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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

09 & 10 SEPTEMBER 2019 **INVERNESS**

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Claire Mack

Chief Executive

Scottish Renewables

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Plenary 1

Marine Energy: The Value Case

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#SRMARINE19

Audrey MacIver

Director of Energy and Low Carbon

Highlands and Islands Enterprise

#SRMARINE19

Highlands and Islands Enterprise
Iomairt na Gàidhealtachd 's nan Eilean

Scottish Renewables Marine Conference

AUDREY MACIVER
DIRECTOR OF ENERGY AND LOW CARBON

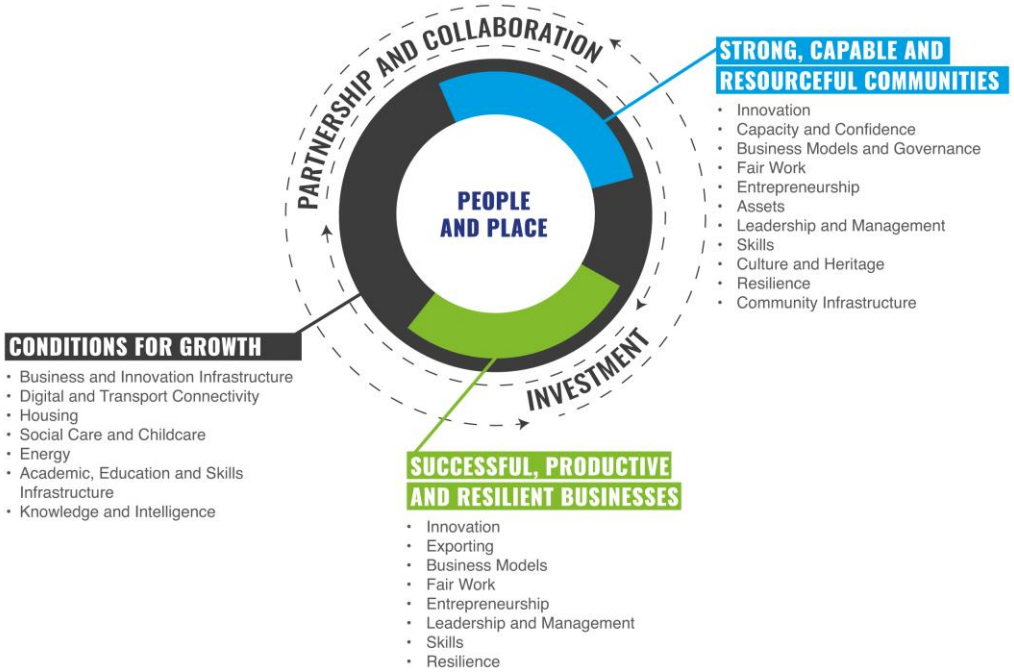
9 September 2019

Background to HIE

Our Vision

We want the Highlands and Islands to be a highly successful, inclusive and prosperous region in which increasing numbers of people choose to live, work, study and invest.

Our Priorities



DRIVERS OF CHANGE

1965

Establishment of Highlands and Islands Development Board (HIDB)

1975

Local government reform

1970's

Exploitation of North Sea oil

1970/80/90's

Upgrading of transport infrastructure

1980/90/00s

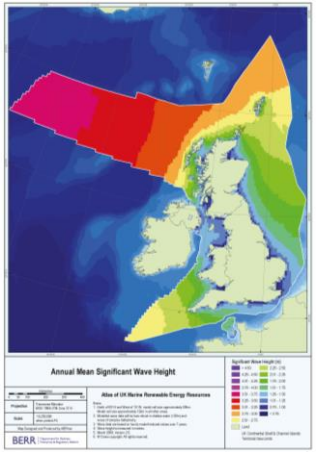
Upgrading of telecoms infrastructure

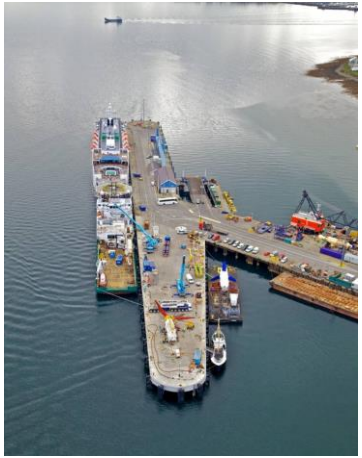
2010/20s

Marine Energy

Why Marine Energy?

- Natural competitive advantage
- Strong fit with HIE purpose
- Unique physical assets (> £0.25bn total investment in ports/harbours over last decade)
- Experienced supply chain (oil/gas diversification, marine operators, consultancy support, manufacturing)
- Academic excellence (ICIT, SAMS, ERI, ORIC)
- Contribution to Net Zero





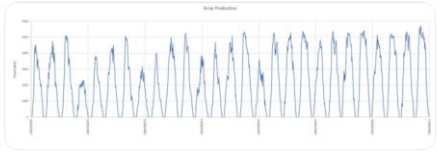
Industry Progress 2019

BT 4G 16:17 75%

Tweet

SIMEC Atlantis Energy
@simecatlantis

A brilliant week of generation last week at MeyGen, with 100% availability across the array. We exported 329MWh to the grid, now over 17GWh in total. Great work from the team!



15:59 · 17/06/2019 · Twitter Web Client

9 Retweets **21** Likes

Tweet your reply

BT 4G 16:19 73%

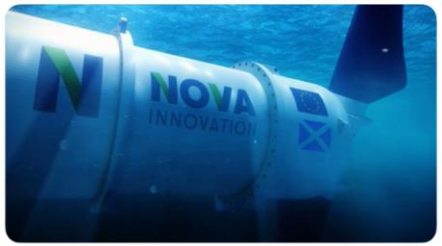
Tweet

Nova Innovation
@NovaInnovation

"PTO technology to reduce costs of tidal power"

Great coverage of our progress to reduce the cost of #TidalEnergy by 30% in @maritimejournal.

bit.ly/2KwcU7j



Tweet your reply

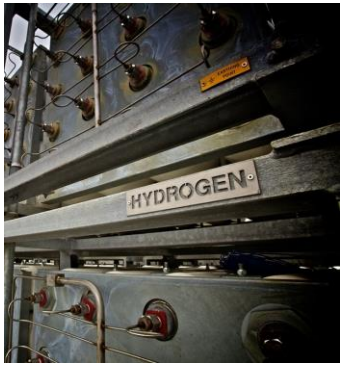
BT 4G 16:14 76%

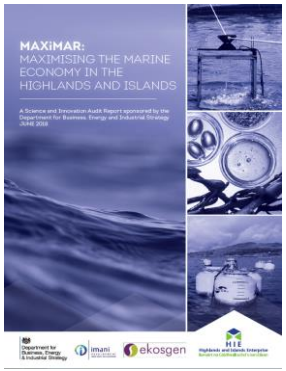
Orbital Marine Power
@Orbitalmarine

£3.4m @scotgov funding towards delivery of world's most powerful tidal turbine "..award will enable us deliver a truly exciting and transformational project and continue the proud tradition of Scottish innovation and engineering." CEO, Andrew Scott orbitalmarine.com/news/135-o2-sa...

Tweet your reply

Near and Mid-term Ambitions





- Celebrate and communicate success
- Support/influence conditions necessary to create market (domestic and international)
- Marine Energy established as a key driver of the Marine and Rural Economy
- Competitive, agile, robust, internationally renowned supply chain
- Continued excellence in R, D & D

Closing Remarks

- We must continue to build a robust evidence base in context of Net Zero
- We have a fantastic story to tell – “Vision 2045”
- We need a collective determination to stay the course – “keep the faith”
- Persistence and optimism is well founded

Thank you

@HIEScotland
@hienergyscot
@MaciverAudrey

Anna Kynaston

Head of Future Low Carbon

Scottish Government

#SRMARINE19

Morag Watson

Director of Policy

Scottish Renewables

Tweet @ScotRenew

#SRMARINE19

The Energy White Paper

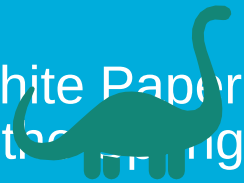
Just in case you were too afraid to ask…**White Papers** are policy documents produced by the Government that set out their proposals for future legislation.

15 Nov 2018

Greg Clark ‘Trilemma’ Speech

I am going to set out more details through a policy paper in the next few weeks, before publishing a detailed White Paper to follow in the new year.

White Paper in the Spring



White Paper in

BEIS/Ofgem Consultation Blizzard

?

Significant Code Reviews

1) TARGETED CHARGING REVIEW (TCR)

- Principles-based assessment of options based on: **fairness**, **reducing distortion** and **practicality and proportionality**.
- consider **reform of residual charging arrangements** for both **generation and demand**, to ensure it meets the interests of current and future consumers;
- keep the other **'embedded benefits'** that may distort investment or dispatch decisions **under review**.

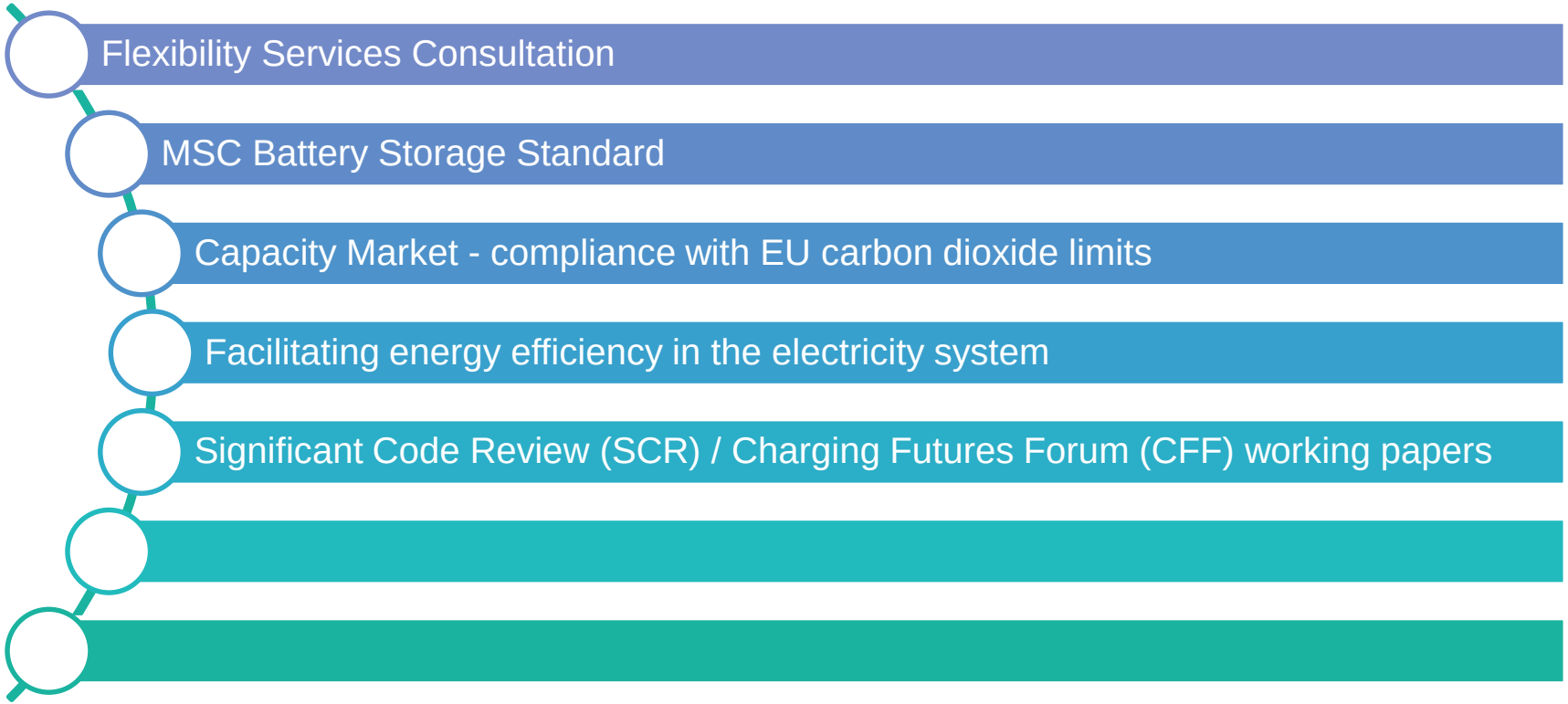
2) ELECTRICITY NETWORKS ACCESS PROJECT (ENAP)

- Objective: to ensure electricity networks are **used efficiently and flexibly**, reflecting **users' needs** and allowing **consumers to benefit from new technologies and services** while **avoiding unnecessary costs** on energy bills in general.

BEIS/Ofgem Consultation Blizzard…

- Reforming the energy industry codes
- Carbon capture, usage and storage (CCUS): business models
- Flexible and responsive energy retail markets
- Application Interactivity and Connection Queue Management
- Regulated Asset Base (RAB) model for nuclear
- Open Letter Consultation on the RIIO-ED2 Price Control
- Position Paper on DSO: our approach and regulatory priorities

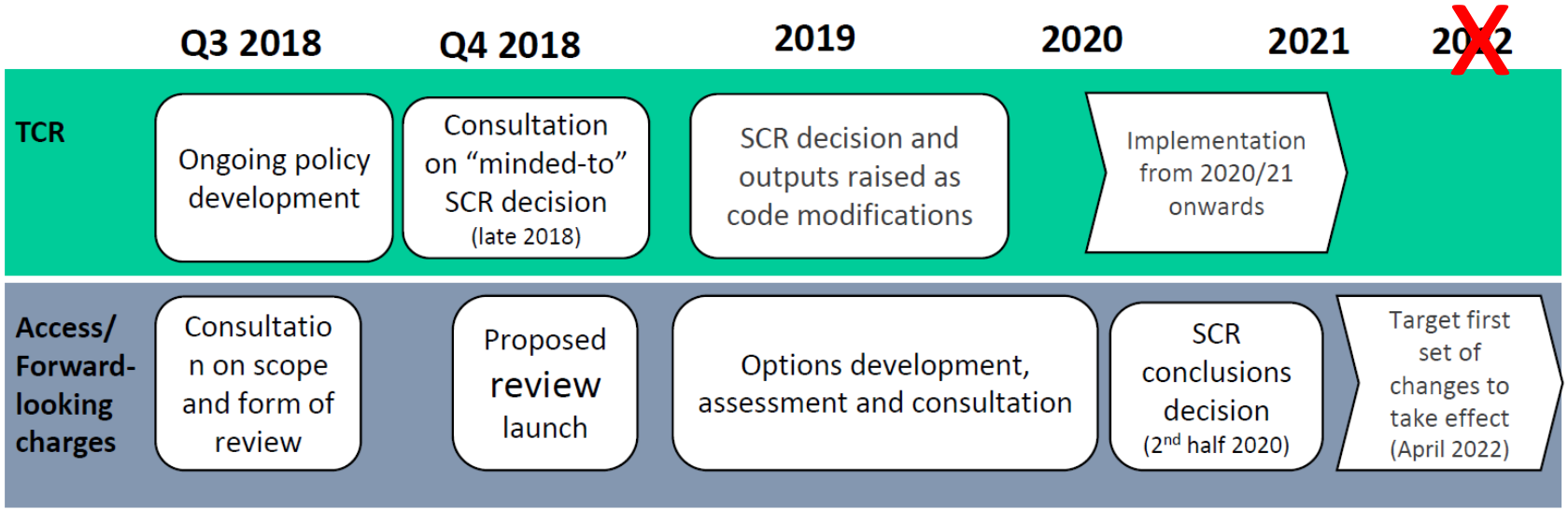
…BEIS/Ofgem Consultation Blizzard



This will last for years – and now a kick into the long grass

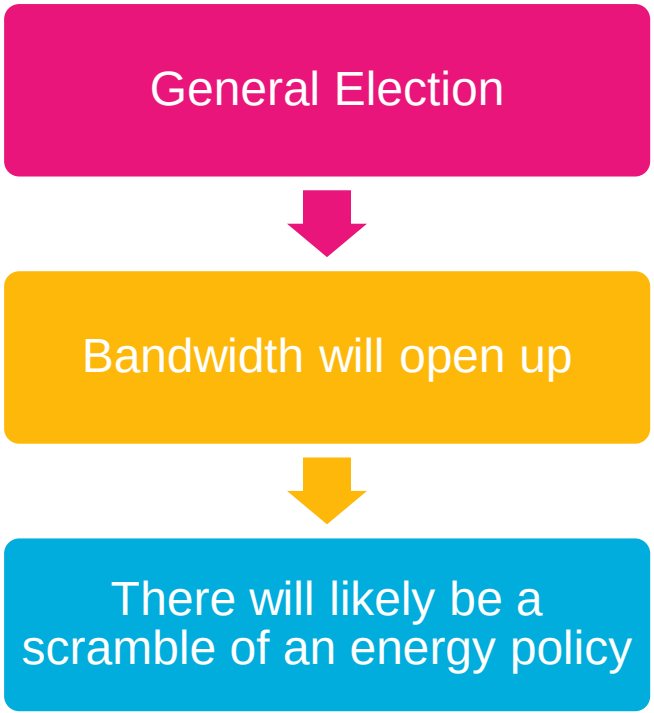
ofgem Making a positive difference for energy consumers

Key timings and how to engage



Meeting with Lord Duncan

A General Election and COP26



The COP (Conference of Parties), is the decision-making body responsible for monitoring and reviewing the implementation of the United Nations Framework Convention on Climate Change.

It brings together the 197 nations and territories – called Parties – that have signed the Convention.

COP26 will be held at the end of 2020. Turkey is also in the running to host this event, but the joint UK/Italy bid is seen as the clear favourite.

What does a COP look like?

Claire Mack

Chief Executive, Scottish Renewables

Audrey MacIver

Director of Energy and Low Carbon, Highlands and Islands Enterprise

Anna Kynaston

Head of Future Low Carbon, Scottish Government

Morag Watson

Director of Policy, Scottish Renewables

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David Langston

Programme Manager

Wave Energy Scotland

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@ScotRenew #SRMARINE19

Parallel 2A
Technology Showcase

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@ScotRenew #SRMARINE19

Tim Hurst

Managing Director

Wave Energy Scotland

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Simon Grey

Director

AWS Ocean Energy

#SRMARINE19

AWS Ocean Energy Ltd

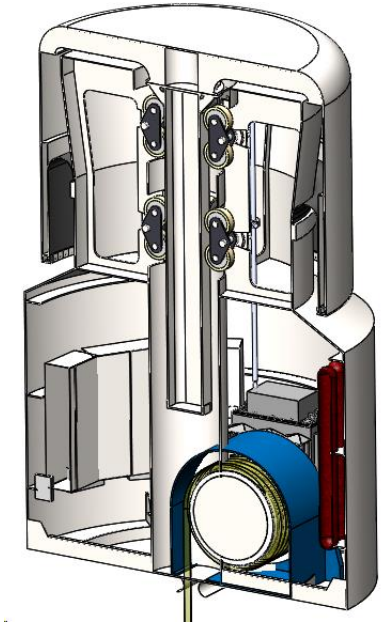
NWEC 3 Update

SR Marine 2019

Simon Grey

At-sea demonstration of Advanced Archimedes Waveswing

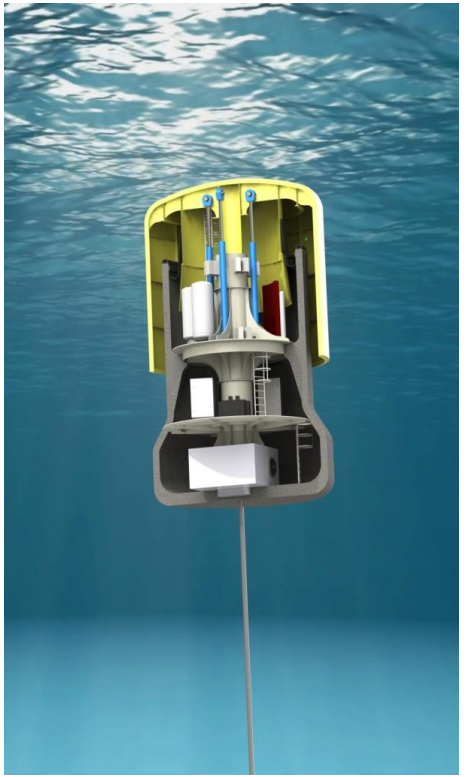
- Wave Energy Scotland NWEC Stage 3 project
- Design, construction, deployment and testing of a ½ scale Archimedes Waveswing
  - 4m diameter device rated at 16kW
  - 6 month deployment in Scapa Flow
  - Focus on key risk areas – marine operations, seal, sub-system reliability
  - Full shake-down ahead of offshore deployment planned for 2021



wave energy SCOTLAND

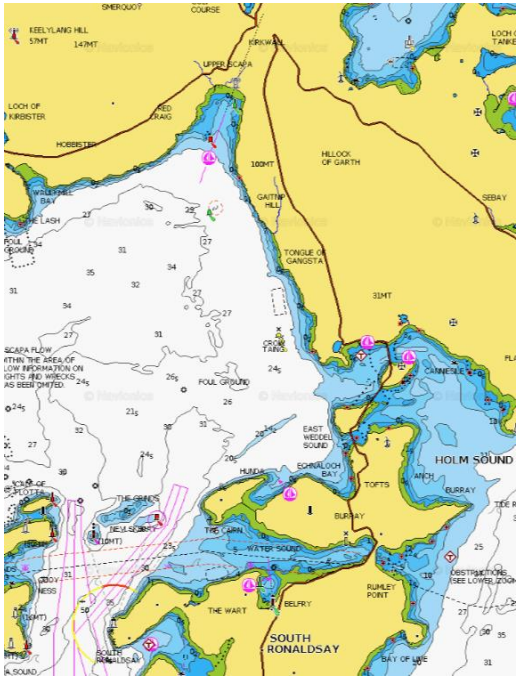
Project objectives

- De-risk best-in-class technology ahead of offshore deployment
  - Make sure WEC can be deployed, recovered and survives before worrying about performance!
- Demonstrate power generation using smart control
  - Essential for long-term economics
- Success milestone in WES NWEC programme
- Investor demonstration - seeing is believing
  - Essential step in attracting private finance
- Confirmation of business case inputs
  - CAPEX, OPEX, availability, AEP …



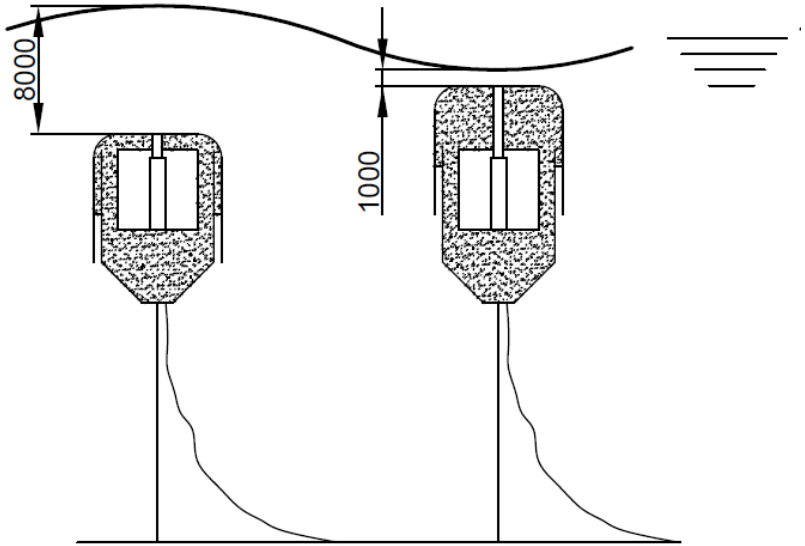
Project overview

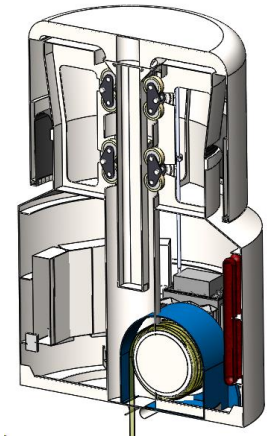
- Build deploy and test a real Waveswing
- Half scale but all key functions as per commercial intent
- 6 month deployment at EMEC scale test site in Scapa Flow
- Address key technology risks by testing:
  - Longevity of rolling seal
  - Functional performance of PTO
  - Effect of biofouling
  - Unforeseen deployment / recovery issues
  - Device loads and stability as volume is reduced
  - Durability and longevity of sensors in harsh environment
  - Functionality and reliability of survival systems
  - Functionality and reliability of internal pressure control
  - General system reliability and availability
- Shake down system before possible offshore deployment in 2021



Waveswing fundamentals

- Sub-sea pressure-differential device which works in anti-phase with wave, thus amplifying force
- Intrinsically capable of capturing significantly more power than a similarly-sized surface floating device.



