

# Synergies for a wave-wind energy concept

“Bringing together waves and wind”

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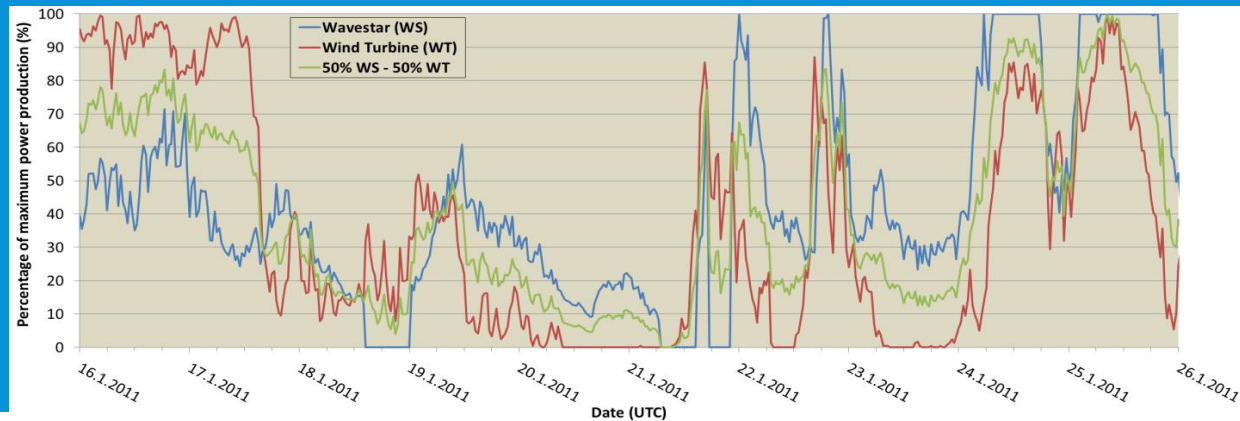
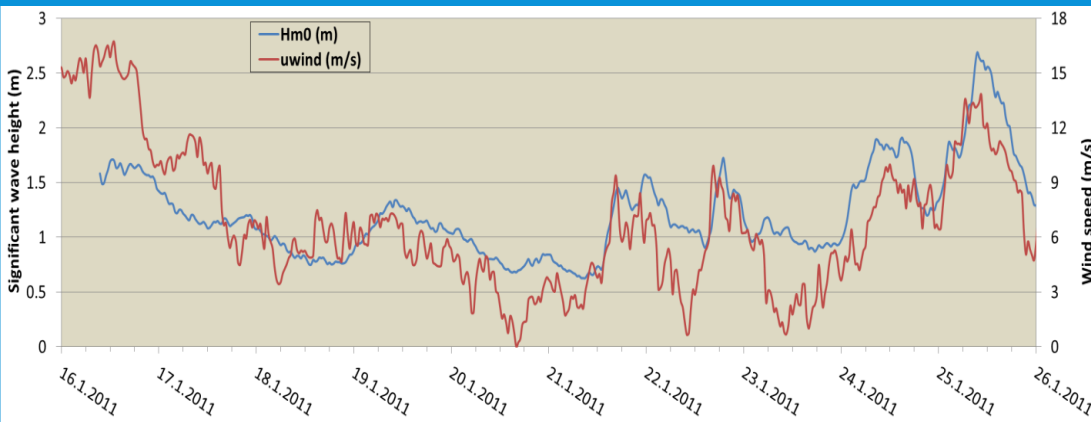
**Dr. Julia Fernandez-Chozas**

