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RTD - Energy
ENER - Renewables, R&I, Energy Efficiency
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SET Plan Secretariat

Integrated SET Plan Actions No.1&2

ISSUES PAPER on OCEAN ENERGY

Purpose of this document

This document[1] is intended to advance the implementation of the actions contained in the SET-Plan Communication[2] and specifically the actions concerned with the priority "Number 1 in renewable energy". It is part of a series of Issues Papers jointly prepared by the services of the European Commission and discussed with the representatives of EU member states and countries part of the SET Plan, working together in the SET Plan Steering Group.

The Issues Papers propose to stakeholders strategic targets in various areas of the energy sector. The input from, and positions of, stakeholders for each area will be used to come to an agreement on targets in a dedicated meeting of the SET Plan Steering Group with a representation of key stakeholders.

Stakeholders are invited to take position on the proposed targets in accordance with the guidelines set out in the paper ***The SET Plan actions: implementation process and expected outcomes*** and submit their positions to SET-PLAN-SECRETARIAT@ec.europa.eu by 17 June 2016 at the latest. All relevant documents and material is available on the SETIS website https://setis.ec.europa.eu/.

1 This document is a working document of the European Commission services for consultation and does not prejudge the final form of any future decisions by the Commission.

2 Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation" (C(2015)6317)

Introduction Ocean Energy

Ocean energy is abundant, geographically diverse and renewable. Ocean energy can play an important role in the energy mix in a low-carbon economy as it is very predictable. This means it has the potential to contribute substantial value to the energy system. Under the right conditions for both technological development and project deployment, 100GW of ocean energy capacity could be installed by 2050, feeding around 350 TWh of power to the grid. The potential contribution of ocean energy is estimated to be of around 10% of EU power demand by 2050; with ocean energy thus playing a significant role in the future EU energy system.

There are five main ocean energy sources: tidal stream, wave, tidal range, salinity gradient, and ocean thermal gradient (OTEC). Currently, the different technologies to capture these resources are at varying stages of development in Europe.

Tidal stream and wave are terms that cover a family of technologies, depending on whether the devices are intended for deployment far-shore, near-shore, close to shore, or co-located on existing marine infrastructure such as dams, harbour walls or breakwaters. Over the past ten years, over 20MW of tidal stream and wave devices on different scales have been tested in European waters.

A number of MW-sized tidal stream turbines have been deployed and grid connected, whilst the first multi MW array is expected to be grid connected by the end of 2016.

Technological development and deployment of wave energy is a few years behind that of tidal stream. The difficulty in attracting investor capital for emerging technologies has compromised a number of wave energy projects over the past years, numerous prototypes and demonstrators have been deployed and tested in both the high-resource Atlantic arc and in the lower-resource North and Mediterranean seas. Between 2016 and 2018, the first MW-size arrays are expected to be deployed.

A 240 MW tidal range power station has been in operation in France since 1966, and there are some ideas about building on the same principle similar type of projects. Small scale prototypes of Ocean Thermal Energy convertors have been built already, and a small- scale demonstration salinity gradient plant is in operation in the Netherlands. An important issue with tidal range, OTEC and salinity gradient energy convertors is that the replicability potentials seem rather limited. Furthermore, the potential contribution to OTEC and salinity gradient to EU energy system is somewhat limited with the highest resources located outside of the main EU borders.

Ocean energy is still at pre-commercial stage and considerable progress is required in the research, development, demonstration and validation of technology to improve performance and reduce the cost of energy, to allow the sector to realise its potential contribution to energy supply, industrial leadership, economic growth and mitigation of climate change.

Targets

The high level targets for the ocean energy sector are to bring ocean energy to commercial deployment, to drive down the levelised cost of energy (LCoE), to maintain and grow Europe's world leading position in ocean energy and to strengthen the European industrial technology base, thereby creating economic growth and jobs in Europe and allowing Europe to compete on a global stage.

Ocean energy technologies need to demonstrate their reliability and capacity to survive in aggressive sea conditions insuring, thus, device availability to reduce risk for project developers and investors. They need to demonstrate their market potential and they should be cost-competitive in comparison with other energy technologies.

Proposed targets in ocean energy

Development of cost competitive ocean energy technologies with high replicability potential.

