Ocean Energy Europe

oceanenergy.eu

International Wave Update

Donagh Cagney, Policy Director, Ocean Energy Europe

Ocean Energy Europe

- 120 members
- Lead partners:

Global Shifts

The logic of Net Zero

An electrified future

Floating wind opportunities

European Green Deal

Energy security is back on the agenda

Stronger Support for Wave


EU Offshore Renewable
Energy Strategy
European Commission
Commission européenne
#EUGreenDeal

EU Offshore Renewables Strategy

100 MW by 2025 & 1 GW by 2030

European funding

‘Green Deal’ call funds 1st wave array

2023-24 calls are circa x3 bigger

Spanish Marine Renewables Strategy

€200m for offshore renewables R&I by 2023

Italy’s Recovery and Resilience Plan

€700m for innovative renewables R&I – wave explicitly mentioned

US Energy Sec Jennifer M. Granholm :

"Harnessing the unrelenting power of the ocean is a clean, innovative, and sustainable way to curtail carbon pollution – benefitting American businesses and families, especially coastal communities hit hardest by the impacts of climate change"

Funding test sites & developers

PACWave, WETS …

C-Power,

Calwave

Ocean Energy (Ireland) …

Wave Taking Opportunities

GLOBAL TOTAL

WAVE ENERGY

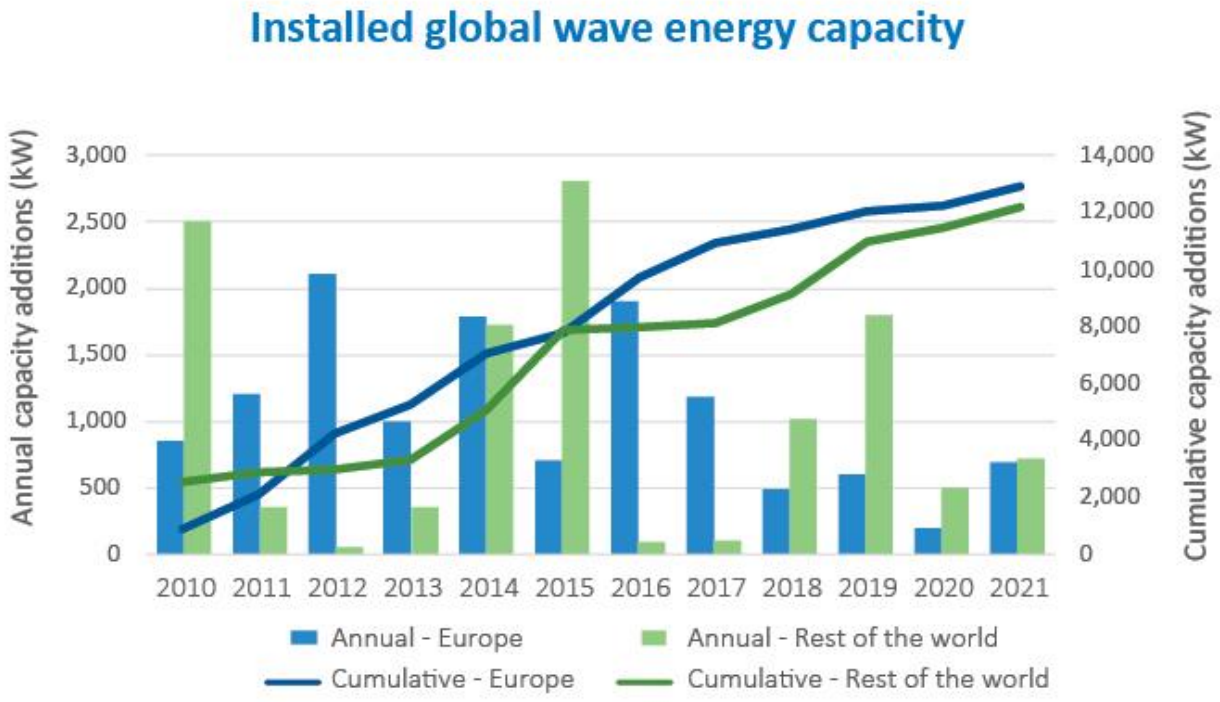
2021 capacity additions

+681 kW in Europe

+704 kW rest of world

Cumulative global installations since 2010

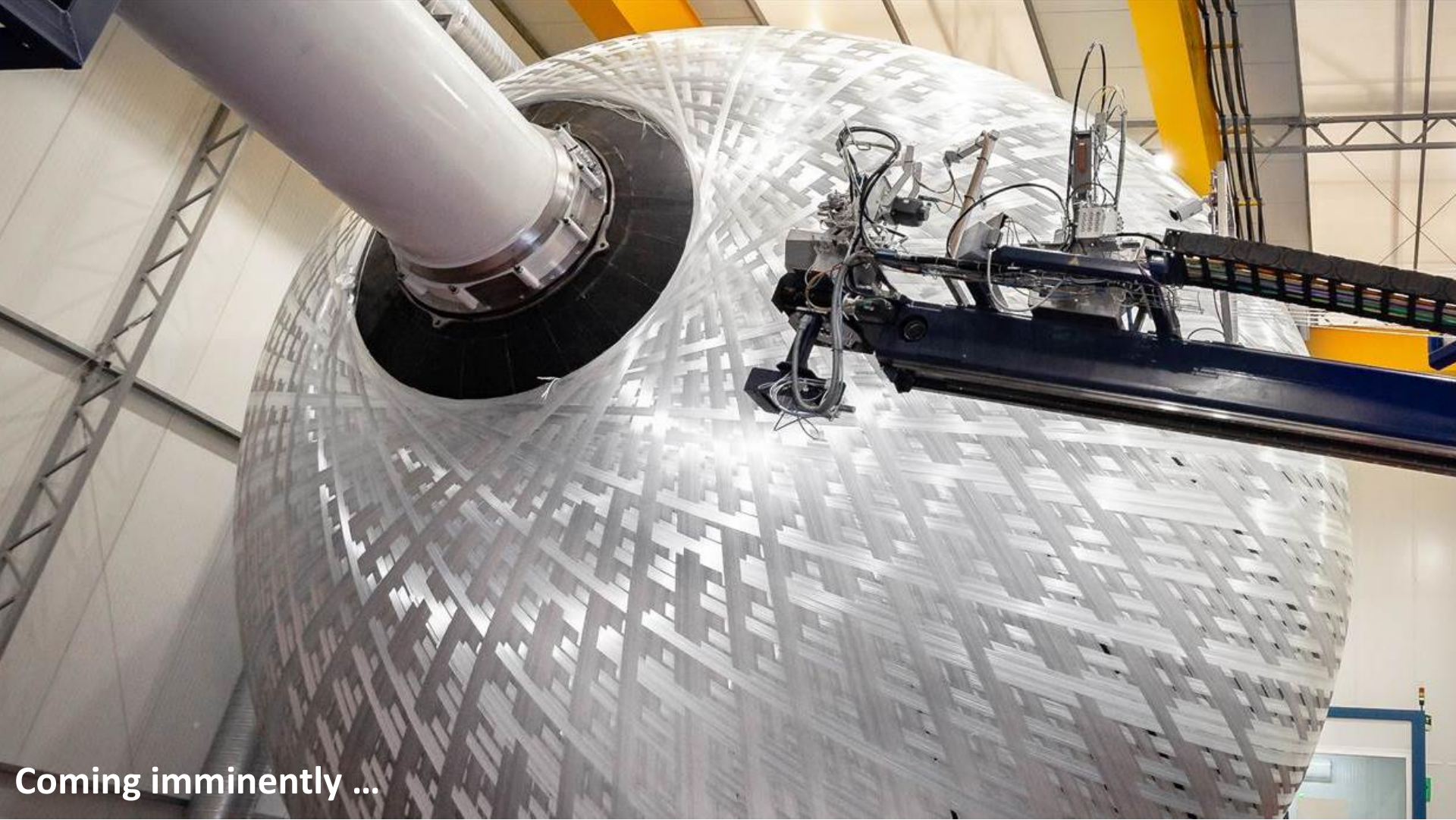
24.7 MW



Improved process of wave development

- Graduated development
- Dry testing
- Performance metrics & certification
- Academic & industrial partnerships
- Designs increasingly informed by:
  - Commercialisation goals
  - Operational needs


Coming imminently …



Coming imminently …

Coming imminently …

Coming imminently …

Ocean Energy Europe

oceanenergy.eu

Stay tuned!

