LIFE Project Number

LIFE14 CCM/ES/001209

Final Report

Covering the project activities from 01/10/2015 to 30/06/2019

Reporting Date

28/10/2019

LIFE PROJECT NAME or Acronym

LifeDemoWave

Data Project

Project location:	Galicia, Spain
Project start date:	01/10/2015
Project end date:	30/09/2018 **Extension date:** 30/06/2019
Total budget:	1.836.788 €
EU contribution:	1.034.119 €
(%) of eligible costs:	60%

Data Beneficiary

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Instructions:

Please refer to the General Conditions annexed to your grant agreement for the contractual requirements concerning a Mid-term/Final Report.

Both Mid-term and Final Reports shall report on progress from the project start-date. The Final Report must be submitted to the EASME no later than 3 months after the project end date.

Please follow the reporting instructions concerning your technical report, deliverables and financial report that are described in the document "Guidance on how to report on your LIFE 2014-2020 project", available on the LIFE website at: http://ec.europa.eu/environment/life/toolkit/pmtools/life2014_2020/documents/how_to_report_on_your_lifeproject.pdf. Please check if you have the latest version of the guidance as it is regularly updated. Additional guidance concerning deliverables, including the layman's report and after-LIFE plan, are given at the end of this reporting template.

Regarding the length of your report, try to adhere to the suggested number of pages while providing all the required information as described in the guidance per section within this template.

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2. List of key-words and abbreviations

CIMA: Centre for Mechanical and Automotive Engineering (University of Vigo)
GPI-RV: Image Processing and Virtual Reality Group (University of Vigo)
en.e: Electrical Engineering Group (University of Vigo)
ACSM: Advanced Crew and Ship Management
EC: European Commission
LCA: Life Cycle Analysis
WEC: Wave Energy Convert
PTO: Power Take Off
CAPEX: Capital expenditure.
OPEX: Operational expenditure.
LCOE: Levelized Cost of Energy
TRL: Technology Readiness Level
EMEC: European Marine Energy Center (Scotland, UK)
BIMEP: BIscay Marine Energy Platform (Vasque Country, ES)

3. Executive Summary

LifeDemoWave project, “Demonstration of the efficiency & environmental impact of wave energy converters (WEC) in high energy coasts”, was originally aimed to demonstrate the feasibility of the use of wave power for electric generation in order to reduce greenhouse gases’ emissions and to mitigate the climate change with easily repeatable equipment.

For demonstration purposes, two prototypes of wave power generation, 25kW each, reproducible and scalable at high level, were to be installed in the Galician coast.
The LifeDemoWave project considered as well, in its design and implementation, the environmental impact in the installation areas and its effect on biodiversity, trying to minimize as much as possible any of these effects and to quantify them explicitly.

After three years of development and an extension of nine additional months, the project has come to an end on June 30, 2019. A brief summary of the project development per action is provided below.

A - Preparatory Actions

A.1 - Analysis of existing technologies and production geographical areas

First stage of LifeDemoWave worked to identify several areas for the realization of the planned demonstration in order to select the most favorable location and start the administrative procedures for the installation of the prototypes. The selected area and studied in depth was the Punta Langosteira Site, managed by Inega (www.inega.gal/). The most remarkable result of the activity was to obtain the permits for the installation of the prototypes in the experimental site (Annex 9.2.4).

C - Implementation Actions

C.1 - Design and fabrication of WEC prototypes

Activity C1 focused mainly on the design and mechanical fabrication of the prototypes, with a particular focus to their scalability and replicability. The main result of the activity was to have the mechanical set of prototypes.

C.2 - Design and implementation of the generator and electric control

In parallel to the mechanical development, LifeDemoWave worked on the design of the Electricity Generation and Control System. The result of this activity was the installation of all the generation systems on the mechanical assembly resulting from the C1 activity.

C.3 - Design and implementation of control systems and telemetry

Like C2, activity C3 was carried out in parallel to C1 and consisted in the design of the control and communications system, necessary for the correct operation of the prototypes and their control from the ground. As a result of this activity, the equipment was equipped with a control and telecommunications dome with remote control.

C.4 - Mooring system design and WEC stabilization

The C4 action focused on the design of the equipment making up the anchoring train. Within the scope of it and, as a result of the activity, all the components that are part of the mooring system were manufactured and acquired.

C.5 Installation and set-up in production geographical areas

The aim of this action was to carry out the commissioning of the prototypes in the extraction points. Deployment of first prototype was done in June 2018, and installation in experimental site later, in August. First installation was for the Hydraulic prototype, which allowed to develop first tests of and validate main systems. During April 2019 was installed Mechanical prototype in order to test the second prototype.

C.6 Demonstration days

This action was aimed at performing three demonstrative generation days. These demonstration sessions were done along the project duration, in the site before the installation, during the assembly phase in Outer Harbour of A Coruña next to prototypes, and finally with installed prototypes in the experimental Site.

D - Monitoring Actions

D.1 Monitoring of the impact on the public target of the project

This action had a double objective: to develop the political implications of the project based on the results obtained and to confirm the impact of the project. To this end, several events throughout the project were organized where stakeholders related to wave power electric generation were be involved: political authorities, the scientific community, users (companies and individuals) and the general public.

D.2 Monitoring of environmental impact

This action was aimed to monitor the environmental impact of all stages of the project. To this end, environmental conditions were monitored along project duration, with and without prototypes installed. The results after the analysis of all parameters studied have demonstrated the low impact of the prototypes in the environment

D.3 Monitoring of the energy efficiency

LifeDemoWave monitored the energy efficiency of the equipment by performing a real-time monitoring of the site's waves, which allowed the characterization of the wave spectrum and the calculation of the energy per meter of wave front. On the other hand, the average generation values for the annual production calculation were recorded.
Regarding the results got, the generation levels set as indicators were not reached but they are considered acceptable for a device with these characteristics, as well as they allowed to identify aspects that could be improved for commercial equipment.

E - Communication and dissemination Actions

For de diffusion of the project, LifeDemoWave carried out a dissemination plan that included the creation of a website (http://www.life-demowave.eu/en/), the installation of informative panels, the edition of brochures, newsletters and layman report among others. In addition, LifeDemoWave participated in 33 events including the opening and closing ones and the EU Green Week 2017 in Brussels, where LifeDemoWave first contacted to EMEC in order to continue investigation with a new larger prototype foreseen for 2020-2023.

F - Project management Actions

Management actions were developed according to the needs of the project and what was originally set. Special mention need to be done regarding After Life plan, since the consortium is planning to develop a new project with a commercial scale larger prototype, and make use of the current one to previous tests.

4. Introduction

The main objective of the project LifeDemoWave is the demonstration of the feasibility of the use of wave power for electric generation in order to reduce greenhouse gases' emissions. Thus, according to the regulation LIFE 2014-2020 Regulation (EC) No 1293/2013 the specific objective (d) set in article 14 would be reached. Thus, it will contribute to the development and demonstration that the use of other technologies such as wave power helps to mitigate the climate change with easily repeatable equipment. This project wants to raise awareness in society, proving that this is a way to reach clean energy, one of the biggest barriers nowadays.

Additionally, this goal is in accordance with the policies of the EU, which set guides for a European strategy for sustainable, competitive and safe energy through the Green Paper (8th of March of 2006). Furthermore, the Directive 2009/28/CE set that in 2020, 20% of the EU energy consumption has to come from renewable sources, although this value was only up to 14% in the EU. On the 20th January 2014 it was presented an action plan named «The blue energy», highlighting the support to wave power and tidal power as one of the priority areas in the EU to mitigate climate change, being wave power the solution proposed in LifeDemoWave. The final objective of this project is to help the implementation of these policies and support the adaptation of the applicable legislation in order to adopt these technologies, achieving what was set in section (a), article 14.

For demonstration purposes, two prototypes of wave power generation, 25kW each, will be installed in the Galician coast, (Galicia stands out for having up to 75kW per each meter of wave front) that will be reproducible and scalable at high level.

Another objective is to quantify the reduction of the carbon footprint and the emission of pollutants (NOx, NMVOC, SO2, NH3, PM25…). The aim is to reach the set values in the performance indicators, thus, allowing to adjust to the EU environmental policies such as Directive (2008/50/EC), (2001/81/EC), (94/63/EC), etc.

LifeDemoWave project will consider as well in its design and implementation, the environmental impact in the installation areas and its effect on biodiversity, trying to minimize as much as possible any of these effects and to quantify them explicitly in accordance with the directives in the water framework (2000/60/CE) and the directive (2008/56/CE); Directives (2011/92/UE), 97/11/CEE, 2001/42/CE and 2003/35/CE for plan or projects of environmental protection nature.

Expected results as they were set are:

- Demonstration of the technical viability and survival capacity of two WEC prototypes (25 kW each) on the Galician coast under extreme conditions.
- Demonstration of the energy efficiency, power quality and high generation ratio of the systems.
- Demonstration of the electricity generation potential of these systems in comparison with other solutions.
- Extrapolation of the results so that models and designs could be applied and scaled-up in any location to ensure the technology's transferability.
- Measurement of the carbon footprint throughout the life cycle of the WECs and establishment of a calculation method to quantify their impact.

- Qualitative and quantitative determination of the parameters to characterize the environmental impact on marine biodiversity and environment, including an analysis of pollutants and damage to the seafloor.
- Demonstration of the low environmental impact compared with other technologies.
- Energy and environmental comparative report for all marine energy generation technologies.

Once developed the project, LifeDemoWave has shown promising results, with high survival behaviour in extreme wave conditions, a compact and non-aggressive anchoring system; low costs in both CAPEX and OPEX (thanks to its ease of access for maintenance and minimal submerged mass); and competitive returns at generation level compared to similar technologies for a TRL 5. This project has been another step towards obtaining alternative clean energy, future versions that can be optimised thanks to hydrodynamic behaviour correlated with sea simulations and trials. The goal is to increase the scale of production and create wave energy parks to obtain in future iterations the desired TRL 9 with a competitive LCOE compared to other energy sources.

Also noteworthy is the contribution of the project to the launch of the experimental site of Langosteira. LifeDemoWave, together with INEGA (http://www.inega.gal/), set the technical and administrative criteria for the use of the site, being the work done from the consortium the documentary standard for the management of application for permits. An important amount of work regarding promotion of the project has been carried together with INEGA, advertising as well about the power resource. Evidence of this is that other initiatives requested the use of the site to test their products after the installation of LifeDemoWave prototypes, who pioneered.

