OceanSET Annual Report | 2022

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EXECUTIVE SUMMARY

The report updates the SET Plan implementation working group for ocean energy (OE-IWG) on progress in the sector in the calendar year 2022.

Member countries continue to support the ocean energy sector through the development of national and regional policies for offshore renewable energy, revenue support mechanisms, national and regional test and demonstration facilities, and funding programmes. However, the ocean energy sector must compete frequently with the mature energy sectors such as offshore wind. Specific policy targets, dedicated revenue support mechanisms and focussed funding programmes would accelerate the roll-out of ocean energy technology.

Twenty (20) new ocean energy projects received a total of €25.7 million in grant aid in 2022, the European Commission committing some €13.4 million of grant aid to five (5) projects through its research and innovation programmes and OE-IWG countries committing some €12.3 million to fifteen (15) projects through national and regional programmes. While most projects related to the tidal stream and wave sub-sector, ocean thermal energy conversion and tidal range projects were also supported.

An assessment of progress in delivering the expected investment in the Technical theme actions of the Implementation Plan (IP) identified 151 projects receiving public grant aid of some €496 million:

- 108 projects, receiving €332 million, addressed a Technical theme action ('in-scope' projects).
- 43 projects, receiving €164 million, did not address a Technical theme action ('out-of-scope' projects).

The 'in-scope' projects represent approximately three-quarters of the number of projects and approximately half the public finance recommended in the IP. While progress appears to be on track in terms of committed grant aid, there are a greater number of lower-valued projects than recommended. Furthermore, 'in-scope' projects are not distributed across the actions as recommended, e.g., two actions have already received greater attention than recommended while three actions have received no attention. Also, grant aid committed to 'out-of-scope' projects is significant, at a little under one third of the total committed grant aid.

Under the Environmental, Policy and Socioeconomics theme, nine (9) of the twelve (12) EU Member States represented on the OE-IWG had an approved Maritime Spatial Plan by the end of 2022 [Action 2.2]; the remaining three (3) countries are expected to approve their plans in 2023. While the MSPs specify zones designated for the development of offshore renewable energy this tends to mean offshore wind almost exclusively. Belgium, Germany, Portugal and Sweden mention ocean energy in relation to these offshore renewable energy zones while The Netherlands has explicitly not pursued a policy on ocean energy.

Under the Market Uptake and Financial theme, while technology agnostic revenue support schemes continue to prevail, the effectiveness of dedicated single technology schemes has been demonstrated in the UK's fourth Contracts for Difference (CfD) allocation round which incorporated ring-fenced support for tidal stream technology that resulted in four contracts to deliver 40.82MW of capacity [Action 3.1]. The preferred form for establishing an insurance and warranty fund to underwrite technology-related financial risks associated with pre-commercial ocean energy projects [Action 3.3] has been elaborated further in a study commissioned by the UK's Offshore Renewable Energy Catapult through the Tidal Stream Industry Energiser (TIGER) project. However, no evidence of progress in the creation of a Common Investment Support Fund [Action 3.2] is noted. Meanwhile the uptake of innovation procurement mechanisms continues through the cross-border (Scotland-Basque Country) EuropeWave project and the Basque Energy Agency's TurboWave project.

The principal targets for the ocean energy sector remains the deployment of 100 MW of capacity by 2025, together with a pathway to achieving a levelised cost of energy (LCOE) of 15cEUR/kWh by 2030 [tidal stream] and by 2035 [wave].

Identified deployment projects suggest the capacity target can be met but not until 2027. Installed capacity is estimated as 13.3 MW at the end of 2022 and is projected to increase to approximately 25 MW by 2025 and approximately 105 MW by 2027.

Technology developers remain reluctant to share techno-economic metrics for their technology and deployment projects. The relevance of metrics such as LCOE for early-stage prototype demonstration deployments has been questioned.

RECOMMENDATIONS

- Continue to argue for explicit national/regional strategies, policies and targets that support the deployment of ocean energy.
- Tailor national and regional funding programmes to address the Implementation Plan's Technical theme actions.
- Evolve existing revenue support schemes to allow ocean energy deployment projects to secure support.
- Identify mechanisms to progress the implementation of a Common Investment Support Fund [Action 3.2].
- Identify mechanisms to progress the implementation of an Insurance and Warranty Fund [Action 3.3].
- Monitor the update to the Strategic Research and Innovation Agenda (SRIA) for ocean energy and consider revising the Implementation Plan accordingly.

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1. Introduction

1.1 The SET Plan and ocean energy

The European Strategic Energy Technology Plan (SET Plan) [1] aims to accelerate the transformation of the European energy system. The SET Plan is the EU's main research and innovation policy.

Two of the SET Plan's ten actions are intended to position Europe as "*Number 1 in renewable energy*" through the development and deployment of low-carbon technologies, improving new technologies and bringing down their costs.

The SET Plan has put forward a specific vision for several technology areas (including ocean energy). Through setting ambitious targets and developing implementation plans the SET Plan will place Europe at the forefront of the next generation of low-carbon energy technologies.

The current SET Plan Implementation Plan for Ocean Energy 2 identifies the key challenges for the ocean energy sector (and particularly the wave and tidal-stream energy sub-sectors) for the period 2021 to 2025, expressed as a collection of priority actions grouped under three themes (Table 1).

- Technical (fifteen actions)
- Environmental Policy & Socioeconomic (three actions)
- Market Uptake and Financial (five actions).

Number 1 in renewable energy

1. Sustain technological leadership by developing highly performant renewable technologies and their integration in the EU's energy system.
2. Reduce the cost of key technologies.

The fifteen actions in the Technical theme are aligned with the Challenge Areas and Priority Topics identified in the sector's Strategic Research and Innovation Agenda (SRIA) [3]. The mapping is summarised in Table 1.

The targets for each technical action are focussed on general ambition of achieving:

- A deployed capacity of 100MW by 2025; and,
- A pathway to a levelised cost of energy (LCOE) of 15cEUR/kWh by 2030 [tidal] and 2035 [wave].

[1] Communication from the Commission C(2015) 6317. Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation.

[2] The Implementation Plan was first published in March 2018 and revised in October 2021 to reflect the European Commission's 'Strategy on Offshore Renewable Energy' (published in November 2020) and the 'Strategic Research and Innovation Agenda for Ocean Energy' (SRIA).

[3] The 'Strategic Research and Innovation Agenda for Ocean Energy' was published by the European Technology and Innovation Platform for Ocean Energy (ETIP Ocean) in June 2020 [https://www.etipocean.eu/knowledge_hub/strategic-research-innovation-agenda-for-ocean-energy/]

TABLE 1: THE ACTIONS OF THE IMPLEMENTATION PLAN

Theme	ID	SRIA Challenge Area & ID [a]		Action Description
Technical	1.1	Design and Validation of Ocean Energy Devices	1.1	Demonstration of ocean energy devices to increase experience in real sea conditions
	1.2		1.2	Demonstration of ocean energy pilot farms
	1.3		1.3	Improvement and demonstration of PTO and control systems
	1.4		1.4	Application of innovative materials from other sectors
	1.5		1.5	Development of novel wave energy devices
	1.6		1.6	Improvement of tidal blades and rotor
	1.7	Foundations, Connections and Mooring	2.1	Advanced mooring and connection systems for floating ocean energy devices
	1.8		2.2	Improvement and demonstration of foundations and connection systems for bottom-fixed ocean energy devices
	1.9	Logistics and Marine Operations	3.1	Optimisation of maritime logistics and operations
	1.10		3.2	Instrumentation for condition monitoring and predictive maintenance
	1.11	Integration in the Energy System	4.1	Developing and demonstrating near-commercial application of ocean energy in niche markets and hybrid systems.
	1.12		4.2	Quantifying and demonstrating grid-scale benefits of ocean energy
	1.13	Data Collection & Analysis and Modelling Tools	5.1	Marine observation and modelling to optimise design and operation of ocean energy device
	1.14		5.2	Open-data repository for ocean energy operation and performance
	1.15	Cross-Cutting Challenges	6.2	Standardisation and certification
Environmental, Policy and Socioeconomics	2.1	De-risking of environmental consenting through an integrated programme of measures • Promoting open data sharing on environment, consenting procedures and policy among MS • Promoting the development of environmental standards and certification • Encouraging a circular economy approach in the design of ocean energy technologies • Promoting simplified consenting procedures (including cross-border deployments)		
	2.2	Promoting ocean energy in Maritime Spatial Planning		
	2.3	Promoting political support and public backing for ocean energy		
Market Uptake and Financial	3.1	Dedicated revenue support for the first wave & tidal demonstration farms.		
	3.2	Creation of an Investment Support Fund for ocean energy farms.		
	3.3	Creation of an EU Insurance and Warranty Fund to underwrite various project risks.		
	3.4	Funding from EU, national, regional and private sector to support demonstration and innovation projects under the Technical and Environmental, Policy and Socioeconomic actions		
	3.5	Support the development of novel mechanisms to close funding gaps (such as a Public Procurement of Innovative solutions)		
	[a] "Challenge Area" is the phrase used in the SRIA to mean "an R&I field identified as most worthy of investment" during the period of the SRIA.			

1.2 The Implementation Working Group for ocean energy

The Implementation Working Group for ocean energy consists of representatives from relevant government and public sector agencies of fourteen (14) countries (12 EU Member States, Norway and the UK) (Table 2). In 2022, representation was expanded to include regional agencies as well as national agencies.

Stakeholder bodies representing the industrial and research community participate also participate as do representatives of the European Commission.

The IWG is chaired currently the National Agency for New Technologies, Energy and Sustainable Economic Development (Italy) and Wave Energy Scotland (Scotland, UK).

1.3 Report scope

The purpose of the annual reporting is to present a **clear and easy to communicate picture of the advancement of the ocean energy sector** during the year in question.

- Monitoring relevant aspects of the national/regional political support for ocean energy,
- Monitoring the technical activity,
- Assessing the progress against the actions of the implementation plan for ocean energy.

The principal audience of the annual report is

- the membership of the OE IWG (i.e., the country and region representatives and other stakeholders)
- other national and regional public authorities
- the membership of the wider OE community
- SETIS, i.e., the Commission
- the wider public.

TABLE 2: COMPOSITION OF THE IMPLEMENTATION WORKING GROUP FOR OCEAN ENERGY

Country	Organisation
Belgium	FPS Economy (DG Energy)
Cyprus	To be confirmed
Denmark	Ministry of Climate, Energy and Utilities (Danish Energy Agency)
Finland	Ministry of Economic Affairs and Employment
France	Agency for Ecological Transition
Germany	Ministry for Economic Affairs and Climate Action (Project Management Juelich)
Ireland	Sustainable Energy Authority of Ireland
Italy	Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile
Netherlands	Ministry of Economic Affairs and Climate Policy
Norway	Ministry of Petroleum and Energy
Portugal	Direção Geral de Energia e Geologia
Spain	Centre for the Development of Industrial Technology
Sweden	Swedish Energy Agency
UK	Dept for Business, Energy and Industrial Strategy
Stakeholders	**Organisation**
Industry	Ocean Energy Europe
Research	European Energy Research Alliance Joint Programme on Ocean Energy
European Commission	DG-RTD, DG-MARE, DG-JRC, DG-ENER

2. Member State Support for Ocean Energy

2.1 National/regional policies supporting ocean energy

Analysis of statements in the Ocean Energy Systems' (OES) Annual Report for 2022[4] under the subsection "National Strategy" reveals that while all OE-IWG countries have renewable energy strategies and policies to support the delivery of carbon neutrality targets, currently only a few have explicit strategies or policies to support ocean energy or have set explicit targets for ocean energy.

That said, ocean energy frequently appears in the scenarios for future carbon-neutral energy mix planning. For example: each of the four scenarios in ADEME's pathways to carbon neutrality for France include ocean energy; Ireland's NECP includes trajectories for ocean energy of 30MW by 2030 and 110MW by 2040; Portugal's National Ocean Strategy expects to establish approximately 370MW of offshore energy by 2030 (300MW of offshore wind and 70MW of wave).

Several OE-IWG countries continue to progress their plans for developing offshore renewable energy.

Ireland's Marine Area Planning Act, which came into force in December 2021, will streamline the consenting process and Ireland is also in the process of updating its Offshore Renewable Energy Development Plan (OREDP), first published in 2014, beginning a consultation phase in Q1 of 2023.

In Italy, Decree 199/2021, issued December 2021, included provision for the procurement of innovative technologies, one of the ad hoc measures for innovative technologies (including ocean energy) anticipated in Italy's NECP.

Ireland, France, Portugal and Spain are collaborating in the Atlantic Action Plan 2.0 of the Atlantic Maritime Strategy the overarching objective of which is to unlock the potential of blue economy in the Atlantic area. Pillar III (Marine Renewable Energy) has the objective of promoting *"… carbon neutrality through marine renewable energy*" and actions that include the setting of deployment objectives and implementing incentives in the Atlantic regions.

