



The Middelgrunden wind case & the upcoming wave energy project

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Middelgrunden Offshore Wind 40MW

Background Hans Chr. Sørensen



Business and university background

- PhD, 40 years with business development

Project management large projects

- Ocean wave energy (Wave Dragon), Tidal current (Tideng)

- Offshore wind (Middelgrunden 40 MW, Samsø 23 MW, Hvidovre 7.2 MW)

Committees

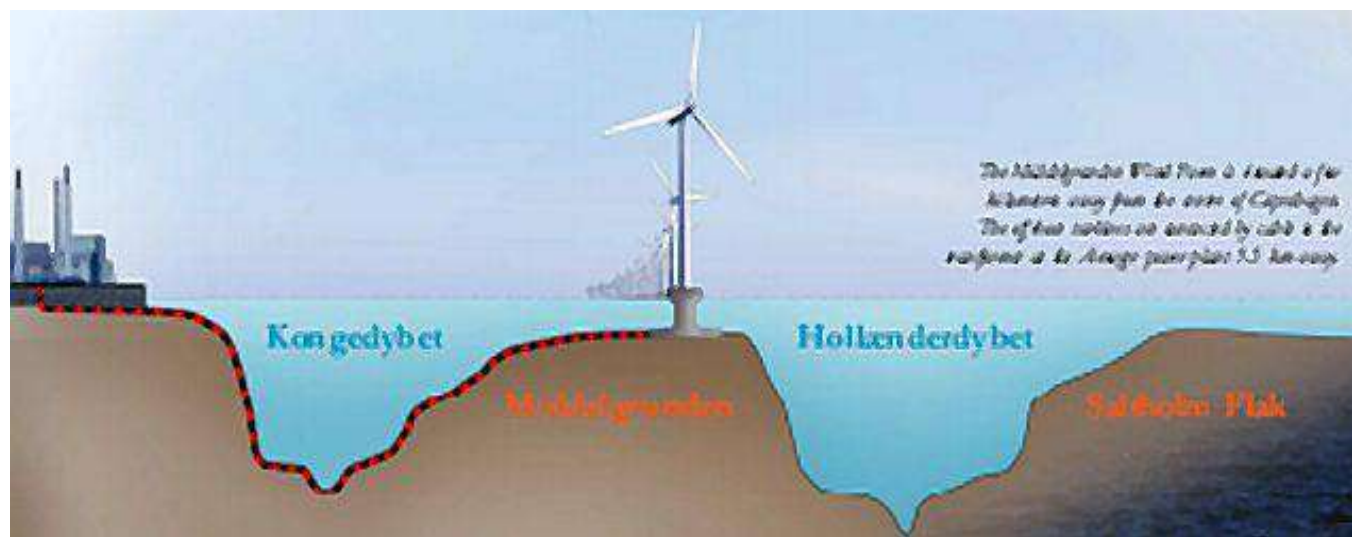
- Danish Wind Turbine Owners Association, board to 2018

