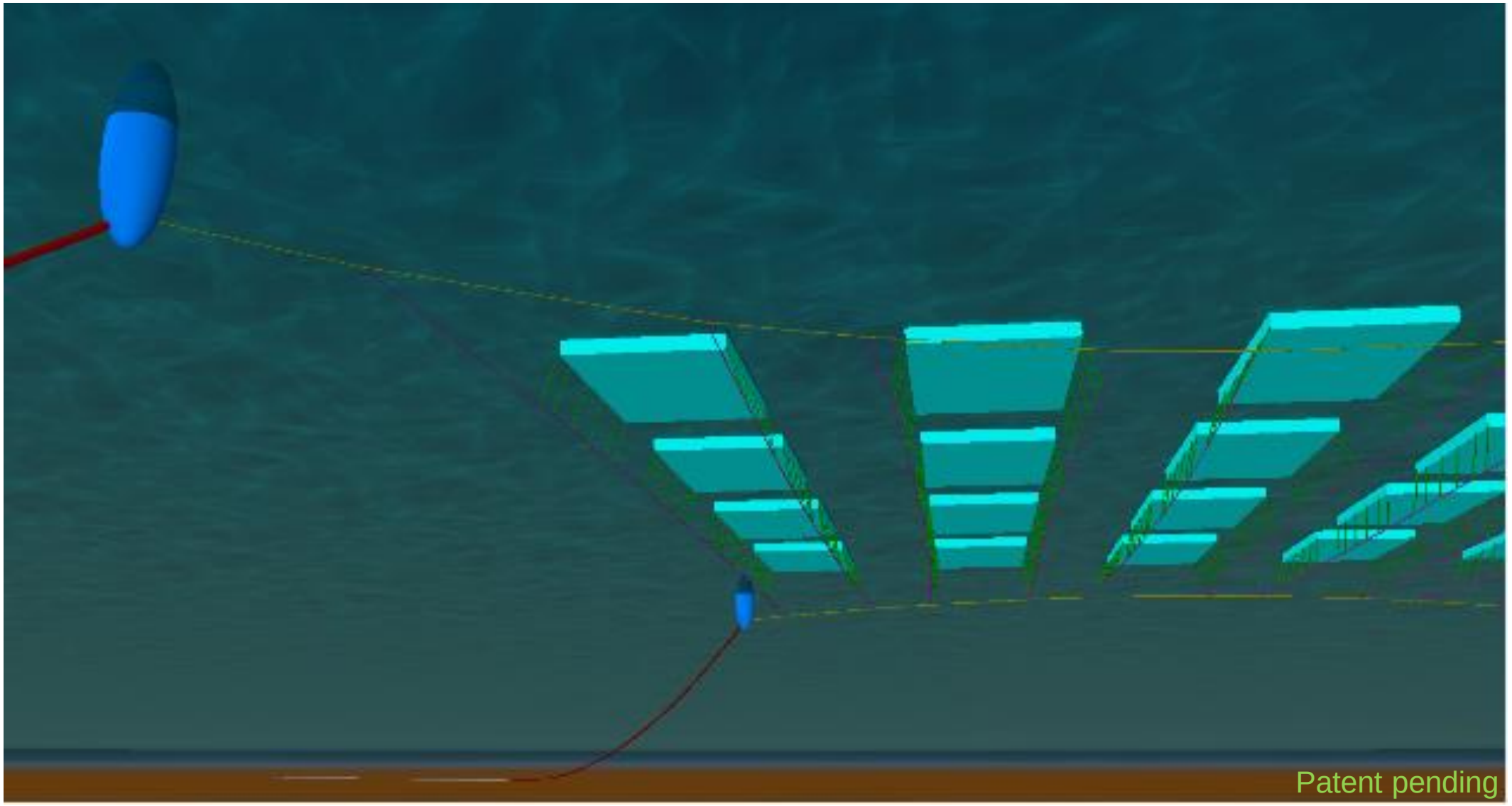
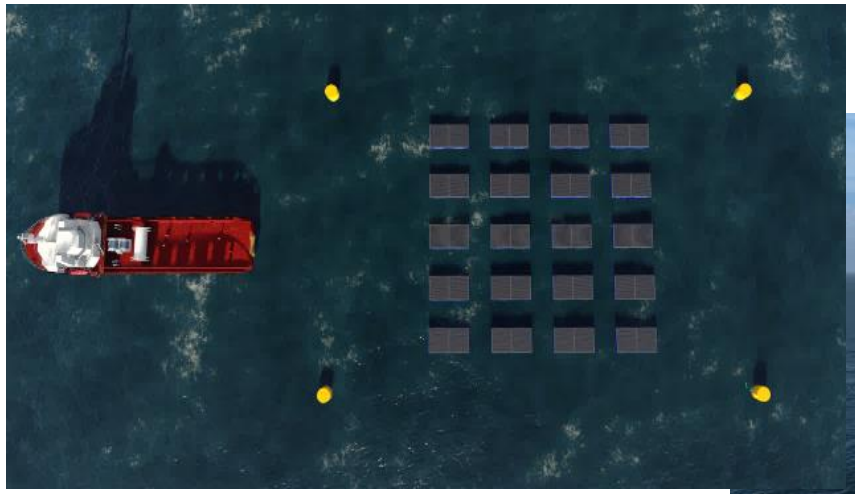