Denmark continues to lobby for national and regional wave energy deployment targets in the North Sea region.

Several countries recognise ocean energy as being a highly relevant emerging sector in the medium-term: Belgium, particularly the Flanders region; Ireland; Portugal. Ireland notes ocean energy as being relevant for achieving their post 2030 targets, however, offshore wind will be the focus for achieving their 2030 targets. Similarly, in the Netherlands, offshore wind is the focus of its Maritime Spatial Plan.

Portugal's National Ocean Strategy 2021-2030 includes Priority Intervention Area 7 (PIA7 Renewable Ocean Energy) which foresees the gradual adoption of offshore energy technology, beginning with mature more cost-effective technology (most likely offshore wind) but progressively incorporating more innovative, less mature, technology (such as wave energy). The associated Action Plan

4 Ocean Energy Systems, the intergovernmental Technology Collaboration Programme on Ocean Energy Systems established by the International Energy Agency. The annual report may be found here

includes relevant measures for ocean energy; Simplify licensing of oceanic renewable energy projects (#71); Decarbonize and promote transition, efficiency and energy autonomy in the maritime economy sectors, the development of technologies and the production of oceanic renewable energy (#72).

In addition, Decree-Law nº15/2022 established a legal framework for Technological Free Zones (ZLTs), physical spaces for the testing and demonstration of new technologies and innovations, in a real environment, under special legislation and permanent monitoring by regulatory entities. A ZLT for marine renewable energies projects was announced in 2022 located offshore of Viana do Castelo, northern Portugal.

2.2 Market incentives (revenue support)

TABLE 3: REVENUE SUPPORT SCHEMES

Type		Country	Observation
Competitive a	Dedicated	UK	Contracts for Difference (CfD) scheme. The fourth CfD allocation round (launched in Dec 2021) included a separate auction process for 'less established' technologies (including ocean energy) and a ring-fenced minimum support for tidal stream (£20 million). Four tidal stream projects received contracts to deliver 40.82MW at a strike price of £178.54/MWh.
	Restricted	France	Energy and Climate Act, 2019, Article 33 …"The experimentation contract". Feed-in-tariff for innovative renewable energy technology projects. Terms are decided on a case-by-case basis in response to a call for projects.
		Spain	General incentive scheme for renewable energy technology providing support through annual competitive public tender processes. Projects propose a value they are willing to accept and the most competitive are selected. Separate auction for at least 20MW capacity of 'other technologies' (including ocean energy) every second year (Order TED/1161/2020).
	Open	Netherlands	SDE++ is a general technology agnostic subsidy scheme. Annual rounds with phased allocation, subsidy increases in later phases. Subsidy is benchmarked against offshore wind costs. Subsidy is expected to decrease year on year. Maximum subsidy in 2022 was 300 €/ton avoided CO2.
		Ireland	The Renewable Electricity Support Scheme is a general technology agnostic auction-based subsidy scheme. A variant dedicated to offshore wind, the Offshore Renewable Electricity Support Scheme (ORESS), was launched in 2022. It is conceivable the ORESS could evolve to support ocean energy technology.
		Italy	Ministerial Decree 23 June 2016 defines the scheme. Guaranteed incentive for 'small' plant up to 60kW (direct access). Larger capacity projects must apply for entry in the registries, or, where capacity exceeds 5MW, compete in a reverse auction competition. Base tariffs and capacity quotas are defined by technology type, including 'offshore energy' although it is not clear whether ocean energy is considered.
Other		Belgium	Federal and regional tradable green certificate schemes. Network operators obliged to secure a quota of green certificates from generators at a minimum price.
None		Denmark	-
		Norway	Renewable electricity certificate scheme (run jointly by Norway and Sweden) closed to new generation plant on 31 Dec 2021. Policy is technology agnostic, so no specific instruments to incentivise ocean energy technology.
		Sweden	

[a] Competitive schemes are categorised as:

- Open: all technologies compete on equal terms (i.e., the scheme is technology agnostic).
- Restricted: technologies are grouped in some way and compete only with technologies in their group.
- Dedicated: a single technology competition.

A stable revenue support mechanism is consistently reported as being significant factor for unlocking ocean energy projects [5]. This is recognised by the inclusion of Action 3.1 in the Implementation Plan. Revenue support mechanisms are defined typically at a national level but occasionally at a regional level.

Most OE-IWG countries implement a revenue support scheme for renewable energy generation that typically takes a competitive form, based on periodic public tender or reverse-auction processes. The Scandinavian countries are the exception. None of Denmark, Norway and Sweden operate a current revenue support scheme; the joint Norwegian-Swedish scheme closed to new plant at the end of 2021.

Technology agnostic schemes prevail, in which all technologies compete on equal terms (Netherlands, Ireland, Italy). As this approach is solely based on cost, it favours the mature technologies; less mature technologies such as ocean energy are unable to compete on a purely cost basis.

Restricted schemes, in which grouped technologies compete together, can provide an opportunity for less mature technologies to secure support (France, Spain). However, the likelihood of success for ocean energy will depend on the technologies it is grouped with.

Dedicated single technology schemes naturally provide the best opportunity. Examples of such schemes in the countries represented in the OE-IWG are rare; the UK's fourth CfD allocation round included ring-fenced support for tidal stream and awarded four contracts to deliver 40.82MW of capacity.

In the absence of dedicated schemes, mechanisms incorporated into open competition schemes can be used to support ocean energy. For example, in the Italian scheme 'small' capacity plant are guaranteed support irrespective of technology type ('small' is defined as less than 60kW in this instance). With appropriate definition, this mechanism could provide targeted support for ocean energy.

2.3 Funding programmes

All OE-IWG countries continue to operate general technology research and innovation national funding programmes, i.e., technology agnostic programmes open to applications from any technology sector. Good examples of such programmes are:

- Denmark's Energy Technology Development and Demonstration Program (EUDP) focuses on clean energy technologies and demonstration projects at a TRL of between 4 and 8 with the possibility for commercialisation after project end. In 2022, the program committed 4% of its 67 million EUR budget to wave energy projects.
- Ireland's National Energy Research Development and Demonstration (RD&D) Funding Programme.

Programmes with a narrower focus more relevant to the ocean energy sector are also evident, notably programmes targeting support for the offshore renewable energy sector generally and occasionally the ocean energy sector directly (Table 4).

[5] Stakeholder & policy needs. ETIP Ocean (2019).

TABLE 4: EXAMPLES OF OCEAN ENERGY FUNDING PROGRAMMES

Country	Programme name	Funding	Focus
Belgium	Blue Cluster	€ 8,000,000	Co-funding industry driven offshore renewable energy R&D projects.
Spain (Basque Country)	Demonstration and validation of emerging marine renewable energy technologies	€ 2,500,000	Support for demonstration and validation of emerging technologies in the field of marine renewable energy. Deployments must occur at the region's open sea test site, the Biscay Marine Energy Platform (BiMEP).
Sweden	National ocean energy programme (Phase 2)	€ 10,200,000	The €10.2 million programme operates from Mar 2018 to Mar 2024. Three national calls (in 2018, 2019 & 2020) have funded 21 projects. No further calls planned.
United Kingdom (Scotland)	Wave Energy Scotland	€ 10,000,000	Support for development of technology relevant to the wave energy sector.

2.4 Funding programmes

Nine of the fourteen countries represented on the OE-IWG host open-sea test and demonstration facilities for ocean energy technology. In 2022, twenty-five (25) facilities were reported as being operational with a further four (4) facilities in development (Table 5). Most facilities provide operational environments for either wave or tidal stream technology at mid to late technology readiness levels.

A few facilities have a more general focus supporting material and component testing for offshore renewable energy sector (e.g., Harshlab in Spain (Basque Country), Sweden's Testbed for Marine Materials).

Several facilities established initially to support ocean energy technology, and particularly wave energy technology, are diversifying to support other offshore renewable energy generation technology (e.g., floating offshore wind, floating solar) and alternative energy vectors (e.g., hydrogen). This diversification could threaten the capacity to support ocean energy technology where it takes place within the current site boundaries.

2.4.1 Notable activity

The capabilities of established facilities continue to be enhanced.

- Belgium's multi-sector facility, the Blue Accelerator Platform, is working towards grid connection in 2023.
- The SEM-REV facility in France and the Aguçadoura facility in Portugal are the subject of investment programmes to update infrastructure.
- Portugal's Viana do Castelo Pilot Zone is the subject of a consultation on the creation of a Technological Free Zone (ZLT), a "safe space" for testing innovative products without incurring all normal regulatory consequences.
- The International WaTERS network[6] is developing a database of open-sea test facilities. The launch of the database is expected during 2023.

[6] International WaTERS (Wave and Tidal Energy Research Sites) is a global network of open-sea test centres that encourages collaboration and knowledge transfer [https://www.internationalwaters.info].

TABLE 5: TEST AND DEMONSTRATION FACILITIES

Country (Region)	Facility	Sector
Belgium (West Flanders)	Blue Accelerator Platform	General
Denmark	DanWEC	Wave
France	SEM-REV	Wave, Floating Offshore Wind
	Sainte-Anne du Portzic	Wave
	SEENEOH - Paimpol-Bréhat	Tidal stream
	SEENEOH - Bordeaux	Tidal stream
Ireland	SmartBay	Wave
	Atlantic Marine Energy Test Site (AMETS) *	Wave
Netherlands	Grevelingendam *	Tidal range
Portugal	Aguçadoura	Wave
	Viana do Castelo Pilot Zone	Wave, Floating Offshore Wind
Spain (Basque Country)	Biscay Marine Energy Platform (BiMEP)	Wave, Floating Offshore Wind
	Mutriku	Wave
	HarshLab	General
Spain (Canaries)	Plataforma Oceánica de Canarias (PLOCAN)	Wave
Spain (Galacia)	Punta Langosteira Experimental Marine Energy Zone	Wave, Floating Offshore Wind
Sweden	Lysekil Research Site	Wave
	Testbed for Marine Materials	General
UK (Scotland)	European Marine Energy Centre (EMEC) - Billia Croo	Wave
	European Marine Energy Centre (EMEC) - Scapa Flow	Wave
	European Marine Energy Centre (EMEC) - Falls of Warness	Tidal stream
	European Marine Energy Centre (EMEC) - Shapinsay Sound	Tidal stream
UK (Wales)	West Anglesey Tidal Demonstration Zone (Morlais) *	Tidal stream
	Marine Energy Test Area (META) Phase 1	General
	Marine Energy Test Area (META) Phase 2 - Dale Roads	Wave
	Marine Energy Test Area (META) Phase 2 - East Pickard Bay	Wave
	Marine Energy Test Area (META) Phase 2 - Warrior Way	Tidal stream
UK (England)	Falmouth Bay Test Site (FaBTest)	Wave, Tidal stream
	Perpetuus Tidal Energy Centre (PTEC) *	Tidal stream
* In development		

3. EU support for ocean energy

The European Commission continued its support for ocean energy.

The Horizon Europe 2021-2022 work programme contained four calls associated with ocean energy all which closed for submissions in the first half of 2022 (Table 6).