@EuropeanOceanEnergyAssociation

@OceanEnergyEU

european-ocean-energy-association

@oceanenergyeurope

EVOLVE
Place, Time and Value study for Blue Energy across Europe

System benefits of ocean energy

Shona Pennock

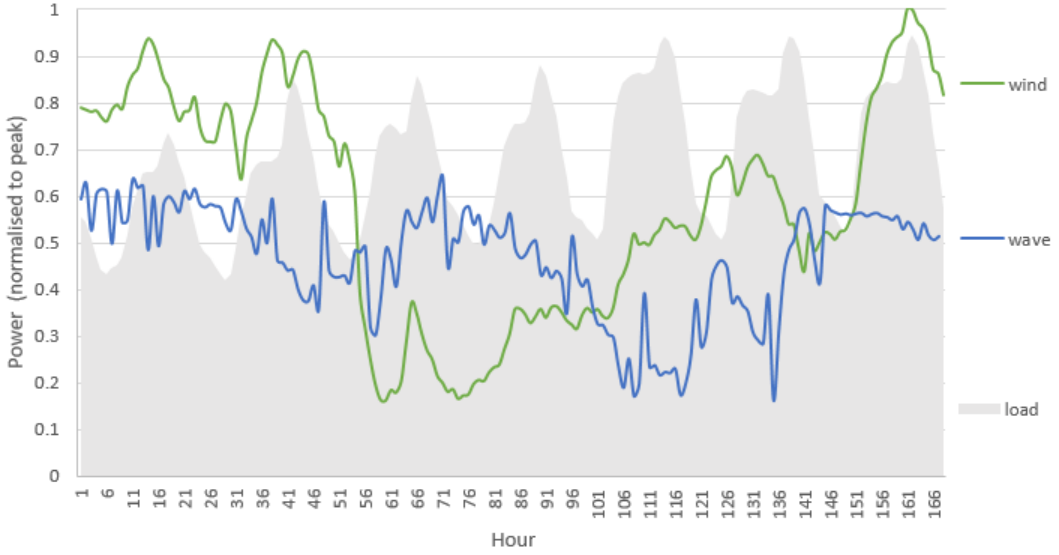
WES Annual Conference - May 2022

Supported by:
OCEAN ENERGY ERA-NET COFUND
Scottish Enterprise
Swedish Energy Agency
FCT Fundação para a Ciência e a Tecnologia
aquatera environmental services and products
WavEC Offshore Renewables
RISE
ORBITAL MARINE POWER
CORPOWER OCEAN
THE UNIVERSITY of EDINBURGH School of Engineering
Policy and Innovation Group

System benefits of ocean energy

Hypothesis: ocean energy can provide additional benefits to low carbon energy systems due to offsetting of resource with established renewable generation – such as wind and solar PV

GB load and generation comparison - first week of January 2015



EVOLVE

The EVOLVE Project

Key question: Can blue energy make an effective contribution to European energy systems and markets, with particular reference to where, what, when, how and at what price?

Spatial modelling:

- 250m RADMAPP model of north-west Europe
  - Resource, demand, grid
  - Technical feasibility, cost of delivery, access to markets

Power systems modelling:

- Country-scale studies (GB, IE, PT)
  - Hourly economic dispatch of net zero deployment 2030 to 2050
  - Marginal electricity prices, balancing costs, system security indices
- Microgrid studies (GB)
  - 100% renewable systems
  - Supply-demand matching, storage requirements, system cost

aquatera
environmental services and products

THE UNIVERSITY of EDINBURGH
School of Engineering
Policy and Innovation Group

RISE

WavEC
Offshore Renewables

EVOLVE

CORPOWER OCEAN

ORBITAL MARINE POWER

EVOLVE country-scale GB model

- Great Britain model split into nine zones based on selected National Grid boundaries
- Computes hourly optimal dispatch: supply-demand matching
- Key model inputs:
  - Hourly demand profile data
  - Hourly availability of intermittent renewables
  - Fuel prices, carbon costs
- Key model outputs:
  - Hourly generation, prices, carbon emissions

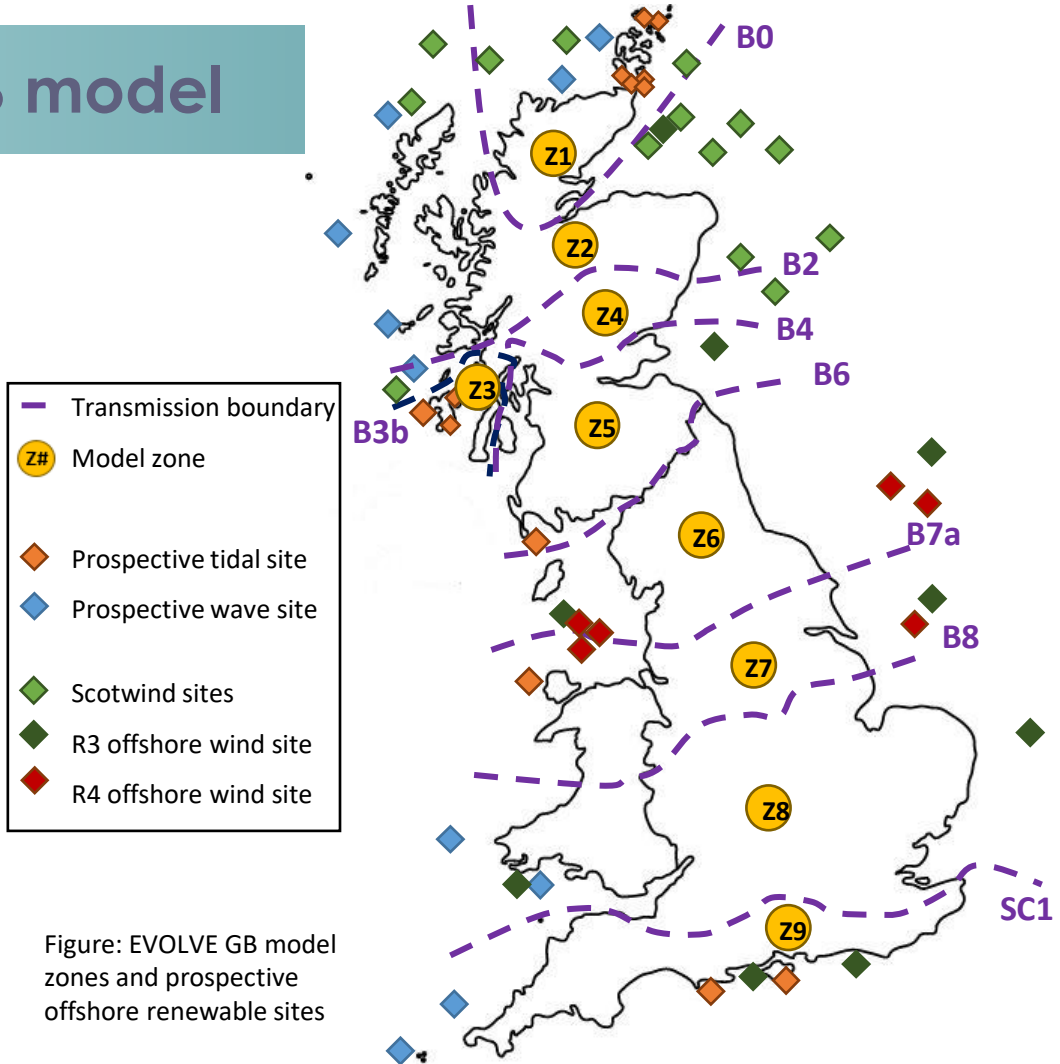


Figure: EVOLVE GB model zones and prospective offshore renewable sites

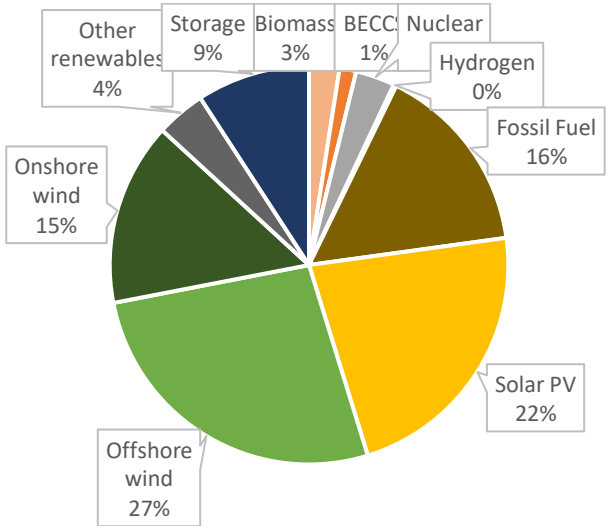
GB 2030 Modelling – Leading the Way Scenario

2030 Scenario selected is National Grid's Leading the Way Scenario:

- High renewable scenario:
  - 4x current offshore wind capacity
  - 2x current onshore wind capacity
  - 3x current solar PV capacity
  - Initial demonstration plants for BECCs and Hydrogen
  - No wave or tidal

Technology	LTW
Biomass	4.36 GW
BECCS	2.40 GW
Nuclear	5.64 GW
Hydrogen	0.39 GW
Fossil Fuel	27.63 GW
Solar PV	39.70 GW
Offshore wind	47.33 GW
Onshore wind	26.33 GW
Other renewables	7.09 GW
Storage	16.26 GW
Wave & Tidal	0 GW