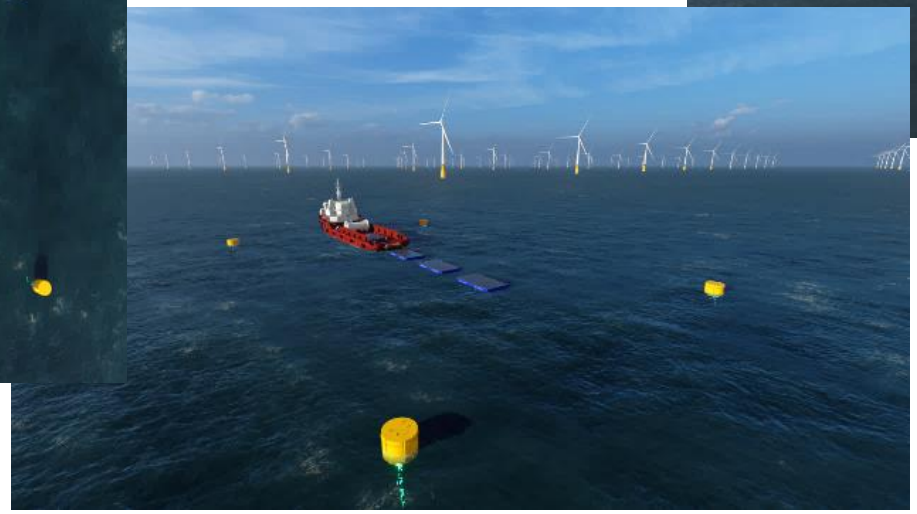
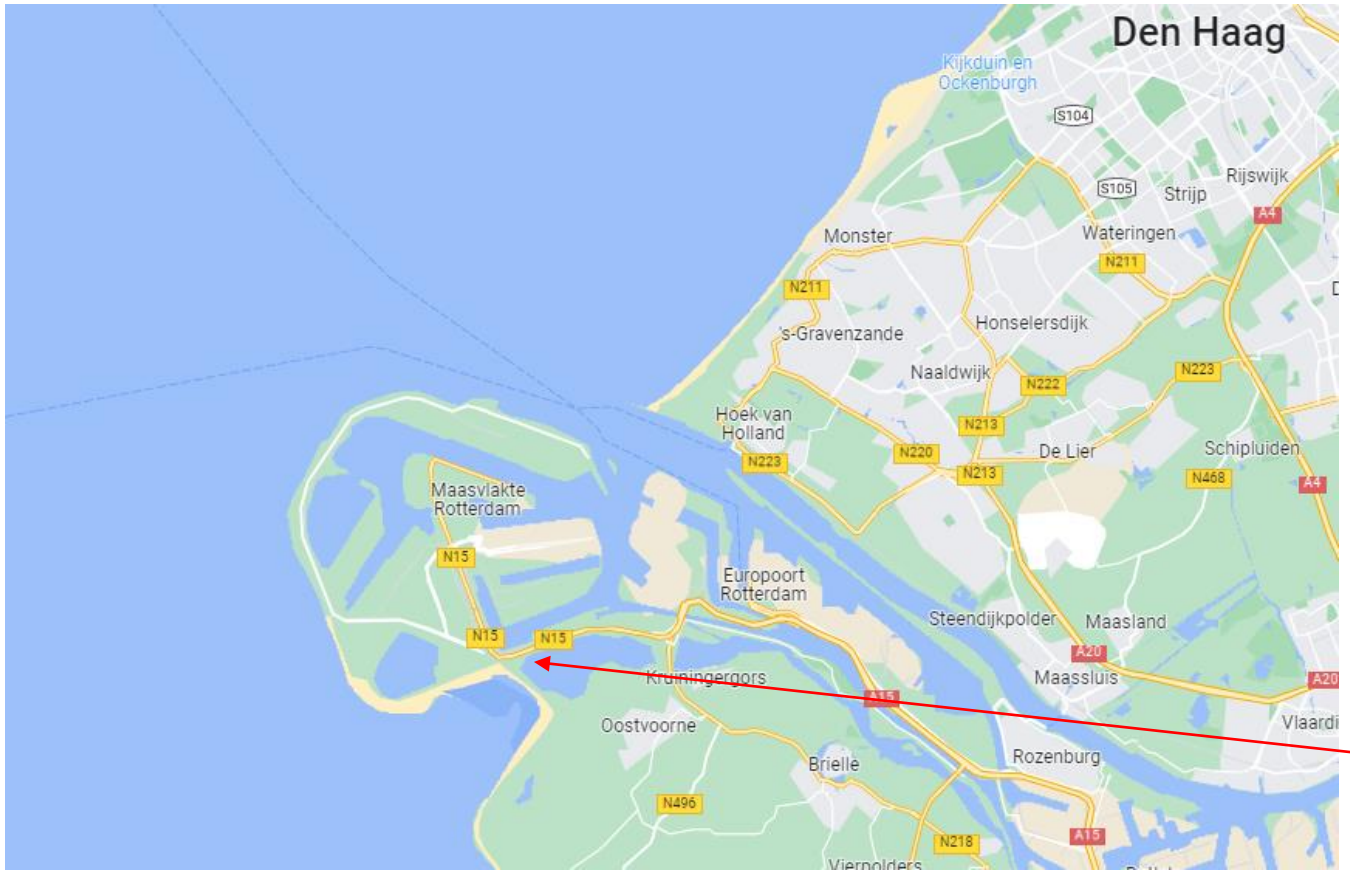


