BLUE MISSION BANOS

1st MISSION ARENA
14-16 November 2023 | Gothenburg, SE

Solar & wind energy combined

Brigitte Marie-Anne Vlaswinkel, PhD
Oceans of Energy

Brigitte Vlaswinkel

Research Director Oceans of Energy

THEME: **Ocean multi-use UNITED Final Event**

#MissionArenaBANOS1

EU MISSIONS RESTORE OUR OCEAN & WATERS

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WWW.H2020UNITED.EU

WP 7 – Implementation of Multi-Use Concepts Within Pilots (Dutch Pilot)

- DEMONSTRATION - Operate a high-wave offshore solar farm in the North sea
- DEMONSTRATION – joint OMM between seaweed farming and offshore solar farm
- MODELLING – Demonstrate and quantify effect of wave dampening of offshore solar array
- FEASIBILITY STUDY - The legal, regulatory & contractual framework for integrated solar and offshore wind
- FEASIBILITY STUDY - Multi Criteria Analysis for the electrical integration of offshore solar parks with offshore wind parks
- FEASIBILITY STUDY - Cost Model analysis for the electrical integration of offshore solar parks with offshore wind parks

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Oceans of Energy - Offshore Solar since 2016

OOE Develops Technology & Services for:

- OOE Offshore Solar Farm System
- Logistics and Offshore Installation works (Final Assembly)
- Offshore Asset Management (incl. monitoring)

OOE Offers to Third Parties / Projects:

- Offshore Solar Farm system hardware
- Project Delivery Services (EPCI)
- Lifetime Support Services / Asset Management

OOE is Additionally Specialized in:

- Environmental research related to impacts & opportunities
- Energy system research & system integration services
- Permitting, funding, and R&D of offshore solar projects

USPs

- Safety / Years Experience Offshore
- Lowest Cost / Material Efficiency
- Integrated Valuechain / One Interface
- Scalability & Modular Technology
- Fast-track Learning & Development
- Eco-Friendly / Nature-Enhancing

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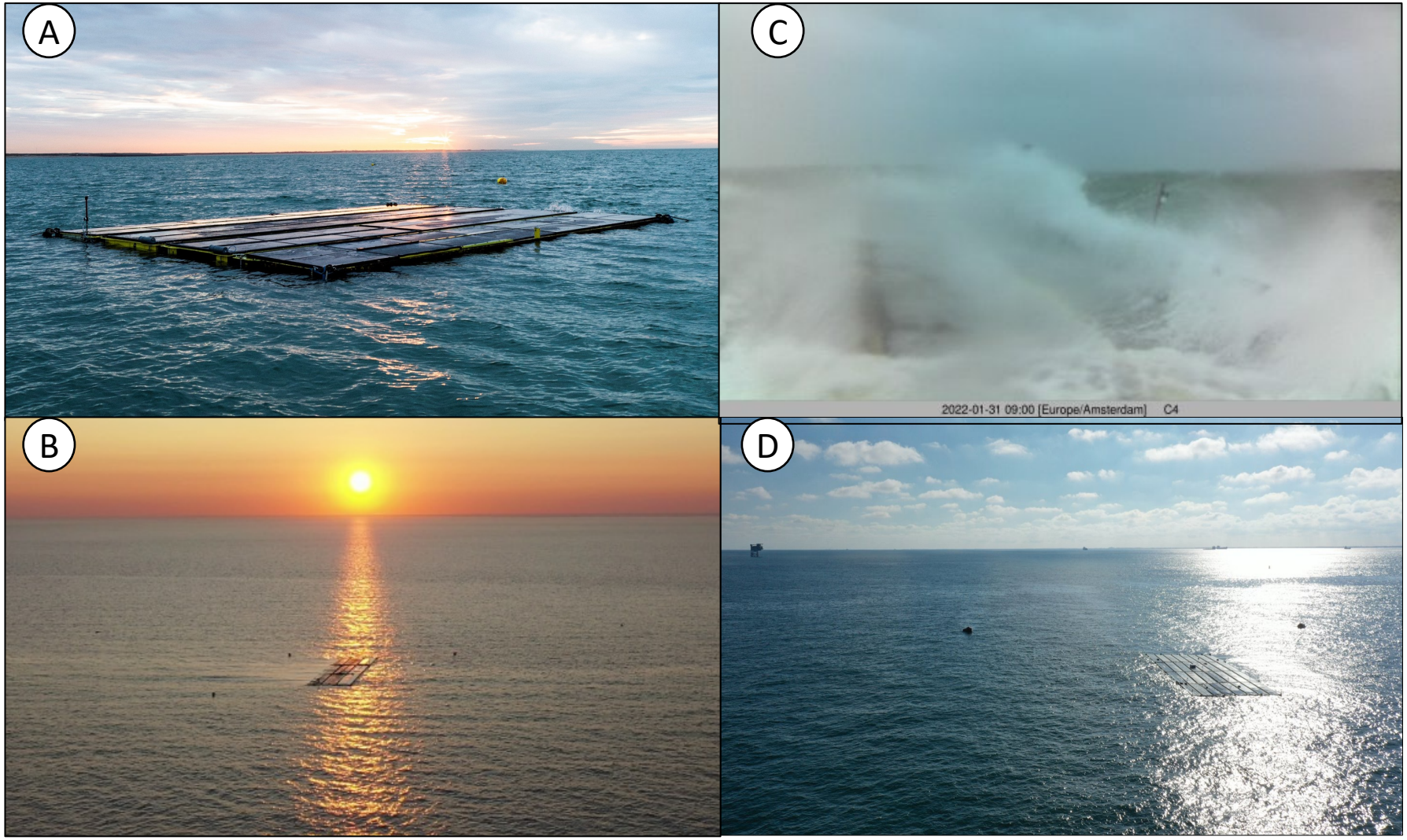
Oceans of Energy Track Record



A) 2019 - OOE Offshore Solar farm system nearshore

B) 2020 - OOE North Sea One Pilot “NS1” 12 km offshore

C) Platform camera during storm Corrie

D) 2021-23 Building “NS2” towards 1MW

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2023/2024 – Follow up 3 MW

Rated capacity	**3000 kWp PV**
Array composition	600 floaters
Offshore solar array footprint	240x80m (2 ha)
Safety zone footprint	350x150m (5 ha)
Visual impacts	Negligible from shore
Distance to shore	2 km (BlueAccelerator Oostende)
Grid connection	Oostende (Belgium), Fluvius

Project goals of H2020 Green Deal 'EU-SCORES':

- Demonstrate utility scale offshore solar
- Prepare for hybrid offshore energy projects
- Assess energy system benefits from diversification
- Reduce risks of offshore solar/wave integration
- Enable business cases for rollout

Accelerating Offshore Energy Transition: Netherlands and Flanders Launch OFFSHORE FOR SURE Project