- European Ocean Energy Association, vice president to 2011

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Basic information

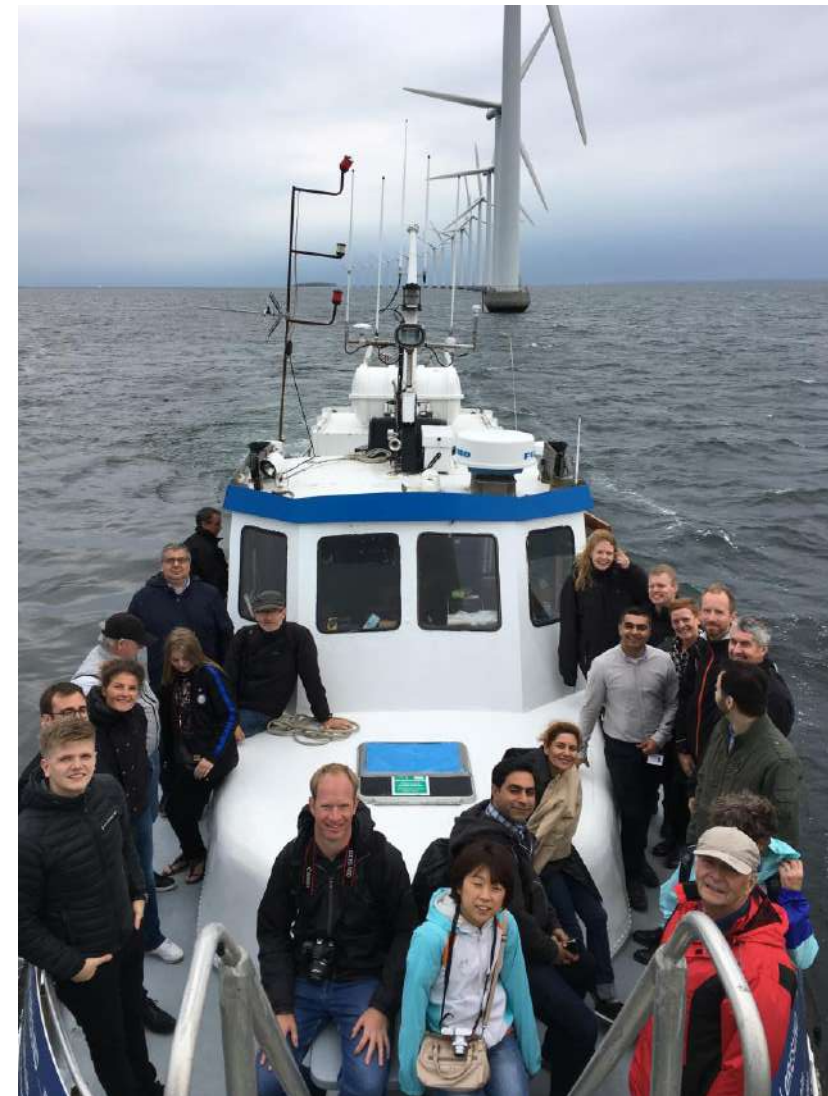
- Situated just 3.5 km's off the harbor in Copenhagen, Denmark.
- Established 2000 as the largest offshore wind farm in the World.
- Delivering 3% of power to Copenhagen.
- Two owners each 50%:
 - ❖ HOFOR (Copenhagen Municipality) and
 - ❖ A Cooperative with 8,550 members



Visiting the windfarm is an old tradition in Denmark

Old tradition

- Owners have been invited to visit their wind farm 3rd Sunday in June (windmill day).
- We started already during the construction phase having 1600 people on the building site.
- At the open day: we have 150-200 people every 2 years on a sailing trip including climbing the turbine.



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How about safety and insurance?

- Only turbines from before around 2003 have several floors and can be climbed without safety line.
- Owners in general - like utilities have no interest in a visiting program- cooperatives have.
- The legal and safety rules for professional service people cannot be followed, - and need not to be followed.
- The UNITED Project is helping to solve these issues more general.

With a large boat for 30 people a stair has been installed to give easy and safe access.



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With a RIB boat the situation is different

- You must enter using the ladder placed outside the foundation.
- The weather situation gives sometimes difficulties with waves and current.

Here a situation where we had to wait 1 hour for an extra person to help



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Also TV is showing interest

- Monday a week in October with the BBC program: *Breaking Dad* running in UK speaking countries for their 4th season.