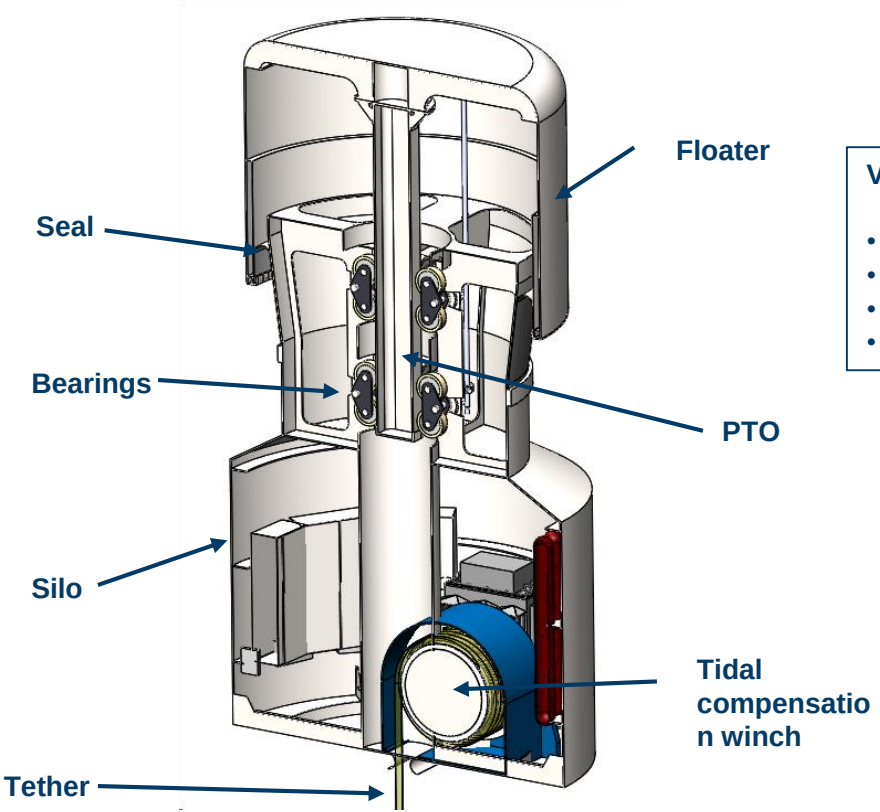


Technology USPs

- Fundamentals cannot be matched by surface-piercing devices
  - Wave forcing from pressure – double the force of equivalent floating device (static case) and enhanced by stroke
  - Controls challenge – velocity matching does not require wave prediction. Proven solution has achieved 70% of limit in irregular waves
- Key selling points
  - Potential for best in class LCOE due to fundamentals
  - Survivability & safety - shut-down and hide from waves
  - Zero visual impact – may be issue in early markets
  - High power density (low use of real-estate)
  - Low impact on fishing due to single-point moorings
  - Major fabrications and marine ops can be local
  - Key technology can be packaged for export (from Scotland)

NWEC3 Further Improved
Geometry And Seal Introduced

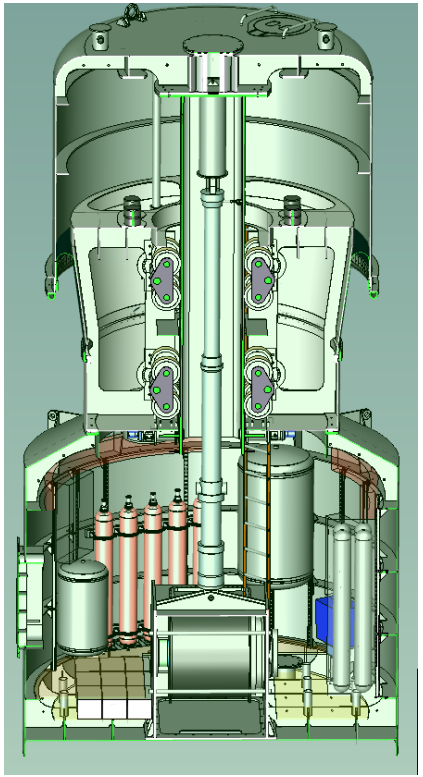
Design preview – half scale



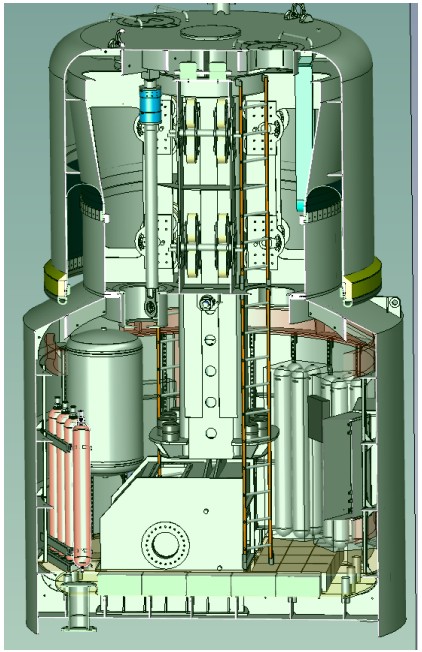
Vital statistics

- 4m diameter
- 28t fabricated steel
- Direct-drive PTO
- 16kW rating

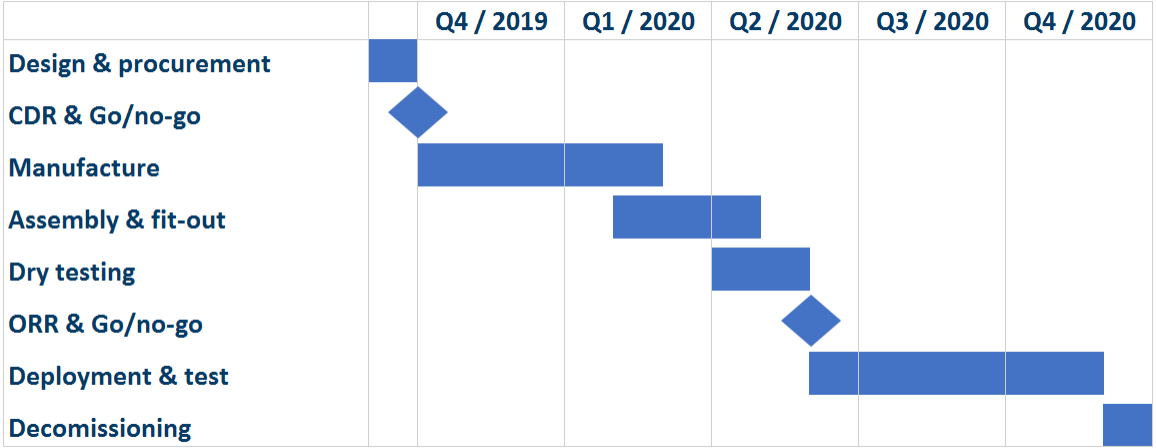
Design progress



- **Major subsystem design largely complete**
- **Internal layout well advanced**
- **Critical design review end September**
- **Begin placing orders mid-October**



Programme



- Programme is tight but workable
- Go/no-go gates are key risk management tools

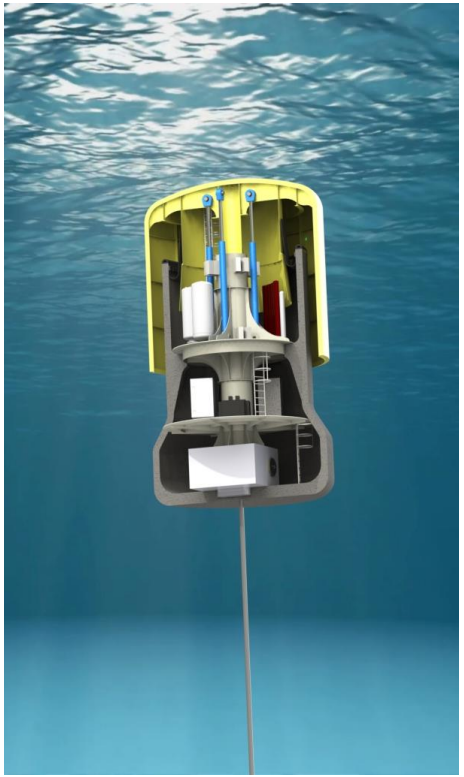
Team

- AWS 15 year history, significant experience in project delivery, commercial and technology management, strong network and key leadership skills
- Contractors engaged for key risk areas:
  - Engineering design
  - Seal development & supply
  - Tank testing and numerical modelling
  - Third-party verification
- Still to be contracted
  - PTO development & supply
  - E, C & I systems, inc hydraulics
  - Device manufacture, assembly and dry-testing
  - Marine operations
  - Etc!
- Come and talk if you have something to offer!

Your logo here!?

Summary

- Best-in-class technology – will be proven within 18 months
- World-class team
- Detailed execution plan with risk management strategy
- Good progress with WES Stage 3
- Tight but workable programme
- Supply chain opportunities remain
- Success not guaranteed but confidence is high!



Cameron McNatt

Director

Mocean Energy

#SRMARINE19

mocean energy

Power your next horizon

Cameron McNatt
Co-founder and Managing Director
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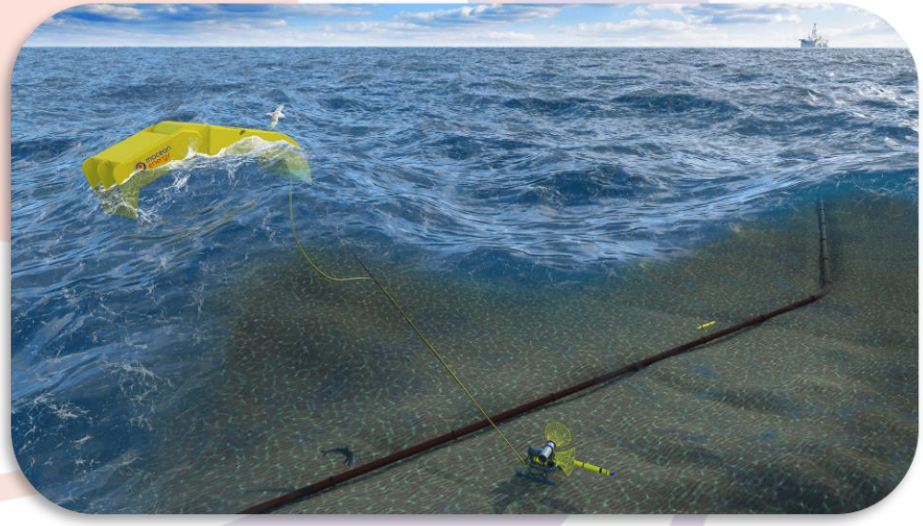
www.mocean.energy

Developing Wave Energy for…

While utility-scale is on our long-term horizon, our focus in on high value markets in O&G.



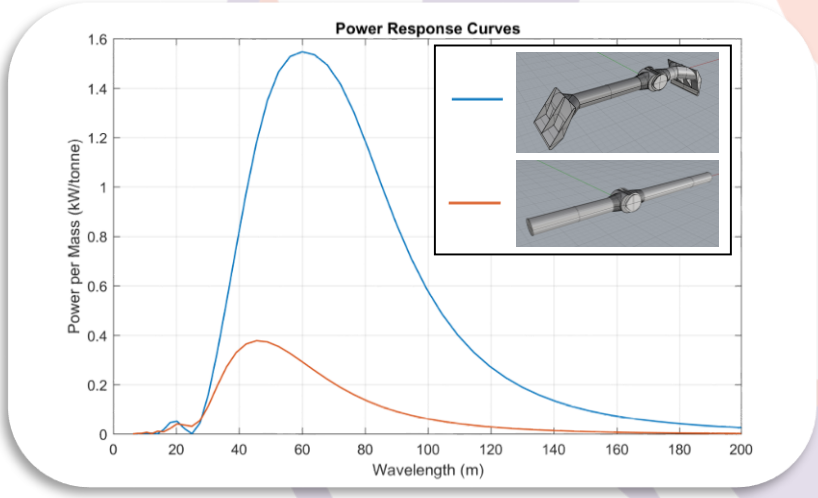
Team and Experience

- Based in Edinburgh
- Small team with expertise in hydrodynamics
- Work with partners to deliver technology
- Development with funding from Wave Energy Scotland
- Industry engagement through Oil & Gas Technology Centre TechX

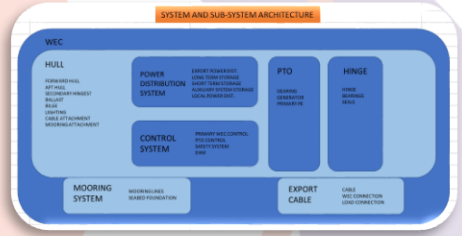
Hinged Raft WEC

Technology: Design Process

Innovative geometry developed through numerical optimization produced 3x more energy than traditional designs

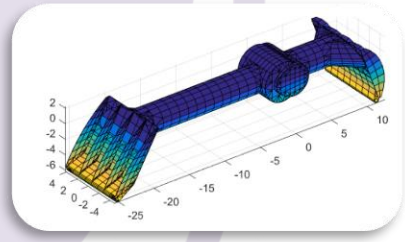


Engineering Requirements



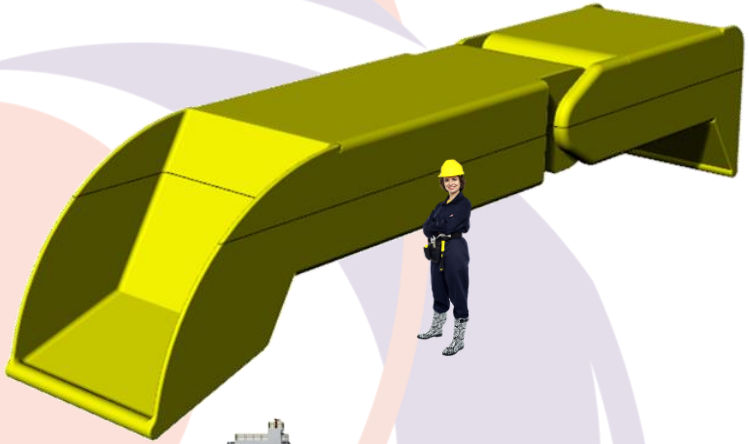
Wave Tank Validation

Numerical Optimisation

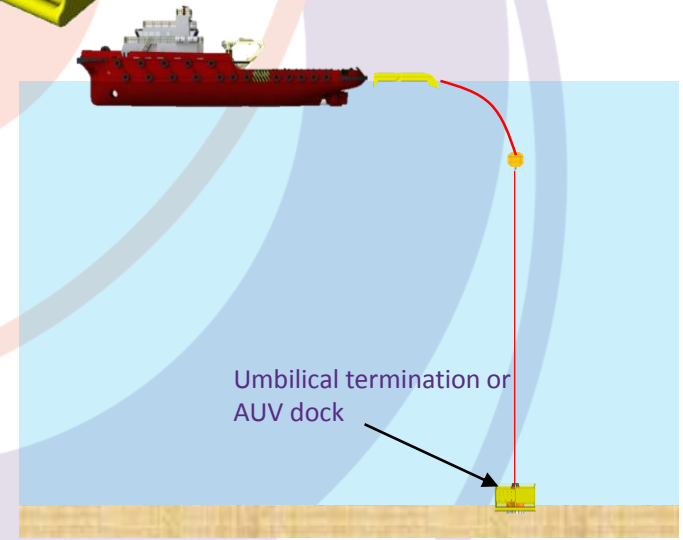


Seabase

Seabase will provide power and communications to offshore O&G applications.

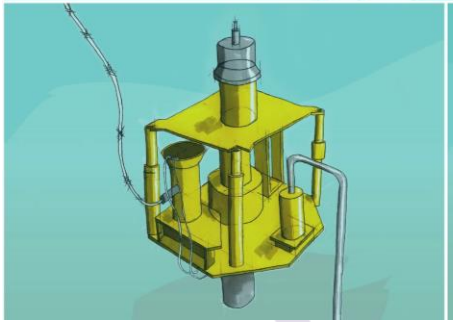


Power	2-4 kW average in North Sea. 50 kWh onboard battery
Dimensions	Fits in shipping container
Mass	10-15 tons
Comms	4G Tampnet Satellite
Mooring	Simple combined mooring-umbilical
Operations	Operations designed to be safe, easy, inexpensive and fast.