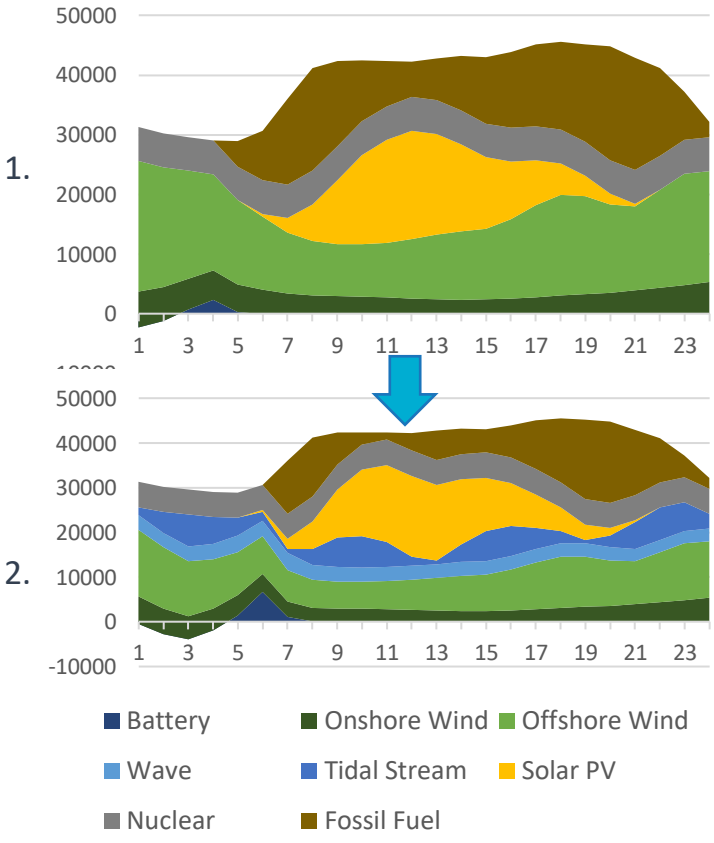
Table: Installed capacities – FES 2030 Leading the Way Scenario



GB 2030 Modelling Results – example summer day

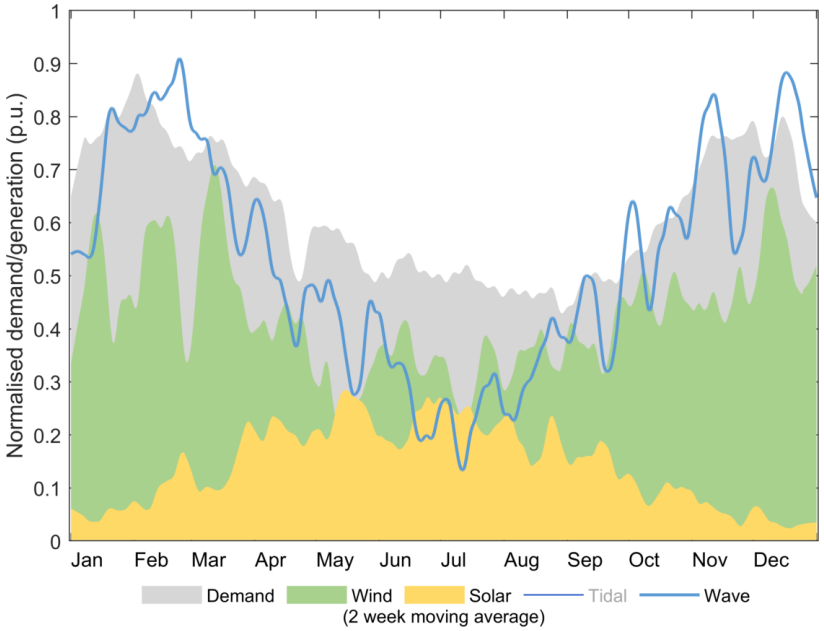
1. GB 2030 scenario 1 (no marine)
2. GB 2030 scenario 2 (15GW marine)

Metric	0GW marine	15GW marine
Average marginal price	£60/MWh	£60/MWh
% renewable generation	61.0%	68.9%
% fossil generation	39.0%	31.1%
Carbon emissions	82.9 ktonnes	56.9 ktonnes



- ✓ 20% reduction in fossil fuel generation
- ✓ 31% reduction in CO_2 emissions from

GB 2030 Modelling Results - full year



- Electricity demand is highly seasonal in GB
- Wind generation higher in winter
- Solar generation higher in summer
- Tidal consistently available - in cycles
- Wave generation higher in winter – coinciding with peak demand

GB 2030 Modelling Results - full year

Scenario 1: 0GW marine, **Scenario 2: 1GW marine** (0.5GW Wave + 0.5GW Tidal)

Scenario 2 (1GW marine) performs best over all metrics

- 1% lower dispatch cost for marine scenario - £114M in savings
- 3% lower carbon emissions - 113ktonCO_2 in savings
- 300 GWh less gas generation dispatched
- 70 GWh less storage required

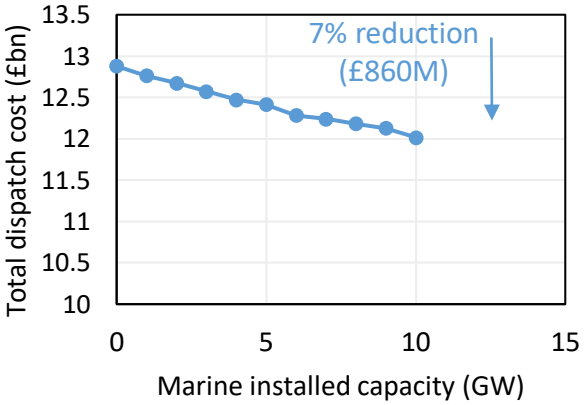
Metric	0GW marine	1GW marine	% change
Average marginal price* (£/MWh)	36.87	36.56	-0.84%
Total cost of dispatch** (£bn)	12.88	12.74	-0.89%
% renewable generation	85.59%	85.71%	+0.14%
% fossil generation	3.26%	3.17%	-2.72%
Carbon emissions (MtonCO_2)	3.97	3.86	-2.85%

*Marginal price capture represents income from wholesale electricity markets
**Total cost of dispatch represents total spend in wholesale electricity markets

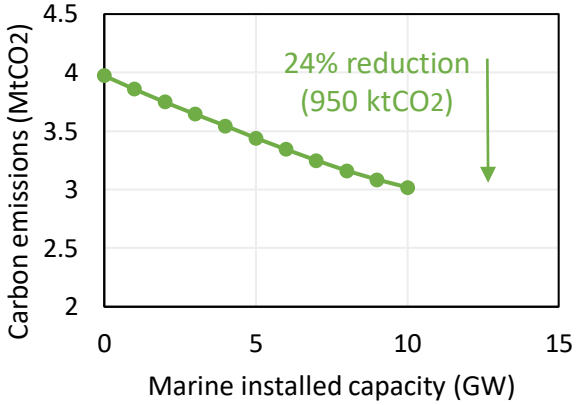
GB 2030 Modelling Results - full year

All metrics continue to improve with increasing marine energy installed capacity:

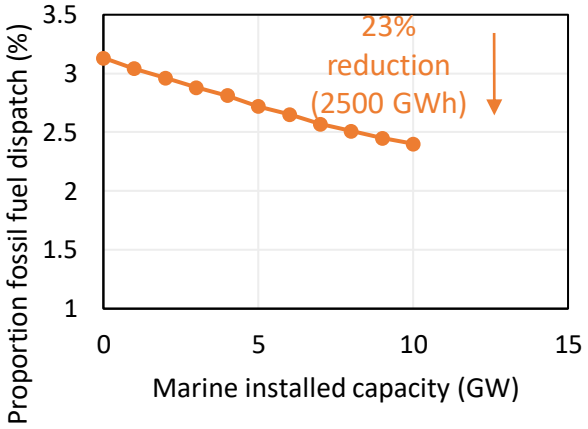
Total dispatch cost



Carbon emissions



Proportion fossil fuel dispatch



Marine energy installed capacity increases

GB 2030 Modelling Results – Price Capture

Marginal price capture represents income from wholesale electricity markets

- Wave captures highest prices:
  - Over £10/MWh than wind and solar
  - 64% higher price capture with 1GW marine deployment (500MW wave)
  - Still 47% higher price capture with 10GW marine deployment (5GW wave)

Price capture (£/MWh)	0GW marine	1GW marine	10GW marine
Solar PV	24.28	24.14	21.60
Onshore wind	22.22	21.89	19.72
Offshore wind	25.44	25.19	24.66
Wave	n/a	38.87	34.81
Tidal Stream	n/a	35.32	23.94

EVOLVE

System benefits of ocean energy

Summary:

- It is postulated that wave and tidal generation can provide additional value to low carbon energy systems due to offsetting with existing intermittent renewables

- The EVOLVE project is producing quantifiable results to show that marine energy:
  - Reduces system dispatch costs
  - Reduces generation required from fossil fuels
  - Reduces system carbon emissions
  - Captures higher market prices

- Future work will include modelling a number of scenarios for British, Irish and Portuguese systems – including net zero (2050) energy mixes

EVOLVE aquatera environmental services and products THE UNIVERSITY of EDINBURGH School of Engineering Policy and Innovation Group RI.SE WavEC CORPOWER OCEAN ORBITAL MARINE POWER

https://evolveenergy.eu/

System benefits of ocean Energy

Thanks for your attention!

