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European Technology & Innovation Platform for Ocean Energy

Prioritisation of Technical Barriers to the Commercialisation of Marine Energy

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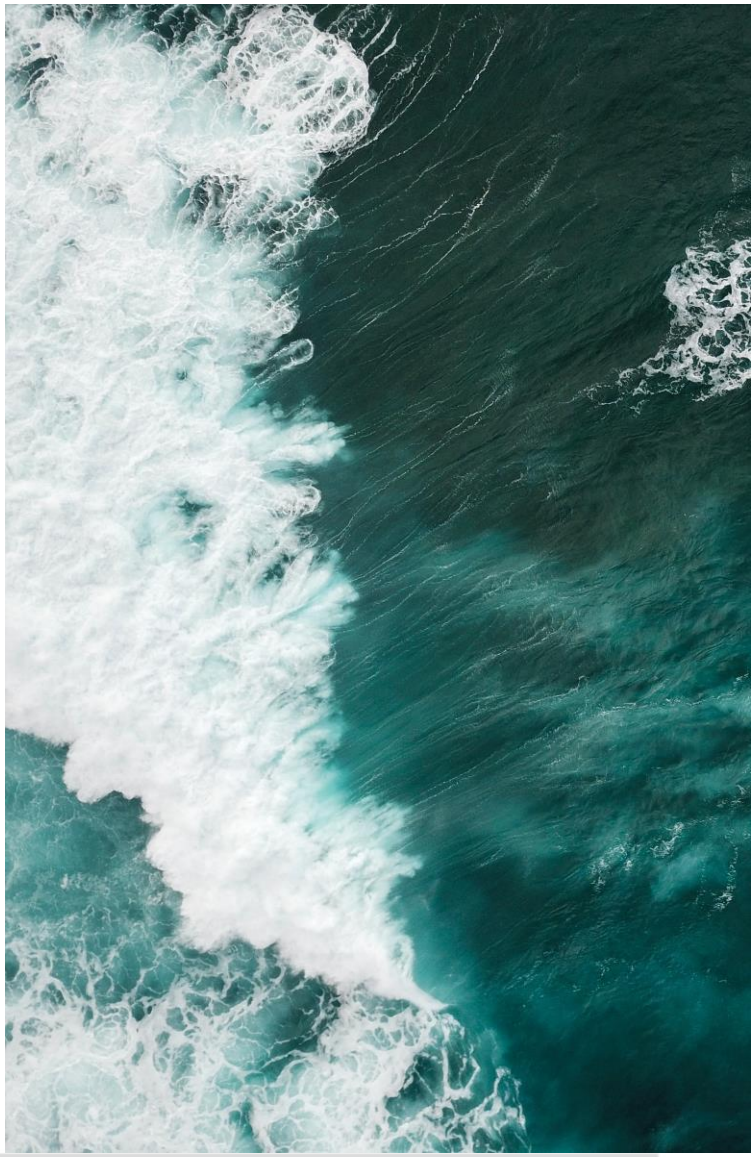
Ocean Energy Europe

Contents



Objective

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- The purpose of these slides is to provide the TWG with an overview of the content to be presented at the webinar on 7th June 2019
  - No action is required from you ahead of the webinar
- Why we are bringing this work to the TWG
  - The TWG has a broad, diverse base of knowledge and experience with which to validate the list of challenges we have identified and their prioritisation

- What we need from you (after the webinar)
  1. Please review the challenges
     - Have any challenges been missed?
     - Are any challenges been included on the list that shouldn't be?
  2. Please review the scores each challenge has received
     - Does the score make sense to you?
     - Would you have scored it differently? If so, why?