Solar@Sea Concept - Installation

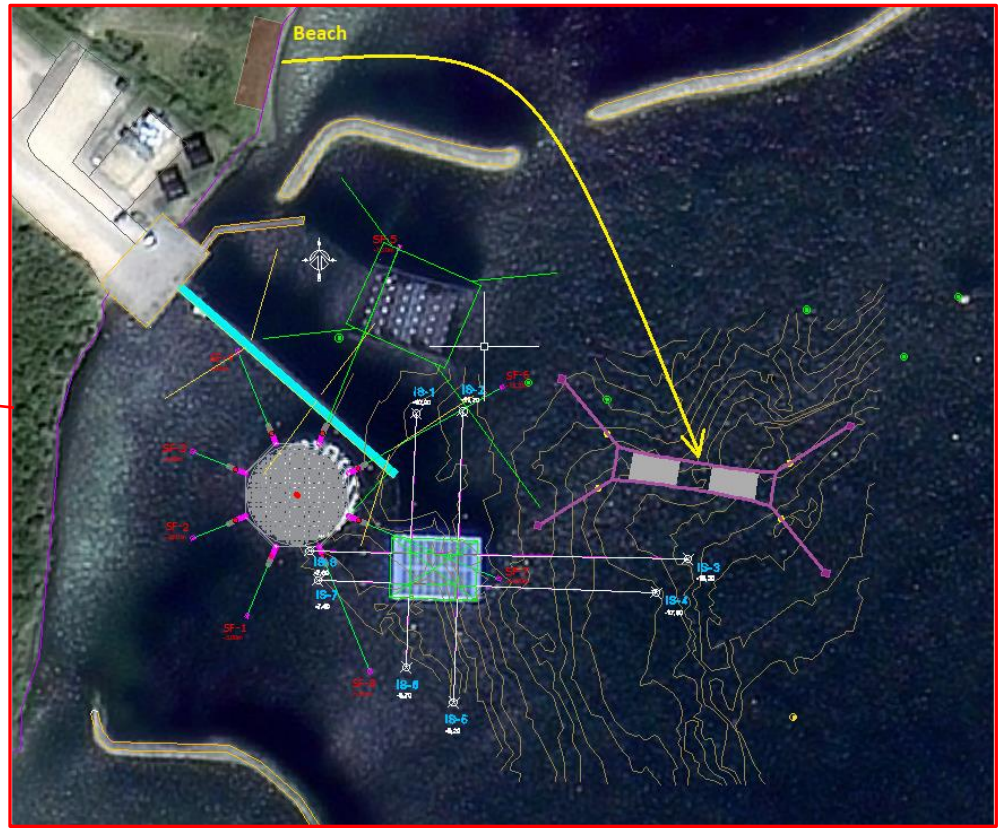




Demo Oostvoorne

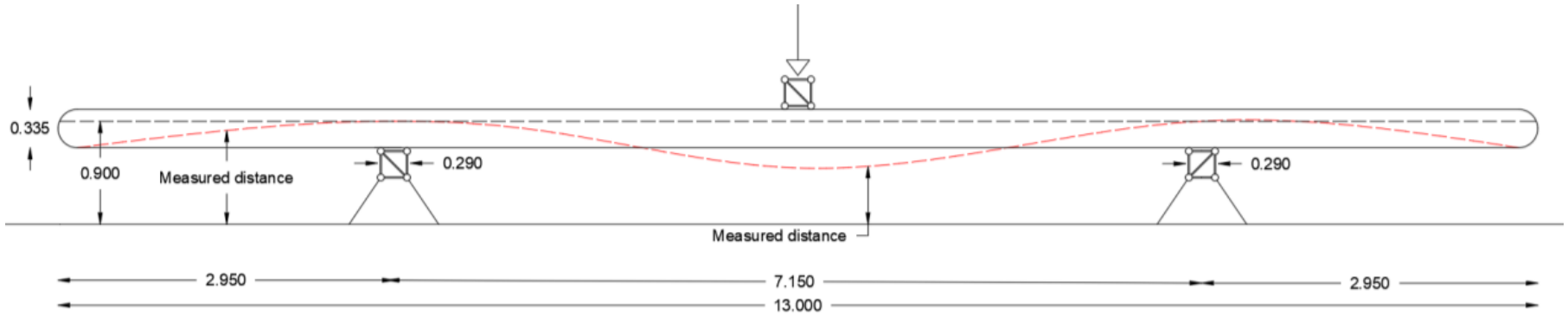


- Full scale Oostvoornse Meer
- November 2021 – November 2022

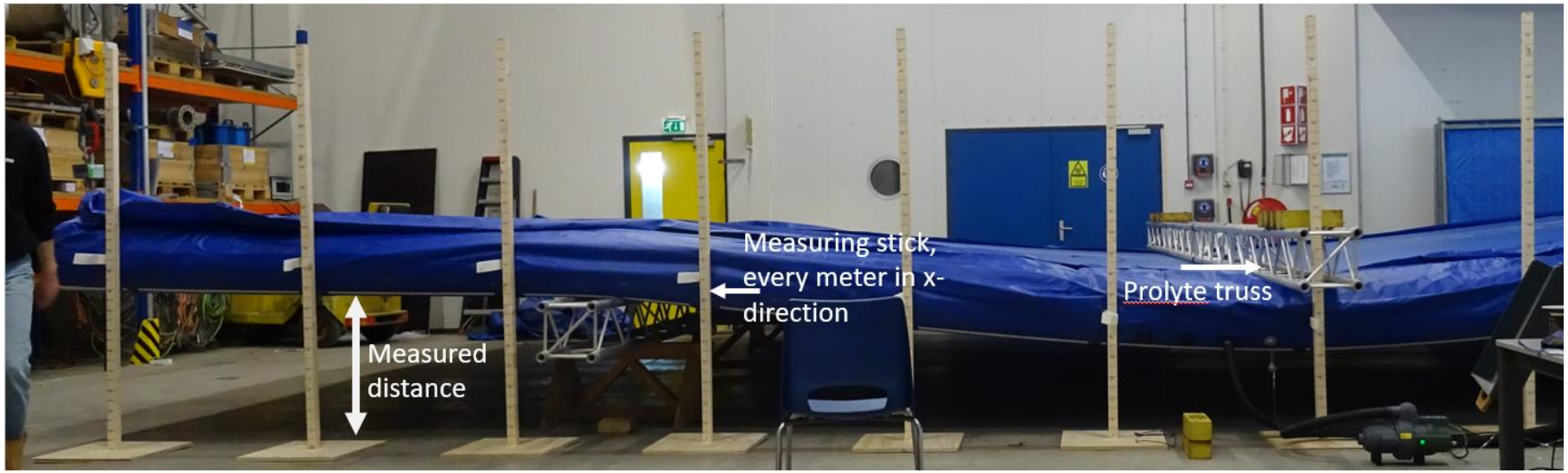


Demo Oostvoorne

Tests - Structural properties floater



three point bending test of the dropstitch floater



Tests - Mechanical degradation

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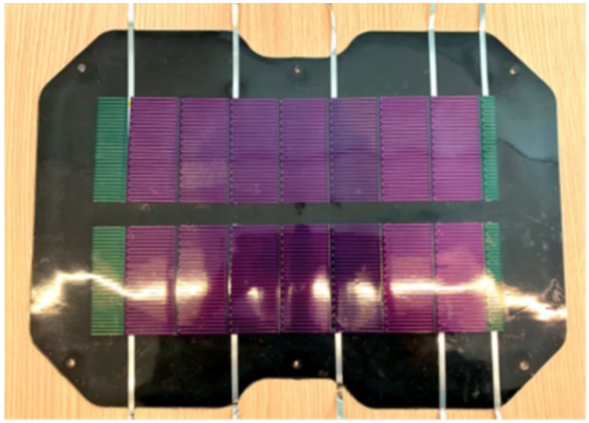
Dancing Beetle