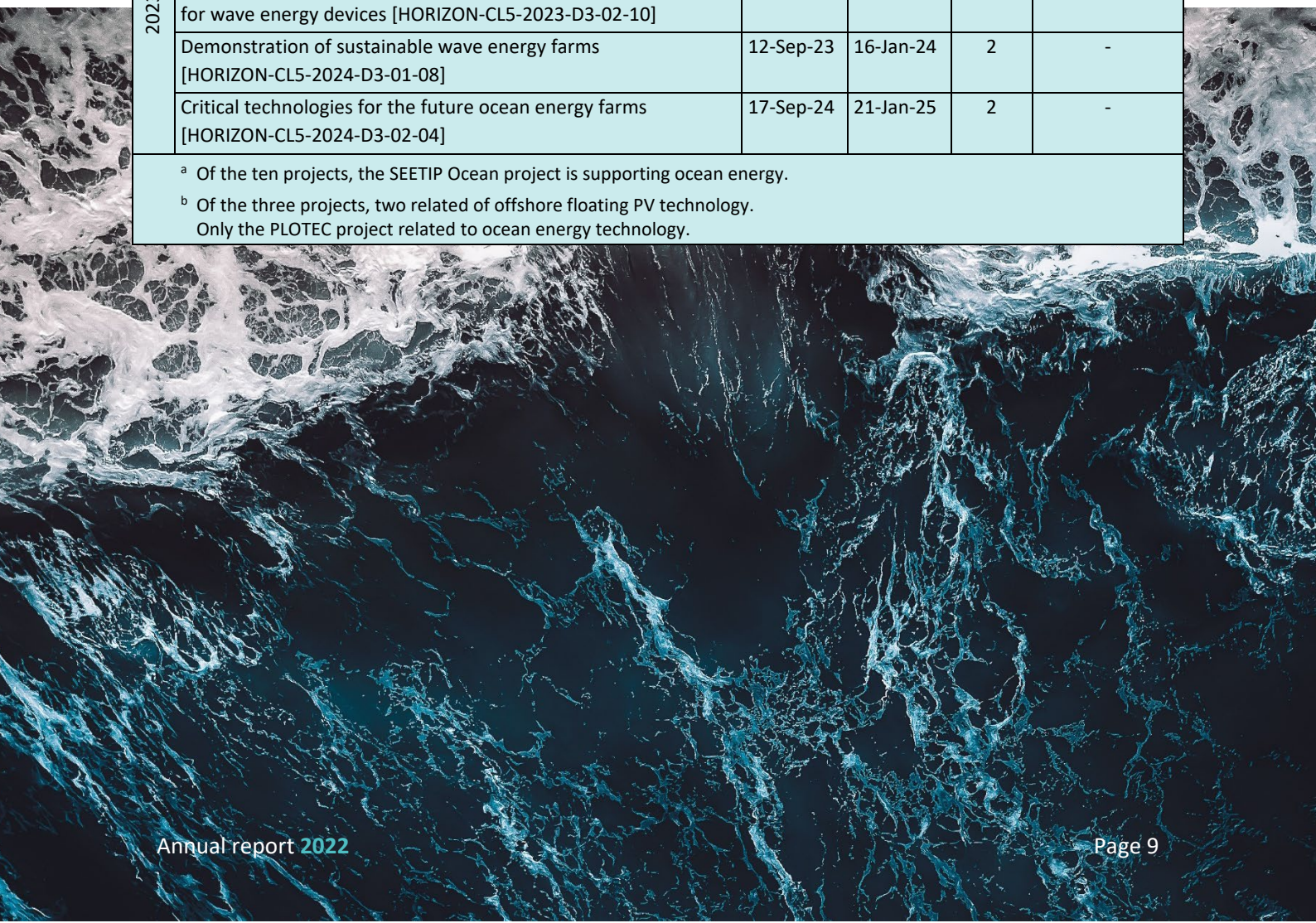
The Horizon Europe 2023-2024 work programme was adopted in December 2022 and includes four calls dedicated to ocean energy, the first of which opened at the end of 2022.

TABLE 6: HORIZON EUROPE WORK PROGRAMME CALLS

WP	Call title	Open	Close	Projects	Project acronym
2021-22	Demonstration of wave energy devices to increase experience in real sea condition [HORIZON-CL5-2021-D3-02-01]	24-Jun-21	05-Jan-22	1	WEDUSEA
	Support to the activities of the ETIPs and technology areas of the SET Plan [HORIZON-CL5-2021-D3-02-15]	24-Jun-21	05-Jan-22	10	SEETIP Ocean
	Innovative foundations, floating substructures and connection systems for floating PV and ocean energy devices [HORIZON-CL5-2021-D3-03-10]	02-Sep-21	23-Feb-22	3	PLOTEC [b]
	Demonstration of innovative rotor, blades and control systems for tidal energy devices [HORIZON-CL5-2022-D3-01-07]	14-Oct-21	26-Apr-22	1	MAXBlade
2023-24	Preparatory phase of new ESFRI research infrastructure projects [HORIZON-INFRA-2023-DEV-01-08]	06-Dec-22	09 Mar-23	1	MARINERG-i_PP
	Demonstration of sustainable tidal energy farms [HORIZON-CL5-2023-D3-01-08]	13-Dec-22	30-Mar-23	2	SEASTAR EURO-TIDES
	Development of innovative power take-off and control systems for wave energy devices [HORIZON-CL5-2023-D3-02-10]	04-May-23	05-Sep-23	2	-
	Demonstration of sustainable wave energy farms [HORIZON-CL5-2024-D3-01-08]	12-Sep-23	16-Jan-24	2	-
	Critical technologies for the future ocean energy farms [HORIZON-CL5-2024-D3-02-04]	17-Sep-24	21-Jan-25	2	-

[a] Of the ten projects, the SEETIP Ocean project is supporting ocean energy.

[b] Of the three projects, two related of offshore floating PV technology. Only the PLOTEC project related to ocean energy technology.



4. Progress of the Implementation Plan Actions

The Implementation Plan sets out a collection of actions grouped by "Theme" and "Challenge Area" (Table 1) that represent the activities considered most worthy of investment over the plan's period. For each action, the plan identifies the anticipated number of projects and the corresponding anticipated investment that is expected to deliver the desired outcome of each action. The Implementation Plan anticipates a total of 143 R&I projects (with a mixture of small, medium and large projects) and an overall investment of 981 million euros with public sector funding amounting to 654 million euros (Table 9).

Progress towards satisfying this expectation is monitored with the OceanSET Register of Projects (the 'Register') which maintains a record of funded projects in the ocean energy sector. The Register includes projects supported by

- European Commission funding programmes (e.g., H2020, HEU, ERDF, EMFF, EMFAF [7])
- National and Regional funding programmes
- Joint funding programmes (e.g., OCEANERA-NET, Clean Energy Transition Partnership)

4.1 Process

The Register has been updated to include R&I projects that were active in 2022.

Projects supported by the European Commission directly were identified through interrogation of the CORDIS database and collaboration with the JRC.

National and Regional funding programmes supporting the ocean energy sector, and projects funded by them, were identified in responses to a request for information issued to the country and regional representatives of the IWG membership.

Each project in the Register is categorised according to its most relevant IP action. A category 'Other' is used where no relevant IP action can be determined. Comparing this categorisation of projects against the expectation of the IP actions provides an assessment of the progress towards achieving the ambition of the IP, an assessment that can guide future public R&I funding to ensure delivery of that ambition. The analysis presents an assessment of the current R&I landscape in the ocean energy sector and of how well it addresses the challenges facing the sector (as defined by the Implementation Plan).

4.2 Projects in 2022

4.2.1 EC funded projects

The Commission committed some €13.4 million of grant aid to five (5) ocean energy related projects in 2022 in a mix of Innovation Actions (IA), Research & Innovation Actions (RIA), Coordination & Support Actions (CSA), and Marie Curie Fellowships supporting wave, tidal stream and ocean thermal energy conversion technologies (Table 7).

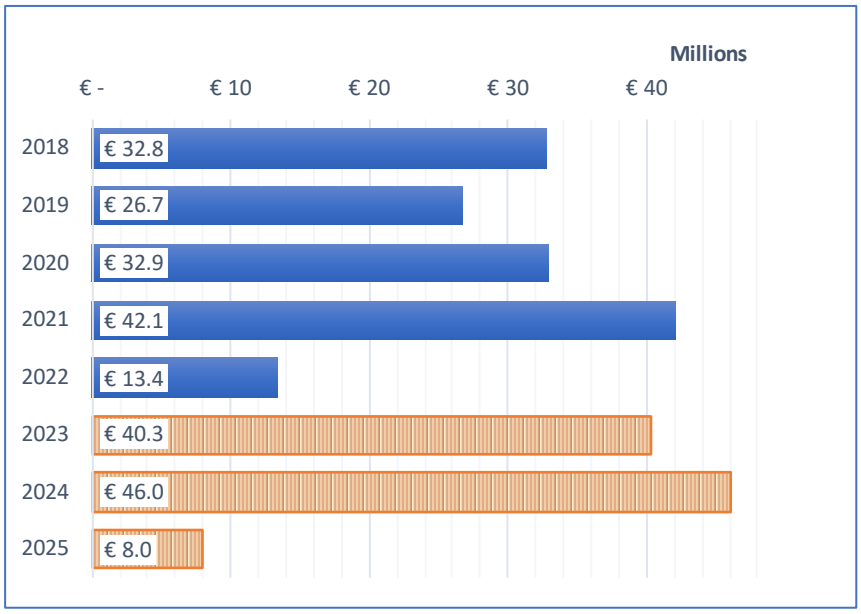
While this sum may appear low in the context of the Commission's past commitments to ocean energy related projects (Figure 1), it is noted that the Commission committed a total of €38.9 million to two projects the second half of 2021, the tidal stream energy project FORWARD-2030 and the wave energy project EU_SCORES. Future commitments announced in the 2023-34 work programme remain at historic annual commitment levels.

[7] H2020 – Horizon 2020; HEU – Horizon Europe; ERDF – European Regional Development Fund; EMFF – European Maritime and Fisheries Fund; EMFAF – European Maritime, Fisheries and Aquaculture Fund.

TABLE 7: OCEAN ENERGY RELATED PROJECTS AWARDED GRANT AGREEMENTS IN 2022. HORIZON EUROPE 2021-22 WORK PROGRAMME.

	Project title	Call topic	Grant aid
May	Enhancing Damage detection and characterisation technologies for complex marine Structures under Extreme environmental conditions [EnDorSE]	MSCA Postdoctoral Fellowships 2021 [HORIZON-MSCA-2021-PF-01-01]	€239,700
July	Support to SET Plan Implementation Working Group and European Technology and Innovation Platform for Ocean Energy [SEETIP Ocean]	Support to the activities of the ETIPs and technology areas of the SET Plan [HORIZON-CL5-2021-D3-02-15]	€788,254
Aug	Wave Energy Demonstration at Utility Scale to Enable Arrays [WEDUSEA]	Demonstration of wave energy devices to increase experience in real sea condition [HORIZON-CL5-2021-D3-02-01]	€9,636,874
Oct	PLOCAN Tested Optimised Floating Ocean Thermal Energy Conversion Platform [PLOTEC]	Innovative foundations, floating substructures and connection systems for floating PV and ocean energy devices [HORIZON-CL5-2021-D3-03-10]	€1,322,523
Dec	Maximising tidal energy generation through Blade Scaling & Advanced Digital Engineering [MAXBlade]	Demonstration of innovative rotor, blades and control systems for tidal energy devices [HORIZON-CL5-2022-D3-01-07]	€1,373,889

FIGURE 1: EUROPEAN COMMISSION COMMITTED GRANT AID BY YEAR OF AWARD. VALUES FOR 2023 ONWARDS REPRESENT INTENDED COMMITMENTS AS PUBLISHED IN CALLS IN THE HORIZON EUROPE WORK PROGRAMME FOR 2023-24.



4.2.2 National & Regional funded projects

The countries and regions of the OE IWG identified commitments more than €12.3 million in grant aid from national and regional programmes to fifteen (15) ocean energy projects in 2022[8].

Most of the fifteen projects were associated with the wave (6) and tidal stream (5) technology sub-sectors. A further two were technology agnostic, i.e., applied to the ocean energy sector generally, while single projects were associated with each of the tidal range and the ocean thermal energy conversion (OTEC) sub-sectors (Figure 3).

FIGURE 2: NATIONAL & REGIONAL COMMITMENTS TO OCEAN ENERGY PROJECTS IN 2022: (A) NUMBER OF PROJECTS (B) GRANT AID.