The task at hand

TPOcean

Challenge Area	Technology Development Challenge	Technology	Sector Dependence (x)	EU Opportunity (y)
Devices	Cost, performance and reliability improvements to existing devices	Both	4.4	3.6
Structure and Prime Mover	Novel materials to reduce biofouling, corrosion and extend lifetimes.	Both	4.4	3.5
PTO and Control	Tidal: Demonstration and improvement of current PTO technology e.g. control systems, gearbox, direct drive, power electronic conversion	Tidal	3.7	3.5
Structure and Prime Mover	Tidal: Development of novel and sustainable materials for device structure	Tidal	3.4	3.5
Arrays	Turbulence intensity and wake effects investigation	Tidal	3.1	3.7
Operations and Maintenance	Condition monitoring of tidal devices and predictive maintenance techniques	Tidal	3.5	3.3
Structure and Prime Mover	New and improved tidal blade technology investigation	Tidal	3.2	3.5
Operations and Maintenance	Tidal: Design and demonstration of improved physical maintenance procedures	Tidal	3.3	3.5
Connection	Improvements to wet mate and dry mate connectors	Both	3.3	3.3
PTO and Control	Increase access to test facilities	Both	2.9	3.6
Energy Yield	Tidal resource modelling – its impact on yield as well as on reliability - blades and PTO loading	Tidal	3.2	2.9
Arrays	Tidal: Array planning & modelling	Tidal	3.1	2.9
PTO and Control	Wave: Lack of controls systems guidelines and specifications	Wave	2.8	3.1
Foundations and Moorings	Wave: Advanced foundation development & demonstration	Wave	2.9	2.9

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Strategic Research and Innovation Agenda (SRIA)

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European Commission

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➢ Delivery June 2019

➢ Delivery December 2019

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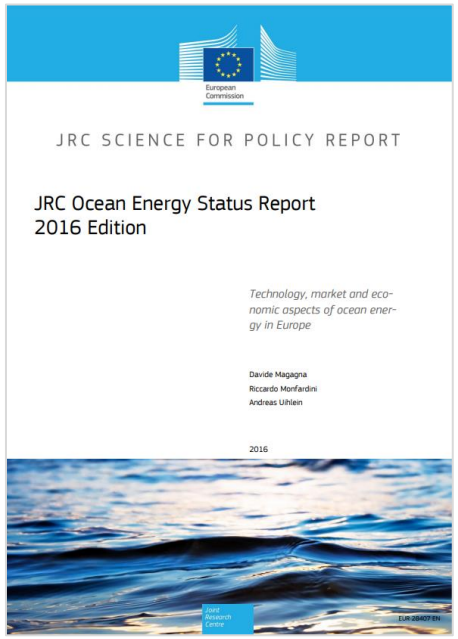
The Challenges

Source material



Supergen Offshore Renewable Energy
RESEARCH LANDSCAPE.

wave energy SCOTLAND
Landscaping Projects

11 Challenge Areas

- Structure and Prime Mover
- Foundations and Moorings
- Energy Yield
- Whole System
- PTO and Control
- Installation
- Operations and Maintenance
- Design and Optimisation Tools
- Devices
- Connections
- Arrays

57 Challenges (Unprioritised) 1 of 2

Challenge Area	Technology Development Challenge	Technology
Structure and Prime Mover	Wave: Advanced manufacturing and design processes	Wave
Structure and Prime Mover	Tidal: Advanced manufacturing and design processes	Tidal
Structure and Prime Mover	Investigation of novel reaction system technology	Wave
Structure and Prime Mover	New and improved tidal blade technology investigation	Tidal
Structure and Prime Mover	Wave: Development of novel and sustainable materials for device structure	Wave
Structure and Prime Mover	Tidal: Development of novel and sustainable materials for device structure	Tidal
Structure and Prime Mover	Difficulty testing novel reaction system designs at part scale in relevant environment	Wave
Structure and Prime Mover	Novel materials to reduce biofouling, corrosion and extend lifetimes.	Both
Structure and Prime Mover	Lack of common, recognised and open access dry and wet testing facilities	Both
Structure and Prime Mover	Wave: Lack of subcomponent validation and certification systems	Wave
Structure and Prime Mover	Tidal: Lack of subcomponent validation and certification systems	Tidal

