



ETIPOCEAN

European Technology & Innovation Platform for Ocean Energy

Funding Ocean Energy Technology Development Using Pre-Commercial Procurement and Stage-Gate Development Processes

5 October 2017 – ETIP Ocean

Agenda

Moderator: Kasparas Kemeklis, Ocean Energy Europe, ETIP Ocean

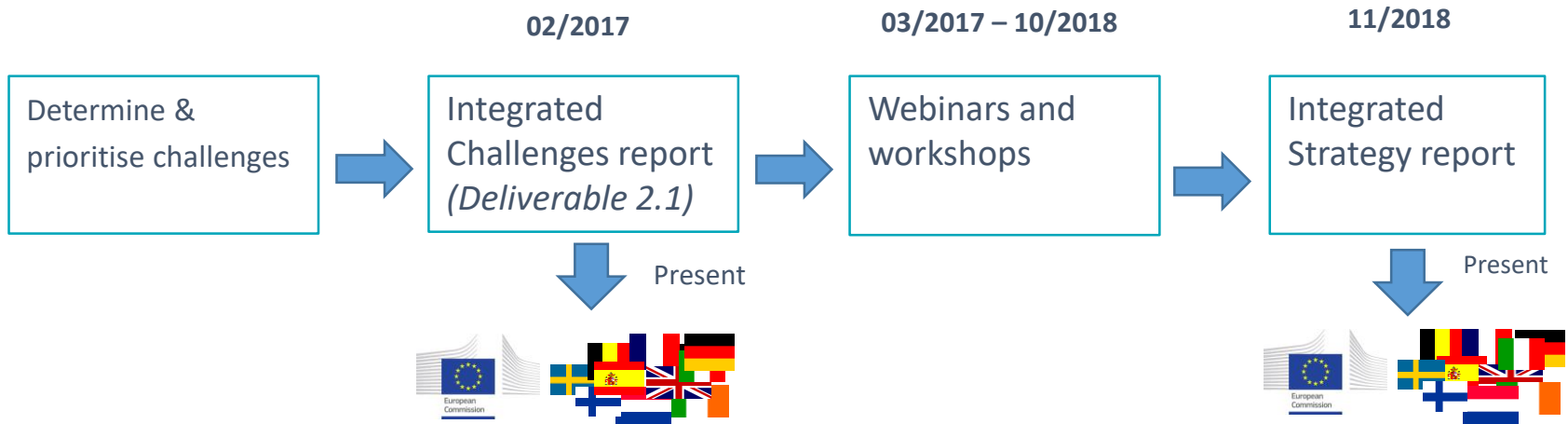
Presentations:

Wave Energy Scotland - **Tim Hurst and David Langston**

CorPower Ocean - **Patrik Moller**

Q&A session with the audience

ETIP Ocean, objectives and timeline



Presentations and summary report will be available on www.etipocean.eu

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ETIP Ocean workshop at OEE2017

Date: 26th October 2017

🕒 26/10/2017



Seminar at OEE2017 Conference: Wave Power Take Off - Have we cracked it?!

25 October 2017

🕒 25/10/2017

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ETIP Ocean

Funding Ocean Energy Technology Development Using
Pre-Commercial Procurement and Stage-Gate
Development Processes

5th October 2017



Overview

- Intro to WES
- Overview of PCP
- Using PCP for the wave energy development



Background



- Collapse of wave energy companies in 2014/2015
- Scot Gov want to encourage development of wave energy sector
- Development of new technology for market that doesn't exist yet
- Provide good access to funding for small companies
- Provide small companies with improved capabilities
- Encourage collaboration between actors
- Up to 100% funding until private investors return
- WES formed in late December 2014

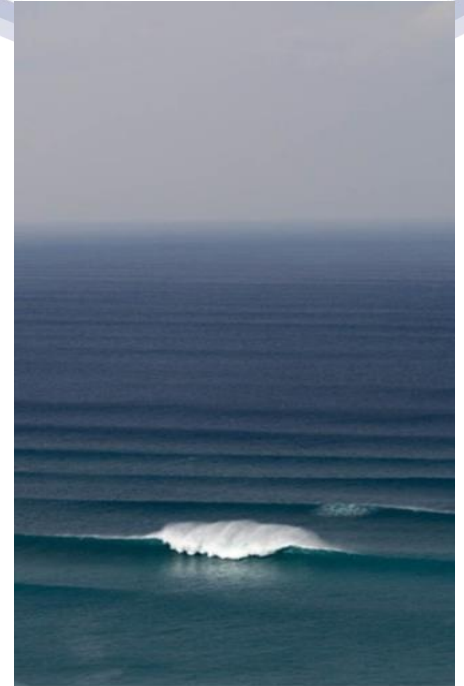
How we operate

WES Activities

- Innovation Calls
- Strategic Projects
- Industry engagement and collaboration

WES Funding

- Up to 100% funding for R&D services
- Pre-Commercial Procurement (PCP)
- Competitive, stage-gated programmes



Our aims and objectives

Develop cost competitive wave energy technology in Scotland
A Research, Development and Innovation Programme that is:

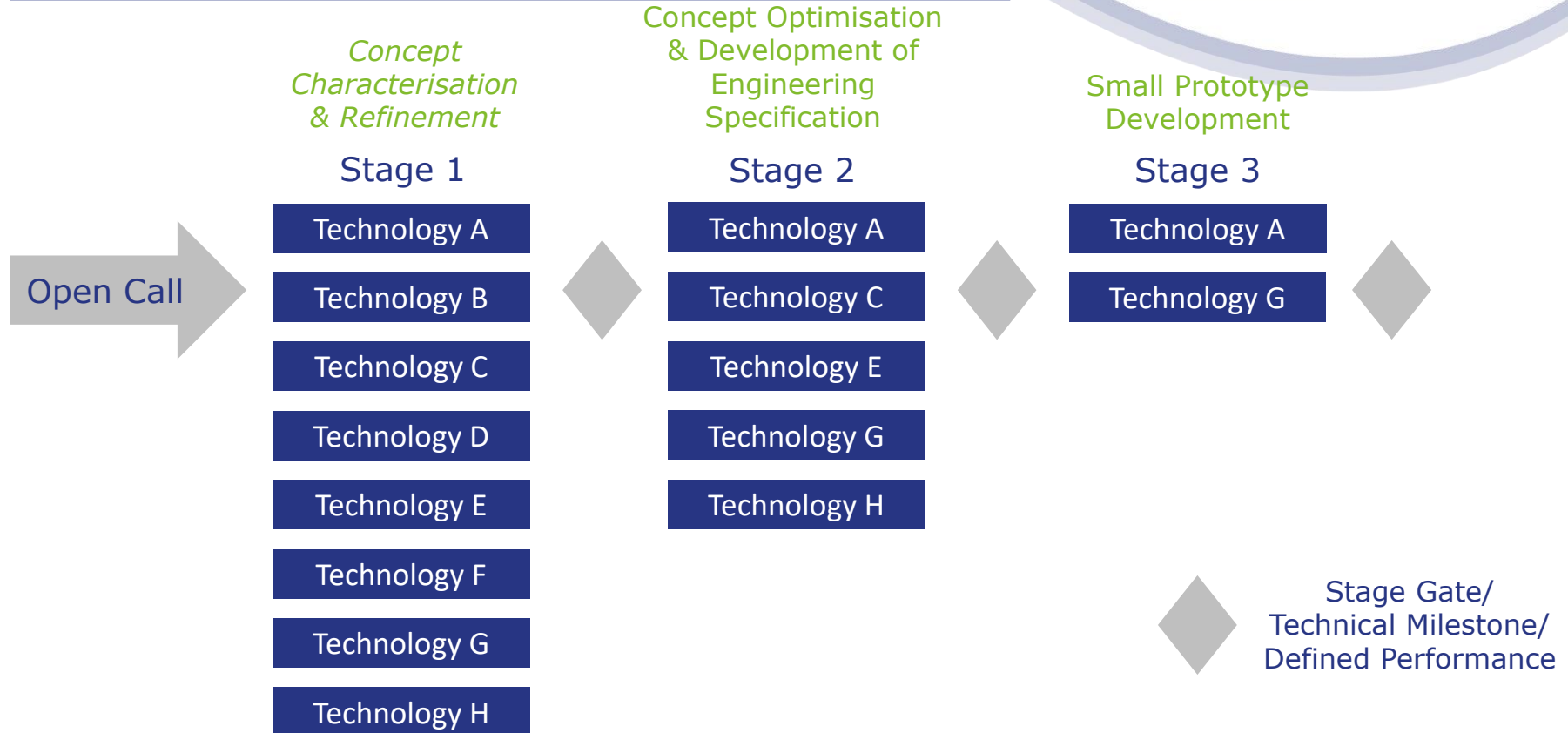
- Supporting the development of wave devices, key sub-systems and component technology
- Capturing experience from previous technology projects
- Drawing on knowledge from other sectors through effective knowledge exchange
- Fostering collaboration between industry and academia
- Provide Continuity of funding
- Ensuring commercial focus – Advisory Group