Shona Pennock – shona.pennock@ed.ac.uk

https://evolveenergy.eu/

Supported by:

This collaborative project has received support under the framework of the OCEANERA-NET COFUND project, with funding provided by the following national/regional funding organisations: Scottish Enterprise, Swedish Energy Agency and Fundação para a Ciência e a Tecnologia.

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Leasing for Offshore Renewables

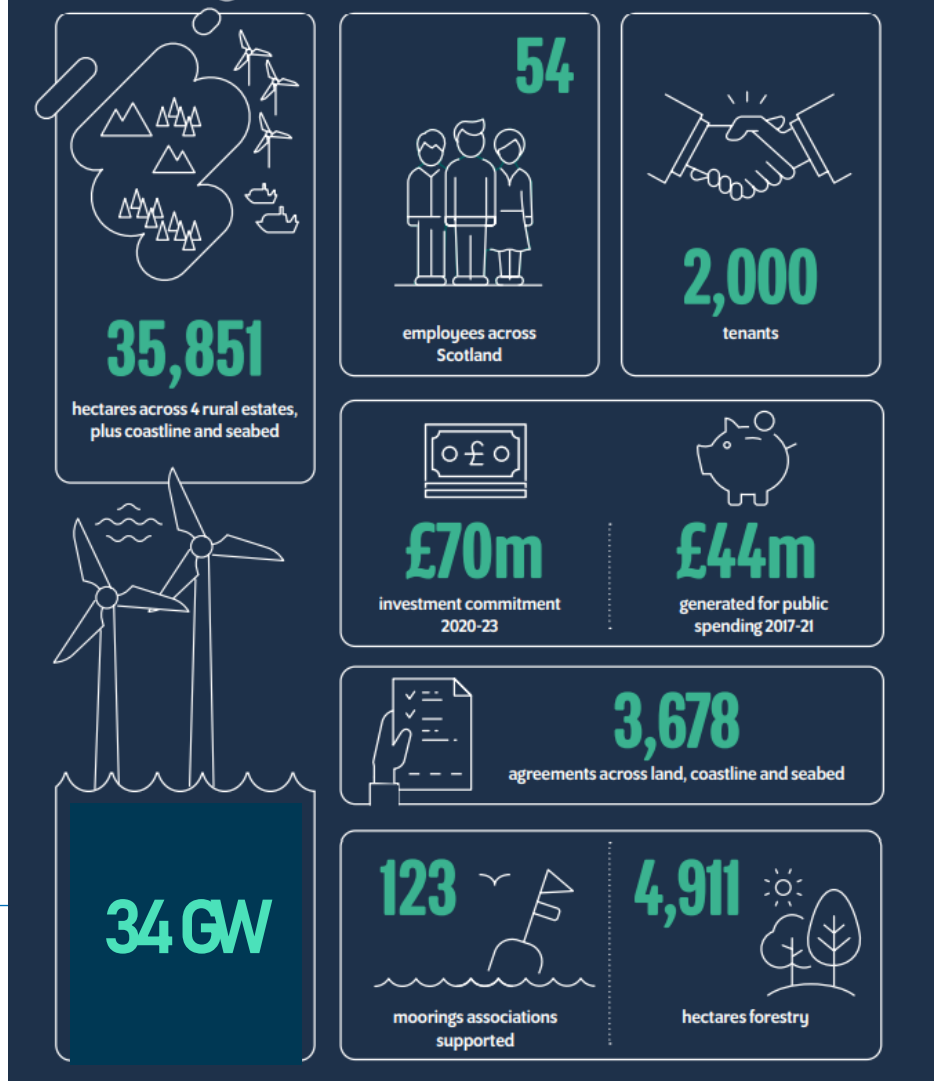
Sian Wilson

Wave Energy Scotland

May 2022

Who we are and what we do

Crown Estate Scotland
Oighreachd a' Chrùin Alba



Building the blue economy

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

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Content

- Offshore wind leasing Rounds
- Marine energy open leasing
- What next?

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Offshore Wind:
ScotWind - Round

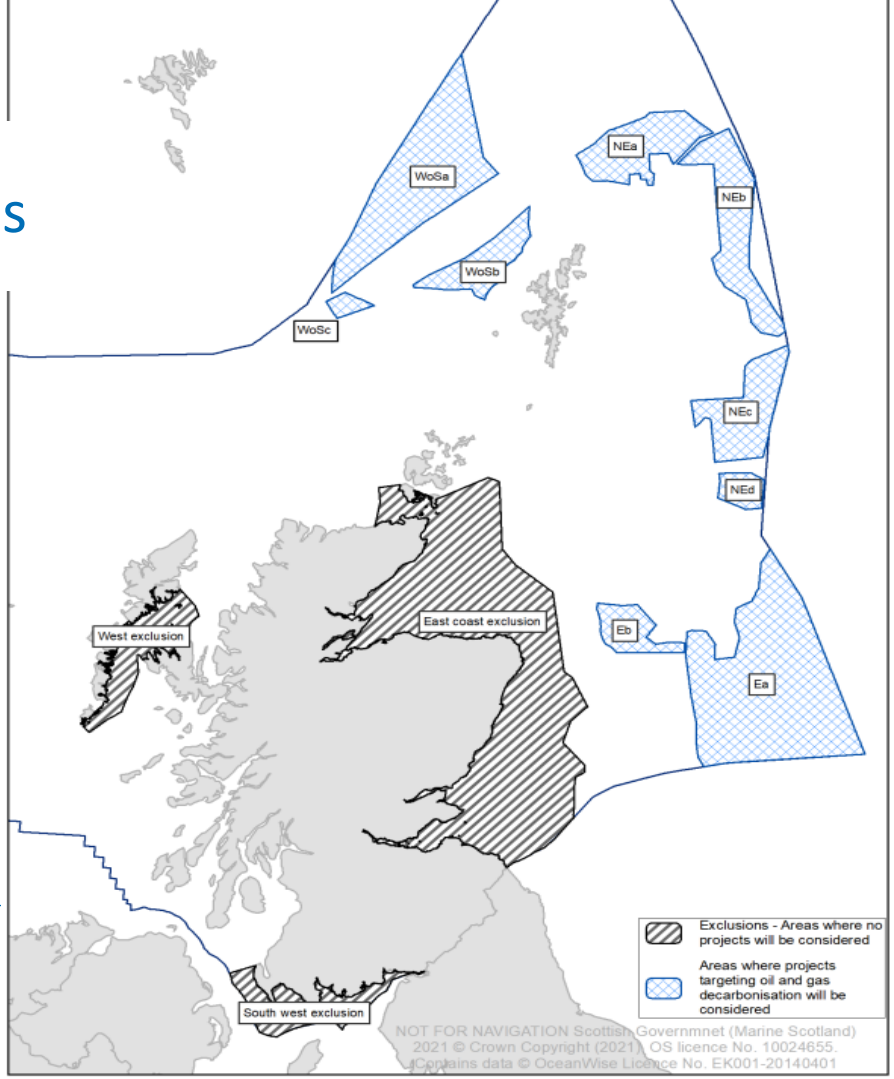
74
Applications from bidders

17
Projects selected

7,000km²
Total seabed area offered as options

Offshore Wind:
Innovation and Targeted Oil and Gas electrification - Round

- Decarbonising O&G operations
- Marine Scotland planning consultation led to MS Initial Plan Framework
- Anticipate leasing launch **this summer**



Offshore Wind:
Innovation and Targeted Oil and Gas electrification

Objectives for Offshore Wind **Innovation** Projects:

- Small scale (less than 100MW)
- To further develop Scotland as a destination for innovation and technical development