Experiment



Test module (50x40 cm^2) with flexible CIGS cells in vertical orientation.

Wave type	Period (s)	Length (m)	Wave height (m)	Maximum bending height (mm)	Maximum theoretical strain (%)
1	4.5	31	0.8	0.96	1.24
2	5.2	43	0.9	0.61	0.79
3	5.4	44	1.2	0.76	0.98
4	5.3	44	2.4	1.55	2.00

Dominant wave types at the North Sea (columns 1-4), and the resulting bending and strain on a 50x40 cm^2 test module (columns 5 &6)

Tests – Basin, uplift

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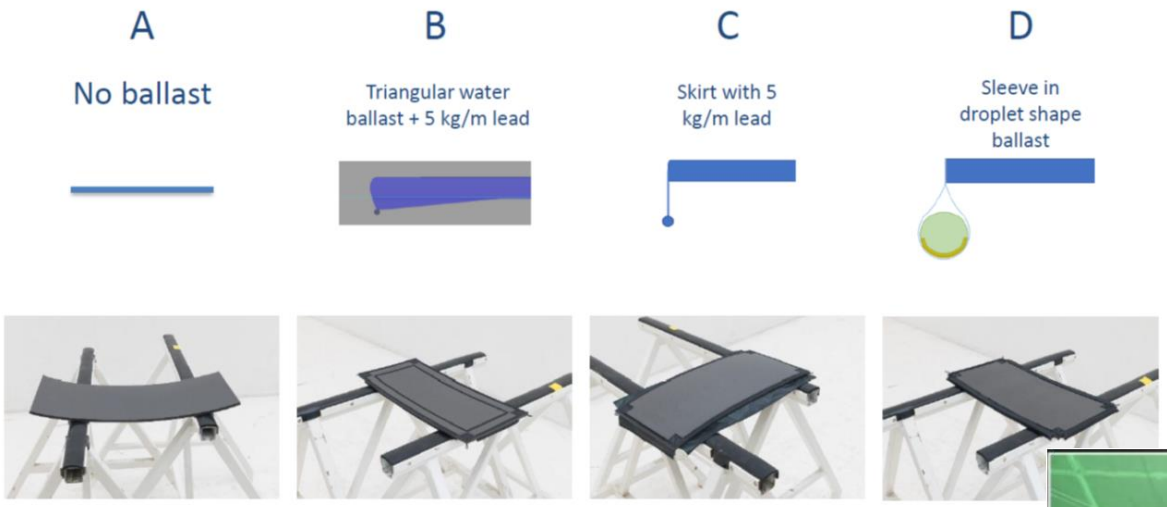
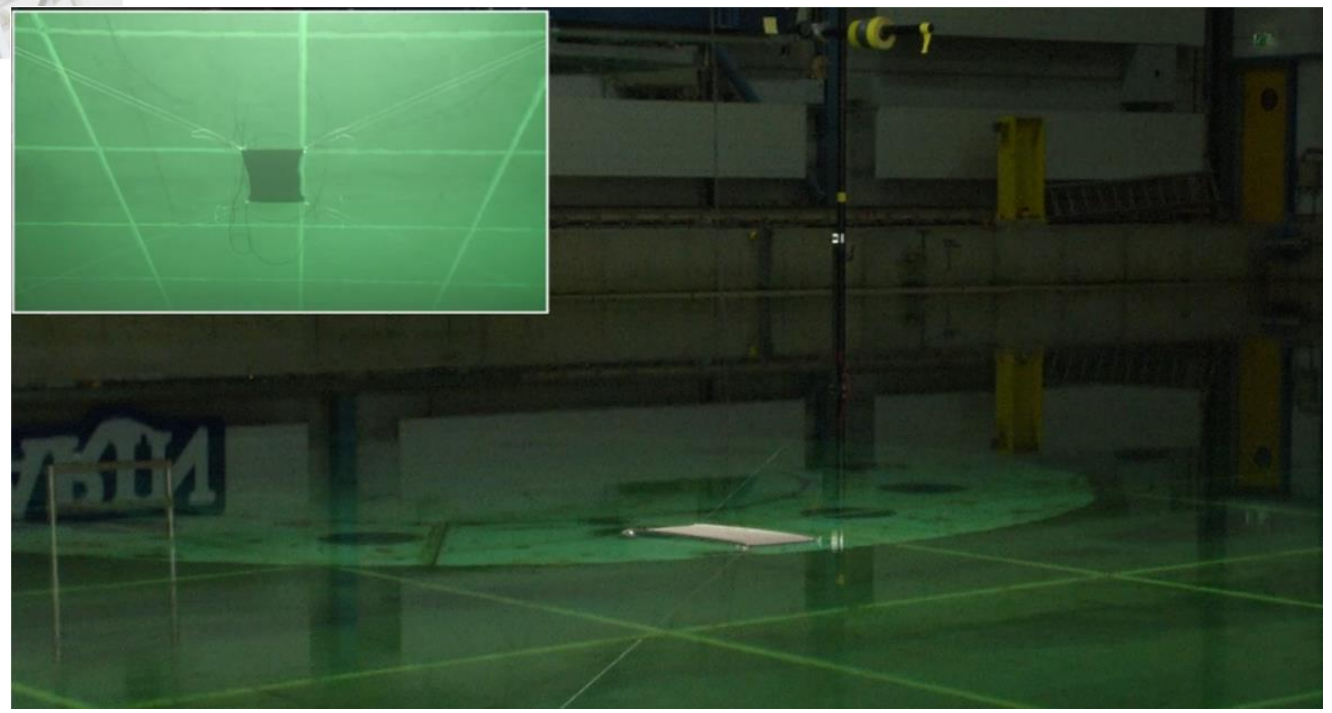
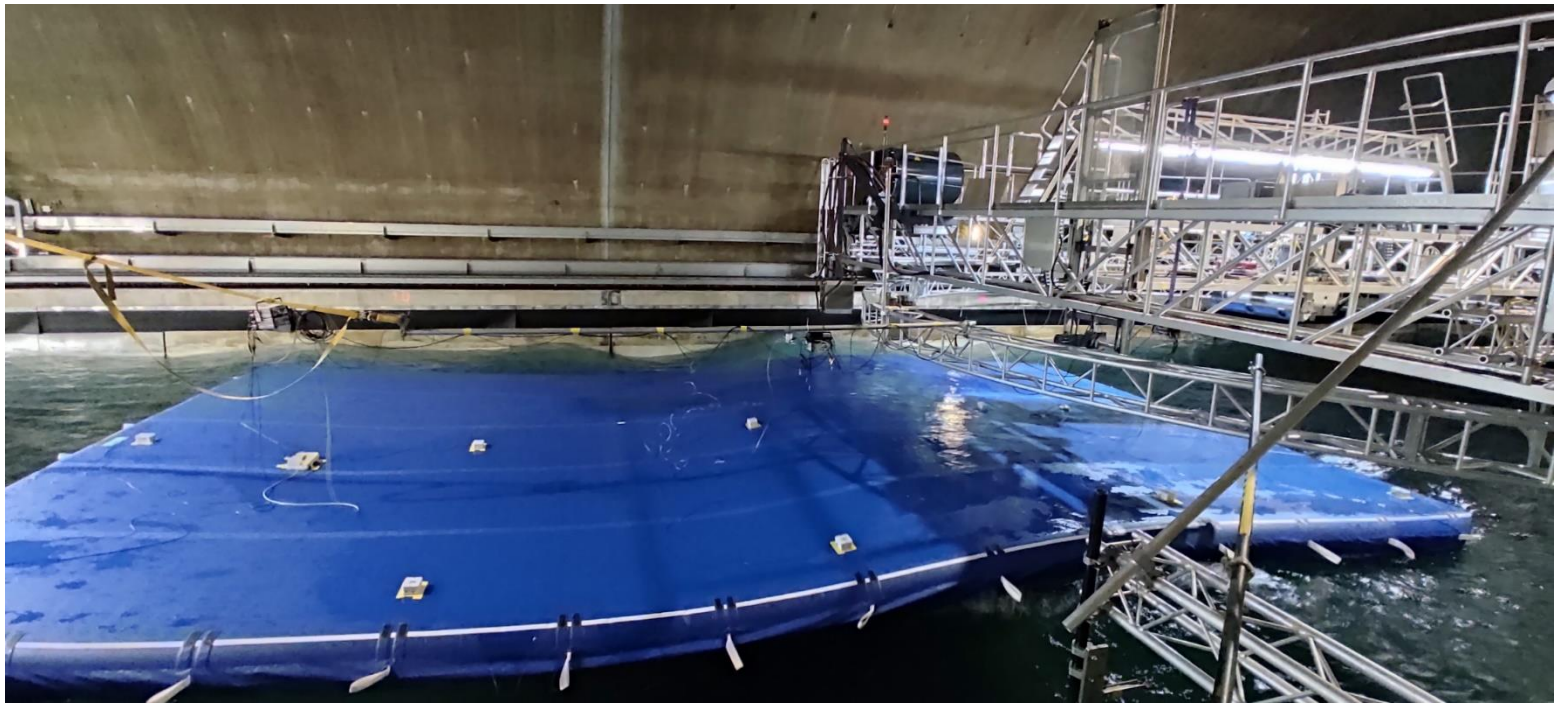
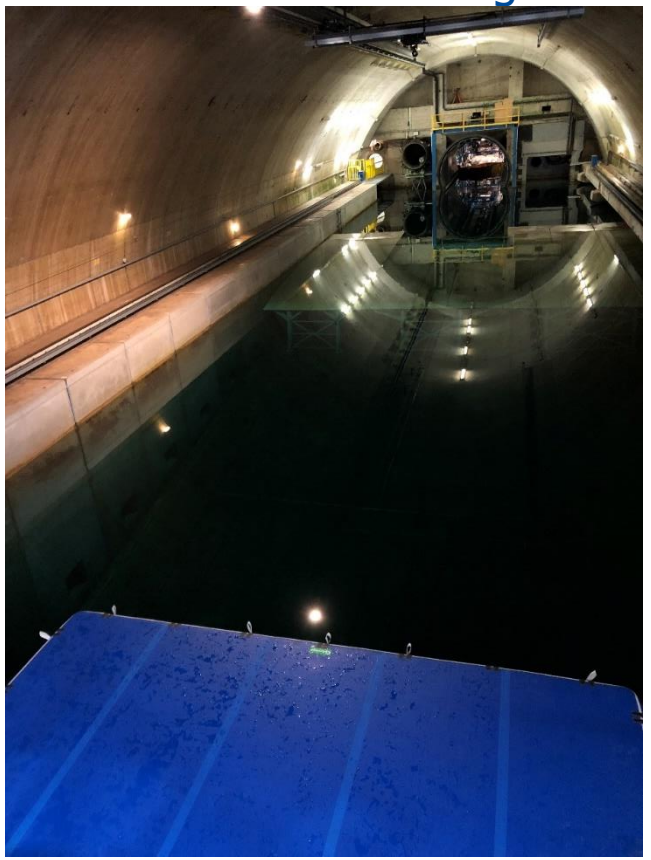




