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MARINE CONFERENCE, EXHIBITION & DINNER

12 & 13 SEPTEMBER 2017 INVERNESS

areg
Aberdeen Renewable Energy Group

Crown Estate Scotland
Oighreachd a' Chrùin Alba

OPENHYDRO
NAVAL ENERGIES

Wave and Tidal Energy: Building an Industry

Jenny Hogan, Deputy Chief Executive, Scottish Renewables

Audrey MacIver, Director of Energy and Low Carbon, Highlands and Islands Enterprise

Robert East, UK Development Manager, OpenHydro

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OPENHYDRO
NAVAL ENERGIES

Wave Energy: The Story So Far

Chair:

Tim Hurst

Wave Energy Scotland

David Langston

Programme Manager

Wave Energy Scotland

SR Marine Conference Inverness

Programme Update

12th September 2017

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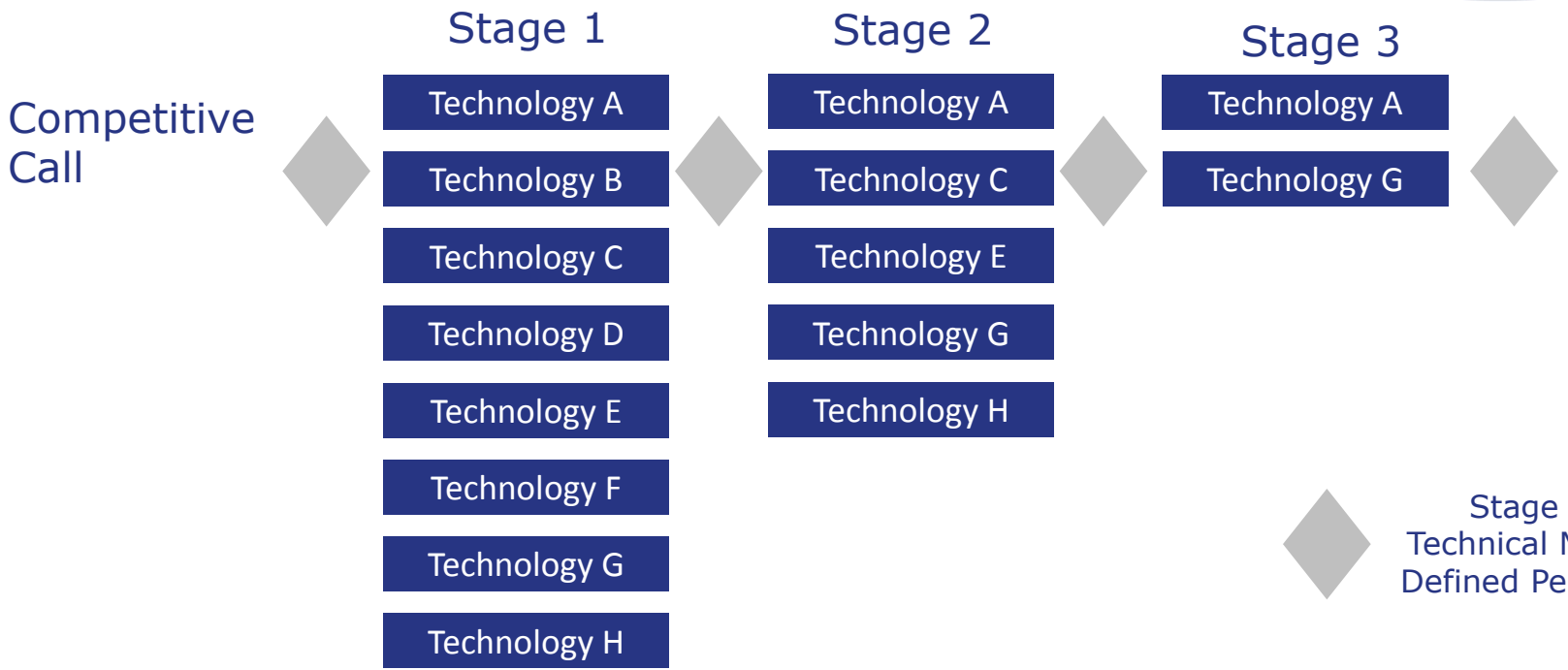
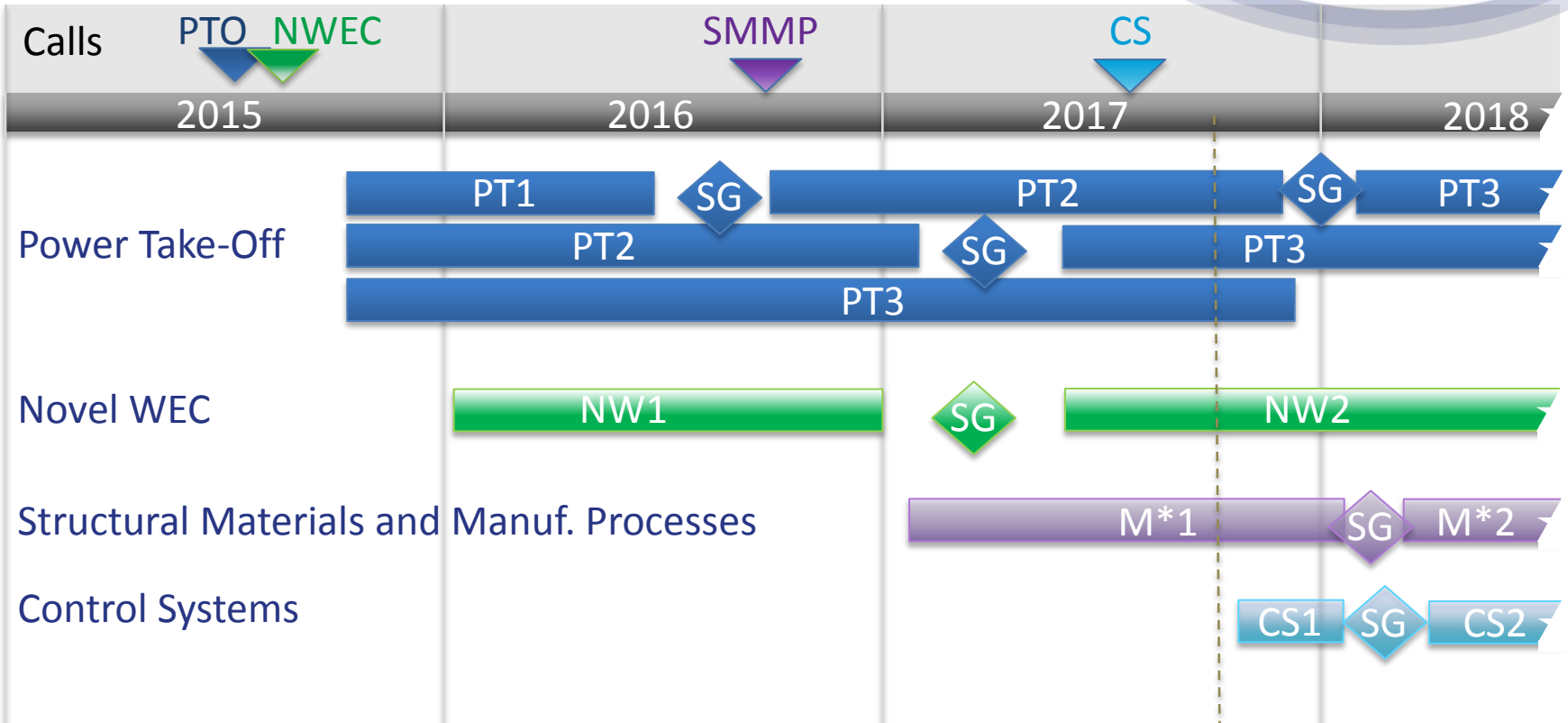
Key facts and figures

- Contracts for R&D&I services and not a grant
- Pre-Commercial Procurement (PCP)
- Up to 100% of project costs
- 61 R&D&I Contracts (incl. Control Systems)
- £25.3m spent/committed on programme
  (incl. landscaping/know how)
- 163 Companies

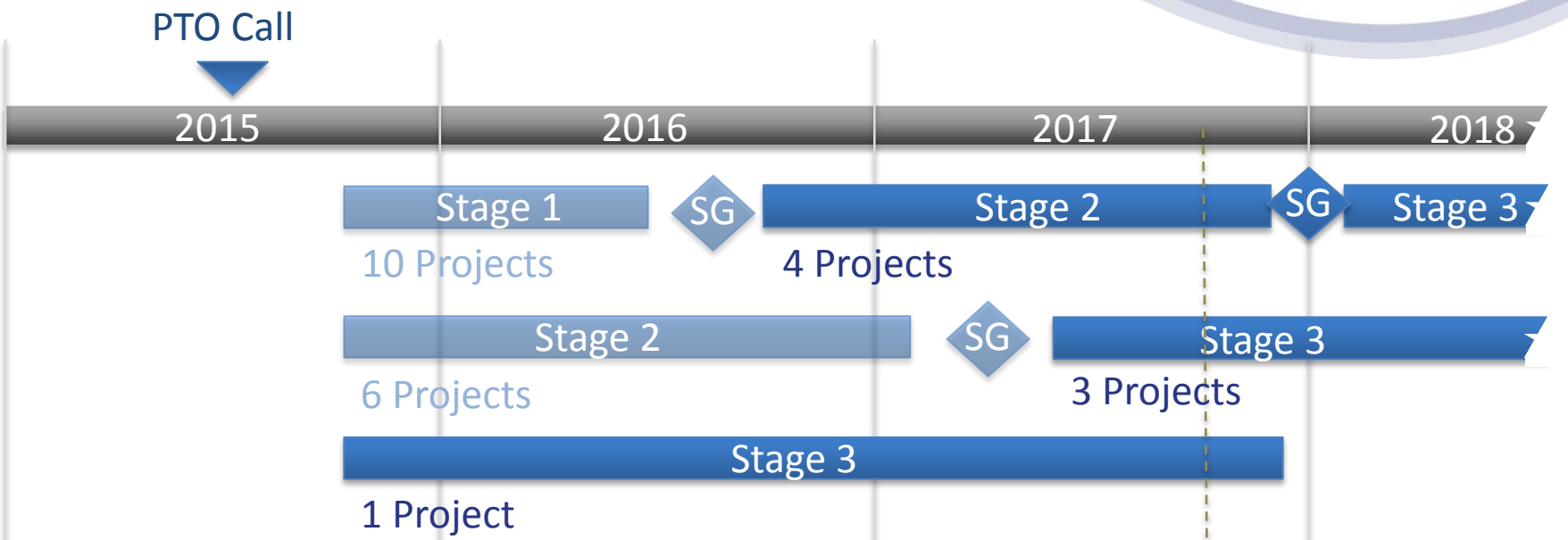
Stage Gate Process



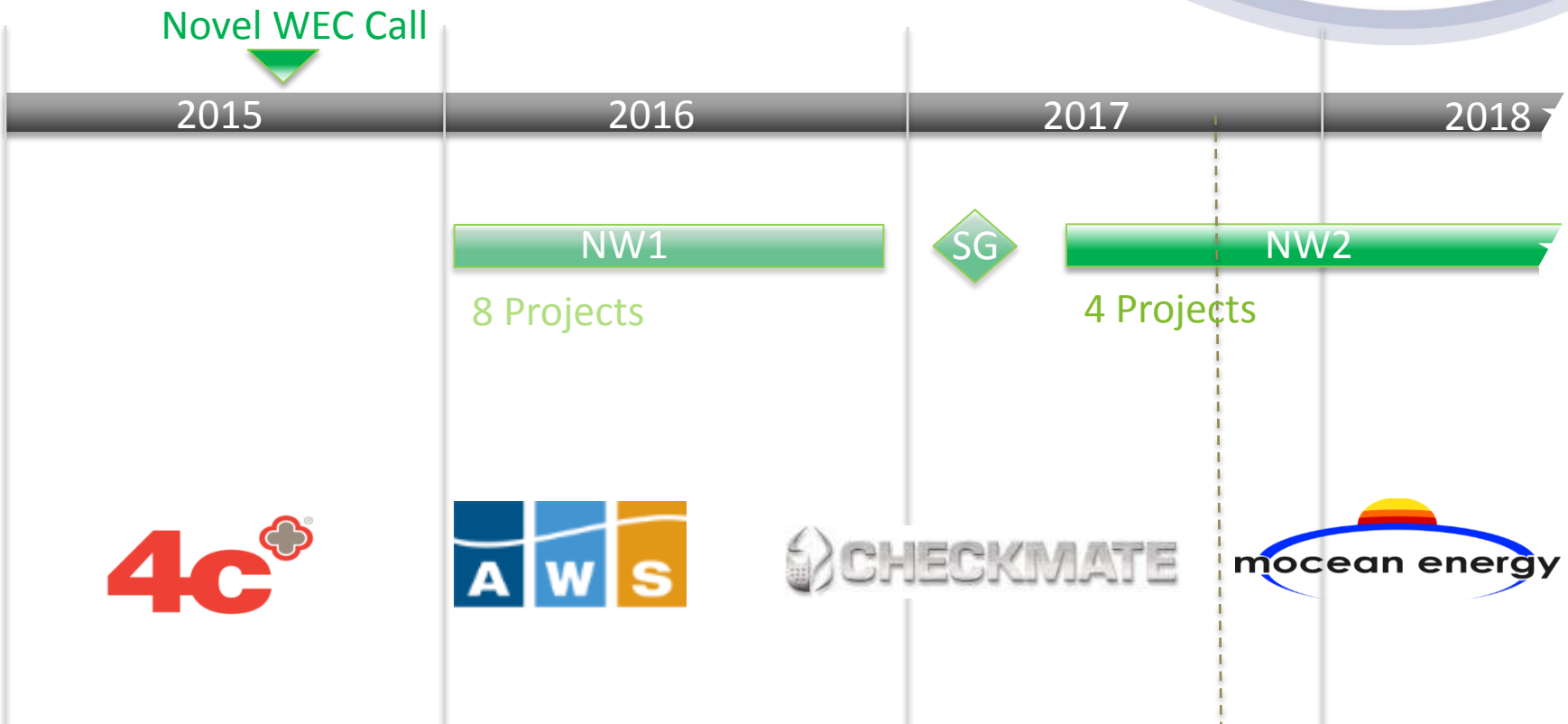
WES Timeline



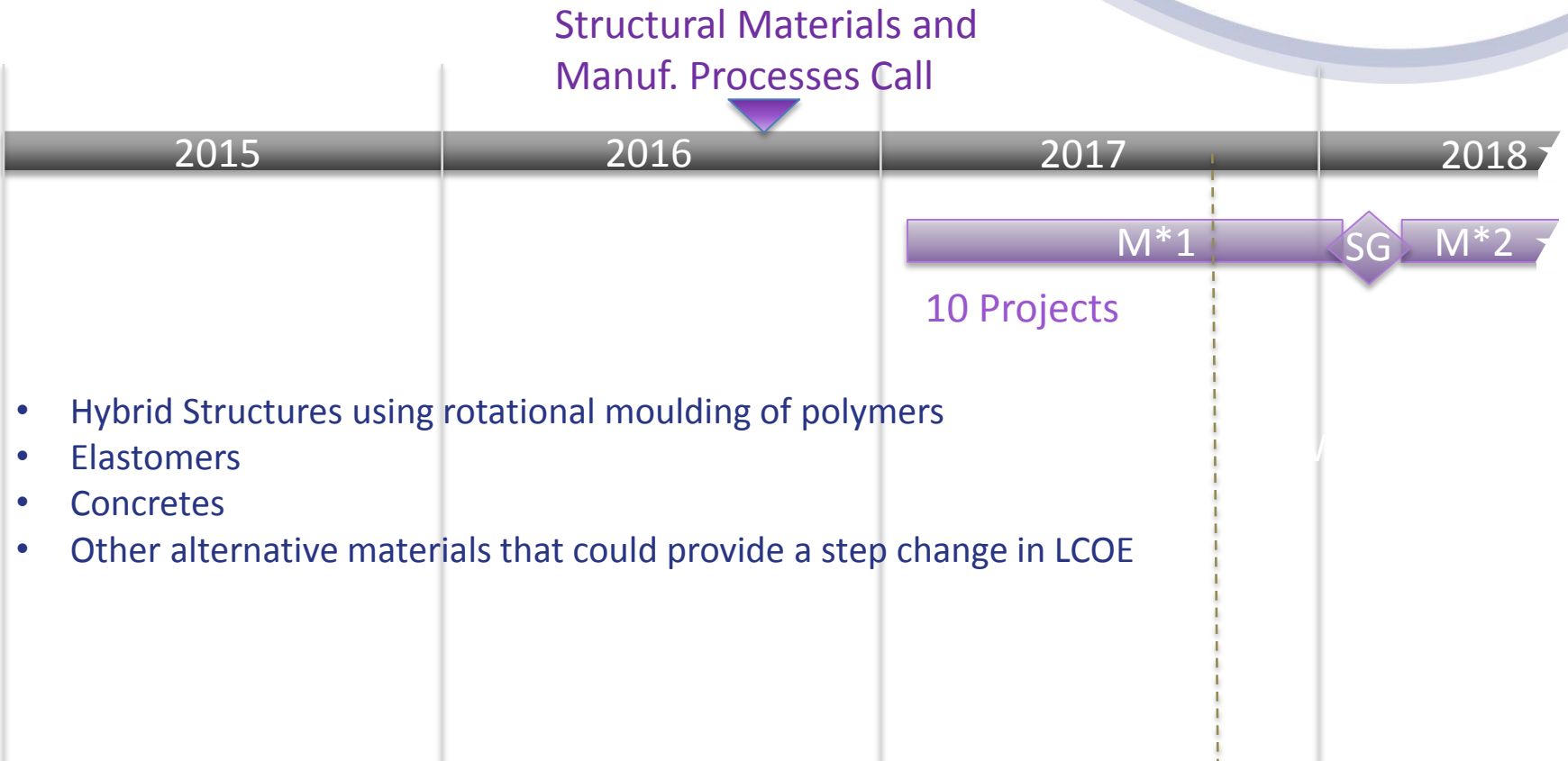
PTO Programme



NWEC Programme

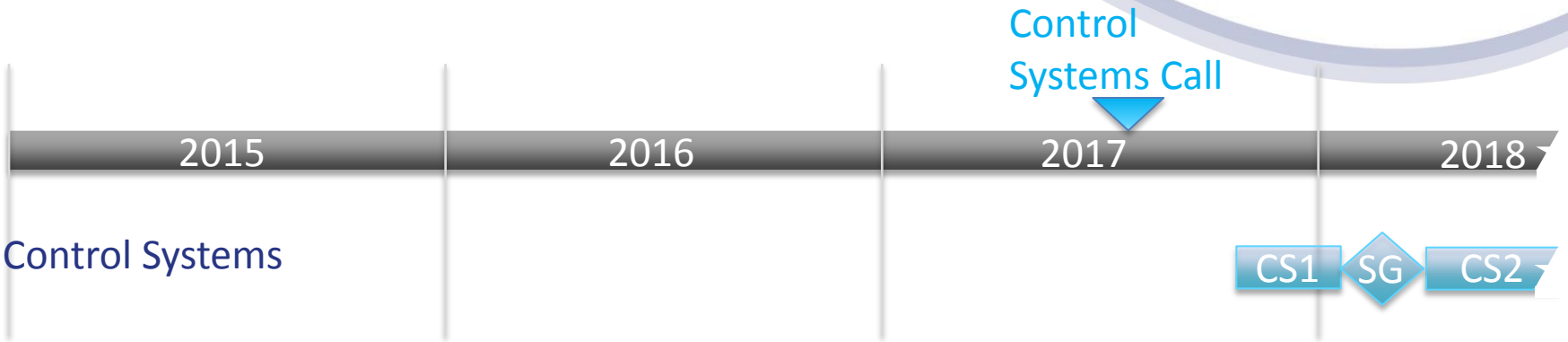


SMMP Programme



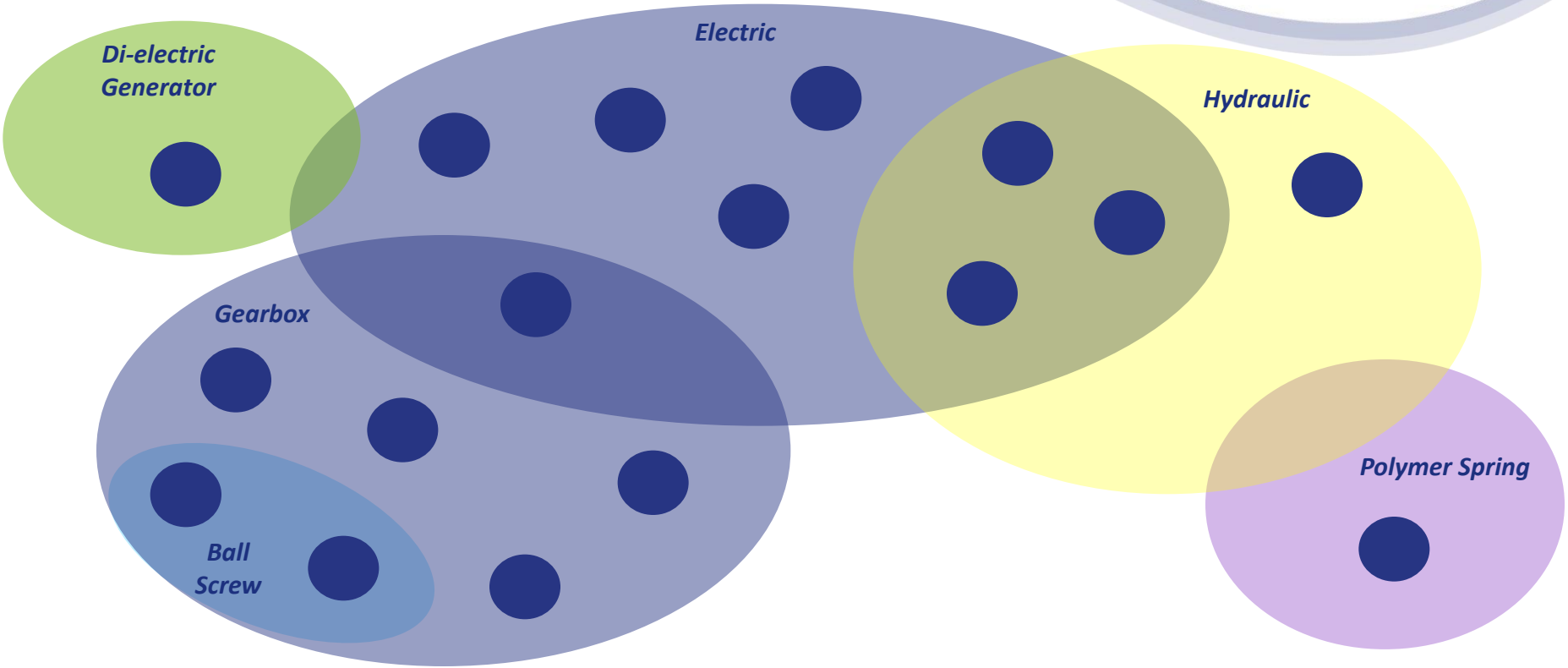
- Hybrid Structures using rotational moulding of polymers
- Elastomers
- Concretes
- Other alternative materials that could provide a step change in LCOE

Control Systems Programme

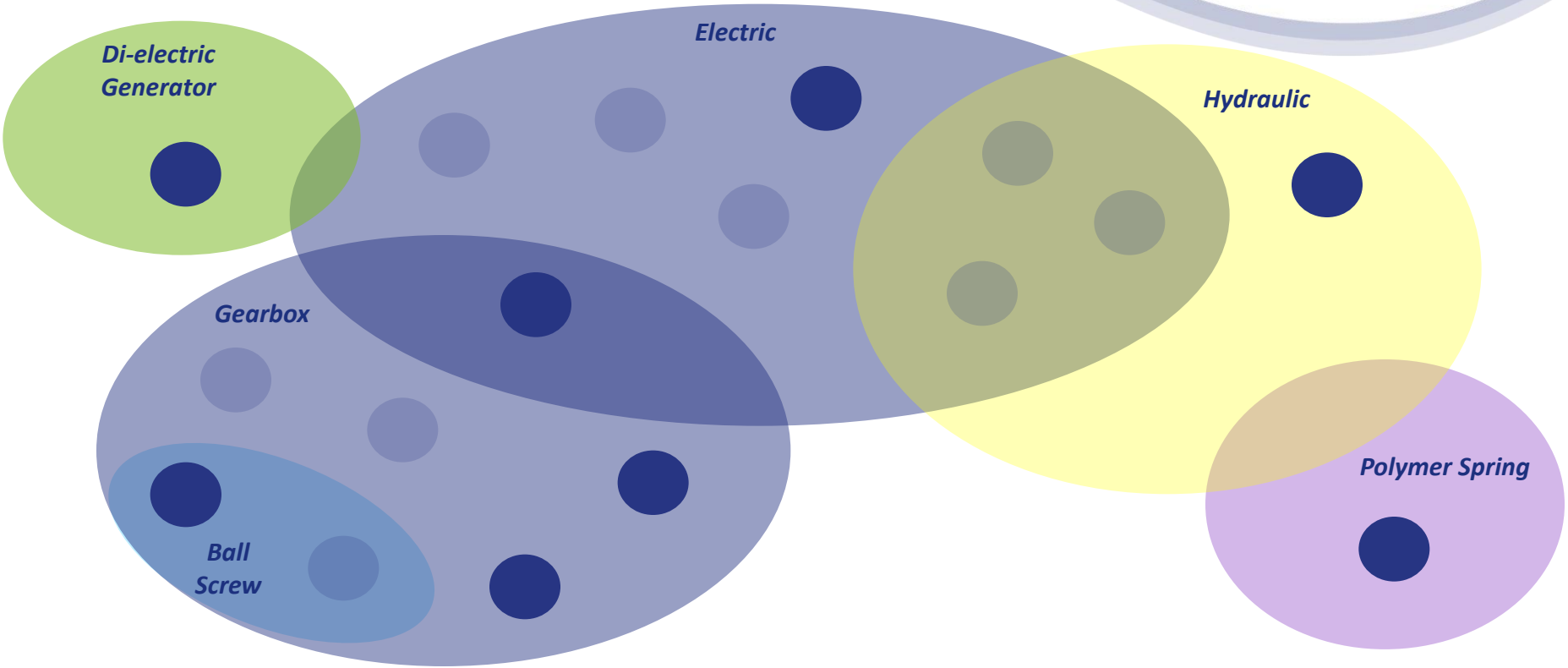


- Contracts currently being finalised

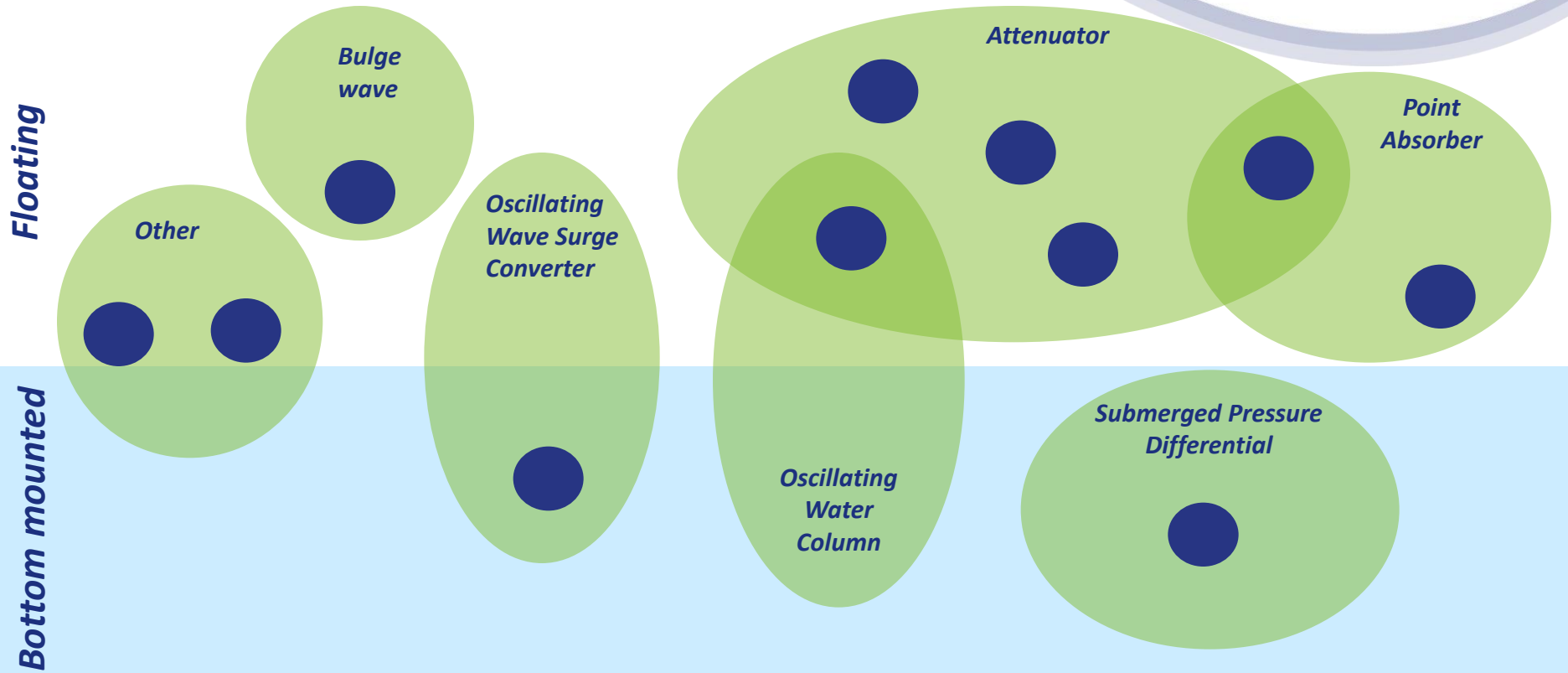
Power Take-Offs



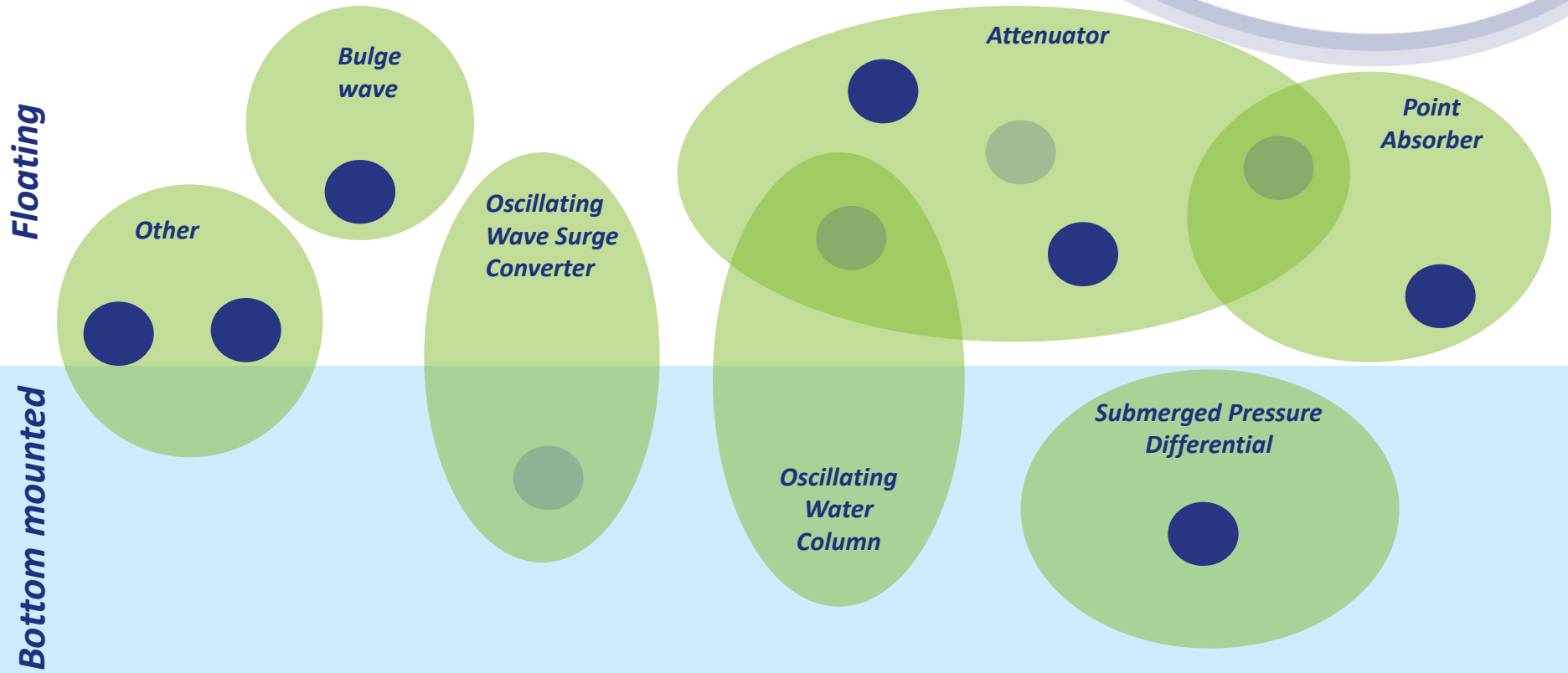
Power Take-Offs



WEC Types before Stage Gate



WEC Types before Stage Gate



Thank you

David.Langston@hient.co.uk

12th September 2017

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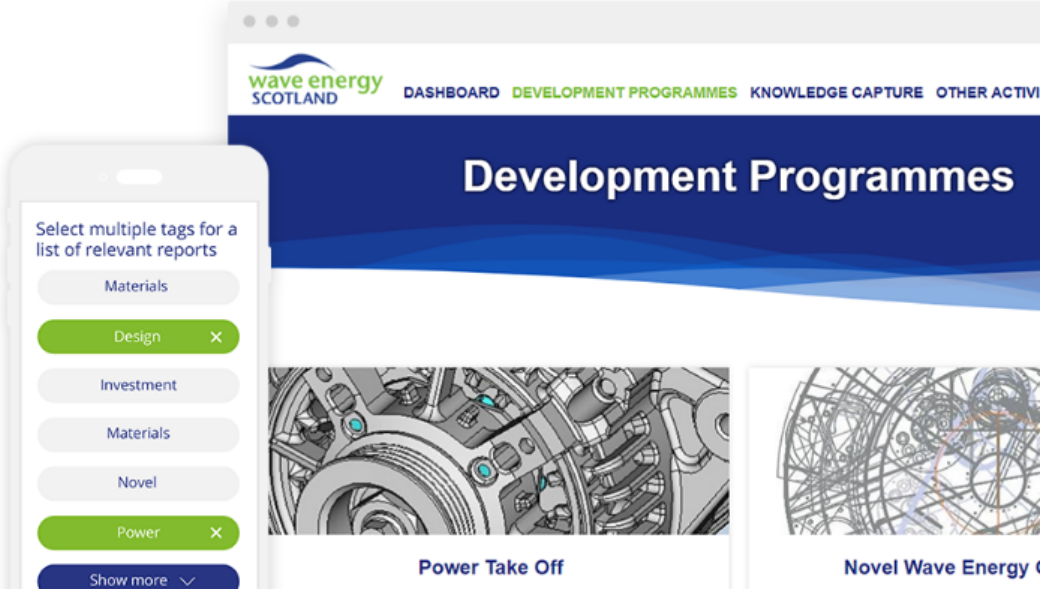
Elva Bannon
Senior Research Engineer
Wave Energy Scotland

Knowledge Library

Wave Energy Scotland is managing the most extensive technology programme of its kind in the wave energy sector. The Knowledge Library provides access to key information and documents generated through this world leading commercial and academic research & development.