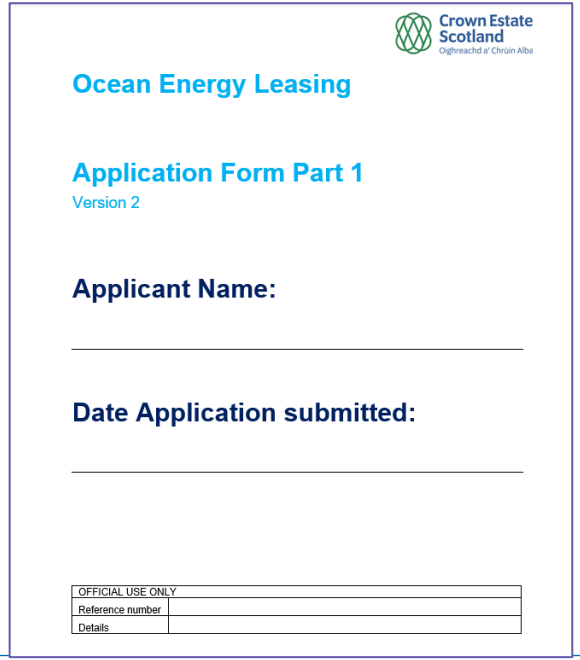
Objectives for **Targeted Oil and Gas** Projects:

- To maximise the role of offshore wind to reduce emissions from O&G production
- To achieve target installed capacity in a way that delivers best value for Scotland and supply chain opportunity

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Wave Energy - Open Process

- Marine@crownestatescotland.com
- Make an application
  - Up to 3MW (T&D)
  - 3MW to 30MW (Experience required)
- Subject to:
  - competition check
  - Plan HRA check
- Application fee and an Option fee



Crown Estate Scotland
Oighreachd a' Chrùin Alba

Ocean Energy Leasing

Application Form Part 1
Version 2

Applicant Name:

_____

Date Application submitted:

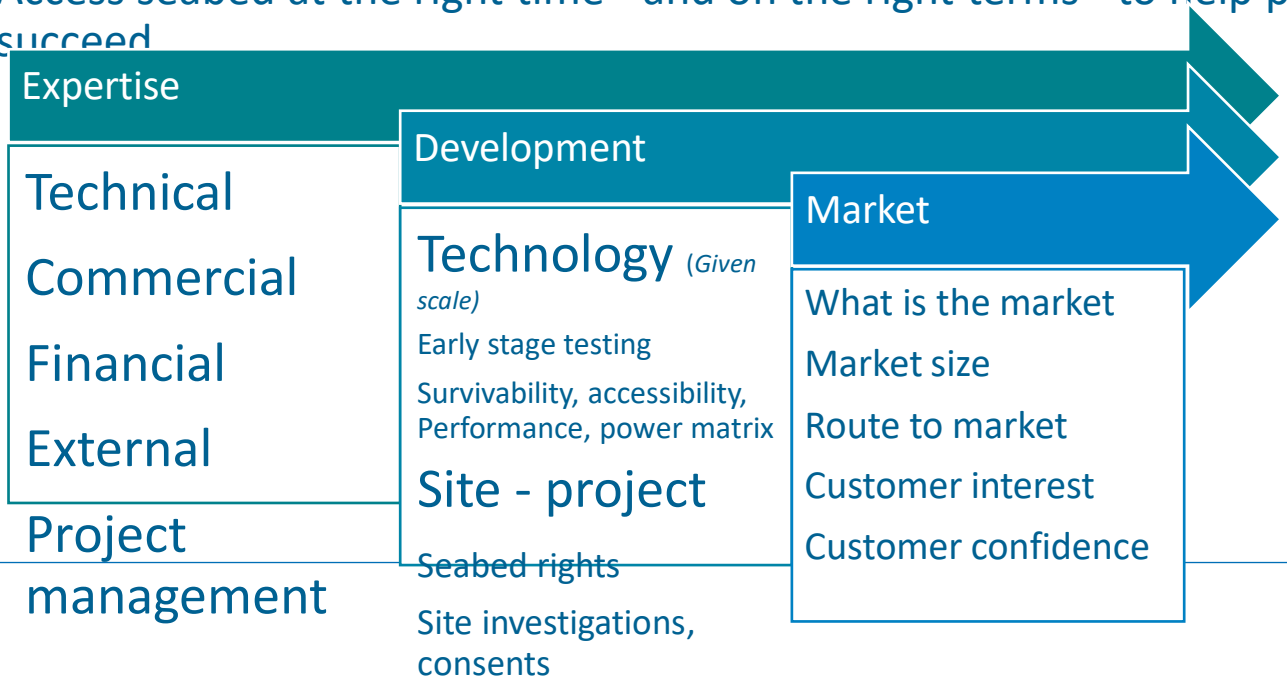
_____

OFFICIAL USE ONLY	
Reference number	
Details	

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Wave Energy - What next?

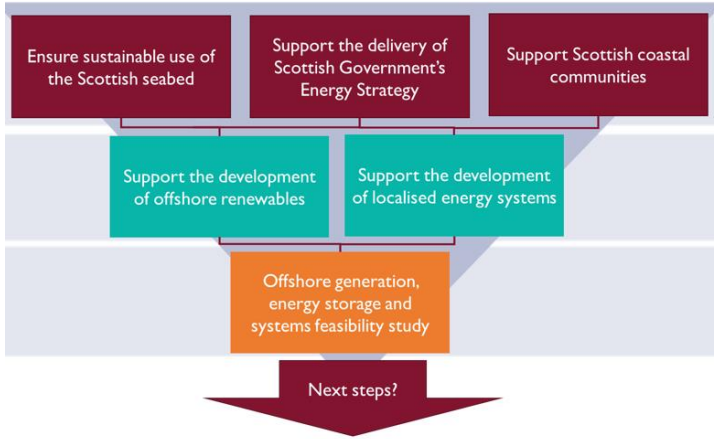
- Type of Leasing: why open process or rounds
- Access seabed at the right time - and on the right terms - to help projects succeed

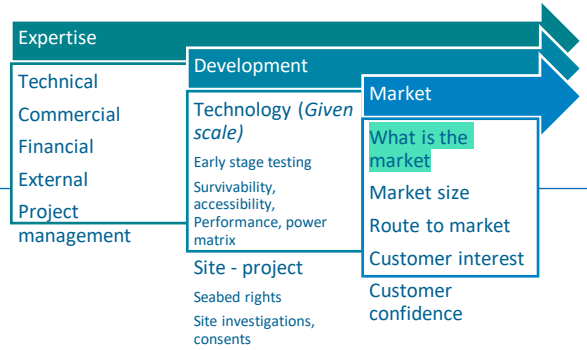


- Timing
- Policy formed

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Wave Energy - What next?





- Status of technology (at proven technology scale)
  - Increasing technical certainty
  - Evidence of power production, survivability, accessibility
  - Demonstration of use
- What is solution offered (using proven technology scale)
  - Decarbonisation of a sector?
  - Local community regeneration?

<Discuss>

1. Opportunities
2. Policy formation and support

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Thank you

Sian.Wilson@CrownEstateScotland.com

www.crownestatescotland.com

INTEGRITY, COLLABORATION, COMMERCIALISM, EXCELLENCE

Task 12 – Performance Metrics

Working Group call

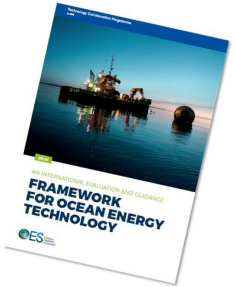
19th April 2022

Technology Collaboration Programme

by iea

Contents

- International standards
  - IEA-OES Evaluation and Guidance Framework
    - Objectives
    - Stakeholders
    - Benefits
  - IEC Technical Specifications
- Open-source tools



International Electrotechnical Commission

DTOcean+

IEA-OES Performance Metrics

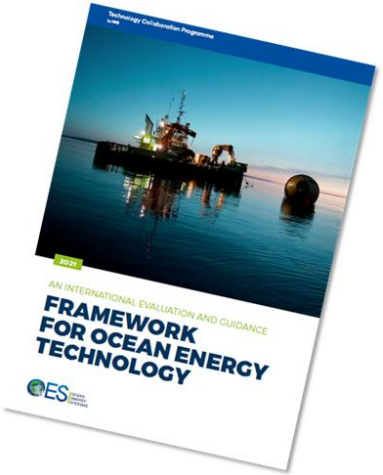
- Objectives

Support investment decision making

Guide appropriate and robust activities

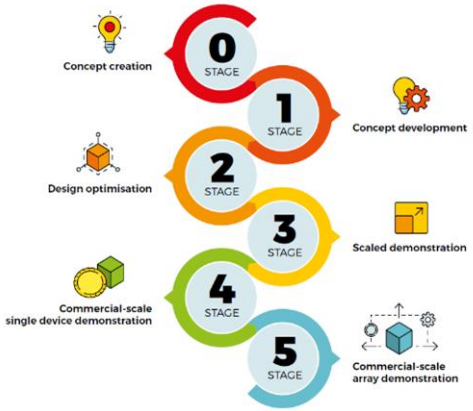
Share knowledge and promote collaboration