Updated: Oct 23 **2023-2026**

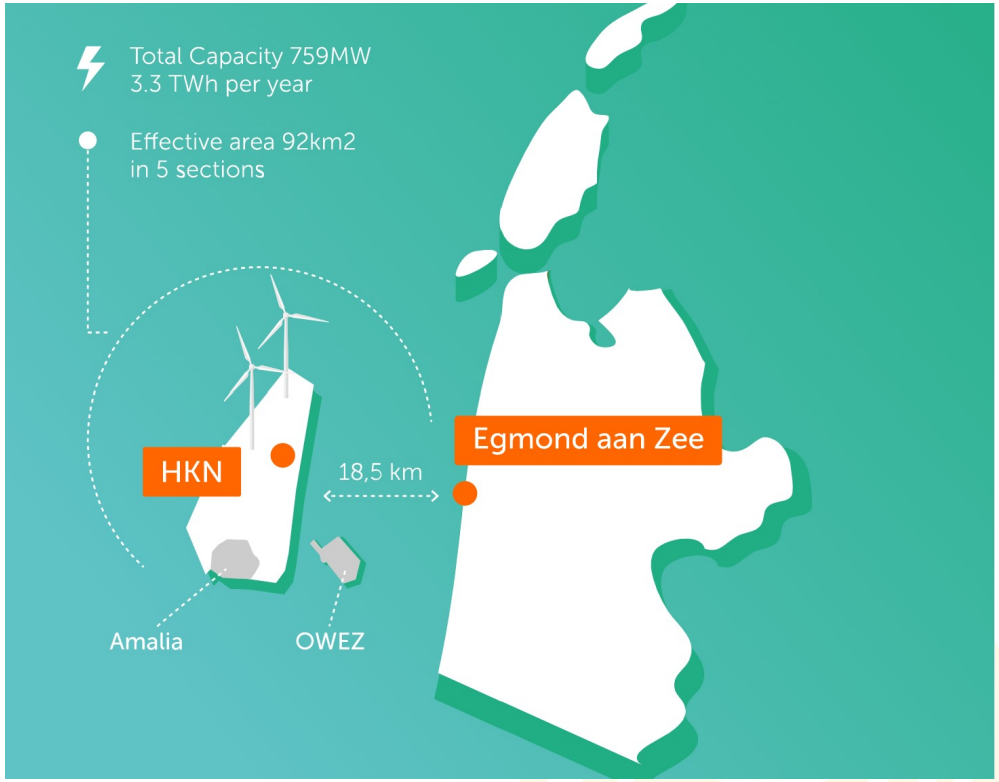
Interreg Vlaanderen-Nederland

Gefinancierd door de Europese Unie

WATER2ENERGY · Dutch Wave Power · FLASC Renewable Energy Storage · GHENT UNIVERSITY · howest hogeschool · deftiq · IMDC · WORLD CLASS MAINTENANCE · BLUE SPRING BE GREEN, GO BLUE. · TOCARDO · Oceans of Energy · PARK WIND JERA GROUP · Ecopower · zmf · Rijkswaterstaat Ministerie van Infrastructuur en Waterstaat

2025 – first commercial offshore solar farm within windpark

Rated capacity	500 kWp PV
Array composition	200 floaters
Offshore solar array footprint	80x80m (0.64 ha)
Year to become operational	2025
Distance to shore	18.5 km (Hollandse Kust Noord)
Grid connection	BaseLoadPowerHub (Crosswind)



Project overview:

- Awarded based on competitive tender (Q2-2023)
- Connect to grid at monopile with dynamic cable
- Develop operational learnings within wind farm
- Monitor structural/power/environmental performance
- Assess potential impacts on windfarms

CROSSWIND

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Upcoming Dutch offshore wind tender asks 50 MW offshore solar (Ijmuiden Ver)

Tender Beta: Q4-2023

Award Beta: Q2-2024

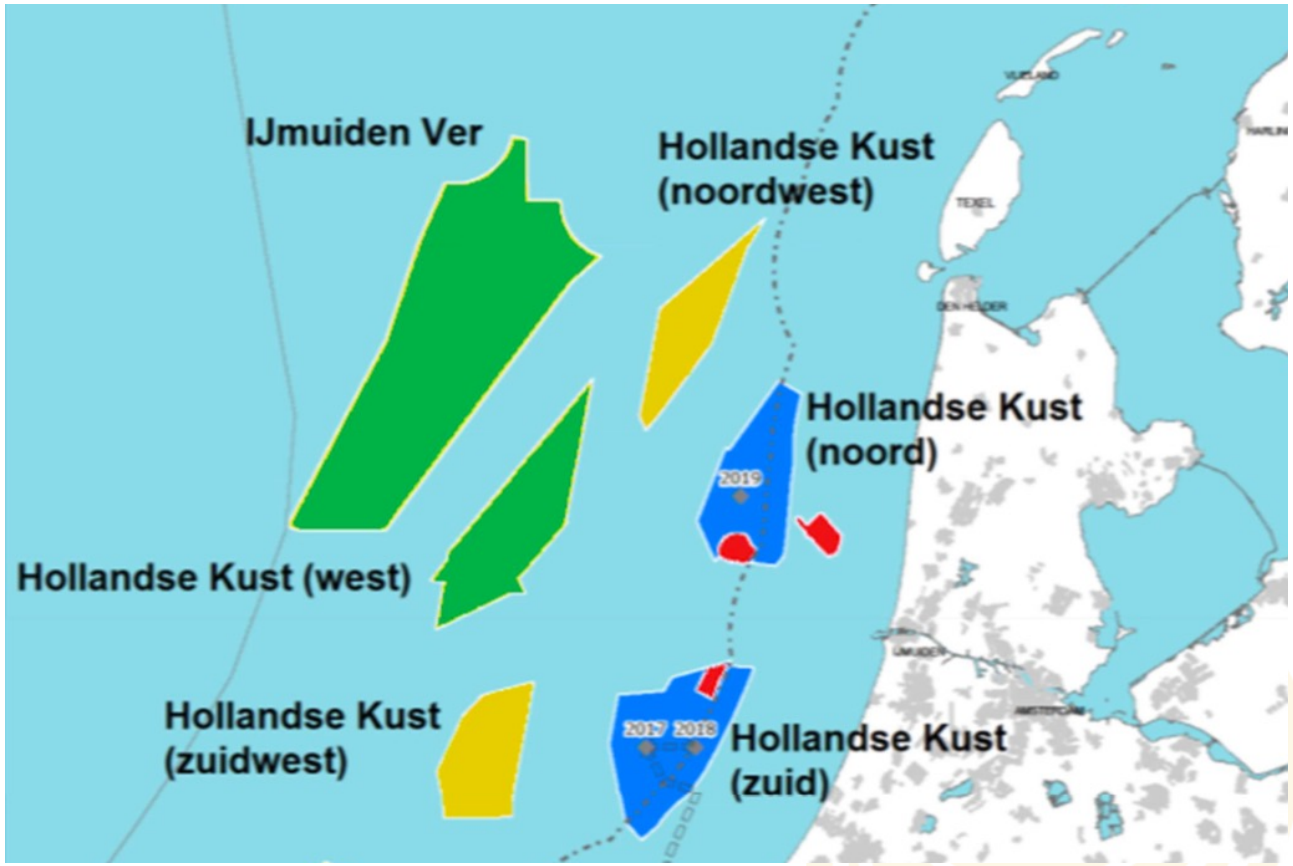
Start installations: Q2-2027

Install completed: Q2-2029

Capacity wind: 2 GW (+4 GW)