Challenge Area	Technology Development Challenge	Technology
PTO and Control	Wave: Demonstration and improvement of current PTO technology e.g. control systems, gearbox, direct drive, power electronic conversion	Wave
PTO and Control	Tidal: Demonstration and improvement of current PTO technology e.g. control systems, gearbox, direct drive, power electronic conversion	Tidal
PTO and Control	Wave: Early stage research for disruptive PTO technologies	Wave
PTO and Control	Tidal: Early stage research for disruptive PTO technologies	Tidal
PTO and Control	Improved pitch and yaw technology investigation & demonstration	Tidal
PTO and Control	Improved control systems for wave energy devices, particularly for extreme conditions	Wave
PTO and Control	Increase access to test facilities	Both
PTO and Control	Wave: Lack of controls systems guidelines and specifications	Wave
PTO and Control	Tidal: Lack of controls systems guidelines and specifications	Tidal
PTO and Control	Lack of integrated design of control system within device as a whole	Both

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Have any challenges been missed?
Are any challenges included on the list that shouldn't be?

57 Challenges (Unprioritised) 2 of 2

Challenge Area	Technology Development Challenge	Technology
Devices	Cost, performance and reliability improvements to existing devices	Both
Devices	Wave: Development of novel devices and investigation into alternative generation methods	Wave
Devices	Tidal: Development of novel devices and investigation into alternative generation methods	Tidal
Foundations and Moorings	Wave: Advanced foundation development & demonstration	Wave
Foundations and Moorings	Tidal: Advanced foundation development & demonstration	Tidal
Foundations and Moorings	Wave: Advanced mooring development & demonstration	Wave
Foundations and Moorings	Tidal: Advanced mooring development & demonstration	Tidal
Energy Yield	Tidal resource modelling – its impact on yield as well as on reliability - blades and PTO loading	Tidal
Energy Yield	Wave resource modelling – Better near-field wave forecasting and measurement to improve controllability and yield of devices as well as survivability.	Wave
Whole System	Developing grid-level system balancing benefits from wave and tidal electricity generation	Both
Whole System	Improving integration with the wider energy system from the nascent design stage through to array deployment to provide added value.	Both
Connection	Standardised electrical architecture and connections	Both
Connection	Dynamic umbilical connection	Both
Connection	Standardised subsea hubs	Both
Connection	Wave: Investigation on cable stability, repairability and survivability	Wave
Connection	HV sub-sea hub	Both
Connection	Installation of cables in different seabed conditions	Both
Connection	Improvements to wet mate and dry mate connectors	Both

Challenge Area	Technology Development Challenge	Technology
Operations and Maintenance	Wave: Design and optimisation of systems to ease design for maintenance	Wave
Operations and Maintenance	Tidal: Design and optimisation of systems to ease design for maintenance	Tidal
Operations and Maintenance	Condition monitoring of wave devices and predictive maintenance techniques	Wave
Operations and Maintenance	Condition monitoring of tidal devices and predictive maintenance techniques	Tidal
Operations and Maintenance	Wave: Design and demonstration of improved physical maintenance procedures	Wave
Operations and Maintenance	Tidal: Design and demonstration of improved physical maintenance procedures	Tidal
Operations and Maintenance	Development of bespoke support vessels	Both
Design and Optimisation Tools	Need for improved analytics in development and implementation of optimisation tools	Both
Design and Optimisation Tools	Need for development of fully integrated or coupled simulation design tools	Both
Design and Optimisation Tools	Limitations to research in gathering, distributing, employing and protecting data within tools	Both
Installation	New and improved installation techniques (e.g. devices, cabling, foundations, anchors)	Both
Installation	Development of bespoke installation vessels	Both