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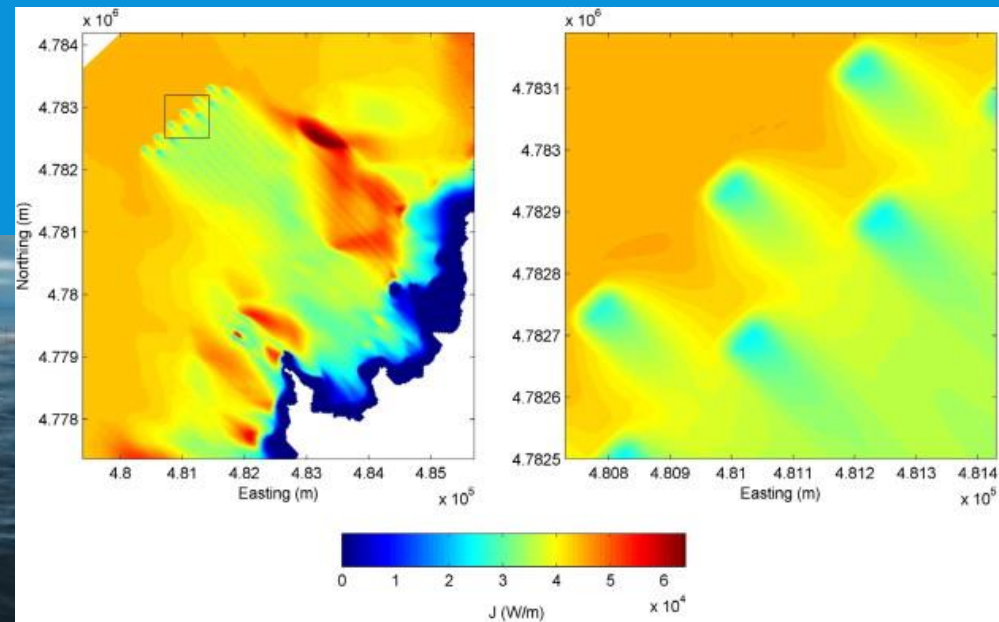
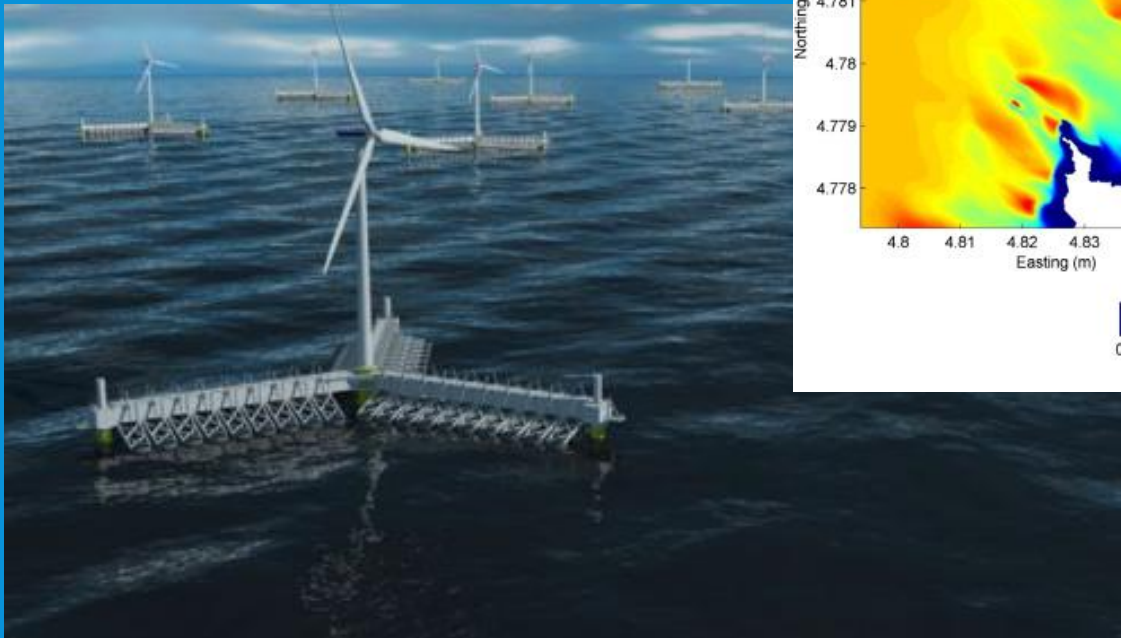
# Synergies I

- An increased energy yield, and predictability;
- A smoothing and highly available power output;



# Synergies II

- Shared cost (e.g. grid, O&M, substructure, logistics);
- Reduced environmental impacts;
- Shadow effects