The design obtained secures the sustainability, replicability and transferability of the project thanks to:

- Design according to the strictest international standards: *OS-C301 Standard "Stability and Watertight Integrity" Stability and Watertight Integrity; Offshore Standard DNV-OS-B101; DNV Certification Note 2.4 "Environmental Test Specification for Instrumentation and Automation Equipment; OS-D202 and Safety shutdown systems in OS-A10; etc.* All these standards are the one required in other high level sites like EMEC.
- Design independent of environmental conditions like the sea level (thanks to decoupling in the mooring system) and is able to operate from 2-15 meters of wave amplitude due to his dynamic reaction system by water column isolation.
- Scalability Report to recreate conditions of other sites and predict its performance.
- Equipment selected easy scalable to higher power
- Design in accordance with DNV-OS-D201
- New regulation system allows to operate in a wide range of waves
- Algorithms are scalable and compatible with databases such as SCADA

All this will help to set technical viability and an agile ability to adapt to new conditions and as a proof of concept to use it in another emplacements.

LifeDemoWave development also contribute to European Union climate change action policies, by quantifying the potential of one of the areas within the EU with the highest energy per meter of wave front (Galician Coast), helping the EU to calculate the quota that these equipment could hold in the future for energy consumption (aligned with Directive 2009/28 /

EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources); by collaborating with the Port of A Coruña in the development of procedures for future deployment of WECs, as well as analyzing the environmental impact on the ecosystem by measuring noise, pollution in the water column and effect on the seabed (aligned with Blue Energy Action needed to deliver on the potential of ocean energy in European seas and oceans by 2020 and beyond /* COM/2014/08 final */.); and by environmental monitoring of the impact of WECs on fishing sector (aligned with EU Water Framework Directive - "Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy").

Regarding future economic exploitation, links were developed with entities and institutions that may be of great interest. The relevance of some of these institutions, such as EMEC, INEGA and Puertos del Estado allow LifeDemoWave to keep open the possibility of developing new initiatives and projects related to wave energy and to study its environmental impact of. This would complement the project and will help to maintain its dissemination. Within this activity is an initiative already underway that will try to develop a new device based on LifeDemoWave and scaled for commercial use, with a TRL 8, and that would be tested at the EMEC experimental site, in the Orkney Islands (Scotland, UK).

Search for new financing channels, some of which have already been developed during the project (DYNAMARE – EAPA 960/2018, within the INTERREG ATLANTIC AREA PROGRAM); while others are ongoing, such as the future OATWave project application in the Fast Track to Innovation call of the H2020 program. The latter has already been funded by the Ministry of Economy, Industry and Competitiveness within the framework of the State Plan for Scientific and Technical Research and Innovation 2013-2016 with Reference EUIN2017-88555, aimed to develop the final proposal.

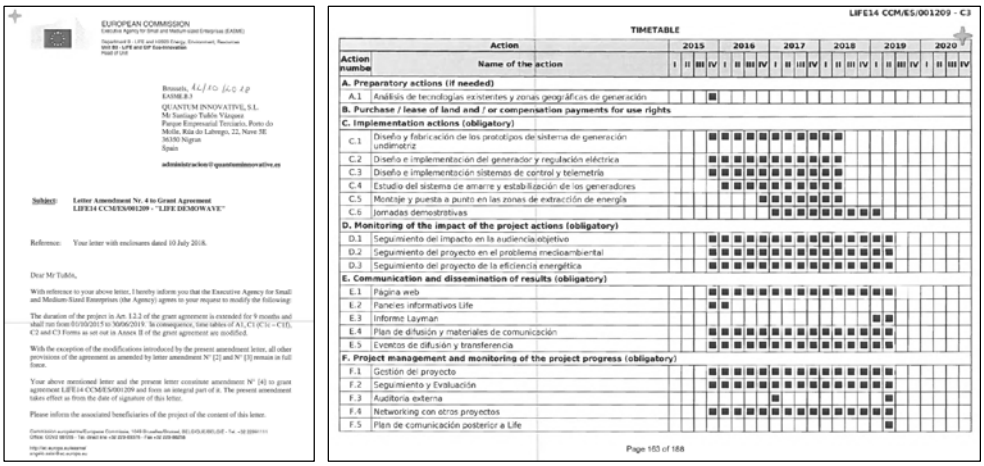
5. Administrative part

At the beginning of the project, a **management committee** was defined, which hold twice-yearly monitoring project meetings. The aim of this committee, which has held several meetings, was to monitor the progress of the project and to solve any problem that may affect its results, with the consequent monitoring of the risks, in accordance with a contingency plan. In addition, this committee had the following functions within the project:

- To make strategic decisions regarding the project;
- To perform administrative and financial coordination;
- And to take responsibility to the EC in all matters related to the project: reports, communications, etc.

The **Partnership Agreement** was approved and signed by all partners involved in the project and was attached to the first progress report.

On July 2018 was requested to EASME an Amendment to the Grant Agreement, asking for an extension in the total duration of the project, in order to carry out all the activities initially planned and aimed to achieve the global objectives of the Project, activities that were delayed due to several factors. Instead the planned end date of the project on 30/09/2018, the consortium asked for an extension of 9 months, until 30/06/2019. On 12/10/2018 the consortium received a letter agreeing the request, as well as the amended C1, C2 and C3 forms of the Grant Agreement.



EUROPEAN COMMISSION

Subject: Letter Amendment Nr. 4 to Grant Agreement LIFE14 CCM/ES/001209 - "LIFE DEMOWAVE"

Reference: Your letter with enclosures dated 10 July 2018.

Dear Mr Tubío,

With reference to your above letter, I hereby inform you that the Executive Agency for Small and Medium-Sized Enterprises (the Agency) agrees to your request to modify the following:

The duration of the project in Art. I.2.2 of the grant agreement is extended for 9 months and shall run from 01/10/2015 to 30/06/2019. In consequence, time tables of A1, C1 (C1c – C1f), C2 and C3 Forms as set out in Annex II of the grant agreement are modified.

With the exception of the modifications introduced by the present amendment letter, all other provisions of the agreement as amended by letter amendment N° [2] and N° [3] remain in full force.

Your above mentioned letter and the present letter constitute amendment N° [4] to grant agreement LIFE14 CCM/ES/001209 and form an integral part of it. The present amendment takes effect as from the date of signature of this letter.

Please inform the associated beneficiaries of the project of the content of this letter.

LIFE14 CCM/ES/001209 - C3

TIMETABLE

Action number	Action / Name of the action	2015				2016				2017				2018				2019				2020			
		I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
A. Preparatory actions (if needed)																									
A.1	Análisis de tecnologías existentes y zonas geográficas de generación			■																					
B. Purchase / lease of land and / or compensation payments for use rights																									
C. Implementation actions (obligatory)																									
C.1	Diseño y fabricación de los prototipos de sistema de generación undimotriz			■	■	■	■	■	■	■	■	■	■	■	■										
C.2	Diseño e implementación del generador y regulación eléctrica			■	■	■	■	■	■	■	■	■	■	■	■										
C.3	Diseño e implementación sistemas de control y telemetría			■	■	■	■	■	■	■	■	■	■	■	■										
C.4	Estudio del sistema de amarre y estabilización de los generadores				■	■	■	■	■	■	■	■	■	■	■										
C.5	Montaje y puesta a punto en las zonas de extracción de energía							■	■	■	■	■	■	■	■										
C.6	Jornadas demostrativas							■	■	■	■	■	■	■	■	■	■								
D. Monitoring of the impact of the project actions (obligatory)																									
D.1	Seguimiento del impacto en la audiencia objetivo			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
D.2	Seguimiento del proyecto en el problema medioambiental			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
D.3	Seguimiento del proyecto de la eficiencia energética			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
E. Communication and dissemination of results (obligatory)																									
E.1	Página web			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
E.2	Paneles informativos Life			■	■																				
E.3	Informe Layman																	■	■						
E.4	Plan de difusión y materiales de comunicación			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
E.5	Eventos de difusión y transferencia			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
F. Project management and monitoring of the project progress (obligatory)																									
F.1	Gestión del proyecto			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
F.2	Seguimiento y Evaluación			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
F.3	Auditoria externa									■									■						
F.4	Networking con otros proyectos			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
F.5	Plan de comunicación posterior a Life																		■						

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Figure 1 - Letter of approval to the Amendment of the Grant Agreement and modified C3 form

6. Technical part

This section of the report covers the work carried out in all actions during the project, including dates and results, as well as deviations if applicable.

6.1. Technical progress, per Action

A. Preparatory actions

A.1 Analysis of existing technologies and production geographical areas		
Foreseen start date: 01/10/2015	Actual start date: 01/10/2015	
Foreseen end date: 31/12/2015	Actual end date: 15/05/2017	
Main tasks	**Responsible**	**%**
A.1.1 Identification and characterization of the zone with greater wave energy potential	Cetmar	100
A.1.2 Analysis of existing technologies	Quantum	100
A.1.3 Bathymetry analysis	HCTech	100
Deliverables and milestones	**Responsible**	**Deadline**
Deliverable: Report on possible locations of experimental sites. (Annex 9.1.7)	Cetmar	12/2015
Milestone: Identify at least 2 zones.	Cetmar	10/2015
Milestone: Permits Granted.	Cetmar	05/2017
Progress Indicators		**Value**
A.1.1 Data of physical, technical and environmental properties of different areas of the coast of Galicia		High
A.1.2 Technical Data of wave generation devices (number of analyzed / evaluated technologies)		10
A.1.3 Data from the bathymetry of the area: nautical chart, orthophotos, topography, previous studies, tides and weather forecast		High

Summary activities undertaken and outputs achieved:

This action started at the beginning of the project, and although it was necessary to extend its duration, is was finished having obtained the permits for the installation of the prototypes. CETMAR identified different areas for testing devices and prototypes for power generation in marine environment, and typified them based on the energy capacity, associated facilities and requirements for obtaining permits. Several trial areas were identified and permits application procedures were started for two of them, the experimental site of Punta Langosteira and the BIMEP at the Basque Country. The information for different locations is included in the deliverable A1 Possible locations for the installation of wave energy uptake on the Galician coast (Annex 9.1.7).