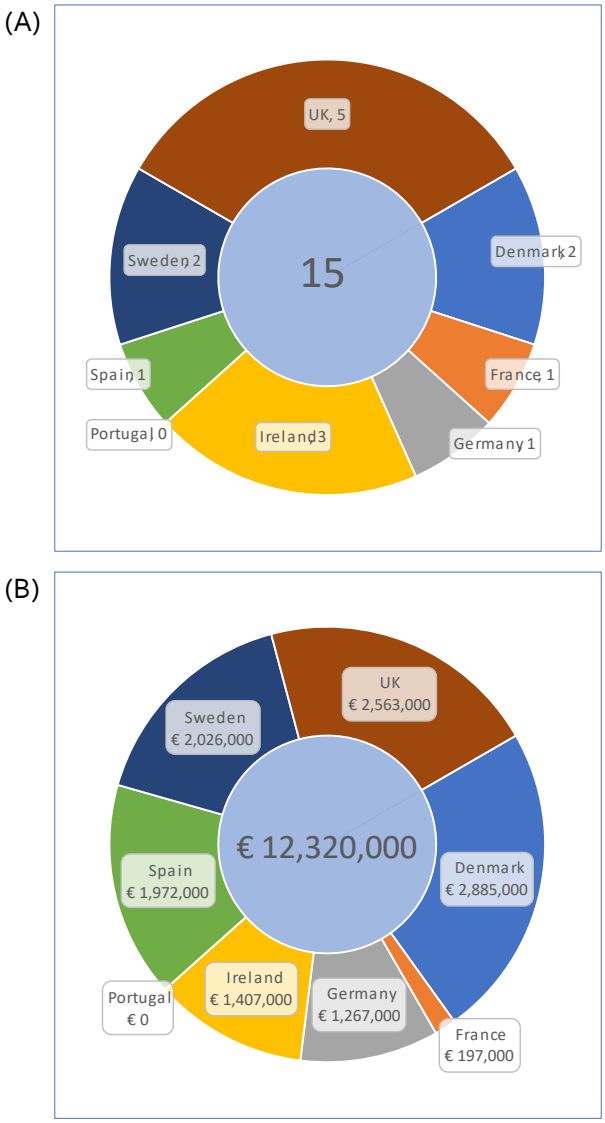
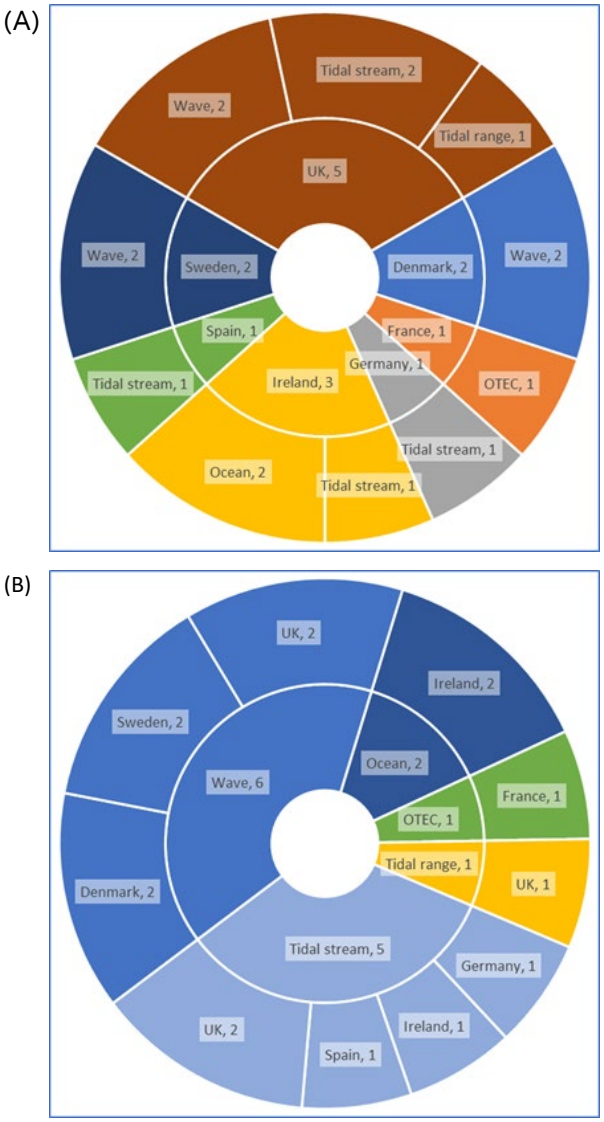


FIGURE 3: NATIONAL &REGIONAL COMMITMENTS TO OCEAN ENERGY PROJECTS IN 2022: NUMBER OF PROJECTS (A) BY COUNTRY AND BY SUB-SECTOR; (B) BY SUB-SECTOR AND BY COUNTRY.



[8] In addition, the Welsh government committed €42.7 million from its "West Wales and the Valleys" European Regional Development Fund (ERDF) programme to two ocean energy projects.

Six (6) IP Actions were associated with the projects (Figure 4):

1.1 Demonstration of ocean energy devices to increase experience in real sea conditions
- Danish support for Exowave ApS [Wave]
- Spanish support for Magallanes Renovables SL [Tidal stream]

1.3 Improvement and demonstration of PTO and control systems
- Danish support for Crestwing ApS [Wave]

1.5 Development of novel wave energy devices
- Swedish support for Ocean Harvesting Technologies AB [Wave]
- UK support for Anchored Engineering Ltd & Seaweed Energy Ltd [Wave]

1.8 Improvement and demonstration of foundations and connection systems for bottom-fixed ocean energy devices
- Irish support for University College Dublin [Ocean]

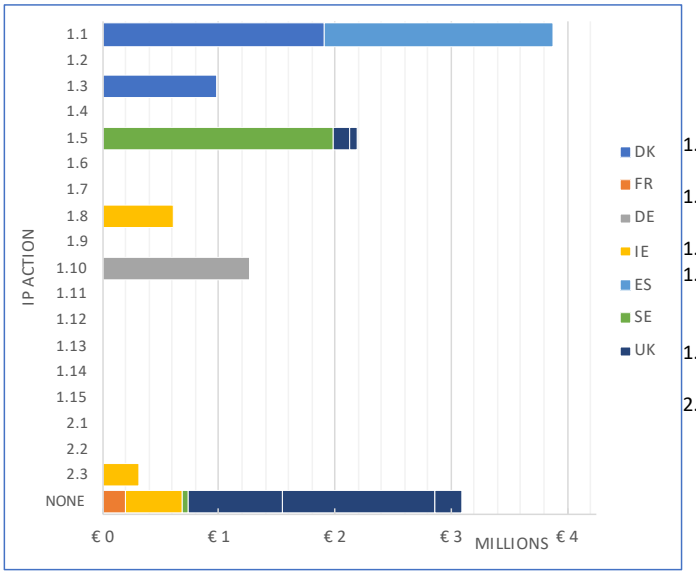
1.10 Instrumentation for condition monitoring and predictive maintenance
- German support for SCHOTTEL Hydro GmbH [Tidal stream]

2.3 Promoting political support and public backing for ocean energy
- Irish support for Aston ECO Management Ltd [Ocean]

However, six (6) of the fifteen projects, with a combined commitment of some €3.1 million (approximately 25% of the total commitment for 2022) were not directly associated with any IP Action.

- French support for DEEPRUN [OTEC] to develop new materials for deep water extraction
- Irish support for ORPC Ireland [Tidal stream] to advance the design of their device concept
- Swedish support for OE System AB [Wave] for business development activities.
- UK support for Nova Innovation Limited [Tidal stream, feasibility study], Achelous Energy Limited [Tidal stream, pilot deployment of run-of-river device], and Cardiff University [Tidal range].

FIGURE 4: NATIONAL AND REGIONAL COMMITMENTS TO OCEAN ENERGY PROJECTS IN 2022: PROJECTS GROUPED BY ASSOCIATED IMPLEMENTATION PLAN ACTION



1.1 Demonstration of ocean energy devices to increase experience in real sea conditions
1.3 Improvement and demonstration of PTO and control systems
1.5 Development of novel wave energy devices
1.8 Improvement and demonstration of foundations and connection systems for bottom-fixed ocean energy devices
1.10 Instrumentation for condition monitoring and predictive maintenance
2.3 Promoting political support and public backing for ocean energy

4.3 Progress against the Technical actions (including gap analysis)

An assessment of the progress in delivering the investment in each Technical theme action was undertaken in collaboration with the UK's Supergen Offshore Renewable Energy Hub (ORE Hub). The study's report was published in July 2023 [9].

Although the study was concerned with the seventeen (17) priority topics of the SRIA, these topics are largely replicated in the fifteen (15) actions of the IP's Technical theme [10].

Only the high-level findings of this study are re-presented here as detailed findings may be found in the study report.

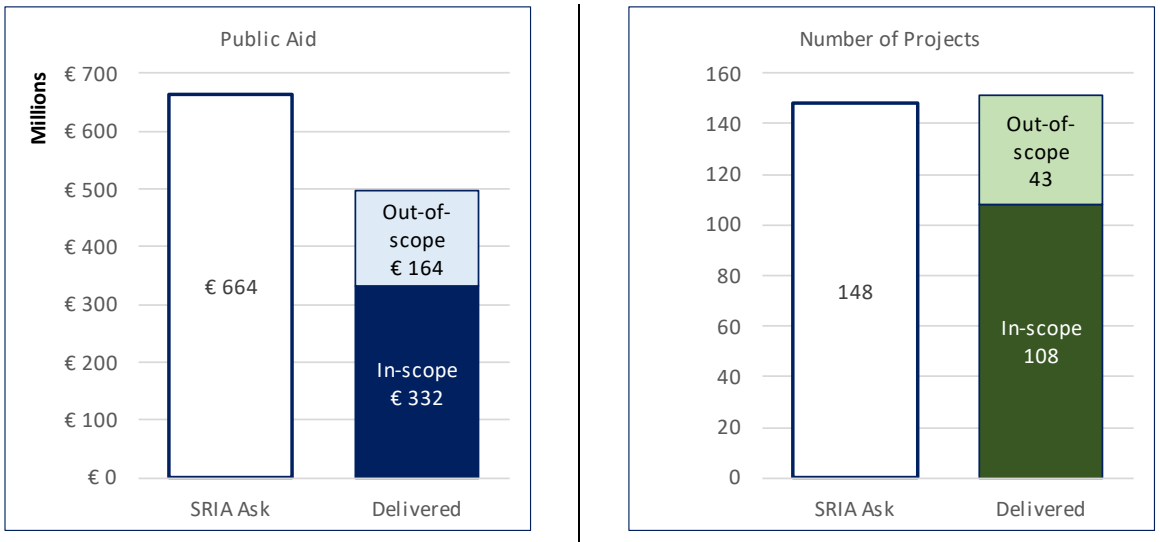
4.3.1 Overview

The SRIA recommends that to address the issues represented by the priority topics associated with wave and tidal stream energy technology would require some €664 million of public finance across 148 projects of varying size over the period 2021 to 2025 [11].

The assessment has identified 151 projects receiving public grant aid of some €496 million [12] (Figure 5).

- 108 projects addressed a priority topic (i.e., considered 'in-scope') receiving €332 million in public aid.
- 43 projects, receiving €164 million in public aid, did not address a priority topic (i.e., considered 'out-of-scope').

FIGURE 5: SRIA RECOMMENDATIONS AND KNOWN COMMITMENTS BY GRANT AID AND NUMBER OF PROJECTS.



[9] Research and Innovation for Wave and Tidal Stream in the UK and EU: A 2023 Summary. https://www.policyandinnovationedinburgh.org/research-and-innovation-for-wave-and-tidal-stream-in-the-uk-and-eu-a-2023-summary.html

[10] One SRIA priority topic, namely 1.7 [Development of other ocean energy technologies], is omitted as an IP technical action. The SRIA priority topic 6.1 [Improvement of the environmental and socioeconomic impacts of ocean energy] effectively equates to the three IP's Environmental, Policy and Socioeconomic actions.

[11] The stated values represent those SRIA priority topics focussed on the wave and tidal stream energy sub-sectors, i.e., SRIA priority topic 1.7 [Development of other ocean energy technologies] was excluded in the study.

[12] Projects which concluded before or during 2021 have been excluded from the assessment on the basis that they would not have been responding to the recommendations of the SRIA.

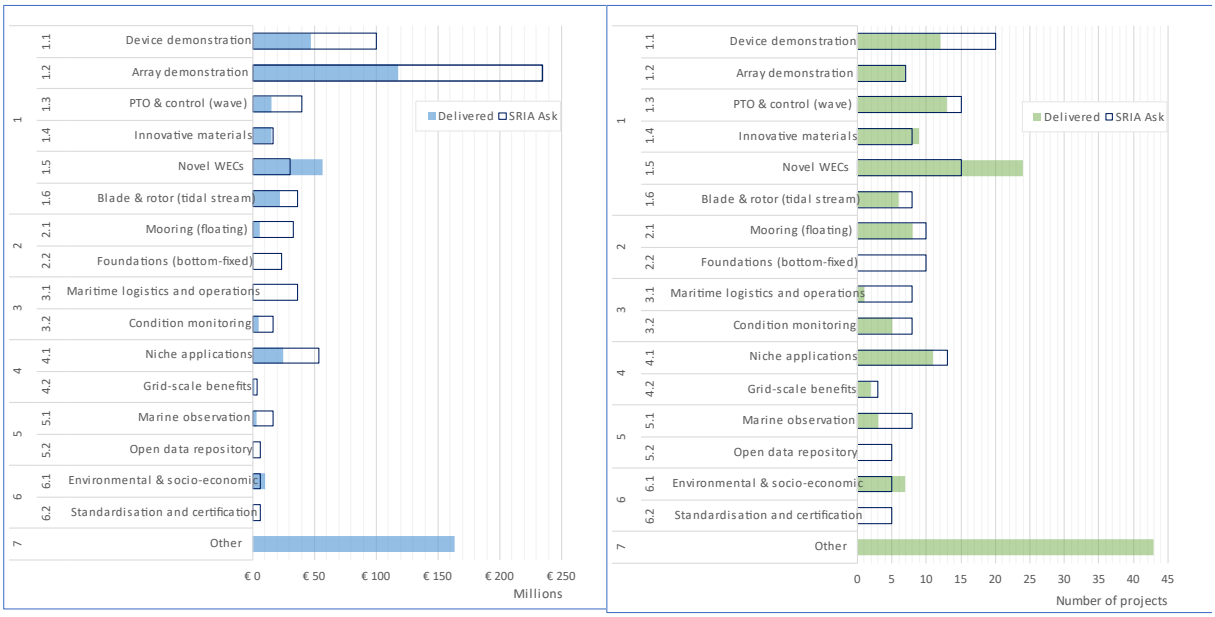
The in-scope projects represent approximately three quarters of the SRIA's recommended number of projects and approximately half the recommended public finance. On this basis progress appears to be on track to meet the SRIA recommendations in terms of committed grant aid, however it suggests the average project grant aid is lower than expected resulting in a greater number of smaller projects than recommended.