Tests – Basin, full scale



- Performed at Marin, May 2021
- Wave and drag tests
- Full scale floater
  - Limits on wave height



Tests – Basin, full scale

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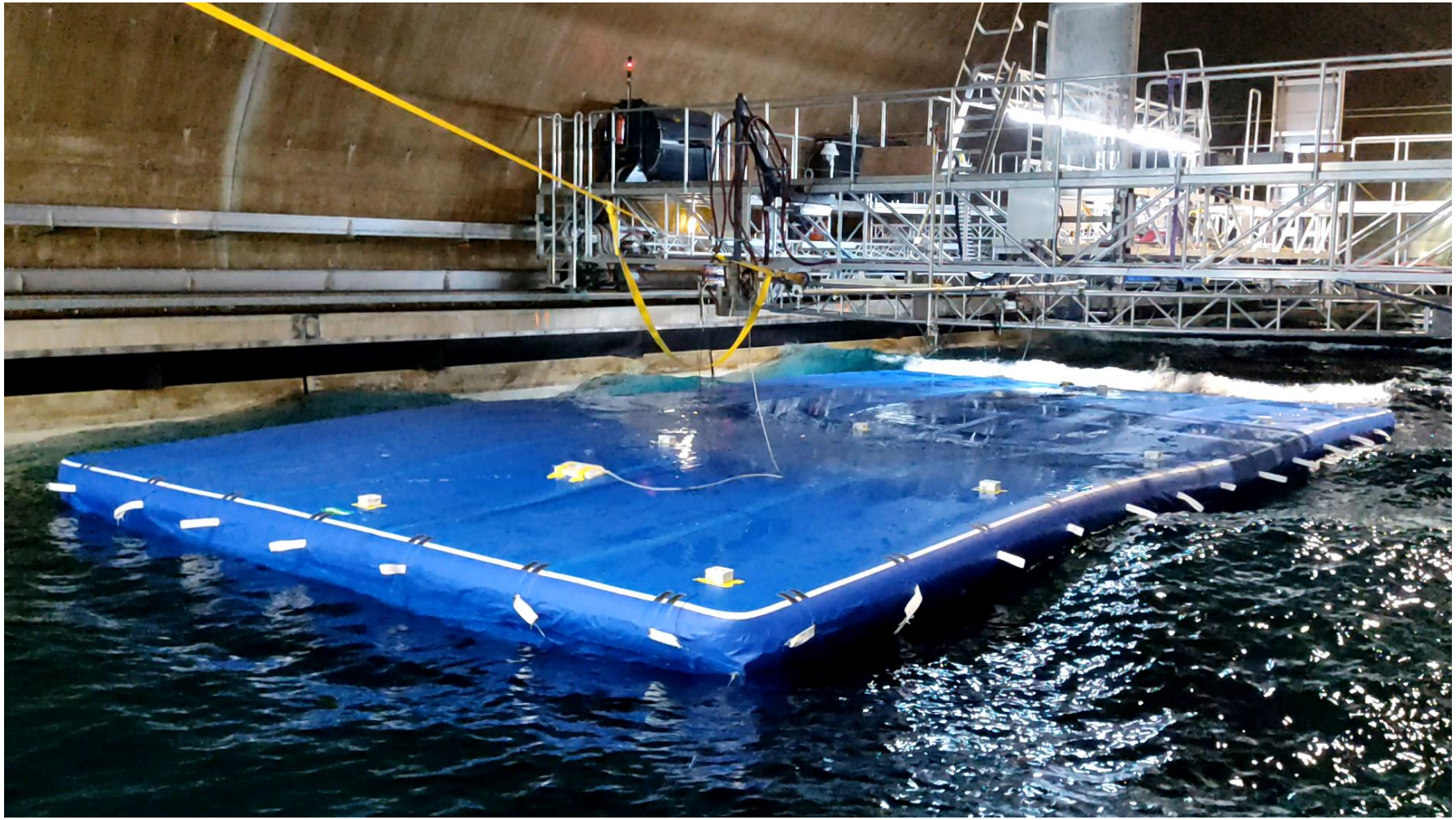
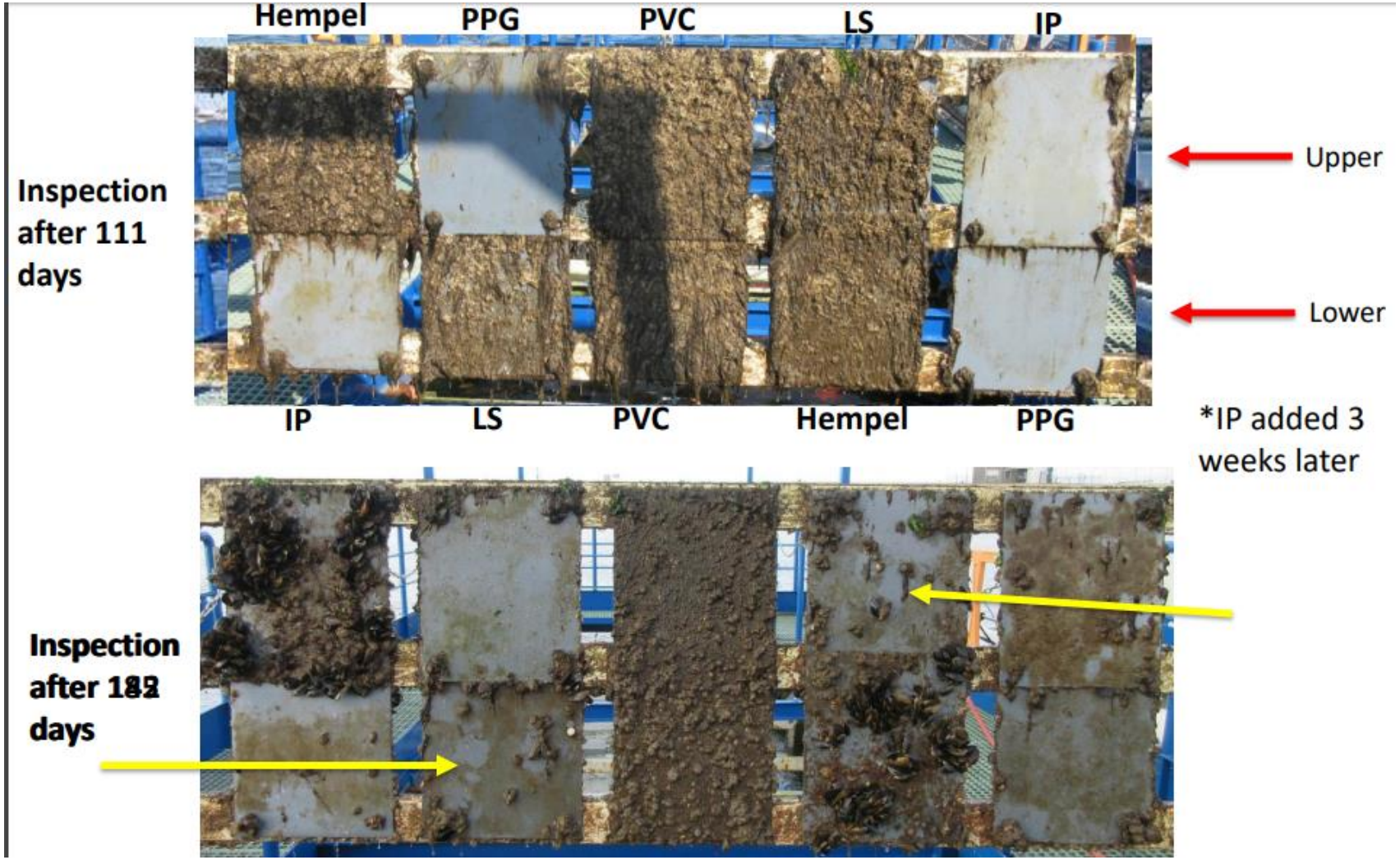