What is PCP?

- An approach to public procurement of R&D services
- Public sector tool to stimulate innovation
- Steer development of new solutions directly towards its needs
- Buy R&D services from several competing suppliers
- Act as a "seal of approval" for innovative companies

Stage Gate Process



Open Calls and Stage Gates



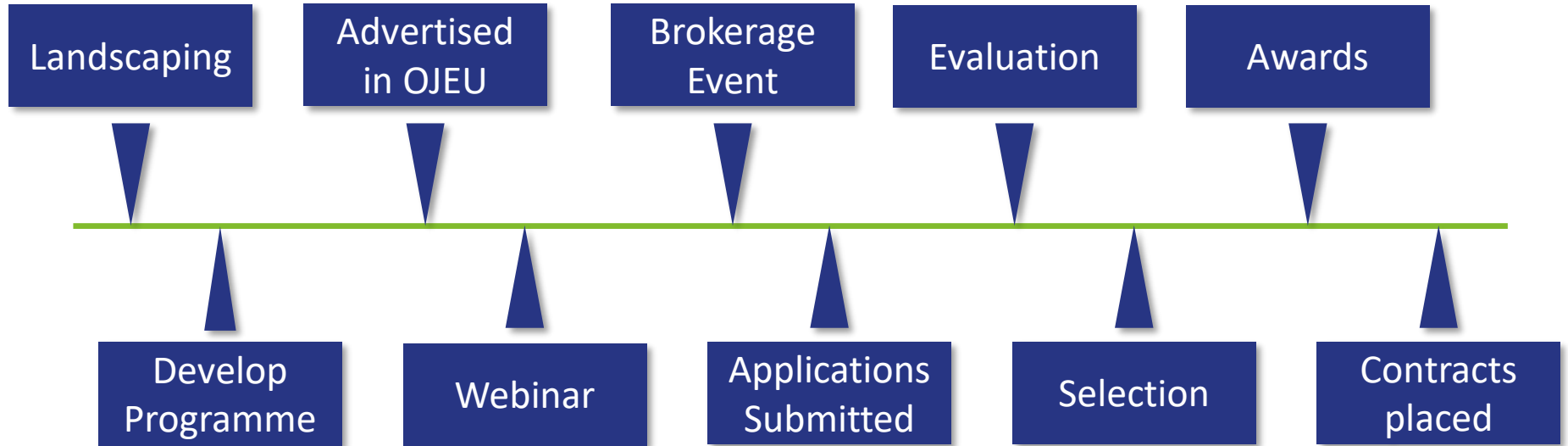
- PCP is exempted from EU Procurement Directives
- However WES run Open Calls and Stage Gates in accordance with HIE Procurement rules
- Maintain general procurement principles:
 - equality of treatment
 - transparency
 - mutual recognition
 - proportionality

What PCP provides

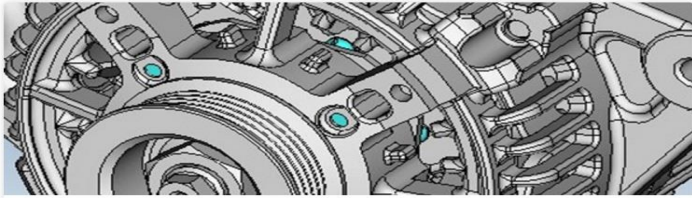


- Can provide up to 100% funding
- Provides good access to funding for small companies
- Provide small companies with improved capabilities
- Supports development of the best technology from across Europe
- Encourages collaboration between actors
- Development of technology for market that doesn't yet exist