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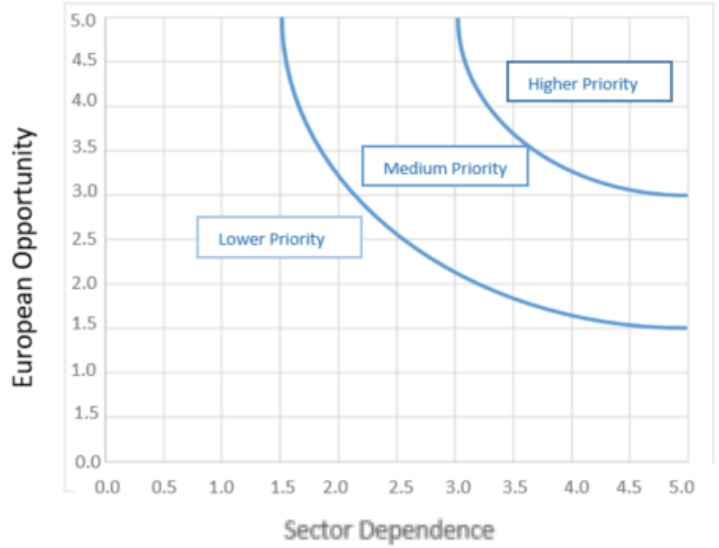
Have any challenges been missed?
Are any challenges included on the list that shouldn't be?

Methodology

Scoring Criteria

Sector Dependence	Assessment Criterion	Description	Weighting (%)
	Sector urgency	How important is it to the sector that the challenge is tackled rapidly?	20
	Cost reduction potential (impact on CAPEX)	What impact will tackling the challenge have on ocean energy project CAPEX?	20
	Cost reduction potential (impact on OPEX)	What impact will tackling the challenge have on ocean energy project OPEX?	20
	Impact on performance (energy yield and efficiency)	What impact will tackling the challenge have on the energy yield and efficiency performance of ocean energy systems?	15
	Impact on reliability, technical risk and survivability	What impact will tackling the challenge have on reliability, technical risk, and survivability of ocean energy systems?	15
	Cross-cutting	How diverse is the range of other ocean energy technologies and other sectors that stand to benefit from the resolution of this challenge?	10

EU Opportunity	Assessment Criterion	Description	Weighting (%)
	Dedicated funding stream	To what extent does this challenge require funding to be overcome?	33
	European capability to deliver the solution	How well-placed is the sector in Europe to deliver the solution to this challenge?	33
	Risk of duplication	To what extent is work not already being carried out to overcome this challenge?	33



Do you agree with the scoring criteria? If not, why not? How would you score differently?