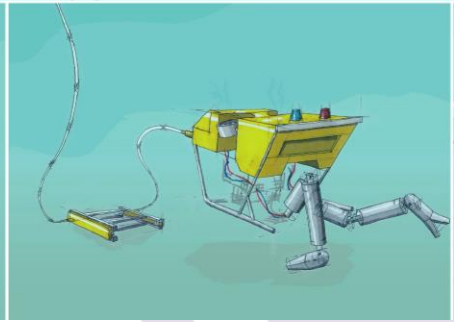


Applications

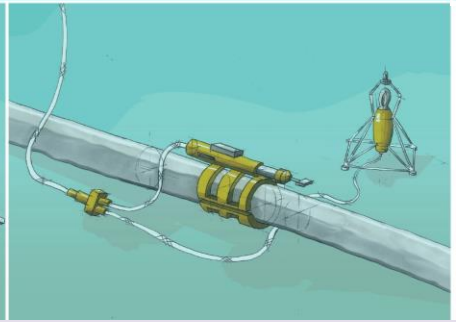
Monitoring



Subsea equipment



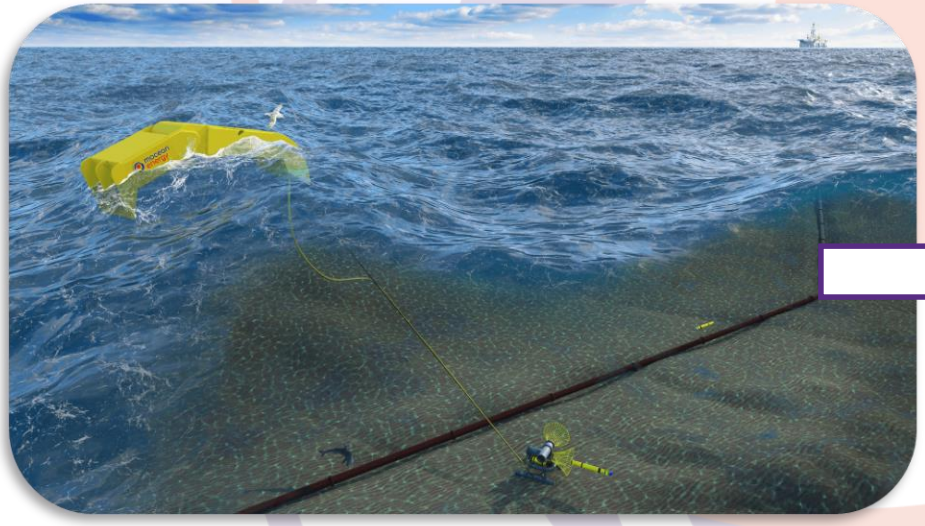
Residential robots



Sensors

The Energy Transition

Near term: decarbonize operations

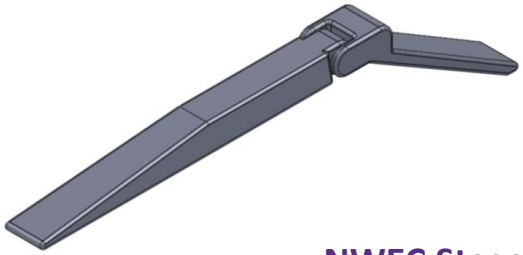


Long term: grid-scale wave energy

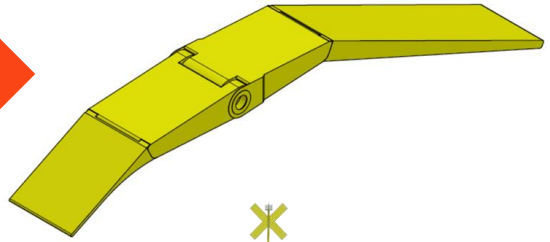
Evolution through WES Program

wave energy SCOTLAND

NWEC Application

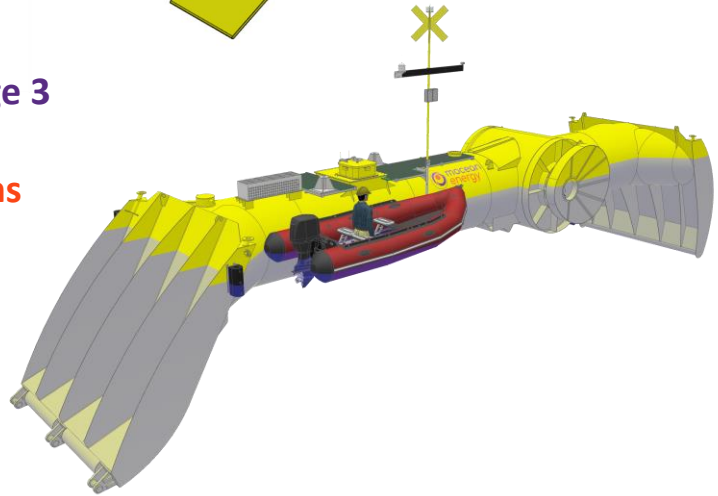


NWEC Stage 1



NWEC Stage 2

NWEC Stage 3



- 10 kW, 20 m, 30 tons
- Fabricated in Fife
- Tested in Orkney

BLACKFISH
ENGINEERING DESIGN AND PRODUCT DEVELOPMENT

THE UNIVERSITY OF EDINBURGH

mocean energy

Cameron McNatt
Co-founder and Managing Director
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Jonathan Hodges

Senior Innovation Engineer

Wave Energy Scotland

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@ScotRenew #SRMARINE19

Technology evaluation in ocean energy – a global challenge

Jonathan Hodges

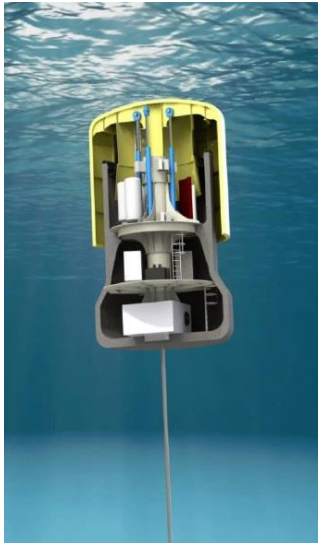
9th September 2019

wave energy SCOTLAND

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

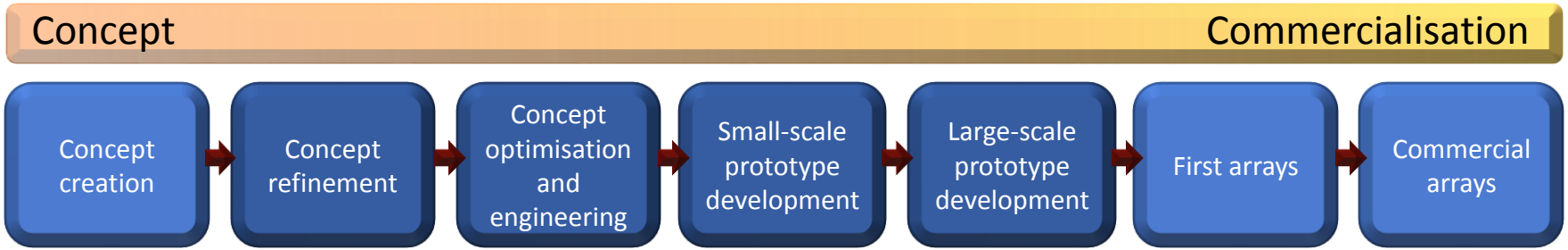
Technology evaluation

- Stage gates and metrics
- Technology evaluation benefits
- Global collaboration
- Driving innovation



Stage-Gates and Metrics

- Technology development

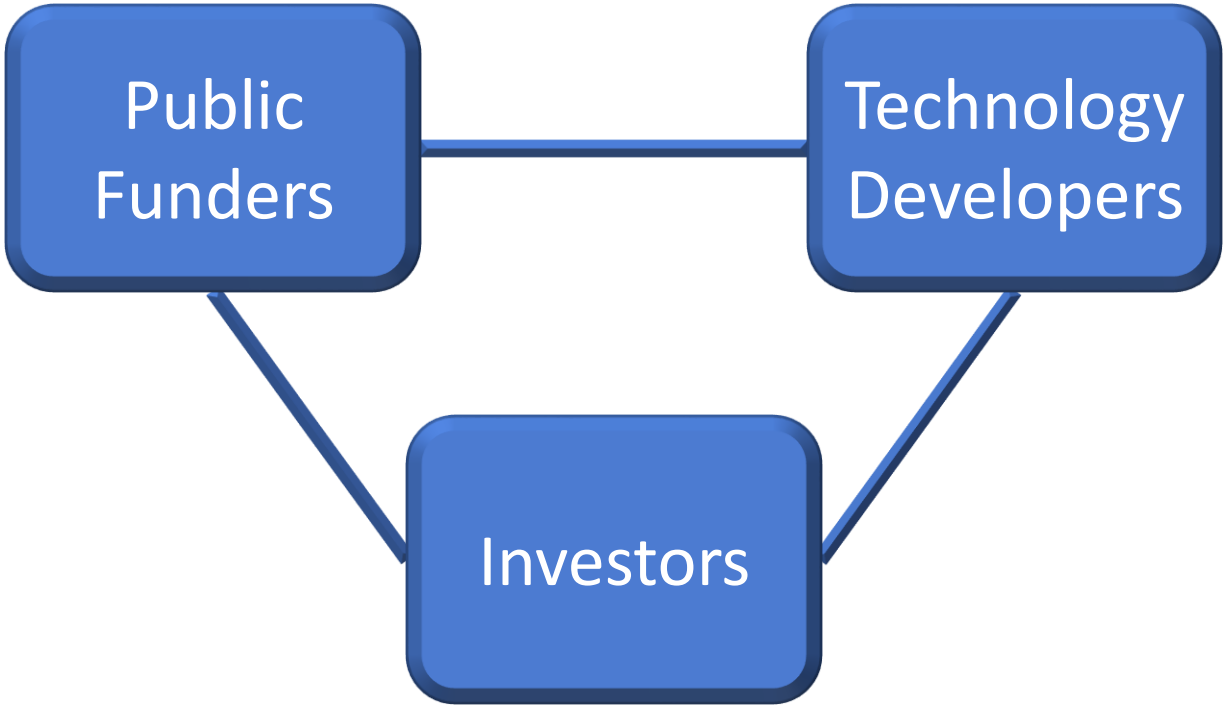


- WES funding calls

PTO | Devices | Materials | Controls | Connectors

- Technology Readiness AND Technology Effectiveness

Technology evaluation benefits



Global Collaboration

- IEA-OES Task 12
  - “International Technology Evaluation Framework for Ocean Energy”

- Clear definitions
- Evaluation methods
- Links to existing standards
- Wide review network to gain consensus

Driving Innovation

- International collaboration on funding
- Common challenges and opportunities
- Developing tools
- Providing a common supporting framework

TASK 12

Technology evaluation in ocean energy – a global challenge

Jonathan Hodges

Senior Innovation Engineer

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wave energy SCOTLAND

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Tim Hurst

Managing Director, Wave Energy Scotland

Simon Grey

Director, AWS Ocean Energy

Cameron McNatt

Director, Mocean Energy

Jonathan Hodges

Senior Innovation Engineer, Wave Energy Scotland

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@ScotRenew #SRMARINE19

ORGANISED BY

scottish renewables

IN ASSOCIATION WITH

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wave energy SCOTLAND

MARINE CONFERENCE, EXHIBITION & DINNER

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Parallel 2B

The UK & Global Outlook

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#SRMARINE19

David Jones

Project Director

Marine Energy Wales

#SRMARINE19

"Creating a supportive marine energy landscape in Wales"
David Jones, Project Director, Scottish Renewables 2019

MARINE ENERGY WALES
YNNI MOROL CYMRU

www.marineenergywales.co.uk

Marine Energy Wales brings together technology developers, the supply chain, academia and the public sector to establish Wales as a global leader in sustainable marine energy generation

- CiC / MEP2008 / MEW2016 - SPA
- 20 international and national wave and tidal developers interested in Wales / SC / Gov / PB
- Policy / Supply Chain / Research / Consents / Collaboration / Test Centre Network
- MoU Canada / Cornwall / Wave Hub / Brittany / Sweden
- Wales is committed to Marine Energy

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www.marineenergywales.co.uk

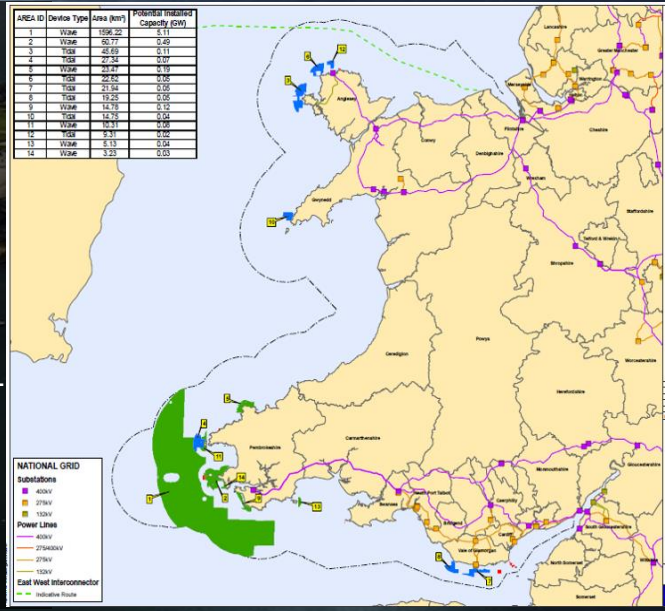
Policy and Welsh Government Support

- Since 1999 Wales legal duty relating to sustainability
- Legislative Framework - the Wellbeing of Future Generations Act 2015, the Planning (Wales) Act 2016 and Environment (Wales) Act 2016
- Welsh National Marine Plan
- Marine Renewable energy's role in achieving the Welsh target of generating 70% of its electricity consumption from renewable energy by 2030 – NRP 2017 Increasing renewable energy as 1 of 3 national priorities
- FM priorities – Renewables, Marine, Consenting - Climate change emergency

"*We hope that what Wales is doing today the world will do tomorrow*"
United Nations

Evidence Based Approach – Policy Delivery

- Diverse resource - Tidal Stream / Wave 6.4 GW / Tidal Range 10+
- World class ports, skills and energy sector supply chains
- Grid access
- 2 Array Scale Demonstration Zones - TCE 2014
- EU Structural Funding - €100,428,444M prioritising Marine Energy in Wales 2014 - 2020 / £60M SBCD / NWGD – Morlais / 200M TLP
- €299.3M for Research and Innovation – SEACAMS



Tidal energy impoundment and coastal defence

North Wales Tidal Energy | Ynni Llanw Gogledd Cymru

£27M / UK HQ in Anglesey 80MW / Created 30 jobs 100 SC / £3m UK contracts / Fabrication Hall with Stenna

Minesto

YnNi Llŷn community project local use of energy

NOVA INNOVATION

£3M MPS constructed ¼ scale WaveSub device in Pembroke Dock / Testing / Full Scale Design

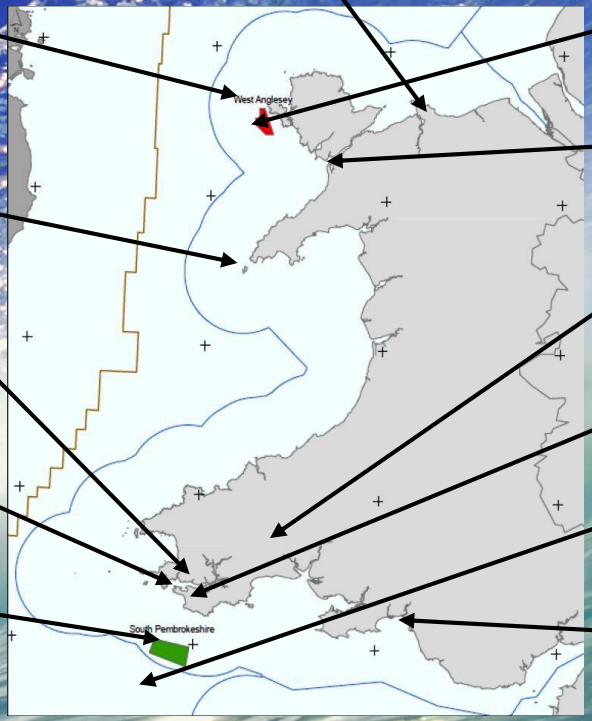
MARINE POWER SYSTEMS

£6M Wave-tricity constructed and testing Ocean Wave Rower PTO and design

wave-tricity

£0.5M Pembrokeshire Demonstration Zone Feasibility

Wave Hub



£33M / 8 developers awarded berths at West Anglesey Demo Zone 193.5MW of grid agreement. Shared inf with Minesto 240MW

morlais ANGLESEY MARINE ENERGY

£17M SEACAMS 2 Research

SEACAMS

£76m Pembroke Dock Marine

UK Catapult MEECE / META / Demo Zone / Port Inf

Pembroke Port | CATAPULT Offshore Renewable Energy | Marine Energy Wales | Wave Hub

EU HQ in Pembroke £20M project using META

bombora wavepower

Offshore floating wind

£1.3B SBTL project / Development consent / Hendry Review recommendation for pathfinder project is a "no regrets policy"

TIDAL LAGOON SWANSEA BAY

MARINE ENERGY WALES
YNNI MOROL CYMRU

www.marineenergywales.co.uk

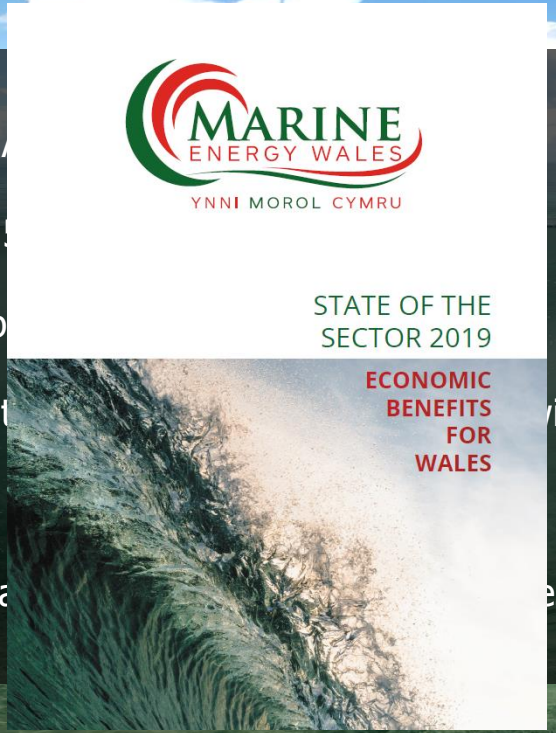

£45.4 million
2015
£68.3 million
2017
£96.2 million
2019

Marine Energy in Wales – Socio-economic benefits

- Coastal regions = £46m /
- £46M tidal stream / £12.
- 566 person years of emp
- > 50% Welsh SC content
- Supply chain capability
- Driving international inwa

ithin 20 mile radius

esearch



Decarbonising the future in Wales

RWE Pembroke Power Station
2200MW Combined Cycle Gas Turbine

Valero Pembroke Refinery
270,000 bpd, 10.5m barrels storage

SemLogistics
8.7mb petroleum products storage facility

Dragon LNG
Liquefied Natural Gas terminal

South Hook LNG
Liquefied Natural Gas terminal

Puma
1.4m m^3 storage facility

An extensive energy port with a high-skill, experienced supply chain

- Mechanical engineering
- Marine engineering
- Electrical engineering
- Fabricators
- Ship repairs and building
- Lifting and crane hire
- Tugs, barges, workboats
- Dry dock
- Wide load escorts
- Safety and training
- Bunkering
- Marine simulator

Pembroke Dock Marine

Reshape the physical infrastructure of Pembroke Port Gate 4, to ensure maximum operational efficiencies for UK industryA

Create pre-consented zones within the Milford Haven Waterway for component and scaled device testing (META)

Consents and planning for PDZ array scale testing for wave and floating wind technologies

Establish the Marine Energy Engineering Centre of Excellence for research and innovation

Training and Education

Port of Milford Haven

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Wave Hub

CATAPULT
Offshore Renewable Energy

Regional Learning Part.
Swansea Uni
Pembs College

SC Diversification / Clusters

+

enhanced operational efficiencies

+

increased innovation

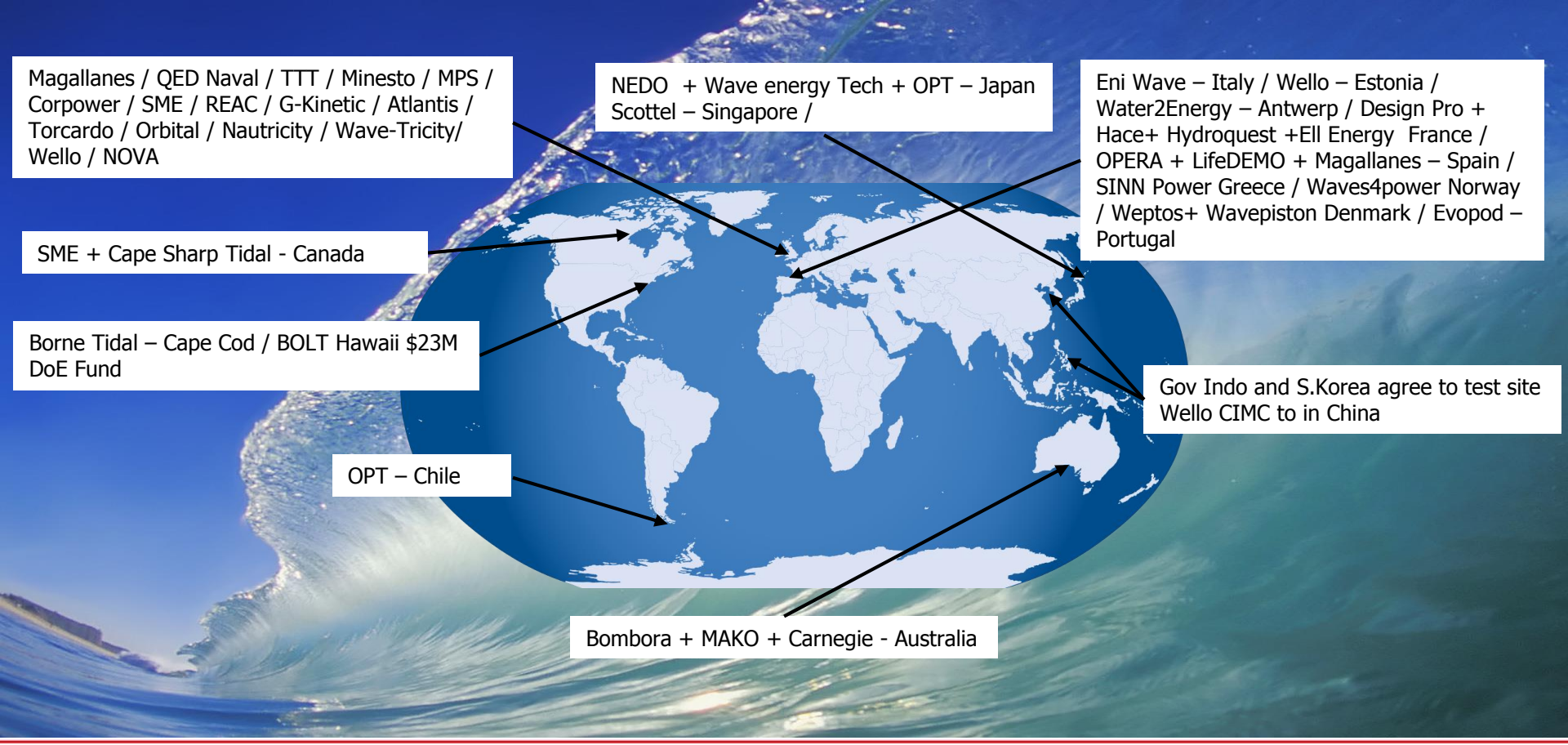
to

LCOE

£60.31M project funded by WG/UK/WEFO

Marine Energy in Wales – next steps

- Continue to push UK Gov for revenue support – Collaborate
- Deliver the WEFO pipeline 100M
- Finalise the SBCD / PDM
- Continue to develop NWGD
- Deliver SELKIE
- Get marine into the Prosperity Fund
- Deliver for the FM