The consequence of this observation in relation to achieving the objectives of the priority topics is not certain. While it is conceivable the objectives may be met through a greater number of lower valued projects, this is not what the sector identified in the SRIA as being required to accelerate development and realise cost-reductions. Low value projects are frequently synonymous with low technology readiness level (TRL) activities, and it is certain that the ocean energy sector will not achieve industrial scale development with a disproportionate focus on low TRL activity.

4.3.2 IP Actions

Categorising the 108 in-scope projects by their associated priority topic reveals progress is not consistent across all priority topics (Figure 6).

FIGURE 6: PROGRESS AGAINST RECOMMENDATIONS FOR EACH PRIORITY TOPIC BY GRANT AID AND NUMBER OF PROJECTS.



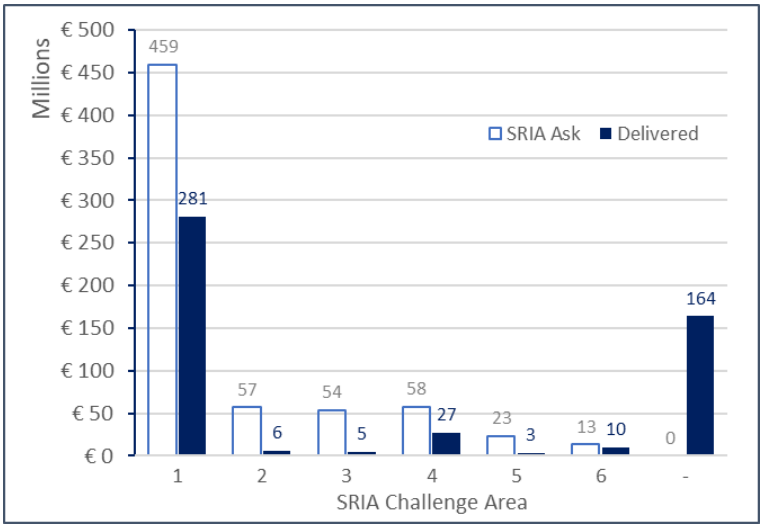
Given that the assessment has been undertaken at the start of the third of the five-year SRIA period, i.e., approaching the midpoint of the period, notable observations are:

1) Two priority topics have received greater attention than recommended, in terms of both grant aid and number of projects:
   - 1.5 [Development of novel wave energy devices]; and,
   - 6.1 [Improvement of the environmental and socio-economic impacts of ocean energy].
2) One priority topic has broadly received the recommended attention, in terms of both grant aid and number of projects:
   - 1.4 [Application of innovative materials from other sectors].
3) Three priority topics have yet to receive any attention:
   - 2.2 [Improvement and demonstration of foundations and connection systems for bottom-fixed ocean energy devices];
   - 5.2 [Open-data repository for ocean energy]; and,
   - 6.2 [Standardisation and certification].

4) The remaining priority topics are grouped broadly around three quarters of the recommended number of projects (75% ± 20%) and a little under half of the recommended grant aid (40% ± 20%).

Of the challenge areas and priority topics in the SRIA, the six (6) topics of challenge area 1 [Design and validation of ocean energy devices] were deemed to require the greatest investment (Figure 7).

FIGURE 7: GRANT AID ACROSS THE SRIA CHALLENGE AREAS



4.4 Progress against the Environmental, Policy and Socioeconomics actions

Three (3) actions are presented in the Environmental, Policy and Socioeconomics theme.

4.4.1 Environmental consenting

Action 2.1 concerns the streamlining of the consenting process [13] to accelerate the

deployment of ocean energy technology while protecting the marine environment. While no update on the progress of streamlining national consenting processes is provided in this report, it is noted that accelerating the consenting process for renewable energy projects is a priority for the European Commission. This action will be the subject of closer scrutiny in the next annual report.

Meanwhile, OES has a permanent task maintaining an overview of the consenting processes for ocean energy in most of the countries represented on the OE-IWG [14].

4.4.2 Maritime Spatial Planning

Action 2.2 concerns using the maritime spatial planning process to support the deployment of ocean energy and particularly using the process to assist in achieving the targets published in the EU Strategy on Offshore Renewable Energy.

The Maritime Spatial Planning Directive required the twenty-two (22) coastal EU Member States to produce maritime spatial plans (MSPs) for the marine waters under their jurisdiction by March 2021, and to review them at least every ten years. This includes the twelve (12) EU Member States represented on the OE-IWG.

A Commission review [15] identified that as of February 2022, fourteen (14) Member States had adopted an MSP, three (3) were at an advanced stage of preparation and were expected to adopt plans imminently, and five (5) had not made sufficient progress and had been issued letters of formal notice. The latter group included two (2) OE-IWG member

[13] The process of securing the permits, licenses and other forms of authorisation necessary to allow the deployment of ocean energy technology.

[14] https://www.ocean-energy-systems.org/oes-projects/consenting-processes-for-ocean-energy-on-oes-member-countries/

[15] Commission Communication COM(2022) 185 final, published May 2022. [https://oceans-and-fisheries.ec.europa.eu/news/european-commission-report-implementation-maritime-spatial-planning-directive-good-progress-more-2022-05-03_en]

countries, Cyprus and Italy, although in the autumn of 2022 Italy published a draft MSP for public consultation.

By the end of 2022, nine (9) of the twelve (12) EU Member States represented on the OE-IWG had an approved MSP [16]. Cyprus, Italy and Spain expect to achieve an approved MSP in 2023. The following observations are noted regarding the approved MSPs

- Designated zones for ocean energy production: None.
- Designated zones for offshore renewable energy production: Belgium, Denmark, Finland, Germany, The Netherlands, and Sweden. These zones are almost exclusively associated with offshore wind development, although Belgium, Germany and Sweden mention ocean energy in relation to these zones.

Other pertinent observations

- Ireland's National Marine Planning Framework presents a set of planning policies to support the development of offshore renewable energy. Spatial designations for maritime activities, including offshore renewable energy, are to be developed through the new Designated Marine Area Plan (DMAP) process, which will function as a management plan for specific maritime areas.
- The Netherlands has explicitly not pursued a policy on ocean energy (referred to as 'electricity from water') and foresees no explicit provision for ocean energy in the present planning period. However, the MSP's implementation plan commits to conducting research to assess the potential of ocean energy technologies (actions 47-49).
- Sweden's renewable energy production goals are general and not geared towards a particular source of energy production. However, a planning framework for 10TWh of offshore wind exists, although no equivalent planning framework exists for ocean energy.

The extent to which the aim of this action has been achieved in the current adopted maritime spatial plans is unclear. OE-IWG member countries should review their adopted maritime spatial plans from this perspective and engage with the responsible national authorities to ensure provision for the deployment of ocean energy technologies in future revisions.

In noting the challenges encountered in preparing maritime spatial plans, the Commission's review highlighted the lack of clear targets in the various sectors active in the maritime space had created difficulties in prioritising maritime space uses and allocating space at sea to enable various economic activities and achieve various policy objectives, while at the same time protecting the environment or leaving space for future uses. The targets pertaining to ocean energy published in the EU Strategy on Offshore Renewable Energy should be used as the basis for targets in MSPs.

[16] The European Maritime Spatial Planning Platform, an information and communication gateway supporting EU Member States implement maritime spatial planning, summarises the status of each country's maritime spatial plan [https://maritime-spatial-planning.ec.europa.eu/]

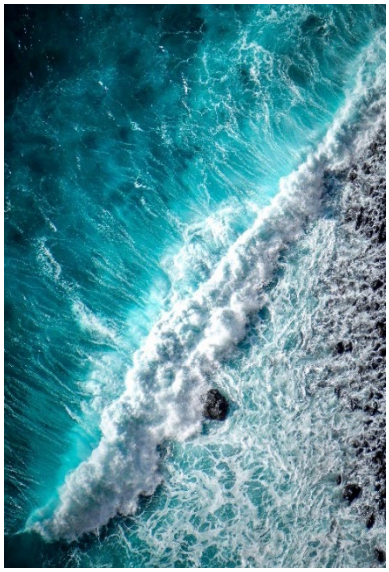
TABLE 8: COMMENTARY ON THE MARITIME SPATIAL PLANS OF THE OE-IWG COUNTRIES

Country	Commentary
Belgium	First issue covering the period 2014-2020. Designated one zone for offshore renewable energy. Second issue covering the period 2020-2026. Designates three additional zones for offshore renewable energy. Explicitly mentions offshore wind, wave, and tidal stream.
Cyprus	-
Denmark	Designates development zones for offshore renewable energy. No explicit mention of ocean energy.
Finland	Designates development zones for offshore renewable energy but identifies these with offshore wind explicitly. No explicit mention of ocean energy.
France	Four MSPs one for each sea basin area: • East Channel-North Sea • North Atlantic-West Channel • South Atlantic • Mediterranean The provision for ocean energy (particularly) and offshore renewable energy (generally) is not clear.
Germany	First issue came into force in 2009 (two distinct plans: one for the North Sea and one for the Baltic Sea). Second issue came into force in 2021 (a single plan). Designates development zones for offshore wind. Area plans include a limited provision for 'Other energy generation' which theoretically includes ocean energy.
Ireland	National Marine Planning Framework presents a set of planning policies relating to offshore renewable energy. Spatial designations for future activity, including offshore renewable energy, will be developed through the new Designated Marine Area Plan (DMAP) process. DMAPs which will act as a management plan for specific maritime areas.
Italy	Draft MSP issued for public consultation in the autumn of 2022.
Netherlands	First issue in 2009 (known as North Sea Policy Document). Second issue in 2015 covering the period 2016-2021. Third issue in 2022 covering the period 2022-2027 (part of the North Sea Programme 2022-2027). Designates zones for offshore wind (pre- and post-2030). No explicit provision for ocean energy is foreseen in the present planning period.
Portugal	First issue came into force in 2019. The Situation Plan is the primary instrument, supplemented by Allocation Plans that allocate uses and activities not identified in the Situation Plan. Designates a 'pilot zone' for offshore renewable energy demonstration projects (Viana do Castelo) where activities are not subject to the usual title assignment requirements (TUPEM). Indicates intention to expand an area with an existing private use of the sea (TUPEM) permit for a previous wave energy demonstration project (Almagreira, Peniche).
Spain	Approval of MSPs for each of its five marine subdivisions expected in early 2023. • North Atlantic • South Atlantic • Estrecho and Alboran • Levantine-Balearic • Canary Islands.
Sweden	Separate MSPs for each of three marine areas. • Gulf of Bothnia • Baltic Sea • Skagerrak/Kattegat Designates zones for offshore renewable energy. Explicitly mentions offshore wind and wave.

4.4.3 Promoting political support & public backing for ocean energy

Action 2.3 concerns the identification and assessment of the socio-economic impact of ocean energy deployments by reviewing the supply and value chain structure, industry plans, social acceptance, and education needs to establish the best routes to favour developers, communities and the EU, with a particular focus on European islands with significant endogenous resource.

A mechanism for monitoring progress in this action has not been established.



4.5 Progress against the Market Uptake and Financial theme actions

Five (5) actions are presented in the Market Uptake and Financial theme.

4.5.1 Revenue support

The current situation concerning revenue support for the first wave and tidal stream demonstration projects [Action 3.1] is presented in section 2.2.

Although general technology agnostic revenue support schemes continue to prevail, examples exist of restricted schemes in which a sub-set of technologies are grouped and compete amongst themselves (France, Spain) and of derogations within general schemes that guarantee support irrespective of technology type (Italy). Meanwhile, the effectiveness of dedicated single technology schemes was demonstrated in the UK's fourth CfD allocation round which incorporated ring-fenced support for tidal stream technology that resulted in four contracts to deliver 40.82MW of capacity.

The implementation of restricted and dedicated schemes should be continued and expanded to other jurisdictions.

4.5.2 Investment Support Fund

Action 3.2 concerns the creation of a Common Investment Support Fund that would provide flexible capital for ocean energy projects.

The action anticipated a feasibility study to consider the viability of such a fund. There is no evidence to suggest that this study has been undertaken.