Capacity solar: 50 MW*

Requirements: min. 10y operations



*Conceptregeling kavel Beta, MinEZK NL, 06/4/2023, table 6, p15

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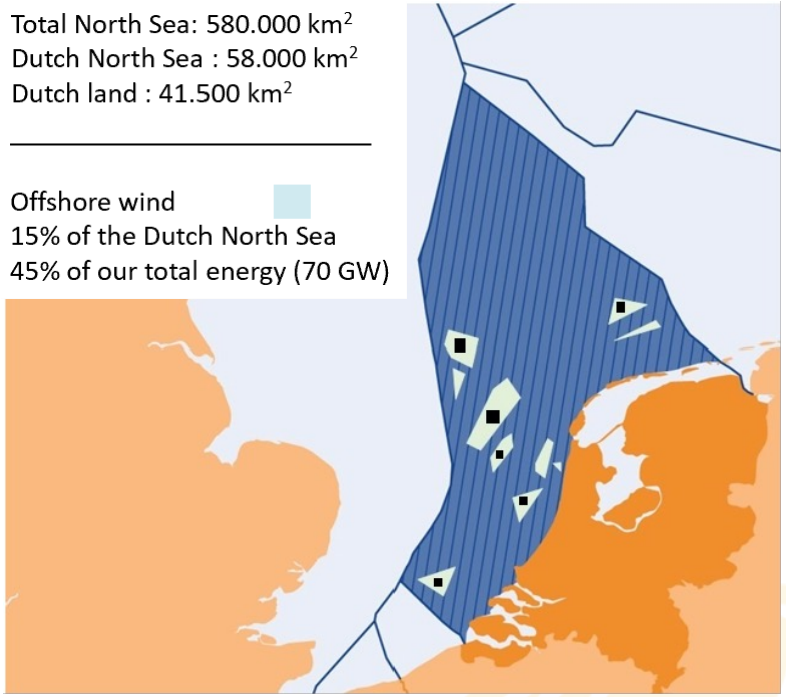
Dutch government's ambition – 3 GW in 2030

https://www.rijksoverheid.nl/actueel/nieuws/2023/04/26/extra-pakket-maatregelen-dicht-gat-tot-klimaatdoel-2030

Total North Sea: 580.000 km^2
Dutch North Sea : 58.000 km^2
Dutch land : 41.500 km^2

Offshore wind
15% of the Dutch North Sea
45% of our total energy (70 GW)



Offshore solar
3% of the Dutch North Sea
45 % of our total energy

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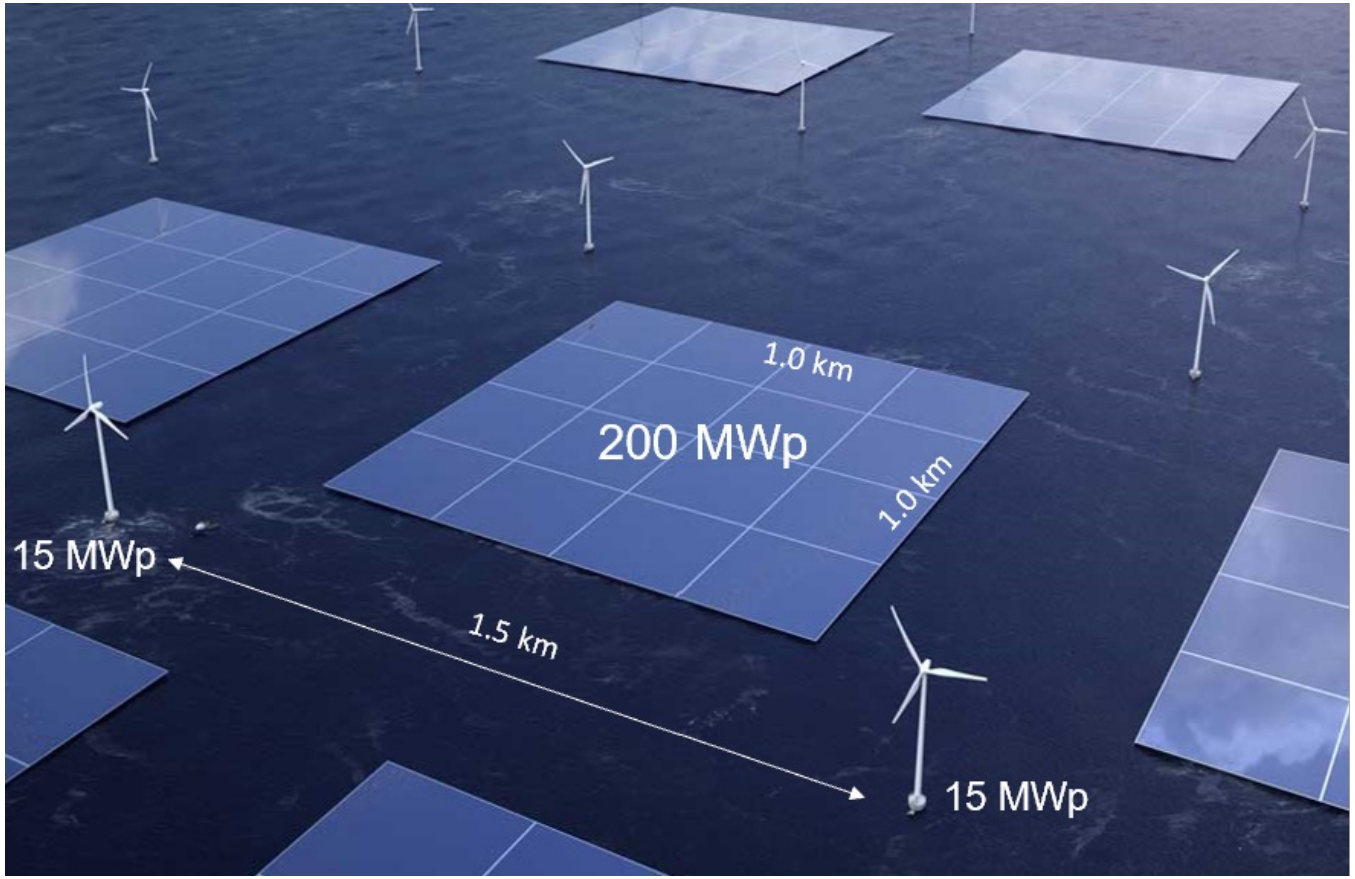
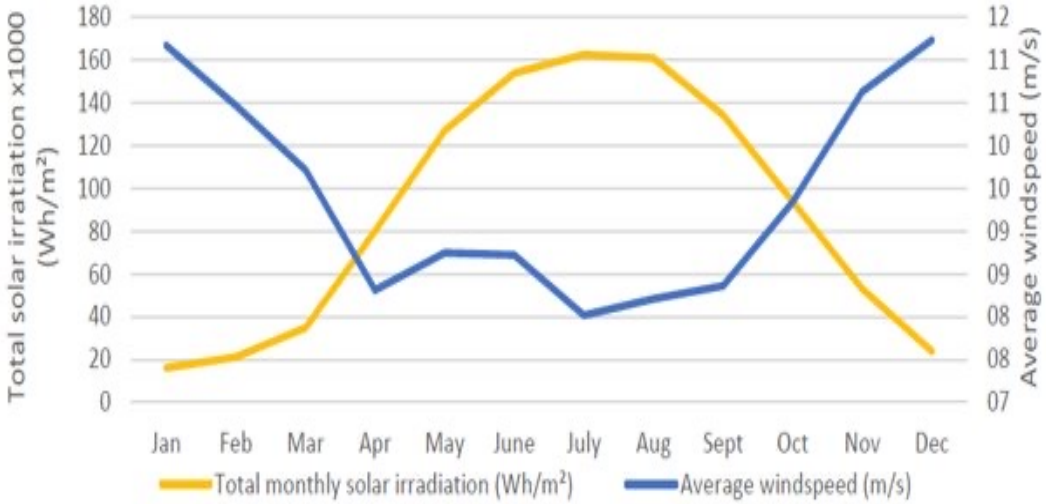
Offshore solar & wind – an excellent combination





Up to 5x more energy per year per km², when PV is installed between windturbines, still leaving open corridors of 500 meters in between 1 km² fields.