Access world leading R&D in wave energy technology

- → Discover the projects supported through the Wave Energy Scotland Programme
- → Find Potential collaborators in your own or other fields
- → Search project reports on work completed through Wave Energy Scotland Programme
- → Find information on previous wave energy technology development in Scotland



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LAUNCHED JULY 2017

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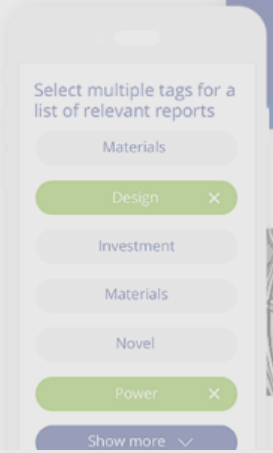

Power Take Off

Novel Wave Energy

Wave Energy Scotland - Objectives

- Seek to retain the **intellectual property and know-how** from device development in Scotland for future benefit;
- Enable Scotland's indigenous technologies to reach **commercial readiness** in the most efficient and effective manner, and in a way that allows the **public sector to exit** in due course;
- **Ensure that the learning gained** from support for wave device development and deployment to date, in particular the learning from Scotland's leading wave technologies, is retained and used to **benefit the wave energy industry;**
- **Avoid duplication in funding**, encourage collaboration between companies and research institutes and foster greater standardisation across the industry;
- Ensure **value for money** from public sector investment; and
- Promote greater **confidence** in the technical performance of wave energy systems in order to encourage the return of private sector investment.

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Navigation

- Layout of the site roughly follows the main WES programme activities
  - Development Programmes
  - Knowledge Capture
  - Other Activities
- Dashboard is a users ‘home’ page
- Also includes ‘Profile’
  ‘Search’

Available Information

Development Programmes

- Power Take Off
- Novel Wave Energy Converter
- Structural Materials & Manufacturing Processes *
- Control Systems *

* Denotes only project details available

Knowledge Capture

- EMEC & Orkney Supply Chain
- AWS
- Aquamarine
- Pelamis

Other Activities

- Landscaping Studies
- Operations & Maintenance Tool
- Annual Conference Presentations
- Public Presentations

Knowledge Capture Projects

- Aquamarine (2015)
  - Offshore Operational Experience
  - Corrosion & Protection in a Disturbed Water Environment
  - Supply Chain (marine components)
  - Tank Testing of WECs
  - Maintainability Improvements from Oyster 1 to Oyster 800
- AWS (2015)
  - Wave Power Development Experience
  - AWS Technology Description and Status
  - LCOE Parametric Modelling Tool
  - Cost of Energy Sensitivity Modelling
  - Recommendations for Future R&D Work

Knowledge Capture Projects

- Pelamis Wave Power (2015)
  - Tank Testing and Scale Models
  - Power Take Off
  - Mooring and Connection Systems
  - Simulation and Modelling
  - Economics
- EMEC & Orkney Supply Chain (Summer 2017)
  - Guidance on Compliance
  - Guidance on Handling
  - Guidance on Installation
  - Guidance on Operations and Maintenance

Other Activities

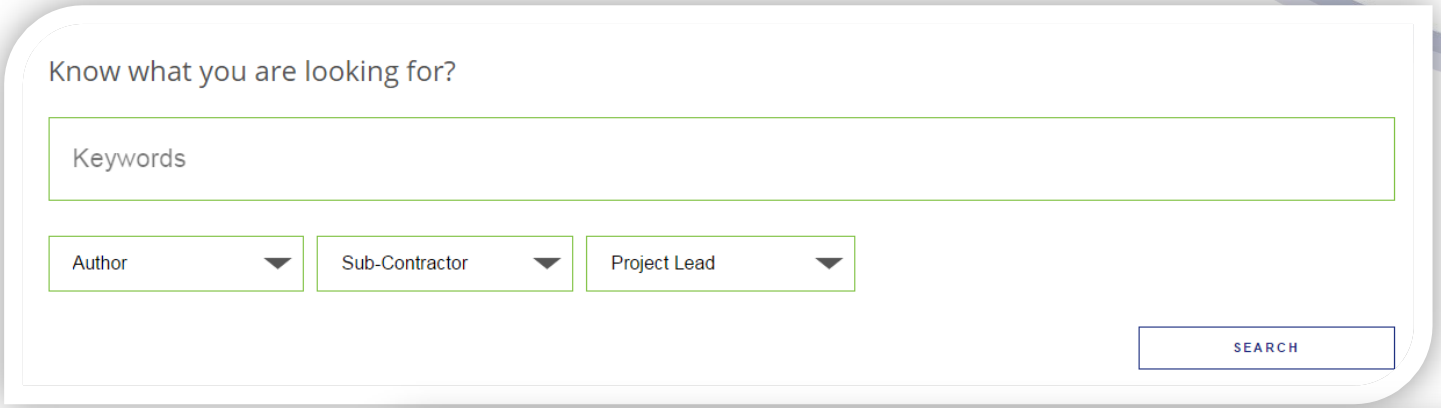
- Landscaping (2016)
  - Structural Forces and Stresses for Wave Energy Devices
  - Control Requirements for Wave energy Converters
  - Structural Materials and Manufacturing processes
  - Technology Transfer
- WES Annual conference (2016)
  - Presentations
- IDCORE (2 EngD projects on Control Systems and O&M)

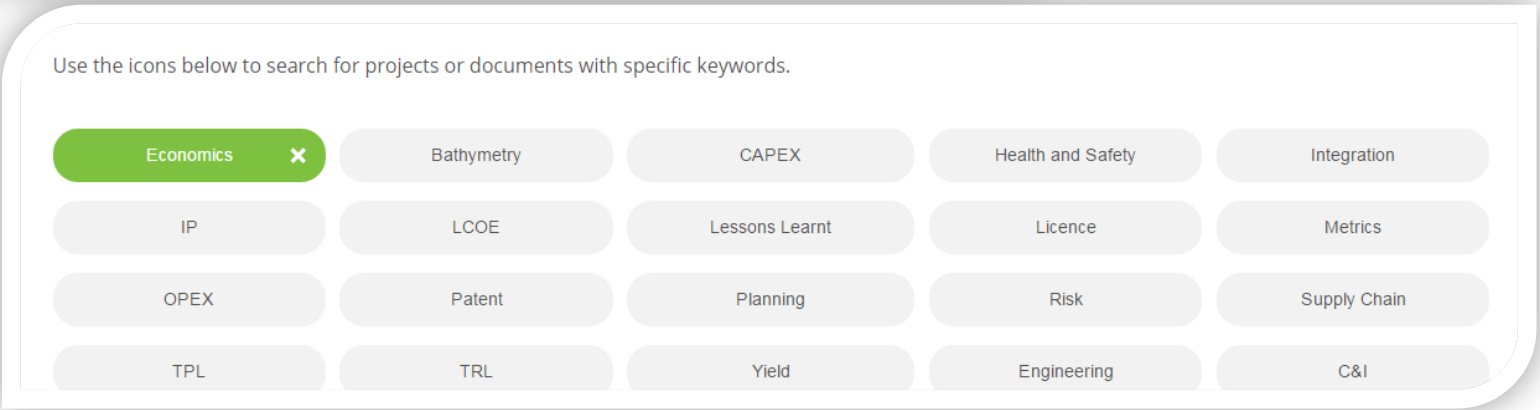
Operations & Maintenance Model

- EngD Project (IDCORE)
- Initially built for Pelamis, adapted for Albatern
- Working with other developers

- Allowing more complete estimates of O&M costs
- More accurate LCoE calculations
- Better informed maintenance strategy
- Identify critical components for device design

Search and Filter





Site Statistics

- In less than 8 weeks…
- 316 registered users
- From 25 countries
- 80 documents available
- Almost 1000 document downloads

Live Demo

- WES stand - afternoon coffee break
  - 16.00
  - 16.25

Thank you

Elva.bannon@hient.co.uk

12th September 2017

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Jonathan Hodges
Senior Innovation Engineer
Wave Energy Scotland

Scottish Renewables Marine Conference

WES Future Calls and Innovation Landscaping

12th September 2017

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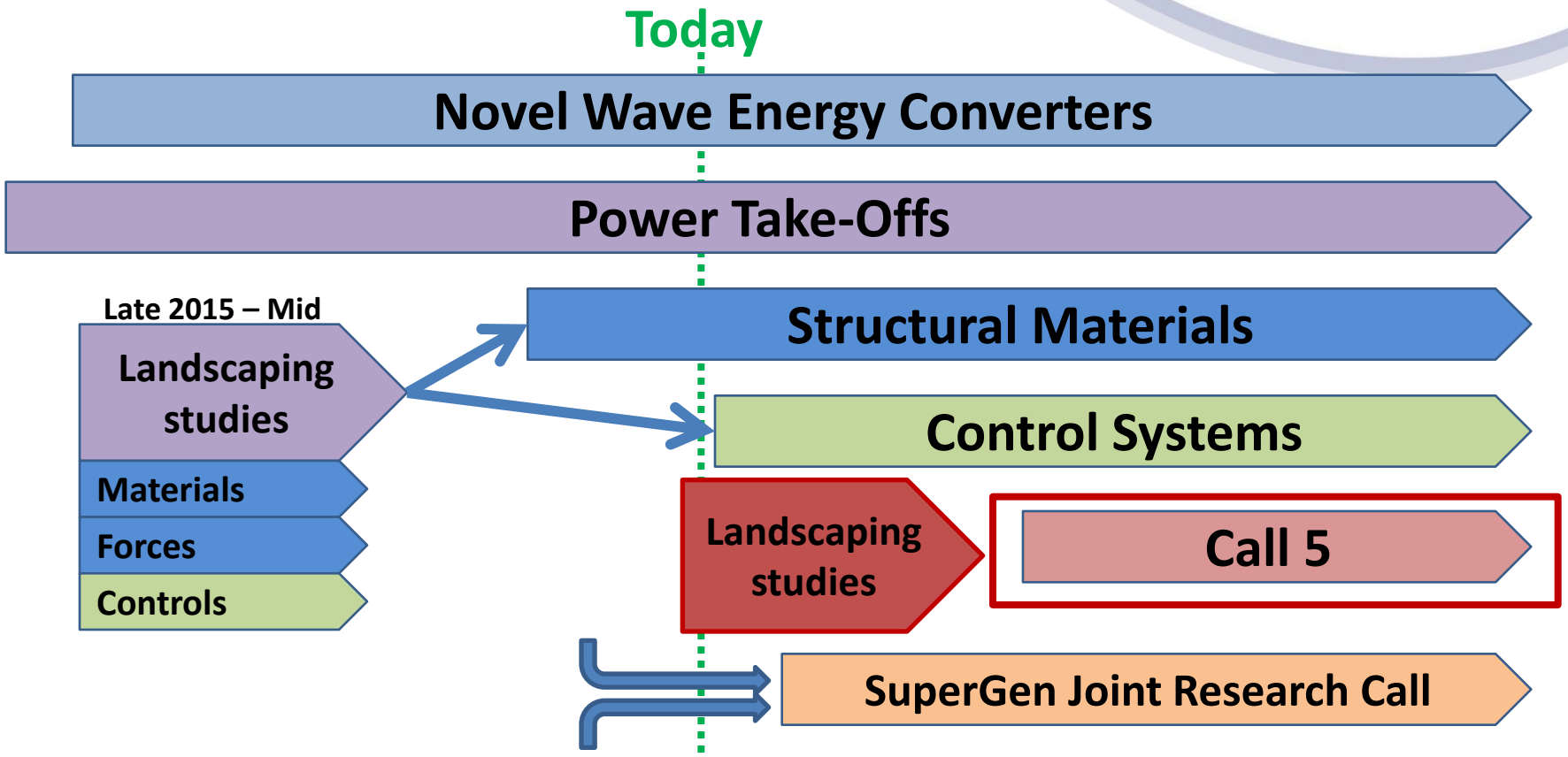
Contents

- Status of WES Innovation Programme
- Future plans
  - Innovation Landscaping projects
  - Joint WES-SuperGen research projects
  - Future calls

WES Work Programme

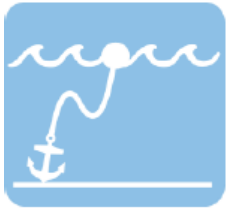


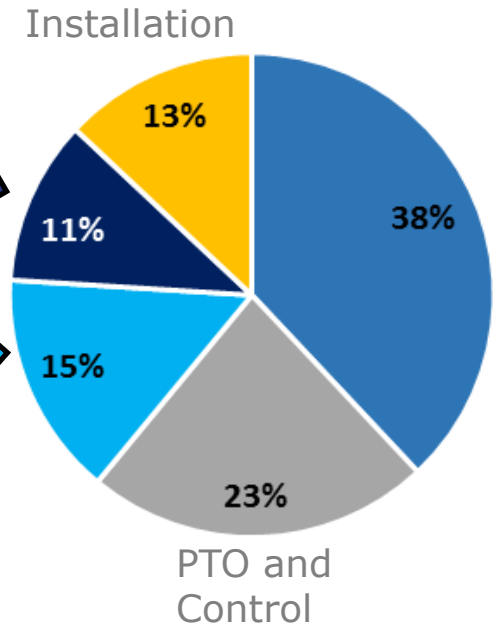
Innovation Landscaping

Cost Reduction in Supporting Infrastructure

1. Electrical Connection

2. Moorings & Foundations





% Typical CAPEX

Innovation Landscaping

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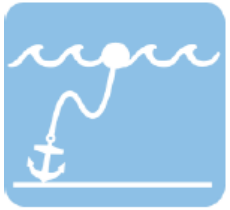
Objective:

- Opportunities for step-change cost reductions
  - Infrastructure sharing
  - Combination of sub-systems and/or their functions
  - Resulting component/sub-system deletion, re-sizing or replacement
  - Application of innovative or novel techniques or technologies
- Scope

Electrical generation
to
Grid Connection



Entire station
keeping function

Innovation Landscaping

Next generation of competitive solutions:

3. Very Large Scale Wave Energy Generation

4. Alternative Generation Technologies

Innovation Landscaping

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Very Large Scale Wave Energy Generation

Objective:

- Opportunities for step-change cost reductions

- Scope
  - Other renewables
  - Theoretical limits
  - Suitability of existing or novel device types
  - Impact, benefits and practical considerations
  - CAPEX, OPEX and LCOE benefit to common baseline

Innovation Landscaping

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Alternative Generation Technologies

Objective:

- Opportunities for step-change cost reductions

- Scope
  - Generation capacity and scale opportunities
  - Suitability for a realistic wave energy environment
  - Technology readiness and availability
  - R&D activity
  - Supply chain
  - Physical routes to implementation
  - CAPEX, OPEX and LCOE benefit to common baseline

Innovation Landscaping

- **4 projects**
- **3-4 months duration each**
- **£70-80k each excl. VAT**
- **Open tender via Public Contracts Scotland – open shortly**

public contracts scotland

publiccontractsscotland.gov.uk

wave energy SCOTLAND

waveenergyscotland.co.uk
twitter.com/waveenergyscot

Thank you

Jonathan.Hodges@hient.co.uk

12th September 2017

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SR Marine Conference Inverness

Structured Innovation and Metrics

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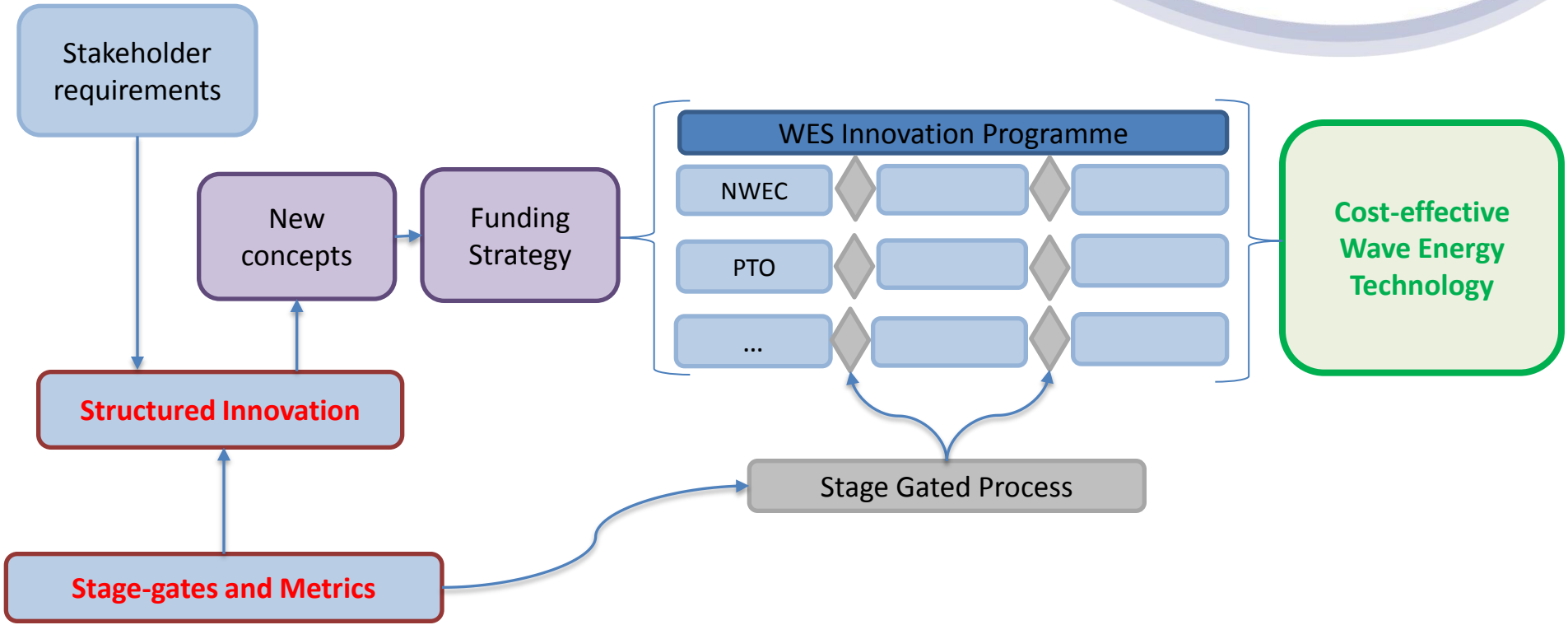
Structured Development

- What?
  - Continuing to apply structured processes to wave energy technology development
- Why?
  - Fund the right technologies
  - Increase likelihood of success

Technology Development



Stage Gate Metrics

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Iomairt na Gàidhealtachd 's nan Eilean

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Functional Requirements & Capabilities

Areas for measurement of success

Defined Metrics

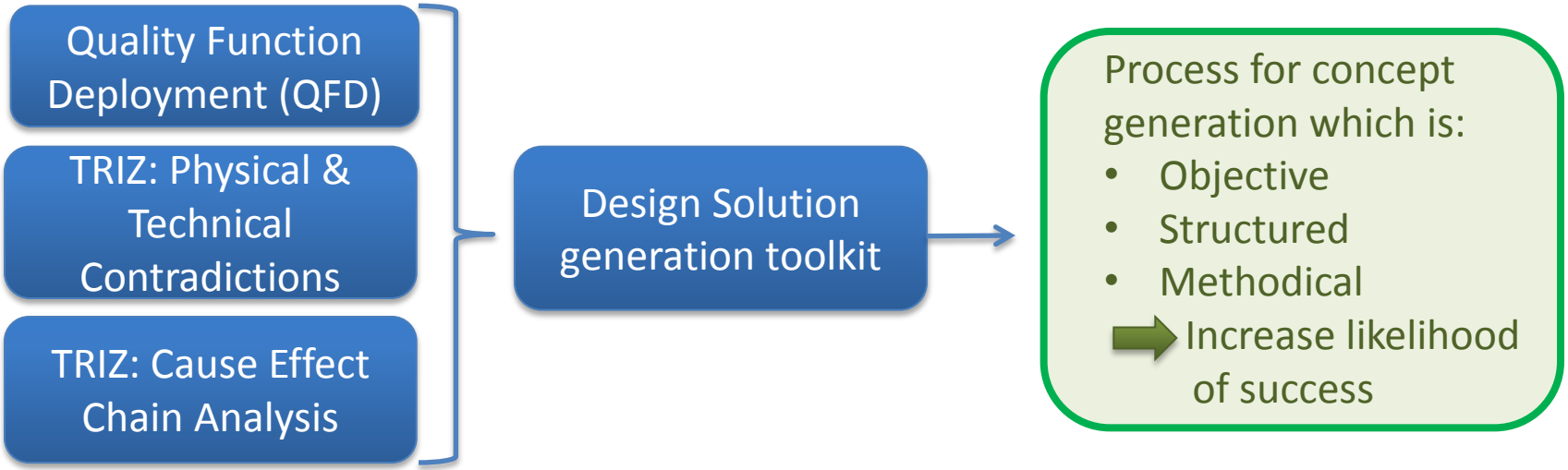
Cross- sector approval
→ Key stakeholders

Tools

Achievability ☑
Attractiveness ☑

Structured Innovation

- Techniques for problem solving and design improvement
- Successfully used in Automotive and Defence industries
- Bespoke process for ocean energy sector



Tools

Structured Innovation tools

Assessment tools

Design tools

Method of assessing performance:

- Numerical models
- Optimisation
- Calculations, relationships, equations
- Qualitative and quantitative

Tools

Structured Innovation tools → Concept generation & technology selection

Assessment tools → Levelised Cost of Energy, Achievability, Attractiveness

Design tools → Optimisation for performance, reliability, cost

Tools to be applied at all TRL levels

TRL 0 → TRL 2 - 4 → TRL 4 - 6 → TRL 6 - 9 → Competitive LCoE

Collaboration

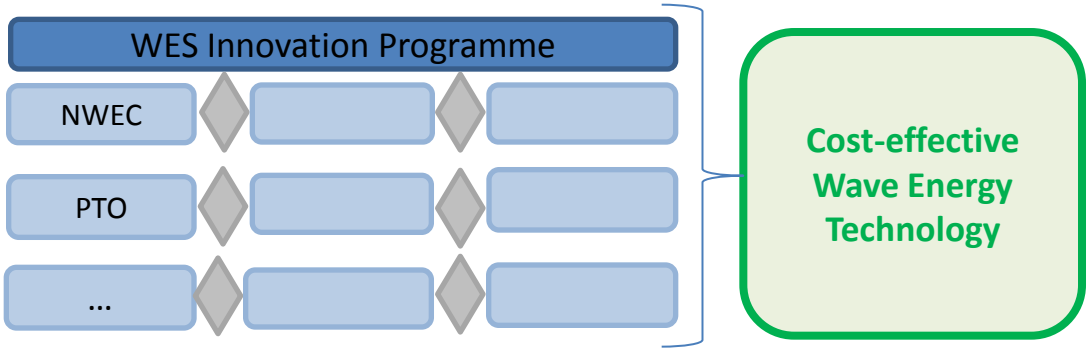
- Network of international collaboration on metrics to support stage- gated development

- UK: Wave Energy Scotland
  Ireland: WestWave
  USA: Department of Energy

Structured Innovation & Metrics

– Fund the right technologies

– Increase likelihood of success



Thank you

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Norman Morrison
Development Manger, Marine Energy
Wave Energy Scotland

Scottish Renewables Marine Conference

Cooperation in marine energy

WES and ETP bringing academia and industry closer together

12th September 2017

What is ETP?

An alliance of 12 Scottish Universities engaged in world-class energy-related RD&D with world-class facilities

200
Academics

700
Researchers

What is ETP?

- ETP is arranged by "themes"

Wind
Strathclyde

Marine
Edinburgh

Grid
Strathclyde

Solar PV
Edinburgh

O&G
Aberdeen

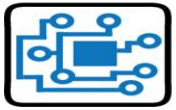
CCS
Edinburgh

Bio
Glasgow

EUB
H-W

ECS
Glasgow

Heat
Glasgow



Energy Systems
Strathclyde

ESP
Strathclyde

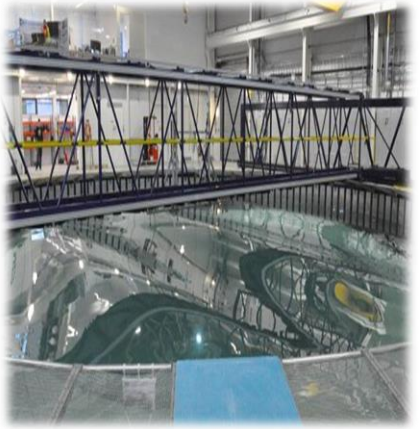
Marine theme

Marine energy expertise

- Resource assessment
- Resource modelling
- Tank testing
- CFD modelling
- Economic modelling and assessment
- Moorings and foundations
- Subsea engineering
- Machine design
- Array design
- Environmental impact modelling

Marine theme

Scottish Energy Laboratory



- OceanLab sea testing facility
- Curved wave tank and wave flumes
- Machine and power electronics test laboratory
- FloWave TT
- Heriot Watt University wave basin
- Kelvin Hydrodynamics Laboratory
- Energy Technology Centre - component test facilities
- European Marine Energy Centre

ETP programmes

KEN (Knowledge Exchange Network)

Team of 7 BDMs covering low-carbon sector
Foster and manage collaboration between industry and academia

PECRE (Post-Graduate Early Career Researcher Exchanges)

Bursaries of £3k available for international exchanges
Available to all PECRs in ETP universities

ETP Energy Industry Doctorate Programme

Funded by SFC & the Scottish Government
Studentships in partnership with industry

ETP achievements

- **95** Energy Industry Doctorates supported, nearly £3M industry funding
- **400** SMEs in low carbon sector supported
- **120** low carbon innovation projects funded
- Over next 2 years, a further **150** SMEs supported, and **40** additional projects funded

What about WES?

- Many WES programmes are collaborative between academic institutions and industry
  - Over **150** organisations and **14** academic institutions
- Actively seek companies from industry to bring expertise to wave energy sector
  - Brokerage events and targeted engagement
- Partnering with Supergen UK Centre for Marine Energy Research
  - Joint call to encourage collaboration
- Planning to support more studentships
  - In partnership with ETP
  - Dissemination of previous PhDs via knowledge library

Get involved

- Collaboration is at the heart of WES and ETP philosophies
- Ensuring that research community and industry are not working in isolation
- Use the knowledge library to familiarise yourself with the projects
- Consider the landscaping activities
- Research ⇄ Industry

Thank you

Norman.morrison@ed.ac.uk

marine@etp-scotland.ac.uk

12th September 2017

Tim Hurst, Wave Energy Scotland

David Langston, Wave Energy Scotland

Elva Bannon, Wave Energy Scotland

Jonathan Hodges, Wave Energy Scotland

Norman Morrison, Energy Technology Partnership

Tidal Energy: Harnessing the Tides

Chair:

Mark Georgeson

Scottish Enterprise

Cameron Smith

Director – Project Development

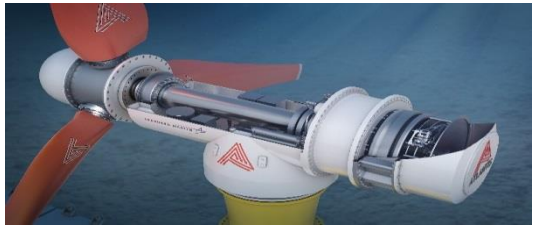
Atlantis Resources

Scottish Renewables Conference September 2017

MeyGen Update

Atlantis Resources Ltd (ARL:LN)

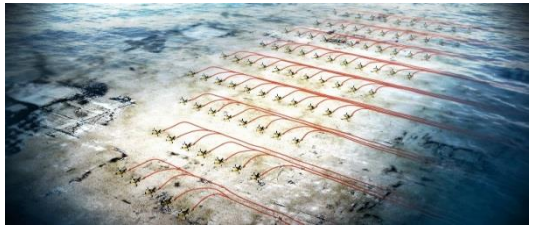
Leading the global development of tidal power generation



Turbine Division

Turbine & equipment sales

Our **Turbine Division** sells tidal turbine generation equipment into our projects and to third party project developers. Supported globally by our technology partners, Lockheed Martin Corporation, Atlantis can provide drivetrain, nacelle fixation, subsea connection and power export equipment to the highest specification, capable of withstanding the harshest environments for the project life. Our new 1.5MW turbine, AR1500, has been deployed on the MeyGen project in 2017



Power Generation Division

Global portfolio of projects

Atlantis is recognised as one of the world's leading developers of tidal power projects. Our **Power Generation Division** takes greenfield sites from concept through to commissioning. The Atlantis project portfolio currently under development is truly global, inclusive of activities in Scotland, China, Canada, India and Australia. We are constantly searching for new tracks of seabed real-estate to secure, consent, develop and finance

The MeyGen Project

World's largest tidal power project

At 398MW, **MeyGen** is the world's largest tidal power project. Located in the inner sound of the Pentland Firth in Scotland, MeyGen is the UK's flagship project. Construction commenced in late 2014 subsequent to achieving financial close in October 2015 for Phase 1A. Atlantis owns 86.5% of the MeyGen project, and the funding syndicate includes the Scottish Investment Bank, The Crown Estate, DECC and HIE. 269 turbines will be installed on the site.

£51M PROJECT FINANCING OF THE FIRST PHASE OF THE WORLD'S LARGEST TIDAL POWER PROJECT, MEYGEN

ATLANTIS RESOURCES

MEYGEN PHASE 1A CLOSED

WHAT AN INCREDIBLE ACHIEVEMENT!