Magallanes / QED Naval / TTT / Minesto / MPS / Corpower / SME / REAC / G-Kinetic / Atlantis / Torcardo / Orbital / Nautricity / Wave-Tricity/ Wello / NOVA
NEDO + Wave energy Tech + OPT – Japan Scottel – Singapore /
Eni Wave – Italy / Wello – Estonia / Water2Energy – Antwerp / Design Pro + Hace+ Hydroquest +Ell Energy France / OPERA + LifeDEMO + Magallanes – Spain / SINN Power Greece / Waves4power Norway / Weptos+ Wavepiston Denmark / Evopod – Portugal
SME + Cape Sharp Tidal - Canada
Borne Tidal – Cape Cod / BOLT Hawaii $23M DoE Fund
Gov Indo and S.Korea agree to test site Wello CIMC to in China
OPT – Chile
Bombora + MAKO + Carnegie - Australia

Diolch yn Fawr

MARINE ENERGY WALES
YNNI MOROL CYMRU

www.marineenergywales.co.uk

Vicky Coy

Project Manager

ORE Catapult

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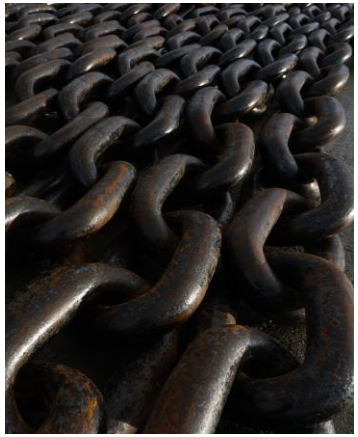
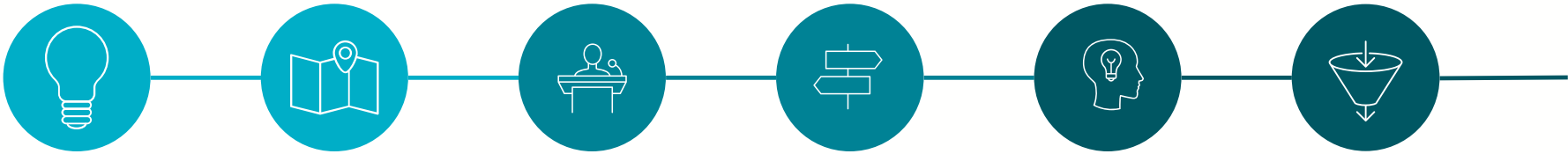


The UK & Global Outlook

9 September 2019 | Vicky Coy

CATAPULT Offshore Renewable Energy

Timeline



2013

Catapult launches

2014

First links made with FORCE

2015

Marine Renewables Canada Conference

2016

OERA, Nova Scotia environment-related work

2017

First links made with CSIRO, Australia

2018

Links made with US DOE, project started with NRC-OCRE

Now and beyond

Strengthening links, providing expertise

2020

2019

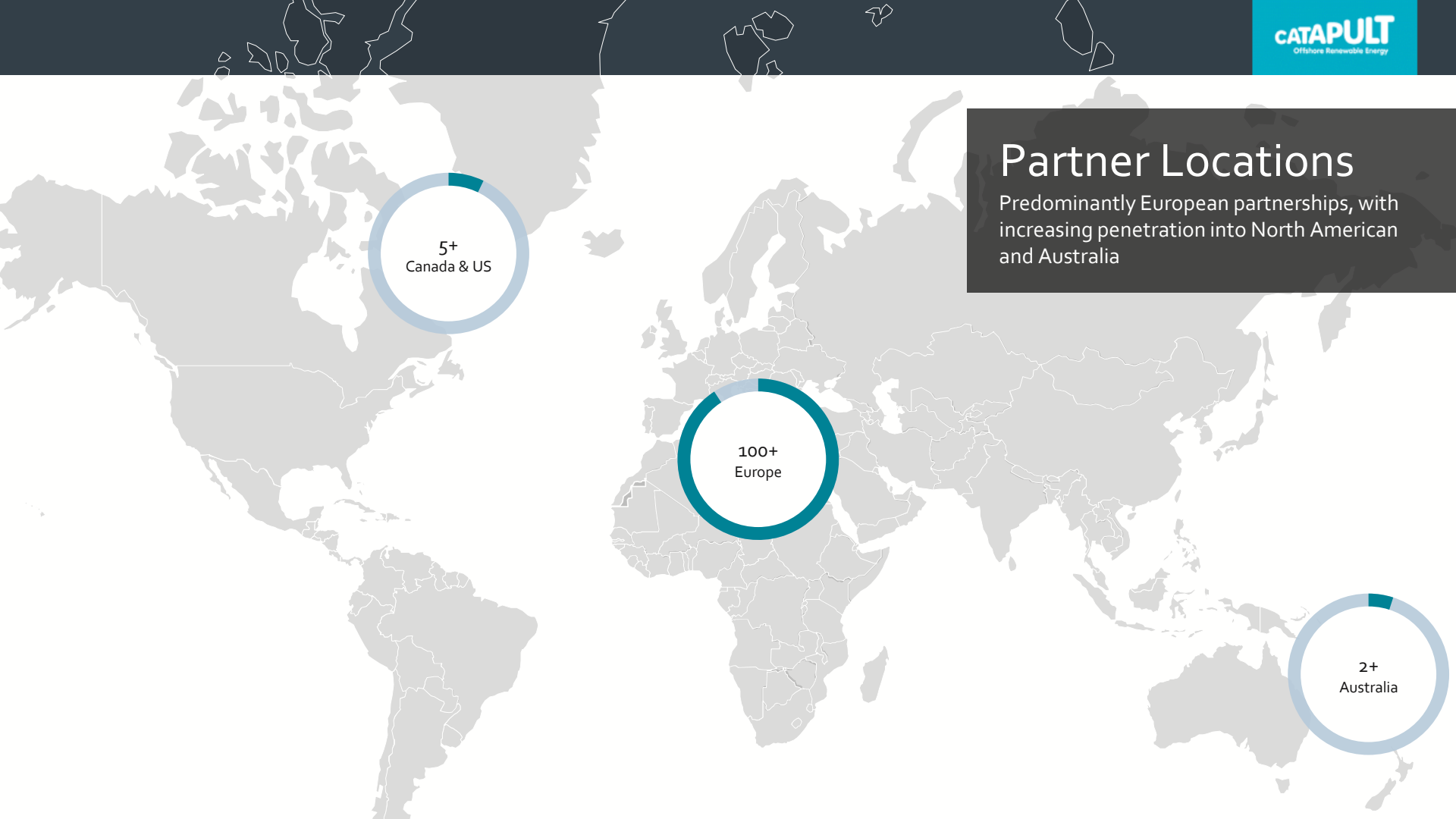
Completion of NRC project, MOU in place, ARENA review completed

2021

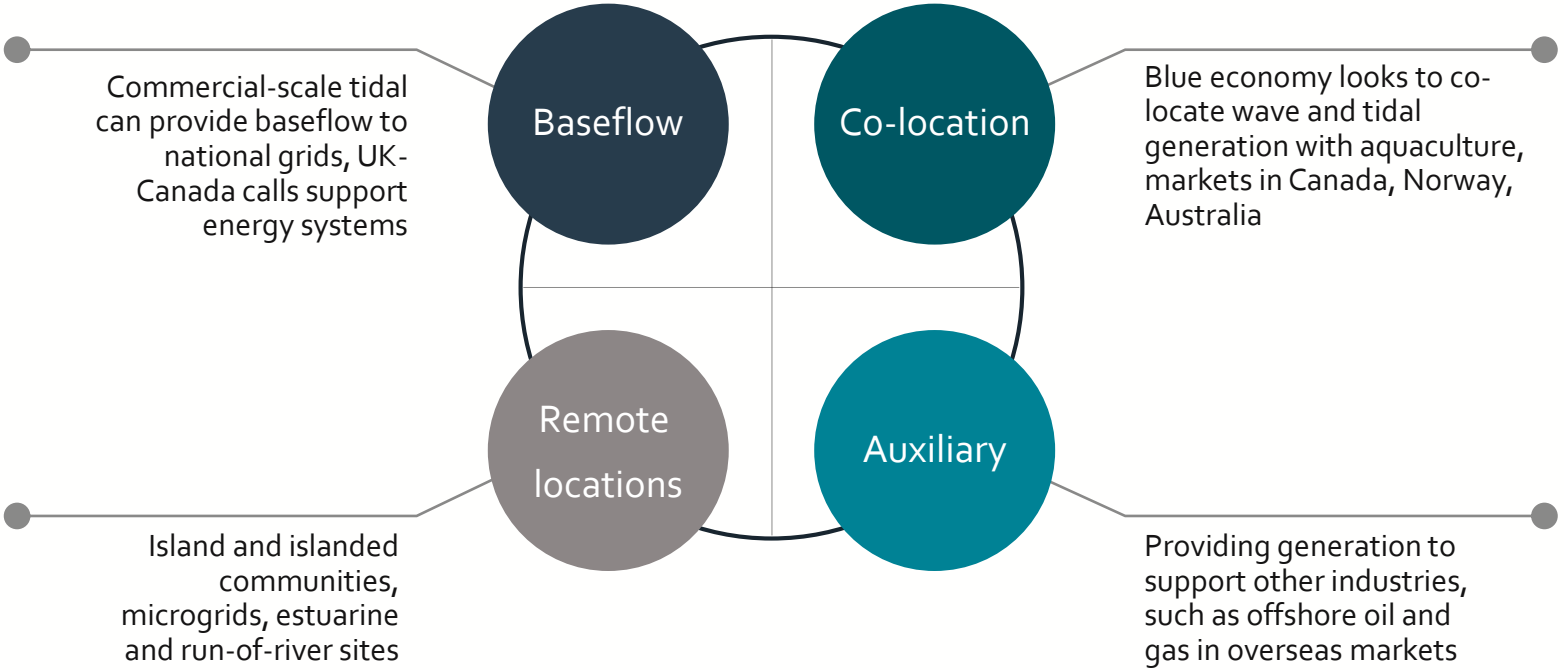
Global partnerships

Partner Locations

Predominantly European partnerships, with increasing penetration into North American and Australia



Opportunities



Going forward

Henry Jeffrey

Chairman of the

International Energy Agency,

Technology Collaboration Program for

Ocean Energy

#SRMARINE19

IEA Technology Collaboration Programme
OCEAN ENERGY SYSTEMS

Henry Jeffrey
Chairman IEA OES

IEA Technology Collaboration Programmes

International Energy Agency

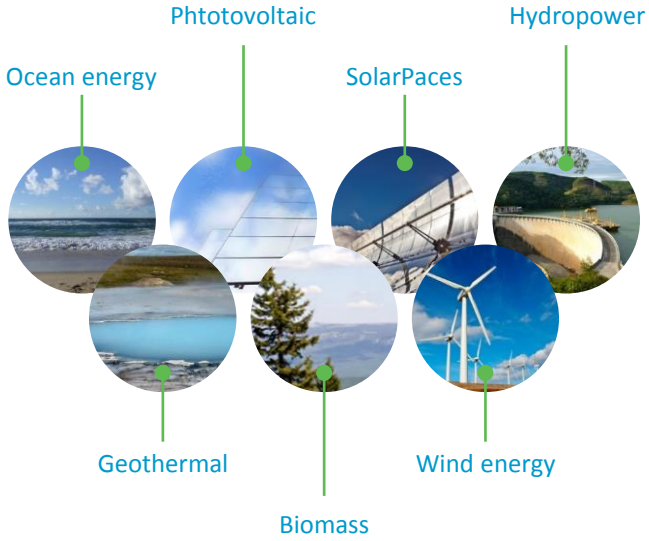
Energy Security | **Environmental** Protection | **Economic** Growth | **Engagement** Worldwide

→ Governments and Industry benefit from sharing resources and accelerating results

→ For this reason the IEA enables independent groups of experts – **IEA Technology Collaboration Programmes**

→ Over 40 groups working in the following areas:

- Efficient end-use technologies
- **Renewable energies**
- Fossil fuel
- Cross-cutting issues



Main sources of ocean energy

- Tidal/Ocean Currents
- Waves
- Tidal Rise & Fall
- Thermal Gradient
- Salinity Gradient

→ OES covers all forms of ocean energy, but NOT offshore wind - **seawater must be the motive power**

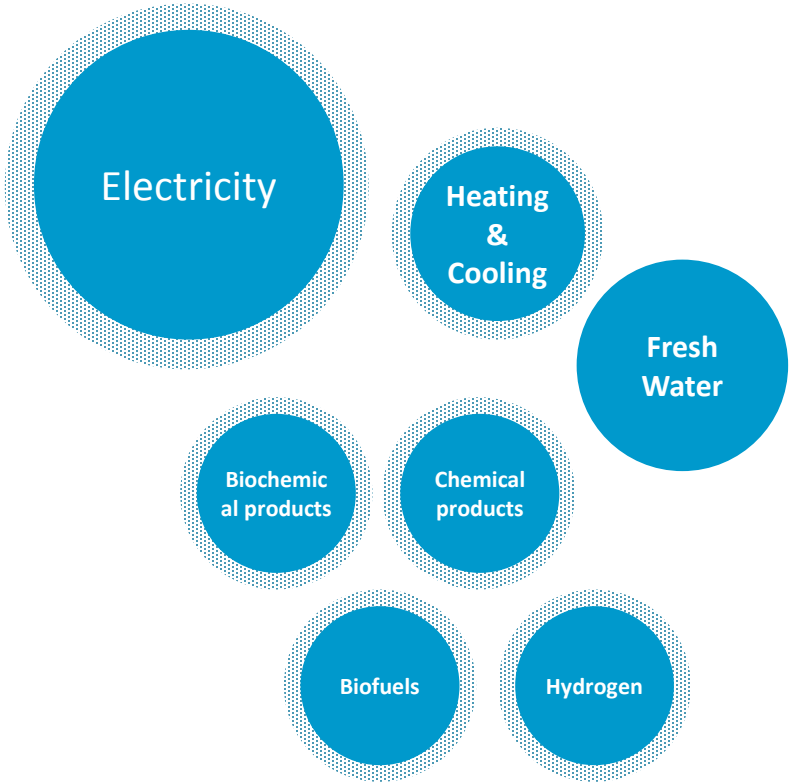
→ **Products can include:** electricity, heat, cooling, water (drinking and pressurized), biofuels, chemicals

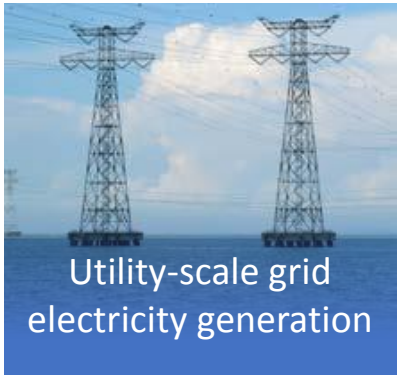
THE OES VISION FOR INTERNATIONAL DEPLOYMENT OF OCEAN ENERGY

→ Worldwide, there is the potential to develop over 300 GW of ocean energy by 2050

→ By 2050, the ocean energy deployment could create 680,000 direct jobs and save 500 million tones of CO_2 emissions.

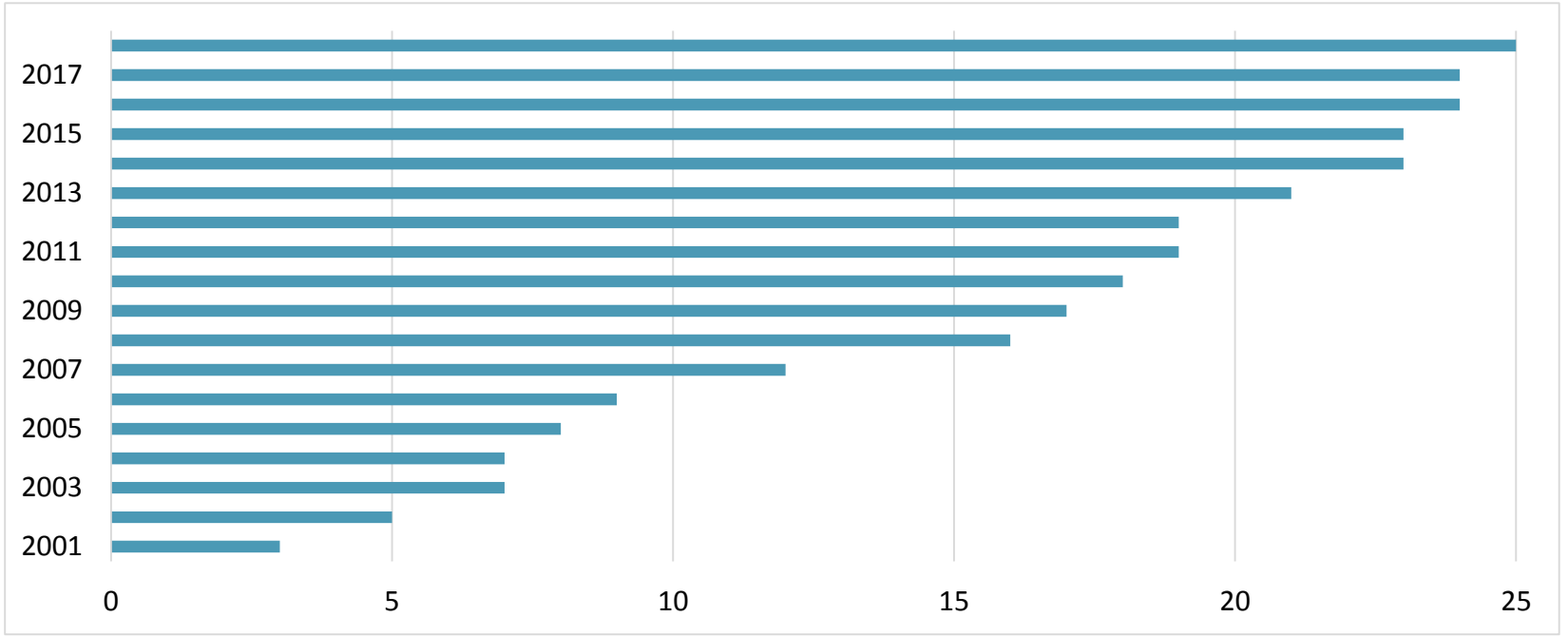
Products and Markets for Ocean Energy



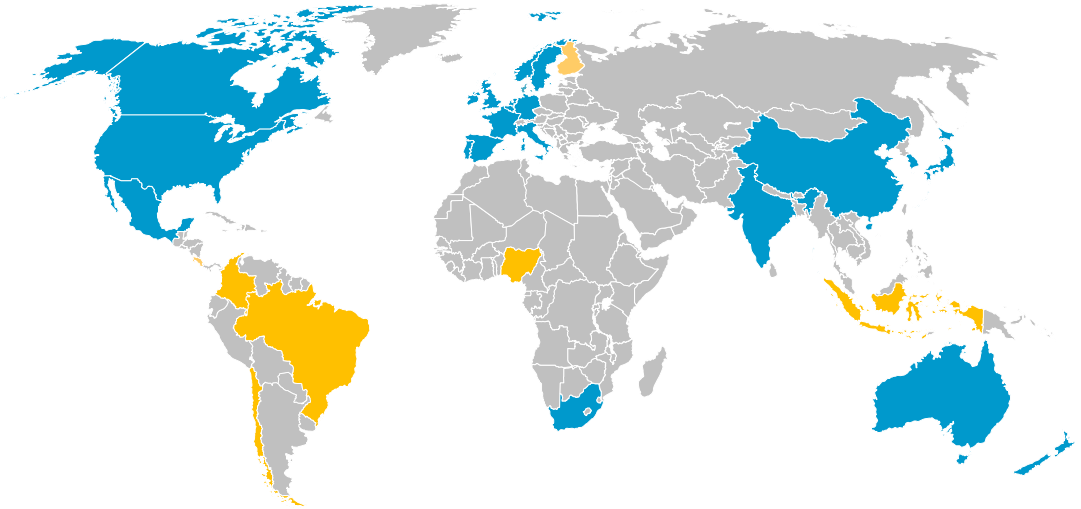


Membership grow

Participation in OES builds connections between national governments and industries, creates networks of experts and expands national research cap



Membership diversification



Member countries (24) + European Commission

Observers; countries invited to join

Diversified representation of interests in the ExCo

- GOVERNMENTAL DEPARTMENTS
- INDUSTRY ASSOCIATIONS
- UTILITIES
- ENERGY AGENCIES
- GOVERNMENTAL AGENCIES
- RESEARCH ORGANIZATIONS
- UNIVERSITIES

Work Program

The OES is self-financed by the participants

Participant contributes to a common fund which can then be used to finance activities under the OES's programme of work