The LCoE for tidal energy should be reduced to at least 20 ct€/kWh in 2020, 12 ct€/kWh in 2025 and 7 ct€/kWh in 2030.
Wave energy technology should follow the same pathway and reach the same cost targets maximum 5 years later than tidal energy: 20 ct€/kWh in 2025, 12 ct€/kWh in 2030 and 7 ct€/kWh in 2035.

The costs for delivering the electricity to onshore substations are taken into account within the LCoE.

To realise this target it will be important to improve the reliability and survivability of the ocean energy converters. The device availability should be at least 80% in 2025, 90% in 2030 and 95% in 2040. Capacity factors should also increase towards 30-35% by 2030. To realise the targets the actions should possibly involve the following elements:

Production value chain performance/cost competitiveness:
Deliver technologies that: 1) generate effectively and reliably and 2) meet or exceed project investment criteria within supported markets. Achieve LCOE targets through the deployment of wave or tidal stream technologies and associated cost reduction through volume, economies of scale and continued innovation. Continue on path to full competiveness with other low carbon options. Research, development and innovation efforts should also focus on technologies and processes necessary to develop and optimise farms, such as subsea power hubs, lay-out optimisation, and characterisation of the environment.

Supply chains:
Ensure a sufficient pipeline of project sites to encourage supply chain investment. Develop standards and standardise operating procedures, vessels, components and subsystems. Increase system lifetime, maintainability, reliability and accessibility offshore. Improve logistics and create supply chains for progressively larger projects. Make anticipatory investments in infrastructure such that grid links, ports and harbours are built in advance of projects.

System integration:
Ensure that the development of European grid infrastructure anticipates the use of large scale ocean energy. Ensure benefits from reduced system costs of integrating temporally diverse ocean energies with other

renewables such as wind and solar are recognised and captured in decisions made about the energy mix and energy system investments. Investigate fuel production and energy storage options.

Non technological aspects:
Achieve a robust business model. Ensure the availability of finance to match market demand and support for global uptake of European ocean technologies. Engage banking and insurance sectors to accelerate market uptake. Remove uncertainties from the potential environmental impact of ocean energy technologies to accelerate consenting.

Societal issues:
Ensure that the increase in knowledge and economic benefits associated with the advancement of ocean energies are recognised and factored into decision making. (eg benefits to remote communities, potential for skills transfer from fishing and other maritime activities, manufacturing benefits, potential for technology transfer to other sectors). Increase public awareness of ocean energy and share knowledge of impacts (or lack of impacts) on the environment to reduce consenting timelines.

Annex 1

Relevant actions to realise the targets can come from the 'Towards an Integrated Roadmap' document of the SET Plan which have been published in 2014 and the Ocean Energy Strategic Roadmap (in preparation by the Ocean Energy Forum, to be published in autumn 2016).

The following targeted R&I actions for the long, medium and short term for ocean energy development in are proposed in Annex 2 of the 'Towards an Integrated Roadmap' document.

Introduction to the Programmes:
While wave and tidal are at different stages of development, it is the opinion of the stakeholders that a common program for both should be maintained, as most issues are similar for both. The timelines are slightly different, as the Advance Research and the Industrial Research and Development programmes are more relevant to wave energy, given its TRLs; whilst the Industrial Research and Development and Market Uptake programmes are more relevant to tidal energy. That said, this is a general rule, but should not be applied systematically but rather on a project by project basis.
Additionally wave and tidal are only two of the existing ocean technology and splitting actions according to respective issues concerning OTEC and Salinity Gradient would add complexity.

ADVANCED RESEARCH PROGRAMME

Action 1: Site Characterisation
Scope: The aim of this action is to develop tools and know-how to the characterisation of:
- Resource: correct assessment of energy available, modelling of the capacity factor and uncertainties associated, and modelling of local phenomena (as turbulence) likely to drive the sizing of devices.
- Physical conditions: sea bed investigation, local current confines, site accessibility.
- Environment: seabed, wildlife and plant life characterisation and impact measurement.

Deliverables:
- Innovative hardware or methodologies; Improved modelling techniques; Best practices for data collection; Joint technological and environmental data collection; Data quality increase; Dissemination; Identification and suitability of resource types per technology.

Expected impact:
- Reduced time and cost for development applications, installation, operation, maintenance, reduced production uncertainty by 10 %; Cross-fertilisation with other sectors for universally valuable data and knowledge gathering.