WE WOULD LIKE TO THANK ALL OF OUR PARTNERS,
WITHOUT YOU, THIS WOULD NOT HAVE BEEN POSSIBLE

ABB · ashurst · ANDRITZ Hydro Hammerfest · BURGES SALMON · Department of Energy & Climate Change · GLOBAL ENERGY GROUP · HSBC · marine scotland · smartestenergy · HIE Highlands and Islands Enterprise Iomairt na Gàidhealtachd 's nan Eilean · JGC

James Fisher and Sons plc Marine Services Worldwide · The Highland Council Comhairle na Gàidhealtachd · LOCKHEED MARTIN · Renewable Risk Advisers · MEYGEN · nationalgrid · xodus GROUP · NORTON ROSE FULBRIGHT · RICARDO

sse Scottish Hydro · mojomaritime · RobertBirdGroup · PRINCE'S FOUNDATION · Scottish Enterprise · DHI · SHEPHERD+WEDDERBURN · THE CROWN ESTATE · HRI ARCHITECTS · jdr

We're bringing the world tidal power energy today,
follow our journey at atlantisresourcesltd.com.

Update | MeyGen 1A

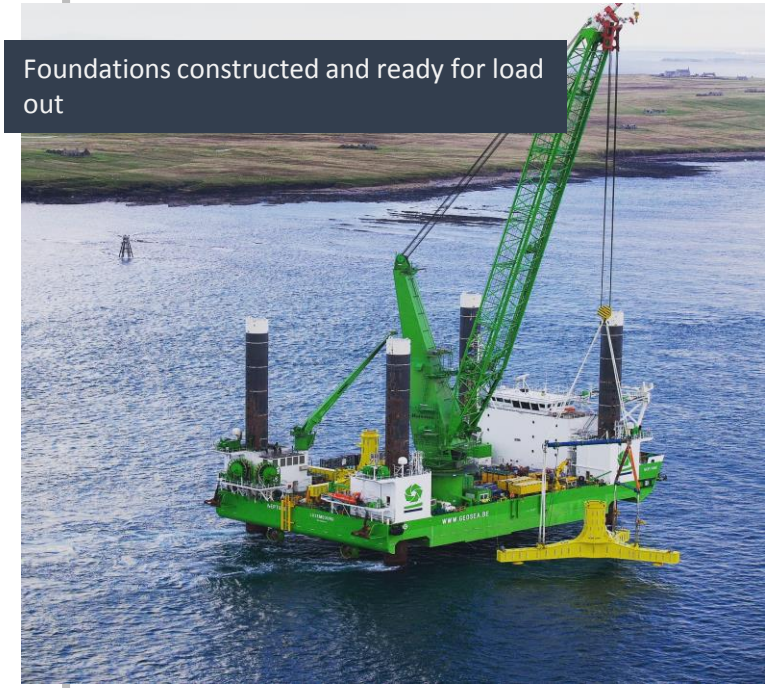
First power in 2016 achieved

Onshore electrical building complete

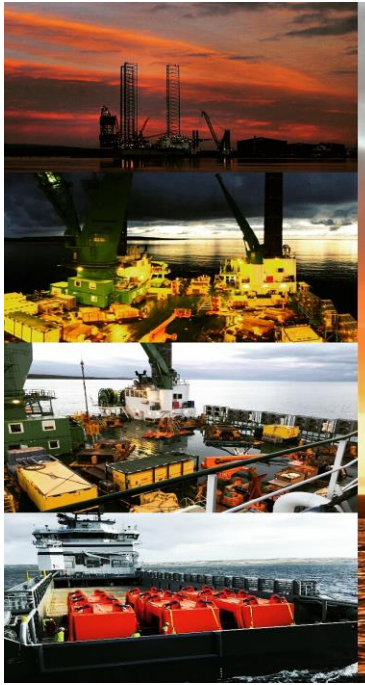
Power converters commissioned and grid connected

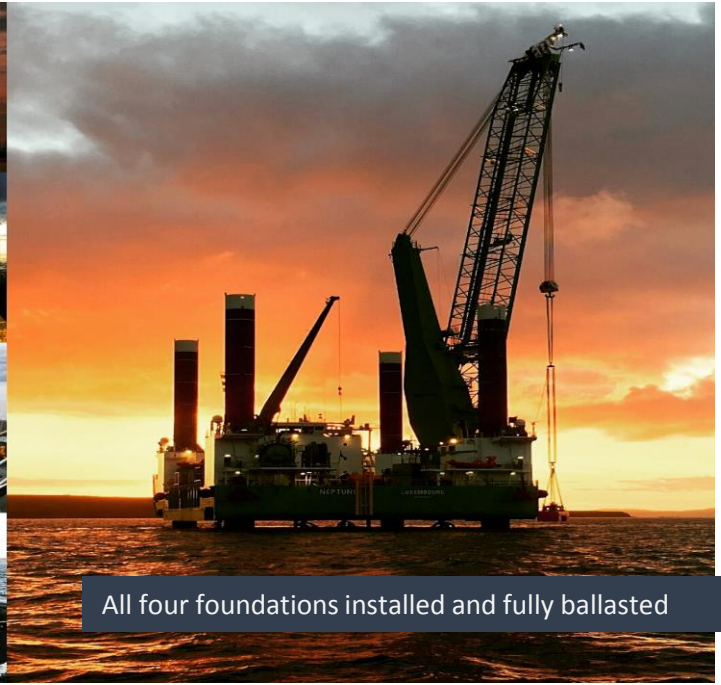
Update | MeyGen 1A

Foundations installed in record time



Foundations constructed and ready for load out

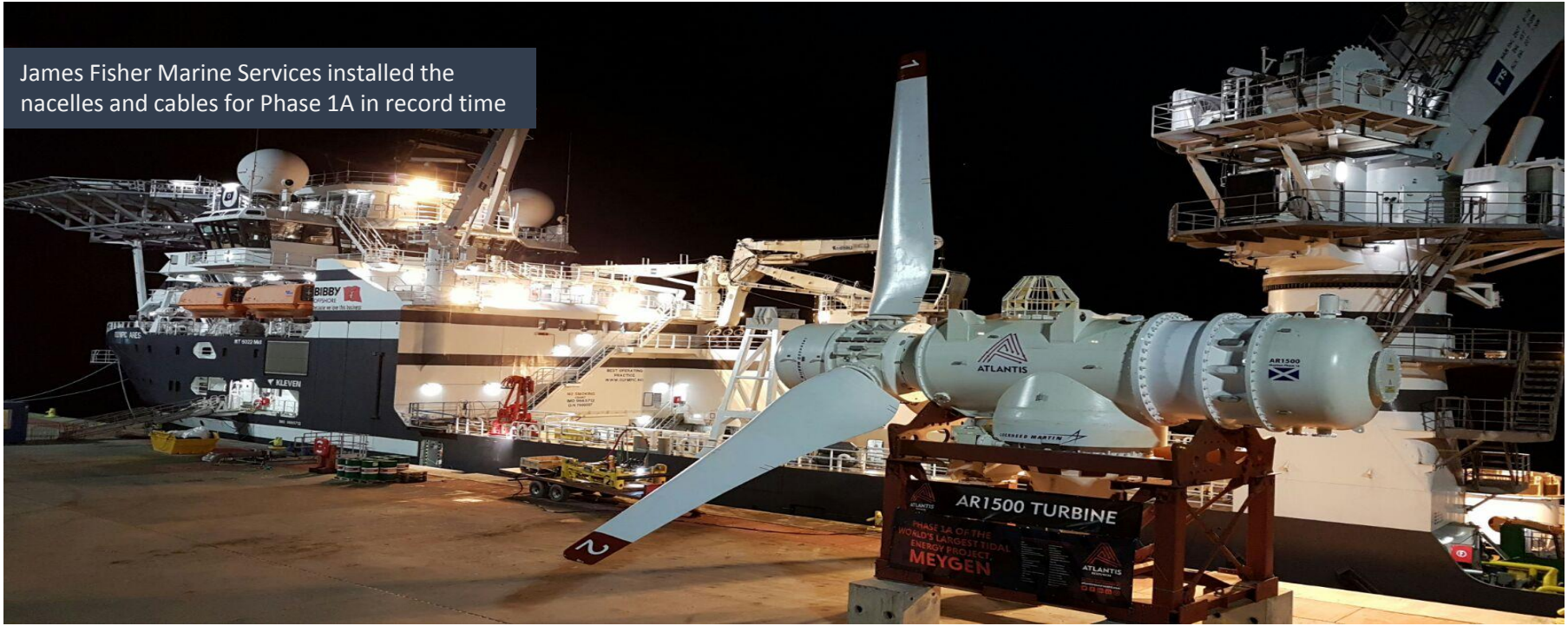




All four foundations installed and fully ballasted

Update | MeyGen 1A

Turbines installed in record times – less than 30 minutes



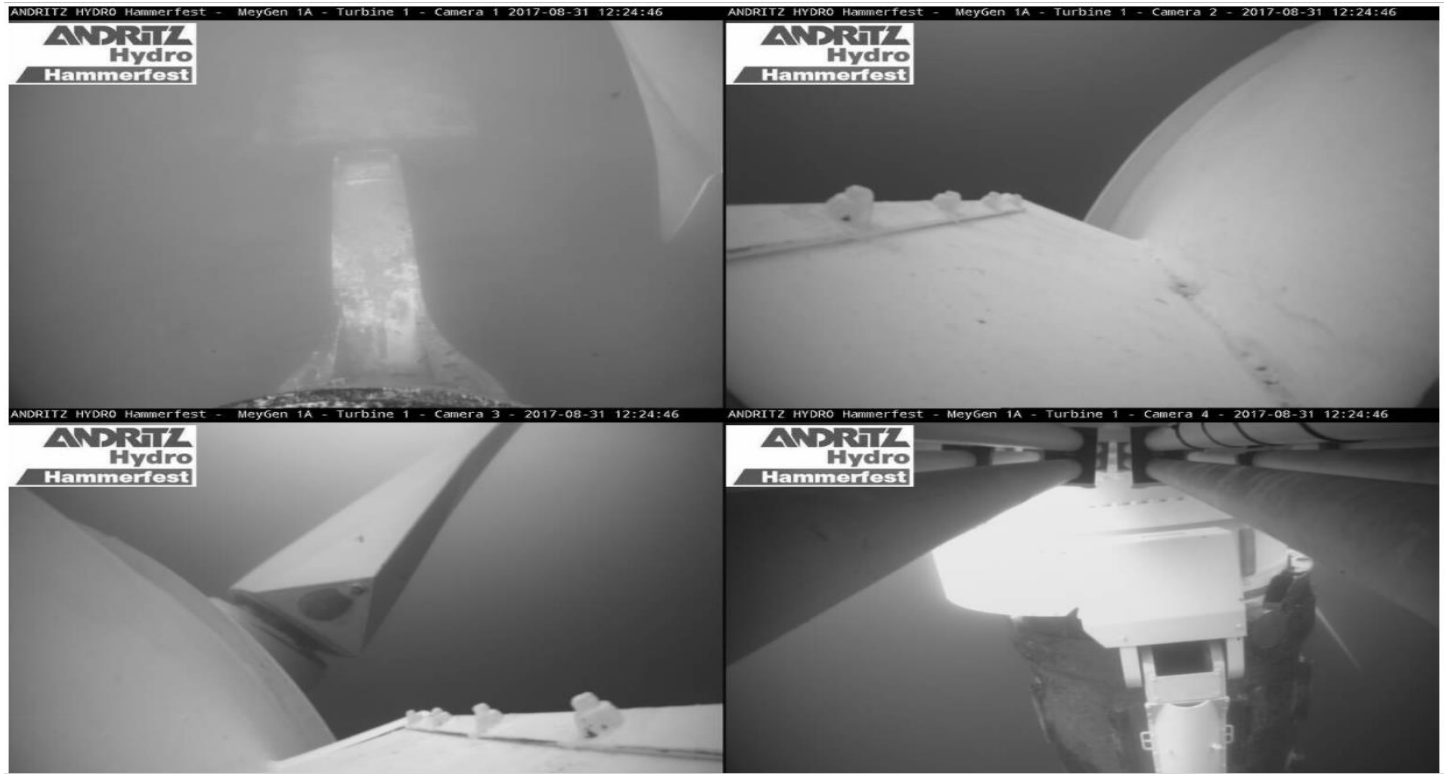
James Fisher Marine Services installed the nacelles and cables for Phase 1A in record time

Update | MeyGen 1A

Atlantis teams deploy improved AHH turbines to time and budget

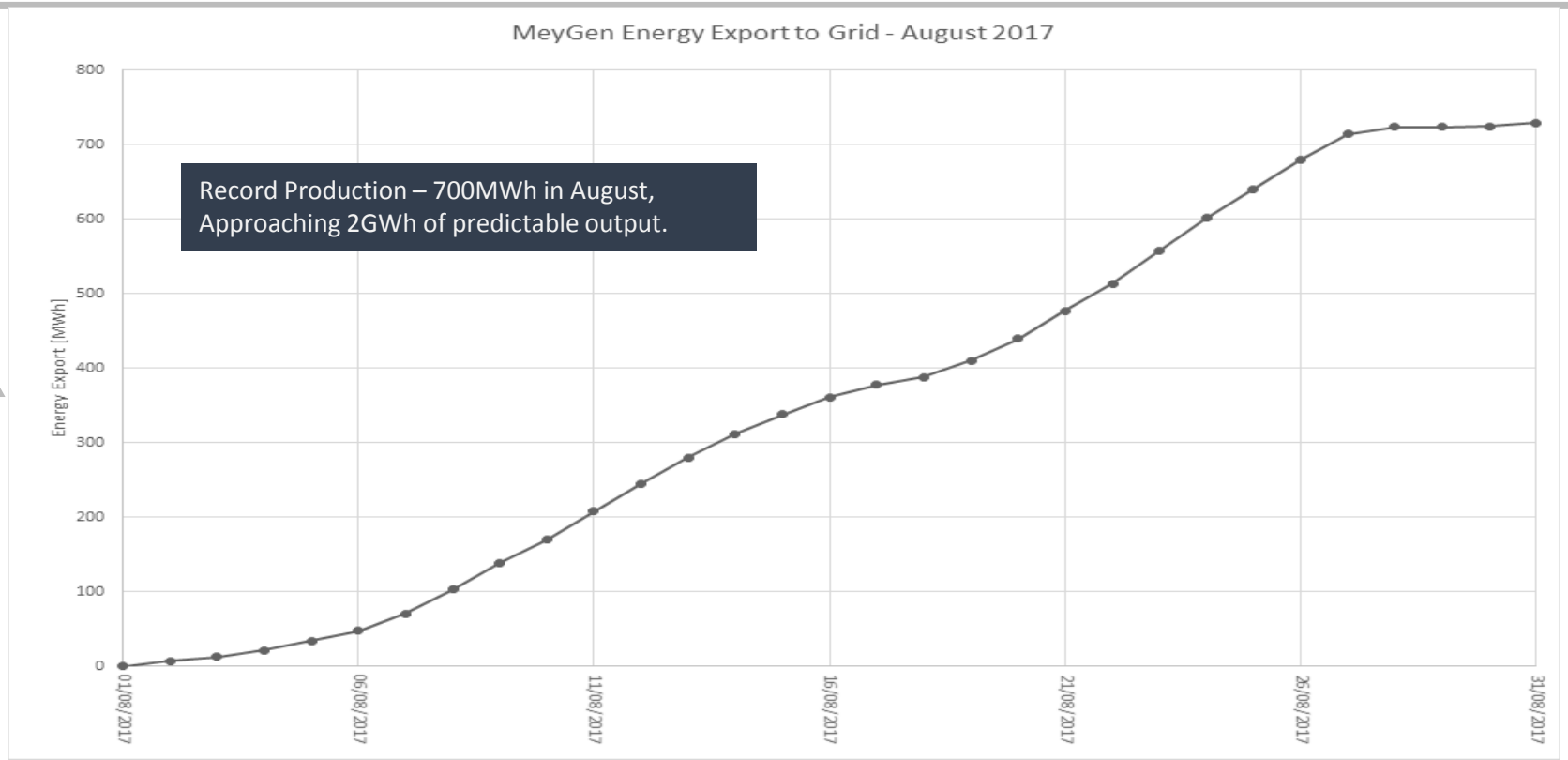
Update | MeyGen 1A

Turbines operating as planned.



Update | MeyGen 1A

Production Report.




AKOFS
Offshore

Andrew Scott

Chief Executive Officer

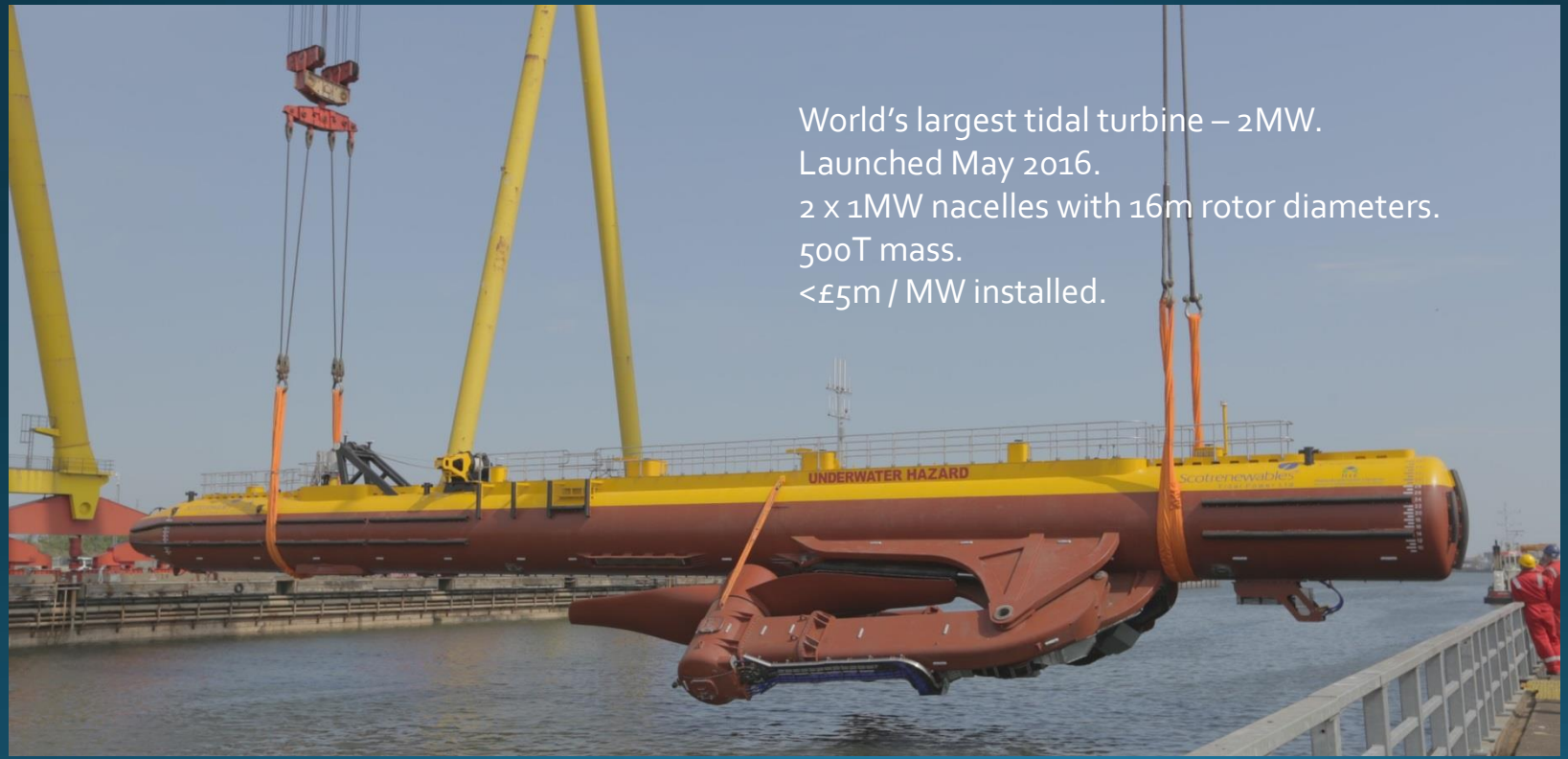
ScotRenewables

SR2000 – Update: Scottish Renewables, September 2017

Scotrenewables Tidal Power Ltd

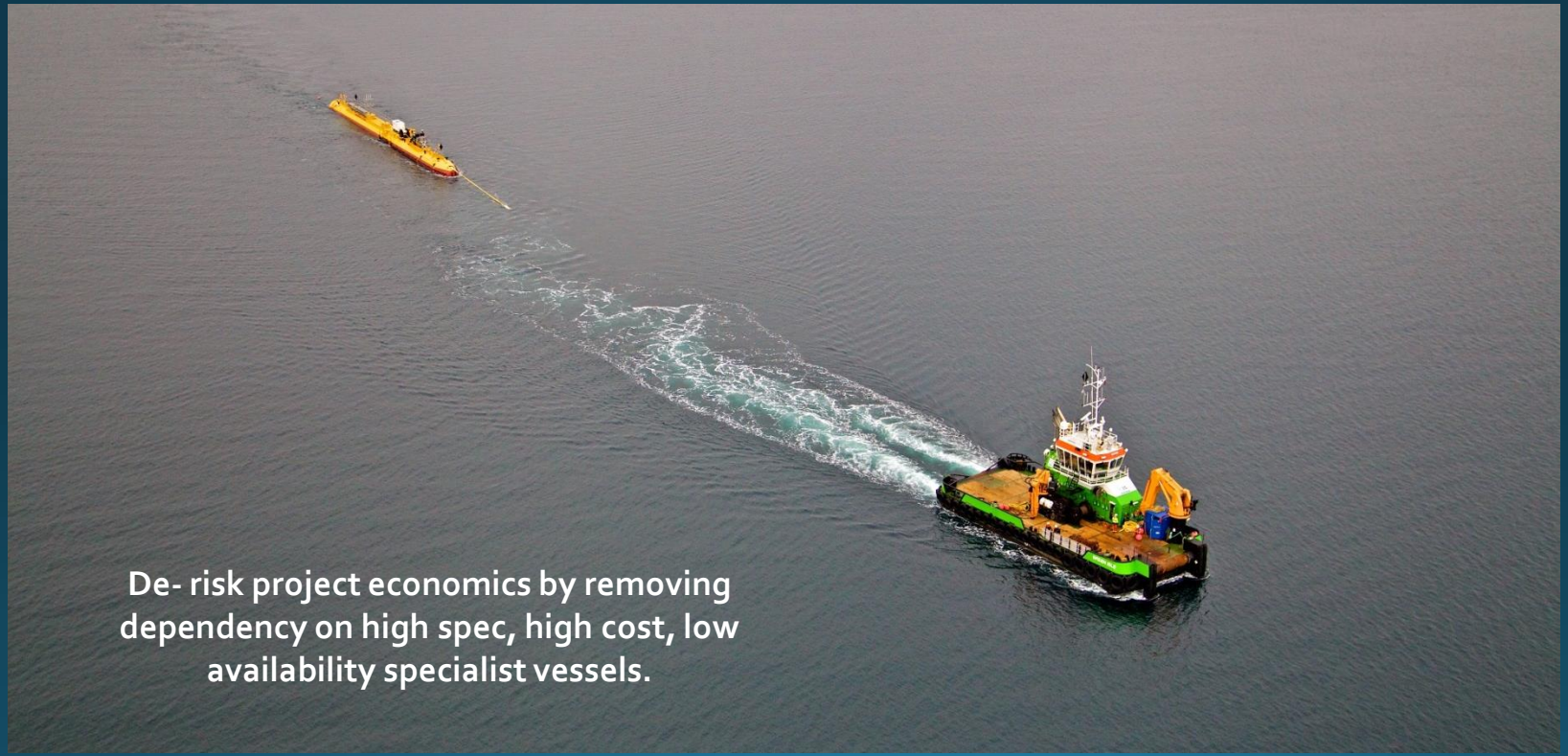
Scotrenewables®
Tidal Power Ltd

SR2000 (2MW) – CAPEX validation.



World's largest tidal turbine – 2MW.
Launched May 2016.
2 x 1MW nacelles with 16m rotor diameters.
500T mass.
<£5m / MW installed.

SR2000 (2MW) – Construction & Operational Philosophy.

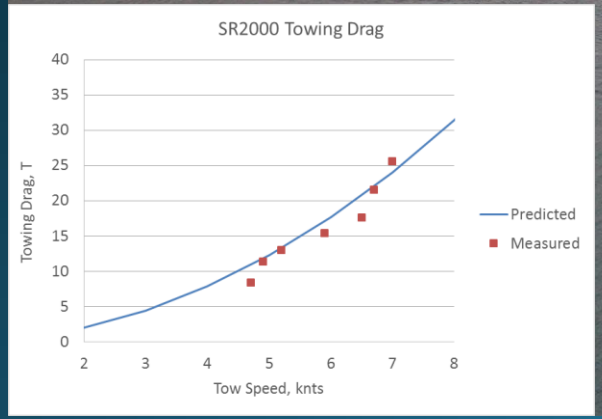


SR2000 (2MW) – Construction validation.

All site construction work completed by multi-cat vessels (£3k per day).

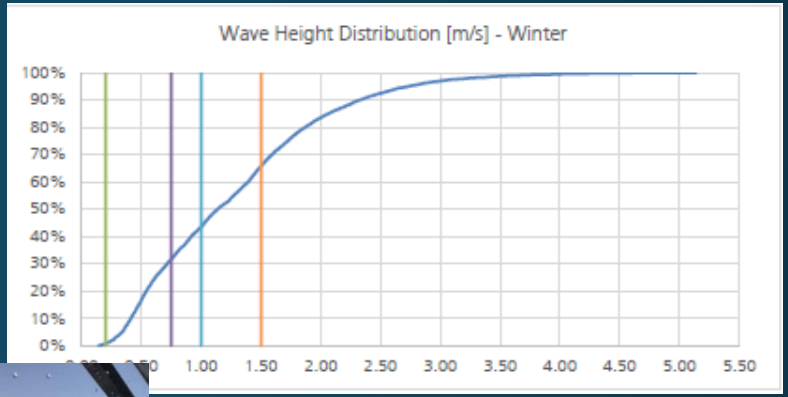
SR2000 (2MW) – Construction validation.

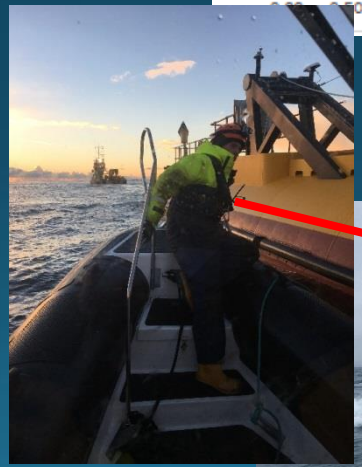
SR2000 capable of quick installation and recovery from site with multi-cat (in under 30 minutes).



SR2000 (2MW) – OPEX validation.

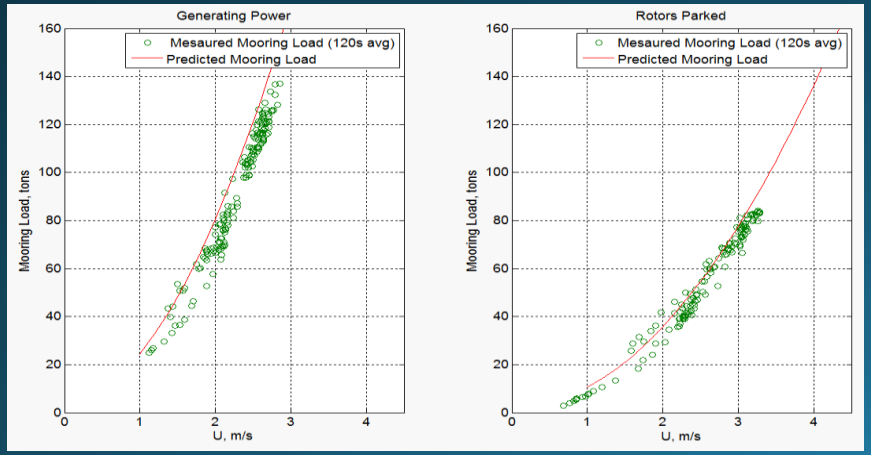
- Hull Access
  - Most equipment and subsystems located in hull.
  - Hull assessable via RIB (<£1k per day).
  - Hull assessable in up to 1.5-2m significant wave height = 95%+ of the year.
  - Onboard work bench.
- Machine removal with small workboat for more major maintenance/overhaul (£3k per day).

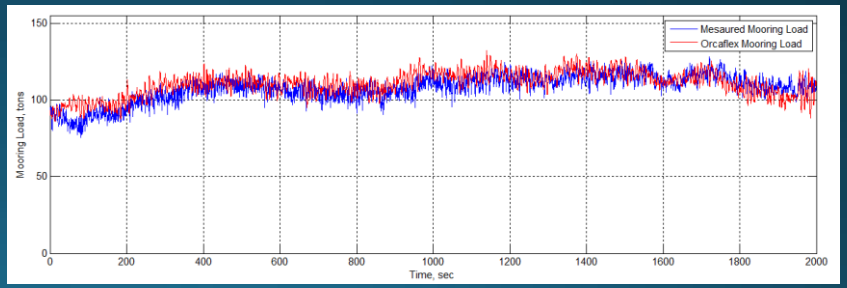




SR2000 (2MW) – Hydrodynamic & Mooring validation.

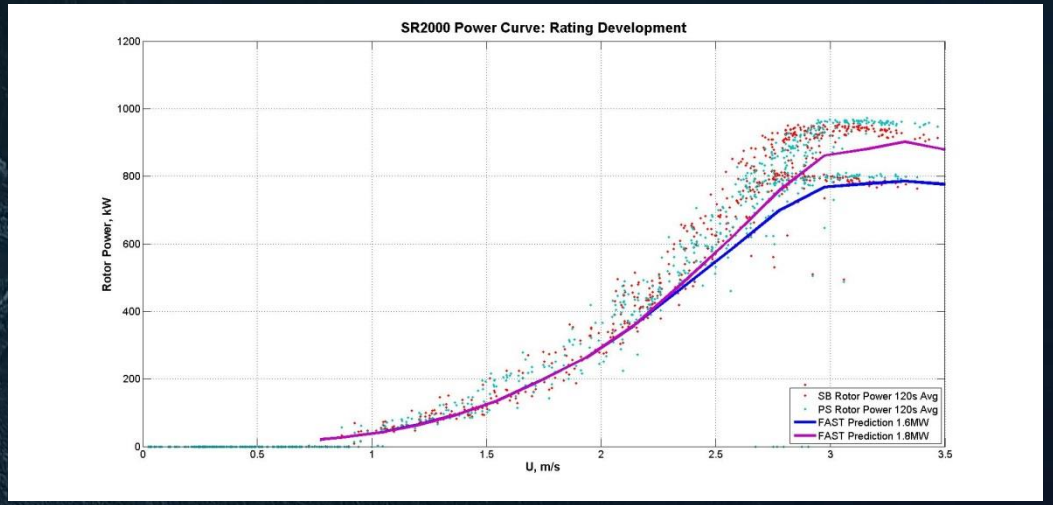
- Thrust and mooring loads in close correlation to simulations = good numerical characterisation of system at large scale.
- Ultimate mooring loads driven by controllable generation thrust (i.e. highly survivable in storm conditions: 6m Hmax experienced).
- Dynamic loading variation due to surface waves manageable for generation across ~97% of annual occurrence.



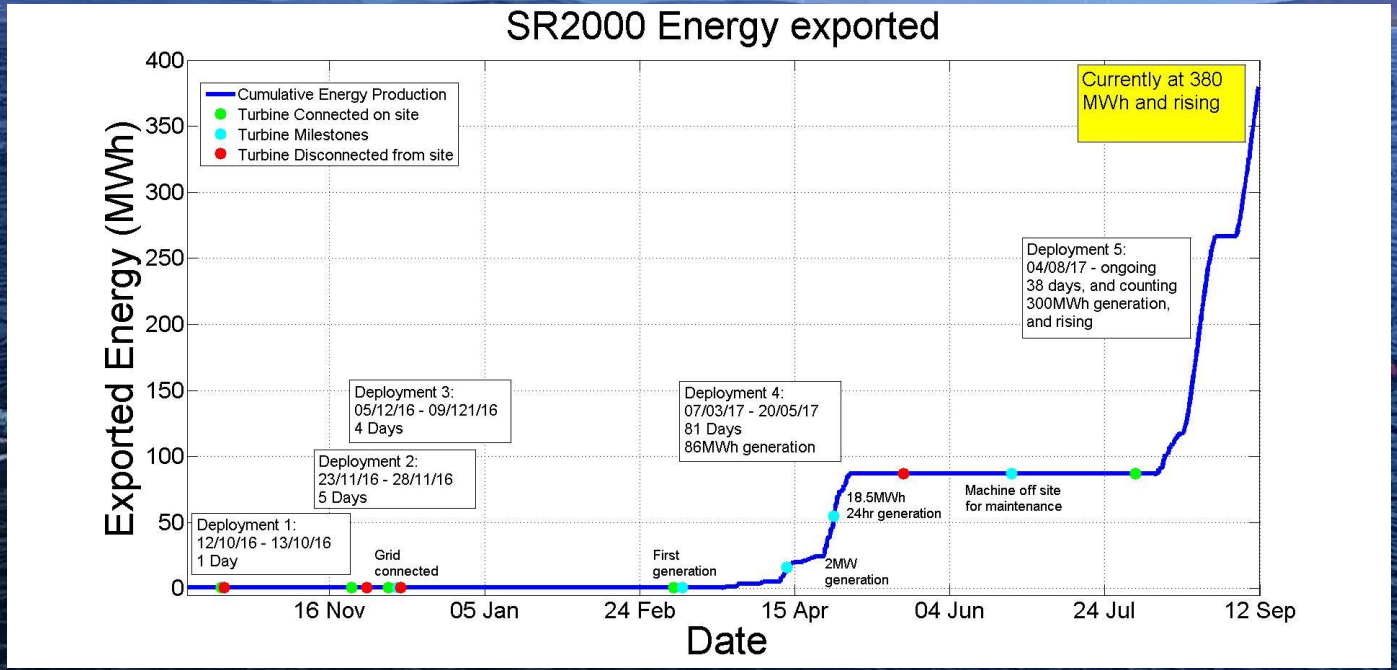


Measured vs Predicted Dynamic Mooring Load. The turbine is operating at 1MW in waves of Hs = 1.2, Tp = 8s opposing of tide of 2.3m/s

SR2000 (2MW) – Yield validation.