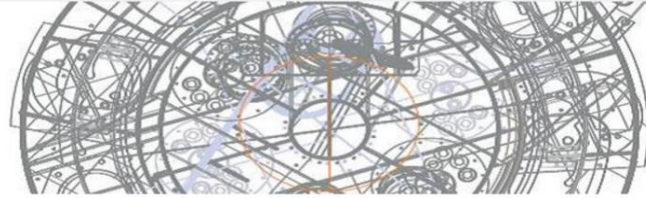
Programme Formation



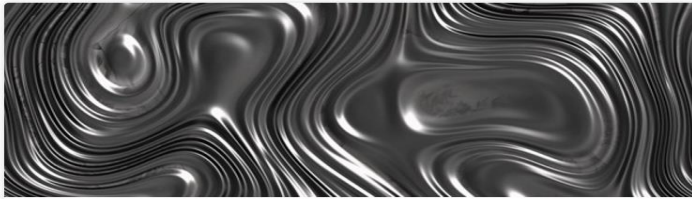
WES Programmes



Power Take-Off



Novel Wave Energy Converter

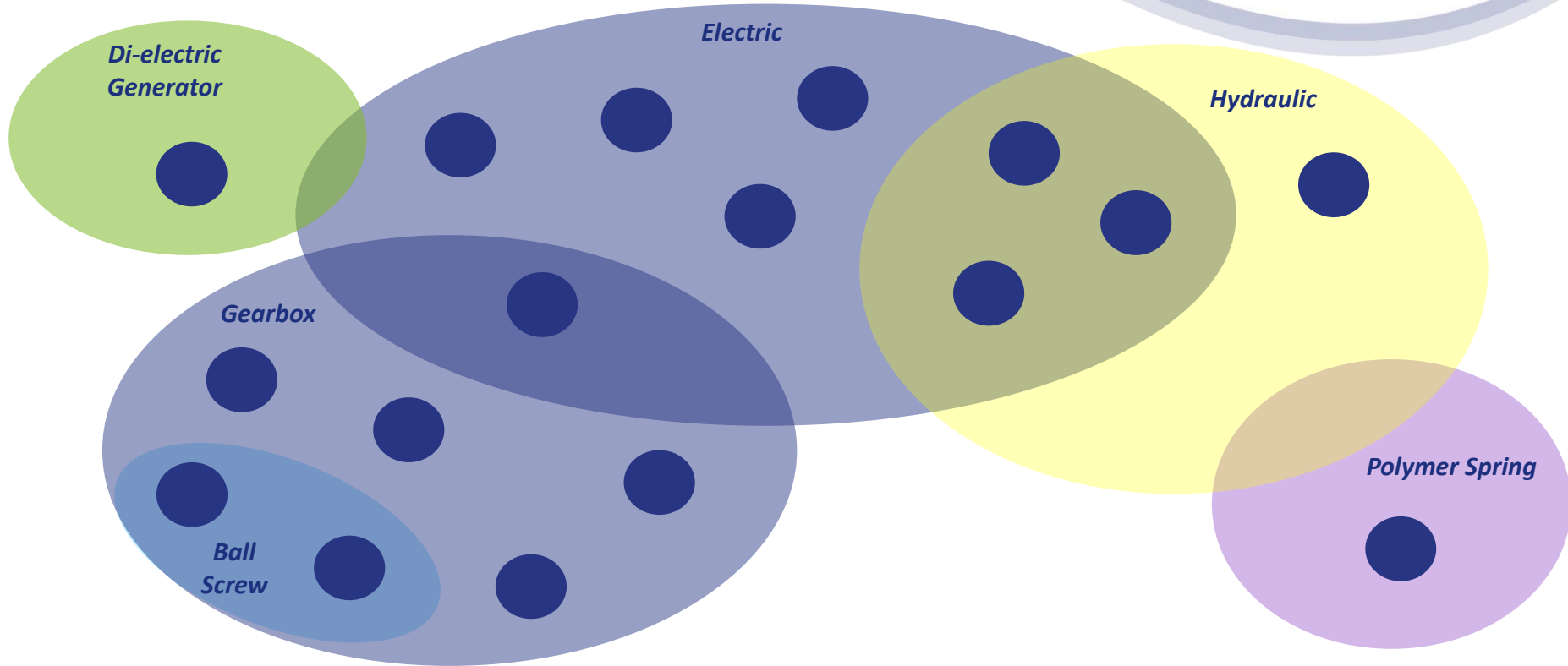


**Structural Materials and
Manufacturing Processes**

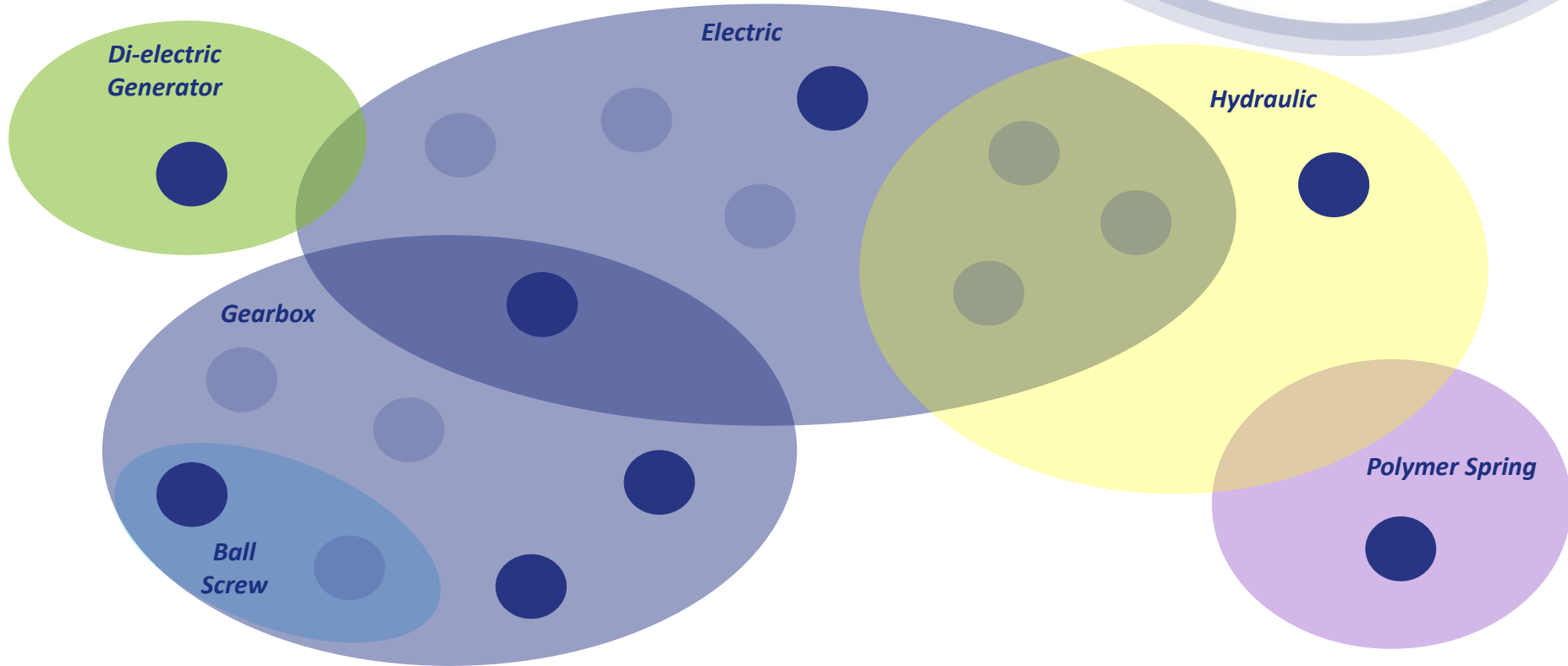


Control Systems

Power Take-Offs



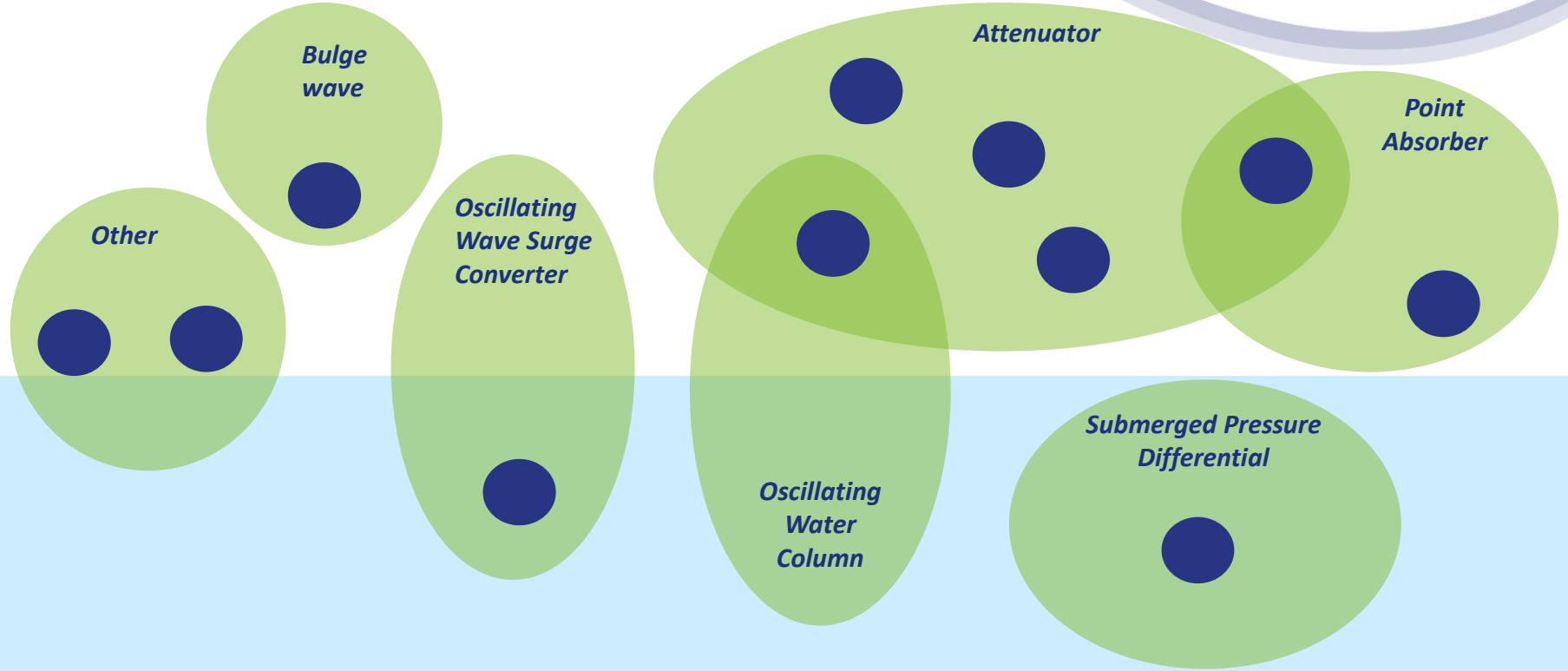
Power Take-Offs



WEC Types before Stage Gate

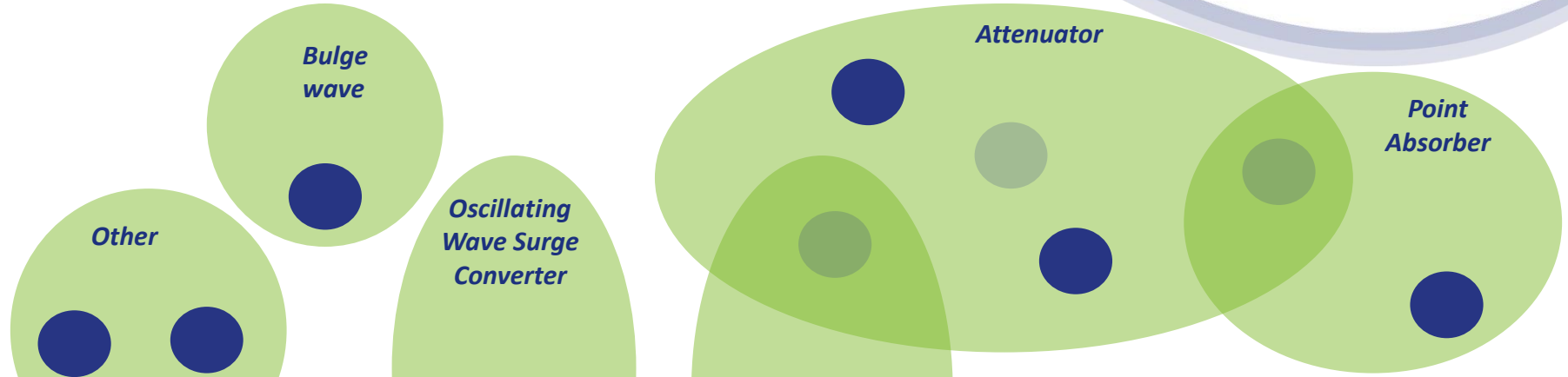
Floating