First option was from the beginning the site located in Galicia, due to the potential power and the proximity of the partners to the area. In addition, studies that quantify the power resource and environmental effects of prototypes installation were performed: protected areas and habitat, distance to the coast and bathing areas, visual impact, fisheries, seabed, freight traffic, and so on. On the other hand, HCTech performed the bathymetry for the evaluation of the conditions of the location. This information allowed the detailed knowledge about the seabed, as well as identifying areas for the location of moorings and quantifying its effect on the

seabed. The information for the bathymetric study is included in the document: A1 Bathymetry site Punta Langosteira (Annex 9.2.3). Within the scope of this action, a study of the state of the art was also made to identify current WEC devices designed for power generation based on the most relevant technologies (Annex 9.2.7)

Modifications regarding planning stated in the proposal:

In the first stage of the project, LifeDemoWave contacted the entity responsible of the site selected (Punta Langosteira), which is INEGA, in order to apply for the installation permits. To be granted, Inega required a in addition to the administrative forms, a technical report with detailed information about the prototypes (Project data, Technical data of prototypes, Structural requirements, Mooring system, Installation plan, dismantling, operation and maintenance, Security, Insurance and certificates,…). This requirement meant an incoherence with the original time schedule, were permits were supposed to be granted on 12/2015, but the final technical design was scheduled for 11/2016. In order to solve this contingence, it was adapted the technical form, including the final design and also the notes collected during the I Panel of Experts (11/2016). Permits form was delivered to INEGA on 1/3/2017.

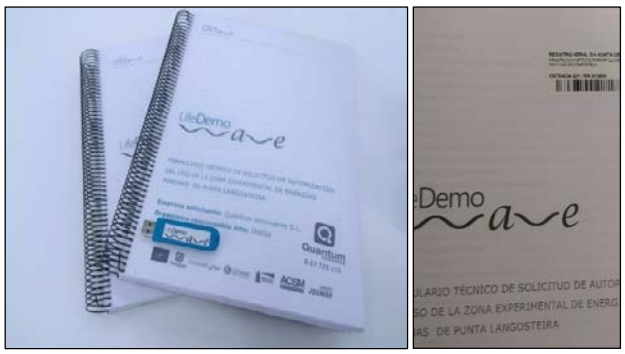


Figure 2: Technical Form required for Permits granting. Date: 01/03/2017

Installation permits were granted by INEGA on 15/05/2017, ending this action. This issue didn't cause any drawback on other actions, since the results obtained by the implementation actions (fulfilling his chronogram) were used in the redaction of the Technical Form required. As it was explained above, the project asked for an Amendment to the Grant Agreement, asking for an extension in the total duration of the project and the demonstration period. Since the permits were originally granted until October 2018, LifeDemoWave asked for an extension on permits duration, which was granted on 03/07/2018 and until 14/04/2019. (Annex 9.2.4)

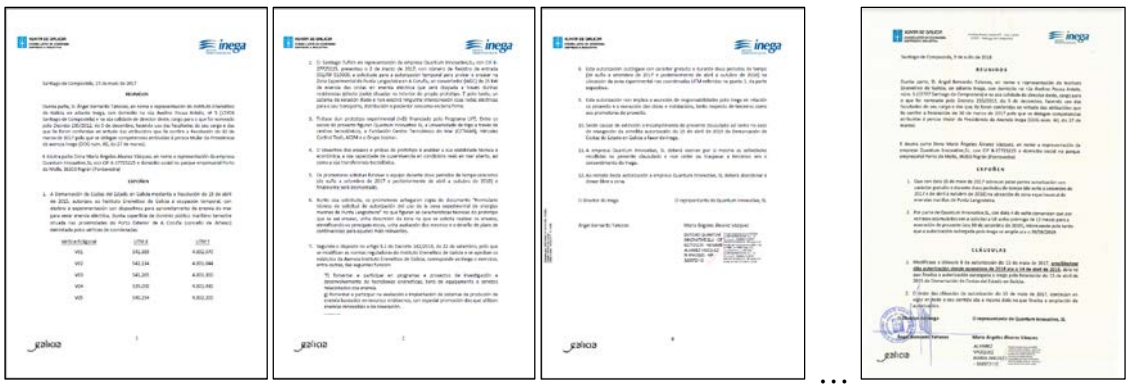


Figure 3: Installation Permits granted by INEGA in the production area for the project LifeDemoWave. Original Signature Date: 15/05/2017 – Extension permits granted until 14/04/2019

Perspective for continuing the action after the end of the project:

- The Technical Form developed is compatible with the format used, the required information and the regulations applied in other experimental sites (EMEC, BIMEP, etc.). In this way, the procedures to apply for in other experimental sites across Europe will be much more agile and with a device according to the parameters demanded in the international community.
- LifeDemoWave was the first prototype related to ocean energies tested in the Galician Region operating in a long period, turning into a pioneer and a flagged device to break down the barriers for this type of energy systems in an area with great wave energy potential.
- The data gathered from the site will allow to create a better correlation between the results of the project and the simulation and lab testing. The data also will be useful for other devices in the future that could be installed in Punta Langosteira.
- The state of the art compiled will empower a better comparative with the WECs in the international community.

C. Implementation actions

C.1 Design and fabrication of WEC prototypes		
Foreseen start date: 01/10/2015	Actual start date: 01/10/2015	
Foreseen end date: 30/09/2017	Actual end date: 30/09/2018	
Main tasks	**Responsible**	**%**
C.1.1 Manufacture the Prototypes	Josmar	100
C.1.2 Design of the buoy	HCTech	100
C.1.3 Design Wave Devices	UVigo/ QTM	100

Deliverable and Milestones	**Responsible**	**Deadline**
Deliverable: Technical Report and manufacturing drawings (Annex 9.1.18)	Uvigo	06/2018
Deliverable: Evaluation Report of results (Annex 9.1.41)	Uvigo	07/2018
Deliverable: Scalability Report (Annex 9.1.38)	Uvigo	08/2018
Milestone: Prototype Manufacturing, Control changes and assessment	Josmar	04/2019
Milestone: Scalability Report Redacted	Uvigo	08/2018

Indicators of progress	**Value**
C.1.1 Design proposals, definition of technical solutions and calculation	100%
C.1.2 Simulations, redesign and validation of the final design	100%
C.1.3 Manufacturing drawings and selection of commercial elements	100%
C.1.4 Prototype Manufactured, counselling and documentation changes	100%
C.1.5 Monitoring and evaluation of the manufacturing	100%
C.1.6 Scalability Report	100%

Summary activities undertaken and outputs achieved:

The objective of this action was to carry out the design and manufacture of the generation system prototypes.

Design Phase: The consortium worked on the design proposals, the definition of technical solutions (fragmentation, a balanced stresses distribution transportation and handling, system for improving the degree of irregularity and standstill periods, dynamic reaction system by water column isolation, creation of an isolated hull for the electric consumption, etc.) and the calculation basis obtaining the final design of the WECs allowing to pass to the manufacturing phase. Several adjustments were made to the original design in order to adjust to international regulations (DNV primarily), manufacturing issues and optimal performance.

Result of this activity is the deliverable “Technical Report and manufacturing drawings (annex 9.1.18)”. This document includes general specifications, stability study, materials, hydraulic system, mechanical system, integrity and floatability, structural requirements, internal environment, environmental issues, etc. In the following figures the final design and the studies carried out for the WECs are illustrated:

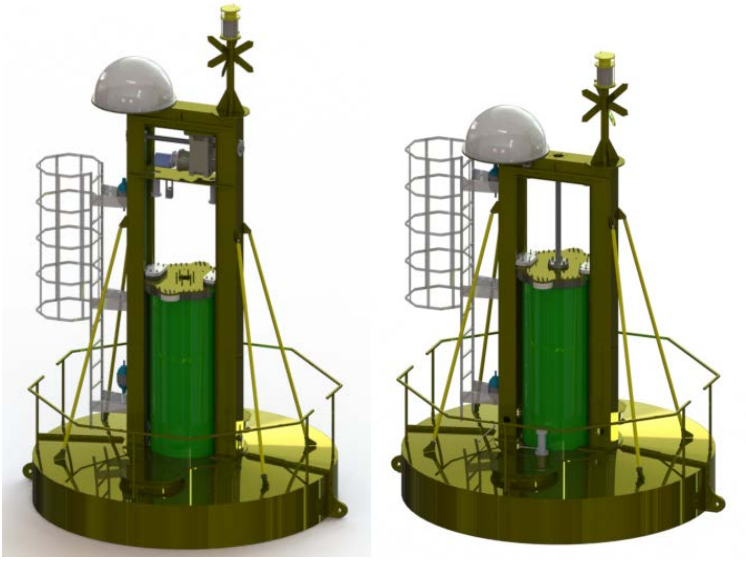


Figure 4: WECs designed

Manufacturing Phase: Once the design phase was completed, the different equipment was built and tested before moving to the site. This phase lengthened over time, impacting on the development of future actions. Because of this, a temporary extension of the schedule was necessary.

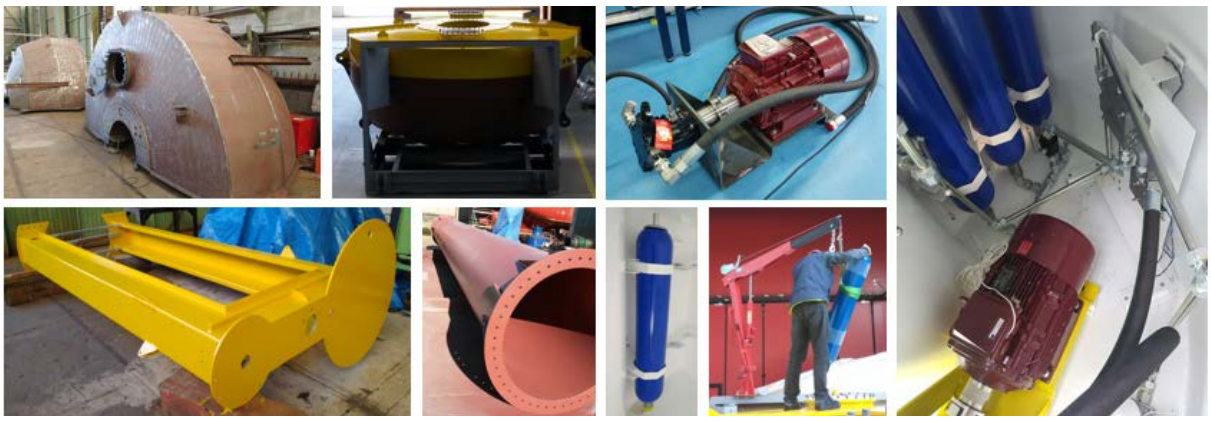


Figure 5: Equipment construction

Scalability for the replicability and transferability: The consortium worked on the setting of simulations and detailed design to optimize performance and integration of energy storage system, hydraulic system, electrical system, control system and telemetry. To complete the activity through virtual simulation calculation, the assembly was optimized and a 1/12 FROUDE scale model was tested for validation in a wave flume test created to this end in order to correlate the results between project-simulations-tests in lab. The main goal was the development of a scalability report (Annex 9.1.38) in order to be able to recreate conditions of other sites and predict its performance with different conditions. The high amount of tests made became more economically viable to create our own wave flume than to rent one.