SR2000 (2MW) – Generation.



www.scotrenewables.com

Scotrenewables®
Tidal Power Ltd

Simon Forrest

Chief Executive Officer

Nova Innovation

Nova Innovation
Tidal Solutions Company

Scottish Renewables - Inverness

12 September 2017

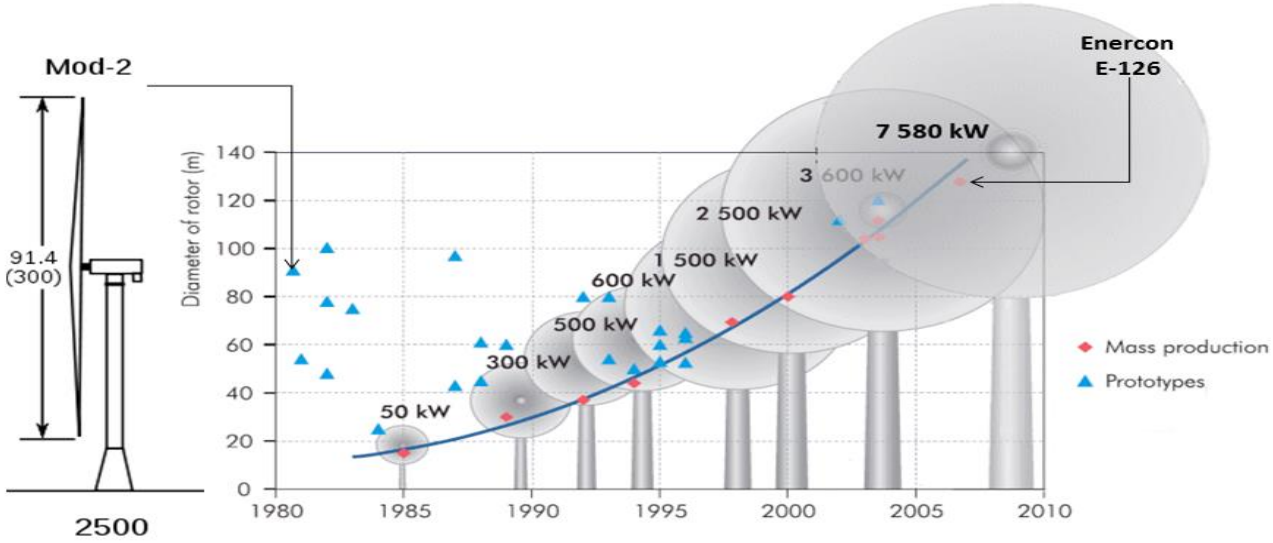
Nova Innovation – Timeline

INNOVATION™
Nova Innovation Ltd

2010	2011	2012	2013	2014	2015	2016	2017
Company founded	Seabed lease: • Nova 30 • Shetland Tidal Array	• Nova 30 design complete • Major contracts signed	• Nova 30 build complete	• Nova 30 installed & commissioned • Shetland Tidal Array contracts signed	• Shetland Tidal Array under construction • All onshore works complete	• World's first offshore tidal array • Direct Drive Prototype	• STA operation • 2nd tidal array planning and development • EC funded R&D projects

Nova Innovation's Strategy

Turbine scaling in the wind industry



Source: IEA technology perspectives 2008, Nova Innovation 2010

Lessons from the wind industry

- Follow the Danish model
- Deploy smaller devices
- Reduce engineering and financial risk
- Accumulate operating hours
- Prove reliability
- Accelerate technology evolution

Shetland Tidal Array – Nova M100

Shetland Tidal Array Video

EnFAIT Preparations: T1-T3 locations

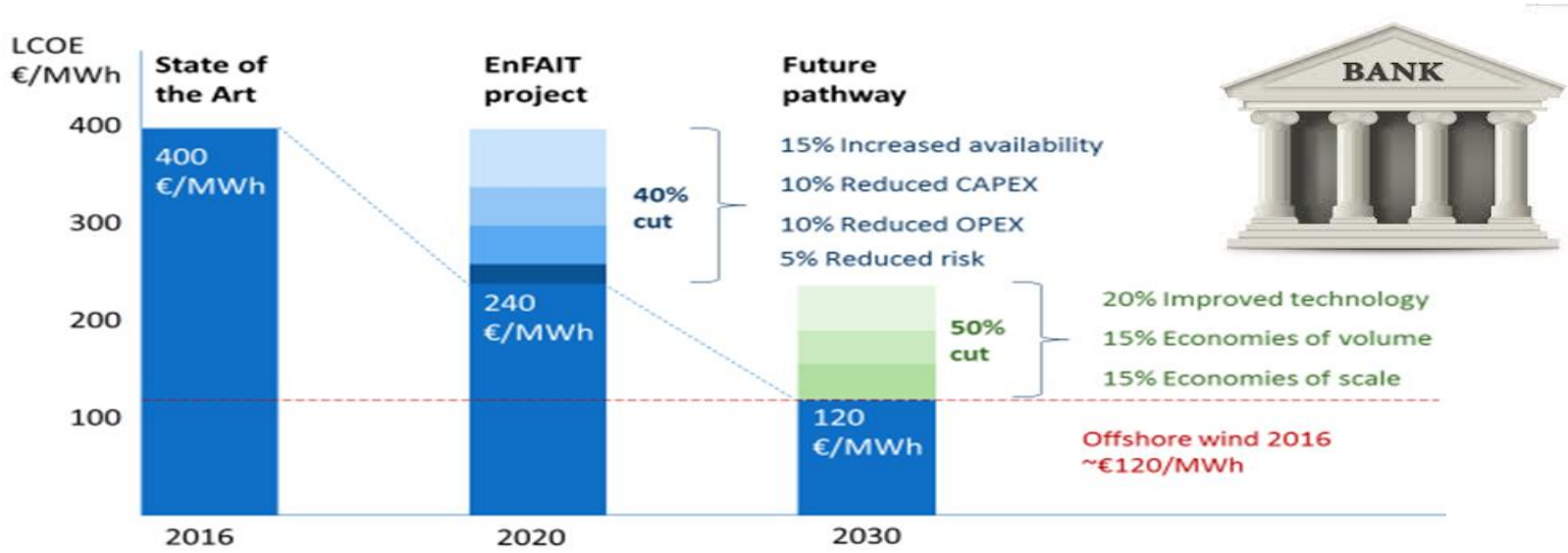
- NOVA INNOVATION-led €20m H2020 funded project
- Nine European partners
- Four Scotland-based partners
- Five year project running until June 2022
- Builds on existing Shetland Array
- Six turbines moved into different config layou

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 745862.

FnFAIT Project Partners

Participant #	Participant organisation name	Short name	Country
1 (Coordinator)	Nova Innovation	NOVA	UK
2	University of Edinburgh	UOE	UK
3	SKF GMBH	SKF	DE
4	HMK	HMK	UK
5	Wood Group Kenny SAS	WGK	FR
6	Offshore Renewable Energy Catapult	OREC	UK
7	ELSA	ELSA	BE
8	RSK Environnement	RSK	FR
9	Mojo Maritime	MOJO	UK

EnFAIT Project – bankability



- **Demonstrate Array:** Deliver a cost-effective array;
- **Reduce Lifetime Cost:** Demonstration of pathways to reduce the cost of energy;
- **Attract Investment:** Make ocean energy more commercially attractive to investors; and
- **Strengthen EU Industry:** build technology base and create jobs and growth in Europe

Nova Energy Storage System

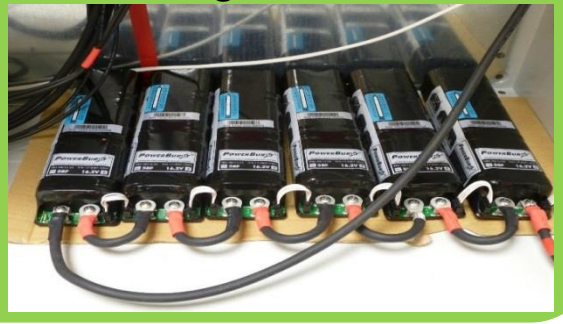
Tidal turbine emulator

User interface

Storage Medium

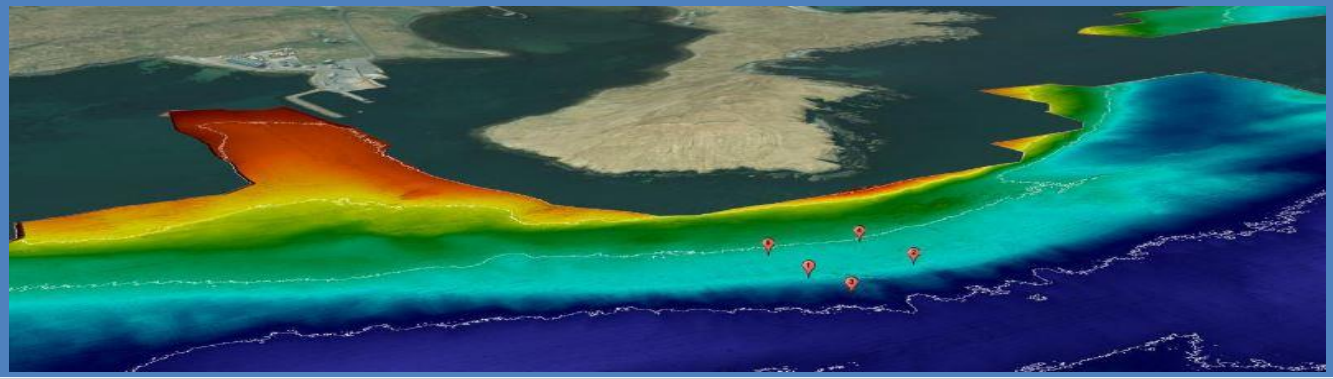
Fully functional lab

tidal simulator

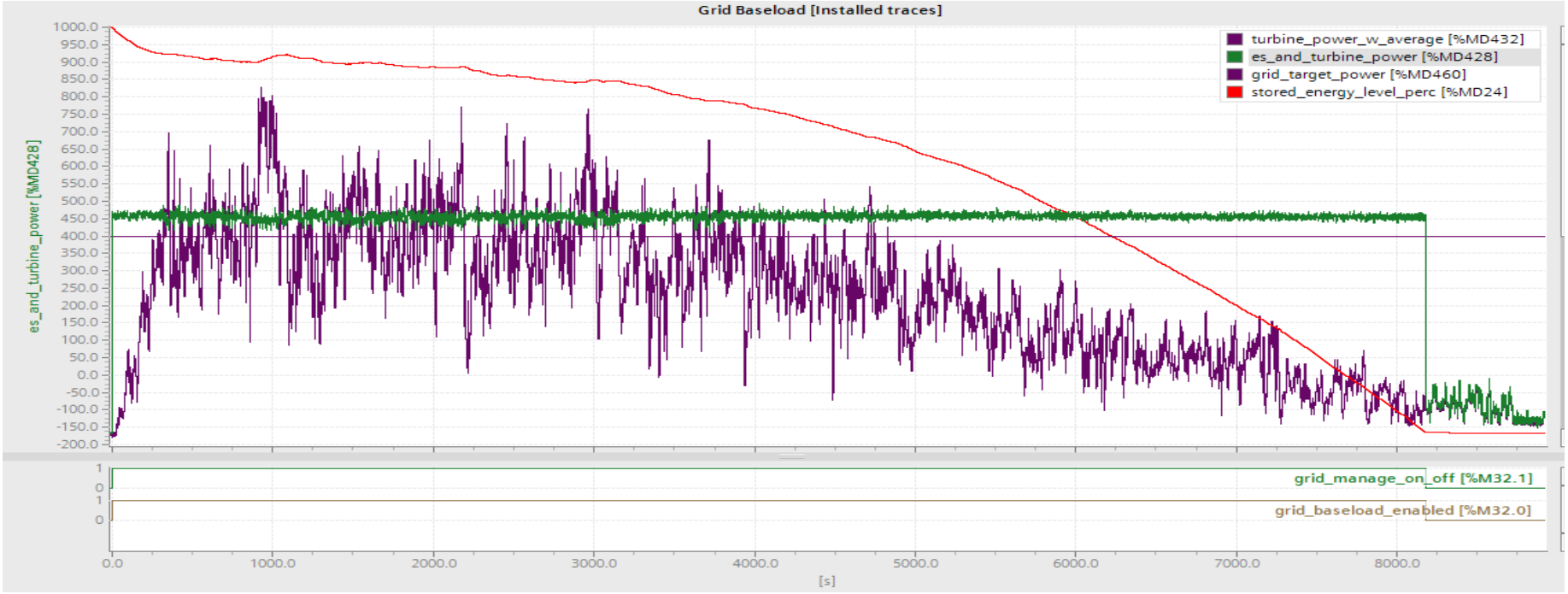


Fully operational site

Active Network Management and grid constraint



Outputs – Baseload Tidal



Discussion

Sue Barr

External Affairs Manager

OpenHydro

OPENHYDRO

HARNESSING THE TIDES

September 2017

Scottish Renewables Marine Conference

OPENHYDRO
NAVAL ENERGIES

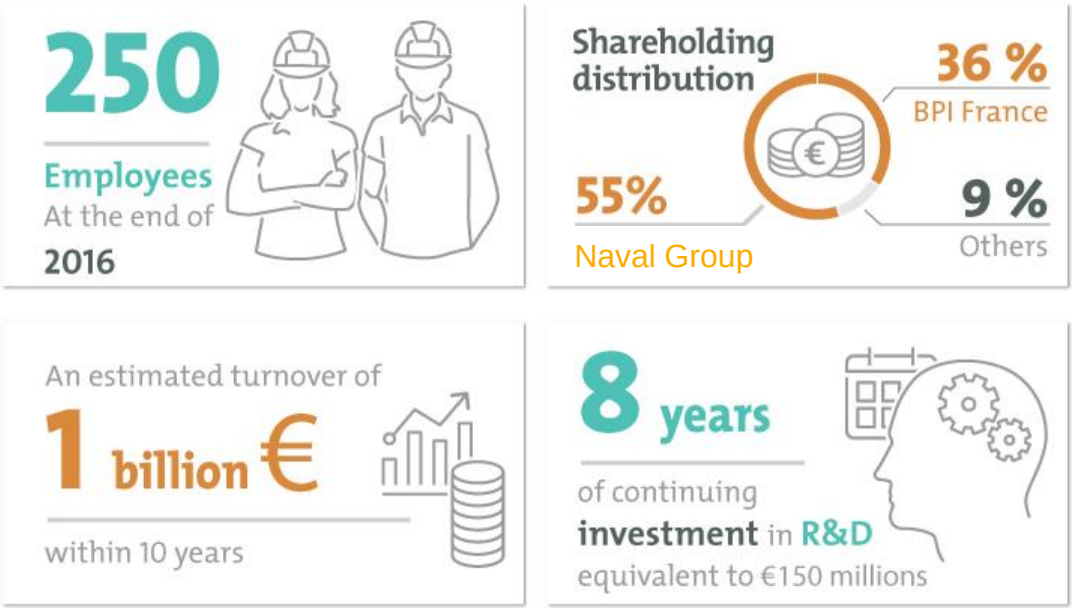
Naval Energies

A new player with global ambitions in Marine Renewable Energies

BUILDING THE BUSINESS

A focussed business, with expertise in all aspects of offshore renewable energy generation.

KEY FIGURES



TECHNOLOGY OVERVIEW

EMEC, Testing and Outcomes

TECHNOLOGY OVERVIEW

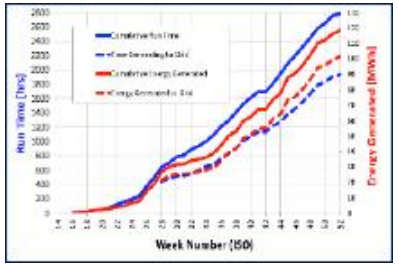
- In stream tidal energy turbine
- Bi-directional permanent magnet ring generator
- Designed for installation on the seabed in tidal races

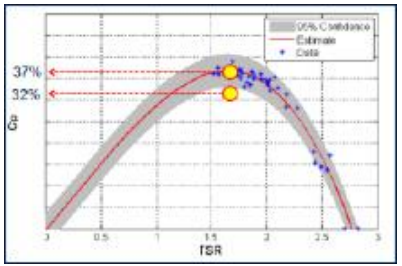
EMEC PROGRESS – OCT-06-07

OpenHydro has been testing at the European Marine Energy Centre (EMEC) since 2006; grid connected in 2008.

2014/15/16 testing focused on new power convertor (ABB) and in-house developed control system:

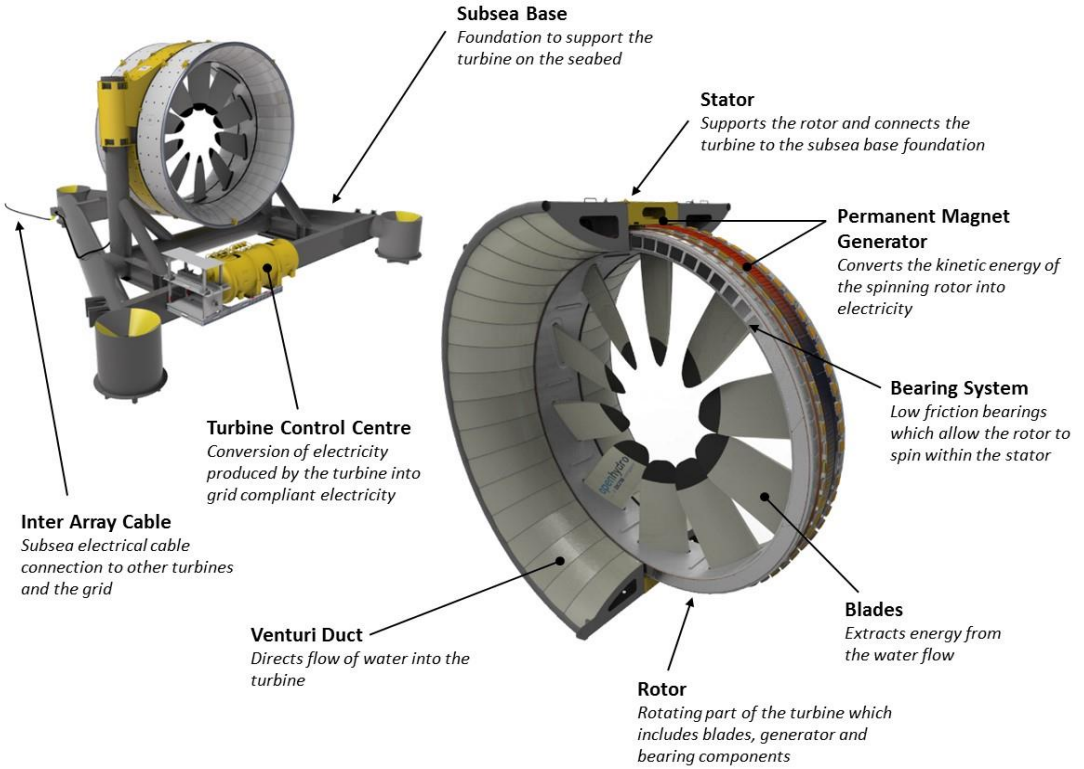
- Over 12,500 hours testing of current turbine.
- 16% improvement in turbine efficiency.





TECHNOLOGY OVERVIEW

- Turbine
- Venturi
- Subsea Base
- Turbine Control Centre
- Cables & connections
- Installation and recovery system



TECHNOLOGY OVERVIEW – SUBSEA BASE

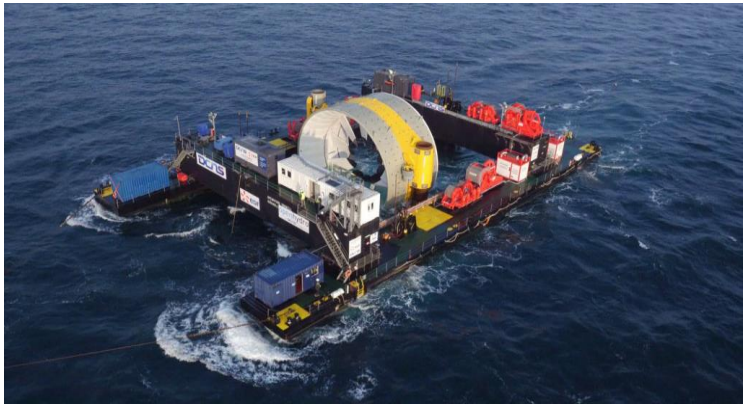
- Simple rolled steel fabrication
- Concrete ballast
- No seabed preparation
- Integrated installation and recovery system

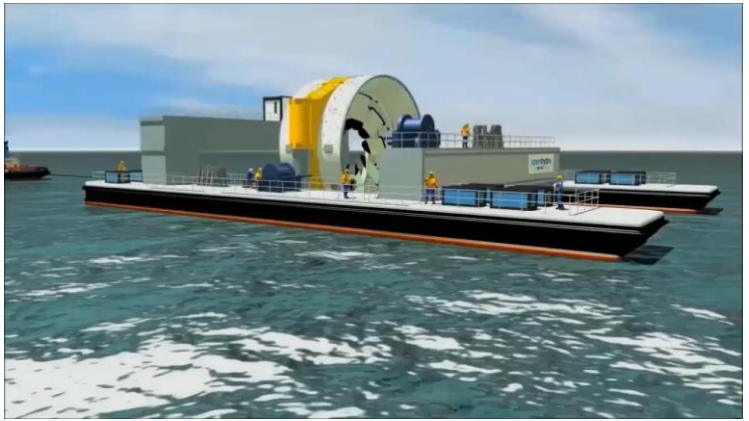
TECHNOLOGY OVERVIEW – TURBINE CONTROL CENTRE

- Power collection
- Power conversion
- Turbine control
- Voltage transformation
- Connection to export cable

TECHNOLOGY OVERVIEW – INSTALLATION BARGE

- Purpose built barges:
  - *OpenHydro Installer* Scotland 2009
  - *OpenHydro Triskell* France 2011
  - *OpenHydro Scotia Tide* Canada 2016
- OH designed lifting system
  - Winches
  - Recovery frame
  - Liftloks





PROJECT PORTFOLIO

Global Projects

DEVELOPMENT STRATEGY

Demonstration Projects

- Cape Sharp Tidal – 4 MW demonstration array, Nova Scotia
- Paimpol-Bréhat – 4 MW demonstration array, NW France
- Goto Islands – 2 MW demonstration project, Japan

Commercial Projects

- OpenHydro have an additional portfolio of commercial projects under development with a total capacity in excess of 900 MW in the UK, France, Canada, and Asia.

DEMONSTRATION ARRAY PROGRESS

Path to Commercialisation

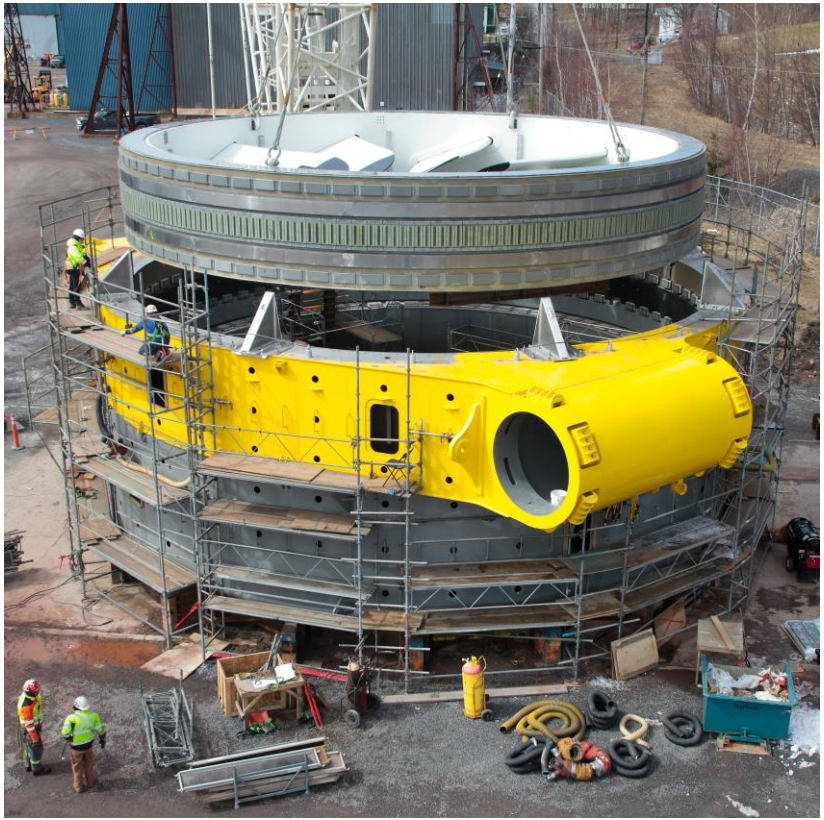
DEMONSTRATION ARRAY – CAPE SHARP

OPENHYDRO NAVAL ENERGIES

CAPE SHARP TIDAL

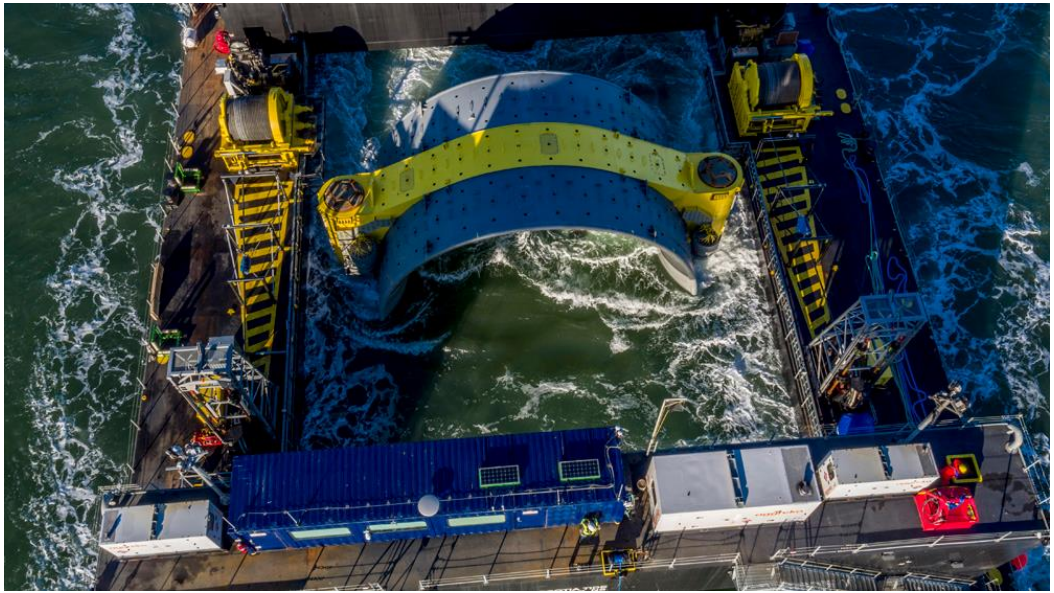
Customer	Emera
Location	Bay of Fundy
Installation	2016-17
Scale	2 x 16m
Turbine rating	2 MW

SYSTEM ASSEMBLY



MOBILISATION TO SITE

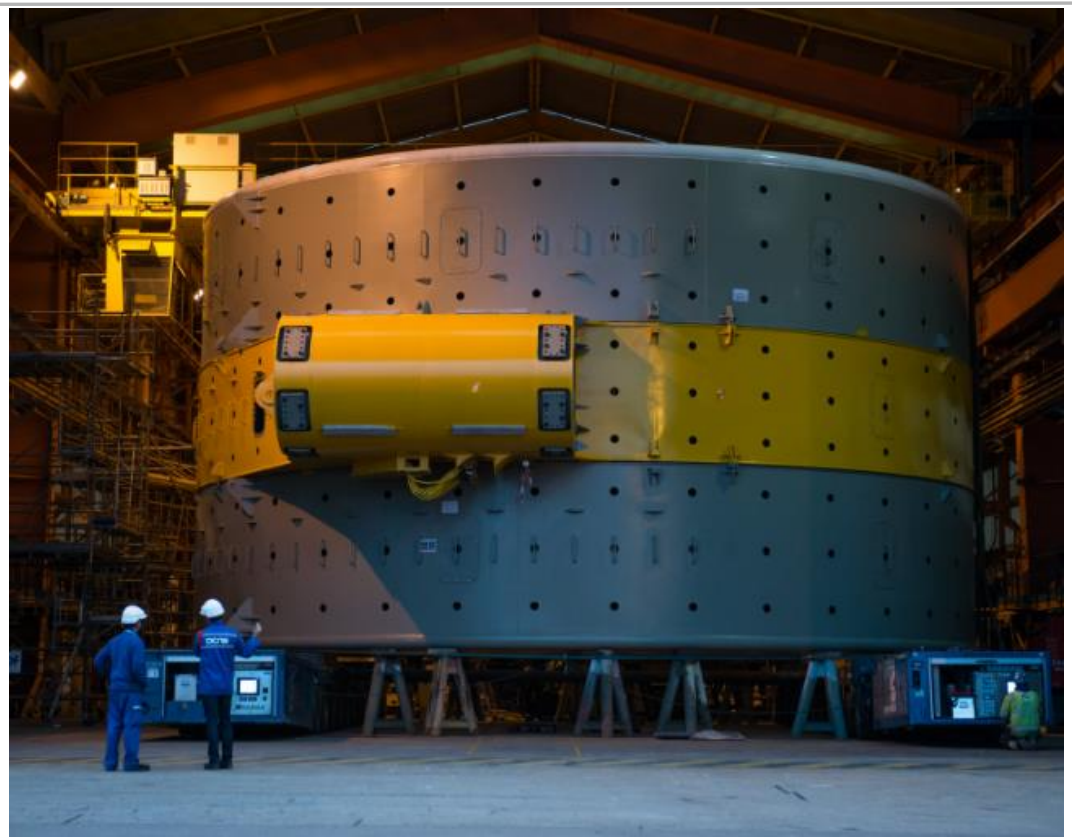
INSTALLATION & CONNECTION



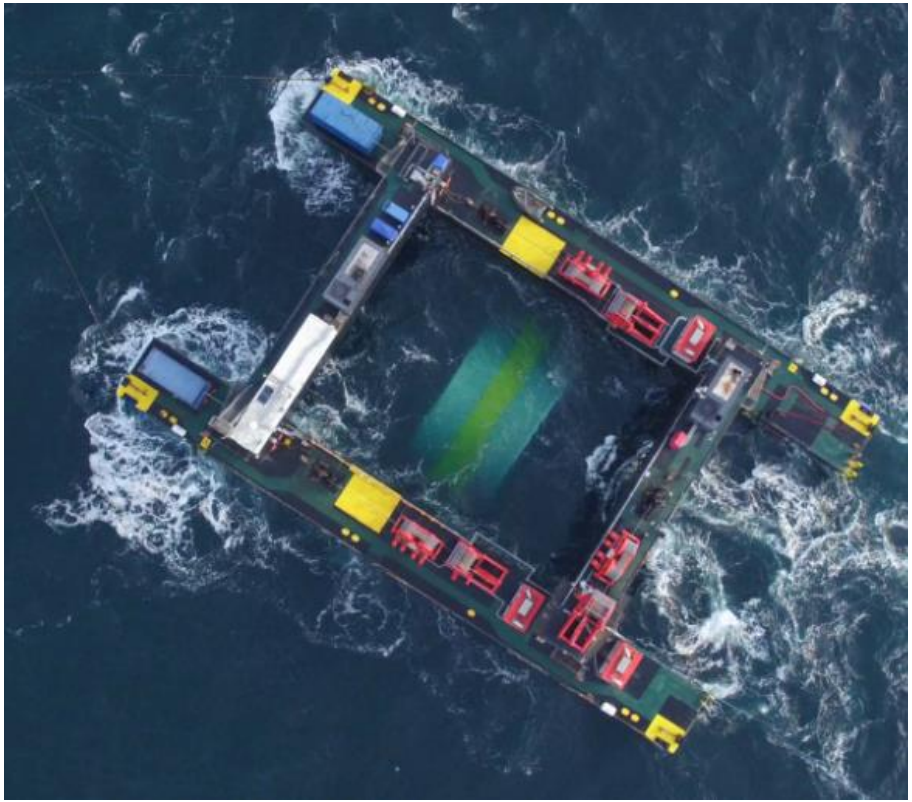
DEMONSTRATION ARRAY – PAIMPOL-BRÉHAT

Customer	EDF
Location	NW France
Installation	2016-17
Scale	2 x 16m
Turbine rating	2 MW