KPIs:
- Increase towards 90-95% predictability of resources.
- Decreasing of development cost by identifying multi-scale sites confines.

Costs: EUR 10 million.
Timeline: 2014-2017.
Modality of implementation: -

Action 2: Technological Research – Devices, components, materials
Scope: Projects in this action should address the designs of basic components and subcomponents and realisation of a first demonstrator for primary technologies of marine energy devices:
- Power take-off.
- Prime-mover, electrical conversion, marine connectors and wires.
- Mooring technologies, drilling, anchoring.

- Installation procedures, vessels and marine technologies.
- Projects should also address fundamental topics, strongly related to marine industry issues, as:
  - Material sciences.
  - Chemistry (corrosion).
  - Hydrodynamics and fluid dynamics, including tank testing.
  - Electromagnetism.
- Projects should study the transfer of existing technologies to marine applications. Development of new technologies also requires relevant protocols for testing, prediction and analysis of load cases.

Deliverables:

- New component functionalities; transfer of existing technology to marine applications; Innovative materials for reduced weight, cost, improved strength and suitability for marine applications; supply chain standardisation.

Expected impact:

- Reduce costs towards the 15-20 c/kWh target (%); Increase yield and life-cycle reliability toward the 15-20 year lifetime target; reduce environmental impact; achieve design consensus on different technologies to unlock mass manufacturing.

KPIs:

- Reliability of the concept tested.
- Measurable cost reduction.
- Component standardisation.
- Environmental impact.
- Compared to similar existing technologies.

Costs: EUR 140 million.

Timeline: 2014-2017.

Modality of implementation: local project gathering technologies developers, utilities, and industrial partner.

Action 3: Grid services and inter-array interactions

Scope: Address the specific issues associated with the efficient, reliable transmission of electricity /energy produced by marine energy devices, alone or in arrays; analysis and design of a dedicated electrical distribution system valid for most devices/arrays; development of cost effective transformers, switch gear, dynamic cabling, connectors and static cabling suitable for the highly dynamic marine environment and on platforms that are most appropriate (e.g. floating, fixed, subsea). Test and evaluation of such components and systems, potentially integrated with action 1 of IR&D Programme and or with other complimentary technologies such as offshore wind.

Deliverables:

- Control algorithms for ocean energy array; smoothing of energy output over time; new electrical distribution systems; standardisation of connectors; umbilical inter-array cabling.

Expected impact:

- Reduce CAPEX linked to cabling; Grid stability services; Industry wide solutions; cable-laying in high energetic zones.

KPIs:

- Measurable reduced CAPEX in the complete chain.
- Standard connectors for 440V, 3KV and 11kV. DC cables.

Costs: EUR 50 million.

Timeline: 2014-2017.

Modality of implementation: -

Action 4: Array design and modelling tools

Scope: Creation of design tools to optimise array layout and understanding of device performance in arrays, independently of device used. Take advantage of the first prototypes of devices and small farms for validation of numerical models. Evaluate uncertainties in modelling. Develop models to determine balance between cost of array, its efficiency and the complexity of the proposed layout. Determine balance of plant for array control algorithms.

Deliverables:

- Design tools and initial analysis report on array design and performance.

Expected impact:

- Improved array performance, reduced cost of energy, industry-wide solutions.

KPIs:

- Decrease uncertainties by less than 10%.
- High array performances.
- Reduce array costs.

Costs: EUR 10 million.

Timeline: 2014-2017.

Modality of implementation: -

INDUSTRIAL RESEARCH AND DEMONSTRATION PROGRAMME

Actions under this programme are derived to encourage technology collaboration on subsystems and components to increase reliability and drive down capital costs of technologies. They have the following impacts:

- Ensure EU industrial leadership is maintained; technical learning.
- Cost of energy reduction; public and private investments triggered.
- Increased market confidence.
- Reduced project risk.
- Blue Growth through supply chain opportunities.
- Increased socio-economic benefits.

Some additional specific impacts are listed for each action below.

Action 1: Technology System Testing and Demonstration

Scope: System-level and device testing, at scale and full-scale operation (typically individual ocean energy converters in real sea test environment – novel concepts and iterations of existing, promising concepts). Focus on: materials and techniques to reduce capital costs, automated machine operation to increase yield; failure prediction and preventative maintenance; reduction in operational costs from wear, fatigue and bio-fouling; increased system reliability; efficient space utilisation, maximising site potential for ocean technologies.