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Take a virtual visit – by using QR codes from the top of different buildings

- Here the Copenhill incineration plant
- Other possibilities:
 - The Science Museum
 - The Round Tower
 - The Lüder Parking House



Take a tour

<https://www.h2020united.eu/pilots-denmark>

The Upcoming wave energy project

Synergies combining wave, wind and seaweed

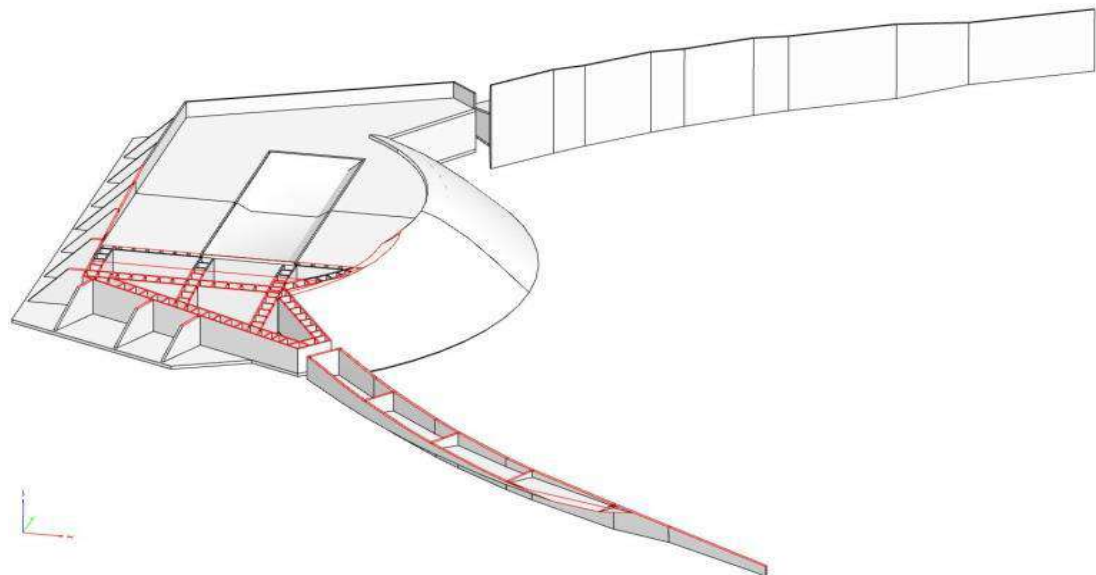


Wave Dragon



- Can bridge production gaps in offshore wind production.
- Can be equipped with wind turbines.
- Can be combined with seaweed production.
- LCOE: 40€/MWh for 24MW units after 100 units.