Figure 6: Tests in lab

Modifications regarding planning stated in the proposal:

The development of this activity suffered several delays, especially regarding the construction and acquisition of the equipment, requiring an extension of the schedule to the European commission to guarantee the execution of the Project, as detailed in section *5. Administrative part* of this report.

Perspective for continuing the action after the end of the project:

The design obtained secures the sustainability, replicability and transferability of the project thanks to:

- Design according to the strictest **international standards**: *OS-C301 Standard "Stability and Watertight Integrity" Stability and Watertight Integrity; Offshore Standard DNV-OS-B101; DNV Certification Note 2.4 "Environmental Test Specification for Instrumentation and Automation Equipment; OS-D202 and Safety shutdown systems in OS-A10; etc.* All these standards are the one required in other high level sites like EMEC.
- Design **independent of environmental conditions** like the sea level (thanks to decoupling in the mooring system) and is able to operate from 2-15 meters of wave amplitude due to his dynamic reaction system by water column isolation.
- **Scalability Report** to recreate conditions of other sites and predict its performance.
- **Equipment selected** easy scalable to higher power

All this will help to set technical viability and an agile ability to adapt to new conditions and as a proof of concept to use it other emplacements.

C.2 Design and implementation of the generator and electric control	
Foreseen start date: 01/10/2015	Actual start date: 01/10/2015
Foreseen end date: 30/09/2017	Actual end date: 30/09/2018

Principal Tasks	**Responsible**	**%**

C.2.1 Design of electrical power generation subsystem	UVigo	100
C.2.2 Generator stockpile and integration design	Quantum	100

Deliverable and Milestones	**Responsible**	**Deadline**
Deliverable: Control and regulation system Report (Annex 9.1.22)	UVigo	03/2017
Milestone: Implementation of electrical subsystem and control	Uvigo	06/2018

Indicators of progress	**Value**
C.2.1 Generator/Converter Design	100%
C.2.2 Control algorithms and regulation Design	100%
C.2.3 Implementation of generator / converter and control system	100%
C.2.4 Set up and verification of the assembly	100%

Summary activities undertaken and outputs achieved:

The objective of this action was to design the electrical generation part of the wave energy converter system, as well as its associated regulation and control systems.

The tasks are grouped into two main blocks; on one hand, the design and implementation generation equipment; and on the other hand, the generation control. On the generation system, the consortium worked on the design of the conversion system of mechanical into electrical energy, the system for electric power extraction, the power generation control and the auxiliary systems. To summarize, the activities achieved during this action were:

- Single-line diagram Design
- Equipment selection and purchase: generators, batteries, protections, etc.
- Development of security systems according to DNV-OS-D201, earth protection, etc.
- Development of alerts system.
- Emergency power supply: batteries, photovoltaic panel system, etc.
- Electricity consumption by electric resistances battery
- Implementation thereof and in sensor system (related to monitoring task)
- Design of control algorithms for energy production optimization.

All this info has been gathered in the Deliverable: Control and regulation system Report (Annex 9.1.22). As a result, the equipment was implemented in the prototypes.

Figure 7: Prototype installation of equipment

Modifications regarding planning stated in the proposal:

The execution deadlines were modified according to the request for extension of the schedule as explained above.

Perspective for continuing the action after the end of the project:

The design obtained secures the sustainability, replicability and transferability of the project thanks to:
- Design in accordance with DNV-OS-D201
- New regulation system allows to operate in a wide range of waves
- Algorithms are scalable and compatible with databases such as SCADA

C.3 Design and implementation of control systems and telemetry

Foreseen start date: 01/11/2015	Actual start date: 01/11/2015
Foreseen end date: 30/09/2017	Actual end date: 30/09/2018

Principal Tasks	**Responsible**	**%**
C.3.1 Design and implementation of control systems and telemetry.	HCTech	100

Deliverable and Milestones	**Responsible**	**Deadline**
Deliverable: Technical report: sensoring system, control and telemetry (Annex 9.1.26)	UVigo	03/2017
Milestone: Implementation of telemetry subsystem	Uvigo	03/2018

Indicators of progress	**Value**
C.3.1 Operative sensoring system	100%
C.3.2 Operative control system	100%
C.3.3 Operative telemetry system	100%

Summary activities undertaken and outputs achieved:

The objective of this action was to design and implement the monitoring system.

The control system and telemetry developed for the buoy wave power generation was able to monitor the energy efficiency of the generators and the inertial movement of equipment, while it recorded images. Waves were also be characterized in real time for comparative study of energy efficiency. So, this action included three main goals described below:

Control systems and telemetry in the WECS
- Marine Signal Design: In accordance with IALA and OS-D202 and Safety shutdown systems in OS-A101
- Set of the parameters to monitor: Inertial Measurement, video on demand, bodies relative movement, electric system, etc.
- Selection of Sensors: Ultrasonic Sensor, IMU, GPS, Camera, Arduino
- Alerts System design

- Control System architecture design and Control System Algorithm Software based in framework opensource ROS.

All the final design was compiled in the *Deliverable: Technical report: sensoring system, control and telemetry. Annex 9.1.26*

Monitoring of waves in experimental site
- Buoy Bares of HCTECH selected and installed in Punta Langosteira.
- Test performed in Punta Langosteira to characterize the wave potential.

Monitoring of environmental impact of generators
- HCTECH Hidroboya system was selected to perform water quality control.
- Test performed in Punta Langosteira to set the baseline in noise level and water quality.

All these actions allowed to correlate the energy produced by the prototypes with the parameters of the wave and also to generate alarms in case of emergency. After the integration in the prototypes and perform the final tests, this action was concluded.

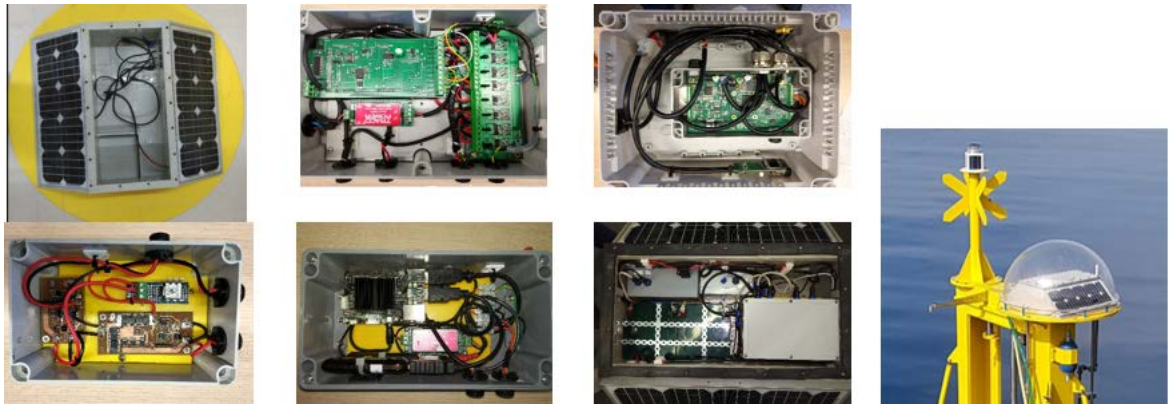


Figure 8: Systems integration

Modifications regarding planning stated in the proposal:

The execution deadlines were modified according to the Amendment to the Grant Agreement.

Perspective for continuing the action after the end of the project:

All the designs in this action can be extrapolated to other environments.

C.4 Mooring system design and WEC stabilization

Foreseen start date: 01/01/2016	Actual start date: 01/01/2016
Foreseen end date: 31/12/2017	Actual end date: 30/09/2018

Principal Tasks	**Responsible**	**%**
C.4.1 Mooring and stabilization design	Quantum	100
C.4.2 Acquisition of Mooring system	Quantum	100

Deliverable and Milestones	Responsible	Deadline
Deliverable: Mooring and stabilization technical Report (Annex 9.1.37)	Quantum	06/2018
Milestone: Stockpile of Mooring system	Quantum	06/2018
Milestone: Mooring Installation	Quantum	06/2018

Indicators of progress	Value
C.4.1 Load Cases	100%
C.4.2 Mooring Preliminary Design	100%
C.4.3 Mooring system Calculation	100%
C.4.4 Drawings of the mooring system	100%
C.4.5 Stabilization Preliminary Design	100%
C.4.6 Stabilization system Calculation	100%
C.4.7 Drawings of the Stabilization system	100%
C.4.8 Mooring Installation	100%
C.4.9 Mooring Stockpile	100%

Summary activities undertaken and outputs achieved:

This action was aimed to carry out the study of the system of mooring and stabilization of the prototypes. Activities carried out:

- Load distribution was evaluated based on several parameters (number of anchors, supports distances, length, use of floating intermediate points, …) in order to cover different locations and configurations in order to obtain the load cases.
- Stabilization system based on a multisection mooring to isolate the main buoy from the seabed and tides so it can operate at maximum potential.
- Location selection in the experimental site and UTM coordinates based in sea level and seabed composition:

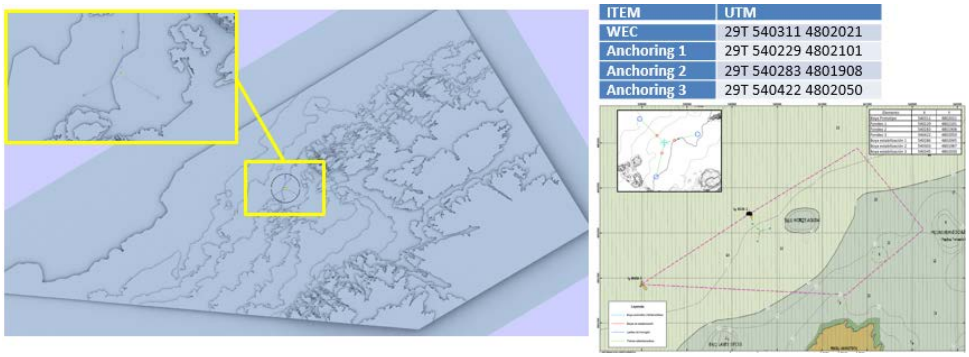


Figure 9: UTM coordinates for prototypes deployment

- Based on two different models, in operation (PTO) and in end (buoy), and with variable wave conditions, the consortium is working on defining the functional requirements for virtual simulations, performed using the ANSYS AQWA software, whose license belongs to CIMA group of University of Vigo for the mooring and stabilization calculation. The results include displacements and forces along time. Currently, maximum stress value is 15 tons, which is being used as an interim measure

for sizing, but this value will be updated according to design evolution. It is also being developed a scaled version to be evaluated by laboratory tests in the wave flume.