Cost-sharing activities, task-sharing or a combination of both

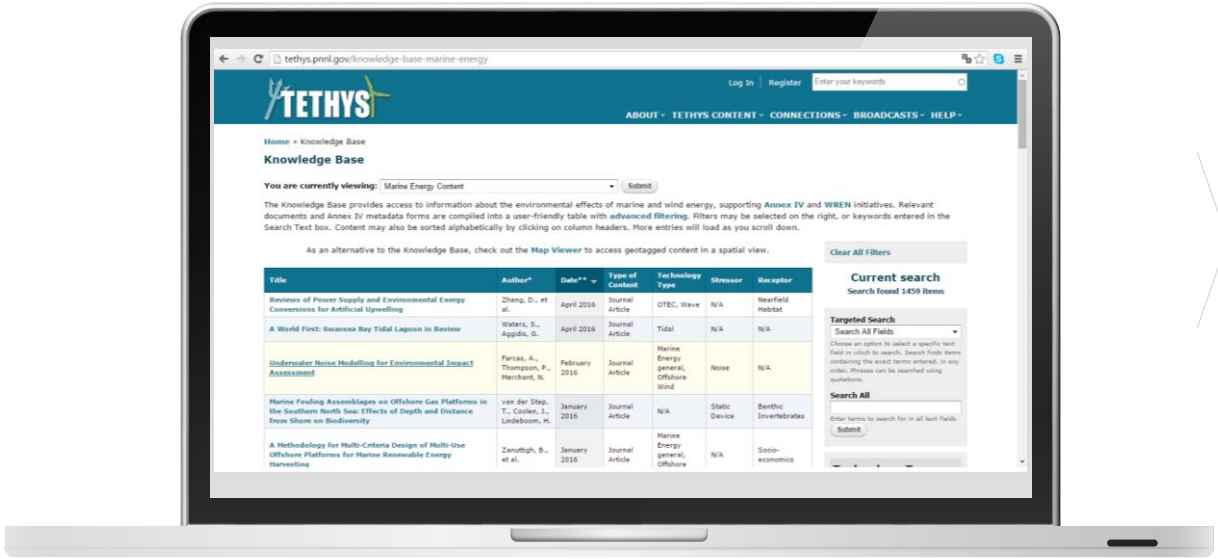
Co-operative tasks bringing together experts from industry, government, and research institutions around the world to exchange

TASK N°	TITLE	LEAD BY	STATUS
1	Review, Exchange and Dissemination of Information on Ocean Energy Systems	Portugal	Active
2	Development of Recommended Practices for Testing and Evaluating Ocean Energy Systems	Denmark	Completed
3	Integration of Ocean Energy Plants into Distribution and Transmission Electrical Grids	Canada	Completed
4	Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal and Current Energy Systems	United States	Active
5	The Exchange and Assessment of Ocean Energy Device Project Information and Experience	United States	Completed
6	Worldwide Web GIS Database for Ocean Energy	Germany	Active
7	Cost of Energy Assessment for Wave, Tidal, and OTEC at an International Level	UK	Active
8	Consenting Processes for Ocean Energy on OES Member Countries	Portugal	Active
9	International Ocean Energy Technology Roadmap	UK	Active
10	Wave Energy Converters Modelling Verification and Validation	Denmark	Active
11	Investigation and Evaluation of OTEC Resource	Japan	Active
12	Stage Gate Metrics International Framework for Ocean Energy	European Commission	Active
13	Tidal Energy Converters Modelling Verification and Validation	Singapore	Active
14	Assessment of Jobs Creation on Ocean Energy (Terms of Reference under preparation)	France	Active
15	Ocean Energy in Insular Conditions		New activities under discussion
16	Open Water Testing		

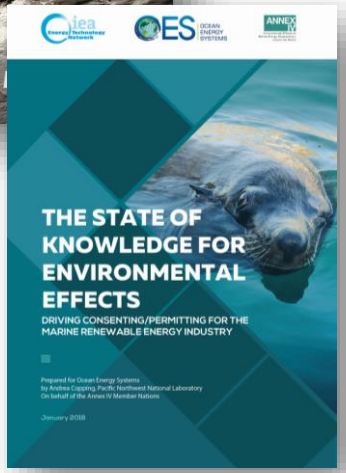
Environmental Issues

Making existing information available and accessible

→ **OPERATING AGENT:** DOE (USA)



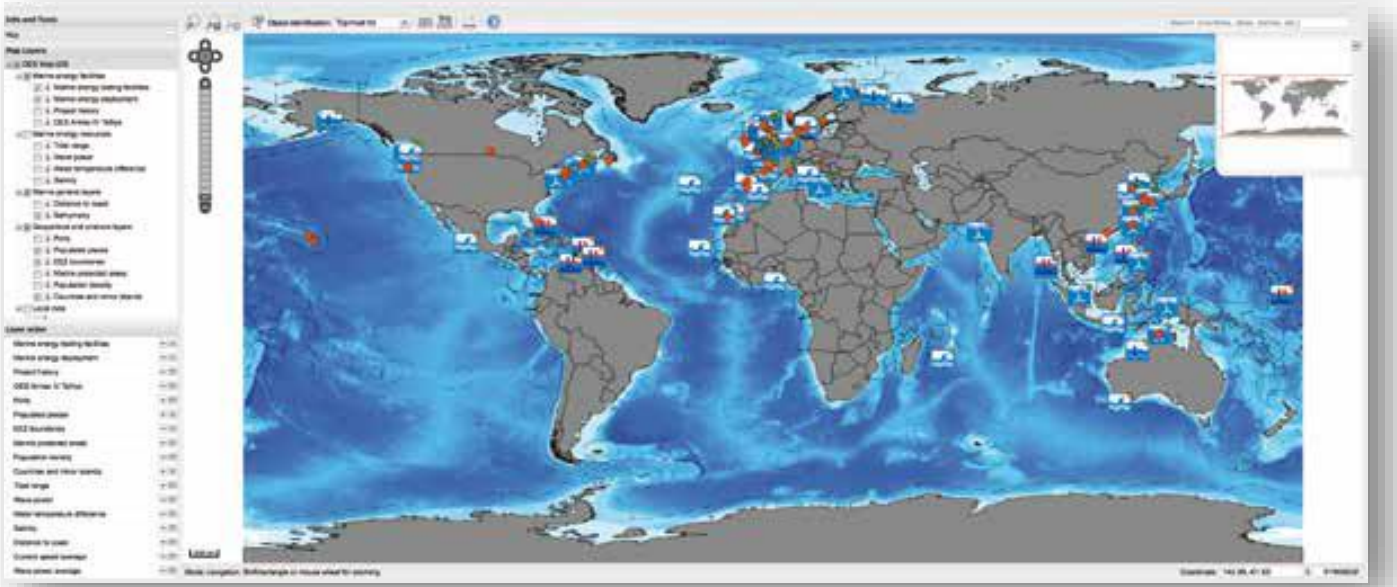
Access Tethys Knowledge Base



Worlwide Web-based GIS database

Providing detailed information on ocean energy resources and related projects

→ **OPERATING AGENT:** Fraunhofer IEE (Germany)



Roadmap for Ocean Energy

→ **OPERATING AGENT:** The University of Edinburgh (UK)

INDUSTRIAL GOAL

By 2050, ocean energy has the potential to have deployed over 300 GW of installed capacity.

SOCIETAL GOAL

By 2050, ocean energy has the potential to have created 680,000 direct jobs and saved 500 million tonnes of CO2 emissions.

International Levelised Cost of Energy for Ocean Energy Technologies

→ **OPERATING AGENT:** The University of Edinburgh (UK)

ACHIEVEMENTS

Through investigation of LCOE for wave, tidal and OTEC technologies; consistent methodology applied

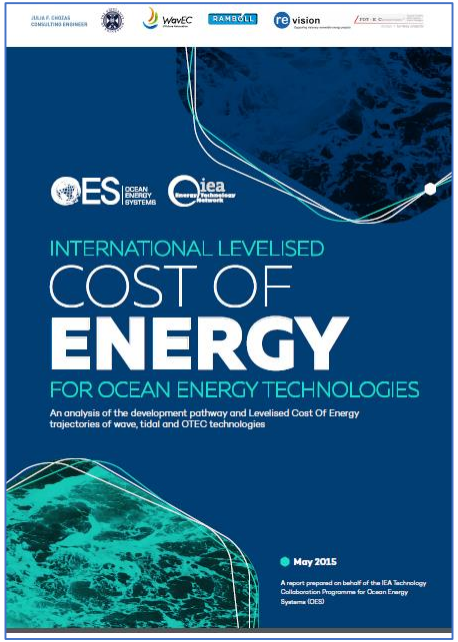
Cost reduction trajectories on an international level

Industry consultation - development of revised cost models

High costs intrinsic to the early stage development of technology

Cost reduction trends: clear trajectory towards a more affordable LCOE

Costs in the long-term are expected to decrease from the first commercial project level as experience is gained with deployment



Consenting Processes for Ocean Energy

→ **OPERATING AGENT:** WavEC (Portugal)

ACHIEVEMENTS

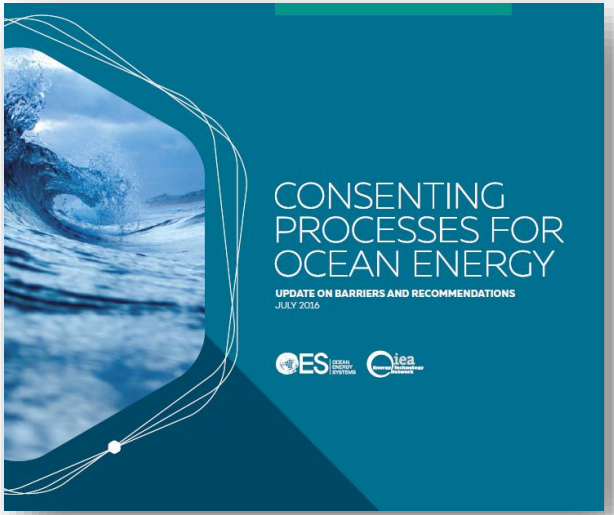
Succinct overview of current practice - providing a holistic picture of the situation in each OES member country

Particular emphasis on investigating the main barriers associated with permitting and licensing with a view to advising regulators and decision-makers.

Developers were given the opportunity to provide their views and insights on barriers.

Particular attention to Marine Spatial Planning and how this is influencing consenting processes.

10 Key Recommendations



Stage Gate Metrics on Ocean Energy

→ **OPERATING AGENT:** European Commission

OBJECTIVES:

Ongoing need to develop a process for defining appropriate and rigorous metrics for measuring success in a number of critical target areas of ocean energy technology development.

To build clarity, information and understanding to support the definition of a fully defined set of metrics and success thresholds.

To establish a common international stage gate metrics framework to be used by technology developers, investors and funders.

Internationally accepted approach

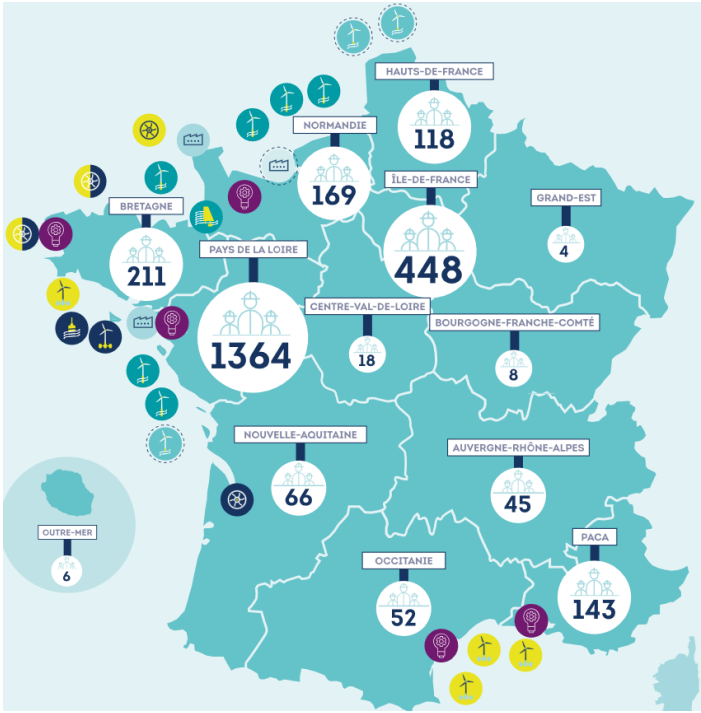
BENEFITS

- Ability to measure technology development progress
- Methodology to assist in the management of competitive calls
- Approach for ensuring appropriate allocation of funding
- To aid in building technology confidence in investors
- Ability to make cross technology funding comparisons
- Decision making assistance for private and public funders

Ocean Energy Jobs Creation

OBJECTIVES:

- To assess an accurate total number of existing jobs directly related to the sector.
- To validate an approach to assess jobs creation in the sector and update projections for the 2030/2050 horizons.
- Combination of surveys and economic models
- **Initiated in August 2019**



Number of jobs - France example:
Source: *L'observatoire des énergies de la mer;* http://merenergies.fr/

Ocean Energy in Insular Conditions

1st Workshop "Ocean Energy in Insular Conditions"
Organised by Nanyang Technological University with OES support OES on 8-9 March 2017, Singapore

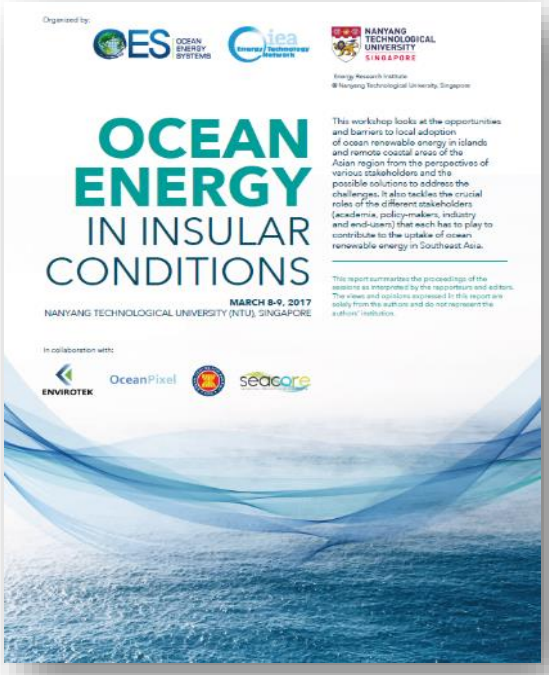
2nd Workshop "Ocean Energy in Insular Conditions"
Organised by Plocan with OES support on 11 June 2018, France

3rd Workshop "Ocean Energy in Insular Conditions"
To be organised by Plocan with OES support, April 2019, Hawaii

DISCUSSION

Opportunities and barriers to local adoption of ocean energy in islands and remote coastal areas region and the possible solutions to address the challenges.

Crucial roles of the different stakeholders (academia, policy-makers, industry and end-users) that each has to play to contribute to the uptake of ocean energy in inslands.



OPEN SEA TEST SITES

There are many open sea test sites established across the world and each has its own challenges, such as consenting issues, resource and operating environments. Test centres also provide very different service offerings to industry.

The development of open sea testing facilities encourages ocean energy development by enabling practical experience of installation, operation, maintenance and decommissioning activities for prototypes and farms, as well as on services and streamlining procedures.

CANADA

TEST SITE NAME	LOCATION
Fundy Ocean Research Centre for Energy (FORCE)	Minas Passage, Bay of Fundy, Nova Scotia
Canadian Hydrokinetic Turbine Test Centre (CHTTC)	Winnipeg River, Manitoba
Wave Energy Research Centre (WERC)	Lord's Cove, Newfoundland & Labrador

USA

TEST SITE NAME	LOCATION
U.S. Navy Wave Energy Test Site	Kaneohe Bay
Pacific Marine Energy Center PacWave North Site	Newport, Oregon
Pacific Marine Energy Center PacWave South Site	Newport, Oregon
Pacific Marine Energy Center Lake Washington	Seattle, Washington
Pacific Marine Energy Center Tanana River Hydrokinetic Test Site	Nenana, Alaska
Jennette's Pier Wave Energy Test Facility	Jennette's Pier, North Carolina
U.S. Army Corps of Engineers (USACE) Field Research Facility (FRF)	Duck, North Carolina
Center for Ocean Renewable Energy	Durham, New Hampshire
UMaine Offshore Intermediate Scale Test Site	Castine, Maine
UMaine Deepwater Offshore Renewable Energy Test Site	Monhegan Island, Maine
OTEC Test Site	Keahole Point, HI
Marine Renewable Energy Collaborative (MRECo) Bourne Tidal Test Site (BTTS)	Bourne, Massachusetts
Southeast National Renewable Energy Center - Ocean Current Test Facility	Boca Raton, Florida

NETHERLANDS

TEST SITE NAME	LOCATION
Oosterschelde	Eastern Scheldt barrier
Tidal Test Centre (TTC)	Den Oever
BlueTec floating platform	Texel Island
REDstack	Afsluitdijk

UNITED KINGDOM

TEST SITE NAME	LOCATION
European Marine Energy Centre (EMEC)	EMEC Orkney, Scotland
Wave Hub	Wave Hub Cornwall, England
FaBTest	Falmouth Bay in Cornwall
Marine Energy Test Area (META)	Milford Haven Waterway in Pembrokeshire
Morlais Tidal Demonstration Zone	West Anglesey

IRELAND

TEST SITE NAME	LOCATION
Galway Bay Marine and Renewable Energy Test Site	Galway Bay
AMETS	Belmullet, Co. Mayo

PORTUGAL

TEST SITE NAME	LOCATION
Pilot Zone	Viana do Castelo
Aguçadora test site	Aguçadora

SPAIN

TEST SITE NAME	LOCATION
BiMEP	Basque Country
Mutriku Wave Power Plant	Basque Country
Oceanic Platform of the Canary Islands (PLOCAN)	Canary Islands

MEXICO

TEST SITE NAME	LOCATION
Port El Sauzal	Ensenada, Baja California
Station Puerto Morelos	Puerto Morelos, Quintana Roo

SWEDEN

TEST SITE NAME	LOCATION
The Lysekil wave energy research test site	Lysekil
Söderfors research site	Dalälven

DENMARK

TEST SITE NAME	LOCATION
DanWEC	Hanstholm
DanWEC NB	Nissum Bredning

BELGIUM

TEST SITE NAME	LOCATION
Ostend wave energy test site	Harbour of Ostend

NORWAY

TEST SITE NAME	LOCATION
Runde Environmental Centre (REC)	Runde Island

CHINA

TEST SITE NAME	LOCATION
National small scale test site	Weihai, Shandong Province
Zhoushan tidal energy full scale test site	Zhoushan, Zhejiang Province
Wanshan wave energy full scale test site	Wanshan, Guangdong Province

REPUBLIC OF KOREA

TEST SITE NAME	LOCATION
K-WETEC (Korea Wave Energy Test and Evaluation Centre)	Jeju
Korea Tidal Current Energy Centre (KTEC)	Undecided

SINGAPORE

TEST SITE NAME	LOCATION
Sentosa Tidal Test Site	Sentosa Island

FRANCE

TEST SITE NAME	LOCATION
SEM-REV, wave and floating offshore wind test-site	Le Croisic
SEENEOH estuarine and ¼ scale tidal site	Bordeaux
Paimpol-Brehat, tidal site	Bréhat

iea Energy Technology Network | OES OCEAN ENERGY SYSTEMS

OES has been collaborating with the **International WATERS group** led by the European Marine Energy Centre (EMEC)

Collaboration with International organisations

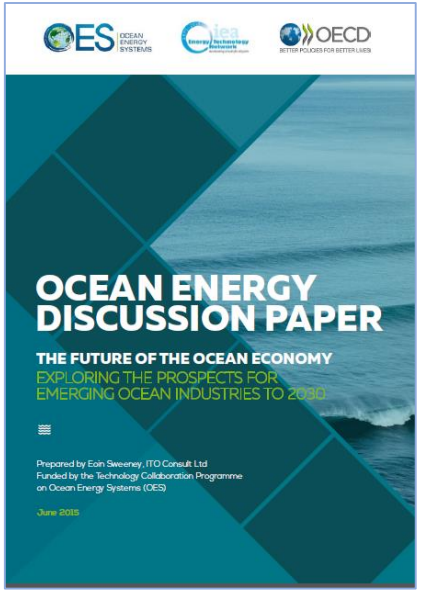
The OES is the organizer of a “poster award” and hosts a website with past conference material

Collaboration with IRENA on specific topics of common interest

Collaboration with the OECD project “The Future of the Ocean Economy”

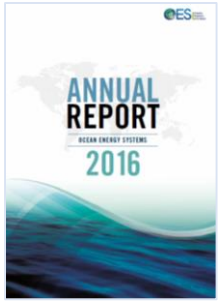
International Network on Offshore Renewable Energy (INORE) - Financial sponsorship

Participation in the Technical Committee (TC) 114: Marine Energy – Wave and Tidal Energy Converters
Collaboration with the IECRE System



OES Annual Report

Authoritative reference source



→Ocean Energy Policy

→Research & Development

→Technology Demonstration

report2017.ocean-energy-systems.org

SPECIAL

THEMES

1

2014 Annual Report
Current Perspectives of 3 Leading Project Developers

2

2015 Annual Report
Interview to funding entities

3

2016 Annual Report
Interview to test centers

4

2017 Annual Report
Environmental Issues on Ocean Energy

5

2018 Annual Report
Interview Performance metrics

Outreach: New brochure

Spotlight on Ocean Energy
launched in 2018

Provides insights of 20 ocean energy projects and 5 policy initiatives on the OES member countries.

Summary

- Utilization of ocean energy resources will contribute to the world's future sustainable energy supply and reduce carbon emissions, whilst minimizing impacts on marine environments.
- Potential to develop 300 GW by 2050 with the right policies.
- Significant benefits in terms of new jobs and investments.
- Wide range of technologies at different stages of development.
- Ocean energy technologies must achieve a significant improvement in reliability and performance whilst reducing overall costs.
- Several sectors are potentially capable of knowledge sharing and technology transfer.
- Government investment is critical to making ocean energy technologies viable but government commitments also encourage and support the larger contribution from public and private investors.