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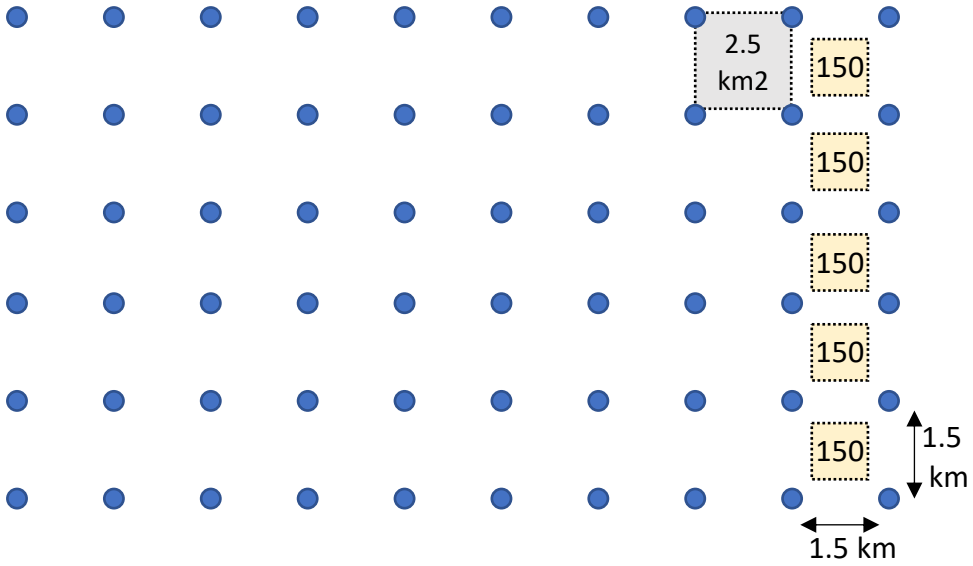
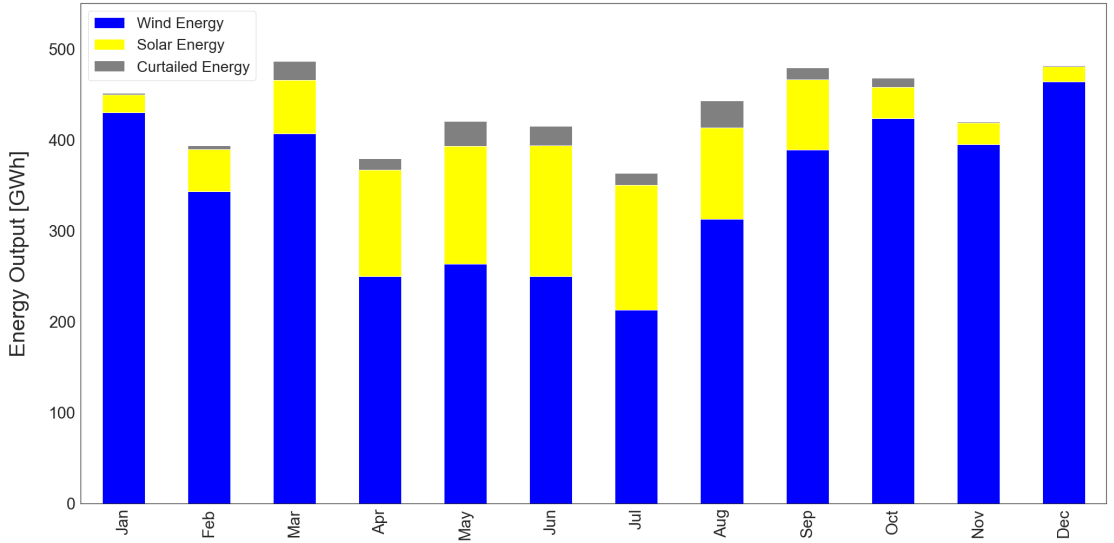
Spatial Integration of offshore solar in windparks

1:1 Integration of Solar requires 3% of space



And results in benevolent energy pattern



125 km2 wind farm of 750 MW + 750 MW

60x 12,5 MW turbines, 1.5km distance +

5x 1km2 = 150+ MW offshore solar farm

NL Simulation based on OOE-OSI1 Model

2020 data from LaRC PowerProject API service

1000 MW of offshore export, wind, & solar

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Learnings from 4 years of operations

Offshore Operations in numbers	
Offshore installation campaigns conducted	>15
Offshore operations & maintenance visits conducted	>60
Offshore system decommissioning campaigns	3
Total hours spend offshore	>3000 hours
Number of employees trained for offshore operations	15

- Keep everybody safe, keep system safe
- Build offshore team, tailor made trainings
- Capture learnings in processes
- Remote monitoring

Photo: OOE offshore team own safety trainings, as well as tailored made safety training with the STC-KNRM

Photo: Contractor vessel operational at Offshore Test Site

Photo: Offshore team departing after winter inspection day at sea

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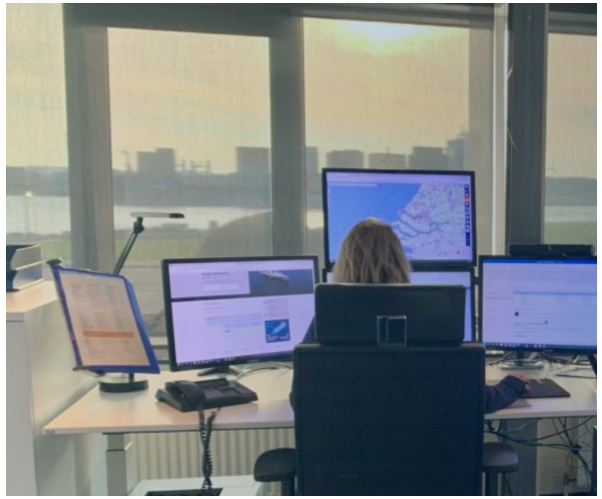
Joint OMM between offshore solar farm and seaweed farming

- Shared offshore trips / shared vessel costs
- shared 24/7 maritime safety support
- Shared environmental monitoring
- Shared inspections (UAVs, robotics, drones)



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Operational in high waves as well as summer calms - North Sea

Storms encountered with names:
Ciara, Dennis, Bella (2020)
Evert (2021)
Corrie, Dudley, Eunice, Franklin (2022)
Poly, Ciaran (2023)

Offshore solar is a reality!