Wave Dragon as foundation for offshore wind

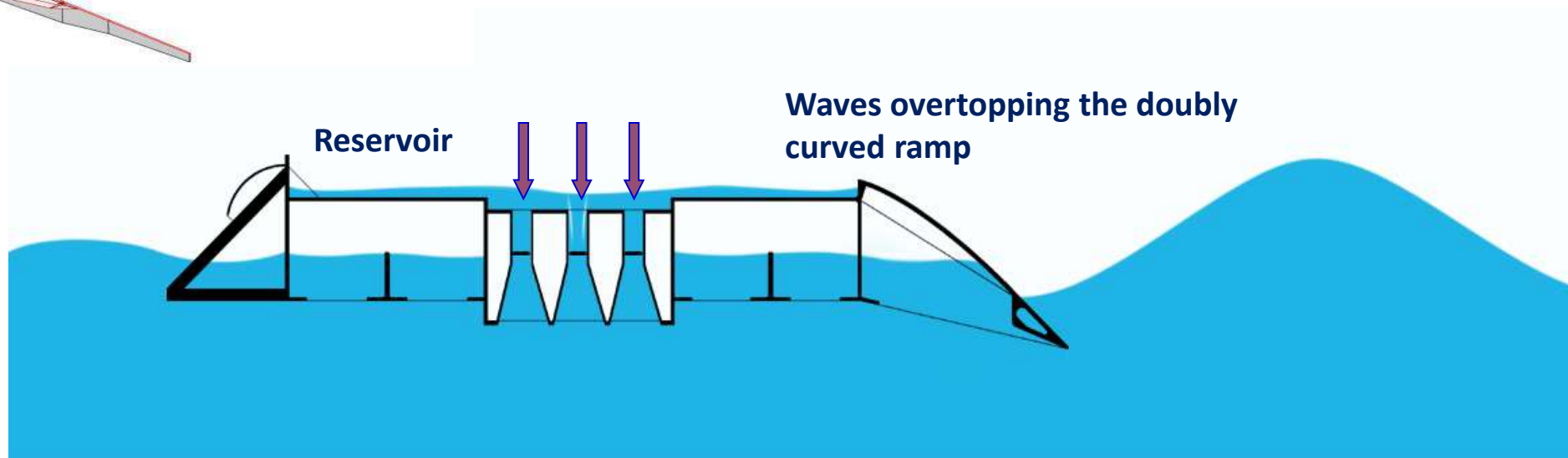


Wave climate - Power - Production

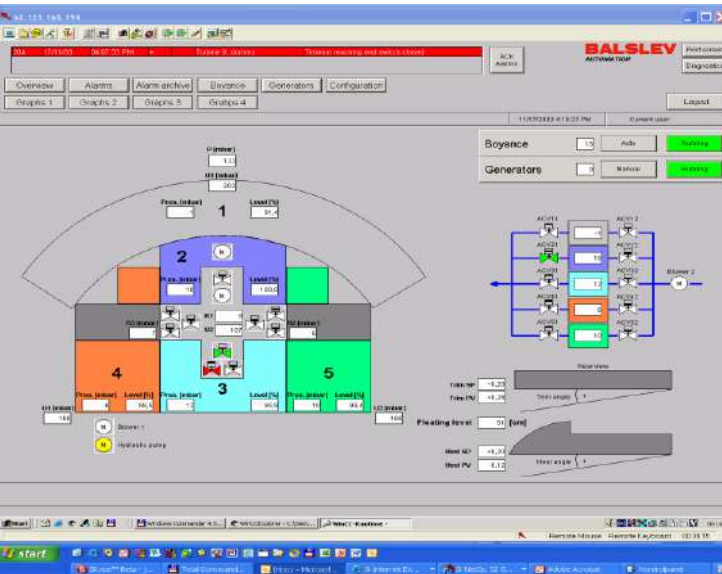
12 kW/m	1.5 MW	4 GWh/y/unit
24 kW/m	4 MW	12 GWh/y/unit
36 kW/m	7 MW	20 GWh/y/unit
48 kW/m	12 MW	35 GWh/y/unit