Bottom mounted

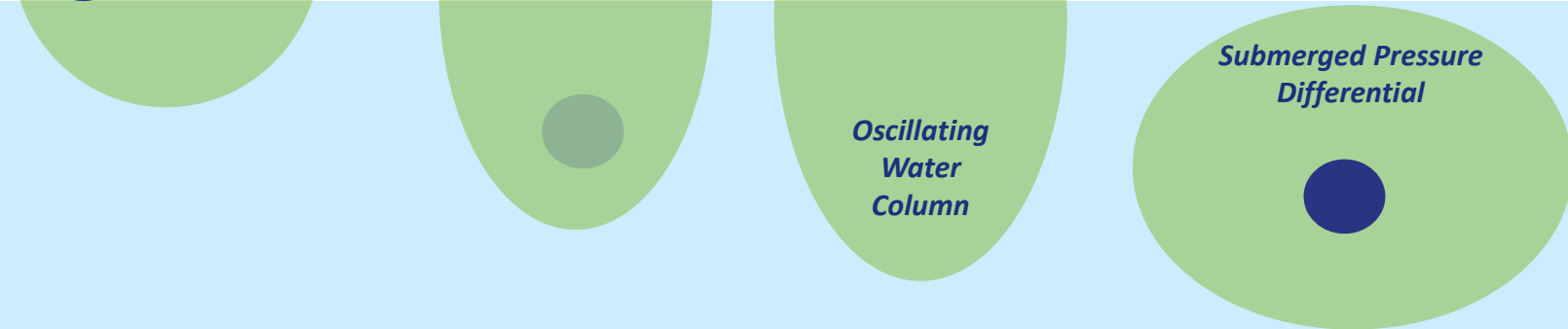


WEC Types before Stage Gate

Floating



Bottom mounted



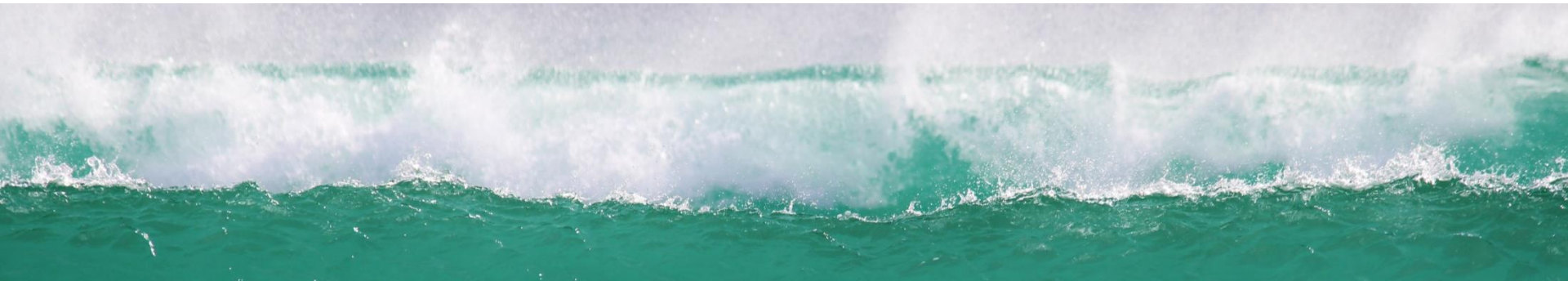
WES key facts and figures

- 61 R&D&I Contracts (incl. recent Control Systems)
- 3 Stage Gates completed (next 3 within 6 months)
- 175 Organisations involved with WES
(With lead contractors from Ireland, Belgium, Spain, Italy, Sweden)
- £25.3m spent/committed on programmes
(incl. landscaping/know how)
- ~2,000 deliverables so far