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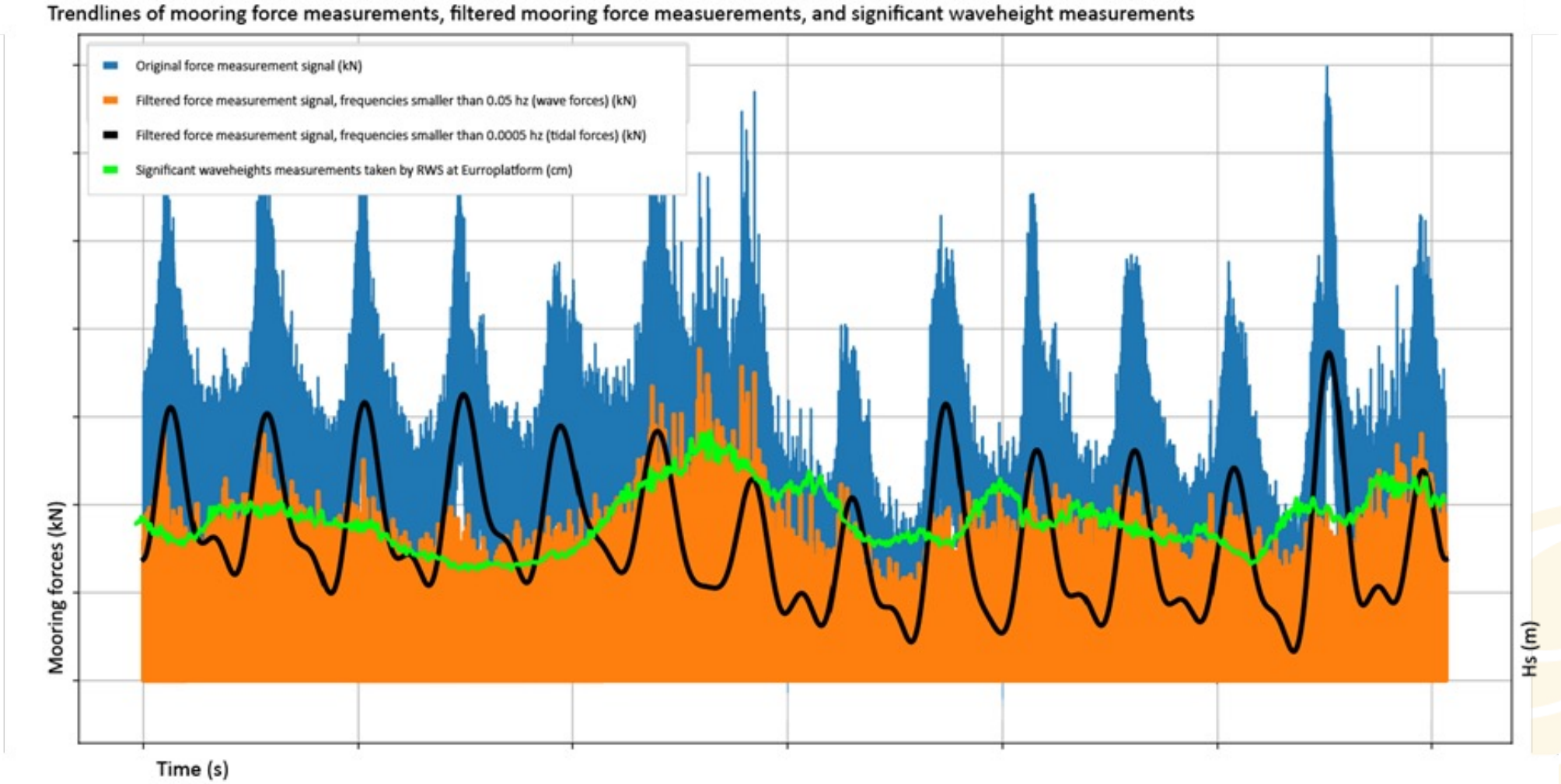
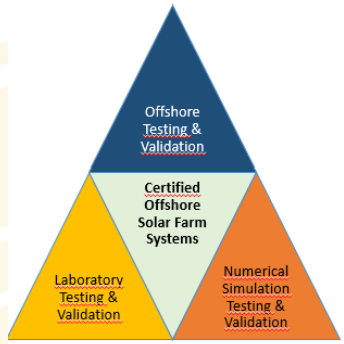
Offshore load measurements





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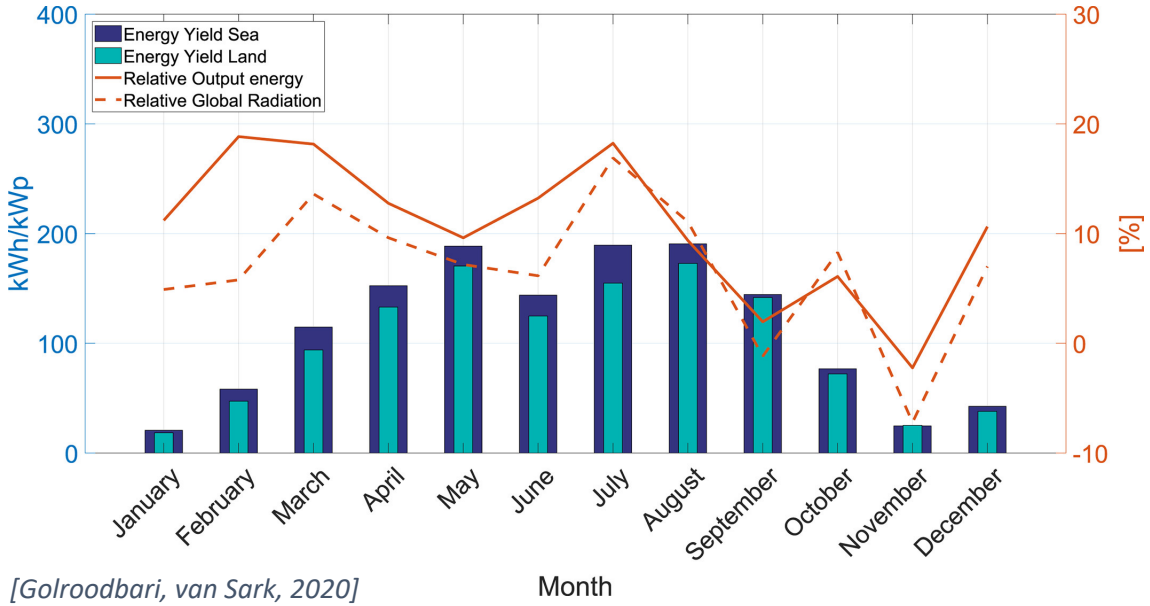
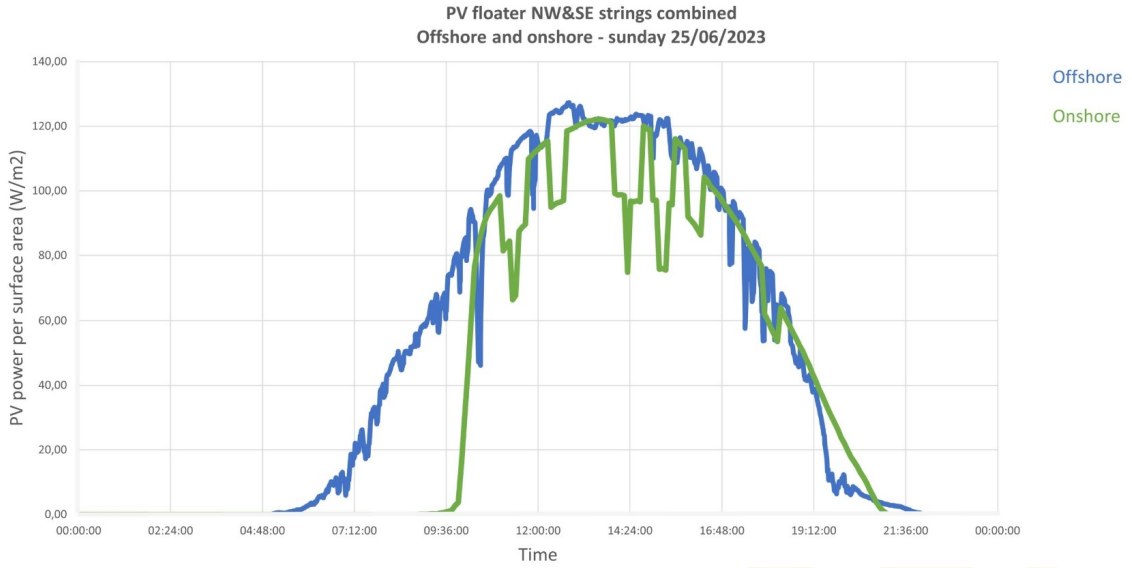
Energy Yield Advantage at Sea (modelled and measured)



[Golroodbari, van Sark, 2020]



Modelled: 13% higher energy yield at sea due to higher irradiation and more cooling