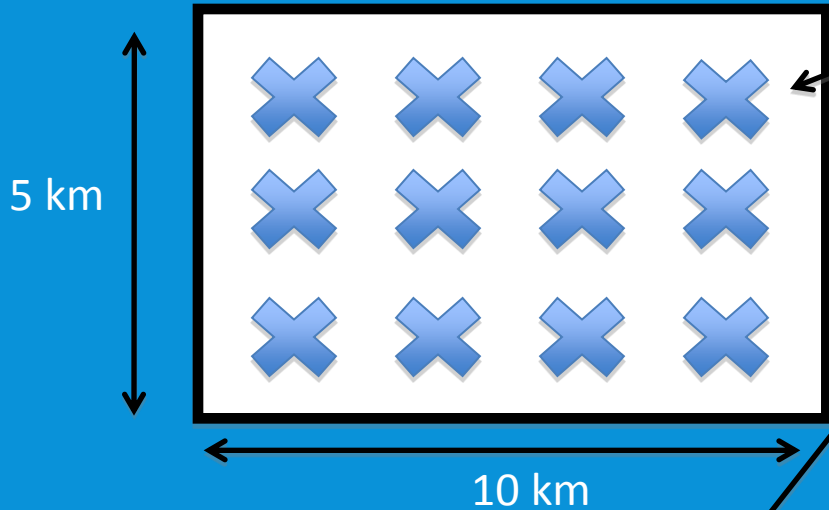
# Risks & challenges

Risks	Challenges
<ul style="list-style-type: none"><li>• Technology readiness of wave energy</li><li>• Uncertainty of mooring lines</li><li>• Lack of experience</li><li>• Impact risk</li><li>• Project insurance</li></ul>	<ul style="list-style-type: none"><li>• Research and development in: new materials, concepts of mooring lines, anti-collision systems, etc.</li><li>• Demonstration of the combined wave-wind technology</li></ul>

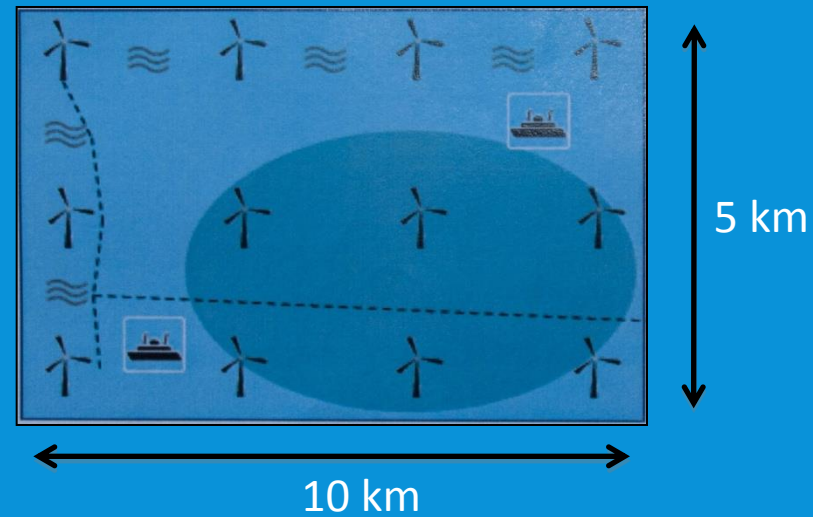
# Case study: Problem definition

Monopile-Driven Wind Turbine

Wave Energy Converter (Floating or Bottom-Fixed)

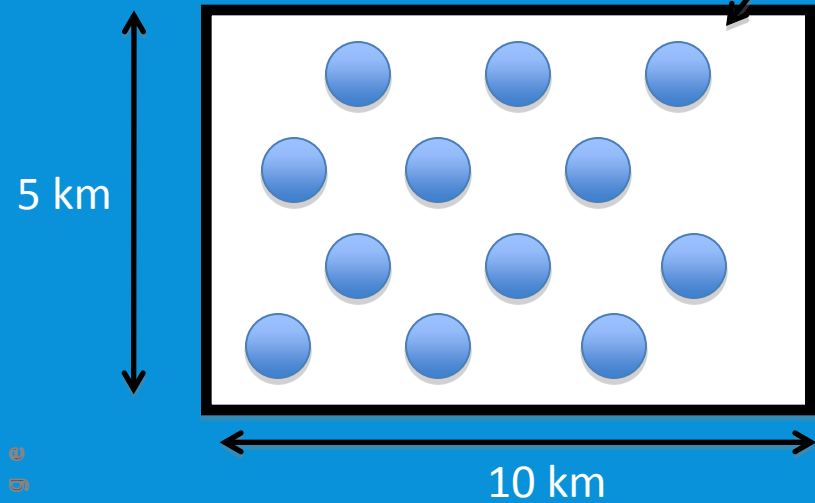


VS



“A generic offshore wind farm”