AN INTERNATIONAL VISION FOR OCEAN ENERGY

Available online at:
https://www.ocean-energy-systems.org/library/vision-and-strategy/

THANK YOU

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Chairman of the International Energy Agency, Technology Collaboration Program for Ocean Energy

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Plenary 3

Delivering the right environment for growth

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Sian Wilson

Senior Development Manager

Crown Estate Scotland

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Delivering the right environment for growth

Sian Wilson

Scottish Renewables: Marine Conference

9 September 2019

Who we are and what we do

- Manage the Scottish Crown Estate
- Return all revenue profit to Scottish Government
- Communities and businesses thriving through enterprising and sustainable development of property and natural resources.

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Natural resources

- Financially sustainable farming
- Natural Capital
- Seaweed cultivation
- Marine litter

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People & Planet

- Local management & partnerships
- Strengthening coastal communities
- Local environmental quality
- Measuring the value

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Doing more in built environment

- Focus on place and partnerships
- Helping development
- Vacant and derelict land

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Building the blue economy

- Offshore renewables
- Ports & harbours
- Marine tourism
- Energy systems
- Carbon capture & storage
- Oil & gas, telecommunications
- Sustainable aquaculture

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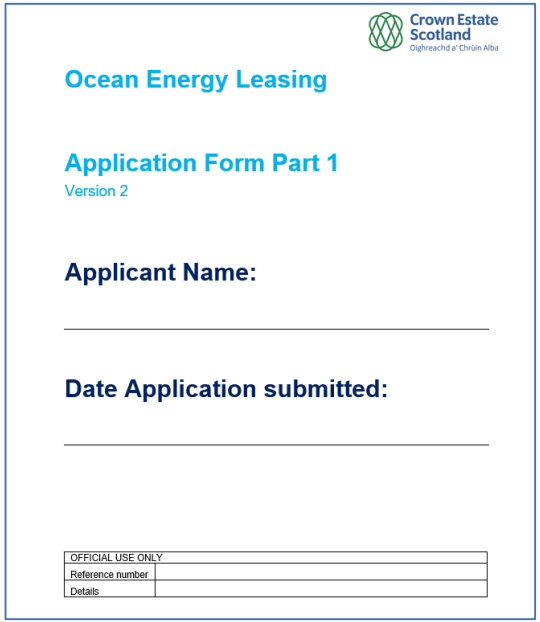
How to access wave or tidal seabed rights

- Marine@crownestatescotland.com
- Make an application
  - Up to 3MW (T&D)
  - 3MW to 30MW (Experience)
- Subject to competition check
- Enable sector growth
- Application fee and an Option fee



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Ocean Energy Leasing

Application Form Part 1
Version 2

Applicant Name:

Date Application submitted:

OFFICIAL USE ONLY	
Reference number	
Details	

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Supporting wave and tidal

- New Leasing - we help developers access seabed at the right time - and on the right terms - to help projects succeed.
- Resource
- Technology
- Expertise
- Consents
- Money

- Confidence
- Timing…..

- **Access to seabed at the right time**
- **Ease hurdles**

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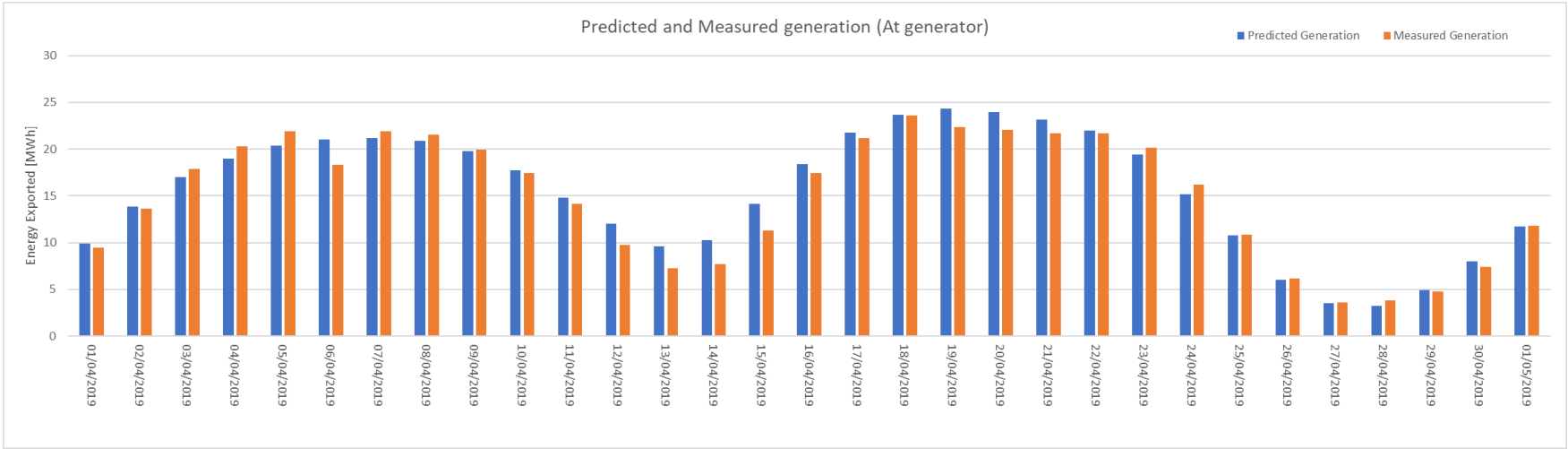
Supporting wave and tidal

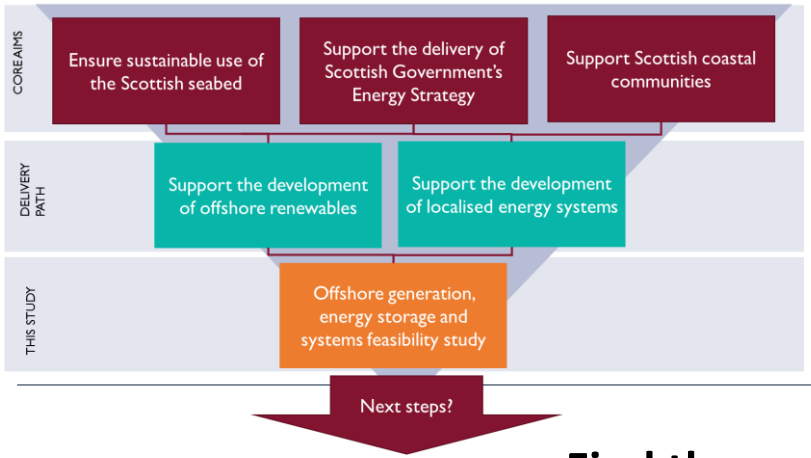
- Important part of a sustainable energy future
- Resource on our doorstep…….opportunity to own an industry
- Prediction: **Evidence** of reliable generation and power prediction

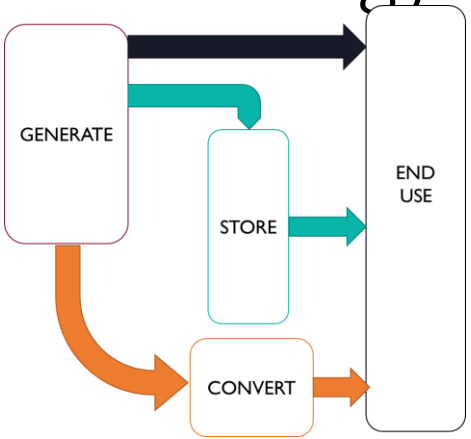


Thanks to Simec Atlantis for use of the data

Supporting wave and tidal – Energy systems

AIM:
To investigate how integration of offshore renewables into a wider localised energy system can support the pathway to commercial viability of offshore renewable projects, whilst benefiting coastal communities through improved local energy solutions.





- Identifies 6 Topographical scenarios;
- Create models – system, commercial, regulatory, community;
- Understand gaps in models and how investment can support potential development;
- Educating development community and drawing out opportunities for further investigation.

- **Find the opportunities in the interim**

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Supporting wave and tidal – market

- Where will the power be used?
- At what cost?
- **Added Value?**
- Who is the customer (IPPA)? And what is the future market for those customers?
- What costs can be avoided if supply is closer to demand (higher grid charges)

- How can wave and tidal power fit in with other sectors?
  - Blue Economy
  - Local community growth (school education/skills)
  - Decarbonisation of heat

- **Find the opportunities**

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What has been on Government agenda in 16/17

- Brexit
- Industrial Strategy
- Clean Growth
- Jobs

- **The opportunities**

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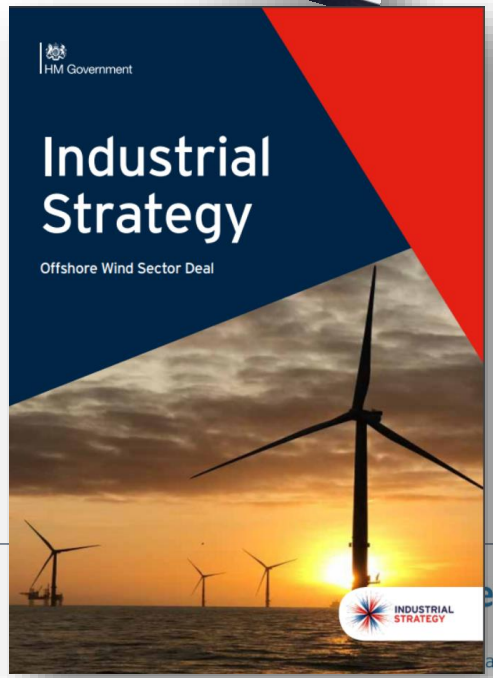
OFFSHORE WIND SECTOR DEAL

Offshore Wind Industry Council

Offshore Wind Sector Deal

A partnership between industry and Government

- Part of Industrial Strategy, and Clean Growth Grand Challenge
- Transformative strategy to deliver at least 30GW by 2030
- Published 7 March 2019, after two years of negotiations
- 10th Government Sector Deal, joining major industries e.g.:
  - Aerospace
  - Nuclear
  - Automotive
- First renewable energy Sector Deal



OffshoreWind IndustryCouncil

A level of certainty unmatched by any other European government

The Deal is built on the five foundations of the Industrial Strategy:

Ideas, People, Infrastructure, Business Environment and Places


SDIC
Red Rock Power Limited


GE Renewable Energy


THE CROWN ESTATE


eDF
renewables


edp
renováveis


e·on


equinor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JDR
TFKable Group


MHI VESTAS OFFSHORE WIND


OffshoreWind
IndustryCouncil


CATAPULT
Offshore Renewable Energy


Ørsted


renewableUK
40
years


SIEMENS Gamesa
RENEWABLE ENERGY


SCOTTISHPOWER
RENEWABLES


sse


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VATTENFALL

Sector Deal: Learnings

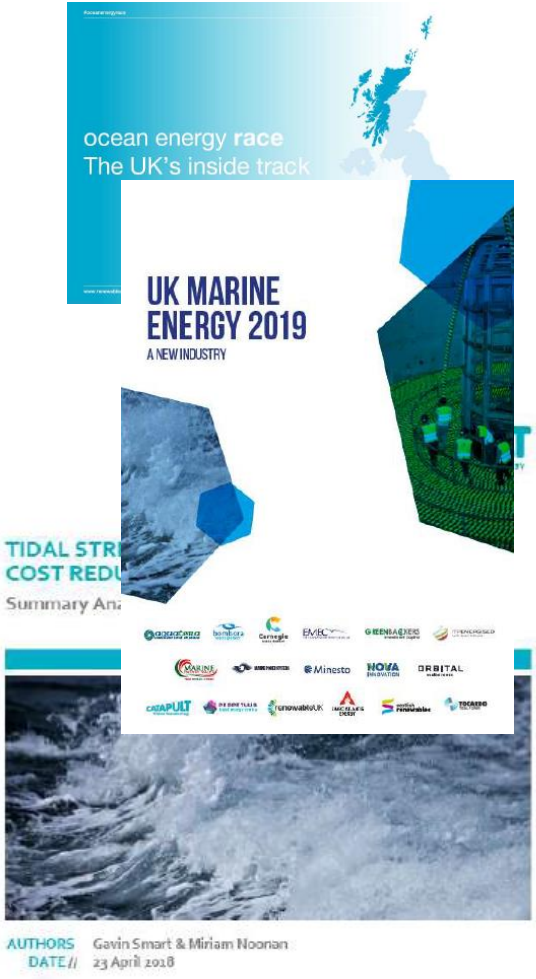
- Collaboration
- CERTAINTY
  - Government certainty that sector would deliver 30GW by 2030
  - Developer certainty re target market (CfD round every 2 years)
  - Developer certainty re costs, LCOE, added value expansion
  - Developer certainty re needs to deliver
  - A clear plan (delivery and timing)

Public Sector – Private Sector – Academia

In progress for W&T?

1 – Cost reduction
2 – Emissions reduction
3 – Global market (benefits)

- Collaboration between public – private - academia
- Certainty
  - Government certainty that technology works?
  - Government certainty of predictable power?
  - Government certainty of job creation?
  - Developer certainty for support and future?



What is on Government agenda now

- Brexit
- Industrial Strategy
- Clean Growth
- Jobs
- Communities / local / Global
- Blue Economy
- Decarbonisation of heat/transport
- O&G MER – diversification (CCUS/H2)

- Climate Change
- Net Zero
  - how will this be delivered

- **The opportunities**

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Increased opportunity

- Government Expectations – cost reduction for consumer
- Single source - Creation of unintended consequences from over reliance without predictability

- Evolving Government focus into:
  - Clean energy/power growth
  - Jobs
  - Blue economy
  - O&G MER
  - Ports and Harbours
  - Local Energy Systems
  - Coastal communities
  - Aquaculture
  - Decarbonisation

- Working cross sectors is important
- Necessity for innovation and **wider value** consideration
- ff - increased investment
- ff - increased innovation and commercialisation support

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Summary

- Welsh and Scottish Government
  - Strong support
- UK Government
  - Evolving agenda on wider issues and this all needs innovation and therefore funding support
- Industry
  - Continue strong messages through single voice, but increase detail on specifics and synergies
  - Create opportunities
  - Be ready to deliver on all aspects when there is a change in support

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Thank you

Sian.Wilson@CrownEstateScotland.com

www.crownestatescotland.com

NTEGRITY, COLLABORATION, COMMERCIALISM, EXCELLENCE

Rhys Wyn Jones

Head of Wales

RenewableUK

#SRMARINE19

Rhys Jones

Head of RenewableUK Cymru

Sept 9 2019

@rhyswynjon

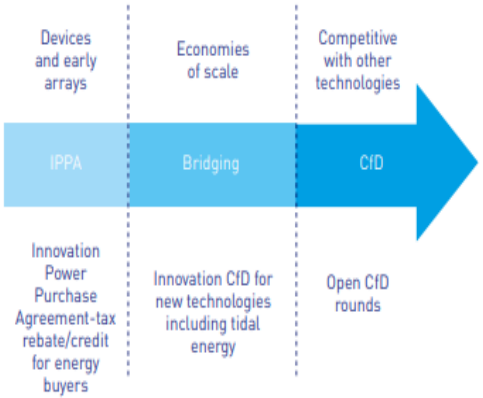
With market uncertainty continuing across the sector, can Scotland retain its global lead? With an energy white paper approaching, what's the role for the UK Government in bringing forward marine energy projects – and where can the Scottish Government best lend its support to the sector? What lessons can we learn from other technologies and processes, such as the Offshore Wind Sector Deal?

Organisational outlook

- Twin policy tracks: support frameworks vs. ‘everything else’
- Our remit is the future of the electricity system
- We know members are reviewing business models
- While we still need to deliver 50-75GE offshore by 2050
- Disruption and innovation aplenty
- We are well placed to respond over the next decade given our composition
- Ultimately however, policy makers must choose their preferred route

Political context

Role for UK Government?



920MW tidal stream required for £90MW LCOE

Government Investment

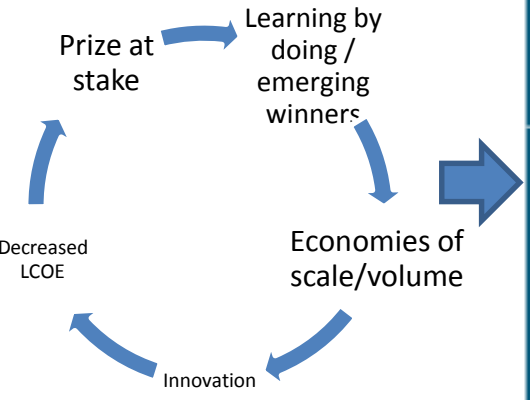
Were the government, in the worst case, to support 120MW of tidal energy capacity using the IPPA as described above and then another 800MW using the iCfD mechanism (these quantities being in line with the Offshore Renewable Energy Catapult report), then there will be the following impact on the government's balance sheet assuming all projects are in the UK:

- £31 million for 5MW of testing capacity (assuming 20% load factor);
- £834 million of tax foregone through the IPPA (assuming a 30% load factor); and
- £1988 million of tax forgone through iCfD (assuming a 30% load factor).

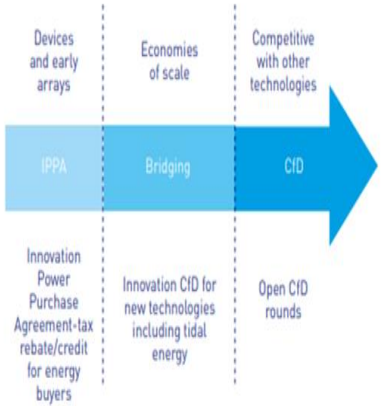
If the industry were to deliver this over twenty years then it would have an average annual cost of £141 million.

Tidal stream industry could generate: UK NCB £1.4bn, 4000 jobs by 2030*

Turning ‘promising’ into ‘compelling’



	Tidal Stream	Wave
Is there a clear cost reduction pathway for the technology, so it can deliver low cost solutions?	Yes Cost has reduced significantly already with minimal deployment. Further reduction will come: economies of scale; learning by doing; maturing market and innovation. We expect LCOE to reduce from £300 per MWh to £90 per MWh by 1GW of deployment.	Too early to analyse Wave cost reduction has not been modelled in this study. The technology is still at an early stage and there is high uncertainty in design and energy yield potential, but we recognise there is huge potential for read across from both offshore wind and tidal supply chains.
Can the UK develop world-leading technology in a sizeable global market?	Yes The UK is an early leader in marine energy. Companies with existing skills in marine technologies are diversifying into tidal stream technology. Almost 4,000 jobs could be supported by 2030 and 22,600 by 2040, focused in Scotland, Wales, and the South West. There is growing interest from global markets which the UK can access through existing supply chain links.	Yes Wave has an abundant global resource. Many of the same companies are moving into wave as well as tidal, however the technology is at an earlier stage. WES is playing a huge role in accelerating development through their competitive stage gate process which have used 71% UK content on average to date.
Does the technology deliver maximum carbon emission reduction?	Yes Tidal energy is an abundant resource with low operational CO2 emissions. It could reduce emissions by over 1MtCO2 per year in 2030 and over 4MtCO2 per year in 2040.	Yes Wave energy is an abundant resource with low operational CO2 emissions. It could reduce emissions by over 1MtCO2 per year in 2040.



OWSD lessons?

Bad day / good day

“Then all collapsed, and the great shroud of the sea rolled on as it rolled five thousand years ago”

“Just 10 years ago, few people would have imagined that power from offshore wind could be a low cost form of electricity. That is the reality today. We are working in partnership towards a future where green power is the cheapest power, with the potential to be delivered without public subsidy.”

Morag Watson

Director of Policy, Scottish Renewables

Sian Wilson

Senior Development Manager, Crown Estate Scotland

Rhys Wyn Jones

Head of Wales, RenewableUK

Tweet @ScotRenew

#SRMARINE19

Morag Watson

Director of Policy

Scottish Renewables

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Parallel 4A

The road to commercialisation: business models and project finance beyond electricity generation

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#SRMARINE19

Andrew Smith

Managing Director

Greenbackers Investment Capital

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Investment Capital

SR Marine Conference 2019

The Road to Commercialisation

The role of tidal & wave technologies in our new energy system; local energy systems supporting development; recent financing case studies; varied project finance structures; interesting developments.