Results

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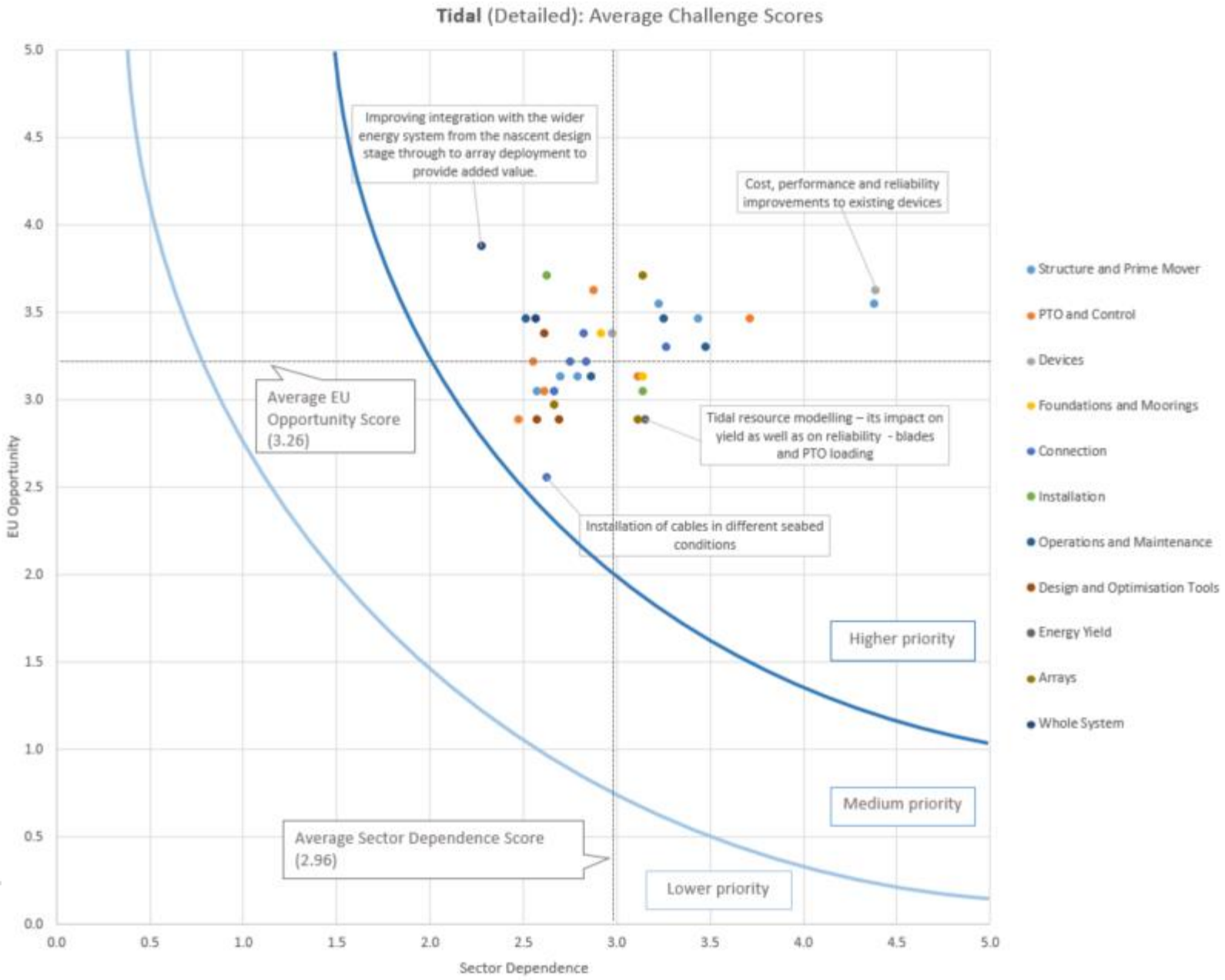
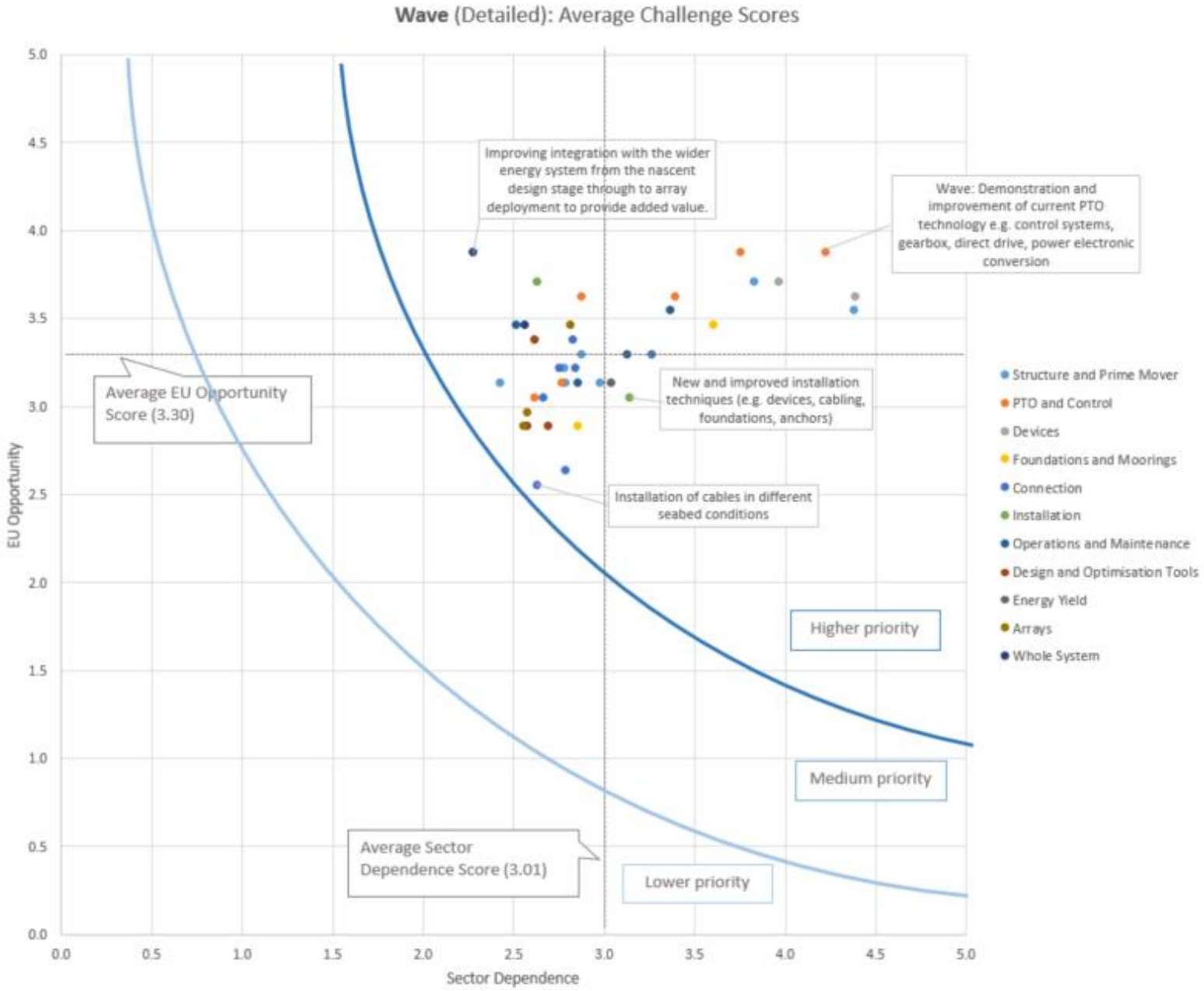
Key results