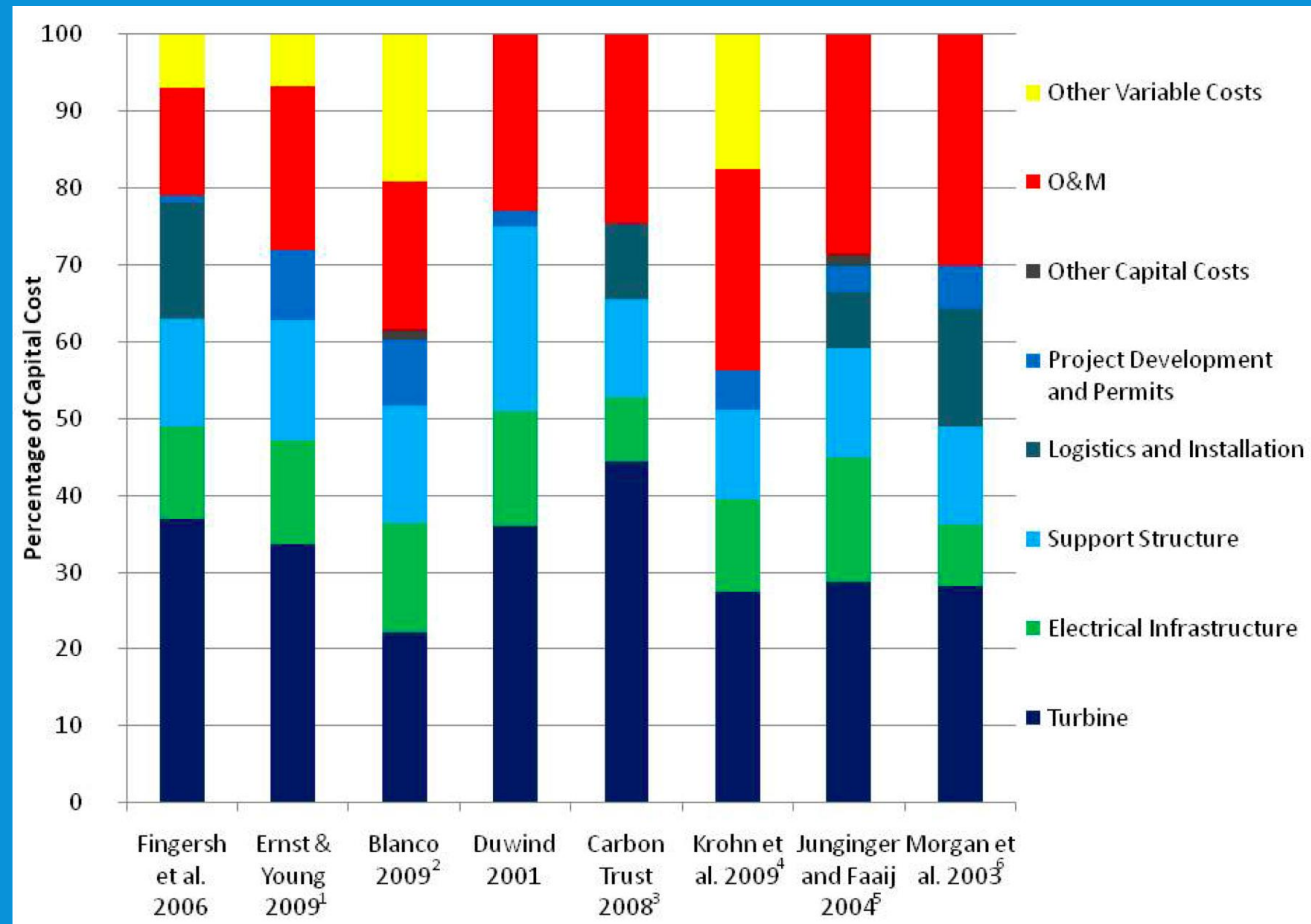
- 20-30 km from shore
- 20 m water depth
- 200 MW