Source:
www.wavedragon.net



Wave Dragon tested 2003-2009 producing power more than 22,000 hours



Fully operational SCADA system controlling the air chambers



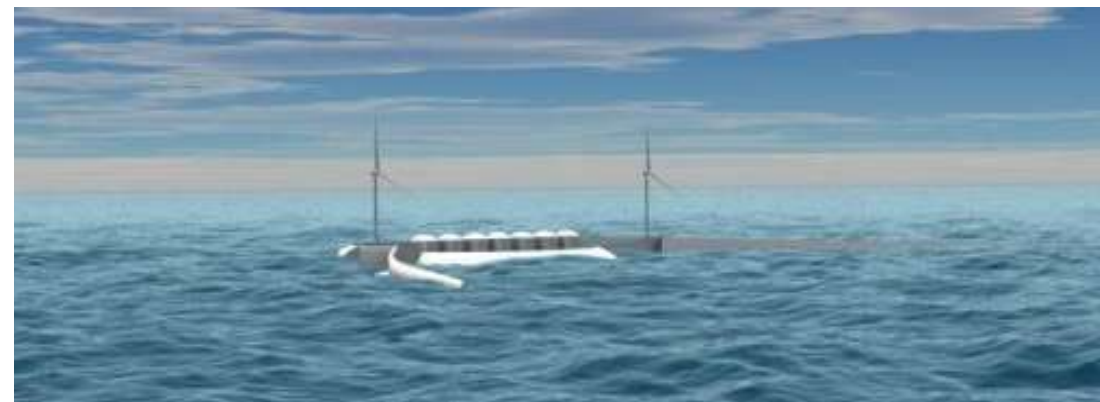
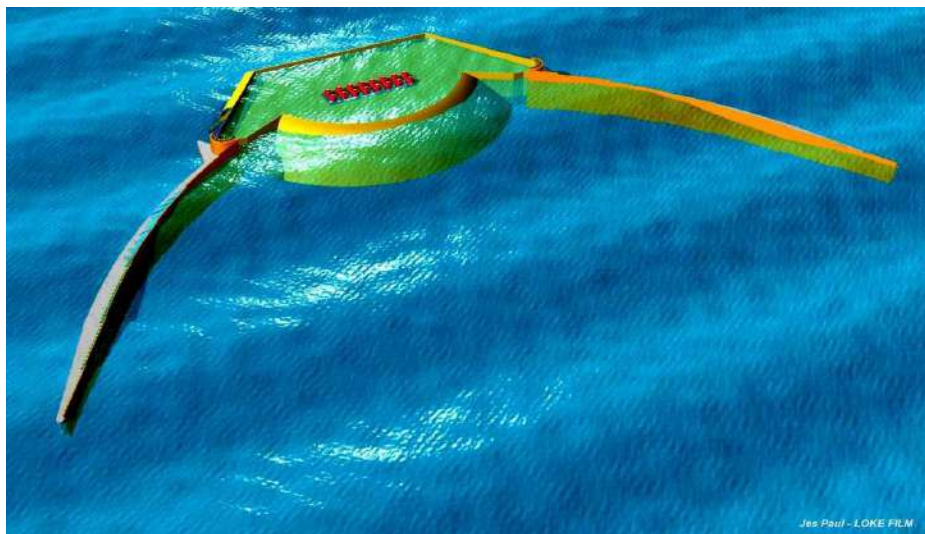
The *Wave Dragon* technology



57 m wide 200 tonnes
Wave Dragon prototype
with 7 turbines deployed
and connected to the grid
in 2003 as Worlds first grid
connected WEC.

www.wavedragon.net

Wave Dragon - multiuse of space - with two wind turbines



The Wave Dragon platform is a reinforced concrete structure well suited as floating foundation for two wind turbines – the difference in natural period is 10 times larger than for the wind turbine

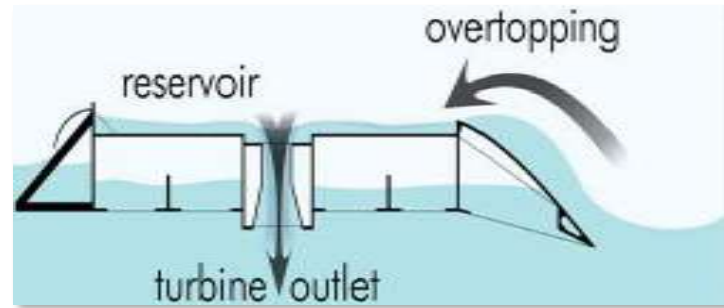
Expected rated power and annual power production of 4 sizes of Wave Dragon + 2 wind turbines, calculated for an annual mean wind speed at 8.5 m/sec (46% capacity factor)

Source: Feasibility and LCA for a Wave Dragon platform with wind turbines, ISOPE 2016