SYSTEM ASSEMBLY



MOBILISATION AND INSTALLATION

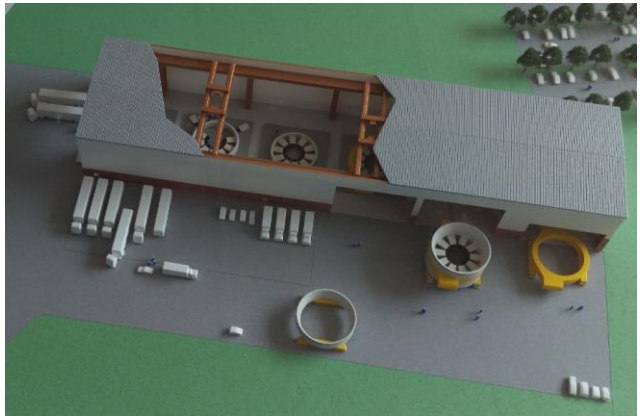


ASSEMBLY FACILITY

Cherbourg, France

ASSEMBLY FACILITY

- Capacity: 25 turbines / year
- Extendable to 50 turbines / year
- First turbine to be delivered Q1 2019



OPENHYDRO

NAVAL ENERGIES

scottish renewables

IN ASSOCIATION WITH

HIE
Highlands and Islands Enterprise
Iomairt na Gàidhealtachd 's nan Eilean

wave energy SCOTLAND

MARINE CONFERENCE, EXHIBITION & DINNER

12 & 13 SEPTEMBER 2017 INVERNESS

areg
Aberdeen Renewable Energy Group

Crown Estate Scotland
Oighreachd a' Chrùin Alba

OPENHYDRO
NAVAL ENERGIES

Innovating for Marine Energy Technologies

Chair:

Neil Kermode

European Marine Energy Centre

Simon Cheeseman, Sector Lead – Wave & Tidal Energy
Offshore Renewable Energy Catapult

Vicky Coy, Project Manager – Marine
Offshore Renewable Energy Catapult

Innovating for Marine Energy Technologies

12 September 2017 | Simon Cheeseman & Vicky Coy

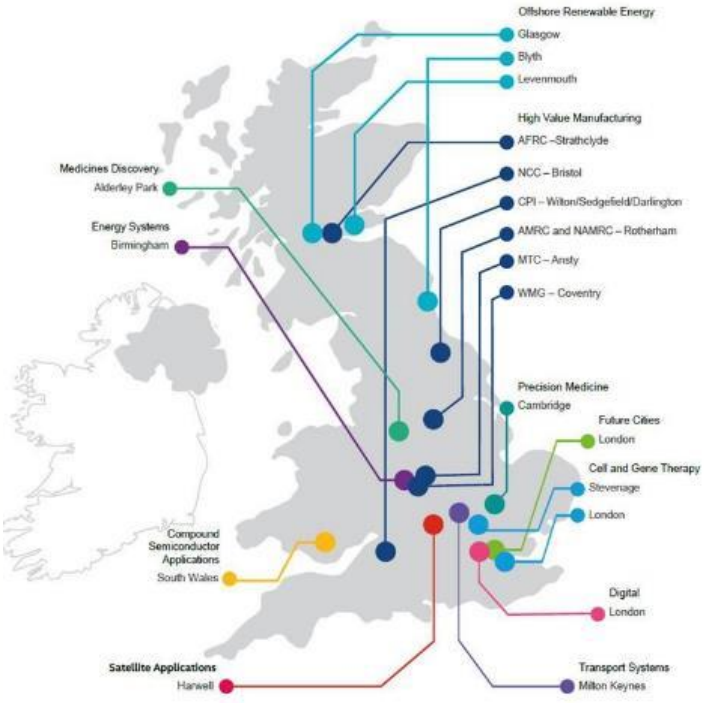
CATAPULT
Offshore Renewable Energy

The catapult network:

A long-term vision for innovation & growth

11 **Catapults**

- Established by InnovateUK
- Designed to transform the UK's capability for innovation
- Core grant leveraged with industry and other public funding
- Catapults all highly connected to their sector and each other



ORE Catapult

- Research
- Testing
- Advisory Services

Impact:

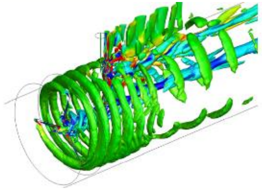
A long-term vision for innovation & growth

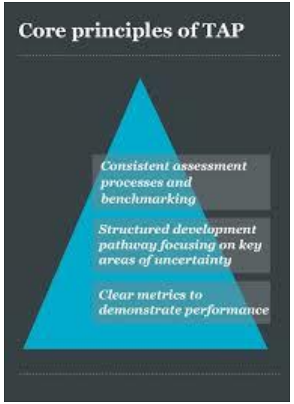
Innovation Processes

Innovation Funding

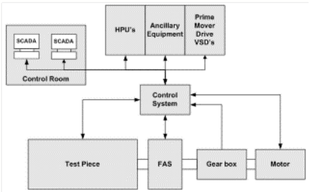
Research → Technology Assessment → Component Testing → Device Testing → Real Sea Testing

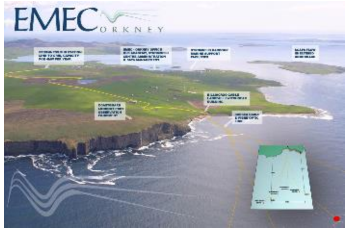
SUPERGEN MARINE





Components Guidelines

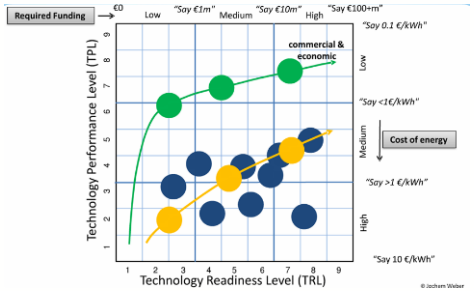




Organisation	Location	Zone type / project name
Wave Hub	North Cornwall	Wave demonstration **zone**
	North Devon	Tidal stream demonstration **zone**
	South Pembrokeshire	Wave demonstration **zone**
Siemens MCT	Dorset	Portland Bill, tidal stream **project** site
	Northern Ireland	Strangford Lough, tidal stream **project** site
	Scotland	Mull of Galloway, tidal stream **project** site
EMEC	Scotland	Isle of Harris, wave demonstration **zone**
	Scotland	Islay, tidal stream demonstration **zone**
	Scotland	Stronsay Firth, tidal stream managed test facility **project**
Menter Môn	Wales	West Anglesey, tidal stream demonstration **zone**
Minesto	Wales	Holyhead Deep, tidal stream **project** site

Wave and Tidal current demonstration zones

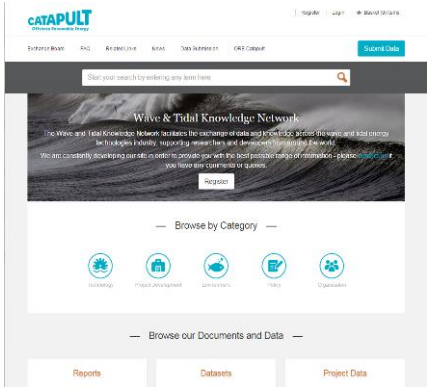
Technology – Core Characteristics

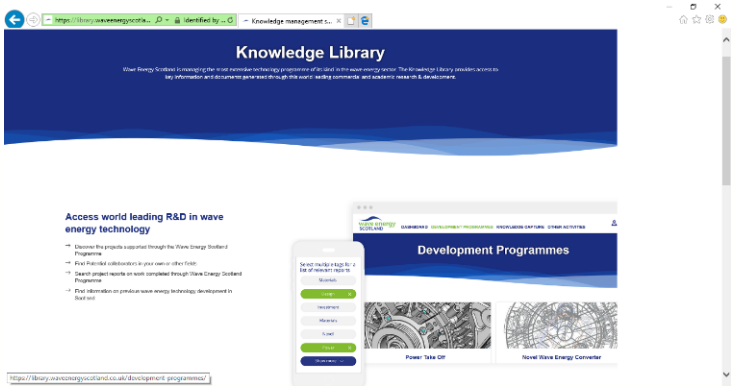


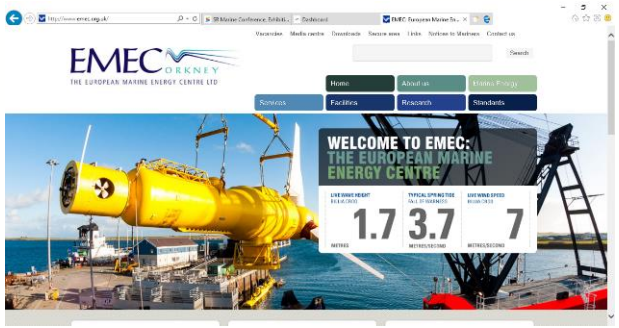
The contribution of any innovation towards LCOE depends upon a number of 'core characteristics', the most important being:

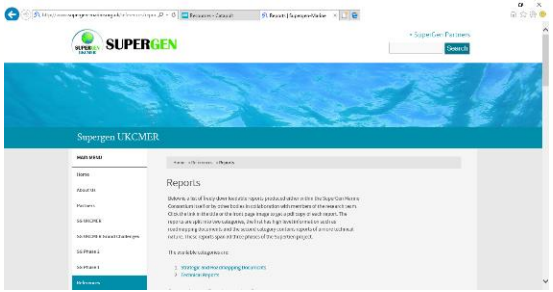
- Performance – how does the innovation boost energy productivity,
- Reliability – how does the innovation improve overall system uptime,
- Survivability – how does the innovation contribute to the system's ability to endure the external environment,
- Cost – how does the innovation contribute to a lowering of system costs.

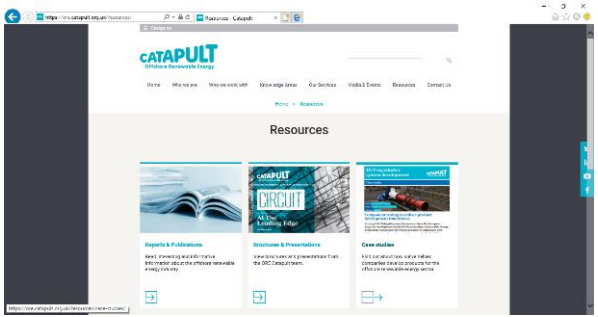
Learning – *No need to reinvent the wheel*











Innovating for Marine Energy Technologies

12 September 2017 | Vicky Coy

CATAPULT
Offshore Renewable Energy

Driving projects through innovative processes, technology and learning

- Understanding what keeps project and technology developers awake at night

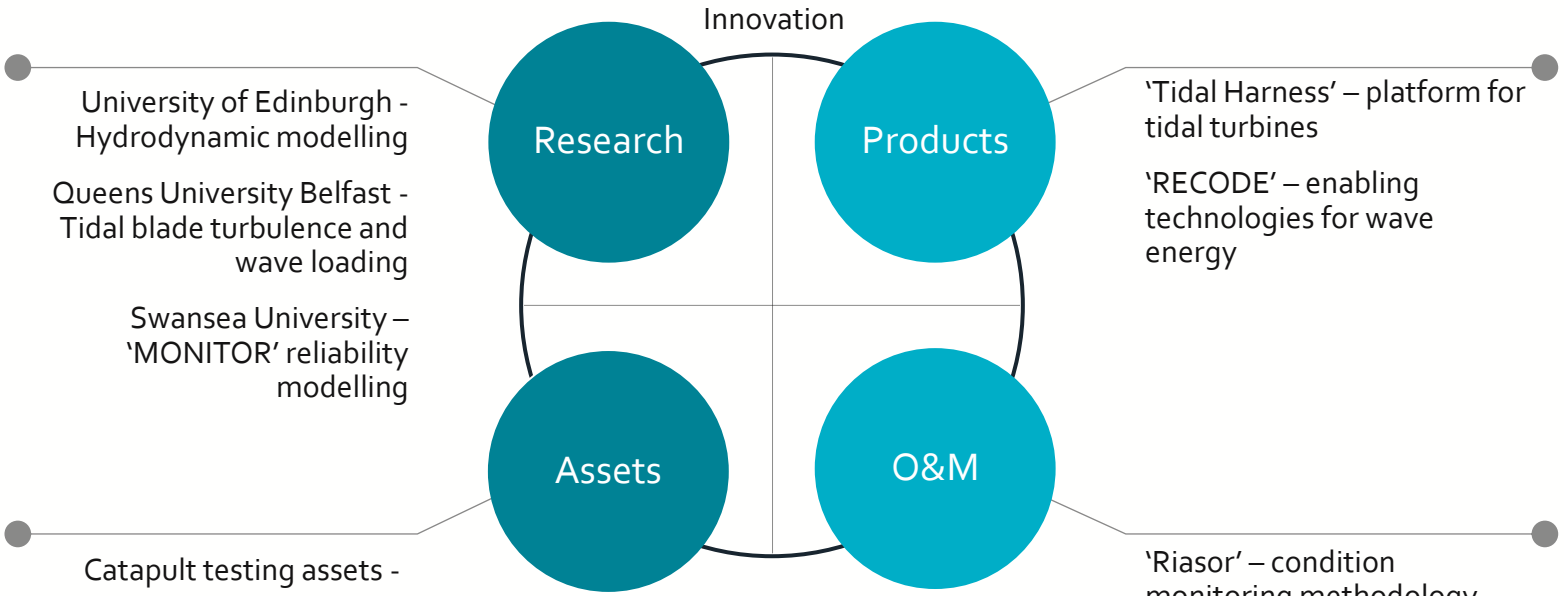
- Frequent, face-to-face meetings
- Following up on issues
- Pushing out Innovation challenges

- Identifying opportunities for collaborative funding
- Supporting partner on bids

- Using our 80+ technical staff to deliver and support
- Supplying access to our testing assets

- Build on relationship
- Advocate on policy
- Influence and lobby

Marine energy innovation projects

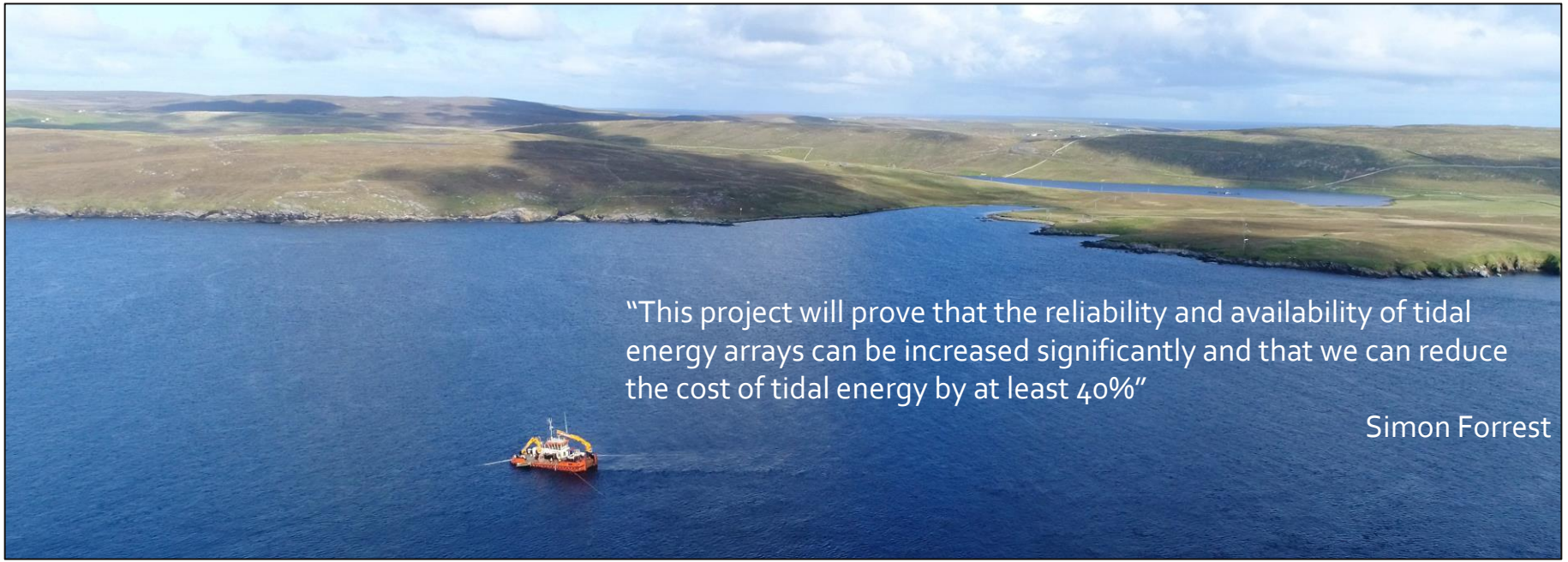


EnFAIT

- Nova Innovation actively engaged Catapult in 2013
- Led to one-to-one trusted relationship
- Identified funding calls, partnered on bid
- Successfully won largest EU-funded ocean energy project to date
- Technical delivery
- Relationship grows and we continue to identify challenges

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 745862.

EnFAIT



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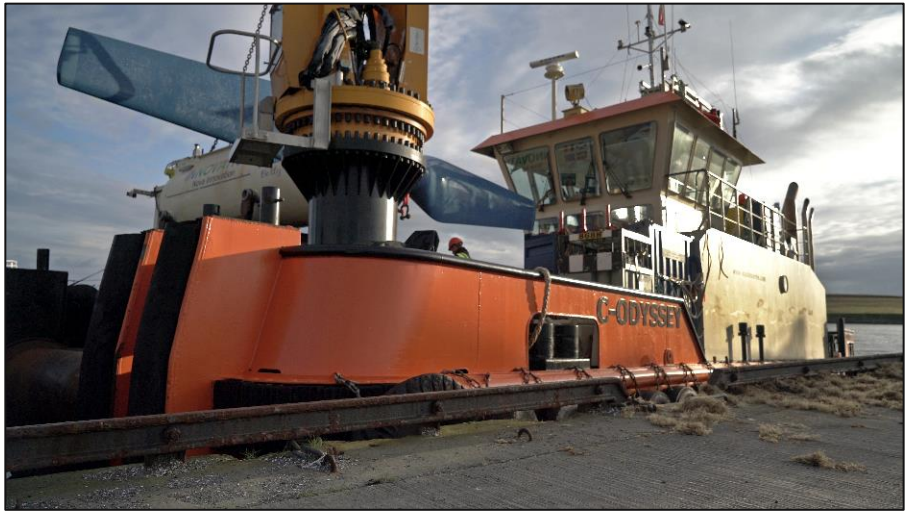
ore.catapult.org.uk
@orecatapult

EnFAIT

EnFAIT will build on existing Shetland Array of three turbines and will scale-up to six turbines



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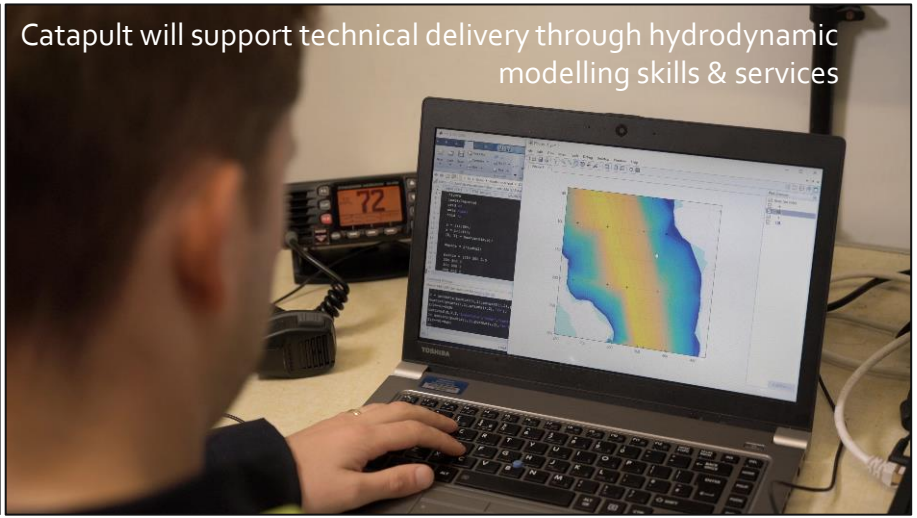
EnFAIT



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Sian Wilson
Development Manager
Crown Estate Scotland

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Marine energy innovation

Sian Wilson

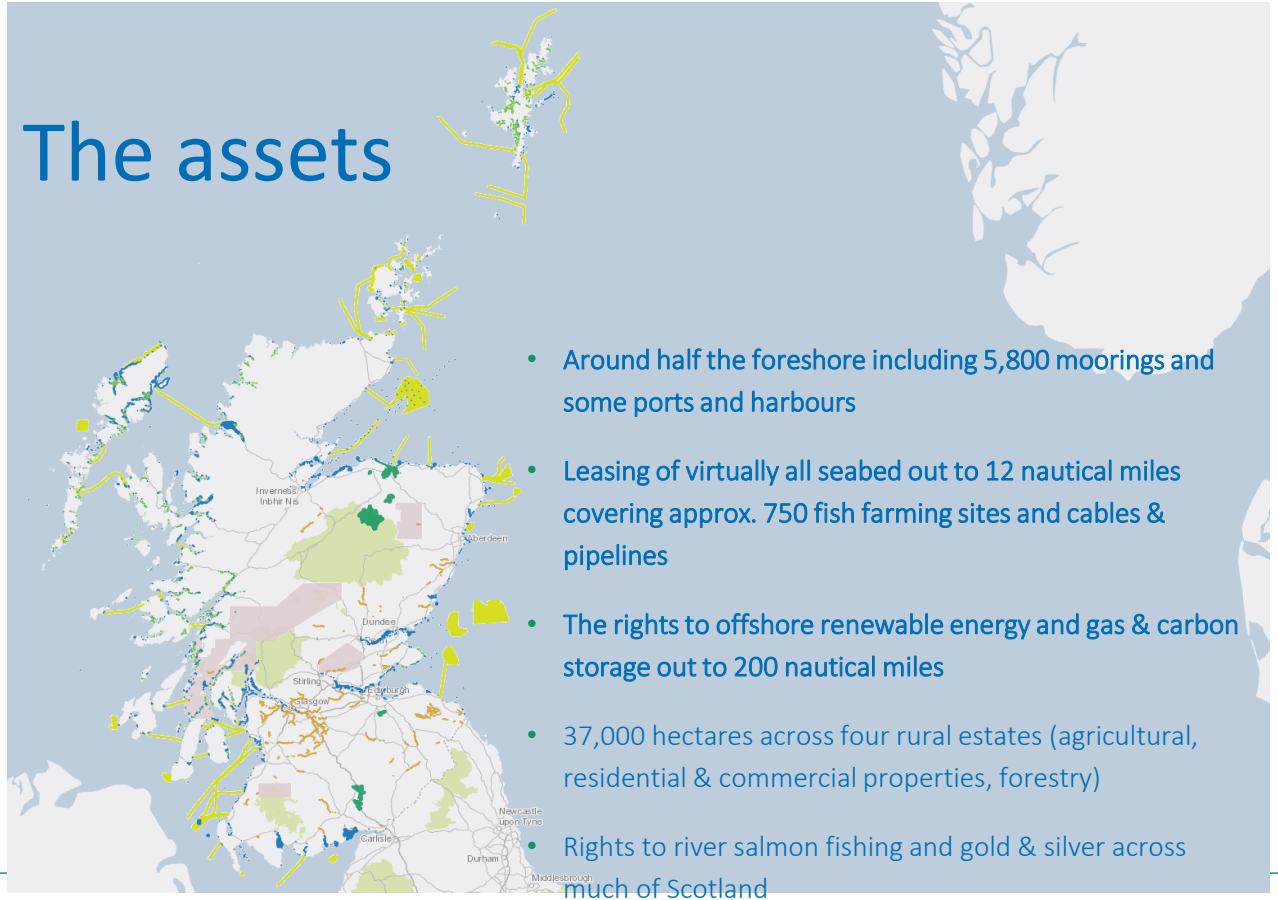
- SR Marine Conference 12th September 2017

Crown Estate Scotland

- Set up on 1st April following the Scotland Act 2016 to manage land and property owned by the Monarch
- Crown Estate Act 1961 tasks us with enhancing value and revenue ‘with due regard to the requirements of good management’
- We ensure the assets are developed and enjoyed sustainably to deliver benefits to communities and to Scotland as a whole

Crown Estate Scotland
Oighreachd a’ Chrùin Alba

The assets



- Around half the foreshore including 5,800 moorings and some ports and harbours
- Leasing of virtually all seabed out to 12 nautical miles covering approx. 750 fish farming sites and cables & pipelines
- The rights to offshore renewable energy and gas & carbon storage out to 200 nautical miles
- 37,000 hectares across four rural estates (agricultural, residential & commercial properties, forestry)
- Rights to river salmon fishing and gold & silver across much of Scotland
- One office unit on George St, Edinburgh

Crown Estate Scotland
Oighreachd a' Chrùin Alba


Our interest is in this….
.. And the value that development can bring to people, businesses and communities
How the establishment of a competitive marine energy sector is being driven by innovative processes, technology and learning

Consolidation – array deployment

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Innovative…

Processes

- Funding awards – winners and losers
- Leasing

Technology

- Many firsts….
- 1.5MW – 2MW machines in the water!
- Specific components/systems

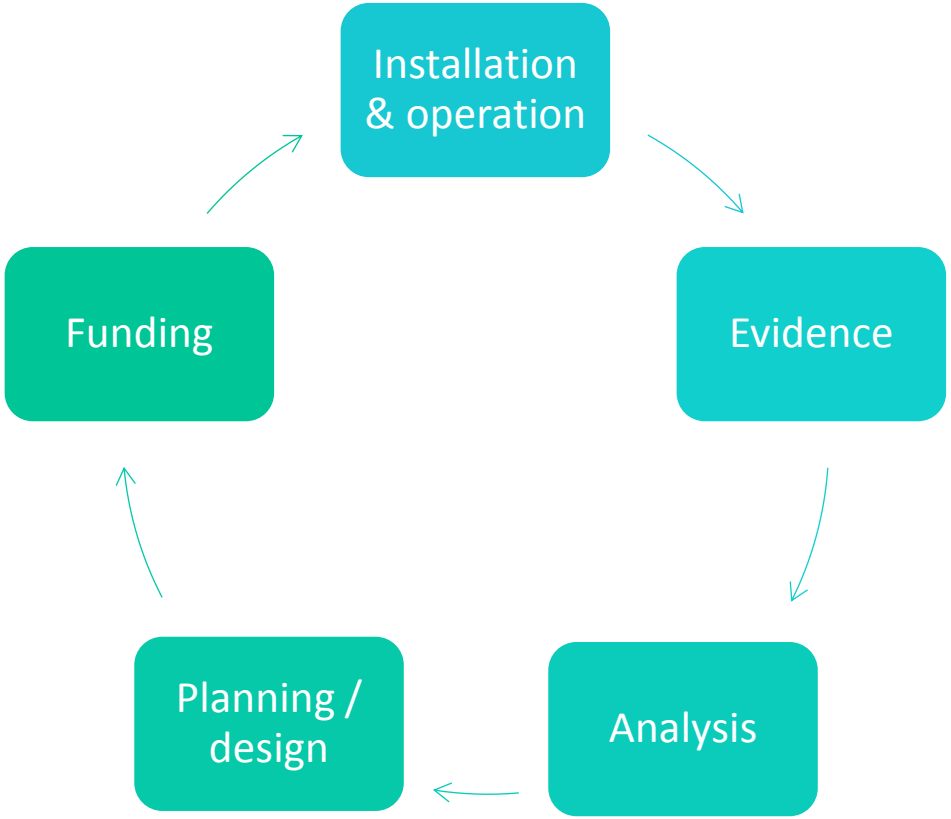
Learning

- Identifying lessons and learning

Teams

- Individuals

Project development



Conclusions

Clear value proposition

We have a clear ask – commercial support

Renewables is on the world stage at the moment

Continue to drive more innovation

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Thank you

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Crown Estate Scotland
Oighreachd a' Chrùin Alba

Neil Kermode, European Marine Energy Centre

Vicky Coy, Offshore Renewable Energy Catapult

Simon Cheeseman, Offshore Renewable Energy Catapult

Sian Wilson, Crown Estate Scotland

Marine Conference Dinner

Buses depart main entrance at 17:45

Sponsored by

Crown Estate Scotland
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scottish renewables

IN ASSOCIATION WITH

HIE
Highlands and Islands Enterprise
Iomairt na Gàidhealtachd 's nan Eilean

wave energy SCOTLAND

MARINE CONFERENCE, EXHIBITION & DINNER

12 & 13 SEPTEMBER 2017 INVERNESS

areg
Aberdeen Renewable Energy Group

Crown Estate Scotland
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OPENHYDRO
NAVAL ENERGIES

Jenny Hogan, Deputy Chief Executive, Scottish Renewables

Paul Wheelhouse MSP, Minister for Business, Innovation and Energy, Scottish Government

Tim Hurst, Managing Director, Wave Energy Scotland

Andrew Scott, Chief Executive Officer, ScotRenewables

scottish renewables

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Highlands and Islands Enterprise
Iomairt na Gàidhealtachd 's nan Eilean

wave energy SCOTLAND

MARINE CONFERENCE, EXHIBITION & DINNER

12 & 13 SEPTEMBER 2017 INVERNESS

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Crown Estate Scotland
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OPENHYDRO
NAVAL ENERGIES

Consenting and the Environment

Chair:

Caitlin Long

European Marine Energy Centre

Jonny Lewis

Secretariat

ORJIP Ocean Energy

Ocean Energy orjip working to accelerate offshore consenting

ORJIP Ocean Energy

Scottish Renewables Marine Conference

13th September 2017

Sponsors

The Crown Estate

marinescotland

Llywodraeth Cymru Welsh Government

Scottish Natural Heritage
All of nature for all of Scotland

Cyfoeth Naturiol Cymru Natural Resources Wales

Secretariat

aquatera environmental services and products

MarineSpace Making Sense of the Marine Environment™

EMEC Orkney The European Marine Energy Centre Ltd

ORJIP background

- **Offshore Renewables Joint Industry Programme (ORJIP)** is a UK-wide collaborative programme of environmental research with the aim of reducing consenting risks for offshore wind and marine energy projects. **http://www.orjip.org.uk/oceanenergy/about**

- ORJIP Offshore Wind already established and managed by Carbon Trust.

- **ORJIP Ocean Energy (ORJIP OE) was formed in March 2015** following a significant amount of work that demonstrated that a similar programme was needed for covering wave, tidal stream and tidal range.