- Mooring Design based in the DNV-OS-E301 with intermediary buoy, decoupling of the seabed, catenary to absorb tides, ropes to minimize the mooring train weight, etc.

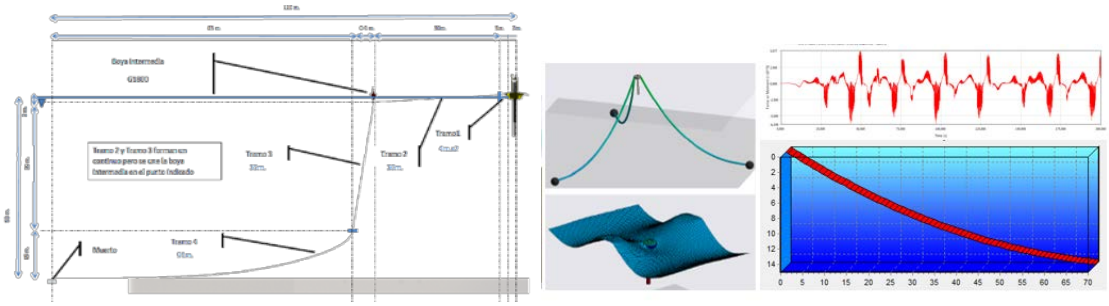


Figure 10: Mooring design

- Selection of the final chain, rope, deadweight, shackles, etc. already done.

As a result of the activity the components, were manufactured and acquired.

Figure 11: Mooring components

Modifications regarding planning stated in the proposal:

The execution deadlines were modified according to the Amendment to the Grant Agreement.

Perspective for continuing the action after the end of the project:

All procedures of calculation are applicable for other sites, and modifying the lengths of the different sections can be adapted to different locations. The equipment acquired for this action will be only useful in similar conditions, but the morphology is universal.

C.5 Installation and set-up in production geographical areas

Foreseen start date: 01/10/2016	Actual start date: 01/10/2016
Foreseen end date: 31/10/2017	Actual end date: 30/09/2018

Principal Tasks	**Responsible**	**%**
C.5.1 Mooring Execution	ACSM	100

C.5.2 Setting the telemetry system	UVigo	100

Deliverable and Milestones	**Responsible**	**Deadline**
Deliverable: Mooring and commissioning Report (Annex 9.1.32)	ACSM	06/2018
Milestone: Mooring Installation	ACSM	06/2018
Milestone: Testing and set-up of the prototypes in the site	ACSM	06/2018

Indicators of progress	**Value**
C.5.1 Mooring Installation	100%
C.5.2 Testing and set-up of the prototypes in the site	100%
C.5.3 Testing and set-up of the prototypes in the site Report	100%

Summary activities undertaken and outputs achieved:

The objective of this action was to carry out the implementation of prototypes at the experimentation site and its set up. The work carried out consisted of:

- Feedback between actions C4-C5. There are strong links between them since almost all the studies carried out within Action C5 were needed for the complete development of C4, due to the necessity of the inputs of ACSM for the design and study of the site. Every result from C4 was reflected in this deliverable.
- Ship selection for the maritime operation able to perform the manoeuvres with the associated requirements.

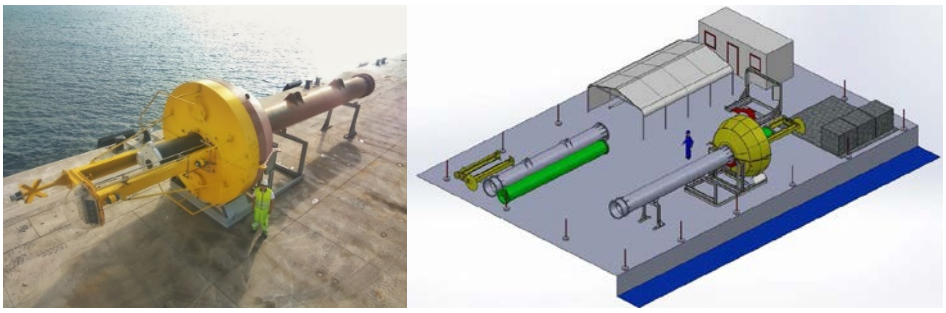


Figure 12: Planning and results of activities in the Port of A Coruña

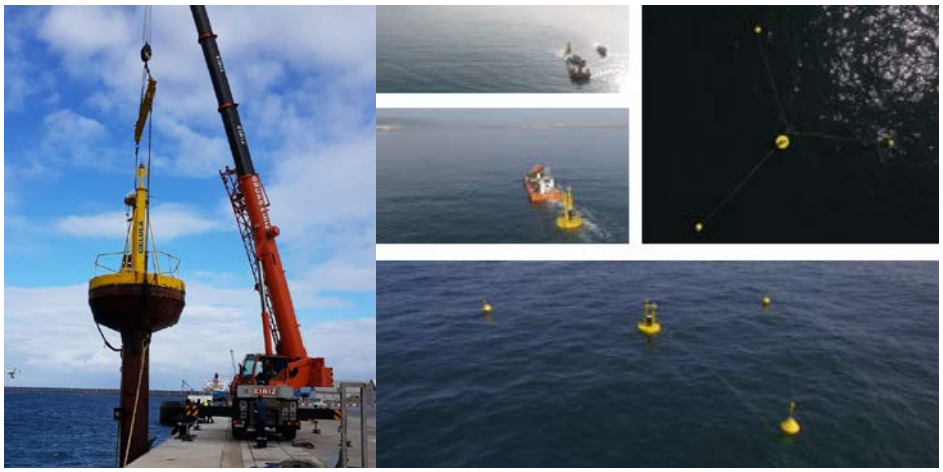


Figure 13: Installation of prototypes

- Study of the Puerto Exterior de Coruña: dock available, depth, cranes, etc. Final assembly study. Road transportation study.
- Mooring Installation, prototype installation and decommissioning plan redaction.
- Bid specifications redaction to get insurances (requirement for the permits)
- Selection and hiring of staff needed for the installation: divers, technicians, crane operators…, as well as verification of right climate conditions to perform the installation.

Equipment decommission was also included within the scope of the activity:

Figure 14: Decommission of prototypes

Modifications regarding planning stated in the proposal:

The execution deadlines were modified according to the request for extension of the schedule included in the Amendment to the Grant Agreement.

Perspective for continuing the action after the end of the project:

This action is very specific for the site although the road transport is in accordance with EU regulations (no need of special transport), the site will be reserved after–life to perform out more tests, and the plans redacted can be transferred to other sites.

C.6 Demonstration days

Foreseen start date: 01/01/2017	Actual start date: 01/01/2017
Foreseen end date: 31/05/2018	Actual end date: 30/04/2019

Principal Tasks	**Responsible**	**%**
C.6.1 Demonstration Days	Quantum	100

Deliverable and Milestones	**Responsible**	**Deadline**
Deliverable: Minutes and videos of the initial demonstration day of data gathering (Annex 9.1.23)	Quantum	03/2017
Deliverable: Minutes and videos of the midterm demonstration (Annex 9.1.39)	Quantum	08/2018
Deliverable: Minutes and videos of the final demonstration (Annex 9.1.44)	Quantum	03/2019
Milestone: Replicability Report	Quantum	03/2019
Milestone: Test Results Evaluation Report	Quantum	17/2018
Milestone: Initial Demonstration Days	Quantum	03/2017
Milestone: Intermediate Demonstration Days	Quantum	07/2018
Milestone: Final Demonstration Days	Quantum	03/2019

Indicators of progress	Value
C.6.1 Data gathering in the site	100%
C.6.2 Design proposals for the mechanical WEC	100%
C.6.3 Design proposals for the hydraulic WEC	100%

Summary activities undertaken and outputs achieved:

This action covered the development of demonstration days during the different stages of the project.

Initial demonstration days: They were organized several days of data collection in Punta Langosteira (A Coruña) to have real information on the environmental situation of the area. Throughout the different days, samples and data have been collected for further processing: underwater video recordings, submarine noise recording by hydrophones, samples of the seabed, real-time records of the properties of the water in a multiparameter probe and water samples for more specific analyses. The results were included in the "Deliverable: Minutes and videos of the initial demonstration day of data gathering" Annex 9.1.23. Below are shown some images of the initial demonstration days:

Figure 15: Initial demonstration days

Intermediate demonstration days: In June 12th a demonstrative event took place at the facilities of the port of A Coruña, where the prototypes were shown to the press and to different authorities and stakeholders. This event has been scheduled in accordance with the agenda of the Department of Industry of the Xunta de Galicia, and involved members of the Government of Galicia, Ports of Galicia and of Spain, INEGA, Maritime captaincy, Fisherman's associations, Industry stakeholders, etc. Attached to this report is included Annex 9.1.39 C6 Minutes and videos of the intermediate demonstration days.

Figure 16: Intermediate demonstration days

Final demonstration days took place in April 2019. The demonstration days included the exhibition of the prototypes installed on the Experimental Site of Punta Langosteira. Members of the consortium and of industries interested in the operation of the prototypes and their future scalability and exploitation participated in the demonstration days.