- All challenges have been scored as 'High Priority'. This demonstrates that all challenges identified are appropriate and will require attention in the near or distant future.
- The following slides show the challenges plotted across the two prioritisation axes – Sector Dependence and EU Opportunity.
- The priority curves are approximations of high, medium and low score ranges.
- Challenges were scored individually, then the scores within each category were averaged to give a 'challenge area' value. The purpose of this was to provide simplified results and to prioritise overall areas at a higher level.

Tidal


Tidal (Detailed): Average Challenge Scores
EU Opportunity
Sector Dependence
Improving integration with the wider energy system from the nascent design stage through to array deployment to provide added value.
Cost, performance and reliability improvements to existing devices
Average EU Opportunity Score (3.26)
Tidal resource modelling – its impact on yield as well as on reliability - blades and PTO loading
Installation of cables in different seabed conditions
Higher priority
Medium priority
Lower priority
Average Sector Dependence Score (2.96)
Structure and Prime Mover
PTO and Control
Devices
Foundations and Moorings
Connection
Installation
Operations and Maintenance
Design and Optimisation Tools
Energy Yield
Arrays
Whole System

Wave


Wave (Detailed): Average Challenge Scores
EU Opportunity
Sector Dependence
Improving integration with the wider energy system from the nascent design stage through to array deployment to provide added value.
Wave: Demonstration and improvement of current PTO technology e.g. control systems, gearbox, direct drive, power electronic conversion
Average EU Opportunity Score (3.30)
New and improved installation techniques (e.g. devices, cabling, foundations, anchors)
Installation of cables in different seabed conditions
Higher priority
Medium priority
Lower priority
Average Sector Dependence Score (3.01)
Structure and Prime Mover
PTO and Control
Devices
Foundations and Moorings
Connection
Installation
Operations and Maintenance
Design and Optimisation Tools
Energy Yield
Arrays
Whole System