ORJIP Ocean Energy

- The programme sponsors are:

- The programme sponsors have commissioned a Secretariat to manage the programme. Since 2015 to date, the Secretariat is being run jointly by:

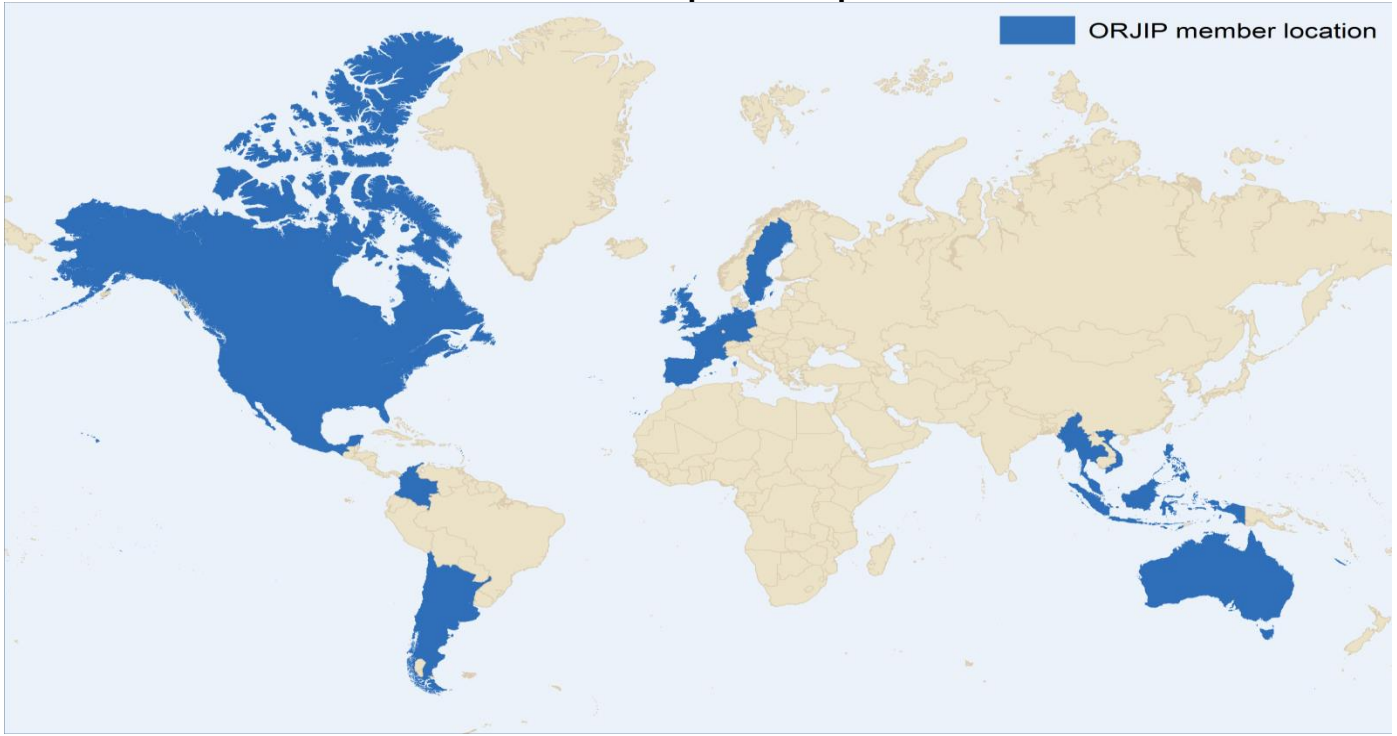
- The Secretariat seeks to stimulate the identification and collaborative commissioning of the priority research projects by identifying project leaders and funders from within the network of members. The Secretariat is the

Progress to date (1/3)

Apr 15	Steering Group convened and Network formed
Apr 15	First “Call for Evidence” circulated
Jul 15	First version of “Forward Look” document completed
Dec 15	Second “Call for Evidence” circulated
Jan 16	Second Draft of “Forward Look” issued to Steering Group
Jan 16	Second Steering Group Meeting
Mar 16	“Call for Evidence” circulated specific to Tidal Range projects
Sep 16	MoU signed with OES Annex IV
2016	Attendance at range of conferences and events
Feb 17	Fourth Steering Group Meeting
May 17	Joint ORJIP OE/NERC Tidal Lagoon workshop (Bristol)
Jun 17	Forward Look updated with Tidal Lagoon R&D priorities

Progress to date (2/3) - Network coverage

- International Network with 72 participants from 21 countries



Progress to date (3/3)

- Key links established:

seacore
southeast asian collaboration for ocean renewable energy

CATAPULT
Offshore Renewable Energy

WORLD OCEAN COUNCIL
The International Business Alliance for Corporate Ocean Responsibility

MARINE ALLIANCE SCIENCE TECHNOLOGY SCOTLAND

PRIMaRE
Partnership for Research In Marine Renewable Energy

OES OCEAN ENERGY SYSTEMS
An IEA Technology Initiative

SEACAMS

- Representation on industry forums:

Ocean Energy Forum – Environment and Consents Group

High priorities (wave/tidal stream)

- **Collision risk**
  - Near field monitoring
  - Research into the likelihood, probability and consequences of collision
  - Development of instruments and methodologies for monitoring
- **Underwater noise**
  - Development of noise propagation models
- **Displacement**
  - Development of an agreed approach to assessment

High priorities (wave/tidal stream)

- **Regulatory issues**
  - Review of the PBR approach to regulation
  - Development of methods/approaches to managing risk
  - Agreed methods/processes for developing Project Environmental Management Plans (PEMPs) for demo and commercial scale projects
- **Shipping and navigation**
  - Further development of approaches to assessing potential impacts on shipping and navigation

High priorities (wave/tidal stream)

- **General**
  - Monitoring to help better understand wildlife behaviour around machines and arrays (including development of instruments)
  - Further development of mitigation measures
  - Further research into potential population level effects
  - Review and dissemination of environmental monitoring results

High priorities (tidal lagoons)

- ***Potential* R&D Priority Projects**
  - Good Practice Guidance on Assessing Physical Process Impacts of Tidal Lagoon Developments
  - Good Practice Guidance on Methods and Criteria for Collecting Fish Data to inform EIA for Tidal Lagoon Developments
  - Good Practice Guidance on Methods of Impact Assessment for Fish Ecology in relation to Tidal Lagoon Developments
  - Review of effective and suitable mitigation and monitoring strategies for marine/estuarine and freshwater diadromous fish in relation to tidal lagoon developments

Hendry Review - 2016

- ORJIP OE provided a formal response to the Hendry Review process in 2016

- Key elements of the ORJIP OE submission built upon comments obtained via the CfE process (Mar/Ap 2016)

- ORJIP OE subsequently invited to meeting (Mar 17) between Charles Hendry and selected eNGO's (hosted by the Wildlife Trusts) in London

Next Steps – 2017 and beyond

- 9-month extension to the ORJIP OE agreed with all project sponsors
- Update and re-issue of Forward Look
- Discussion at next Steering Group meeting (Oct 17) on priority R&D projects and mechanisms for funding these
- Look to secure funding and initiate high priority projects that will reduce

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Paul Darnbrough
Associate Director
ITP Energised

ITPENERGISED
Earth. Smart. Solutions

Consenting in the Marine Environment

By Paul Darnbrough

Introduction to ITPEnergised

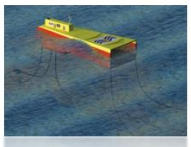
- Provide renewable energy, engineering and environmental consultancy
- In 2016: itp › ITPENERGISED Earth. Smart. Solutions
- Offshore renewable energy group in Bristol since 1991
- Over 100 offshore energy projects, 28 technologies


1991 Tidal Stream Demo - Loch Linnhe


2003 Worlds' First Marine Current Turbine - SEAFLOW


2008 PS100 Installation in the River Humber


2008 Wavestar Demonstrator


2011 OWEL Demonstrator

2014 – present Minesto


2015 / 2016 Instream Platform


2012 - present PTEC 30MW tidal site

My Experience

Aberdeen

Ardrossan

MacDuff

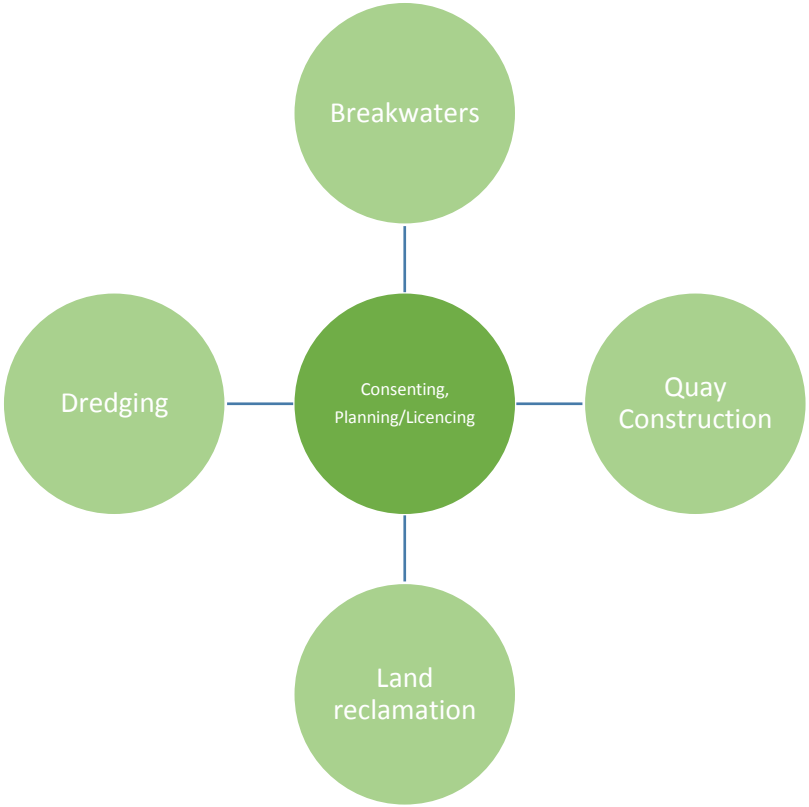
Lerwick

Port of Tyne

Dunbar

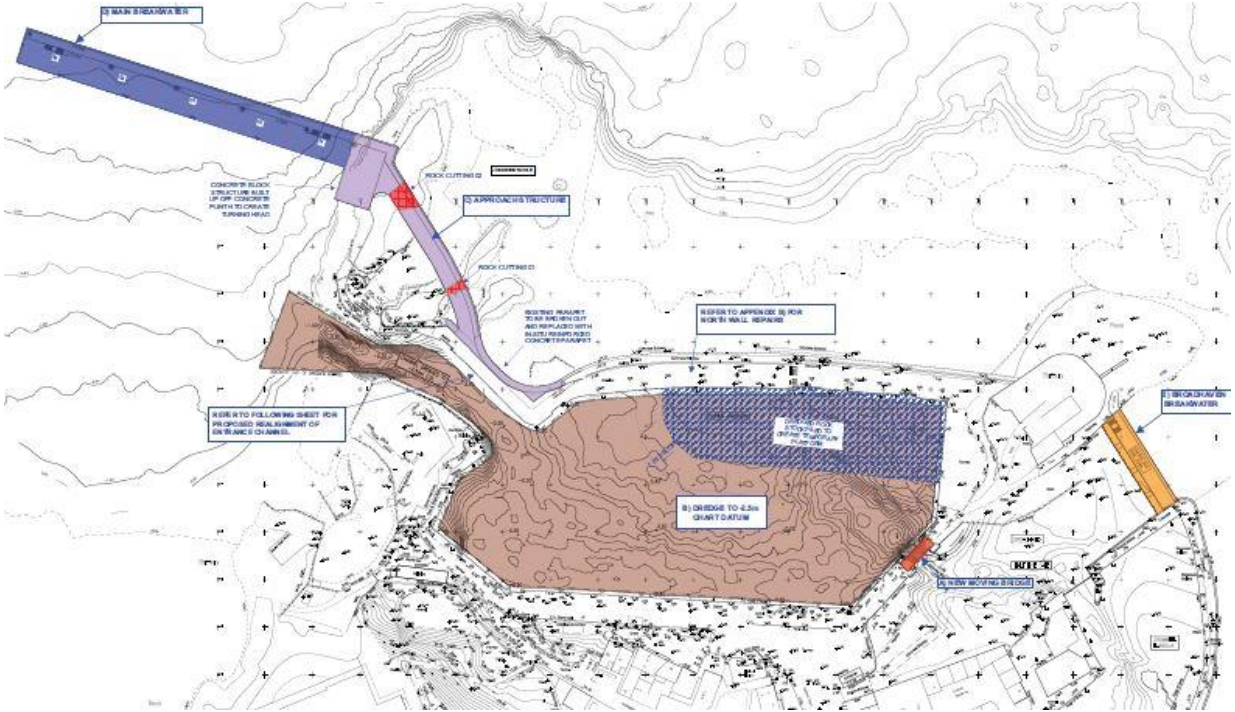
Mallaig Harbours

Hendry Review of Tidal Lagoons in the UK



Aim-Provide guidance and tips on securing marine consents.

Define the Project



What are you seeking consent for?

Provide clear plans

Establish lead regulator

Understand the Sensitivities

Consult

Empathise with the regulators

Proactively consult the community

Be prepared to lead

Be open, flexible and adaptable

Use visualisation


BEFORE


AFTER

Let the science talk!

Use technical specialists

But communicate in non-technical terms

State limitations clearly

Be willing to share the knowledge

Case study

ITPENERGISED
Earth. Smart. Solutions

Post-consent

- Put theory into practice
- Don’t rest on our laurels
- Produce a thorough Construction Environmental Management Plan
- Apply the mitigation and monitoring
- Appoint an Environmental Clerk of Works (ECoW)

Thanks for listening

www.itpenergised.com

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Chris McCabe
Environmental Consultant
BMT Cordah

BMT Cordah

"Where will our knowledge take you?"

It's the simple things that can catch you unaware:

Potential Management Plans for Marine Growth in the Marine Renewables sector

Chris McCabe, BMT Cordah
September 2017

Contents

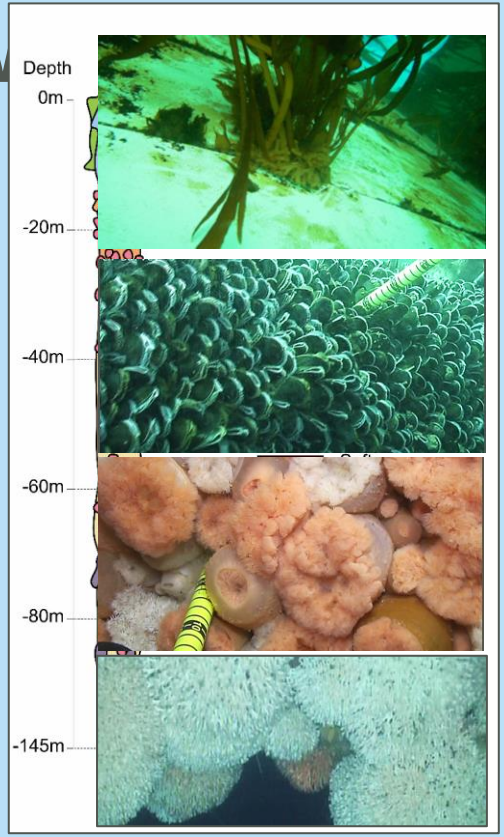
- Marine Growth
  - Introduction
  - BPS Case Study
  - Spatial Database
- eDNA
  - Introduction
  - Application
- Applications & Management Plans

What is Marine Grow

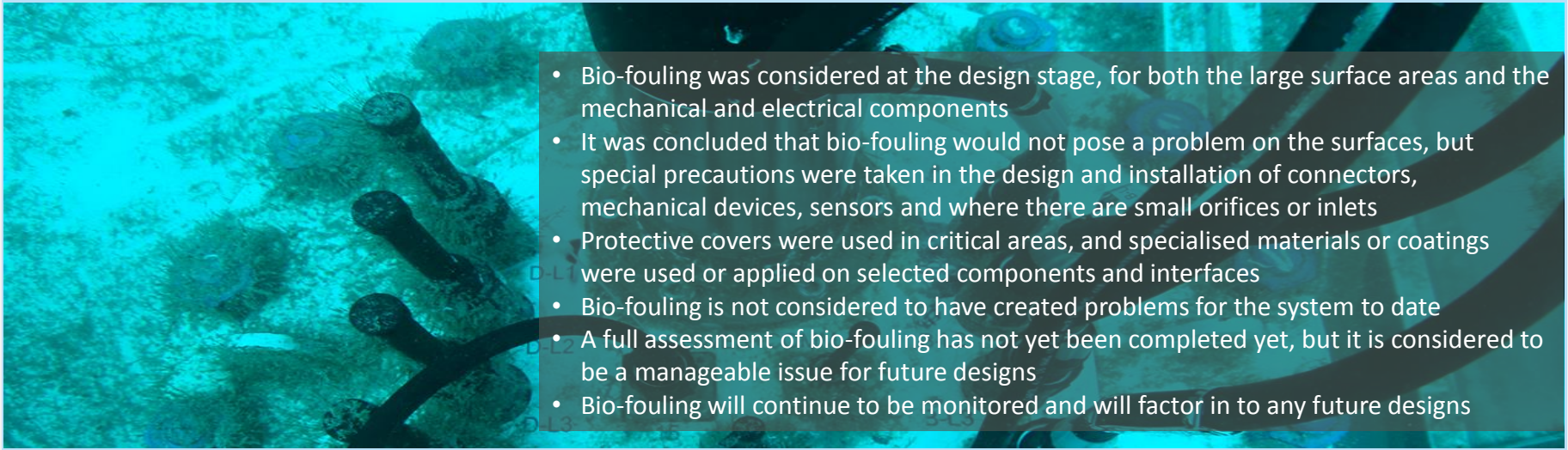
Marine growth is a term used to describe sessile organisms that colonise submerged structures/infrastructure, also known as **“Marine Fouling”**

Effects and Considerations for offshore industries:

- Hydrodynamic
- Use of land-based resources (landfill facilities)
- Weight
- Corrosion and Surface Damage
- Odour impact
- Reduction of Efficiency
- Seabed impact from marine growth removed in situ
- Increased Maintenance Requirements
- Health and Safety Issues
- Protected and non-native or invasive species may be present
- Legislative Issues



Bio-fouling Considerations for the bioWAVE Pilot Project, Australia



- Bio-fouling was considered at the design stage, for both the large surface areas and the mechanical and electrical components
- It was concluded that bio-fouling would not pose a problem on the surfaces, but special precautions were taken in the design and installation of connectors, mechanical devices, sensors and where there are small orifices or inlets
- Protective covers were used in critical areas, and specialised materials or coatings were used or applied on selected components and interfaces
- Bio-fouling is not considered to have created problems for the system to date
- A full assessment of bio-fouling has not yet been completed yet, but it is considered to be a manageable issue for future designs
- Bio-fouling will continue to be monitored and will factor in to any future designs

Marine Growth - Spatial Database

- BMT Cordah has over 30 years' ex
  assessments and holds marine gro
  representative coverage of the Nort
  - The numerous years of experienc
    allowed BMT Cordah to contribut
    that have required such a broad s

OBJECTIVE

- Estimate dispersal potential of representative marine growth species between offshore North Sea oil and gas platforms
- Model the ecological consequences of altering the configuration of this subsea network

The ANChor Project

- Appraisal of Network Connectivity
  oil and gas infrastructure

EcoConnect

- Assessing the Ecological Connec
  structures in the North Sea

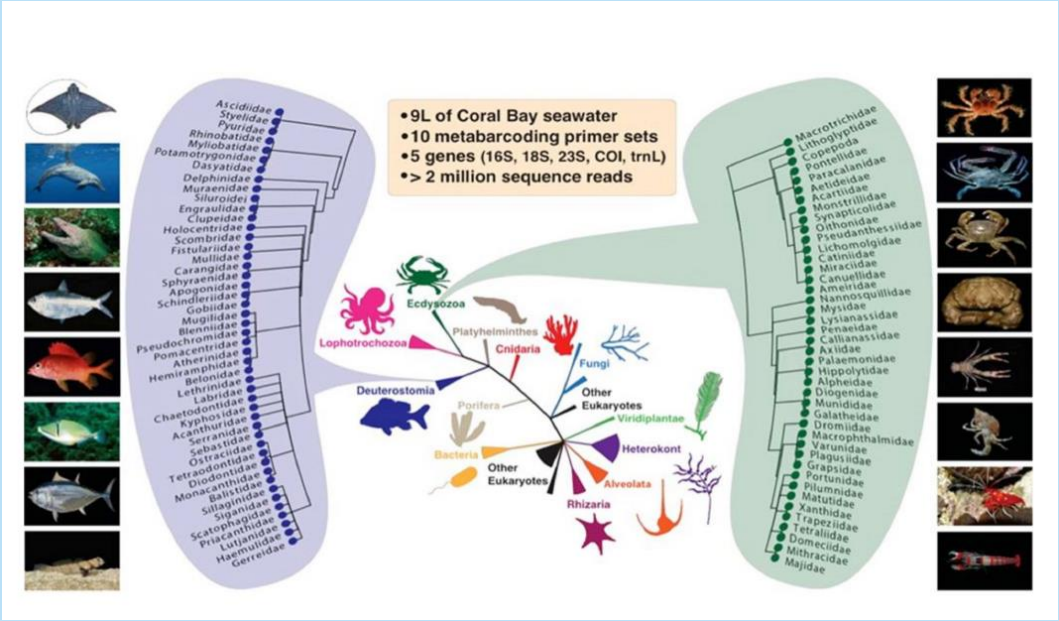
RECON

- Reef effects of structures in the North Sea: Islands or

BMT Cordah

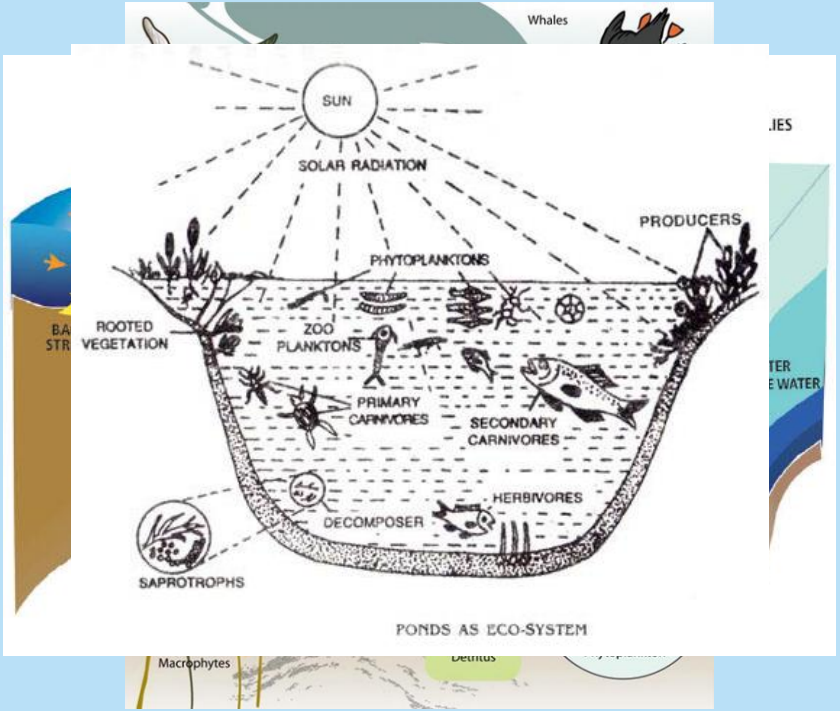
eDNA

- eDNA – Definition “eDNA (Environmental DNA) – describes the DNA that is released by an organism into the surrounding environment”
- Genetic identification the presence of marine species



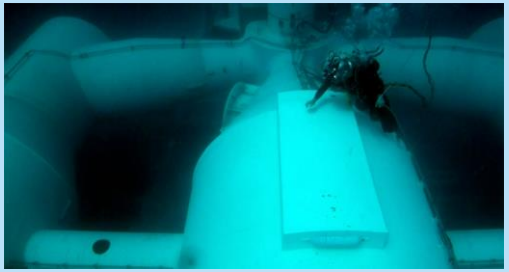
eDNA – The Application

- Challenges
  - The marine environment
  - Temporal degradation
- Previous Studies
- Application



Application and Management Plans

- Marine Growth = **Issue**
- eDNA = **Precursor to advise**
- Spatial dataset + Experience = **Predictive tool**
  - Species composition
  - Settlement
  - Invasives
- This will allow for a risk/ evidence based assessment of the area of deployment, allowing for appropriate action to be taken:
  - Site Designation
  - Anti-fouling measures
  - Planning of assessment/ cleaning/ treatment
  - Design and Innovation



BMT Cordah

"Where will our knowledge take you?"

Thank you

Special Thanks:

- Tim Finnigan, BPS
- Faron McLellan & Claire Hinton, BMT Cordah
- Chris Shearer, BMT WBM

Sarah-Jane McArthur
Kirsty Macpherson
Partners
Brodies

BRODIES LLP

Crofting, Cable Routes and Grid Sharing

Kirsty Macpherson, Partner

Sarah-Jane McArthur, Partner

13 September 2017

Outline

- Crofting
- Cable Routes
- Constrained Grid and Sharing

Crofting Background

- What is a croft
- Who is a crofter
- Where are crofts found
- Are crofters any different to other occupiers of ground?

Crofting Background

- Where do rights stem from?
  - Clearances
  - 19th century they were recognised in their own right
- What is the key aim of the Crofting Laws?

Crofting

- How does it affect tidal schemes?
  - Most likely for the cable route
  - Only if located in crofting areas
  - This can include foreshore
  - Common grazings may affect

Crofting

- What do you do if there are areas affected
  - Obtain their consent
  - Land Court require to give input on this
- What type of rights might a developer require?
  - servitude for the cable
  - A lease of the sub-station

Crofting

- Servitude
  - No consent required by crofter
  - But – what about compensation for loss of grazing
  - What rights does developer require?
    - Initial build
    - Maintenance, repair, rebuild
  - Temporary or permanent

Crofting

- Lease of sub-station
  - Crofters' rights affected for the duration of the scheme
  - Therefore require crofter consent

Crofting – form of consent

- Either servitude or Lease
  - You are likely to require crofter consent
  - What does this involve?
- If crofter agrees
  - S 5 (3) Agreement
  - Land Court process
- Crofters refuse to consent
  - S19a Scheme for Development

Constrained Grid Options

- Grid constraint particularly affects remote coastal and island projects
- Long term there may be infrastructure solutions
- For projects in development now there are still options
  - Grid Sharing
  - Active Network Management
  - Incorporating Storage
  - Private Wire/ Local Supply

What do we mean by Grid Sharing?

- Essentially sharing a grid connection between one or more projects
- Usually sharing the same cable but not essential
- Works on private wire or grid network connection.
- Set-up Options
  - Simple grid access agreement
  - Grid share with multiple developers
  - Structured arrangement with Grid Co

General Pros and Cons

- Advantages:
  - Earlier grid access
  - Co location of technologies may allow export to be maximised.
  - Ability to share grid costs

- Disadvantages:
  - Less control over export route.
  - May not be able to export full capacity.
  - Structured arrangements required for finance.
  - Power purchase and metering can be complex.

Pros and Cons

Simple Access

- Straightforward to set up and document

BUT

- Very limited control over the grid connection.
- Little protection if the grid connection is disconnected
- Exposed to insolvency risk of primary connection holder
- Funding will be difficult.

Simple access may still work for some projects.

Pros and Cons

Simple Grid Share

- Relatively straightforward to set up and document

BUT

- As with Simple Access, little control over the grid connection and little protection if the primary connection is disconnected.
- Exposed to insolvency risk of primary connection holder and funding may be difficult

Can work well for portfolio projects.

Pros and Cons

Structured Grid Share

- More complicated to set up as grid co is required.
- ‘Insolvency remote’ structure may affect cashflow.
- All generators have more control over the grid connection.
- Default of primary connection holder can be managed.
- Structure is more likely to be fundable.
- Power can be sold on an aggregated basis.

BRODIES LLP

What Next?

- No ‘one size fits all’ solution but a range of options
- Consider your options and carry out a project specific assessment
- If grid sharing might work for you then consider the pros and cons of the various structures
- Early thinking can allow solutions to be built in to the project structure and enable known risks to be mitigated

BRODIES LLP

Crofting, Cable Routes and Grid Sharing

Kirsty Macpherson, Partner

Sarah-Jane McArthur, Partner

13 September 2017

Contact details:
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sarah-jane.mcarthur@brodies.com | 0141 245 6276

Supply Chain

Chair:

Norma Hogan

Highlands and Islands Enterprise

Joao Cruz

Principal Engineer

Cruz Atcheson

Am I Investable?

Scottish Renewables Marine Conference
Inverness

13th of September 2017

cruz atcheson
CONSULTING ENGINEERS

Contents

- Introduction to Cruz Atcheson
- Motivation
- Overview of the Methodology
  - Characterising those Seeking Investment
  - Characterising Early-Stage Investors
- Bridging the Gap - New Proposed Process
- Next Steps

Cruz Atcheson in a Nutshell

- Founded in Lisbon in 2015, Cruz Atcheson is an independent engineering consultancy, specialising in wave, tidal and floating offshore wind energy applications.
- Our three key areas of work are: concept design, due diligence support and project development support.
- We work closely with our clients across the globe to deliver solutions to the most challenging engineering problems.
- We are 100% independent, having no equity stake on any project or technology.

wave energy SCOTLAND · WAVEROLLER · Sandia National Laboratories · CalWave Power Technologies · AQUA POWER Technologies · MAKO Tidal Turbines · ALLSWATER · MARINE POWER SYSTEMS · OERA Offshore Energy Research Association · Carnegie wave energy · ARUP

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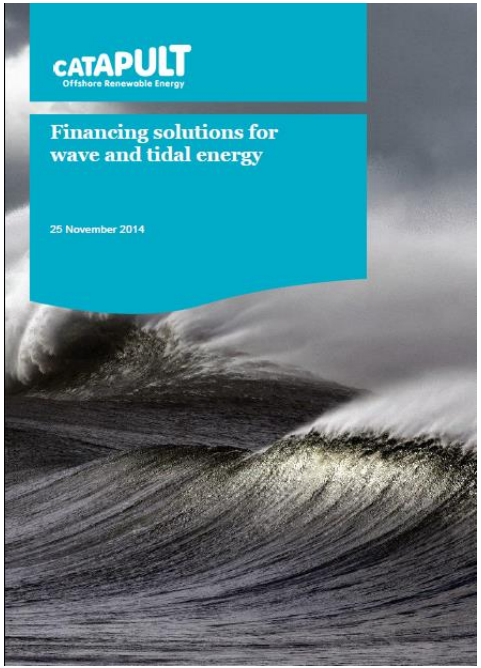
Motivation

1. Are there pre-engagement milestones the early-stage renewable energy companies need to reach before engaging with different types of investors?
2. Are there any salient investor characteristics?
3. Are there other items that could be explored to enhance investor appetite?
4. Can a process that enhances the probability of an early stage renewable energy company securing investment be devised?



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Overview of the Methodology

- Characterise those seeking investment
  - Custom online survey to key technology developers active in the wave, tidal and floating offshore wind sector.
- Characterise those providing investment
  - Literature review to assess the dominant characteristics of investors active in seed and early stage renewable energy investments.
  - Data from ThomsonOne database for seed/early stage investment in renewable energy companies for 20 years (1995 – 2015).
  - Analyse data to gain insight into investment patterns in the sector.

Characterising those Seeking Investment

Online survey conducted in May/June 2015. Valid responses from 21 companies in Europe, USA and Japan.

Overview of findings:

- 75% of respondents secured investment to-date.
- +80% of respondents identified angel investors as a source of funding in the initial stages and 50% Venture Capitalists.
- Round 1 and 2 account for 75% of all investments made, highlights early stage.
- Average age at financing 43.2 months.
- Equity amount secured in latest round: 93% of respondents selected between £1m - 5m.

Characterising the Investors

Pre-Engagement Milestones

Qualitative	Quantitative	Background Role
• Analysis of regulatory environment, competitive situation, technology risks, market uncertainty and supply chain bottlenecks	• Supply evidence of a minimum of 6 months track record of operational data	• Existence of support mechanisms, either of the technology push type (e.g. government grants), or market pull types (e.g. feed-in tariffs)

Investor Characteristics

Angel Investors	Venture Capitalists
• Regional focus • Mostly active in seed or start-up phase • Look for investor / entrepreneur profile (same sector) • Less risk aversion and more willingness to accept longer exit horizons • Expect high-level due diligence and contract renegotiations	• Look out for technology, people or financial investors • Higher importance given to receipt of government grants, IP protection, product uniqueness • Work with regional differences: investor, coach or partner role • Expect VC decision to influence other institutional investors

Qualitative Analysis

- Explore a priori beliefs of investors.
- Work with investor conviction that technology reliability needs to be demonstrated, yet market inefficiencies can be corrected later.
- Potential benefits of searching for investors with balanced portfolios.
- Geographical proximity to venture capital complexes and the related network.