A second stage of the demonstration days included sampling in the experimentation zone, in order to make a comparison with the baseline and to study the real impact that the prototypes had on the environment during their installation and operation. Attached to this report is included Annex 9.1.44 C6 Minutes and videos of the final demonstration days.

Figure 17: Final demonstration days

Modifications regarding planning stated in the proposal:

The dates of demonstrative days were adjusted to the evolution of the project and the extension of the Schedule.

Perspective for continuing the action after the end of the project:

This task is ended at the close of the project, but the analysis of the data collected will allow to take decisions about future installations taking into account the impact generated on the environment.

D. Monitoring of the impact of the project actions

D.1 Monitoring of the impact on the public target of the project	
Foreseen start date: 01/10/2015	Actual start date: 01/10/2015

Foreseen end date: 30/09/2018	Actual end date: 30/06/2019

Principal Tasks	**Responsible**	**%**
D.1.1 Panel of Experts Reunions	Quantum	100
D.1.2 Stakeholders Identification	Cetmar	100

Deliverable and Milestones	**Responsible**	**Deadline**
Deliverable: Questionnaire model (Annex 9.1.29)	Quantum	07/2017
Deliverable: Panel of Experts Reunion Minutes (Annex 9.1.51)	Quantum	03/2019
Milestone: Panel of Experts Members Identification	Quantum	01/2016
Milestone: Panel of Experts Reunion I	Quantum	11/2016
Milestone: Panel of Experts Reunion II	Quantum	09/2017
Milestone: Panel of Experts Reunion III	Quantum	03/2019
Milestone: Panel of Experts Reunion IV	Quantum	06/2019

Indicators of progress	**Value**
D.1.1 Number Panel of Experts Reunions	4
D.1.2 Number of reports emitted	4
D.1.3 Number of members in the Panel	10
D.1.4 Number of Questionnaires filled	36
D.1.5 Number or administrations supporting the project	6
D.1.6. Number or companies interest in the construction	1
D.1.7. Number of suggestions received by the experts	17
D.1.8. Number of researchers asking for results of the project	15
D.1.9. Number of publications with the results of the project	1

Summary activities undertaken and outputs achieved:

The aim of this action was to monitor the impact that the project had on interest groups.

There have been identified and characterized entities in four different interest groups, with two main objectives: ensuring project success and guarantee of continuity. In each case, it has been set the most appropriate information method or most viable one, role in the project and chain value. Regarding Expert Panel Meetings, during these almost 4 years a total of 4 meetings have been held, as explained below.

- The first panel was held at the INEGA facilities (Galician Institute of Energy) in November 2016. Authorities responsible for the granting of installation permits participated in the Panel: INEGA, Ministry of Fisheries of the Xunta de Galicia, Meteogalicia and Demarcation of Coasts. In addition, participated other entities like the Zero Waste Association and Nodosa Shipyards, as well as project partners. The main theme of this meeting were the technical aspects of the design of the WECs prototypes and its impact on installation operations.
- The II Panel of Experts was held at the facilities of the Port Authority of A Coruña in September 2017. The debate focused on the implications of the installation of this type of equipment in port activities. The panel was attended by leading authorities of the Port of A Coruña and the Galician Institute of Energy, as well as members of the LifeDemoWave consortium.

Figure 18: Panels of experts

- The III Panel of Experts took place at the headquarters of the Provincial Federation of Fishermen's Associations of A Coruña, attended by the Authorities of such Federation and members of the consortium that develop the project. This panel of experts, developed in March 2019, discussed the implications that WEC devices may have on fishing and maritime activities.
- IV Panel of Experts took place in June 2019 and involved members of the consortium, external evaluation team and INEGA. During the panel, the activities carried out during the project, its results and its conclusions about the impact and future of this system and others related to wave energy were discussed, as well as the synergies that can be created between the renewable energy industry and other rooted ones such as the naval, as well as research centers.

Indicators have been almost fulfilled. Nevertheless, In the case of companies interested in the project (D.1.6), shipyards and workshops like Anvala and Nodosa have shown interest in future development of commercial devices, but the partners finally make an agreement with Cancelas shipyard in order to participate in the future development of OATWave (see After Life plan for details), so just one company is considered involved. Other companies like Ardentia Marine have shown interest in participate as well in future projects as adviser in commercial scale mooring operations. On the other hand, regarding commercial exploitation, Gas Natural and EDP were contacted by Quantum, but they prefer to keep themselves informed about the regard, but not to participate directly.

Publication numbers were as well not fulfilled as stated in the proposal (D.1.9), but there are expected more questions in the future since the results were published at the end of the project.

Regarding researchers asking for the project (D.1.8), they were usually researchers from universities and technology centers with scientific profile, interested in evolution and results

of the project, since there is not too much information regarding existing devices of WECs and their results.

Modifications regarding planning stated in the proposal:

Development of panels of experts were adjusted over time to the progress of technical activities in order to have proven information for the study and discussion between the consortium members and the entities involved and considered of interest.

Perspective for continuing the action after the end of the project:

This task was ended at the close of the project, but dissemination work will continue as detailed in the afterlife plan.

D.2 Monitoring of environmental impact

Foreseen start date: 01/10/2015	Actual start date: 01/10/2015
Foreseen end date: 30/09/2018	Actual end date: 30/06/2019

Principal Tasks	**Responsible**	**%**
D.2.1 Data collection	HCTech	100
D.2.2 Environmental Impact Assessment	Cetmar	100

Deliverable and Milestones	**Responsible**	**Deadline**
Deliverable: Baseline evaluation report (Annex 9.1.17)	Cetmar	10/2016
Deliverable: Monitoring report on environmental conditions (Annex 9.1.47)	Cetmar	03/2019
Milestone: Environmental Baselines defined	Cetmar	12/2016
Milestone: Completion of fieldwork for monitoring	Cetmar	03/2019

Indicators of progress	**Value**
D.2.1 Number of sites identified and baseline defined	1
D.2.2 Number of monitoring technologies evaluated	4
D.2.3 Number of devices monitored	2
D.2.4 Number of bathymetry	1
D.2.5 Number of water quality measurements	2
D.2.6. Number of hours of video recording	23
D.2.7. Number of attenuated wave measurements	0
D.2.8. Maximum variation of contaminants per cubic meter of water	0
D.2.9. Variation of chlorophyll per cubic meter of water	0
D.2.10. Ha of water affected	1
D.2.11. Underwater noise level (dB re 1 μPa)	110
D.2.12. Reduction of CO2 compared to the average generation in Spain (Tons of CO2/life)*	17,56
D.2.13. Reduction of other greenhouse gases compared to the average generation in Spain (CH4/N2O/NOx/COVNM/SOx/NH3/CO) (Kg/life)*	3,28/0,19/5,30/ 0,22/4,21 /0,00247/1,04
D.2.14. Total area affected by the project	1

**See 9.1.52 D3 Monitoring report for more details. Units were changed from a year to life of the prototype (15 years) for a more accurate measure of the emission reduction compared to the LCA. A value of 349.36 Tn CO2 was estimated for future prototypes with a correction described in 9.1.43. D3 Temporal measures results report.*

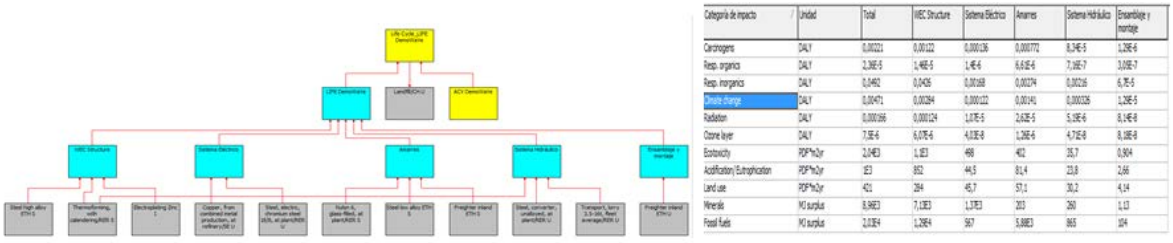
Summary activities undertaken and outputs achieved:

This Action was aimed to evaluate the environmental impact of the prototypes. In order to do so, at the beginning of the project it was made a study about the legislation that affects the project regarding environmental impact, identifying affected variables. After the evaluation of these data, a Contingency Plan was drafted.

During the demonstration stage of the project, a multiparameter probe was installed in order to record in real time different water parameters: temperature, conductivity, salinity, dissolved oxygen, turbidity and chlorophyll, data that is shown on the project website (14 months, 6 samples per day, which means about 2500 samples during the project; see http://www.life-demowave.eu/es/demostrative/environment_data/ for details). After analyzing the results of this monitoring activity, it can be concluded that the presence of the prototypes has not had any appreciable impact on the measurements.

In addition, an environmental monitoring of the water and the seabed was carried out: bathymetry, video recording, water quality analysis and analysis of sediment status; and wave measurements at the location set for the prototype. Part of this information can be found on the project website. The information regarding the preliminary analysis of the area affected by prototypes installation can be found in the Deliverable: Baseline evaluation report (Annex 9.1.17).

At the end of demonstrative stage, all collected data were included in the Monitoring report on environmental conditions (Annex 9.1.47). In this goal, the calculation of the carbon footprint, the life cycle of the prototypes and several impact categories were also selected. The collected data in this activities are shown as indicator 2.5.



Categoría de impacto	Unidad	Total	WEC Structure	Sistema Eléctrico	Amarres	Sistema Hidráulico	Ensamblaje y montaje
Carcinogens	DALY	0,00221	0,00122	0,000136	0,000772	8,34E-5	1,29E-6
Resp. organics	DALY	2,36E-5	1,46E-5	1,4E-6	6,61E-6	7,16E-7	3,09E-7
Resp. inorganics	DALY	0,0402	0,0426	0,00168	0,00274	0,00216	6,7E-5
Climate change	DALY	0,00471	0,00284	0,000122	0,00141	0,000326	1,29E-5
Radiation	DALY	0,000166	0,000124	1,07E-5	2,62E-5	5,18E-6	8,14E-8
Ozone layer	DALY	7,3E-6	6,07E-6	4,03E-8	1,26E-6	4,71E-8	8,18E-8
Ecotoxicity	PDF*m2yr	2,04E3	1,1E3	498	402	35,7	0,904
Acidification / Eutrophication	PDF*m2yr	1E3	852	44,5	81,4	23,8	2,66
Land use	PDF*m2yr	421	284	45,7	57,1	30,2	4,14
Minerals	MJ surplus	8,96E3	7,13E3	1,37E3	203	260	1,13
Fossil fuels	MJ surplus	2,03E4	1,29E4	567	5,88E3	865	104

Figure 19: LCA calculation

The results for the developed prototype are about 56 tCO2eq in the life cycle and an estimated value of 140 tCO2eq for a 200kW commercial device, value with some uncertainty due to scaling calculations.