Andrew Smith, Partner
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Twitter @renewableandrew
Twitter @GreenbackersIC

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Ex ecoConnect, ABB, Worldcom, GEC-Marconi

Advisors & Fund Brokers

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The role of tidal & wave technologies in our new energy system

- *As a part of a suite of technologies supplying energy to remote or island communities (Sabella)*
- *As energy where and when needed at the right power levels in the right environments – oil & gas , buoys (C Power)*
- *As stand alone grid scale devices in farms (Simec Atlantis)*

Local energy systems supporting development

- *As a part of a suite of technologies supplying energy to remote or island communities (Sabella)*
- *The Scottish Whisky sector – Island distilleries*
- *Orkney – surf & turf*

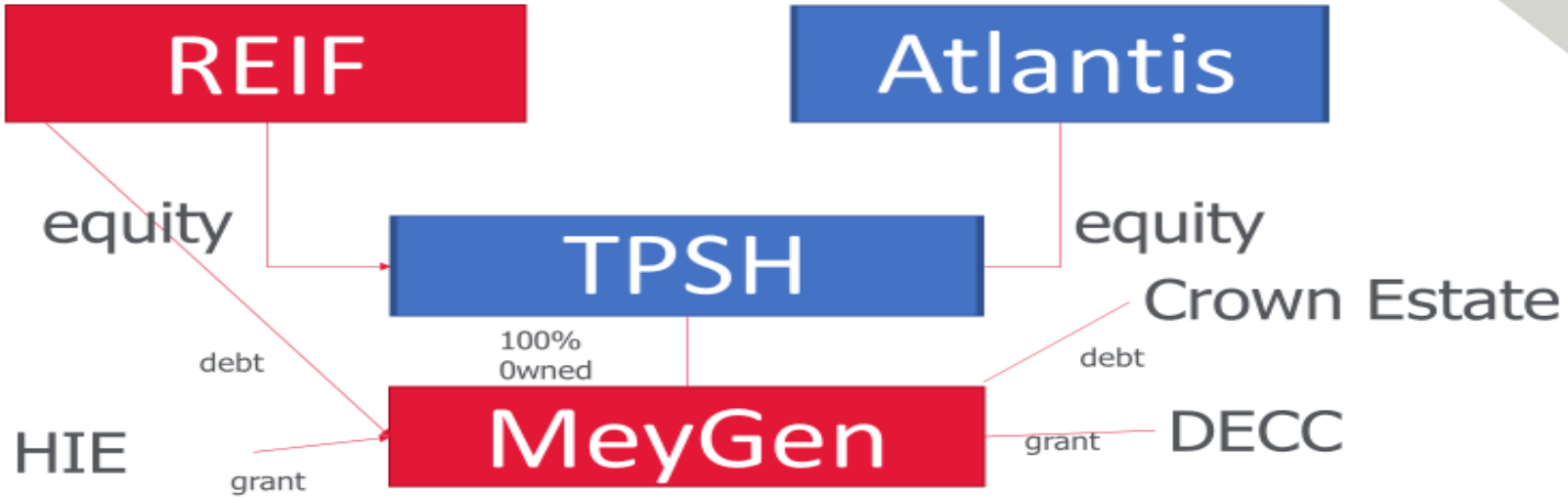
Recent financing case studies

- *Orbital Marine on Abundance* a 30 month secured Debenture to help build the first production model Orbital O2 2MW tidal turbine ….. the project had already secured more than £9 million in grants and equity funding
- *Nova Innovation on Seedrs* "We're launching a crowdfunding campaign to give people who care about sustainability, the environment and social value, an opportunity to invest in the next generation of clean energy.
- *Scottish Investment Bank with SME* SIB Director Kerry Sharp said: "SME has repeatedly proved its resourcefulness, culminating in the successful testing of its innovative PLAT-I platform and generation of first power. We've supported the company every step of the way since it relocated to Scotland in 2016 and have underlined our continued backing by contributing to its latest fund-raise."
- *Simec Atlantis – at the start*

Project Finance Structures

Funding MeyGen 1A – high Level background
2 of 2

Original Structure



Conditions for successful Blended Finance

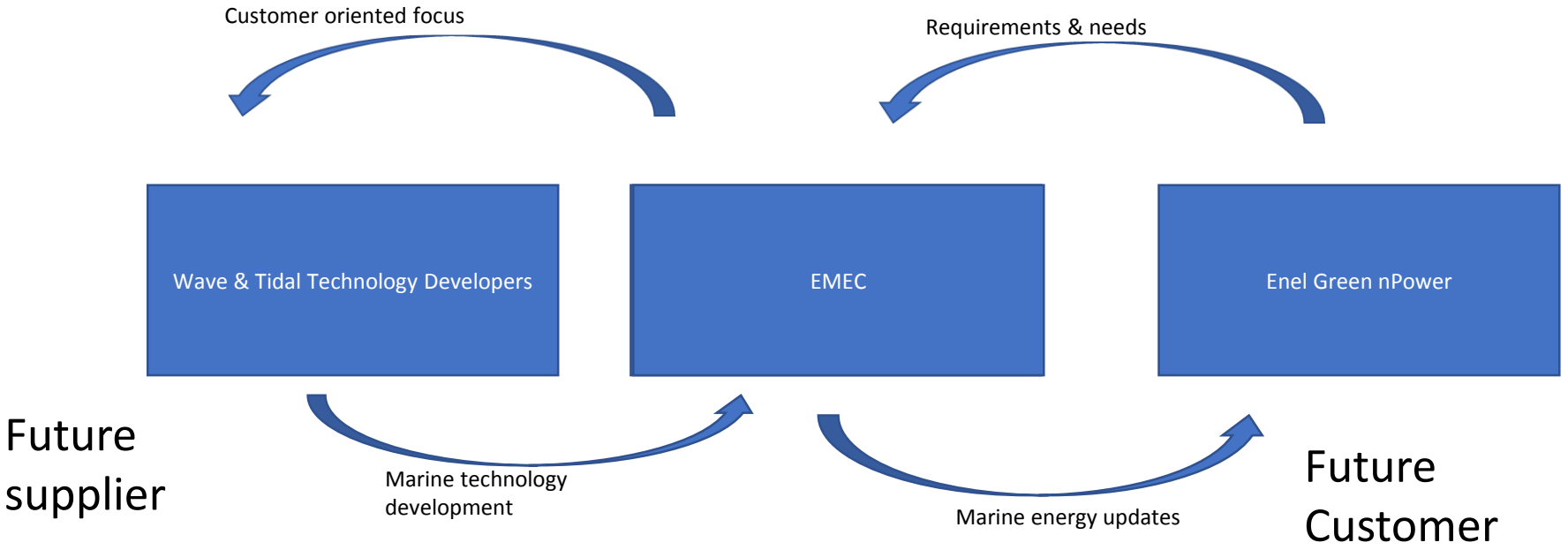
Agreed common objectives
Flexibility in the public funding – because that is where the strategic element lies and where the flexibility should be
Co invest to attract investors – and de risk it for them
A good delivery team
Strong consistent policy and political support
A programme of size with an initial declared long running time

Interesting Developments

- Sabella
- Simec Atlantis
- OGTC – Tech X

- EGP & EMEC
- New EU Innovation Fund – but beware Brexit

EGP & EMEC MoU – April 2019



New EU Innovation Fund - Key features

https://ec.europa.eu/clima/policies/innovation-fund_en#tab-0-1

Volume of at least EUR 10 billion at current carbon prices

Support of up to 60% of additional costs related to innovative technology

First call expected for 2020 and regular calls up to 2030

Financed from the revenues of the EU Emissions Trading System

Support of additional capital and operating costs (up to 10 years)

Comprehensive selection criteria and project development assistance

GREENBACKERS
Investment Capital

Thank you!

London, Glasgow, Cardiff
Finance

Equity, Impact, Asset & Project

Andrew Smith – Partner
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Twitter @renewableandrew
Twitter @GreenbackersIC

Mike Wilson

Chairman

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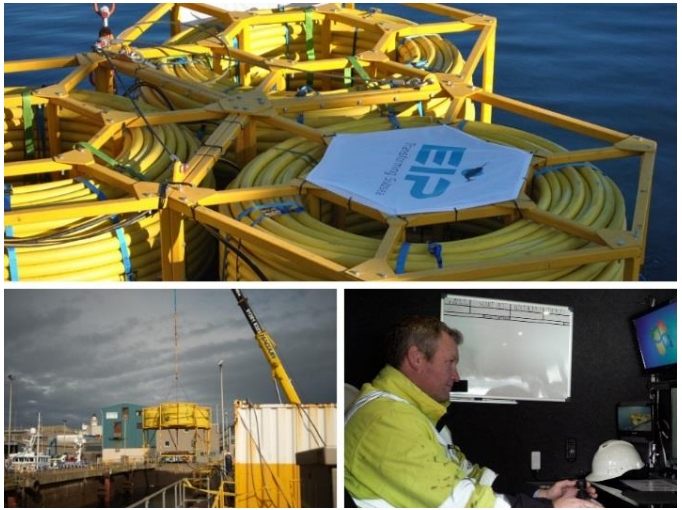


EIP
Transforming Subsea

Ambient Lifter

- Modular and flexible solution to lift, lower and move items subsea
- Scalable lift capability from 50kg to 2500t at **any** depth
- Lift without the use of heave compensated cranes, deployed from small low-cost vessels
- Can be used in subsea, decommissioning, renewables, salvage and military sectors
- Will significantly reduce costs of subsea operations
- Operational in much wider weather windows

Unique Selling Points

- Can be operated from platform or low-cost vessel (no heave compensated lifting required)
- Weather window much wider than vessels (up to 60%) and effective in high current areas
- New way of lifting things underwater
- Simple, robust technology
- Cheaper than all crane lift methods
- Much safer and more controllable than airbags
- Tow from harbour install on site with one simple tool

Kim Hamilton

Hydrogen Development Officer

European Marine Energy Centre

#SRMARINE19

Scottish Renewables
Marine Conference 2019

EMEC HYDROGEN

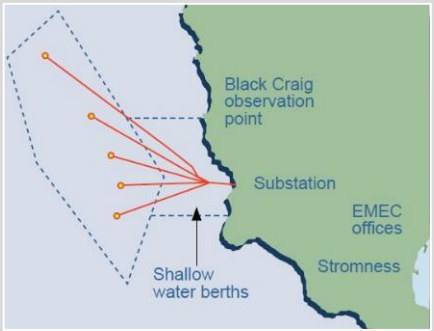
EMEC's Hydrogen Story So Far

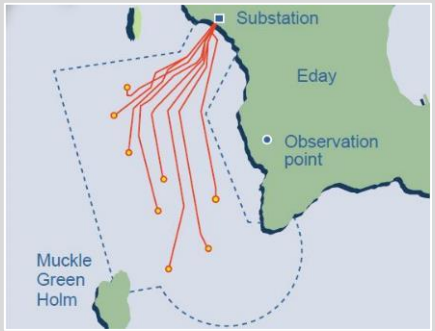
Kim Hamilton
Hydrogen Development Officer

Grid-connected test sites for wave & tidal energy

Wave: Billia Croo

Tidal: Fall of Warness



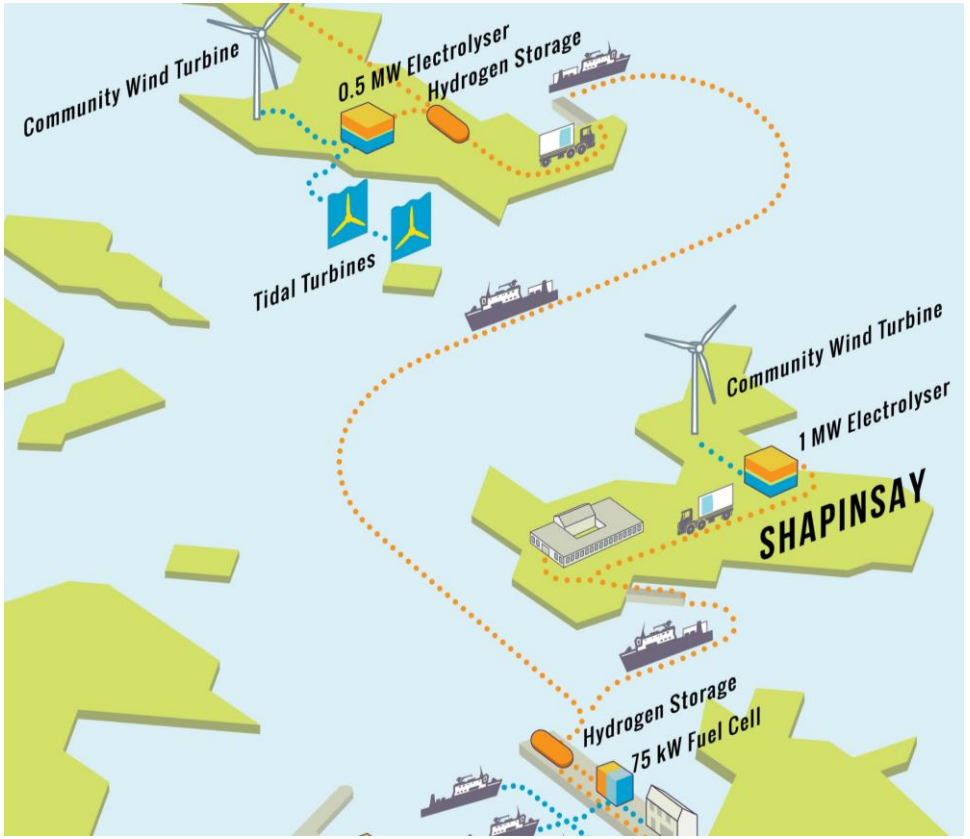


A peedie storm

Orkney Hydrogen

Orkney Hydrogen Infrastructure

EMEC HYDROGEN



Current Projects

EMEC HYDROGEN

H2 Production

H2 Logistics

H2 Applications

HYDIME

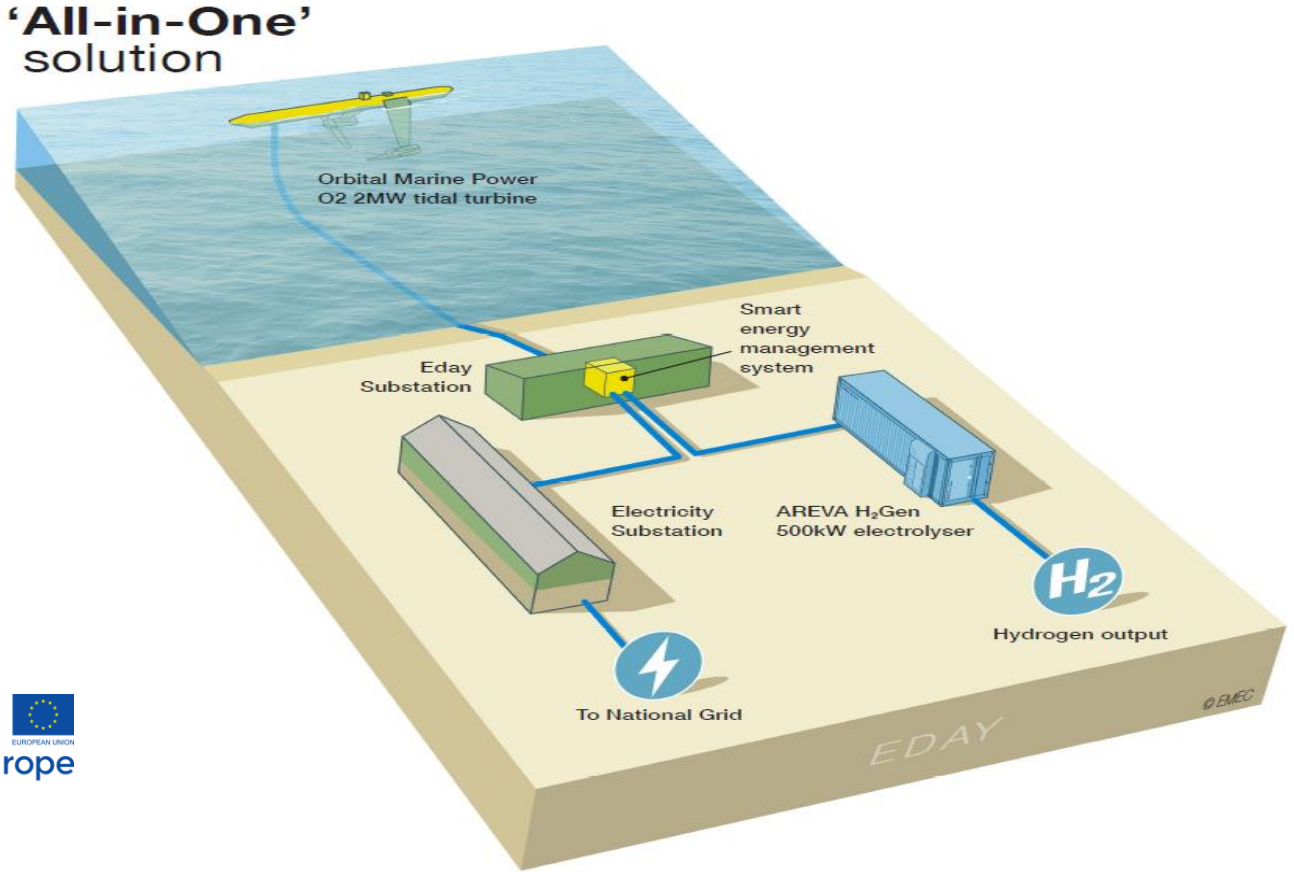
SURF 'N' TURF
Tide | Wind | Hydrogen

HySpirits

Interreg
EUROPEAN UNION
North-West Europe
ITEG
European Regional Development Fund

BIG H2IT
Building Innovative Green Hydrogen Systems in Isolated Territories

ITEG – Caldale Site, Eday



Crown Estate Scotland

- **Offshore Generation, Energy Storage & Systems Feasibility Study.** April 2019

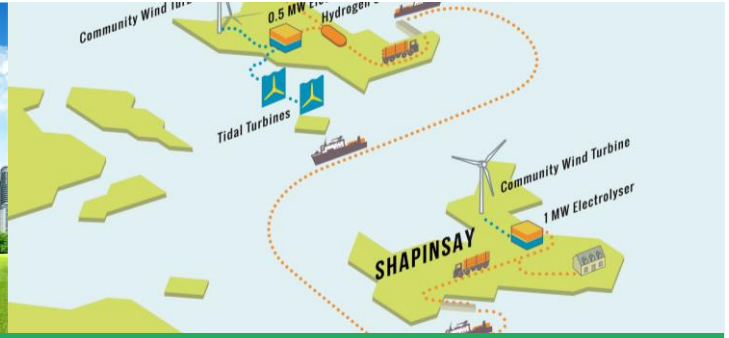
www.crownestatescotland.com/maps-and-publications

Orkney Hydrogen Economy

EMEC HYDROGEN

Now

Heat & Power



Island Communities

Very Soon!

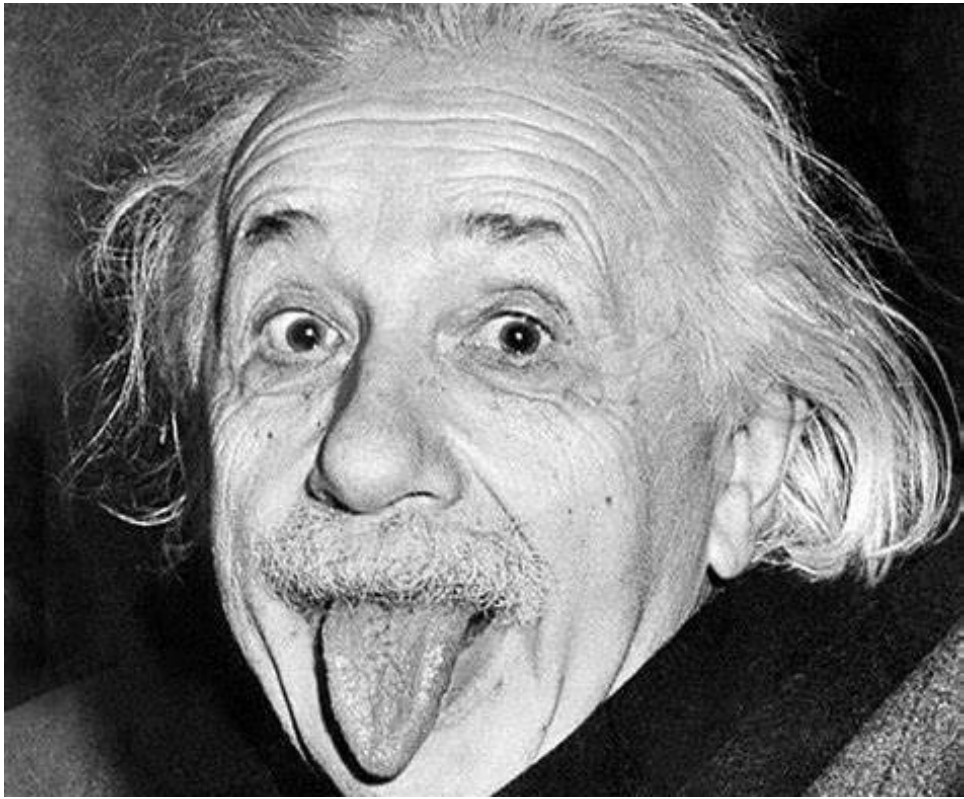
Food & Drink Industry

Marine Sector

Future?

"If at first the idea is not absurd, then there is no hope for it."