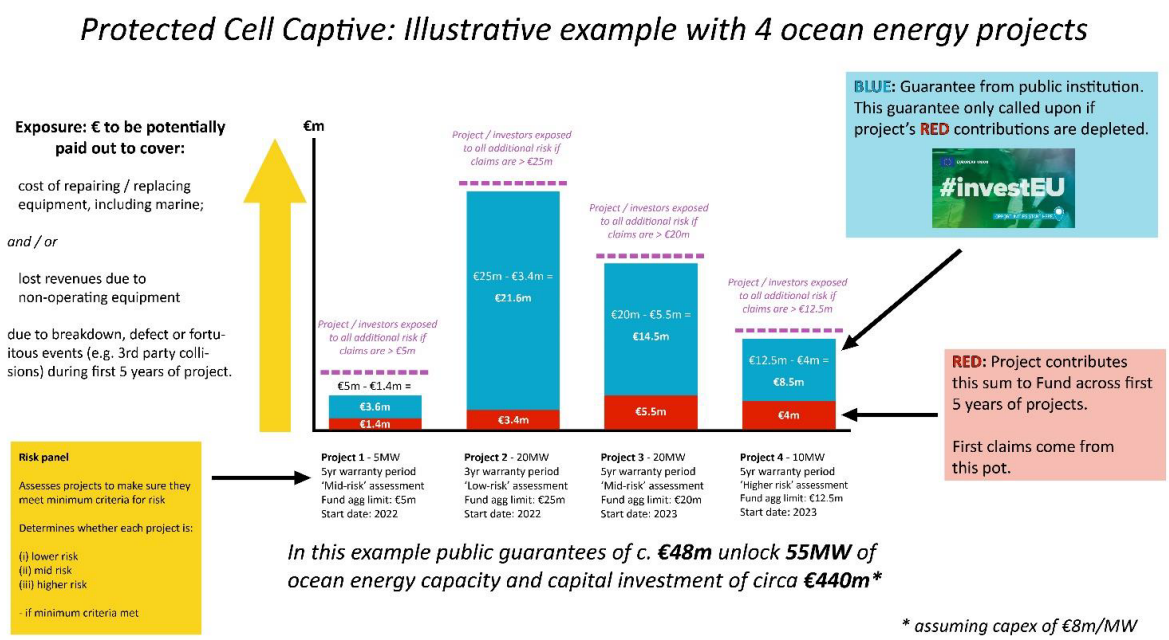
4.5.3 Insurance and Warranty Fund

Action 3.3 concerns the creation of a European insurance and warranty fund to underwrite certain technology-related financial risks associated with pre-commercial ocean energy projects. Commercial insurance for such risks does not exist currently and the fund would lower the cost of capital and overall cost of these pre-commercial ocean energy projects.

A feasibility study, commissioned by the OE-IWG through the OceanSET project and published in July 2021, considered how such a fund might be established and operated [17].

[17] 'Design Options for an Insurance and Warranty Fund', July 2021, OceanSET project. https://www.etipocean.eu/wp-content/uploads/2022/04/OceanSET_Design-Options-for-an-Insurance-and-Gurantee-Fund.pdf.

FIGURE 8: STYLISED ILLUSTRATION OF THE OPERATION OF THE PROPOSED INSURANCE & WARRANTY FUND



A follow-on study [18], commissioned by the UK's Offshore Renewable Energy Catapult through the Tidal Stream Industry Energiser (TIGER) project and published in October 2022, has provided greater detail of a preferred form, that of a protected cell company (PCC) (Figure 8), the governance structure for managing the entity, and of the types of coverage that could reasonably be provided. The study identified a 'short-list' of fourteen (14) ocean energy projects [thirteen (13) tidal stream projects and one (1) wave energy project] that might be considered eligible to participate in such a fund.

The cooperation of relevant national and regional industry bodies must now be enlisted to support approaches to European, national and regional governments to secure the finance to establish an ocean energy insurance entity based in the proposed PCC structure.

4.5.4 Funding of demonstration and innovation projects

Action 3.4 concerns the funding of projects to address the actions of the IP, particularly those of the Technical theme. The current situation is presented in section 4.3.

4.5.5 Novel public funding mechanisms

Action 3.5 concerns the use of innovation procurement mechanisms to overcome the difficulties of securing private finance to match conventional grant aid support for R&D. The action is particularly focussed on supporting (a) the development and demonstration of utility-scale wave energy converters and (b) the operation of small demonstration wave or tidal stream arrays.

Pre-commercial procurement is proving to be an effective mechanism for public agencies to support R&D in the ocean energy sector through the purchase of targeted R&D services. The mechanism was the basis for the development programmes undertaken by

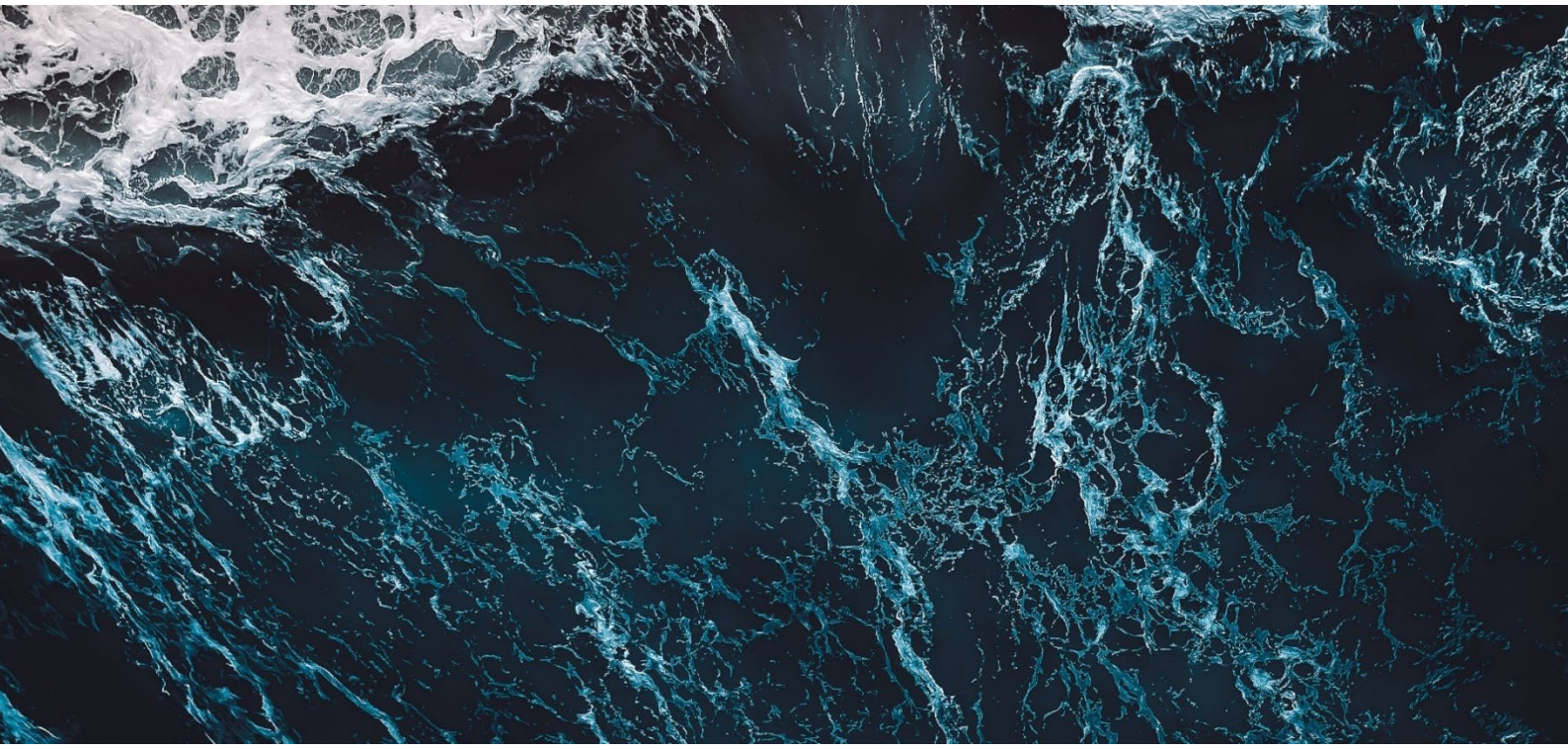
[18] 'The Ocean Energy Accelerator', October 2022, Tidal Stream Industry Energiser (TIGER) project. https://interregtiger.com/download/tiger-report-the-ocean-energy-accelerator/

Wave Energy Scotland (Scotland, UK). Two other instances are currently underway.

EuropeWave: The EuropeWave project is a cross-border collaborative R&D programme for wave energy systems [19]. An open procurement exercise in the latter half of 2021 resulted in the award of seven (7) contracts for the first phase of the EuropeWave programme, five (5) of which subsequently progressed to the second phase in September 2022. A further selection during summer 2023 will award three (3) contracts for the final phase which will culminate with the deployment and operation of three large-scale prototypes in 2025 at the test sites of BiMEP in the Basque Country and EMEC in Scotland.

TurboWave: The Basque Energy Agency is independently preparing to use the pre-commercial procurement mechanism to accelerate the development of air turbine technologies tailored to a wave power application generally and specifically to the technical requirements of the Mutriku wave power plant. The TurboWave request for tenders was published in December 2022 following a year of market consultation activities. Research contracts are expected to be awarded by summer 2023.

[19] The 20 million EUR procurement exercise is being undertaken by a buyers group consisting of Wave Energy Scotland (Scotland, UK) and the Basque Energy Agency (Basque Country, Spain). The procurement is funded in part by the Horizon 2020 programme. https://www.europewave.eu/



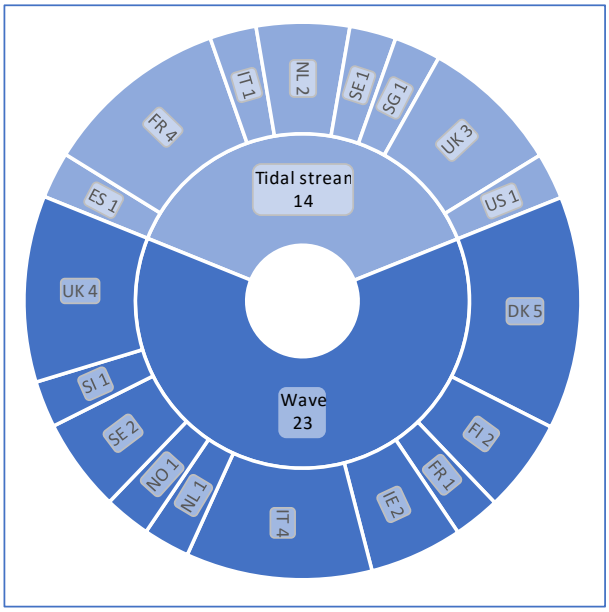
5. Technical Progress

The deployment of 100 MW of ocean energy capacity by 2025 represents the principal target of the technical actions of the implementation plan for ocean energy, together with a pathway to achieving a levelised cost of energy (LCOE) of 15cEUR/kWh by 2030 [tidal stream] and by 2035 [wave].

An assessment of the timeline of known current and planned deployments of both wave energy and tidal stream energy systems in European waters has been prepared through direct engagement with the technology and project developers.

A request for information (RfI) was issued to thirty-seven (37) technology and project developers [20] identified as actively pursuing the deployment of whole-system wave and tidal stream technologies in European waters [21] (Figure 9).

FIGURE 9: DEVELOPER REQUEST FOR INFORMATION. INNER: BY SUB-SECTOR; OUTER: BY COUNTRY.



Developers were invited to provide administrative information of current and planned deployments as well as techno-economic information.

Responses from eleven (11) developers were received regarding thirteen (13) deployment projects (six (6) wave energy and seven (7) tidal stream). This information was augmented with publicly available information.

5.1 Whole system deployments

The following analysis is based on deployment projects where an installation date has been identified (actual or anticipated) [22].

Known deployments of wave energy and tidal stream systems in the period from 2020 to 2031 are presented in Figure 10 and Figure 13 respectively. The data presented considers deployments that are complete (i.e., the devices have been recovered and the deployment decommissioned), are currently operational, are under-construction, or, are in-development. In the latter two categories, the installation date is provisional and subject to change. In all categories other than 'complete', the deployment duration is as intended and subject to change.

[20] A technology developer being an entity whose primary activity is the development of a technology. A project developer being an entity whose primary activity is the development of a project that will use a technology developed by a technology developer. A technology developer frequently adopts the role of project developer in the latter stages of the technology development process when demonstrating the technology at full-scale.

[21] The entity (the technology or project developer) leading the deployment can be registered in a non-European country.