After the study of all the data collected, the installed equipment did not represent variation in the quality parameters of the analyzed medium, data reflected in indicators D.2.8 and D.2.9. So, the result of the study is very positive in regard direct environmental impact of the equipment. Regarding reduction of GHG (D.2.12 and D.2.13), these indicators are

directly related to the energy got. In this case, since the equipment did not reach the estimated production capacity, the emission reduction is lower than that the expected and submitted in the proposal. Despite this, a LCA calculation was done aimed to compare with other devices, and the result is very competitive compared to other devices developed within initiatives that have a high degree of development and investment (See Apt 6.4, Environmental benefits section, for details.

Regarding D.2.6, video on demand was operational during full duration of demonstratives (124 days with prototypes installed, almost 3000 hours of video on demand). However, due to constraints in data transmission and storage, just between 10 to 15 minutes per day (about 23 hours during the whole project) were recorded, time enough to check the operation and the location of prototypes.

Regarding attenuation of waves (D.2.7), prototypes were installed during 124 days, but no influence in the waves was observed since one device has a negligible influence in this parameter. Anyway, an offshore area with commercial devices is still considered as an attenuator of waves in the coast near of it.

Area affected by the project (D.2.14) in considered null since it is limited to the extension of the site during the demonstration months, and no affected area is identified once the prototypes are withdrawn, as shown in KPI section of this report.

Modifications regarding planning stated in the proposal:

The duration of demonstrative was adjusted to the evolution of the project and the extension got after the Amendment to the Grant Agreement.

Perspective for continuing the action after the end of the project

This task is closed once the project was ended.

D.3 Monitoring of the energy efficiency

Foreseen start date: 01/10/2015	Actual start date: 01/10/2015
Foreseen end date: 30/09/2018	Actual end date: 30/06/2019

Principal Tasks	**Responsible**	**%**
D.3.1 Design of energy monitoring systems	UVigo	100
D.3.2 Integration in prototype of energy monitoring systems	Quantum	100

Deliverable and Milestones	**Responsible**	**Deadline**
Deliverable: Measurement acquisition and regulation report (Annex 9.1.42)	UVigo	10/2018
Deliverable: Temporal measures results report (Annex 9.1.43)	UVigo	10/2018
Deliverable: Monitoring report (Annex 9.1.52)	UVigo	05/2019
Milestone: Evaluation Report	UVigo	05/2019

Indicators of progress	**Value**
D.3.1 Analysis of buoy performance and adjustment of algorithms	100%

D.3.2 Evaluation of behaviour	100%
D.3.3 Produced energy	5670 kW
D.3.4 Minimum number of days of operation	124 days
D.3.5 Cost per prototype	4,75€/kWh
D.3.6. Cost per industrial model	6c€/kWh

Summary activities undertaken and outputs achieved:

This action is aimed to measure the energy got relating electric energy produced with measurements of wave's parameters.

The waves were monitored, making a characterization of the wave spectrum. Using the data collected during the monitoring phase, the dispersion diagram of Punta Langosteira is calculated. The result is a total annual energy of 273MWh per meter of wave front and a power of 31.2 kW per meter of wave front.

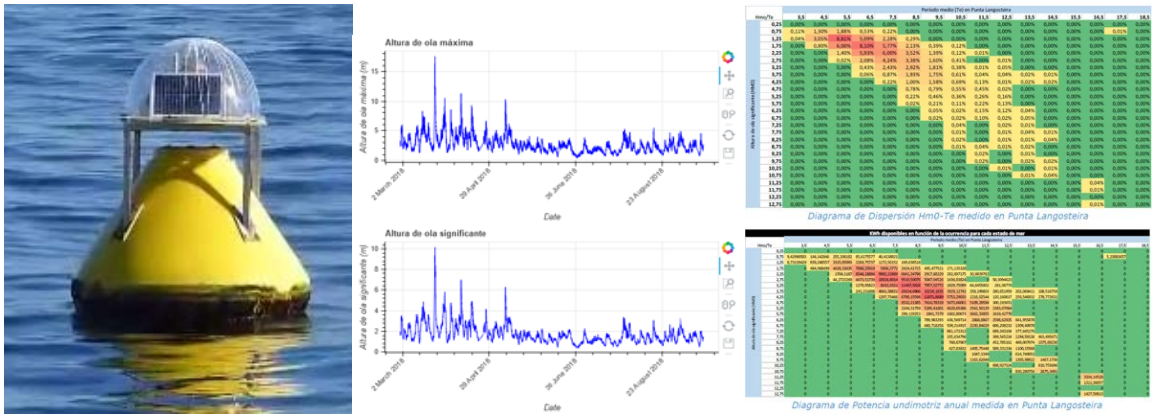


Figure 20: wave data from Langosteira experimentation site

Regarding the production data, due to a communication error, the production could only be recorded during the first stage of the demonstration, that correspond to weeks in which resource was lower than the design parameters of waves (between September and early December 2018). The data got for an average maximum height of 4-5 meters, average generation values are next to 3 kWh.

Based on the production data it was got the generation ability of the prototypes, and production tables were drawn up according to the waves recorded. The resulting energy production capacity is 5670 kW/year/prototype; this value was limited by issues related with the relative movement between flotation and inertial body. Future implementations already planned are aimed to get 94.68 MWh/year/prototype through the technical models updated. Those improvements are focused on implementation of new valve blocks aimed to reduce load losses and modifications in the reaction body to increase energy extraction ability.

The prototype has a very high inertia since it is designed for a nominal wave value of 12 meters, having a lower performance value for smaller waves. For new developments, based on the characteristics of the location, the reaction body must be adapted to adjust the performance of the equipment to the available resource.

Within the scope of the activity, a cost analysis was made related to the energy generated. LifeDemoWave would require modifications for devices aimed to commercial exploitation, and a great deployment to be competitive with current power generation technologies, which is the expectative. As for the current prototype, its cost is between 6.7 and 3.8 €/kWh, within the expected value by the European Union for 2020 and for these technologies. So continuing with these designs, the project is in the path to get competitive systems in 2050, which confirms LifeDemoWave is a step forward to approach to a TRL 9 level.

The cost per prototype (D.3.5) was high compared to the one calculated in the proposal, since the total energy produced was lower; but for commercial equipment it is expected a cost similar to that initially included in the proposal once improvements for commercial scale development included in Annex 9.1.43, apt.2.1 are implemented.

Modifications regarding planning stated in the proposal:

The duration of demonstrative was adjusted to the evolution of the project and the extension of the Schedule according to the Amendment to the Grant Agreement.

Perspective for continuing the action after the end of the project

This activity was completed with the closure of the project.

E. Communication and dissemination results

E.1 Project website	
Foreseen start date: 01/01/2016	Actual start date: 01/01/2016
Foreseen end date: 30/09/2023	Actual end date: 30/06/2024

Principal Tasks	**Responsible**	**%**
E.1.1 Web creation and maintenance	Quantum	100

Deliverable and Milestones	**Responsible**	**Deadline**
Deliverable: Web Description Report (Annex 9.1.5)	Quantum	12/2015
Milestone: Web Online	Quantum	12/2015

Indicators of progress	**Value**
E.1.1 Web insertions/month	2
E.1.2 Visits/month	300-500
E.1.3 Downloads via web	647

Summary activities undertaken and outputs achieved:

Related to the communication and dissemination actions, action E.1 consisted in the development of a website for the project. This goal was carried out as planned, so in the project website are the results obtained after the demonstration days, the environmental data collected and the conclusions obtained after completion of the project, as well as images, information about the partners, the Life program, etc. The website is described in Annex 9.1.5, LifeDemoWave project website. The content of the website is available in English and Spanish, http://life-demowave.eu/en/.

Modifications regarding planning stated in the proposal:

The action was started as planned, and website was kept active during the whole project, including the 9-month extension in the schedule, as requested in the Amendment to the LifeDemoWave Grant agreement approved by EASME.

Perspective for continuing the action after the end of the project:

The content of this webpage will be kept at least in the following 5 years after the end of the project.

E. 2 Life informative panels

Foreseen start date: 01/10/2015	Actual start date: 01/10/2015
Foreseen end date: 31/03/2016	Actual end date: 31/03/2016

Principal Tasks	**Responsible**	**%**
E.2.1 LIFE Panels Creation	Quantum	100

Deliverable and Milestones	**Responsible**	**Deadline**
Deliverable: LIFE Panels (Annex 9.1.10)	Quantum	12/2015
Milestone: LIFE Panels Installed	Quantum	12/2015

Indicators of progress	**Value**
E.2.1 Number of Life Panels	8
E.2.2 Number of queries resolved on the project	600

Summary activities undertaken and outputs achieved:

Action E.2, part of the dissemination activities of the project, consisted of the dissemination of the activities developed by the partners within LifeDemoWave by means of information panels included in visible areas of all partners' facilities. Panels were designed for each location and contents of each one of them are available on the deliverable, E2 Life information panels (Annex 9.1.10). The action was completed as planned and each partner has its own properly installed panel.

Modifications regarding planning stated in the proposal:

This action was completed with no modifications regarding the schedule.

Perspective for continuing the action after the end of the project:

The panels will remain installed after the project is closed.