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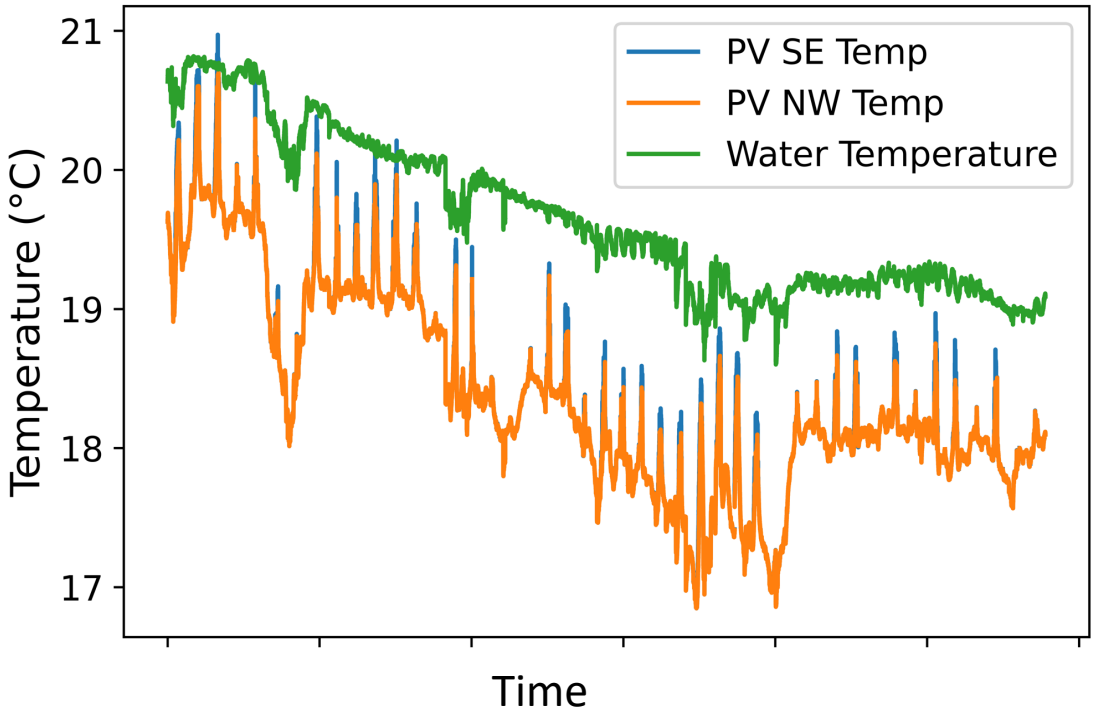
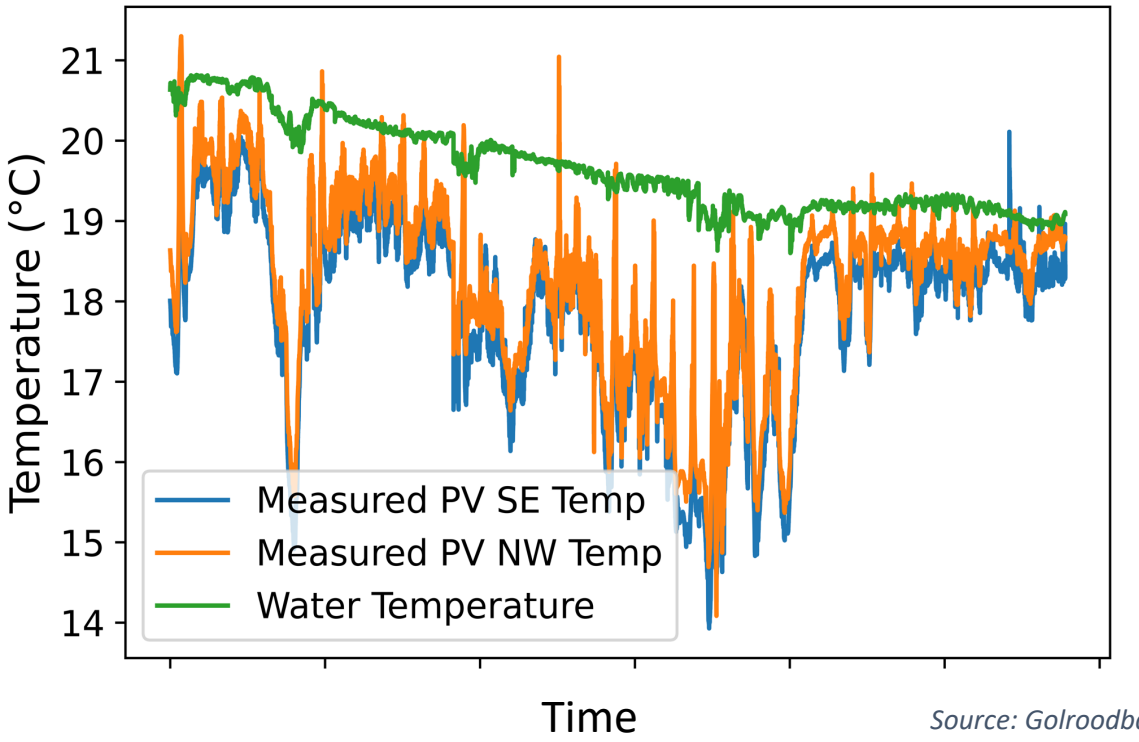
Cooling of PV modules at Sea

modelled



measured



Source: Golroodbari, 2023

Measured temperatures of PV modules at sea follow nicely the model

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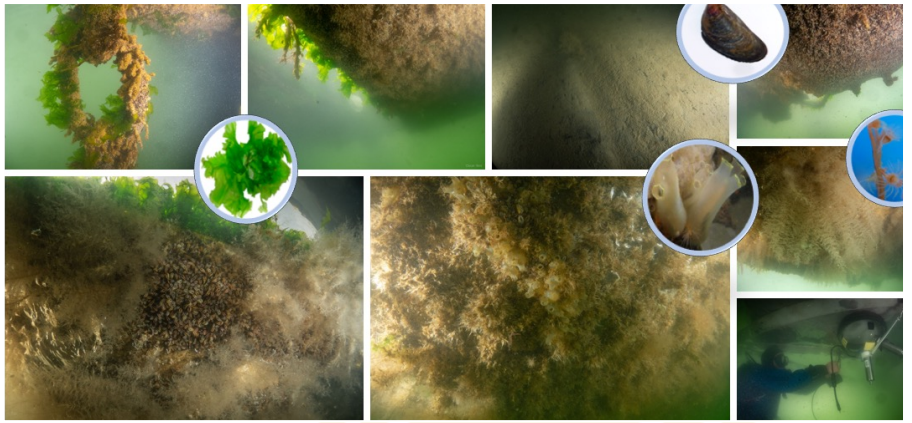
Fouling – above and underwater

- Fouling by bird droppings, salt, marine growth is minimal due to:
  - natural overflowing of the panels due to low freeboard
  - space in between the floaters
  - making use of tilt angles
- Self-cleaning mechanism kicks in with minimal wave action. We do not expect to regularly clean the PV modules (but have tested corrective and preventive measures offshore)

- Underwater: typical NS fouling community with brown and green algae, hydrozoa, and dominantly *Mytilus edulis* (blue mussel), plus many invertebrates, shrimps, crabs etc

➢ Floating reef enhances local biodiversity, more fish observed!