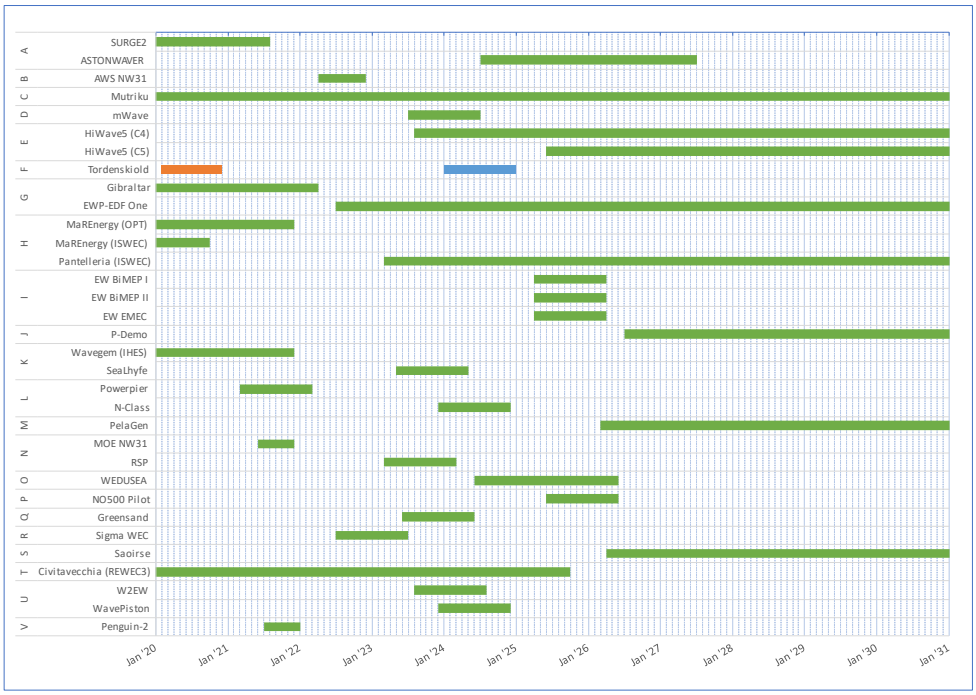
[22] The analysis omits certain known deployment projects where an installation date could not be identified.

5.1.1 Wave energy systems

Twenty-two (22) companies (eighteen categorised as technology developers, four categorised as project developers) were identified as progressing a total of thirty-three (33) deployment projects in the period 2020 to 2031 [23].

At the end of 2022, four (4) were considered operational, nine (9) had been decommissioned and the remaining twenty (20) were categorised as being 'in-development' or 'under-construction'.

FIGURE 10: TIMELINE OF WAVE ENERGY SYSTEM DEPLOYMENTS IN THE PERIOD 2020-2031 (AS OF DECEMBER 2022).



A AW-Energy Oy
B AWS Ocean Energy Limited
C Biscay Marine Energy Platform
D Bombora Wave Power Europe Ltd
E CorPower Ocean AB
F CrestWING ApS
G Eco Wave Power Global AB
H Eni SpA
I EuropeWave
J Floating Power Plant A/S
K GEPS Techno
L Havkraft AS
M Marine Power Systems Ltd
N Mocean Energy Limited
O New Wave Technologies Limited
P Novige AB
Q Resen Waves ApS
R Sigma Energy
S Simply Blue Group
T Wavenergy.IT SrL
U WavePiston A/S
V Wello Oy

Colouring used to distinguish serial deployments of the same device:
first deployment (green); second deployment (amber); third deployment (blue).

The distribution of project types [24] arguably reflects the maturity of the sub-sector's technology with most projects categorised as 'Demonstration (early)', fewer as 'Demonstration (commercial)' and fewer still as 'Production' (Figure 11).

Deployments in both 'Demonstration' categories are being undertaken primarily at pre-consented test sites, although significantly a broadly equal quantity of 'Demonstration (early)' projects are being undertaken at bare sites.

While most deployments up to and including 2025 appear to be associated with short duration demonstration projects, there is evidence that developers are preparing longer

[23] A further seven (7) deployment projects involving five (5) developers were identified but no administrative information was recovered through the RfI or found in the public domain.

[24] 'Demonstration (early)' – typically deployments of a single partial-scale device for periods of up to 12 months, corresponding to OES Stage 3 (TRL5-6).
'Demonstration (commercial)' – typically deployments of a single full-scale first-of-a-kind device for periods of between 12 and 24 months, corresponding to OES Stage 4 (TRL7-8).
'Production' – typically deployments of multiple devices for periods in excess of 2 years, corresponding to OES Stage 5 (TRL8-9).

duration 'Production' deployments after that, notably CorPower Ocean's HiWave C4 and C5 project, Simply Blue's Saoirse project, Floating Power Plant's P-Demo project, and Marine Power Systems' PelaGen project.

The installed capacity at the end of 2022 is estimated at approximately 480 kW, a modest increase over the previous year (Figure 12). However, installed capacity is expected to reach approximately 8.7 MW by 2025 (and approximately 19.7 MW by the following year) if deployment projects currently identified as 'under-construction' or 'in-development' remain on schedule (Figure 12).

FIGURE 11: WAVE ENERGY DEPLOYMENT PROJECTS BY PROJECT AND LOCATION TYPE.

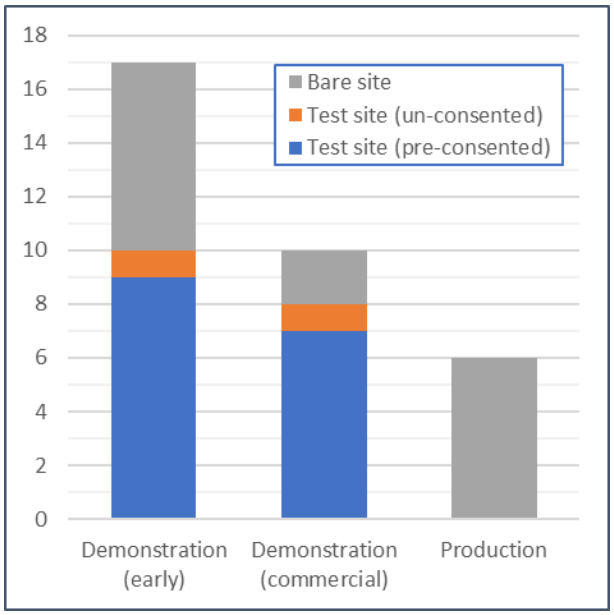
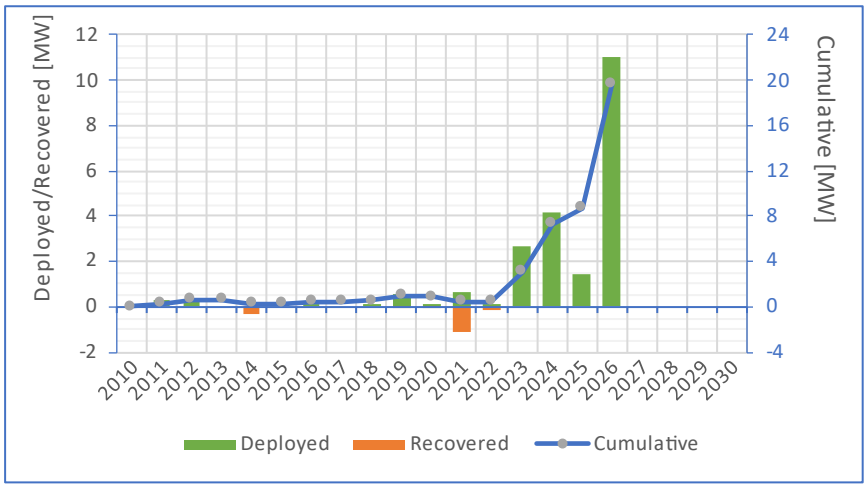


FIGURE 12: INSTALLED CAPACITY OF WAVE ENERGY TECHNOLOGY: ACTUAL AND ANNOUNCED.



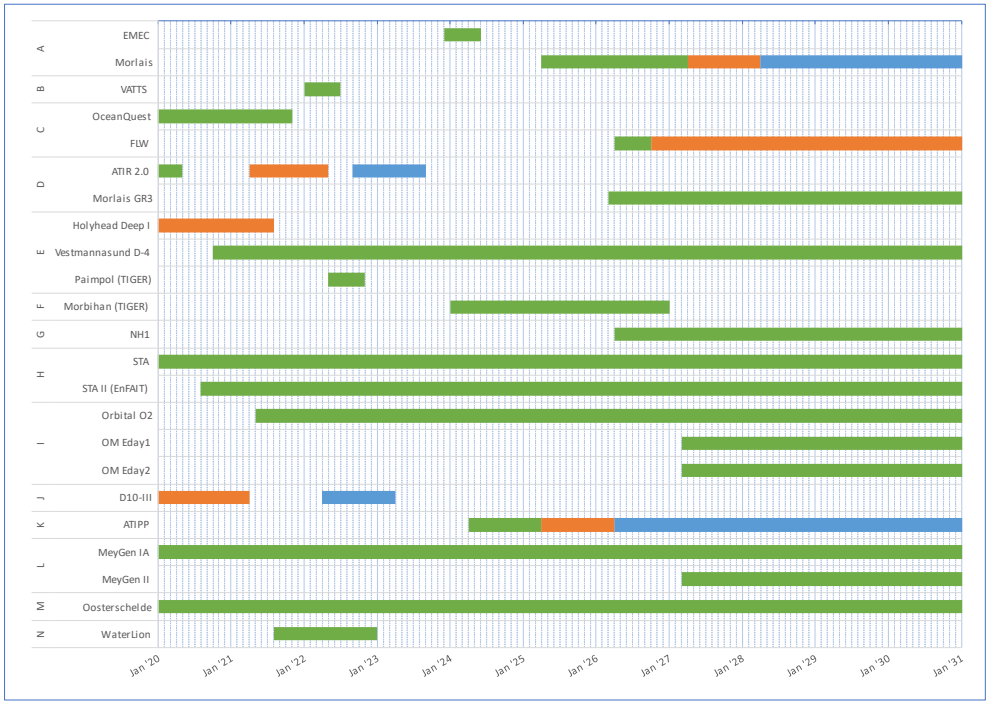
5.1.2 Tidal stream systems

Fourteen (14) companies (of which three are categorised as project developers) were identified as progressing a total of twenty-three deployment projects in the period 2020 to 2031 [25]. At the end of 2022, eight (8) deployments were operational, five (5) had been decommissioned and ten (10) were categorised as being 'in-development' or 'under-construction'.

New deployments in 2022 were either first short-duration deployments of new devices or re-deployments of devices previously deployed and recovered for extended maintenance and sub-system upgrades (Magallanes Renovables' ATIR 2.0 device in the Orkney Islands, Scotland; Sabella's D10 device in the Fromveur Passage, Ushant Island, Brittany).

[25] A further seven (7) deployment projects involving five (5) developers were identified but no administrative information was recovered through the RfI or found in the public domain.

FIGURE 13: TIMELINE OF TIDAL STREAM ENERGY SYSTEM DEPLOYMENTS IN THE PERIOD 2020-2031 (AS OF DECEMBER 2022).



A Aquantis Inc
B Gkinetic Energy Limited
C HydroQuest SAS
D Magallanes Renovables SL
E Minesto AB
F Morbihan Hydro Energies
G Normandie Hydroliennes
H Nova Innovation Limited
I Orbital Marine Power Limited
J Sabella SAS
K SeaQurrent BV
L SIMEC Atlantis Energy
M Tocardo BV
N Water2Energy BV

Colouring used to distinguish serial deployments of the same device, or phased build-out of array first deployment (green); second deployment (amber); third deployment (blue).

The distribution of project types arguably reflects the greater maturity of the tidal stream sub-sector's technology (Figure 14); most projects are categorised as 'Demonstration (commercial)', fewer as 'Production' and fewer still as 'Demonstration (early)'. Deployments are being undertaken at either pre-consented test sites or bare sites in all categories.

The installed capacity of tidal stream energy deployments at the end of 2022 is estimated at approximately 12.8 MW (Figure 15). Little further capacity is expected to be deployed up to the end of 2025. However, substantial increase in capacity is expected over the period 2026 to 2028 resulting in cumulative capacity of approximately 113.5 MW by the end of 2028 if deployment projects currently 'under-construction' or 'in-development' remain on schedule.

FIGURE 14: TIDAL STREAM ENERGY DEPLOYMENT PROJECTS BY PROJECT AND LOCATION TYPE.