Deliverables:

- Progress of ocean energy devices to TRL 6/7 and beyond; system-level demonstration for TRL progression, deployable within devices.

Expected impact:

- Reliable technology, Technical learning;
- Reduced cost of energy;
- Increased market confidence.

KPIs: Number of devices progressing through TRLs, assessed through benchmarking performance across the sector and against standards as these is developed:

- PTO efficiency and capacity factor to reach at least 25% by 2020.

 Increased operational hours.
 Availability >85%.

Costs: EUR 150 million.
Timeline: 2014-2017.
Modality of implementation: European wide cross-country collaboration.

Action 2: Demonstration of Marine Technology Access and Logistics

Scope: Vessels adaptation, innovative vessel design, as well as methodologies for efficient offshore operations, covering construction, operation and decommissioning and innovations to reduce infrastructure bottlenecks (eg ports and harbours). Reduction in time and cost in installation, connection and disconnection of machines; improved accessibility for maintenance; reduction in time and cost for maintenance activities.

Deliverables:
 Demonstration of cross-sector utilisation of existing assets, using innovation for adaptation to Ocean Energy; Demonstration of novel vessels (or supporting solutions) in ocean energy marine operations in period to 2020; integration with other maritime users, eg tracking and navigation.

Expected impact:
 Understand and reduce installation and O&M costs, time to devices; increase days of operability at sea.

KPIs:
 Installation and O&M costs.
 Time to devices.
 Increase days of operability at sea.

Costs: EUR 70 million.
Timeline: 2017-2020.
Modality of implementation: -

Action 3: Monitoring and Analysis of Technology Demonstrations

Scope: Ensuring technical, environmental and socio-economic results from technology demonstrations are captured and disseminated, in order to inform future technology design as well as address environmental considerations feed back into consenting and minimise uncertainties on ocean energy project impacts.

Deliverables:
 Measurement and analysis of key technical parameters across regions and projects in order to consolidate certification procedures and impact assessment knowledge. Establish database of parameterised ocean energy projects, incl. access for diverse stakeholder. Supporting a science based approach to baseline data gathering, avoiding unnecessary work and reducing costs.

Expected impact:
 Comparability of projects; optimised environmental and socio-economic impacts; Consolidate and reduce consenting time.

KPIs:
 Creation of Database.
 N_o of projects analysed.
 Formal engagement and contribution from MS / projects.
 Validation and evolution of assessment criteria for certification bodies and authorities.

Costs: EUR 10 million.
Timeline: 2014-2020.
Modality of implementation: -

Action 4: Pilot Project Support - up to 10 MW, or 3-5 units
Scope: Moving from single device prototype technologies, to multi-device small-scale pilot projects; prove deployment, operability and generation of devices beyond single unit tests. CAPEX assistance required to continue foster innovation, otherwise early arrays will reduce innovation in order to reduce risk.
Deliverables: -
Expected impact:
 Technology deployment and market confidence.

KPIs:
 Number of projects including MW installed deployed using this scheme across Europe and corresponding investment by the private sector.
 Operational hours.
 Installed capacity.
 Inwards investment.
 Technology progression (TRL).

Costs: EUR 150 million.
Timeline: 2017-2020.
Modality of implementation: -

Action 5: Pre-normative research for developing Industry Standards
Scope: Develop industry standards for both the testing and manufacturing of devices, components and subcomponents, taking account of existing IEC/IEA work on standards. Ensure the use of manufacturing readiness level for the engagement of supply chain and OEM at broader scale and reduce CAPEX.
Deliverables:
 Standards and guidance for device and component manufacturing, engagement, consolidation and wider acceptance of standardised procedure for testing of ocean energy technologies.

Expected impact:
 Trigger investments through increased confidence from standard implementation, consistency and safety.

KPIs:
 Number of standards developed, number of standardised components.

Costs: EUR 5 million.
Timeline: 2017-2020.
Modality of implementation: -

INNOVATIVE AND MARKET-UPTAKE PROGRAMME

Actions under this programme have the following impacts: Ensure EU industrial leadership; socio-economic benefits and blue growth; private investments triggered; reduced LCOE; increased technological and environmental learning; market confidence and therefore uptake.
Some additional specific impacts are listed for each action below.