Considerations

- Requires “intelligent customer” to operate PCP
- WES reviews/approves deliverable prior to Milestone payments
- WES employs 11 Engineers to carry programme development and subsequent contract management



Thank You



Stage gate development & techno-economic metrics



ETIP webinar

October 5th 2017

Patrik Möller, CEO

Resonant Wave Energy Converters



Phase control



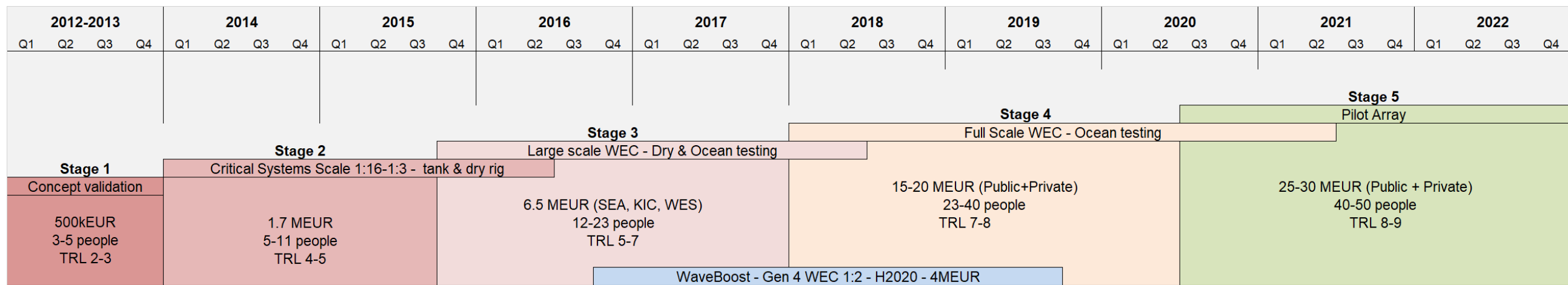
Small & light



*Effective install
and O&M*



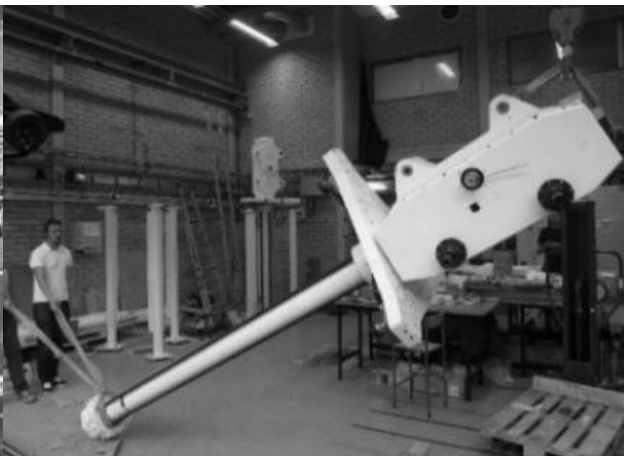
Structured product verification in five Stages



Product verification in 5 stages according to IEA-OES / equimar best practice.



Scale 1:30



Scale 1:3



Scale 1:2



Scale 1:2

Stage 2 tank tests - Ecole Centrale Nantes



Tested survivability in most extreme conditions



WEC Simulation Tool

Output data

V_rack max (m/s)	3.11	P_mech mean (kW)	207.18	P_mech max (kW)	5635.80
D_rack max (m)	3.53	P_trans mean (kW)	185.51	P_trans max (kW)	6175.72
V_FW mean (rpm)	1780.11	P_gen_mech mean (kW)	182.89	P_gen_mech max (kW)	509.32
V_rack mean (m/s)	1.08	P_elec mean (kW)	176.39	P_elec max (kW)	390.91
D_rack mean (m)	1.88	P_fric mean (kW)	6.98	% friction force	3.76
V_FW mean (rpm)	554.44	P_end stop mean (kW)	7.68	F_trans max (kN)	687.54

Simulation Settings

Simulation Time: 300 Ready

Buoy and Wave Data

Wave data: Regular Waves Irregular Waves

Wave period (Tp): 13
Wave Height (Hs): 3.5
Water depth (m): 50

Buoy data: Buoy HA1

Cd (surge): 0.95
Cd (heave): 0.35
Buoy Mass (kg): 30000
Buoy period (s): 4.3
Scale buoy: 1

Scaled data:
Eq point dis (m³): 261.45
Buoy volume (m³): 403.33
Buoy period (s): 4.30
Buoy Mass (kg): 30000.00
F pre (N): 2128474.8
P_start (bar): 80.56
Buoy diameter (m): 8.40

Controller Settings

Wave spring: C3 C4
C3 Threshold: 0.5
Mn unlatch period (s): 0.5
Linear damping coefficient (kg/s): 60000

Rack Mass (kg)	5000	Gear ratio	6.75	Rack dyn friction	6000
PTO	20000	Pinion radius (m)	0.1125	P fraction	1
Flywheel inertia (kgm²)	85	Cylinder Diameter (m)	0.585	End stop Amplitude (m)	3.5
Generator inertia (kgm²)	3.98	V0_Large	14		
Latch disk+gear (kgm²)	6	V0_small	0.4		

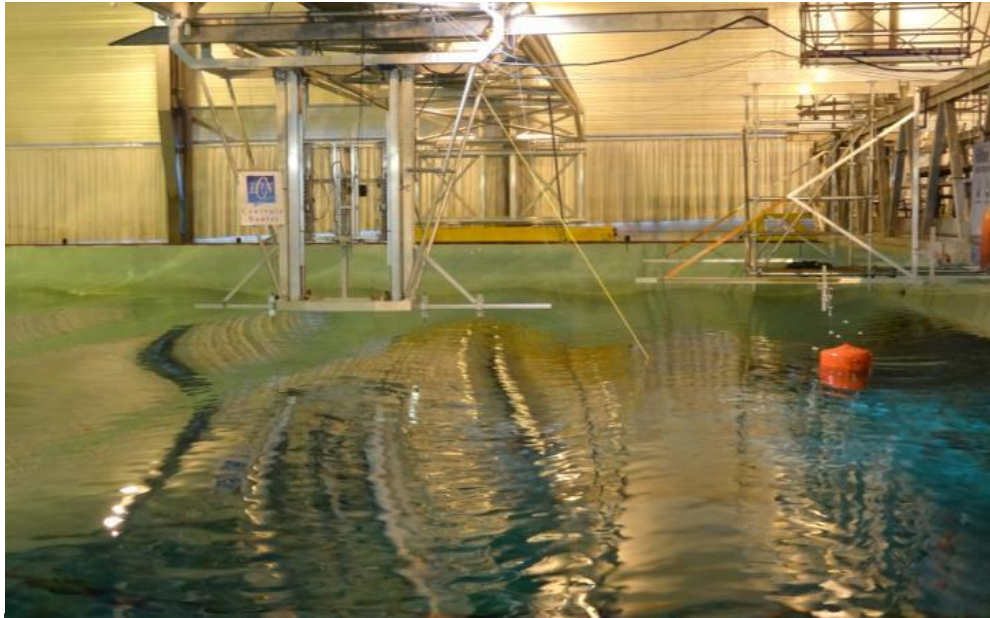
Update PTO

Surf Elev (blue), x_buoy (green)