# Case study: Costs

## Breakdown of Life-Cycle Costs of Offshore Wind Farms in Shallow Water

(NREL)



# Case study: WECs

## Wave Energy Converter comparison

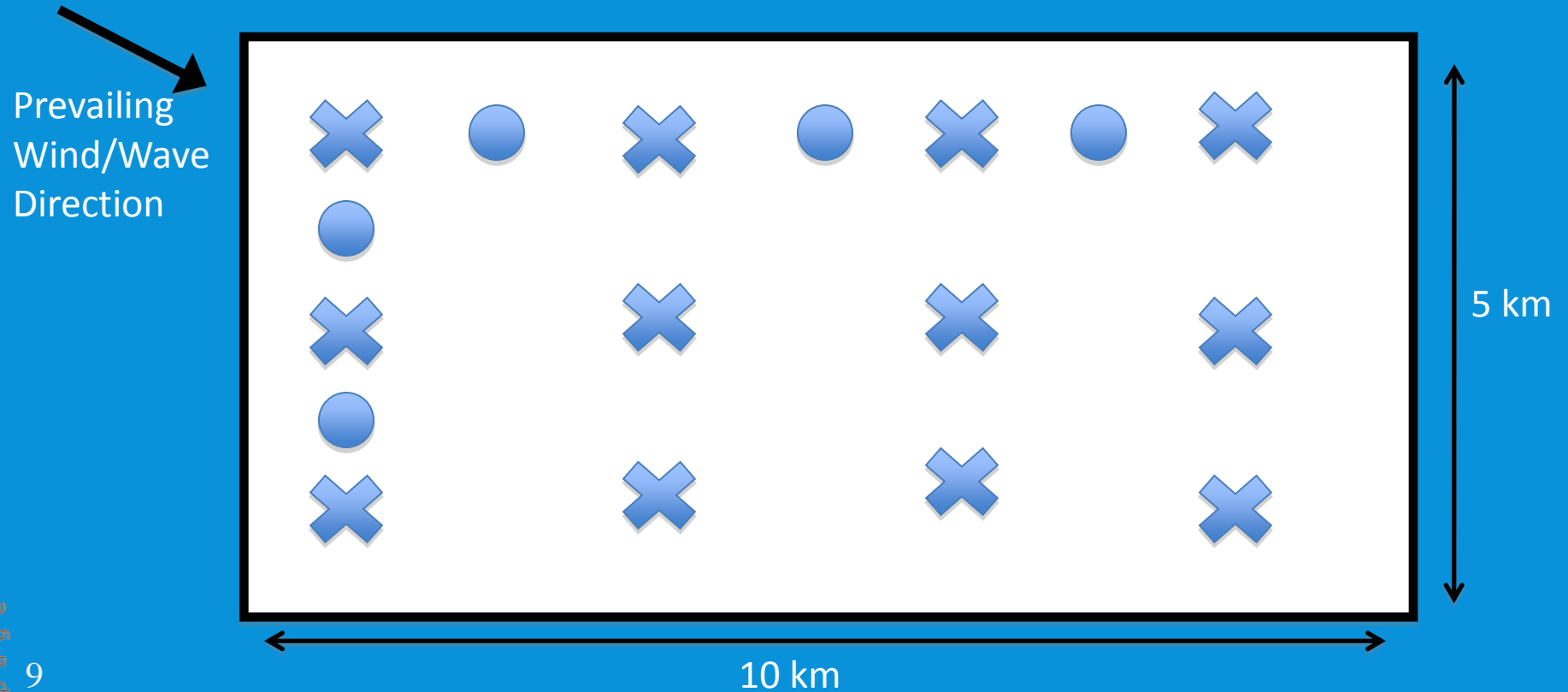
WEC Name	WEC “Main active dimension” [m]	Capture Width [%]	Shielding potential coefficient (regular operation) [-]	Shielding potential coefficient (storm operation) [-]
Wave Dragon	~ 260	0.23	0.60	0.50
WaveBob	15	0.42	0.30	0.20
WaveStar	100	0.40	0.60	0.00