Tests - Fouling



Tests - Fouling

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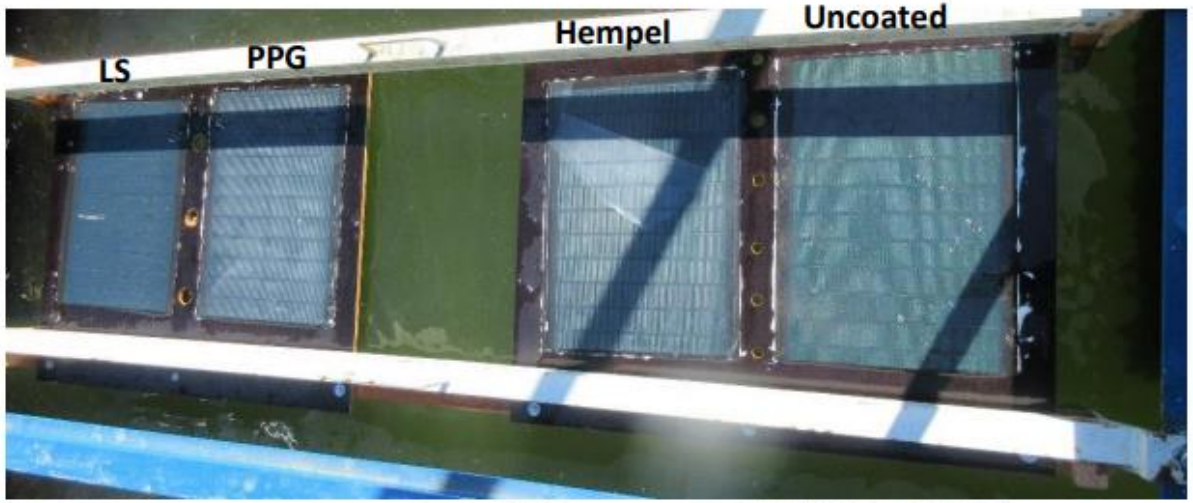
Coated and uncoated PV panel

March



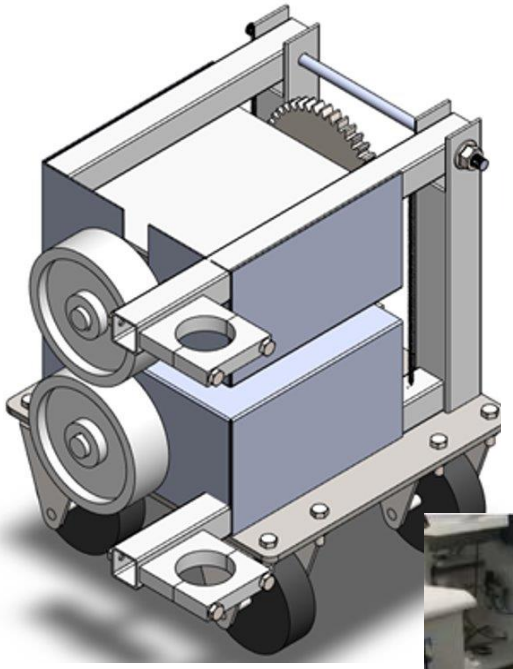
July

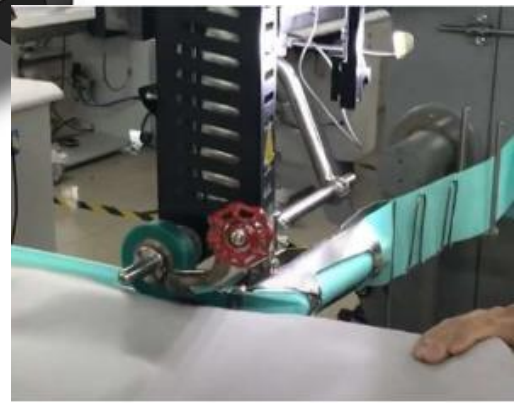
LS

Uncoated

Tests - Manufacturability

- **Analysed peel strength of different joining methods for double wall fabrics (DWFs)**
- **Explored concepts for mass production of floaters**