Source: Oscar Bos (WMR)

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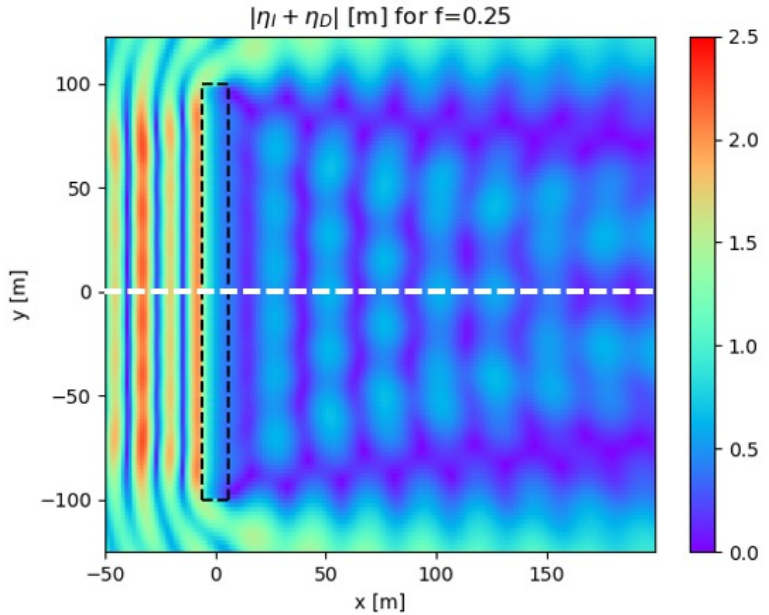
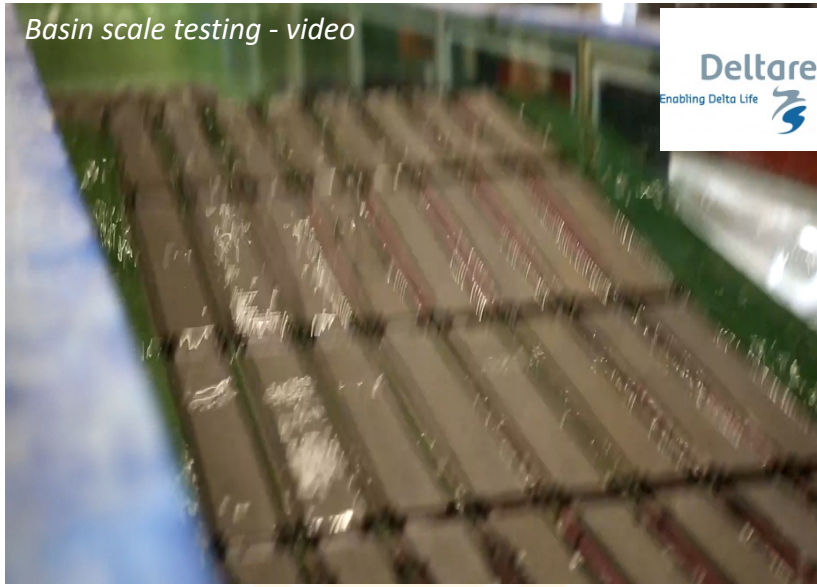
Wave attenuation of offshore solar

- **Multi-scale approach studies** (field measurements, basin testing, numerical modelling)
- Wave attenuation ⟶ down-wave shadow zone
- Combinations with other offshore activities
  - Aquaculture
  - Wind farms
  - Harbour and shore protecti


Wave buoy deployed in North Sea




Basin scale testing - video

Deltare
Enabling Delta Life

Numerical model results of wave attenuation study 2021.Not published yet

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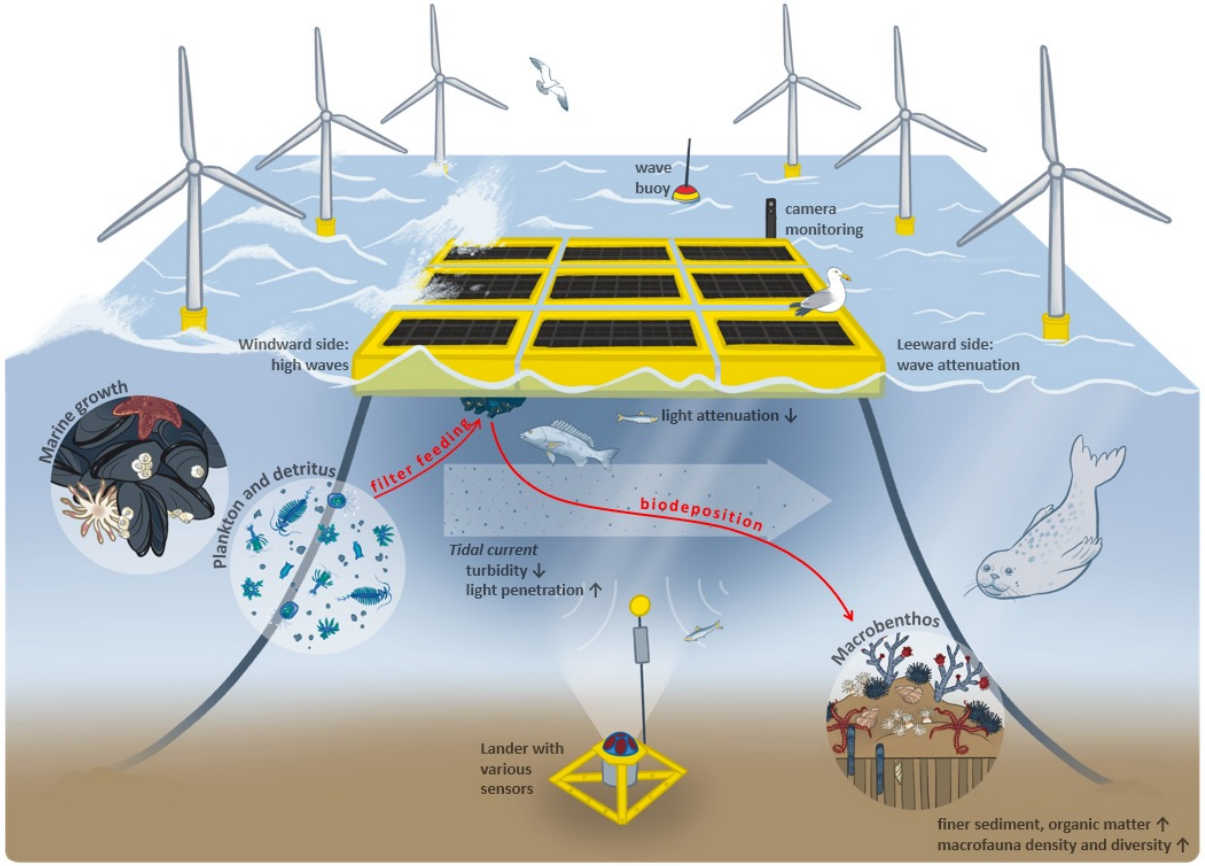
Offshore Solar and the Marine Ecosystem



Offshore Solar Specific Effects
Shadow effect
Fish aggregation
Habitat creation
Wave attenuation
Mixing and destratification
Stepping stone effect
Sediment changes
Enhancing local biodiversity
Birds and seals 'platforms'

Like any man-made offshore development, offshore solar is likely to lead to changes to the environment. Some effects (negative ánd positive) are non-specific to offshore solar, others are. Research focuses on the specific offshore solar impacts and opportunities

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Ocean Sci., 16, 195–208, 2020
https://doi.org/10.5194/os-16-195-2020

Ocean Science Open Access EGU

Effects of large-scale floating (solar photovoltaic) platforms on hydrodynamics and primary production in a coastal sea from a water column model

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Environmental impacts and benefits of marine floating solar

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Biofouling
Ecosystem impact
Artificial reef
Public acceptance