Albert Einstein



Thank You

Kim Hamilton
kim.hamilton@emec.org.uk

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CEO

C-Power

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Columbia Power Technologies

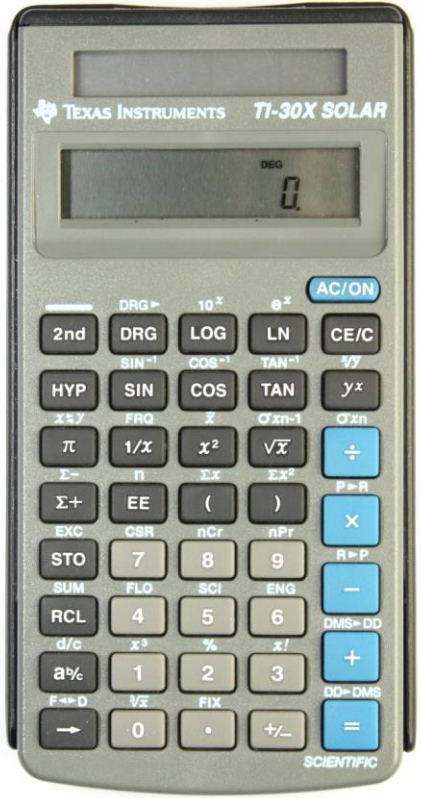
SR Marine Conference

Session 4A: The road to commercialisation: business models and project finance beyond electricity generation

Reenst Lesemann
Co-Chair, U.S. Marine Energy Council
CEO, Columbia Power
rlesemann@columbiapwr.com

Turning waves into electricity

- Based in US, beginning to establish Scottish presence
- Team has decades of wave energy experience
- Named ‘top developer’ in Irish study
- Floating, offshore technology
  - tested over 13,000 hours
  - 3rd party technology certification via DNV
- Three products in the pipeline; two commerialise in 2020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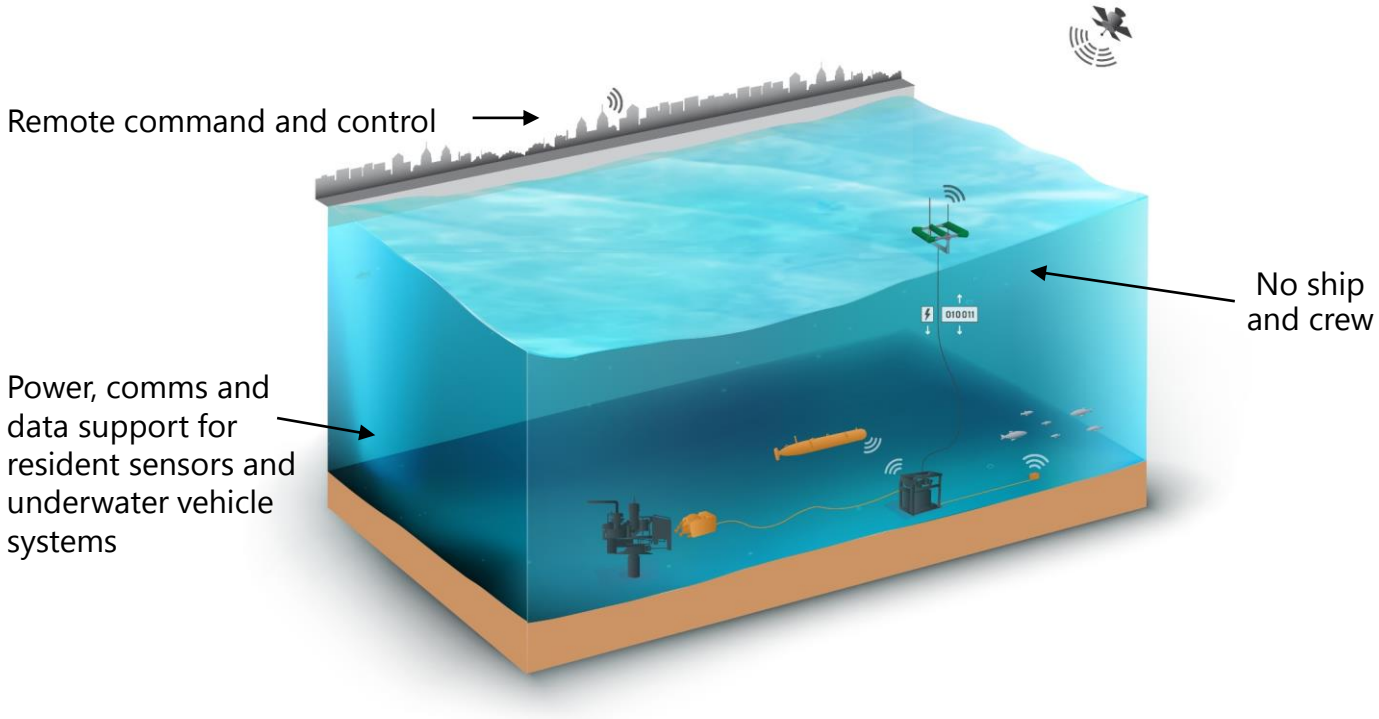
Wave energy enables the Internet of Ocean Things

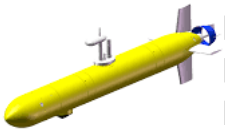


Market applications

Very Low-Power

Low-Power

Utility-Scale (or near it)



Watts

MWs

Power Range

Cost of Ownership

Cost of Energy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Parallel 4B

Innovation and private finance, lessons from the US

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David Oxley

Director of Business Growth

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Tor Jakob Ramsøy

Founder and CEO

Arundo Analytics

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Smarter Operations Through Industrial Analytics

Inverness

September 10, 2019

ARUNDO

provides software products and services to **enable enterprise-scale machine learning** and **advanced analytics applications** for **industrial companies**

OUR SOFTWARE ENABLES **10 x ROI**

- We do secure, live data ✓
- We integrate data science into industrial operations ✓
- We ensure that your employees can make informed decisions ✓
- Less than 90 days from data to value ✓


Oil & Gas


Chemicals


Maritime


Power & Utilities

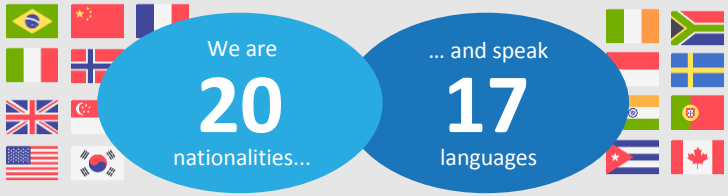

OEM

ARUNDO

Arundo was founded to solve industrial IoT adoption challenges

Key facts

- Founded in 2015 – now 105 “Arundites” (25 PhDs)
- Bringing “Silicon Valley” into asset-heavy industries
- Providing industrial cloud software to enable rapid value from machine learning models at scale



Our employees have a deep and diverse set of backgrounds and experiences:

intel Google CERN Shell pason NOV GE Statkraft
Pivotal MathWorks HALLIBURTON OFFSHORE TOSHIBA McKinsey&Company
Microsoft AkerSolutions ABB SIEMENS accenture AES
Schlumberger ExxonMobil NASA Honeywell ENERNOC BCG DUPONT

MIT Stanford University UiO NTNU Imperial College London
RICE Carnegie Mellon University
PRINCETON UNIVERSITY COLUMBIA UNIVERSITY UCL Georgia Tech

The Arundo Advantage: The emerging leader in Industrial IoT and AI

1. Focus on deployments that deliver initial value within 90 days and >10X ROI over the lifetime
2. Purpose built industrial internet platform and applications for the heavy industry
3. A world class mix of software, data science, and energy expertise
4. Proven methodologies refined through numerous deployments
5. Partnerships with best in class global technology and industrial solution providers

Gartner | Cool Vendors in IoT Analytics

NETWORKWORLD FROM IDG

INSIDER OPINION

10 Hot AI-powered IoT startups

StartX Stanford-StartX Fund

MIT-ILP STEX 25 Startup Exchange

MIT STARTUP EXCHANGE

CRN The 10 Top Big Data Startups Of 2018 (So Far)

SNAPSHOT | ENTERPRISE SOFTWARE

WSJ Funding Snapshot: Arundo Raises $25 Million Series A for Industrial Analytics

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Selection of our customers and partners are the world's largest industrial companies

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The ABB Arundo Virtual Multiphase Flow Meter

Real-time multiphase flow data using existing sensors for oil & gas, chemicals, power generation, water & wastewater, and refining & petrochemicals

From the left: ***Norwegian Prime Minister Erna Solberg*** *and* ***ABB Managing Director Oil, Gas and Chemical Per Erik Holsten*** *at the international launch of the ABB Arundo Virtual Flow Meter*

ABB ARUNDO

We are backed by a world-class Board of Directors

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Senior Advisor, Verdane Capital

Wayne Purboo
CEO, Quickplay
Senior Vice President, AT&T Entertainment Group

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A strong link to selected universities creates to a global tech community and customers

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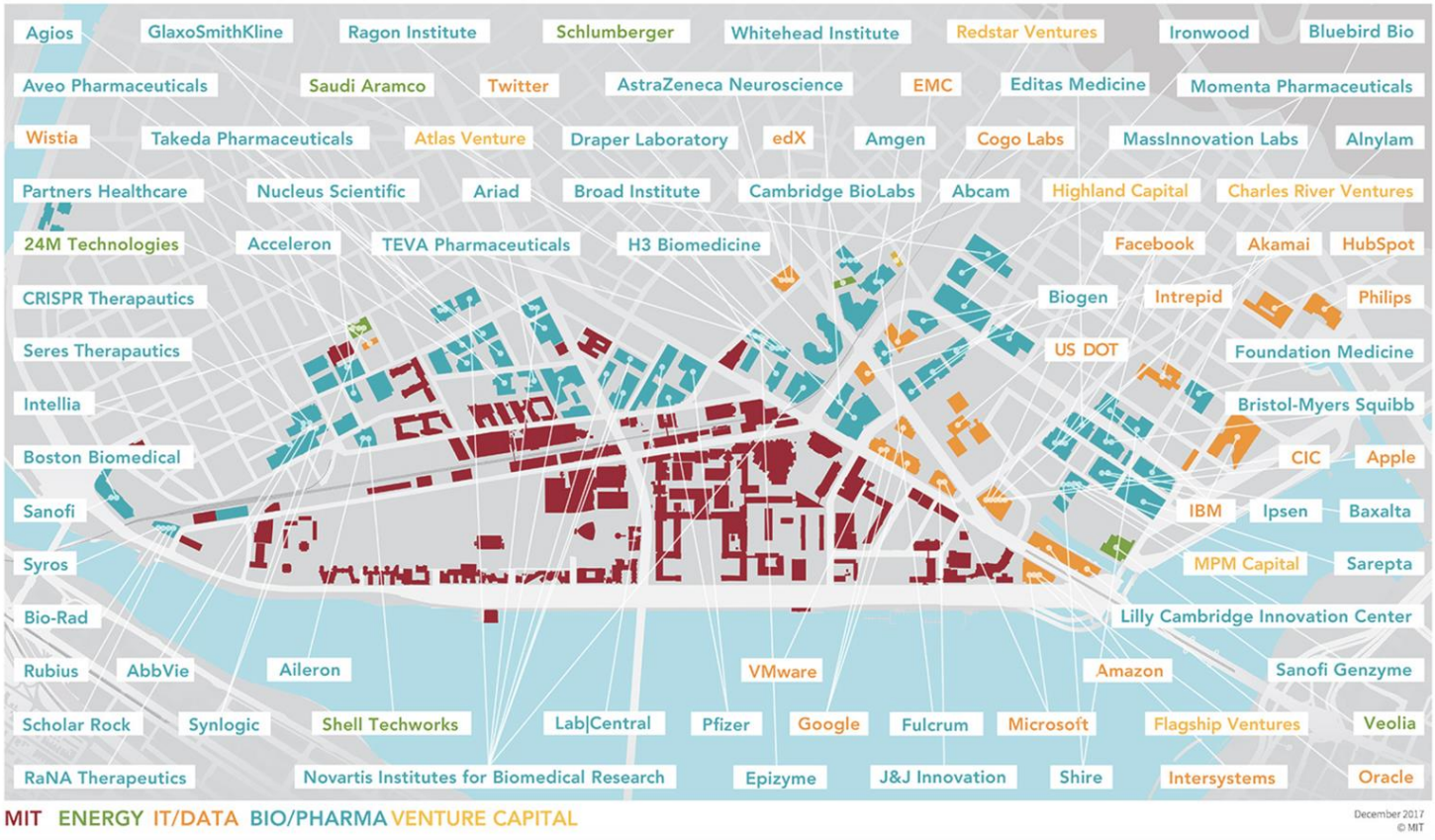
MIT Innovation eco-system



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Boston and Silicon Valley are The World Epicentre for Tech and Innovation

A Complete Ecosystem

Large Talent Pool

Concentration and # of Tech Companies

Access to Competent Capital

World class Universities & research centres

Supportive Culture & Community

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Key differences capital

- Number and types of players
- Syndication
- Liquidity
- Speed
- Convertible notes/convertible debt/SAFE
  (simple agreement for future equity)
- Template-based investment vs case-by-case negotiations

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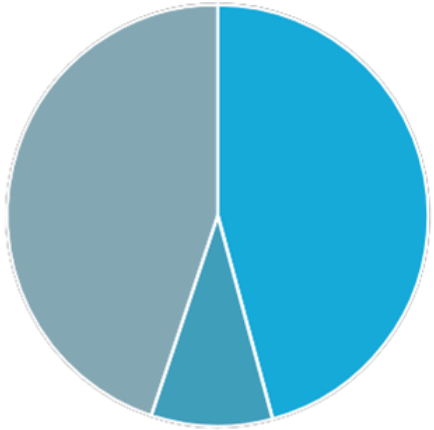
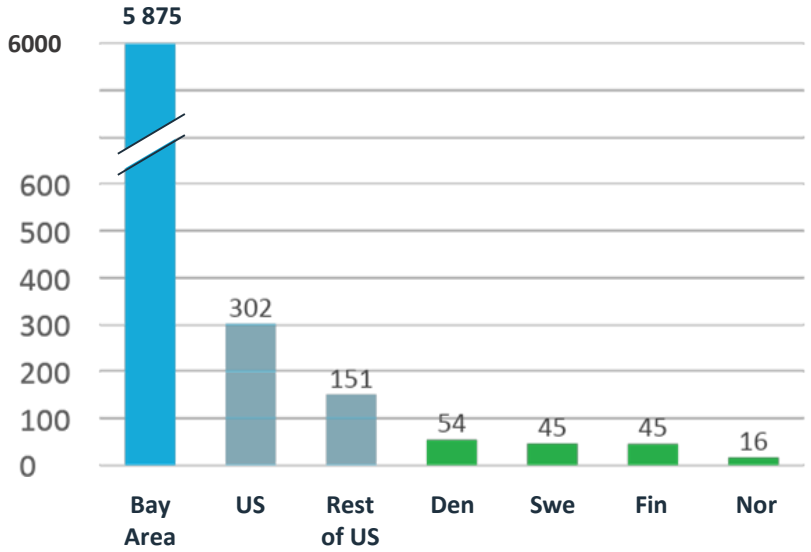
Venture capital in THE Bay Area is a different Game

Total USD 99.5 B +30% from 2017



VC investment density, USD/capita



MAIN TREND: More money, fewer deals -> bigger deals

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The Startup/VC ecosystem is on fire

Investment trends
(US centric)

- ↑ Total investment
- ↑ Deal size
- ↑ Valuations
- ↓ # of deals
- ↓ Higher bar
- → Winner-takes-it-all
- → Conformity
- → Hot & not

Market observations

- ↑ Global activity
- ↑ China %
- ↑ Best practice spreading
- ↓ Europe %
- ↓ Talent war in hotspots
- → VC access asymmetric
- → Globalization of markets

Our investors beliefs

- Old entry barriers fall
- New barriers appear
- Speed & agility win
- Talent is scarce & critical
- Talent vs opportunity distribution mismatch
- Ecosystems value & network
- Enabling tech trends

… but asymmetries are larger than ever

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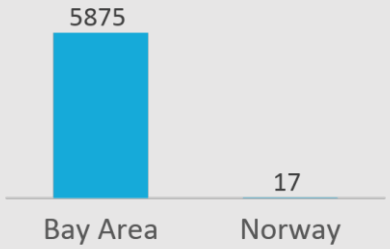
Local focus, Globally orientation

VC Supply side

VC investment (USD/capita)



= Underserved market

NORWAY

← MISMATCH →

↓

Opportunity:

Provide capital, partnership & connections

↓

Leveling the playing field:

- Global best practice & ambition
- Connect to international markets
- Leverage international & remote talent pool

VC Demand side

- Maturing ecosystem
- Top talent choosing startups
- Change the world
- Low friction for business
- More new businesses

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Everything is big in America…




… even **AMBITION** …. especially in Silicon Valley

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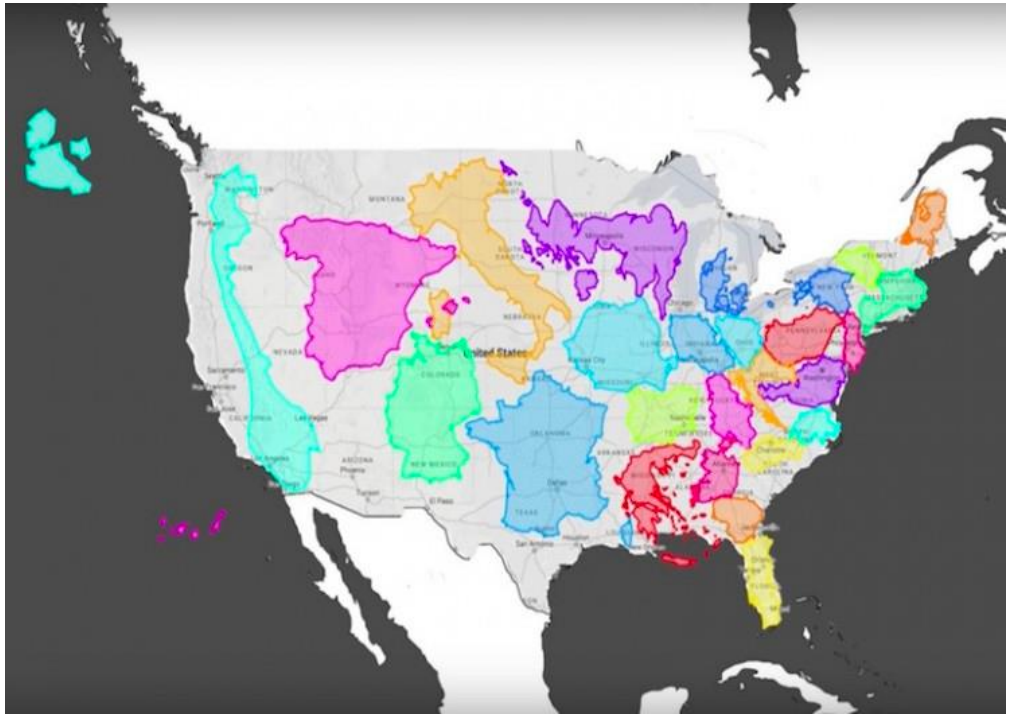
Frame of reference



- Size of home market
- Startup role models
- Culture
- Access to resources
- Is it cory?

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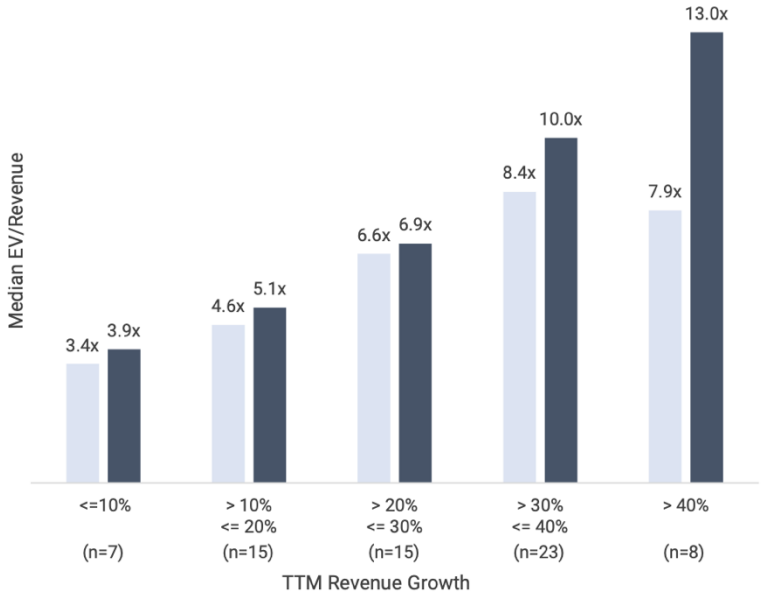
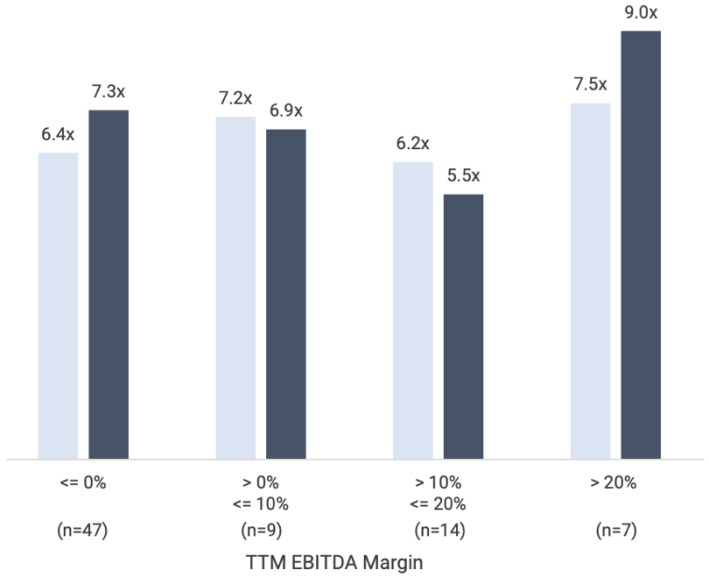
Valuation based on sales and growth

4Q 2017
4Q 2018

EV/revenue vs. TTM revenue growth



EV/revenue vs. TTM EBITDA margin



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SILICON VALLEY
IS A MINDSET
NOT A LOCATION

The Silicon Valley and Boston culture fuels innovation

Disruption

Growth, Ambition and Focus

Pay it Forward Mentality

Learning from Failure

Collaboration

User experience

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Learnings from building a company in US and Europe

- Silicon Valley (Stanford) is for B2C while Boston (MIT) is for B2B
- It takes time, B2B is very different than B2C
- Close link to universities means a lot more in the US, and gives an advantage
- Capital is available in Europe, but much more complicated to find
- Build on the skills and competitive advantage that exists locally

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SENSE OF URGENCY

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Thank you to

Gro Dyrnes

Regional Director Americas,
Director Innovation Norway San Francisco & Silicon Valley

Innovasjon Norge

Arne Tonning

Partner Alliance Venture

ALLIANCE VENTURE

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Leaders' Debate

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