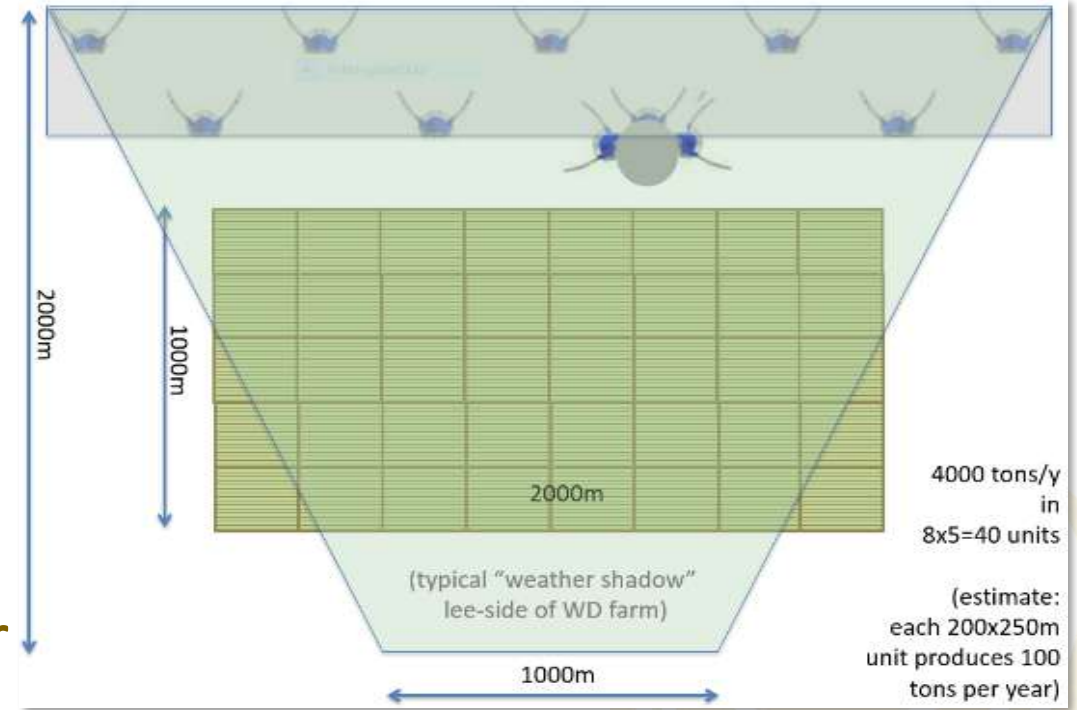
Wave climate (kW/m)	Wave rated power (MW)	Wave Dragon weight (tonnes)	Annual wave production (GWh/y)	Wind rated power (MW)	Annual wind production (GWh/y)
12	1.5	6,500	4	0.85 x 2	6.8
24	4	22,000	12	1.65 x 2	13.2
36	7	33,000	20	2.3 x 2	18.4
48	12	54,000	35	3.0 x 2	24

Plocan, Spain

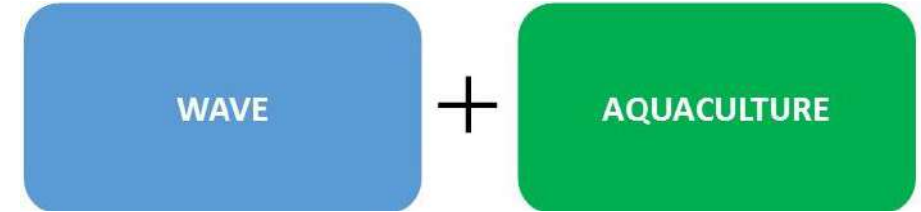
Wave Dragon - multiuse of space – with seaweed production



A Multi use of space example: Combined wave energy converters with a seaweed producing farm – utilizing the calm water behind the Wave Dragon