Quantitative Analysis

Average age at financing	52 months (~4.33 years)
Average funding to date	~£17m (average of 3.5 investment firms involved)
Average valuation at transaction date	£86m
Average equity per deal	~£8m (average of 2.5 investment firms involved)

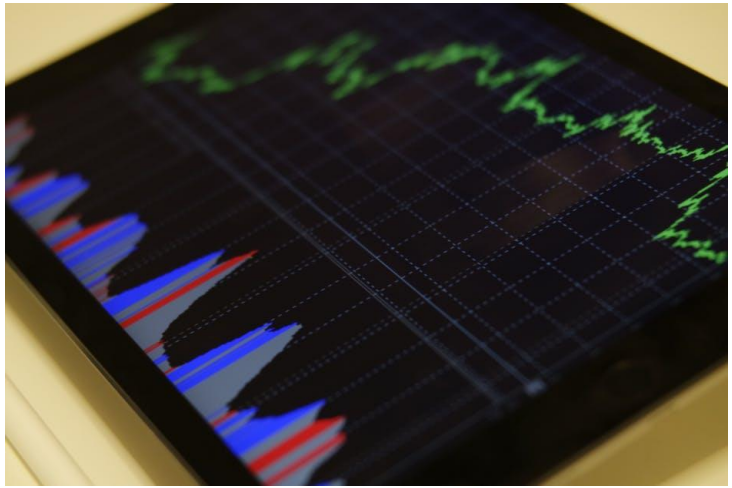
Statistical Correlations

Strong correlations

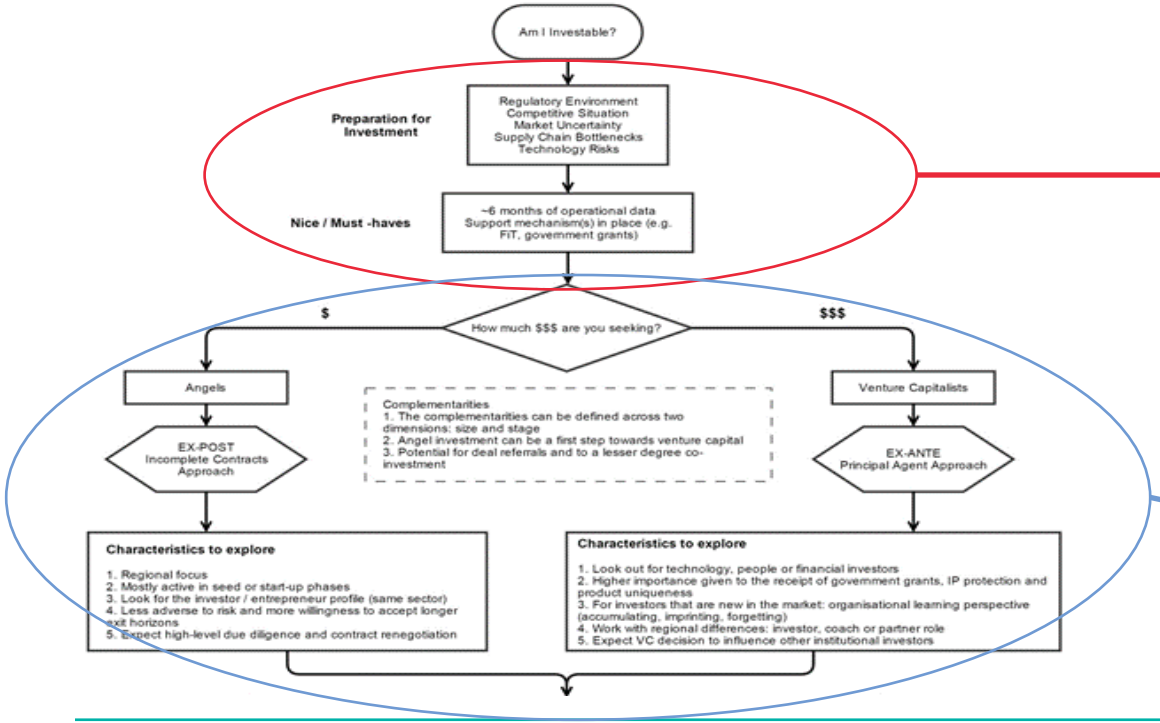
- Equity amount vs. Total funding to date
- Equity amount vs. Valuation at transaction date
- Round number vs. No. of investment firms in total
- Valuation at transaction date vs. Total funding to date

Weak correlations

- Age at financing vs. Total funding to date
- Equity amount vs. Round number
- Valuation at transaction date vs. No. of investment firms in total



Bridging the Gap - New Proposed Process



Pre-engagement milestones

Adjust to key investor characteristics

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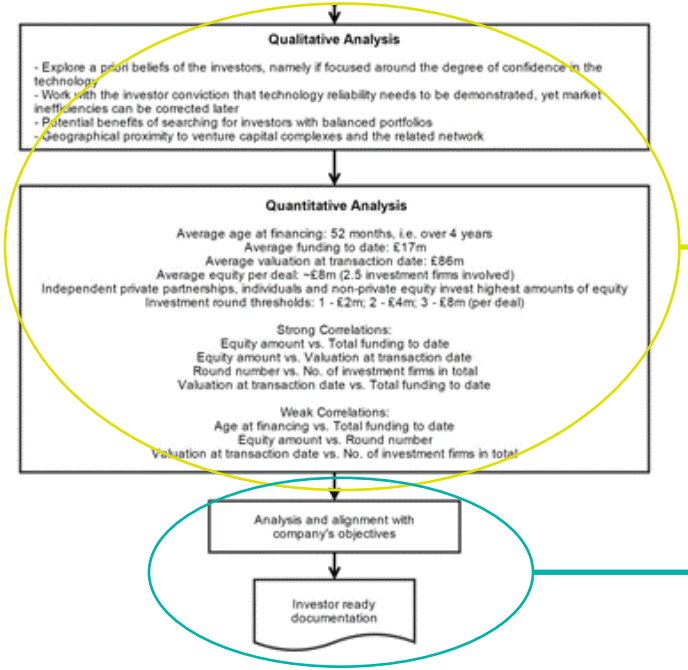
Bridging the Gap - New Proposed Process



Explore additional items to enhance investor appetite

'Reality check'

Investor ready documentation

Next Steps

- New process aspires to be a practical guideline for renewable energy developers seeking investment
- Investigate roles of other key market players, e.g. OEMs, longer-term investors, insurance underwriters, …
- Explore the role of governments and government policy in renewable energy investments

Thank you!

Any questions?

www.cruzatcheson.com

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Max Carcas

Managing Director

Caelulum

Marine Renewables
State of the industry

Research into what the sector has done and where it needs to go

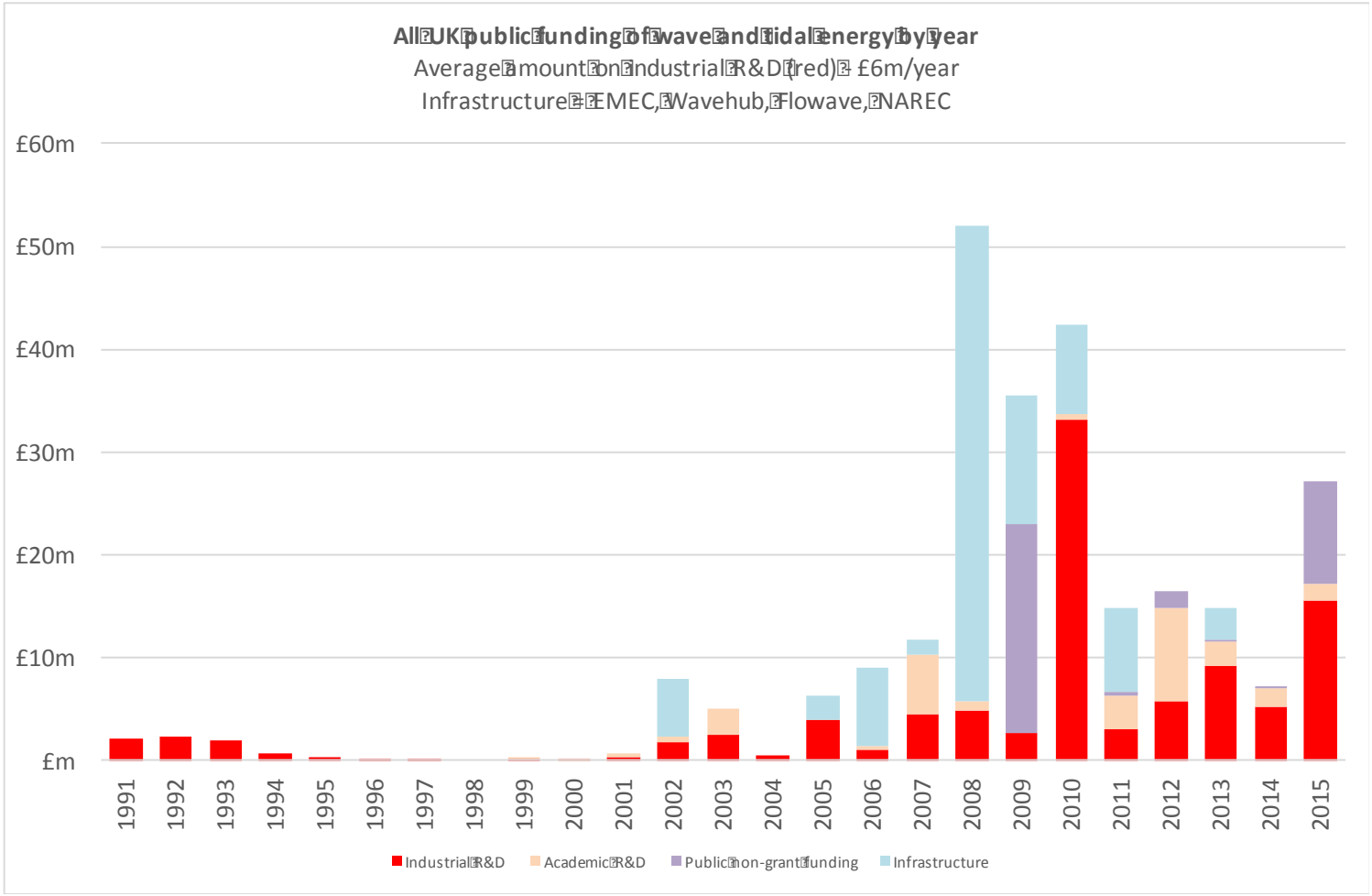
Max Carcas

SR Marine

C A E L U L U M

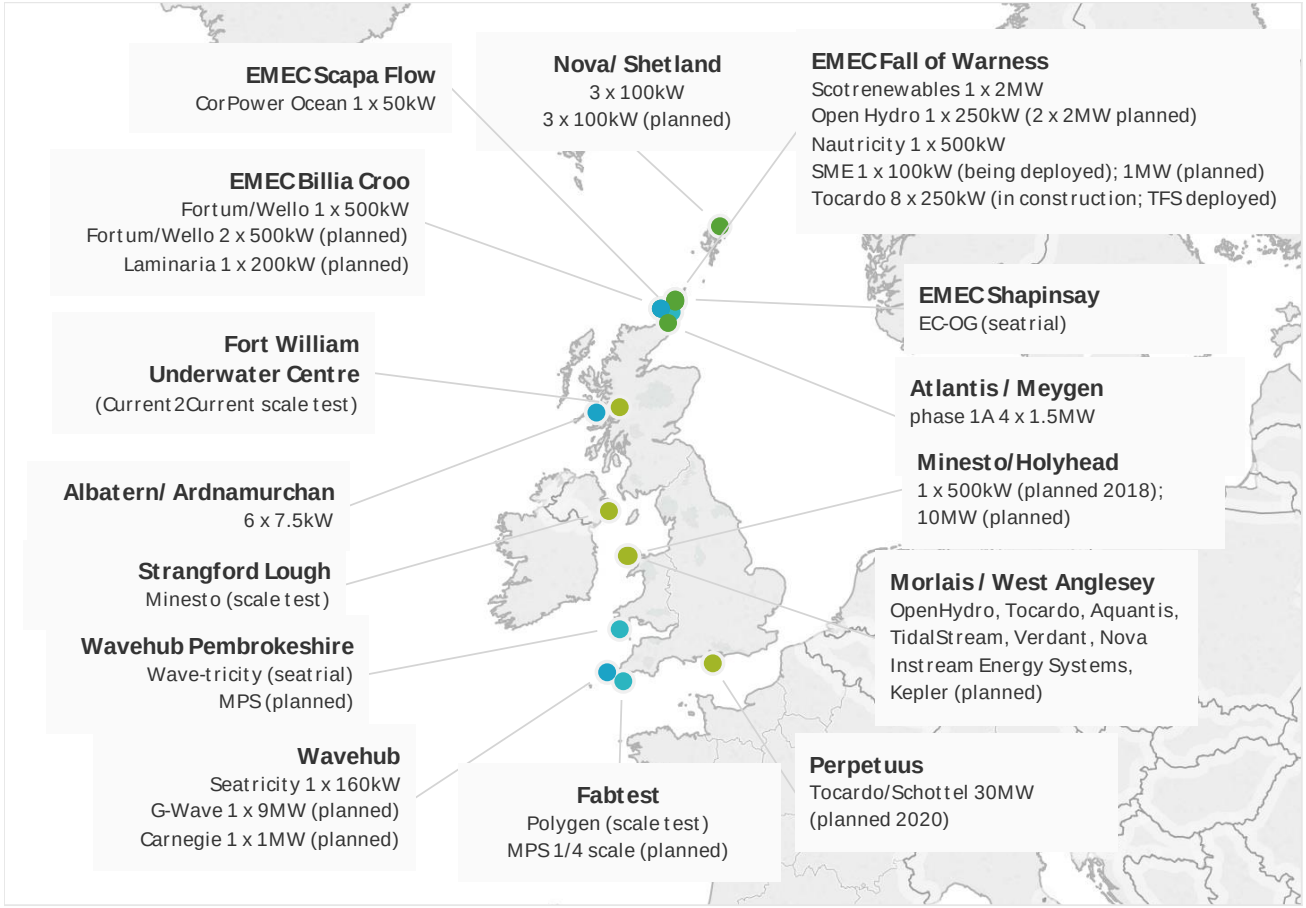
A brief history of time (UK focus)

☺ 1970s: wave energy R&D started in response to oil crisis, work done by CEGB and academia
☹ 1980s: wave energy R&D halted by government
☺ 1998: First premium tariff for wave energy introduced
☺ 2001: DTI admits closing wave R&D programme was a mistake
☹ 2002: RO introduced – 'one size fits all' – more costly technologies must wait
☺ 2003: EMEC established
☺ 2004: first electricity generated from offshore wave power
☺ 2004: Patricia Hewitt announces £50m marine renewables deployment fund (MRDF)
☹ 2006: MRDF opens – onerous requirements and not attractive to investors
☺ 2006: first electricity generated from tidal stream energy
☺ 2009: RO banding finally introduced at UK level….
☹ …. But (deliberately) not at a level to stimulate marine renewables
☺ 2009: £22m MRPF created, allows commercial investment in prototypes
☹ 2010: £50m MRDF withdrawn and replaced with £20m MEAD, however SG provides WATES fund
☺ 2011: RO multiple established for wave and tidal energy
☹ 2012: Multiple ROC to be removed and replaced with unknown level of CFD
☺ 2014: Strike price for marine confirmed at £305/MWh – similar to RO level
☹ ….but only for 15 years (25% less than RO)
☹ various players exit the market – only £10m of MEAD funding allocated
☺ 2015: First multi-turbine tidal project reaches FID, with DECC, Crown Estate and SE support
☺ 2014: Wave Energy Scotland established with ~£10m/year funding, 100% funding
☺ 2017: First tidal arrays operating in UK
☹ 2017: Marine unable to win CFDs competing with GW scale offshore wind projects

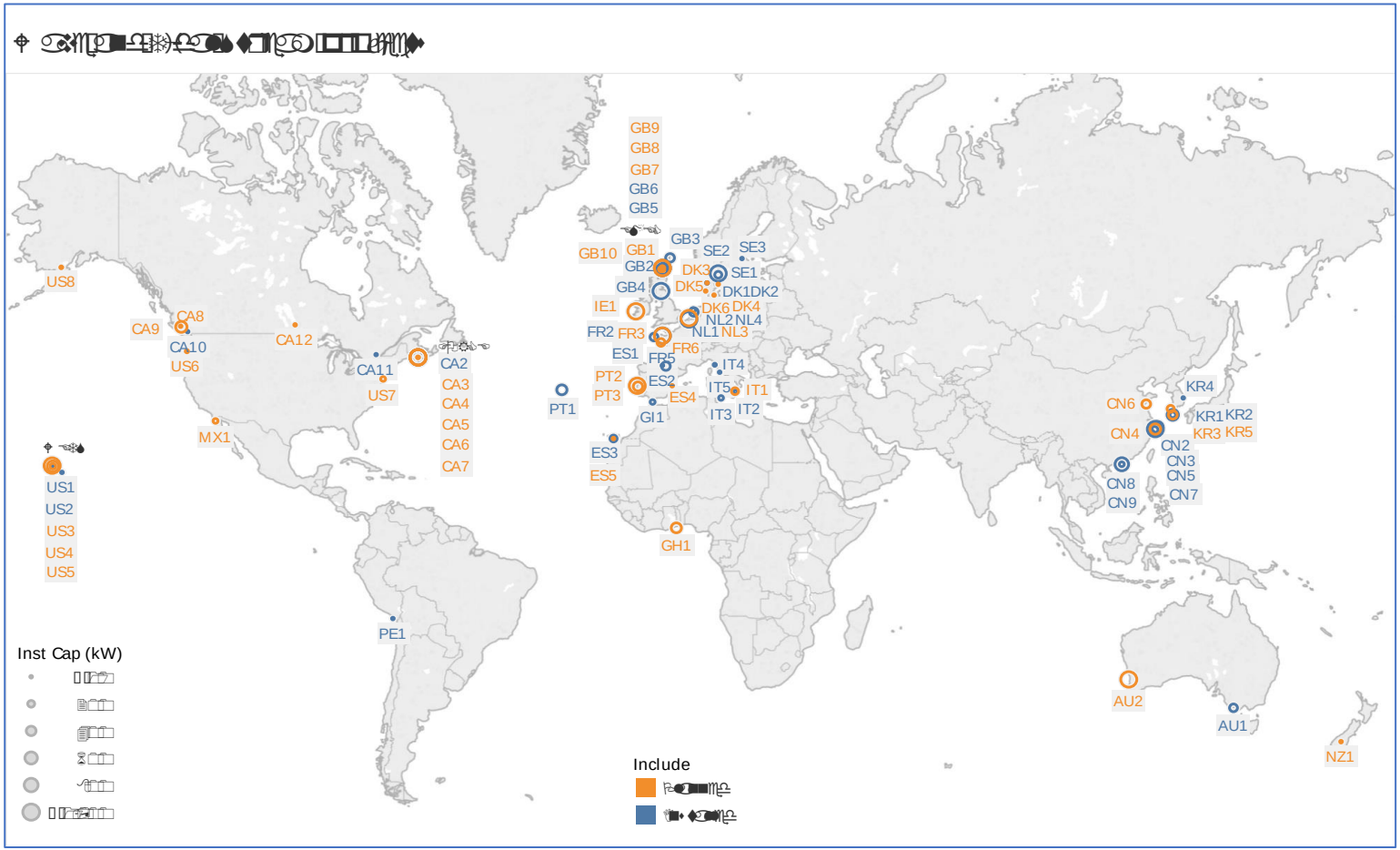

All UK public funding of wave and tidal energy by year
Average amount on industrial R&D (red) = £6m/year
Infrastructure = EMEC, Wavehub, Flowave, NAREC
£60m
£50m
£40m
£30m
£20m
£10m
£m
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Industrial R&D
Academic R&D
Public non-grant funding
Infrastructure

C A E L U L U M

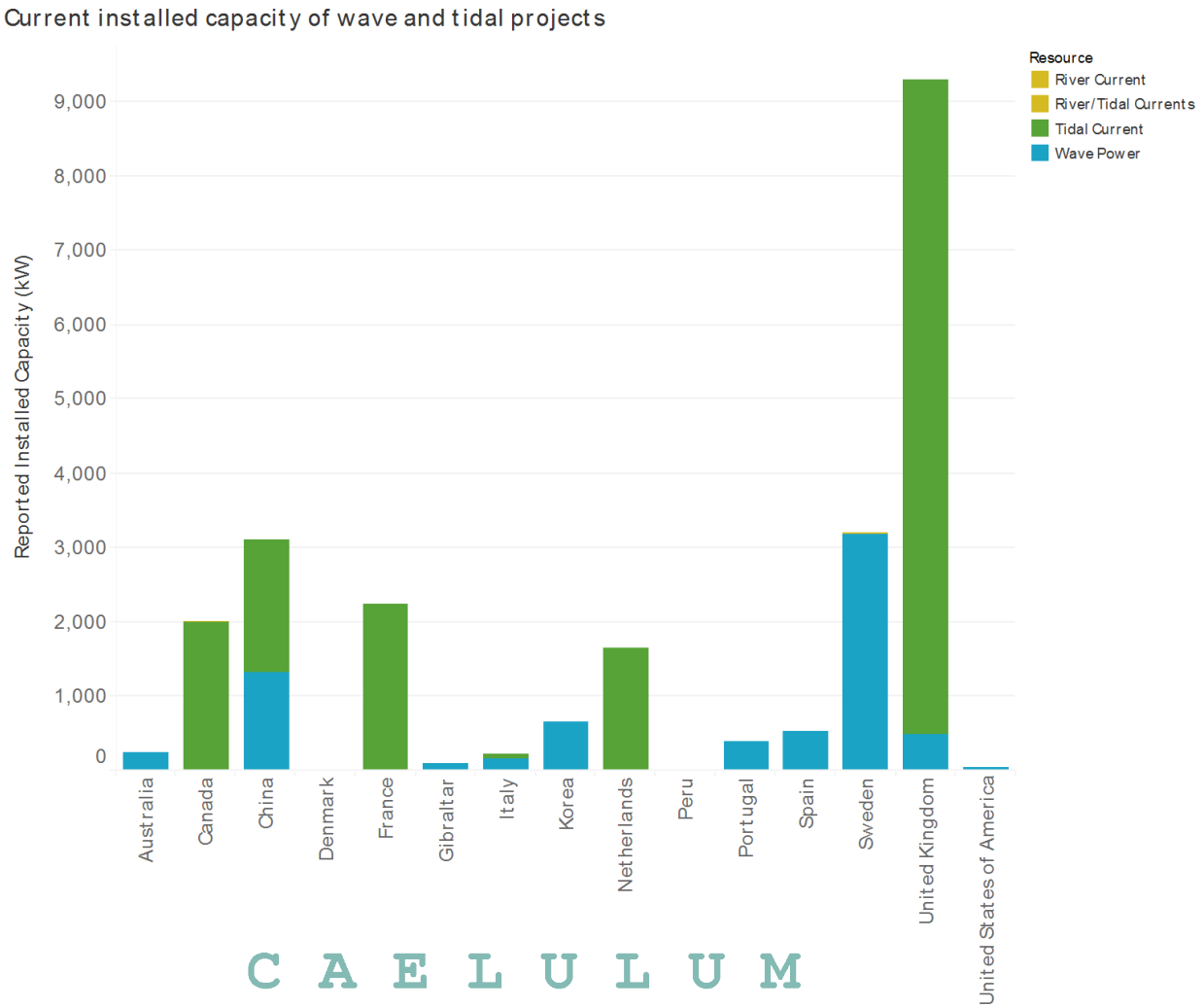
Active UK project sites with existing, recent or planned deployments



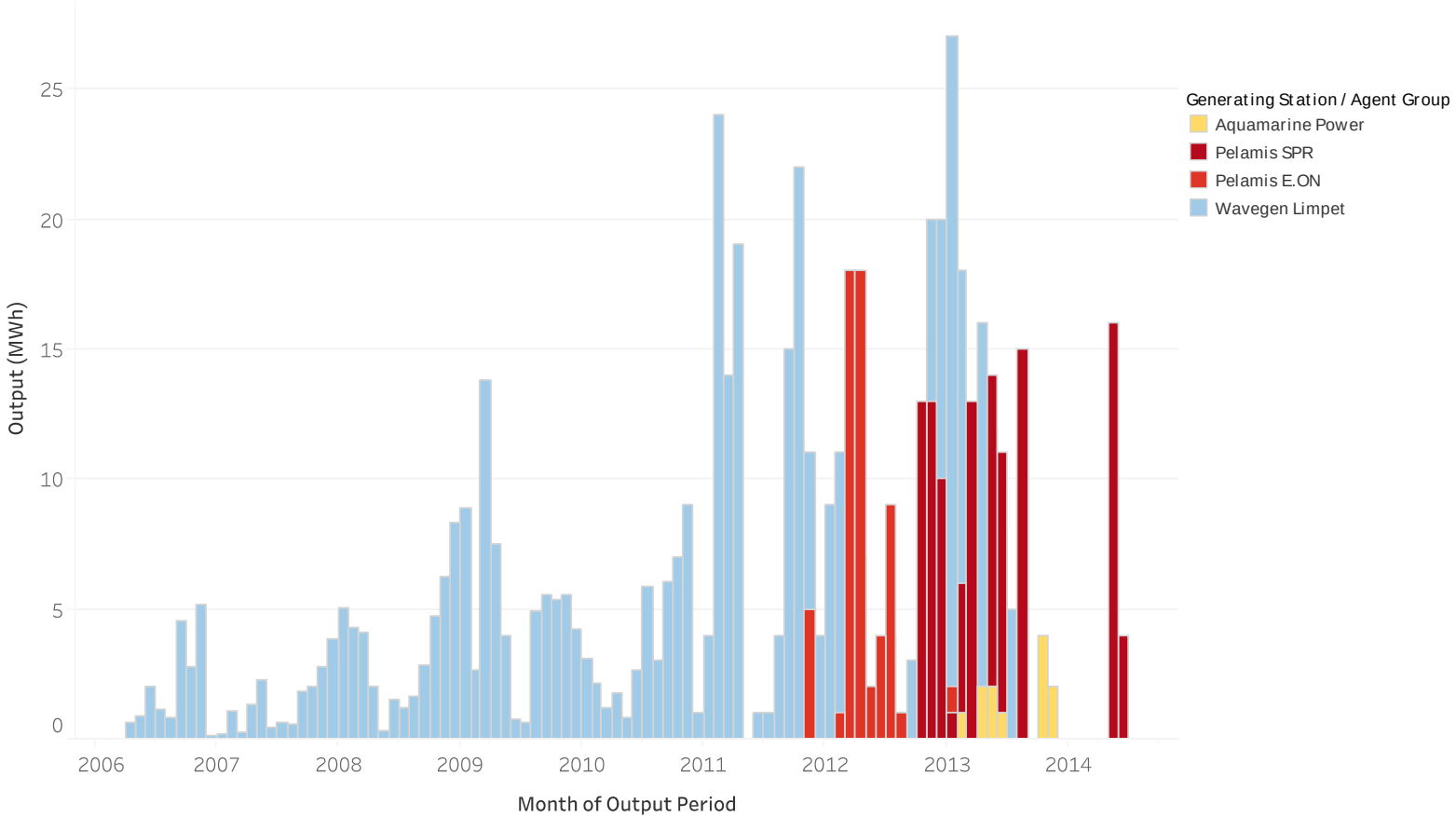
CAELULUM


GB9
GB8
GB7
GB6
GB5
GB10
GB1
GB3
SE2
SE3
GB2
DK3
SE1
GB4
DK5
DK1
DK2
IE1
DK6
DK4
NL2
NL4
FR2
FR3
NL1
NL3
FR6
ES1
FR5
IT4
PT2
ES2
IT5
IT1
PT3
ES4
PT1
GI1
IT3
IT2
ES3
ES5
GH1
US8
CA8
CA9
CA10
US6
CA12
CA11
US7
CA2
CA3
CA4
CA5
CA6
CA7
MX1
US1
US2
US3
US4
US5
PE1
KR4
CN6
KR1
KR2
CN4
KR3
KR5
CN2
CN3
CN5
CN8
CN7
CN9
AU2
AU1
NZ1
Inst Cap (kW)
Include

C A E L U L U M

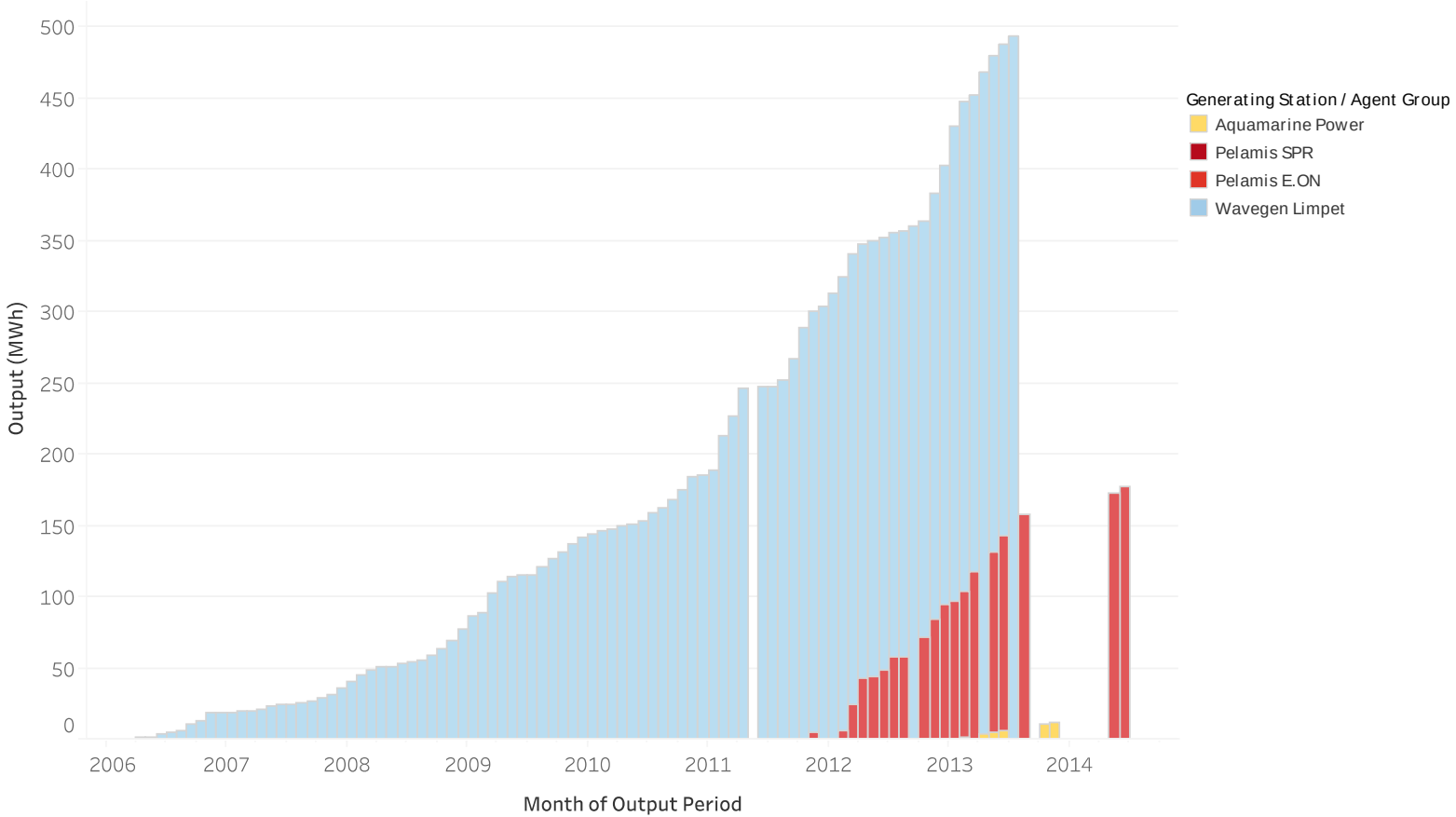

Current installed capacity of wave and tidal projects
Resource
River Current
River/Tidal Currents
Tidal Current
Wave Power
Reported Installed Capacity (kW)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Australia
Canada
China
Denmark
France
Gibraltar
Italy
Korea
Netherlands
Peru
Portugal
Spain
Sweden
United Kingdom
United States of America
CAELULUM