Prioritised **Tidal** Challenges (1 of 2)

Challenge Area	Technology Development Challenge	Technology	Sector Dependence (x)	EU Opportunity (y)
Devices	Cost, performance and reliability improvements to existing devices	Both	4.4	3.6
Structure and Prime Mover	Novel materials to reduce biofouling, corrosion and extend lifetimes.	Both	4.4	3.5
PTO and Control	Tidal: Demonstration and improvement of current PTO technology e.g. control systems, gearbox, direct drive, power electronic conversion	Tidal	3.7	3.5
Structure and Prime Mover	Tidal: Development of novel and sustainable materials for device structure	Tidal	3.4	3.5
Arrays	Turbulence intensity and wake effects investigation	Tidal	3.1	3.7
Operations and Maintenance	Condition monitoring of tidal devices and predictive maintenance techniques	Tidal	3.5	3.3
Structure and Prime Mover	New and improved tidal blade technology investigation	Tidal	3.2	3.5
Operations and Maintenance	Tidal: Design and demonstration of improved physical maintenance procedures	Tidal	3.3	3.5
Connection	Improvements to wet mate and dry mate connectors	Both	3.3	3.3
PTO and Control	Increase access to test facilities	Both	2.9	3.6

Challenge Area	Technology Development Challenge	Technology	Sector Dependence (x)	EU Opportunity (y)
Devices	Tidal: Development of novel devices and investigation into alternative generation methods	Tidal	3.0	3.4
Foundations and Moorings	Tidal: Advanced mooring development & demonstration	Tidal	2.9	3.4
Foundations and Moorings	Tidal: Advanced foundation development & demonstration	Tidal	3.1	3.1
PTO and Control	Improved pitch and yaw technology investigation & demonstration	Tidal	3.1	3.1
Installation	Development of bespoke installation vessels	Both	2.6	3.7
Installation	New and improved installation techniques (e.g. devices, cabling, foundations, anchors)	Both	3.1	3.1
Connection	HV sub-sea hub	Both	2.8	3.4
Connection	Standardised subsea hubs	Both	2.8	3.2
Energy Yield	Tidal resource modelling – its impact on yield as well as on reliability - blades and PTO loading	Tidal	3.2	2.9
Arrays	Tidal: Array planning & modelling	Tidal	3.1	2.9

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Would you have scored any challenges higher or lower? If so, why? Which score would you give it?

Prioritised **Tidal** Challenges (2 of 2)

Challenge Area	Technology Development Challenge	Technology	Sector Dependence (x)	EU Opportunity (y)
Operations and Maintenance	Tidal: Design and optimisation of systems to ease design for maintenance	Tidal	2.9	3.1
Whole System	Developing grid-level system balancing benefits from wave and tidal electricity generation	Both	2.6	3.5
Connection	Dynamic umbilical connection	Both	2.8	3.2
Design and Optimisation Tools	Limitations to research in gathering, distributing, employing and protecting data within tools	Both	2.6	3.4
Whole System	Improving integration with the wider energy system from the nascent design stage through to array deployment to provide added value.	Both	2.3	3.9
Structure and Prime Mover	Lack of common, recognised and open access dry and wet testing facilities	Both	2.8	3.1
Operations and Maintenance	Development of bespoke support vessels	Both	2.5	3.5
Structure and Prime Mover	Tidal: Advanced manufacturing and design processes	Tidal	2.7	3.1
PTO and Control	Tidal: Early stage research for disruptive PTO technologies	Tidal	2.6	3.2
Connection	Standardised electrical architecture & connections	Both	2.7	3.1