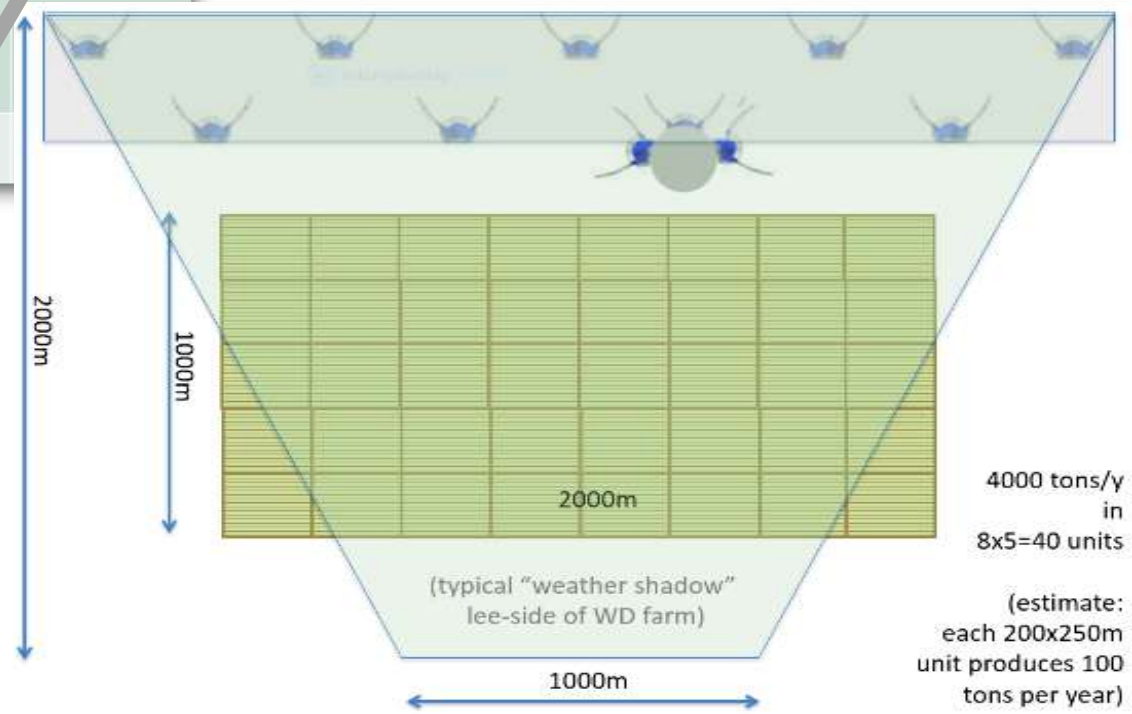


Wave Dragon and Offshore Aquaculture in Wales, UK



Description of projects				
	Pilot project in Wales	1 st Commercial project in Wales	2 nd Commercial project; new location	3 rd commercial project
Wave Dragon	1 WD; 4MW	9 WD; 30MW	9 WD; 30MW	
SES	80 tonnes/y	4000 tonnes /y	4000 tonnes/y	

Key figures	
	3 rd commercial project
Wave Dragon	45WD@4MW = 180MW
SES	20 000 tonnes/y
Pay back	4.3 years
IRR	24.4%

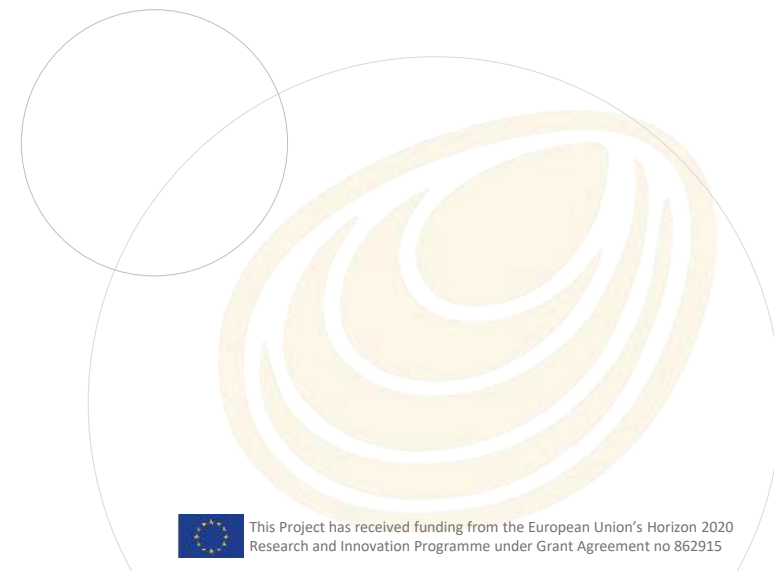


The Perspectives of Multi-Use Platforms

- Plenty of opportunities
- Thank you for your attention

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