Tests - Sustainability

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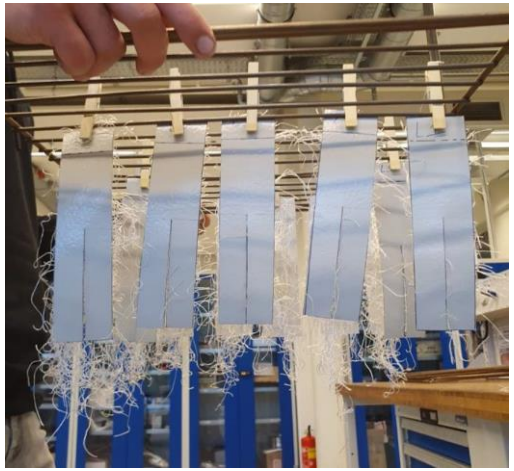
- **Analysed the effects of material aging on tensile strength and tear resistance of DWFs**



Demo Oostvoorne - Lesson learned

- Pressure impressively well kept
- Structural behaviour non-linear
- Floater moves well with waves
- Fouling only on perimeter
- During dry summer period built-up of bird deposits
- Adhesion of panels to floater not in line with results from lab conditions

Conclusion

New technologies - High potential

- Material – Limited use
- Fabrication – Onshore, mass production
- Transport – Limited logistics, low volumes
- Installation – Normal workboats. Mooring can be pre-laid.
- Operation – Easy accessible

Next phase

Jan 2023: Project kick-off Solar@SeaIII

- Offshore environment
- Electrical export cable
- Modelling & testing


Thank you

Solar@Sea Concept - Maintenance

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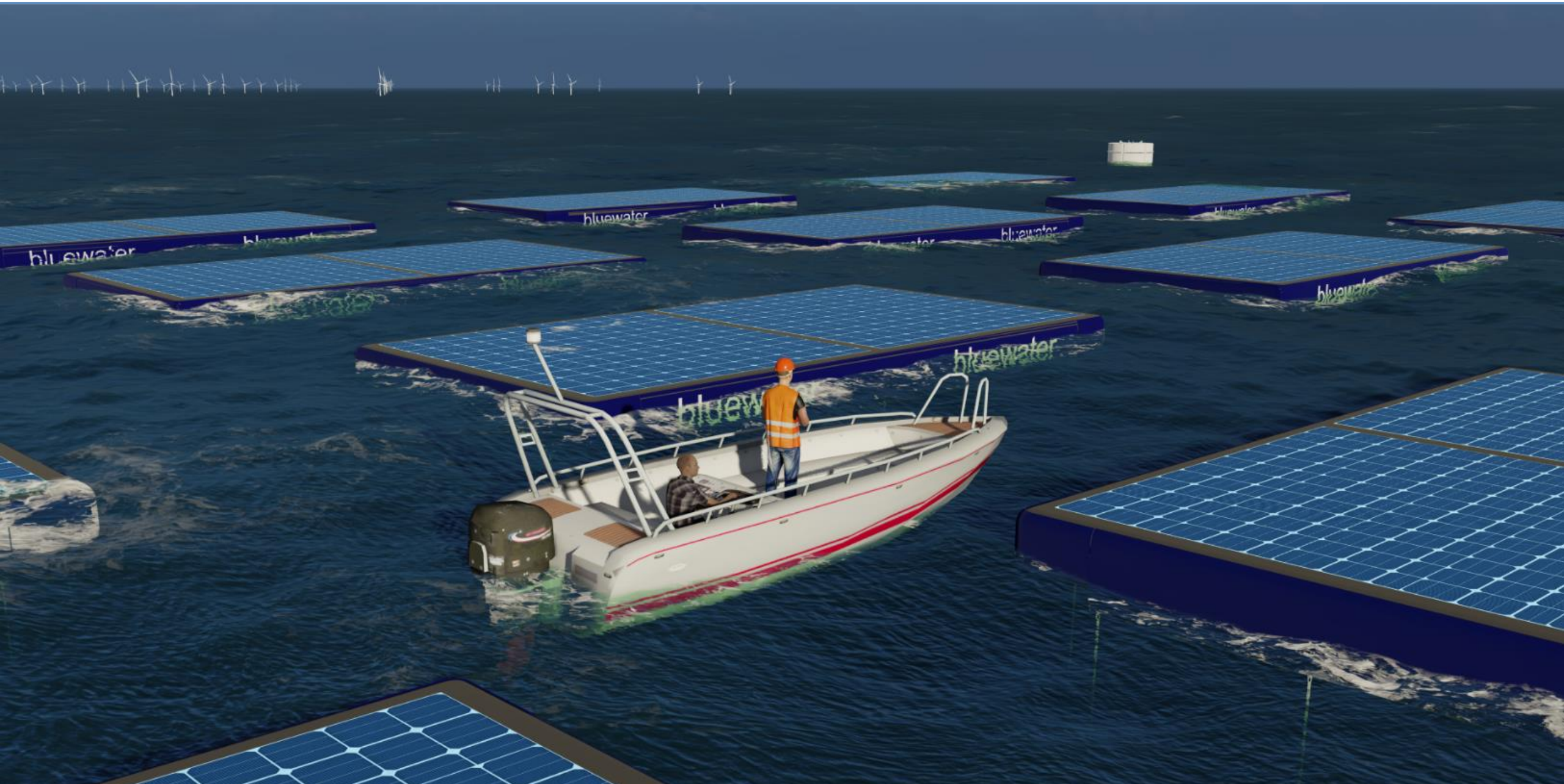

Solar@Sea Concept – Utility scale

Clustered floaters, flexibly connected

Combined mooring and power export per cluster.