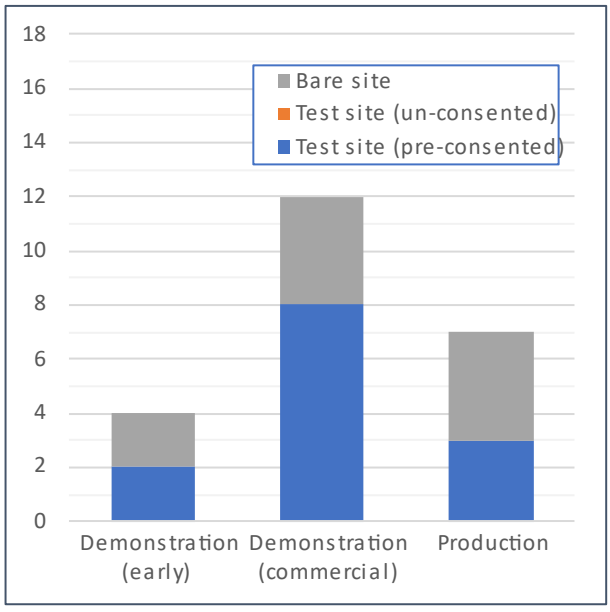
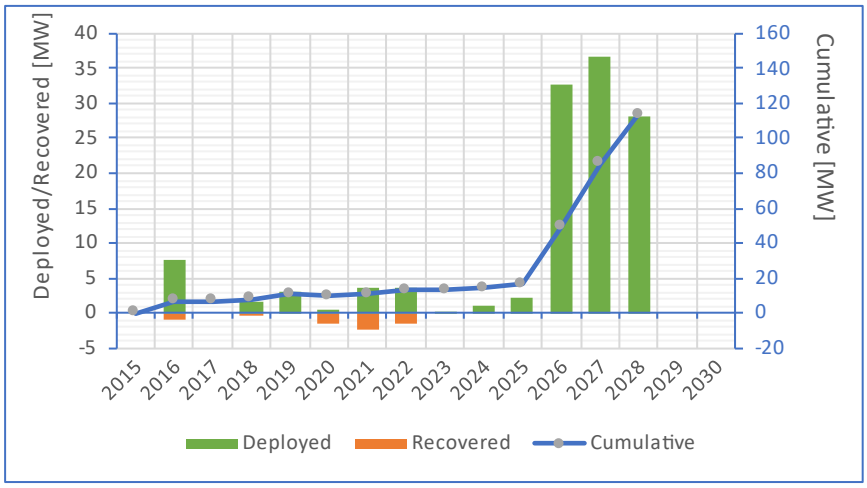


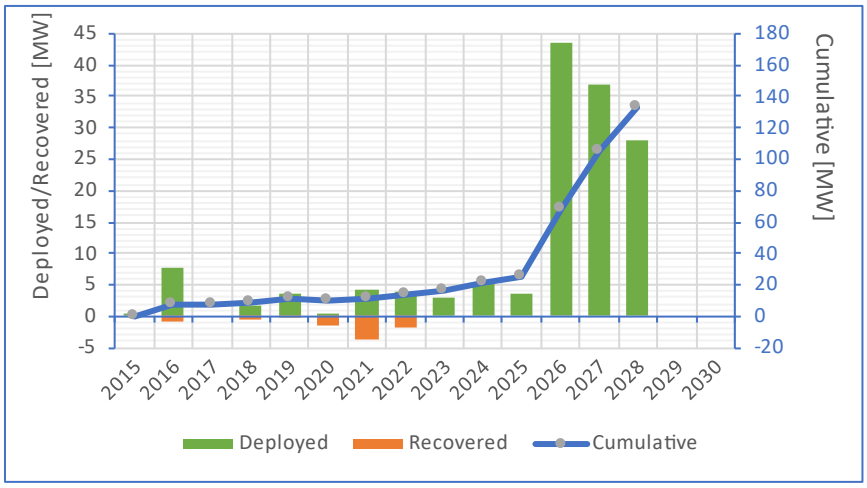
FIGURE 15: INSTALLED CAPACITY OF TIDAL STREAM TECHNOLOGY: ACTUAL AND ANNOUNCED.



5.1.3 Ocean energy installed capacity

Combining the information in Figure 12 and Figure 15 provides an indication of the trajectory for the installed capacity of ocean energy technology over time (Figure 16). The annual increase is expected to be modest through to 2025 with capacity rising from approximately 13.3 MW in 2022 to 24.8 MW in 2025.

FIGURE 16: INSTALLED CAPACITY OF OCEAN ENERGY TECHNOLOGY: ACTUAL AND ANNOUNCED.



However, from 2026 onwards an annual increase of between 30-40 MW is expected assuming deployment projects currently 'under-construction' or 'in-development' remain on schedule. This suggests the target of 100 MW of ocean energy capacity will be achieved by 2027.

5.2 Techno-economic metrics

Developers were invited to provide techno-economic metrics regarding their deployment projects namely: CAPEX (M€/MW); OPEX (€/kW per annum); Availability (%); Capacity factor (%); Average annual energy production (MWh); and Levelised cost of energy (€/MWh).

Initial observations

- The response to the RfI was limited. This means that any interpretation drawn from the techno-economic information provided should not be considered representative of the two sub-sectors.
- 'Demonstration (early)' projects: Developers chose not to provide any techno-economic information, frequently stating that the metrics were not meaningful or relevant for such early-stage demonstration deployments.
- Levelised cost of energy: Developers were reluctant to provide this metric for all categories of project types.

- Project status: Responses are related to projects at the 'in-development' stage except for one response relating to an operational project and one to a decommissioned project. Consequently, the reported techno-economic information is largely aspirational.

5.2.1 Wave energy systems

Six (6) projects responded, two in each of the three categories for project type. The following observations are based on three of these responses[26]:

- In all cases, the rated capacity of a single device was in the range 300 to 350 kW.
- Estimated CAPEX and OPEX varied by an order of magnitude between the projects,
  - The lowest estimated CAPEX was in the range 1.5 to 2.0 million EUR/MW and the highest was in the range 10 to 12 million EUR/MW.
  - The lowest estimate OPEX was reported as less than 25 EUR/kW per annum, while the highest was in the range 400 to 600 EUR/kW per annum.
- Availability was reported in the ranges between 80 and 90% although one project reported a range of 95 to 100%.
- Capacity factor was reported in the ranges 30 to 35%, 40 to 45% and 45 to 50%.

5.2.2 Tidal stream energy systems

Seven (7) projects responded. The following observations are based on four of these responses[27]:

- The rated capacity of a single device varied from 30kW to 2.5MW.
- Estimated CAPEX varied by an order of magnitude across the projects,
- The lowest estimated CAPEX was in the range 0.5 to 1.0 million EUR/MW and the highest was in the range 12 to 14 million EUR/MW.
- Three projects reported OPEX in the range 50 to 100 EUR/kW per annum while the remaining project reported a range of 1500 to 2000 EUR/kW per annum.
- Availability was reported in the ranges between 85 and 95% although two projects reported a range of 95 to 100%.
- Capacity factor estimates varied significantly. Projects reported in the ranges between 25 and 35%, 40 to 45% and 55 to 60%.

5.2.3 Observations

Both sub-sectors reveal a broadly similar wide range of CAPEX estimates.

There appears to be some consistency in the estimate of OPEX with several projects across both sub-sectors reporting a provision of a few hundred euros per kW per annum, albeit with significantly larger and smaller provision reported by the outliers (an order of magnitude larger and smaller).

The estimates of availability and capacity factor range from arguably ambitiously realistic values to arguably overly optimistic values given the type of deployment project being undertaken.

No stronger observations may be drawn without further enquiry into the basis for the reported values.

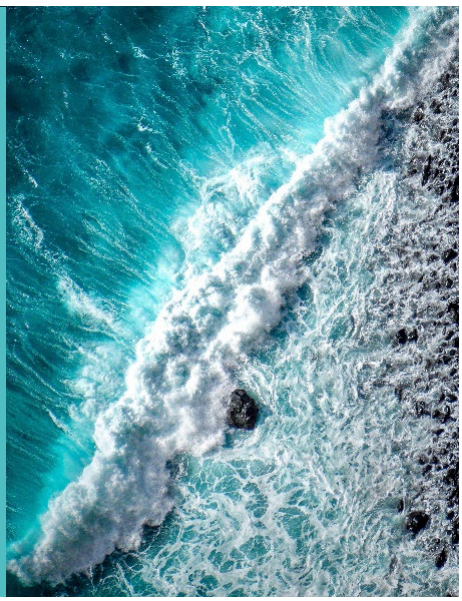
[26] The two projects categorised as 'demonstration (early) did not provide any information and one project was related to a hybrid wind and wave energy system for which it was not possible to separate information relating to the wave energy system.

[27] Two projects categorised as 'demonstration (early)' and one project categorised as 'demonstration (commercial)' did not provide any techno-economic information.

6. Recommendations

A: Continue to argue for explicit national/regional strategies, policies and targets that support the deployment of ocean energy.

Support for offshore renewable energy is clear, however there is a tendency for offshore renewable energy to be interpreted as offshore wind implicitly and to the exclusion of other forms of offshore renewable energy, particularly in the short-term period to 2030. While the zoning of the sea in maritime spatial planning process is making provision for offshore renewable energy production it reveals significant competition for space with other uses. This, combined with a focus on the development of offshore wind in the short-term, risks limiting space for the development of ocean energy in medium-term. The targets for ocean energy expressed in the EU Strategy on Offshore Renewable Energy should form the basis for corresponding targets in national maritime spatial plans.



B: Tailor national and regional funding programmes to address the Implementation Plan's Technical theme actions.

While the funding of research and innovation in the ocean energy sector by European, national and regional programmes does appear to target the actions of Implementation Plan, it appears to be supporting activities at a smaller scale (lower value and arguably lower TRL) than recommended in the Implementation Plan. Furthermore, a significant proportion of the funding appears to support activities not identified in the Implementation Plan or Strategic Research and Innovation Agenda.

C: Evolve existing revenue support schemes to allow ocean energy deployment projects to secure support.

Technology agnostic revenue support schemes continue to prevail, i.e., competitive schemes where all technologies compete on equal terms. However, variants to such schemes restricting competition to groupings of technologies or to a single technology have been successful in securing ocean energy capacity. Derogations from the competitive process for limited (small) capacity deployments can provide guaranteed support for early projects.

D: Identify mechanisms to progress the implementation of a Common Investment Support Fund [Action 3.2].

There is no evidence to suggest that the feasibility study anticipated in this action has been undertaken. The OE-IWG should consider how to determine the feasibility of establishing this fund.

E: Identify mechanisms to progress the implementation of an Insurance and Warranty Fund [Action 3.3].

A preferred form, governance structure, and types of coverage that could reasonably be provided has been developed by the UK's Offshore Renewable Energy Catapult's study through the Tidal Stream Industry Energiser (TIGER) project. The OE-IWG should consider how to support approaches to European, national and regional governments to secure the finance to establish such a fund.

F: Monitor the update to the Strategic Research and Innovation Agenda (SRIA) for ocean energy and consider revising the Implementation Plan accordingly.

The process of reviewing and revising the SRIA for ocean energy for the period 2026 to 2030 is underway, with publication scheduled for summer 2024.

Appendix A – Implementation plan technical theme actions

TABLE 9: EXPECTED ACTIVITY IN EACH TECHNICAL THEME ACTION

IP 2021	SRIA [3] 2021	Number of Projects [4]				Budget [1] (€M)	Public Funding [2] (€M)
		Small < €2M	Medium [€2M, €8M]	Large > €8M	Total		
1.1	1.1	-	10	10	20	150	101
1.2	1.2	7 array scale			7	350	235
1.3	1.3	5	10	-	15	60	40
1.4	1.4	5	3	-	8	25	17
1.5	1.5	10	5	-	15	45	30
1.6	1.6	-	5	3	8	55	37
1.7	2.1	-	10	-	10	50	34
1.8	2.2	5	5	-	10	35	23
1.9	3.1	-	5	3	8	55	37
1.10	3.2	5	3	-	8	25	17
1.11	4.1	-	10	3	13	80	54
1.12	4.2	3	-	-	3	6	4
1.13	5.1	5	3	-	8	25	17
1.14	5.2	5	-	-	5	10	7
1.15	6.2	5	-	-	5	10	7
					143	981	657

[1] Budget assumes project values of 2M€ (small), 5M€ (medium), 10M€ (large) and 50M€ (array scale).

[2] Public funding assumed to be 67% of total budget.

[3] One SRIA priority topic, namely 1.7 [Development of other ocean energy technologies], is omitted as an IP technical action. SRIA priority topic 6.1 [Improvement of the environmental and socioeconomic impacts of ocean energy] effectively equates to the IP Environmental, Policy and Socioeconomic actions.

[4] Number of projects are interpreted from the phrases in the IP as: 'few' (3), 'several' (10).

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