V_rack (blue), D_rack (green), V_FW1 (red), V_FW2 (cyan)

P_gen1 (blue), P_gen2 (green)

Verified actual power and loads vs numerical models



Output data

V_rack max (m/s)	3.11	P_mech mean (kW)	267.18	P_mech max (kW)	5635.80
Drack max (m)	3.53	P_trans mean (kW)	185.51	P_trans max (kW)	6175.72
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Simulation Settings

Simulation Time: 300 Ready

Buoy and Wave Data

Wave data: Regular Waves Irregular Waves

Wave period (Tp): 13
Wave Height (Hs): 3.5
Water depth (m): 50

Controller Settings

Wave spring: C3 C4
C3 Threshold: 0.5
Min unlatch period (s): 0.5

Linear damping coefficient (kg/s): 60000

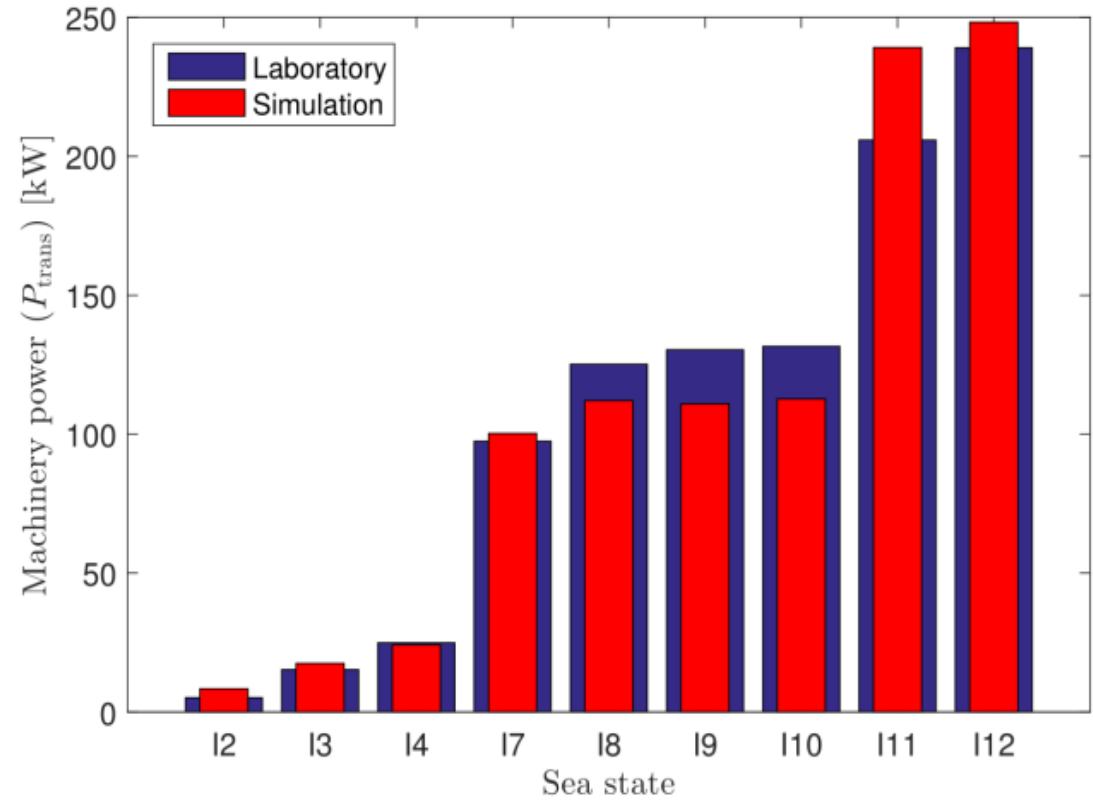
Rack and PTO Settings

Rack Mass (kg): 5000
PTO: 20000
Flywheel inertia (kgm²): 85
Generator inertia (kgm²): 3.98
Latch disk+gear (kgm²): 6

Gear ratio: 6.75
Pinion radius (m): 0.1125
Cylinder Diameter (m): 0.585
V0_Large: 14
V0_small: 0.4

Rack dyn friction: 6000
P fraction: 1
End stop Amplitude (m): 3.5

Buttons: Start Simulation, Stop Simulation, Save Simulation Data as mat file, Save Simulation Data as Excel file, Plot motion curves, Plot force curves, Plot power curves