Action 1: Early Commercial Array Deployment Assistance Scheme
Scope: Deployment of 10+MW Scale Projects; This Action is focused on moving beyond the earliest "Pilot Projects" (addressed in Action within Industrial Research and Demonstration), reduce risk of multi-device deployment through grant schemes building upon innovation (CAPEX assistance). This addresses new, scale of deployment issues and therefore innovation and additional enabling actions are required as projects move towards greater scale.
Deliverables:
 In the region of 5 – 15 Individual projects deployed with the generating capacity of 10 – 50MW in each case.

Expected impact:

 Technology deployment leading to reduced Cost of Energy; Greater volumes creating supply chain opportunities, economic growth.

KPIs:

 MW installed.

 N₀ of individual projects achieving Final Investment Decisions.

Costs: EUR 500 million.

Timeline: 2017-2020.

Modality of implementation: -

Action 2: Grid Integration Assistance, on- and offshore

Scope: Financing electrical studies, focusing on the Integration of ocean energy technologies alongside other RES and non-RES, considering the unique aspects of ocean energy production characteristics concurrently with other forms of generation, from resource through to power take-off systems; Projects demonstrating this integration intention and capability should be supported through CapEx in line with innovation risk. Standardisation of grid access point for offshore RES (including offshore wind) and contribution to the development of smart grid.

Deliverables:

 Increased grid access options for ocean energy projects; understanding of grid services provided by ocean energy, through more efficient use of existing grid infrastructure, etc. Ocean energy-specific electrical system models. Stable grid-connected ocean devices.

Expected impact:

 Access to a wider range of sites; optimisation of EU integrated grid system.

KPIs:

 Number of MWs available in periphery of grid systems.

 Ocean Energy MWs able to connect through existing / shared connections with other generators.

Costs: EUR 15 million.

Timeline: 2014-2020.

Modality of implementation: -

Action 3: Establish consistent Consenting, Environmental and Socio-economic Assessment Baseline Frameworks

Scope: Determine a standard baseline state for several environmental areas impacted by ocean energy: benthos, marine life, sediments, etc. Develop scenarios for impacts at project level, as well as for the overall EU installed capacity. Streamline socio-economic impact assessments of ocean energy projects for consistent evaluation across at national and EU level.

Deliverables:

 Demonstrate co-ordination and consolidated output along with existing working groups and initiatives; National- and EU-wide consistent framework and regulations; Consistent analysis method for environmental impacts and associated uncertainties; Identification and increase of positive environmental Impacts: Established national- and EU-wide assessment method for socio-economic evaluation.

Expected impact:

 Optimised environmental impacts, increased level of social acceptance, and increased ocean energy contribution to economic growth. Improved mitigation measure to reduce potential impacts, increased level of social acceptance. Reduced conflict of use with other marine sectors.

KPIs:

 Number of MS systems subscribed to a given procedural system.

 Number of uncertainties reduced.

 Reduced time and cost of EIAs / consenting.

 Quantification of ecosystem values, quantification of ocean energy project economic value in MS and EU context.

Costs: EUR 15 million.
Timeline: 2014-2020.
Modality of implementation: European, MS and Regional level.

Action 4: Manufacturing and Production Advances/ Supply Chain - ***Est. Cost: EUR 100m***

Scope: Enabling the move from early production requirements (< 5 units) to large-scale manufacturing through automation, mass-production techniques, optimised logistics, etc. in order to facilitate volume capability. This should focus on progression from bespoke practices to incorporation of reduced time and cost of automated processes where possible (e.g. material forming, assembly lines of drive-train, electrical or mechanical load testing, transportation of multiple devices, etc.).

Deliverables:

 Demonstrable migration to automated processes; improved quality control and supply chain opportunities; Evaluation of supply chain value; Training and skills.

Expected impact:

 Reduced cost and time of manufacturing and delivery per MW, increased economic opportunity for supply chain, ensure EU Leadership in the sector.

KPIs:

 Unit cost per MW.

 Manufacturing lead time.

 Production capacity of the entire supply chain.

Costs: EUR 100 million.
Timeline: 2017-2020.
Modality of implementation: -