UK reported monthly wavepower generation to date



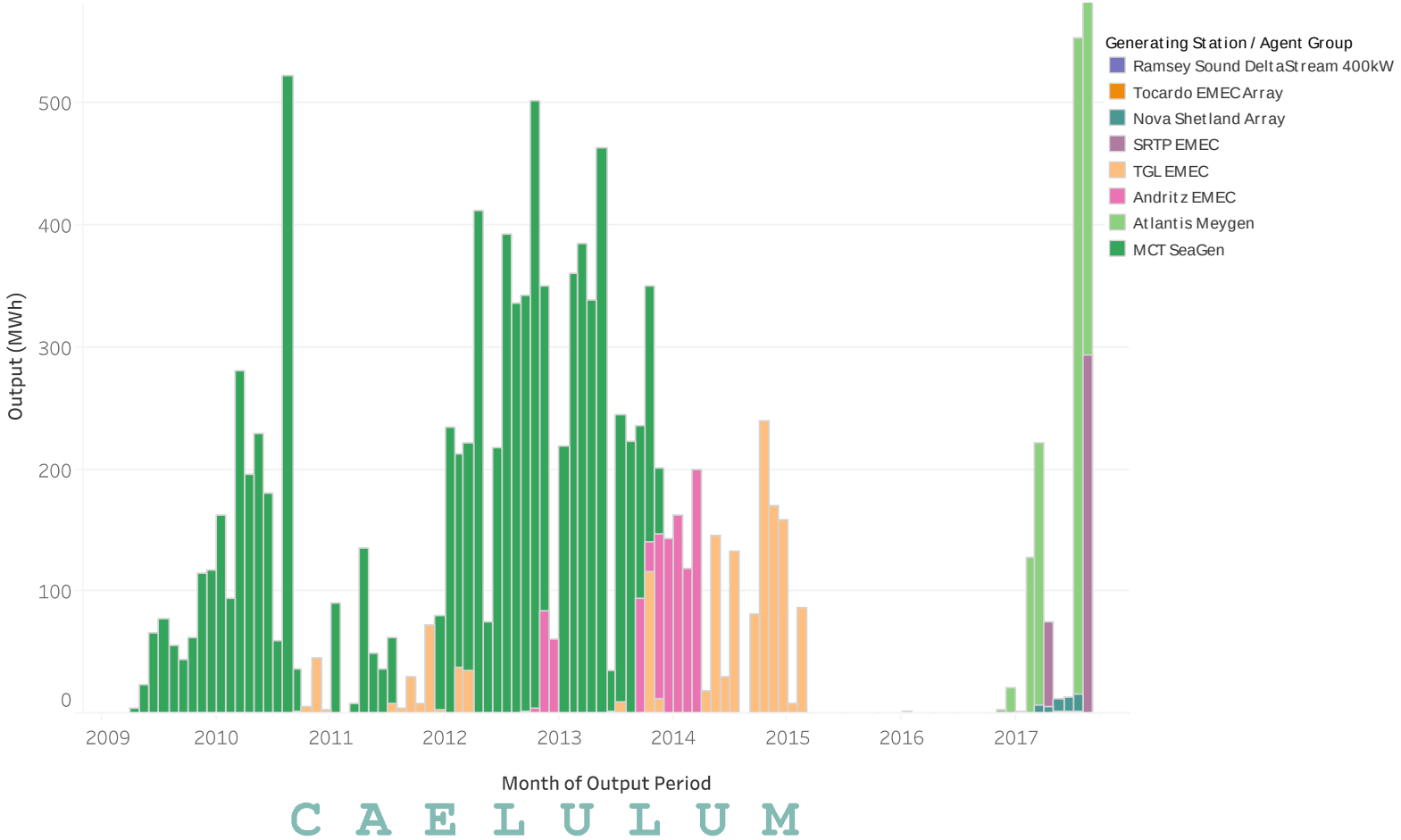
CAELULUM

UK reported cummulative wavepower generation to date



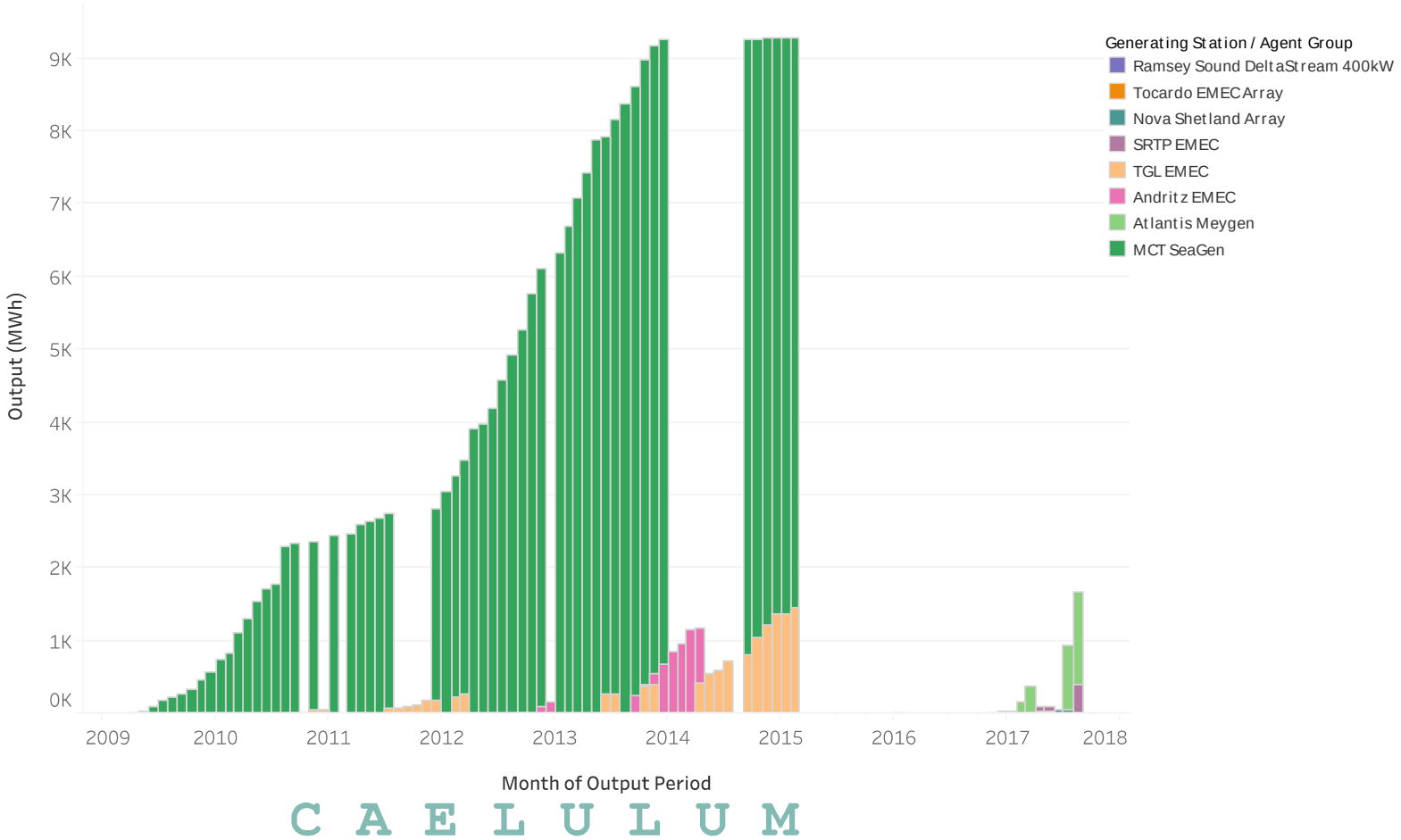
CAELULUM

UK reported monthly tidal stream generation to date



C A E L U L U M

UK reported monthly tidal stream generation to date



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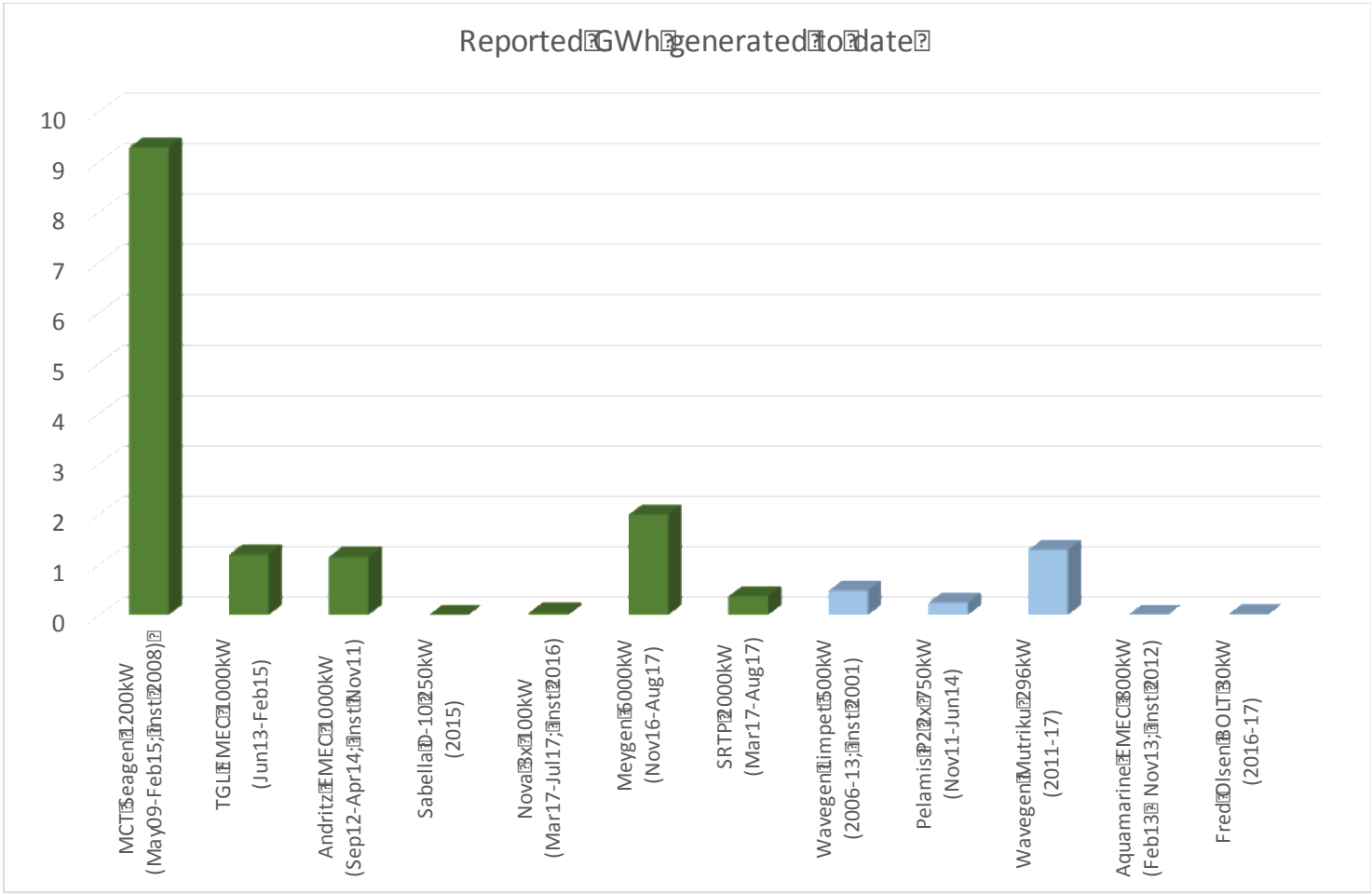
Reported GWh generated to date
10
9
8
7
6
5
4
3
2
1
0
MCT Seagen 1200kW (May09-Feb15; Inst 2008)
TGL MEC 1000kW (Jun13-Feb15)
Andritz MEC 1000kW (Sep12-Apr14; Inst Nov11)
Sabella D-10 250kW (2015)
Nova 3x 100kW (Mar17-Jul17; Inst 2016)
Meygen 6000kW (Nov16-Aug17)
SRTP 2000kW (Mar17-Aug17)
Wavegen Limpet 500kW (2006-13; Inst 2001)
Pelamis P2 2x 750kW (Nov11-Jun14)
Wavegen Mutriku 296kW (2011-17)
Aquamarine ME MEC 800kW (Feb13- Nov13; Inst 2012)
Fred Olsen BOLT 30kW (2016-17)

C A E L U L U M


GWh/year based on reported GWh generated to date
3
2.5
2
1.5
1
0.5
0
TREAT WITH CAUTION!
MCT Seagen 1200kW (May09-Feb15; inst 2008)
TGL EMEC 1000kW (Jun13-Feb15)
Andritz EMEC 1000kW (Sep12-Apr14; inst Nov11)
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Aquamarine EMEC 800kW (Feb13- Nov13; inst 2012)
Fred Olsen BOLT 30kW (2016-17)

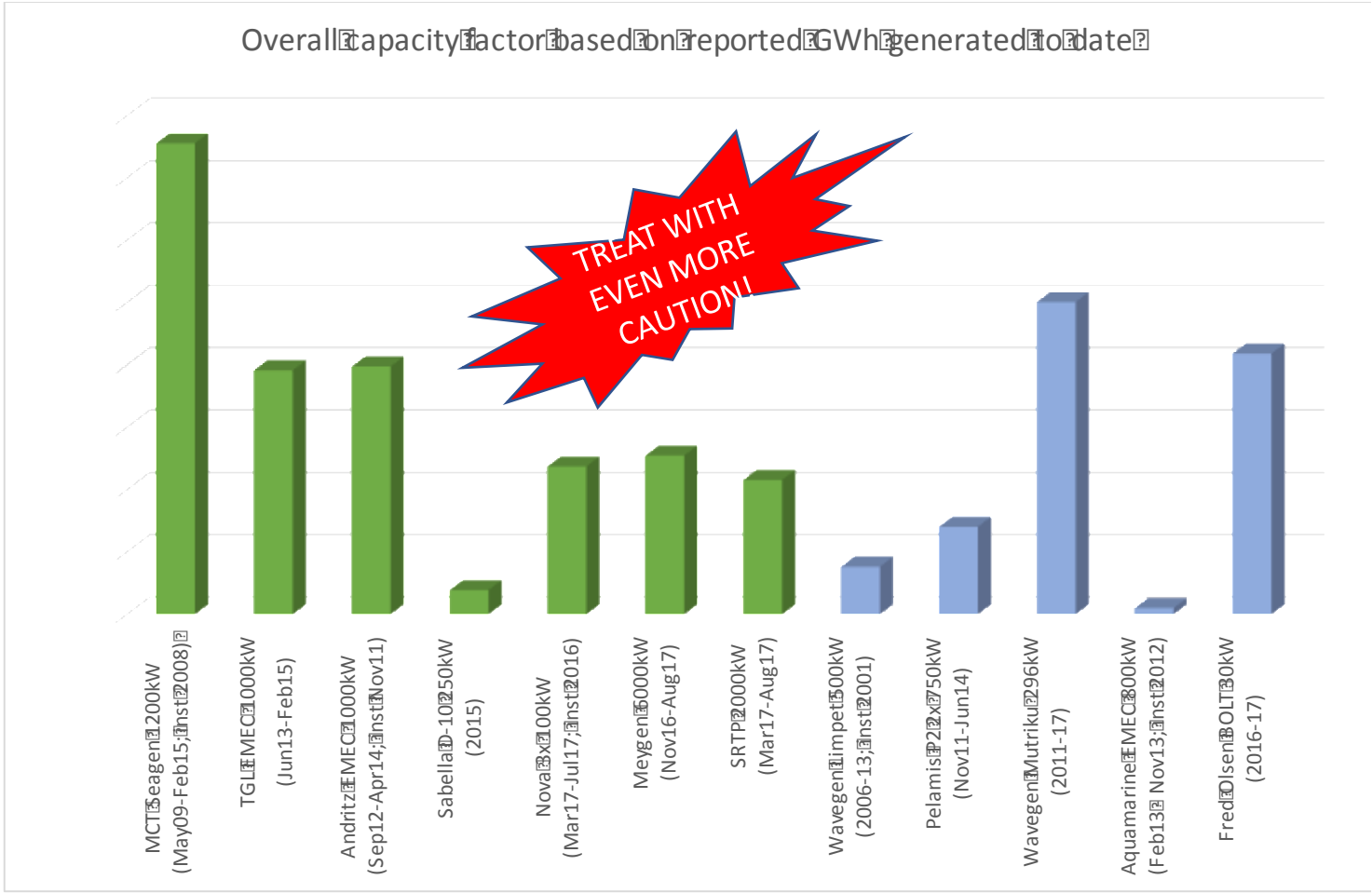
C A E L U L U M

Wind 1980s:

- ~10-1000MW installed
- Typical turbine 75kW
- Capacity Factor 12% (1985, California)
- Annual average: 9kW

Wind 2017:

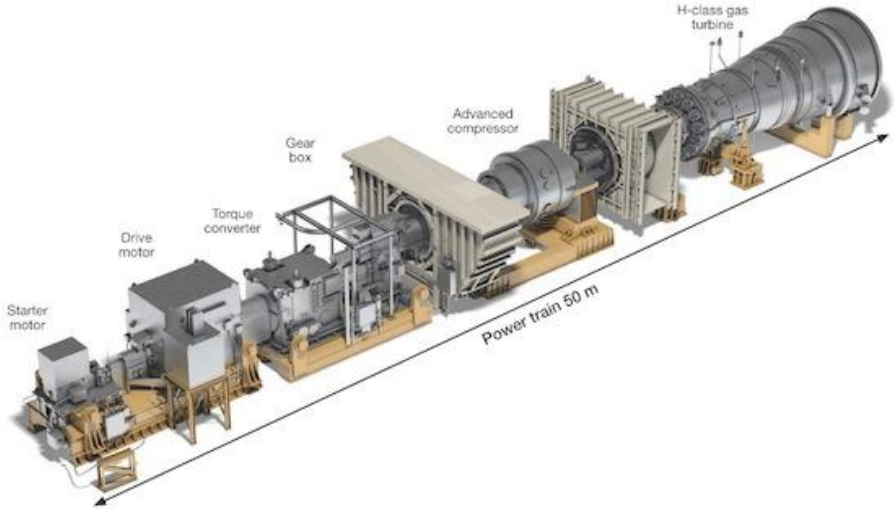
- >100GW Europe alone
- Typical turbine 3-6MW
- Capacity factor 30% (2015, California)
- Annual average: 900kW



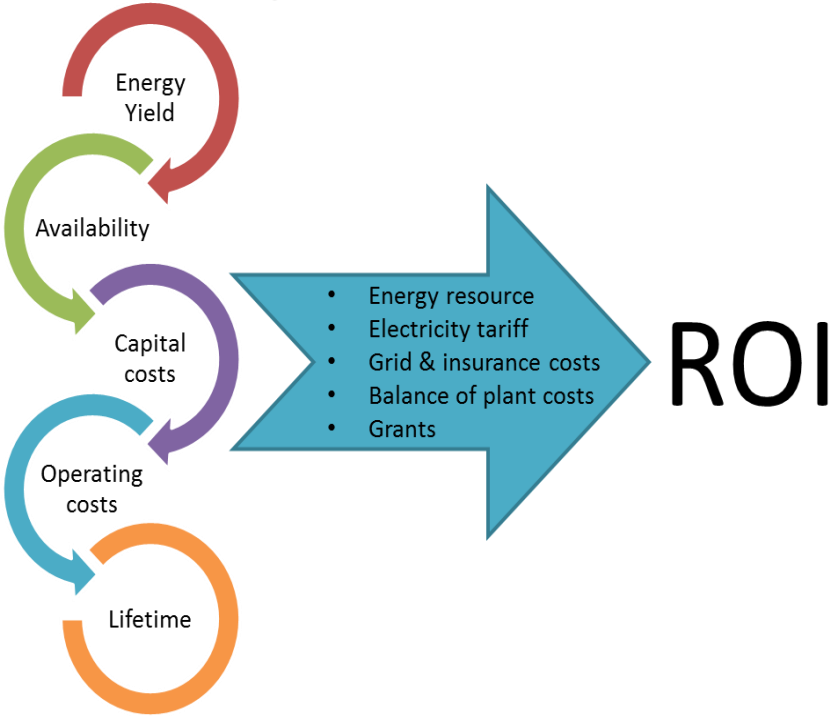
C A E L U L U M

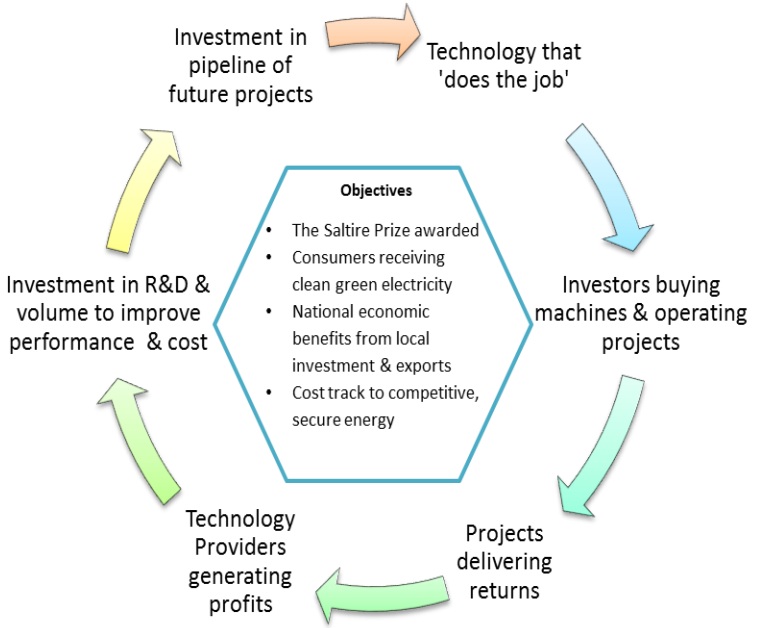
GE Frame 9H turbine, Baglan Bay

- Cost: £300m
- 480MW
- Shipped to Baglan Bay Dec 2000
- Operations began 2002
- March 2005 - GE announced it had reached a milestone of 8,000 hours operation
- 4+ years from delivery on site
- Iteration of a previous model, not an entirely new concept.



Defining ‘Success’





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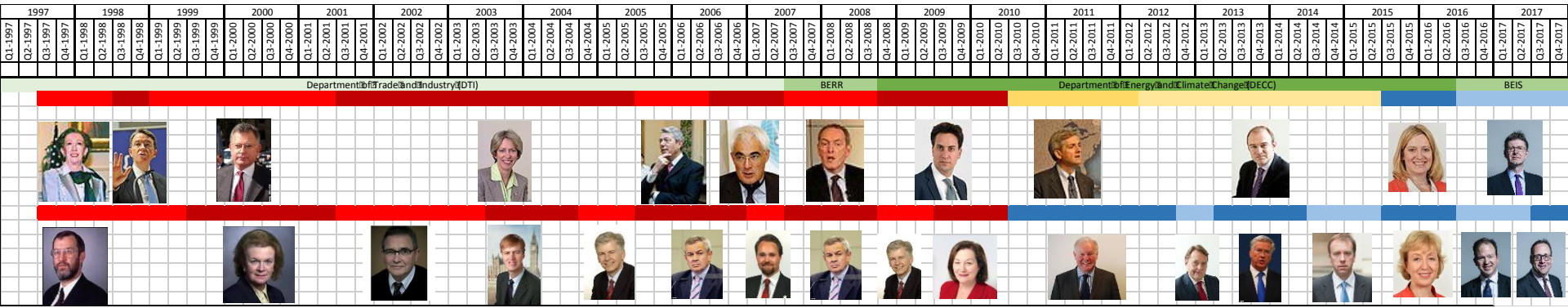
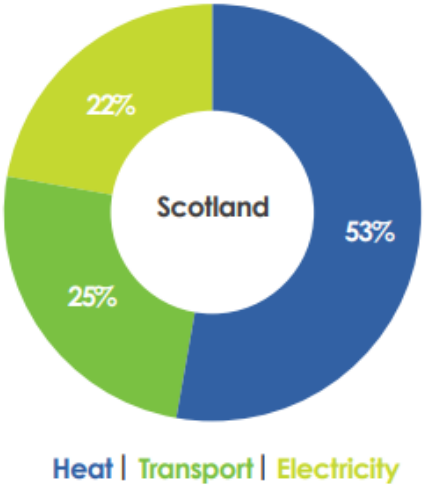
Subsidy cost over twenty years

- Total generation to date: 12.66GWh
- 31,778 ROCs issued to date
- Total subsidy £1.58m
- Grant support for marine device R&D, £1-200m



CAELULUM

The need



- 54% of Scottish electrical demand is from renewables
- BUT electricity is just 22% of total energy demand
- Only 15.2% of Scottish Energy demand is from renewables
- To decarbonize transport and heating electricity is one of the main vectors:
  - Electric cars or hydrogen via electrolysis
  - Electricity for heating – heat pumps or resistive
- Potentially 3-5x more zero carbon electricity generation needed
- We (Scotland, the UK, the world) need ‘everything in the box’!
- The sooner we realise this the quicker we can build the solution

C A E L U L U M

Jason Hayman

Managing Director

Sustainable Marine Energy

SUSTAINABLE MARINE ENERGY LTD

DELIVERING EFFECTIVE TIDAL ENERGY SOLUTIONS

Build a sector on solid rock – and avoid shifting political sand

Jason Hayman, Managing Director

September 2017

THE BRITISH ASSESSMENT BUREAU ISO9001 OHSAS18001

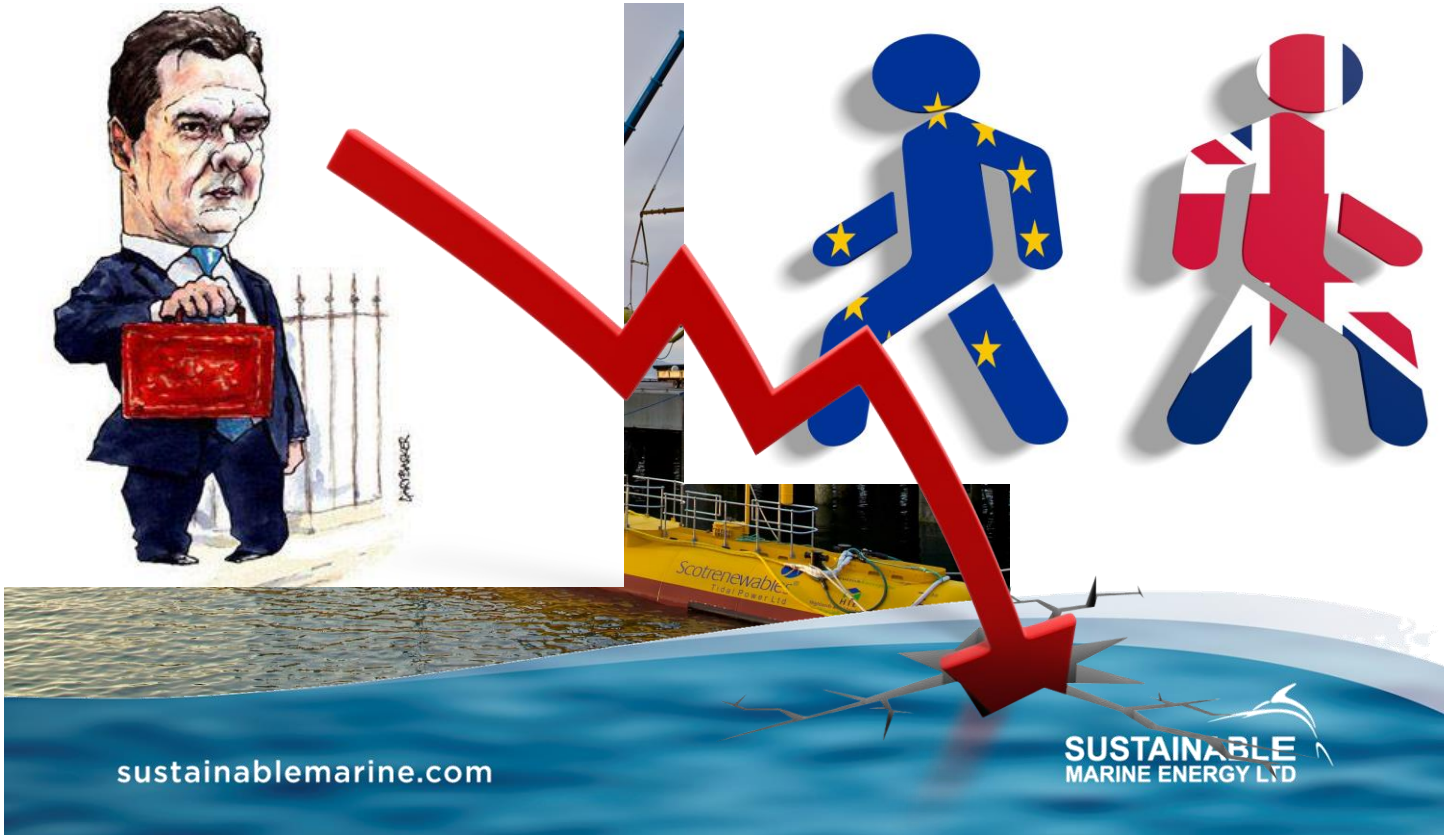
Introduction to SME

- Developer of technical solutions including integrated, turnkey tidal energy systems;
- Tidal energy platforms feature SCHOTTEL HYDRO SIT tidal energy convertors;
  - PLAT-O for energetic, offshore sites
  - PLAT-I for more sheltered inshore sites
- Anchoring and mooring solutions for marine energy devices in challenging environments
  – at a reasonable cost

Testing PLAT-O at EMEC 2016

Our view on the state of the UK industry

- 2016 was the best in terms of technical delivery, in tidal, ever!
- But policy decisions made have wiped out the UK market
- Big hats off to Scotrenewables and Atlantis – MeyGen teams



SME's response to disappearance of UK marine energy market (1)

- Cast our eyes further afield and develop a system for a market where there is real need:

SME's response to disappearance of UK marine energy market (1)

- Build now well underway; aim to test in Scotland before end of the year, and deploy in SE Asia early 2018






SME's response to disappearance of UK marine energy market (2)

- Become part of the supply chain, and commercialise our anchoring solutions;
- Work with fellow technology developers to solve a troublesome issue, reduce costs, and help build confidence in the sector – which we all need!
- Produce a return for our investors by expanding our offering into new markets…

Image Credit: Scientific American

SME Anchoring History

SME has been developing and testing anchoring solutions for marine energy for 5 years.

2012
Under Reamer Prototype
Finger drilling tested in Scotland

RAPTOR anchor Patented

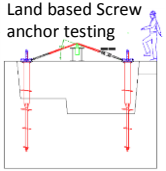
2013
Screw Anchors for Marine Energy Devices (SAMED) Project Begins

2013
First full RAPTOR test carried out in Cumbria 1.75m depth, tested to70T vertical load

2014
First RAPTOR quarry trials in Orkney

2014
RAPTOR collapsible coupling prototype tests in Wallsend

2014
Land based Screw anchor testing



2014
4x PLAT-O Screw anchors installed at Yarmouth

2015
Production RAPTOR 100 testing in Orkney

2015
2nd RAPTOR Patent filed

2016
RAPTOR 100 stem tested to 220t in Wallsend

2016
4x RAPTOR 100s installed at EMEC Falls of Warne

2016
DNV "Statement of Fit for Purpose" issued for EMEC installation

2017
25 Screw anchors installed for Cromarty Mussels Ltd

2017
4x RAPTOR 150s Designed and built for PLAT-I

2017 – Planned
Install RAPTOR anchors for PLAT-I testing

2018 - Upcoming
Delivery of RAPTOR anchors with ~500t holding capacity for third-party offshore renewable energy customers

Solutions Designed to Provide Low Operational Costs

Helical Anchors and A-ROV First Deployment- Solent September 2014

Raptor Testing – Orkney 2015/16

- Five month extensive trial period;
- Anchor loading performance – Lateral, Vertical, Cyclic
- Equipment performance – AROV & HPU
- Team performance and methodology

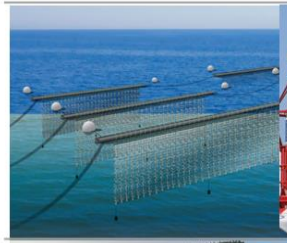
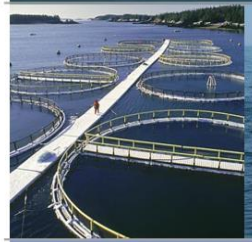




Installation of Raptor Rock Anchors at EMEC - 2016

First Aquaculture Installation – Cromarty Mussels – March 2017

Current Commercial Offering; Rock Anchors

	TYPICAL APPLICATION		ALTERNATIVES
RAPTOR 50 	 	•Shellfish farming •Navigation & instrumentation buoys	Chain & Concrete clumps Helical anchors Traditional anchors
RAPTOR 100 	 	•Finfish farming •Small renewable energy devices	Drag embedment anchors Concrete clumps
RAPTOR 150 	 	•Feed barges •Large renewable installations •Commercial vessel moorings	Large Drag embedment anchors Chain catenery moorings Gravity base structures

scottish renewables

IN ASSOCIATION WITH

HIE
Highlands and Islands Enterprise
Iomairt na Gàidhealtachd 's nan Eilean

wave energy SCOTLAND

MARINE CONFERENCE, EXHIBITION & DINNER

12 & 13 SEPTEMBER 2017 INVERNESS

areg
Aberdeen Renewable Energy Group

Crown Estate Scotland
Oighreachd a' Chrùin Alba

OPENHYDRO
NAVAL ENERGIES