Stage 2 cascade gear – verified with automotive manufacturing partner

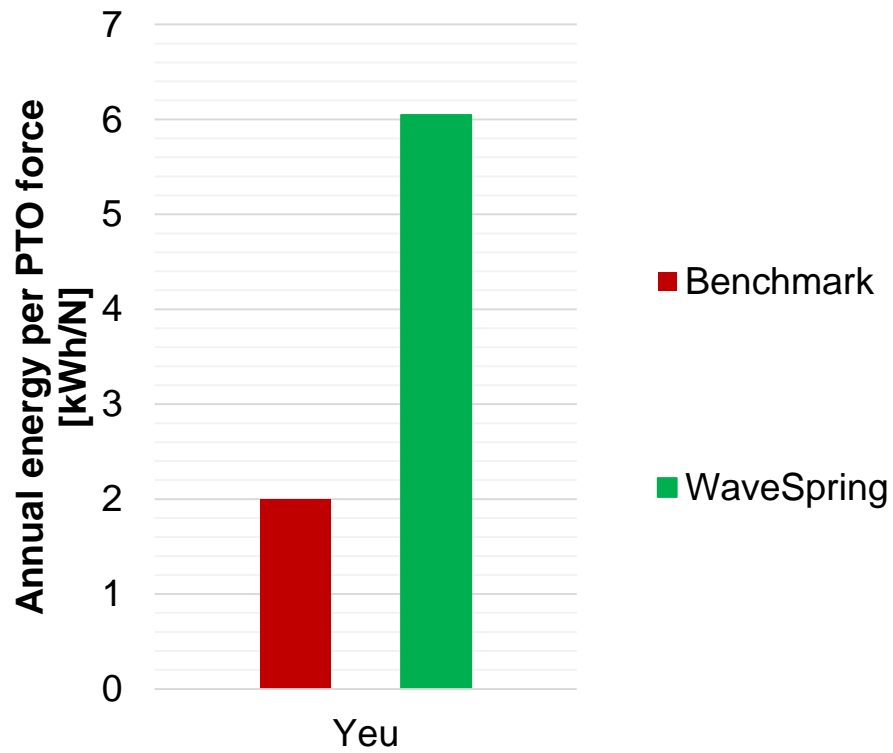


PTO dry test rig - grid connected hardware-in-the-loop



3 times

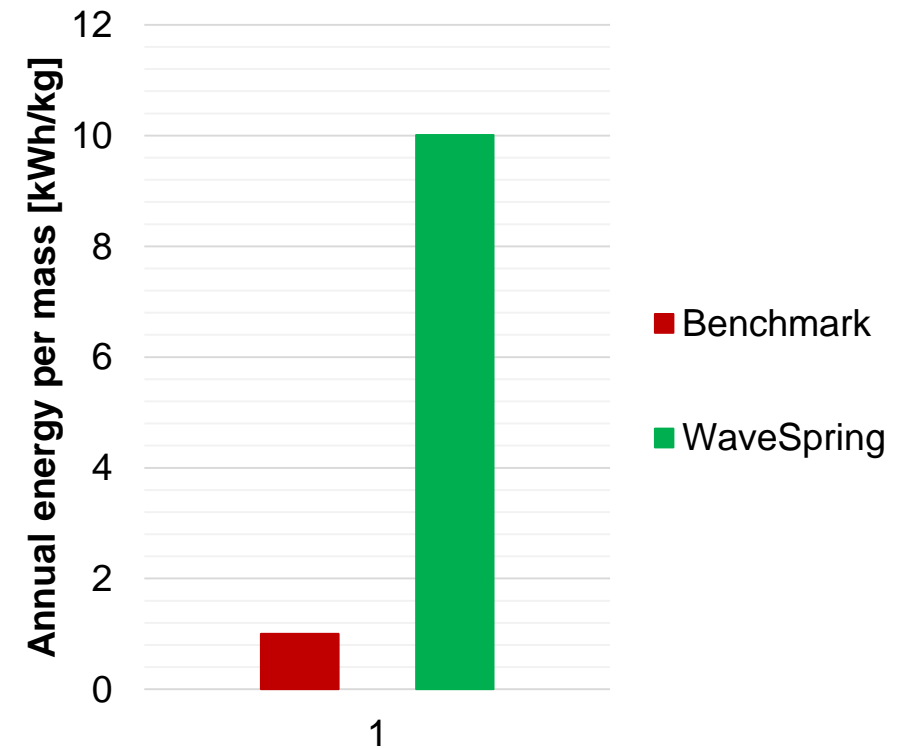
more energy per PTO force



Full scale numbers

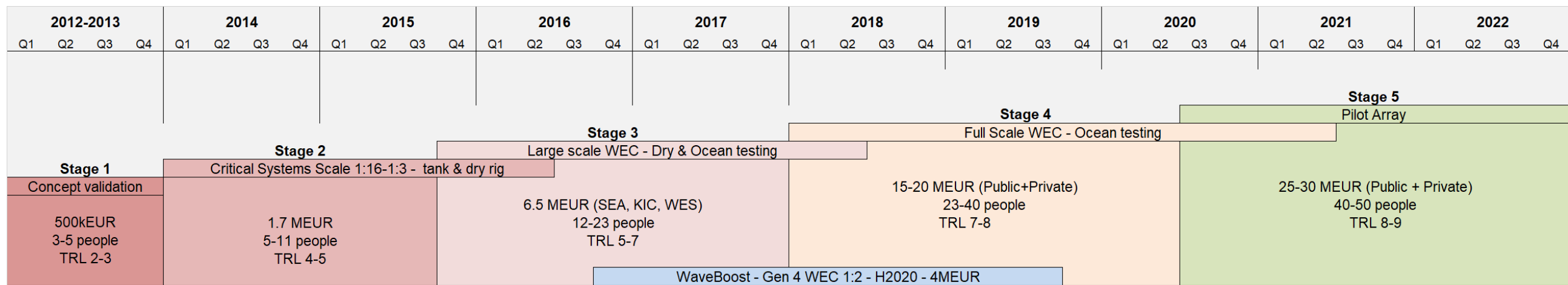
> 5 times

more energy per ton



Benchmark: A. Babarit, J. Hals, M.J. Muliawan, A. Kurniawan, T. Moan, J. Krokstad: *Numerical benchmarking study of a selection of wave energy converters*, Renewable Energy 41 (2012) 44-63

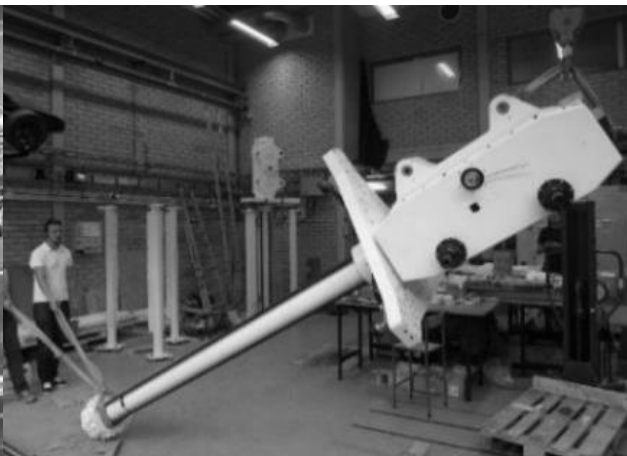
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Product verification in 5 stages according to IEA-OES / equimar best practice.



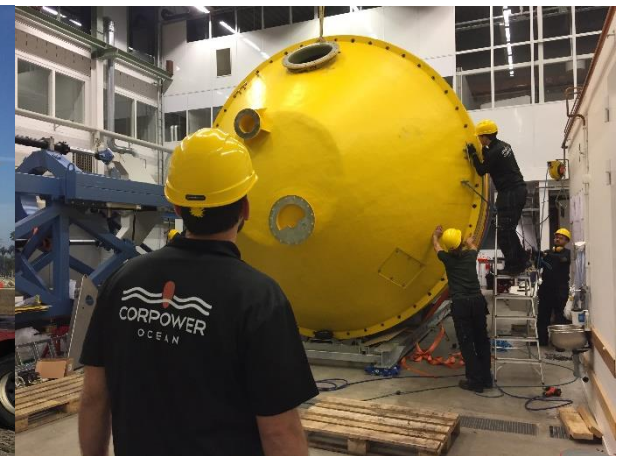
Scale 1:30



Scale 1:3

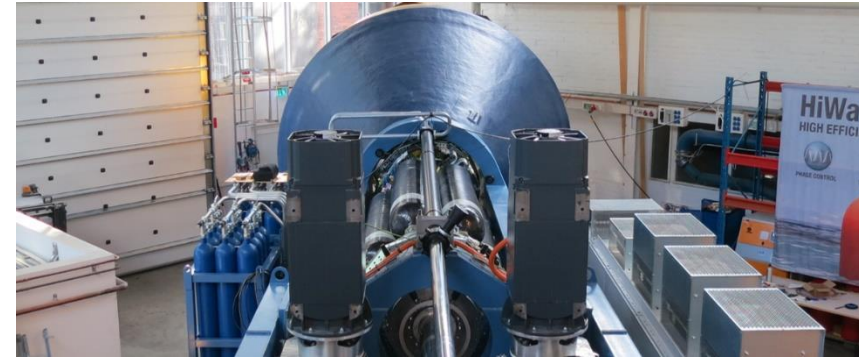


Scale 1:2



Scale 1:2

- Dry rig test program in Stockholm – H1 2017
 - Verification and debugging of all defined functions.
 - De-risking by full range storm loading on-land