Build international consensus



IEA-OES Framework – Content

- Stages



- Evaluation Areas

- Stage Activities

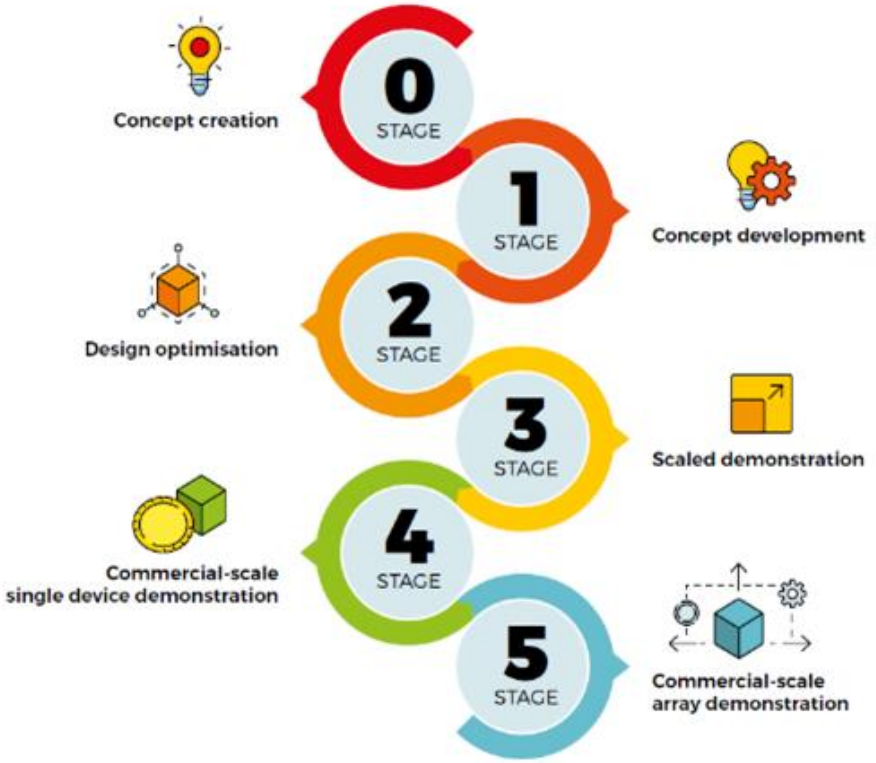
Stage	Stage Activities
Stage 0 Concept creation	• Definition of technology requirements and challenges associated with Power Conversion (the problem statement) • Concept definition and identification of physical/ functional characteristics and fundamental operating principles of PTO, including: ▪ suitability of the PTO to the fundamental operating principle and force of damping requirements of existing devices ▪ suitability for implementation of control systems to maximise performance ▪ potential benefits of control systems ▪ degree of reliance on control systems to achieve functionality • Energy transformation behaviour and efficiency expectations defined based on (or derived from) existing, more mature technologies
	• Development of a numerical model to estimate commercial-scale Power Conversion efficiency and validation against test data • Physical, laboratory or bench testing of main components or subsystems at an

- Evaluation Criteria

Evaluation Criteria	Units	Format
Range of acceptable environmental conditions Wave height – H_{m0} and H_{max} Wave period – T_e Wind speed – U_{10} Tidal current Tidal range or tidal water depth	m s m/s m/s or kt m	Numerical values, upper and lower limits or combinations of conditions
Mean Time to Repair (MTTR, or to maintain) Measure of the time from the start of maintenance - when all resources are available and environmental conditions are within limits - until the system is returned to operation. Mobilisation and transit to site are excluded to remain site independent.	Hours	Numerical values (with **minimum and maximum** to quantify variance and its impact on availability)
Cost to Repair (or maintain)		

IEA-OES Framework – Content

- Stages and activities

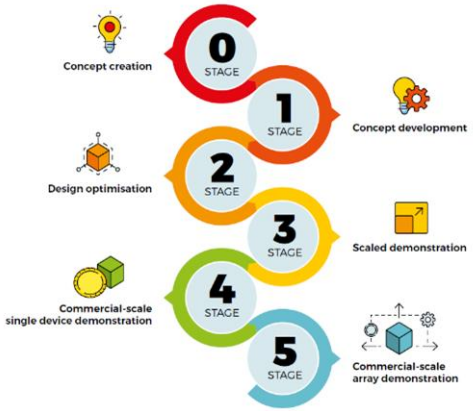


IEA-OES Framework – Content

- Evaluation Areas and criteria (metrics)

IEA-OES Framework – Content

- Stages



- Evaluation Areas

- Stage Activities

Stage	Stage Activities
Stage 0 Concept creation	• Definition of technology requirements and challenges associated with Power Conversion (the problem statement) • Concept definition and identification of physical/ functional characteristics and fundamental operating principles of PTO, including: ▪ suitability of the PTO to the fundamental operating principle and force of damping requirements of existing devices ▪ suitability for implementation of control systems to maximise performance ▪ potential benefits of control systems ▪ degree of reliance on control systems to achieve functionality • Energy transformation behaviour and efficiency expectations defined based on (or derived from) existing, more mature technologies
	• Development of a numerical model to estimate commercial-scale Power Conversion efficiency and validation against test data • Physical, laboratory or bench testing of main components or subsystems at an

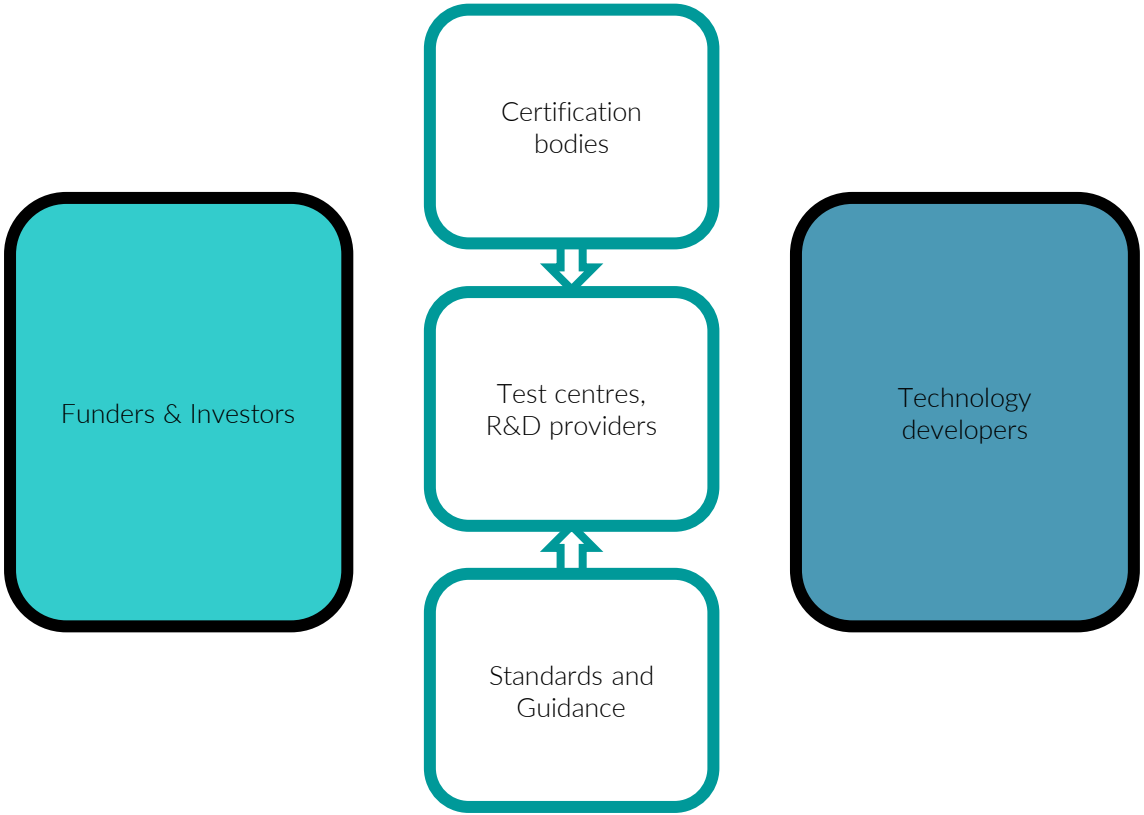
- Evaluation Criteria

Evaluation Criteria	Units	Format
Range of acceptable environmental conditions Wave height – H_{m0} and H_{max} Wave period – T_e Wind speed – U_{10} Tidal current Tidal range or tidal water depth	m s m/s m/s or kt m	Numerical values, upper and lower limits or combinations of conditions
Mean Time to Repair (MTTR, or to maintain) Measure of the time from the start of maintenance - when all resources are available and environmental conditions are within limits - until the system is returned to operation. Mobilisation and transit to site are excluded to remain site independent.	Hours	Numerical values (with **minimum and maximum** to quantify variance and its impact on availability)
Cost to Repair (or maintain)		