ABSTRACT

Deployment of floating solar photovoltaic installations (floatovoltaics) is advancing, with various designs beginning to appear in a range of marine environments. Insight from freshwater floatovoltaics is not readily transferable offshore, and so lessons from other marine energy infrastructure are used to highlight how the marine environment may impact floatovoltaics, how the floatovoltaics impact the environment (both positively and negatively) and the likely societal response. It becomes clear that research to understand the environmental and societal implications of floating solar in the marine environment must proceed in parallel with investigations of the technical and economic feasibility.

sustainability

IMPACT FACTOR 3.889
CITESCORE 5.0

Article

Environmental Observations at the First Offshore Solar Farm in the North Sea

Brigitte Vlaswinkel, Pauline Roos and Mei Nelissen

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1st MISSION ARENA
14-16 November 2023 | Gothenburg, SE

Regulatory framework for offshore wind & solar

Pelle van den Heuvel - Ventolines

THEME: **Ocean multi-use UNITED Final Event**

Ventolines
Moving forward with renewable energy

#MissionArenaBANOS1

EU MISSIONS RESTORE OUR OCEAN & WATERS

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Ventolines
Moving forward with renewable energy

A leading agency in the renewable energy industry

- We have experience in every phase of wind, solar and large-scale energy storage projects
- Both onshore and offshore

100+ professionals

Founded in **2007**

2 GW+ installed renewable energy capacity

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One of our projects: Wind Farm Fryslân

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UNITED report deliverables

- **Regulatory and contractual framework for offshore wind and solar energy**
  - Dutch Exclusive Economic Zone
  - Relevant for other jurisdictions
- **Three concepts** (developed by our partner TNO):
  - **Standalone concept**
  - **Semi-standalone concept**
  - **Turbine integrated concept**

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Greenfield/Brownfield Wind Farms

We distinguish two situations:

- **Brownfield** wind farms = constructed/under construction

- **Greenfield** wind farms = in the development phase

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Key issues regarding project UNITED

- Currently there is no legal framework for offshore solar
  - Unlike: **Offshore Wind Energy Act**
- This gives rise to **several issues**, which can be categorized as follows:

1. **Issues regarding grid connection**
2. **Issues related to brownfield situations**
3. *Issues related to greenfield situations*

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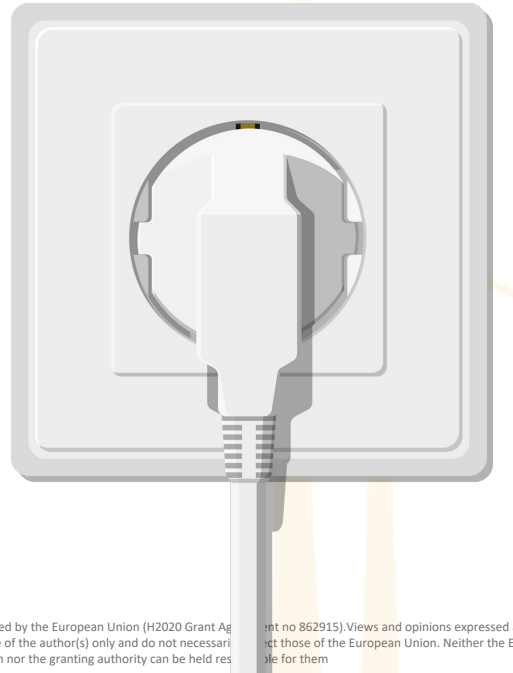
Offshore grid connection issue

- **Dutch offshore grid is reserved for wind farms** (Electricity Act)
- Solar farms **depend** on grid connection wind farm
  - Solar farms will depend on the agreements between network operator and wind farm
  - If wind farm ceases to exist, solar farm will lose grid connection
- **Standalone concepts not feasible** under the current legal framework
- **Bankability issue:** what if wind farm ceases to exist?



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Brownfield issue (1)

- **No obligation for wind farm to cooperate**
- **New legislation necessary**
  - Including compensation for retroactive impacts
- **Contractual arrangements must be made, similar to onshore**
- **Currently, an offshore solar farm is not feasible without the cooperation of an offshore wind farm!**

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Brownfield issue (2)

- Offshore **Wind** Energy Act
- Additional permits for FPV mandatory
- NB: in the Dutch EEZ, Dutch Civil Code does not apply
- Current framework does not provide tender procedures for FPV
- **Unclear: how does the government determine whether a solar farm can be developed at a specific location?**

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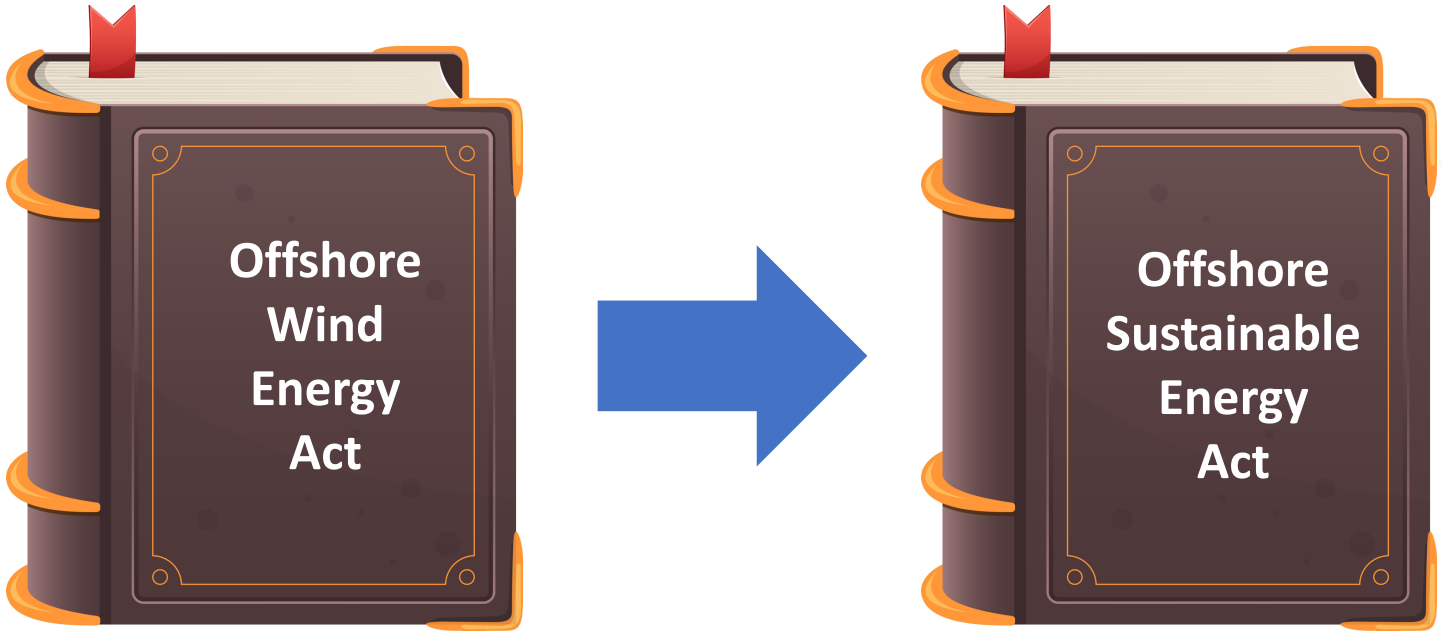
Recommendation

Create comprehensive legislation, addressing:

- Designation of areas for solar energy
- Tender procedures for offshore solar
- Integration of permitting processes
- Conditions to connect solar to offshore brownfield wind farms



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