- Ocean test program at EMEC, Orkney - fall 2017. Final verification - > Stage 4



Stage 3 composite buoy

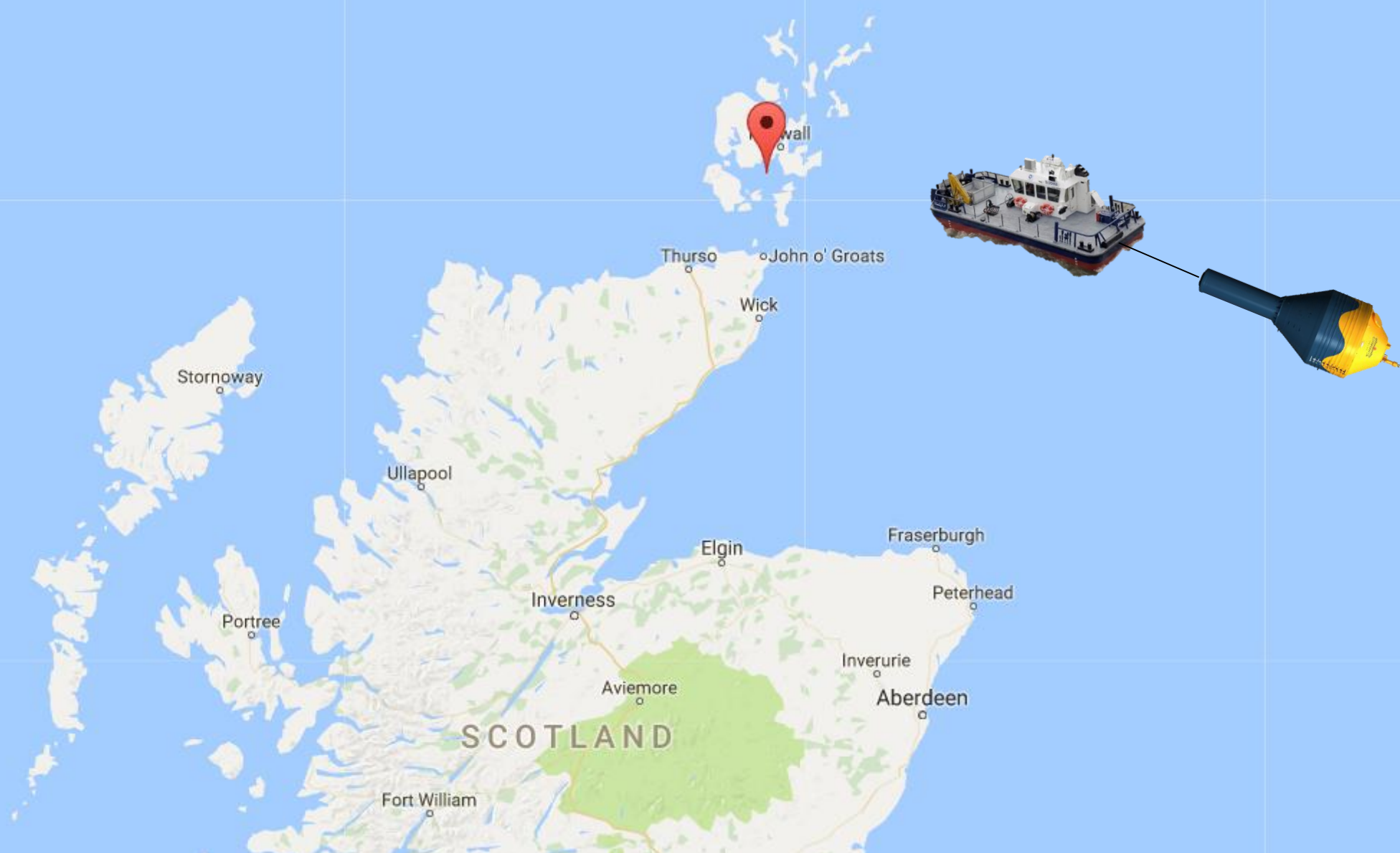


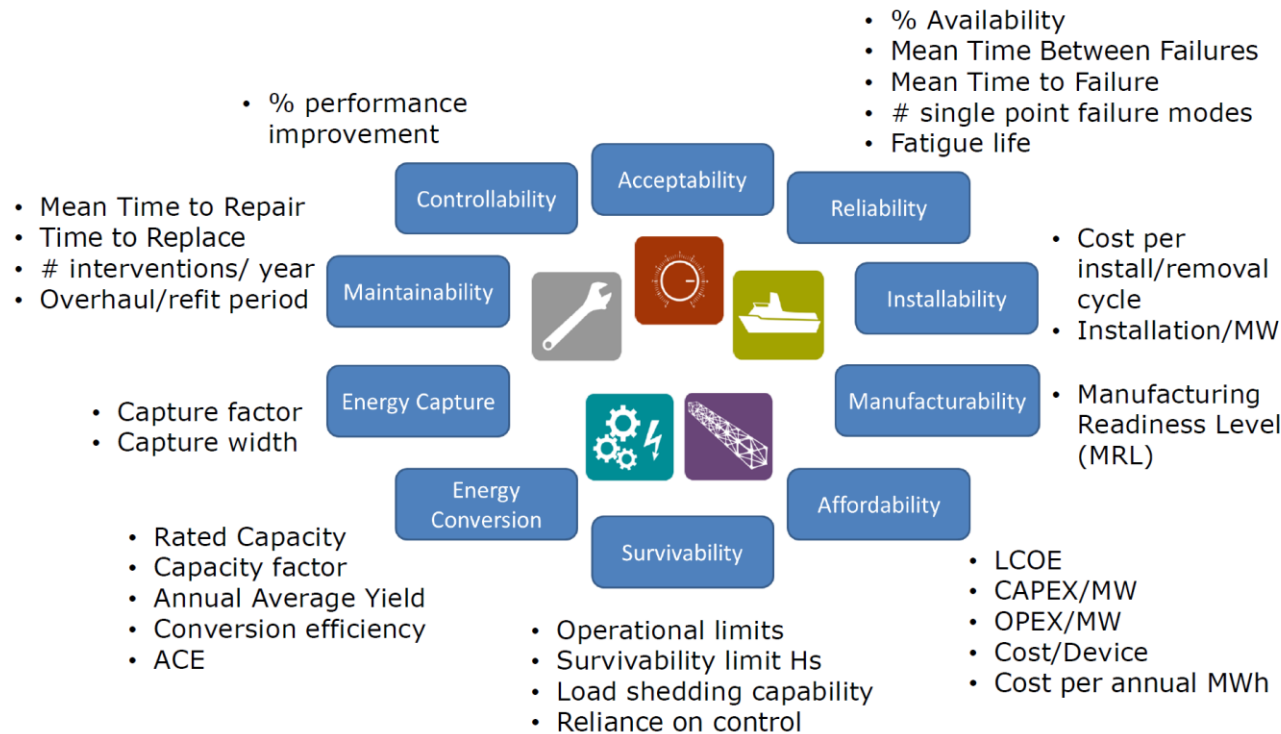


Dry testing of complete WEC - Hardware-In-the-Loop



EMEC Scapa flow deployment - Orkney during fall of 2017





Reliability metric:

A. System passing 2 week non-interrupt dry test

Survivability metric:

B. Demonstrate survivability in all Scapa flow sea states, with load shedding function -> peak loads < 1.6x submersed load.

Performance metrics:

A. AEP / ton > 8 MWh / ton (s1:1)

B. AEP / PTO force > 5 MWh / kN (s1:1)

C. +300% AEP by WaveSpring phase control

Calibration metrics:

D. Dry test Power matrix within +/- 20% of simulated (s1:2)

E. Wet test Power matrix within +/- 20% of dry matrix (s1:2)

Affordability metric:

D. LCOE > 150 GBP / MWh after 200MW installed



High Efficiency

Wave Energy