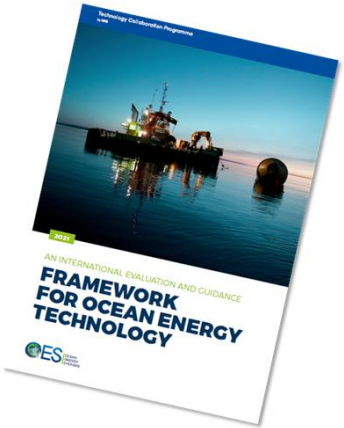
Benefits - Funders & Investors - spoken

- Discrete stages of development enable:
  - Elimination of flawed technology early
  - Focusing of funding on stronger technology
  - Lower financial risk
  - Lower reputational risk
  - Increased contractor motivation
- Stage gate metrics enable:
  - Well defined requirements
  - Regular assessment of technical progress
  - Easier to expose technical risks
  - Enables comparison between technologies
  - Getting benchmark data to quantify and compare the outcomes of programmes/projects
  - Availability of relevant data and evidence of outcomes/impact
  - Reporting up and out –impact of public funding; Ability to demonstrate transparency and strategic utilization of federal government budget allocations.
  - Competitive programmes possible
  - Well defined scope encourages the formation of consortia for a bid
  - Poor visibility of risks and significant potential losses; metrics provide the ability to quantify the risks and there by limiting losses prior to directing further funding
- Clear stage activities enable
  - Ensuring technology applicants are directed and funded at the appropriate stage (TRL). Metrics in early TRL stages provide predictions on performance and through later TRL stages the predictions are further quantified and validated.
  - Ensuring the right activities are carried out in a project; ability to apply metrics at key development stages that provide a feedback loop in the design process
  - Funding scheme design and budgeting
- Consensus and clarity if international standards enables
  - Higher quality of applications
  - Alignment of expectations
  - More effective evaluation of applications

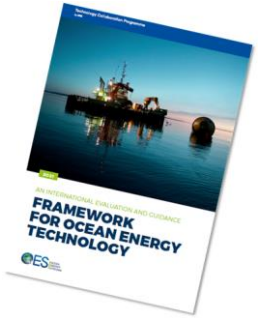
Stakeholders and contributors



Consensus between stakeholders



Funders & Investors	Technology Developers
Demonstrate impact	Measure progress
Technology selection	Acquire funding
Funding scheme design	Select activities
Innovation areas	R&D needs



IEC International Electrotechnical Commission

Technical Specifications and Standards

Open access tools

IEA-OES Framework vs IEC

TS 62600-200:2013

TS 62600-200:2013

TS 62600-201:2015

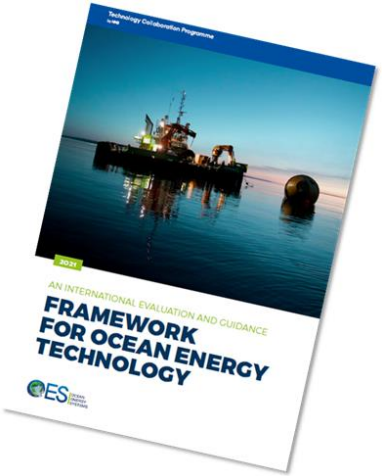
TS 62600-101:2015

TS 62600-103:2018

TS 62600-2:2019

TS 62600-10:2020

Summary



What?

IEC International Electrotechnical Commission

How?

DTOcean+

Consistent open access delivery

Thank you

STANDARDS AND OPEN ACCESS TOOLS

Jillian Henderson

WES AC 2022

wave energy SCOTLAND

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

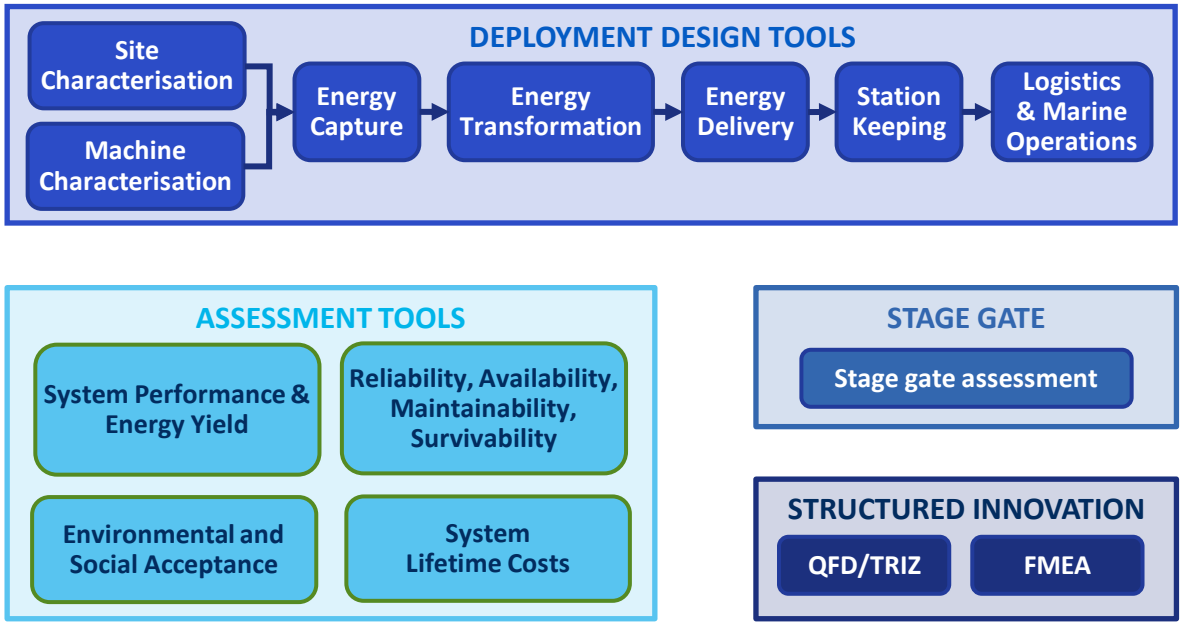
DTOceanPlus

- An EU project (May 2018 -August 2021) with a total budget of **8 million euros.**
- A **TRL6** open-source integrated suite of design tools
- Supports the **entire technology innovation process**, from concept to deployment of sub-systems, energy capture devices and arrays

16 EU partners + 2 US laboratories

https://www.dtoceanplus.eu/

DTOceanPlus

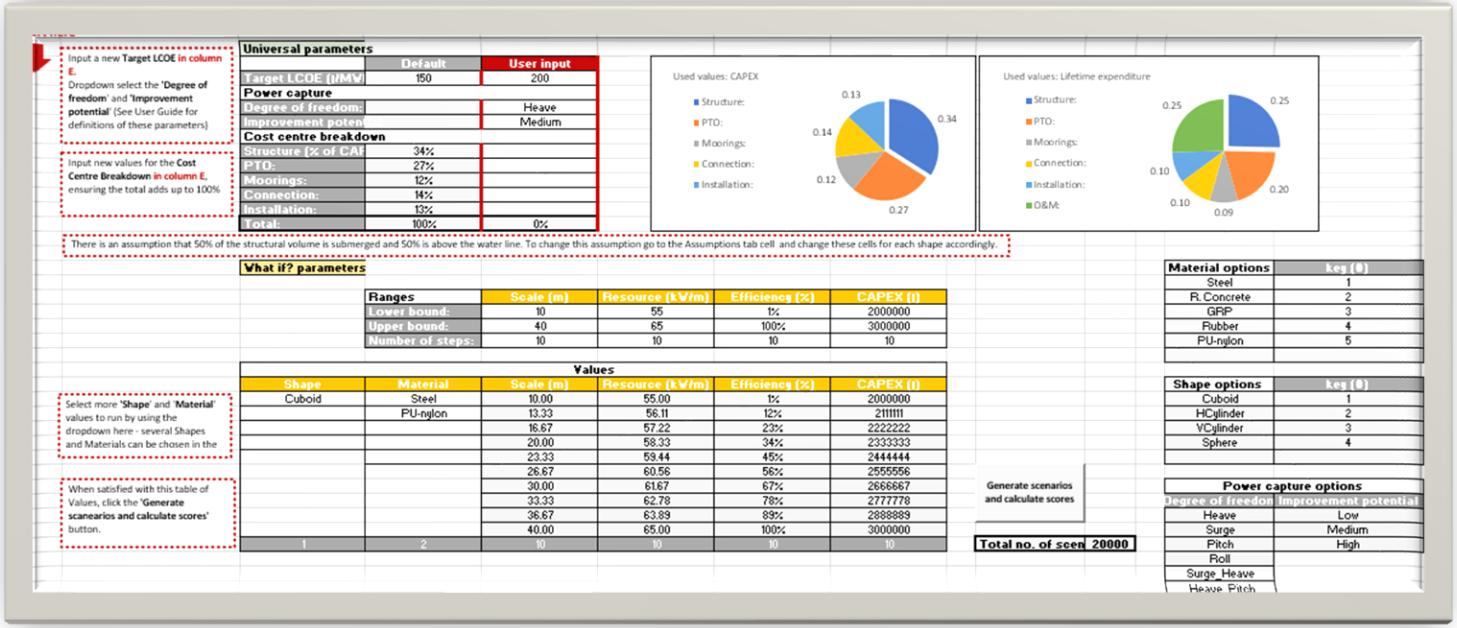


Available resources

- Digital representation for ocean energy systems
- 33 public reports
- 5 reports detailing market analysis for the ocean energy sector
- 8 open access scientific publications
- 1 global database and 3 open source data sets

https://www.dtoceanplus.eu/

Scenario Creation Tool



Input a new **Target LCOE** in column E.
Dropdown select the **'Degree of freedom'** and **'Improvement potential'** (See User Guide for definitions of these parameters)