Challenge Area	Technology Development Challenge	Technology	Sector Dependence (x)	EU Opportunity (y)
PTO and Control	Lack of integrated design of control system within device as a whole	Both	2.6	3.1
Arrays	Tidal: Array design and impact on cable layout and avoided hub cost	Tidal	2.7	3.0
Structure and Prime Mover	Tidal: Lack of subcomponent validation and certification systems	Tidal	2.6	3.1
Design and Optimisation Tools	Need for development of fully integrated or coupled simulation design tools	Both	2.7	2.9
Design and Optimisation Tools	Need for improved analytics in development and implementation of optimisation tools	Both	2.6	2.9
PTO and Control	Tidal: Lack of controls systems guidelines and specifications	Tidal	2.5	2.9
Connection	Installation of cables in different seabed conditions	Both	2.6	2.6

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Would you have scored any challenges higher or lower? If so, why? Which score would you give it?

Prioritised **Wave** Challenges (1 of 2)

Challenge Area	Technology Development Challenge	Technology	Sector Dependence (x)	EU Opportunity (y)
PTO and Control	Wave: Demonstration and improvement of current PTO technology e.g. control systems, gearbox, direct drive, power electronic conversion	Wave	4.2	3.9
Devices	Cost, performance and reliability improvements to existing devices	Both	4.4	3.6
Structure and Prime Mover	Novel materials to reduce biofouling, corrosion and extend lifetimes.	Both	4.4	3.5
Devices	Wave: Development of novel devices and investigation into alternative generation methods	Wave	4.0	3.7
PTO and Control	Wave: Early stage research for disruptive PTO technologies	Wave	3.8	3.9
Structure and Prime Mover	Wave: Development of novel and sustainable materials for device structure	Wave	3.8	3.7
Foundations and Moorings	Wave: Advanced mooring development & demonstration	Wave	3.6	3.5
PTO and Control	Improved control systems for wave energy devices, particularly for extreme conditions	Wave	3.4	3.6
Operations and Maintenance	Wave: Design and demonstration of improved physical maintenance procedures	Wave	3.4	3.5
Connection	Improvements to wet mate and dry mate connectors	Both	3.3	3.3

Challenge Area	Technology Development Challenge	Technology	Sector Dependence (x)	EU Opportunity (y)
PTO and Control	Increase access to test facilities	Both	2.9	3.6
Operations and Maintenance	Condition monitoring of wave devices and predictive maintenance techniques	Wave	3.1	3.3
Installation	Development of bespoke installation vessels	Both	2.6	3.7
Arrays	Understanding farm-level wave device interaction	Wave	2.8	3.5
Installation	New and improved installation techniques (e.g. devices, cabling, foundations, anchors)	Both	3.1	3.1
Connection	HV sub-sea hub	Both	2.8	3.4
Energy Yield	Wave resource modelling – Better near-field wave forecasting and measurement to improve controllability and yield of devices as well as survivability.	Wave	3.0	3.1
Structure and Prime Mover	Investigation of novel reaction system technology	Wave	2.9	3.3
Structure and Prime Mover	Wave: Advanced manufacturing and design processes	Wave	3.0	3.1
Connection	Standardised subsea hubs	Both	2.8	3.2

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Prioritised **Wave** Challenges (2 of 2)

Challenge Area	Technology Development Challenge	Technology	Sector Dependence (x)	EU Opportunity (y)
Operations and Maintenance	Wave: Design and optimisation of systems to ease design for maintenance	Wave	2.9	3.1
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Structure and Prime Mover	Wave: Lack of subcomponent validation and certification systems	Wave	2.4	3.1
Design and Optimisation Tools	Need for improved analytics in development and implementation of optimisation tools	Both	2.6	2.9
Arrays	Wave: Array design and impact on cable layout and avoided hub cost	Wave	2.6	2.9
Connection	Wave: Investigation on cable stability, repairability and survivability	Wave	2.8	2.6
Connection	Installation of cables in different seabed conditions	Both	2.6	2.6

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Would you have scored any challenges higher or lower? If so, why? Which score would you give it?

Summary

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Further information about providing feedback will be given during the webinar