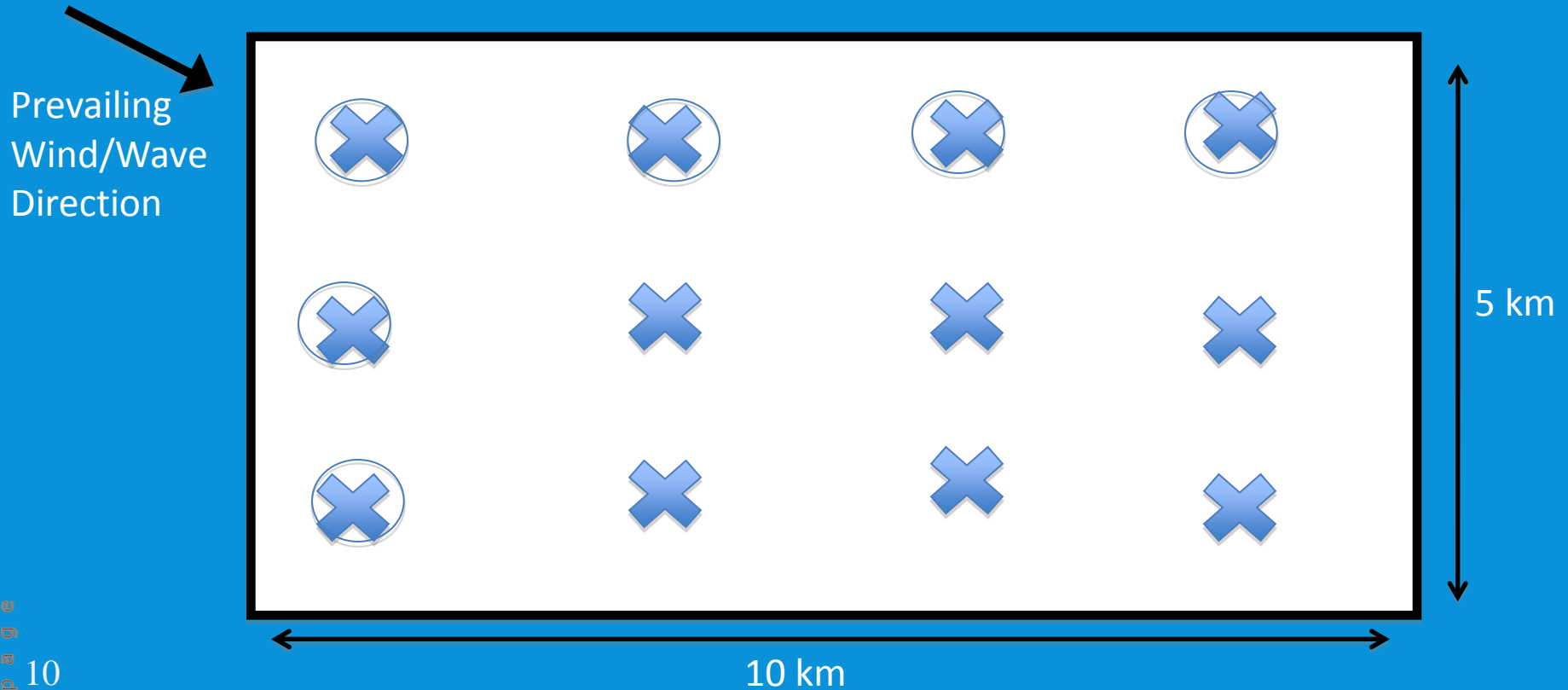
# First solution

Place WECs in between first row and column of Wind turbines



# Second solution

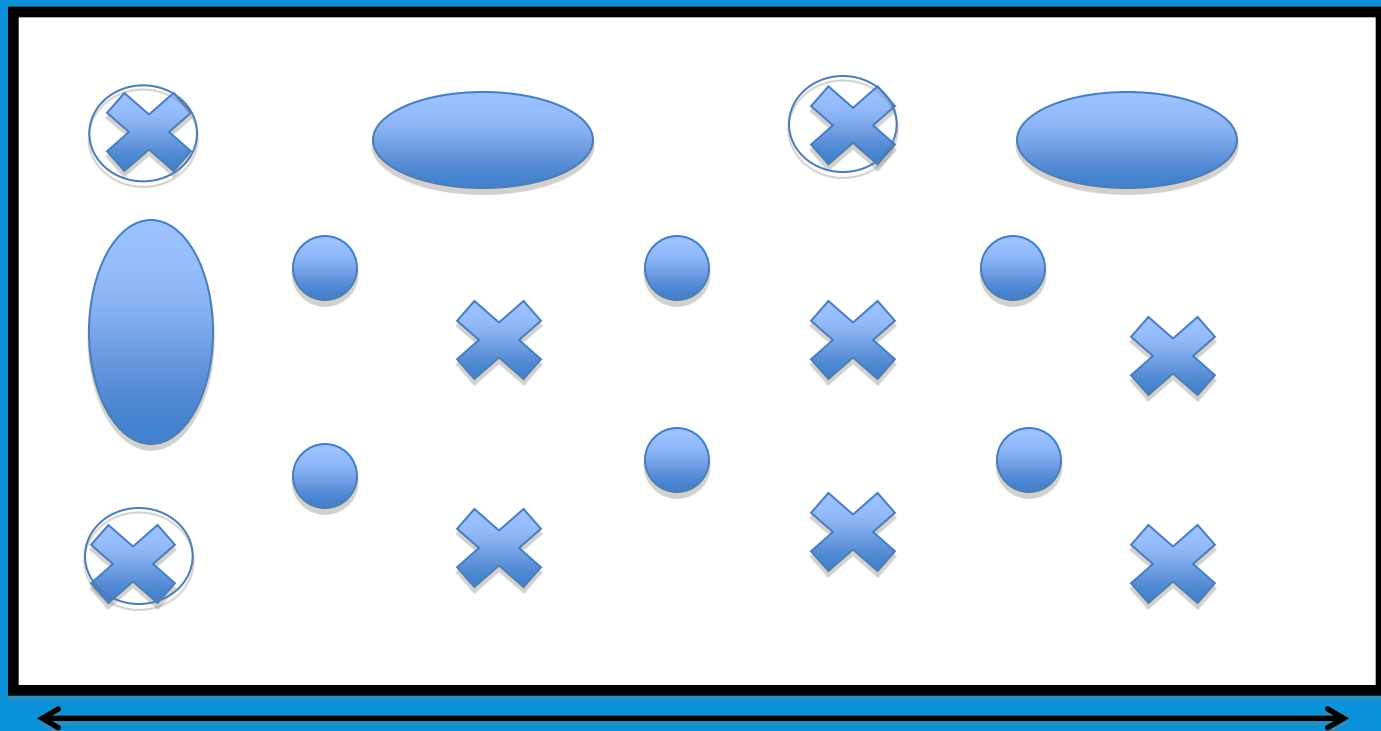
Place bottom-fixed hybrid wave-wind turbines at the perimeter



# Third solution

Place bottom-fixed hybrid wave-wind turbines, remove turbines, add shielding WECs, and small WECs in between

Prevailing  
Wind/Wave  
Direction



5 km

10 km

# Results

	Case Study Solution	1	2	3
Initial Savings	Cable	0,1	0,1	0,1
	Permits	0,05	0,05	0,05
	Support Structure	0	0,05	0,03
Lifetime Savings	O&M	0,2	0,2	0,2
	O&M Weather Window	0,02	0,01	0,03
	Lifespan of Turbines	0,02	0,02	0,02
Shared Costs Total		0,39	0,43	0,43
Loss of WEC Power	Shielding/Turbulence	0	0	0,05
	Wave Climate	0,05	0,05	0,05
Loss Total		0,05	0,05	0,1
Total Savings		0,34	0,38	0,33

- Risk Factor:  $1 < 2 < 3$
- R&D Needed:  $1 < 2 \approx 3$

# Conclusions and future work

- There are strong synergies between offshore wind and wave energy technologies makes a real alternative to combine them;
- There are WEC technologies susceptible for combining considering their actual development status;
- 3 case study have been analysed and it has been found that the third option is the most convenient; and
- Future research is needed to understand in deep this proposals, as well as to face the identified challenges.

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**Thank you**

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