Input new values for the **Cost Centre Breakdown** in column E, ensuring the total adds up to 100%

Universal parameters

	Default	User input
Target LCOE (£/MWh)	150	200
Power capture		
Degree of freedom:		Heave
Improvement potential:		Medium
Cost centre breakdown		
Structure (% of CAPEX):	34%	
PTO:	27%	
Moorings:	12%	
Connection:	14%	
Installation:	13%	
Total:	100%	0%

Used values: CAPEX

Used values: Lifetime expenditure

There is an assumption that 50% of the structural volume is submerged and 50% is above the water line. To change this assumption go to the Assumptions tab cell and change these cells for each shape accordingly.

What if? parameters

Ranges	Scale (m)	Resource (kW/m)	Efficiency (%)	CAPEX (£)
Lower bound:	10	55	1%	2000000
Upper bound:	40	65	100%	3000000
Number of steps:	10	10	10	10

Select more **'Shape'** and **'Material'** values to run by using the dropdown here - several Shapes and Materials can be chosen in the

When satisfied with this table of Values, click the **'Generate scenarios and calculate scores'** button.

Values

Shape	Material	Scale (m)	Resource (kW/m)	Efficiency (%)	CAPEX (£)
Cuboid	Steel	10.00	55.00	1%	2000000
	PU-nylon	13.33	56.11	12%	2111111
		16.67	57.22	23%	2222222
		20.00	58.33	34%	2333333
		23.33	59.44	45%	2444444
		26.67	60.56	56%	2555556
		30.00	61.67	67%	2666667
		33.33	62.78	78%	2777778
		36.67	63.89	89%	2888889
		40.00	65.00	100%	3000000
1	2	10	10	10	10

Generate scenarios and calculate scores

Total no. of scen 20000

Material options	Key ( )
Steel	1
R.Concrete	2
GRP	3
Rubber	4
PU-nylon	5

Shape options	Key ( )
Cuboid	1
HCylinder	2
VCylinder	3
Sphere	4

Power capture options	
Degree of freedom	Improvement potential
Heave	Low
Surge	Medium
Pitch	High
Roll	
Surge_Heave	
Heave_Pitch	

https://tinyurl.com/ynp2vpr3

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 785921.

Why does the wave energy sector need this tool?

- There are many wave energy device ideas being developed – but there is currently **no way of guiding the initial 'concept creation' stage**
- Bringing together all the knowledge we've gained from industry and the WES programme – how to create the next generation of wave energy devices?
- Using **optioneering**, this tool guides the initial concept design to point you in the right direction of your invention process

https://tinyurl.com/ynp2vpr3

Objective of the tool

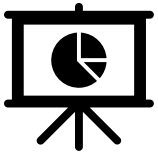
- Identify **attractive business case scenarios** for exploitation of wave energy resources
- Identify **areas** requiring technology development funding to facilitate this exploitation
- Going beyond what already exists to what is possible or could be achievable

https://tinyurl.com/ynp2vpr3

Who is the tool for?

PROJECT SEAWEED

Technology developers → To innovate in their design space



Public funder or Investors → To focus R&D funding effectively

Researchers → To explore relationships between parameters

https://tinyurl.com/ynp2vpr3

What does the tool do?

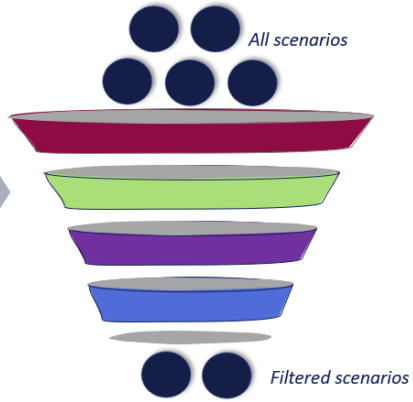
INPUTS

Choices: Degree of freedom
- Target LCOE
- Materials
- Shapes

Ranges: Scale
- CAPEX
- Resource
- Efficiency

FILTERS

- Attractive
- Attractive & possible
- Attractive, possible and achievable



OUTPUTS

- Commercial attractiveness (CA) score
- Technical Achievability (TA) score

Output top 10 results

https://tinyurl.com/ynp2vpr3

Other tools

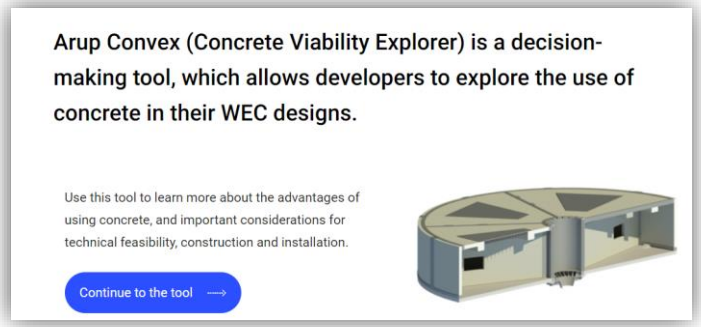
IDCORE ENGD - OPERATIONS AND MAINTENANCE SIMULATION TOOL

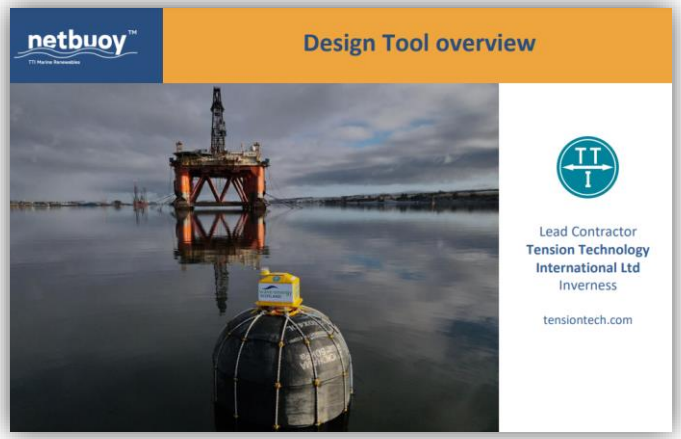
O&M Simulation Tool

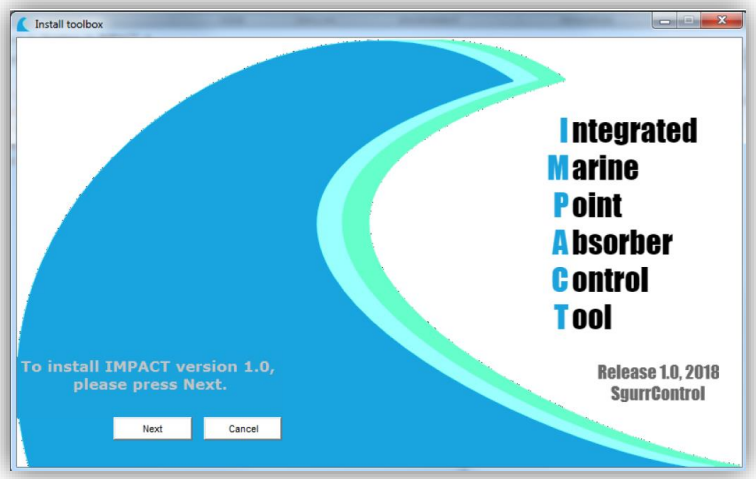
LEVELISED COST OF ENERGY TOOL

LCOE Tool - "WEC Developer" Users

Tools emerging from the WES programme







Summary

- Building consensus on evaluation processes for wave energy helps to accelerate the sector through moving towards same goals
- This shapes the standards we use in industry for development and testing
- The standards are facilitated with the use of tools to enable stakeholders to design and evaluated wave energy systems
- A common approach is the key to success

THANK YOU

Jonathan Hodges and Jillian Henderson

Twitter @WaveEnergyScot
LinkedIn waveenergyscotland

wave energy SCOTLAND

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