E. 3 Layman report

Foreseen start date: 01/04/2018	Actual start date:
Foreseen end date: 30/09/2018	Actual end date:30/06/2019

Principal Tasks	Responsible	%
E.3.1 Layman's Report Redaction (Annex 9.1.54)	Quantum	100

Deliverable and Milestones	Responsible	Deadline
Deliverable: Layman's Report of the project	Quantum	06/2019
Milestone: Layman's Report available	Quantum	06/2019

Indicators of progress	Value
E.3.1 Layman's Report Printed	1.000
E.3.2 Layman's Report sent via email	1500
E.3.3 Layman's Report to stakeholders	25
E.3.4 Layman's Report downloads	10

Summary activities undertaken and outputs achieved:

The Layman Report was drawn up after the technical tasks of the project were completed, and its viability has been demonstrated, in order to explain its actions to the public. According to the timeline, this was done in the last quarter of the project and available in the website in both English and Spanish. Layman reports were also shared by mail to the whole scientific community of Vigo University, and contacts made during the projects; and in printed version during Final Event, as well they are available in partners' facilities to its dissemination.

Modifications regarding planning stated in the proposal:

The only modification to be highlighted in this phase is the 9-month delay in the schedule, as requested in the Amendment to the LifeDemoWave Grant agreement, approved by EASME.

Perspective for continuing the action after the end of the project

After the end of the Project, the distribution of the Layman report will continue.

E.4 Dissemination plan and communication materials

Foreseen start date: 01/10/2015	Actual start date: 01/10/2015
Foreseen end date: 30/09/2018	Actual end date: 30/06/2019

Principal Tasks	Responsible	%
E.4.1 Dissemination plan and communication materials creation	Quantum	100

Deliverable and Milestones	Responsible	Deadline
Deliverable: Dissemination plan and logo (Annex 9.1.2)	Quantum	10/2015
Deliverable: Brochure of the project (Annex 9.1.4)	Quantum	11/2015
Deliverable: Newsletter I (Annex 9.1.9)	Quantum	12/2015
Deliverable: Newsletter II (Annex 9.1.16)	Quantum	06/2016
Deliverable: Inserts in the media (Annex 9.1.19)	Quantum	12/2016

Deliverable: Newsletter III (Annex 9.1.21)	Quantum	12/2016
Deliverable: Newsletter IV (Annex 9.1.28)	Quantum	06/2017
Deliverable: Newsletter V (Annex 9.1.31)	Quantum	12/2017
Deliverable: Newsletter VI (Annex 9.1.35)	Quantum	06/2018
Deliverable: Newsletter VII (Annex 9.1.49)	Quantum	12/1018
Deliverable: Inserts in the media (Annex 9.1.40)	Quantum	12/2017
Deliverable: CD-ROM/DVD with project's results (Annex 9.1.45)	Quantum	06/2019
Deliverable: Newsletter VIII (Annex 9.1.60)	Quantum	06/2019
Deliverable: Publications (Annex 9.1.53)	Quantum	06/2019
Deliverable: Press releases of the end of the project (Annex 9.1.61)	Quantum	06/2019

Indicators of progress	**Value**
E.4.1 Number of brochures printed	2000
E.4.2 Number of brochures distributed	1800
E.4.3 Number of newsletters	8
E.4.4 Number of Specialized publications appearances	4
E.4.5 Number of Specialized publications distributed	1
E.4.6 Number of downloads of newsletters	247
E.4.7 Number of media appearances	93

Summary activities undertaken and outputs achieved:

The objective of this phase was the scientific dissemination of the progress and results of the project, for which different types of tools were used to attract the attention of the interest groups. Specifically, there was an active presence in the national and international press, resulting in more than a hundred insertions in the media, some of which are visited by more than 500,000 people daily.

Every six months, Newsletters have been published, both on social networks and on the project website, in which the progress made in each stage of the project was defined. Given the extension of the project approved by the Commission, it was considered appropriate to carry out two Newsletters more than the originally ones planned.
A total of 1864 brochures and other communication material was distributed in the different events that have been attended (fairs, congresses, networking days, information events, etc.)
The videos and publications made on Social Networks reached impressions of more than 1500 people as a whole.

Modifications regarding planning stated in the proposal:

The only modification to be highlighted in this phase is the 9-month extension in the schedule due to the Amendment to the Grant Agreement approved by EASME. For this reason it was decided to hold two additional Newsletters, in December 2018 and June 2019.

Perspective for continuing the action after the end of the project:

After the completion of the Project, it is intended to continue carrying out communication tasks, in which the communication materials left over from the project will be used.

E.5 Dissemination and implementation events	
Foreseen start date: 01/10/2015	Actual start date: 01/10/2015
Foreseen end date: 30/09/2018	Actual end date: 30/06/2019

Principal Tasks	**Responsible**	**%**
E.5.1 Dissemination and implementation events and conference attendance	Quantum	100

Deliverable and Milestones	**Responsible**	**Deadline**
Deliverable: Opening project event report (Annex 9.1.12)	Quantum	01/2016
Deliverable: Report of participation in LIFE days (Annex 9.1.36)	Quantum	12/2017
Deliverable: Closure project event report (Annex 9.1.58)	Quantum	06/2019
Deliverable: Media coverage of the events (Annex 9.1.57)	Quantum	06/2019
Deliverable: Report on the scientific community events (Annex 9.1.59)	Quantum	06/2019
Milestone: Opening project event	Quantum	01/2016
Milestone: Closure project event	Quantum	06/2019

Summary activities undertaken and outputs achieved:

This action was intended to disseminate the activities and results of the project, for which two high-visibility events took place: the opening of the project event and a final one, as well as LIFE press conferences, participation in scientific congresses and information seminars. Deliverable Media coverage of the events (Annex 9.1.57) compile information about the 33 events where LifeDemoWave participated, outstanding:

- The **inaugural event** was carried out on March 9th, 2016 in Miralles Building, University of Vigo. It was recorded by the media services of the University and can be seen at the URL: http://tv.uvigo.es/serial/index?id=2678. Associated deliverable: Opening project event report (Annex 9.1.12).

- The **closure even**t was carried out on 28 June 28th, 2019 in University of Vigo facilities. It was recorded by the media services of the University and can be seen at the URL: http://tv.uvigo.es. Associated deliverable: Closure project event report (Annex 9.1.58).

Modifications regarding planning stated in the proposal:

The only modification to be highlighted in this phase is the 9-month extension according to the Amendment to the Grant Agreement, approved by EASME.

Perspective for continuing the action after the end of the project:

After the completion of the Project, it is intended to continue carrying out communication tasks, participating in different dissemination events where the technology used, the results obtained and the environmental improvements that its industrial exploitation would entail will be announced.

F. Project management and monitoring of the project progress

F.1 Project management

Foreseen start date: 01/10/2015 Actual start date: 01/10/2015
Foreseen end date: 30/09/2018 Actual end date: 30/06/2019

Summary activities undertaken and outputs achieved:

This phase lasted the whole project, beginning in September 2015 and ending, after the approved extension, in June 2019. During this period a total of 4 Reports were sent to the European Commission, including this one. Within this action they were developed as well a management and contingency plan (Annex 9.1.3) and 8 committee meetings, of which the corresponding minutes are provided (Annex 9.1.6 /9.1.15 /9.1.20 /9.1.27 /9.1.30 /9.1.34 /9.1.46 /9.1.48).

Modifications regarding planning stated in the proposal:

Due to the extension and according to regulations of Life Programme, it was included and additional Progress Report regarding the planned ones.

Perspective for continuing the action after the end of the project

This Final Report ends the Action, three months after the closure of the project.

F.2 Monitoring and assessment

Foreseen start date: 01/10/2015 Actual start date: 01/10/2015
Foreseen end date: 30/09/2018 Actual end date: 30/06/2019

Summary activities undertaken and outputs achieved:

This action includes the assessment of the project. During its first stage it was developed, together with an external collaboration, an evaluation plan which can be found in Annex 9.1.13 F2 Evaluation Plan.

In May 2017 a Midterm Evaluation Report by an external evaluator have been redacted but approved late in June 2017 (to get feedback from the external monitoring team). Annex 9.1.25 to certificate the correct progress of the project and this stage.

In the last stage of the Project, the final evaluation report (Annex 9.1.56) was prepared to certify the completion of the project and the results achieved.

Modifications regarding planning stated in the proposal:

The dates of the deliverables were adjusted to the modification of the schedule requested by the consortium in the Amendment to the Grant Agreement.

Perspective for continuing the action after the end of the project:

With the delivery of the final report done by the external evaluator, this activity is concluded.

F.3 External audit

Foreseen start date: 01/01/2017 Actual start date: 01/01/2017
Foreseen end date: 30/09/2018 Actual end date: 30/06/2017

Summary activities undertaken and outputs achieved:

An auditor independent to the beneficiaries was hired to check the financial status of the project. This report is included as Annex 9.1.24 Audit report, certificating the costs incurred in the project at midterm evolution.

Modifications regarding planning stated in the proposal:

For the Final Report it was decided not to develop an audit since, according to Life Programme Regulations it was considered not necessary due to the budget and due to the audit expenses are not considered eligible expenses for the Life Programme.

Perspective for continuing the action after the end of the project

With the delivery of the Audit Report attached to Midterm Report, this activity was ended.

F.4 Networking with other projects

Foreseen start date: 01/10/2015 Actual start date: 01/10/2015
Foreseen end date: 30/09/2018 Actual end date: in progress (30/09/2018)

Summary activities undertaken and outputs achieved:

As part of this action, distribution lists were drawn up of target project managers with their contact information, as well as a presentation of the project (Annex 9.1.11 F4 Project presentation) to be sent to the members of the distribution list (Annex 9.1.8 F4 Distribution list and project networking links).

Project Blog, LinkedIn, Twitter, Facebook and YouTube channel were created for the project. Information about this tools is included in Annex 9.1.14.

During the project, different members of the consortium have attended more than thirty networking events and dissemination of the objectives of the project (See Annex 9.2.7); participated in online events; involved companies in the project, which results in networks with stakeholders / projects such as wave energy site administrators (EMEC, Langosteira and BimeP), Administrations (Consellería do Mar, MAGRAMA, Puertos del Estado, etc.), energy sector (Gas Natural, ENDESA, ...), projects (iSEAS, FireRS, ...), shipyards (NODOSA), wave energy networks (WavEC, REDEMAR, ...), research community (Universidade de A Coruña, MeteoGalicia), etc.

Regarding indicators of progress, it was developed a distribution list that was kept up-to-date regarding project evolution, and where anyone can sign up. More than 30 events were attended by LifeDemoWave partners, where project managers were contacted. As a result, 8 visits between projects were developed (See Annex 9.1.50 for details). LifeDemoWave counted as well with several 2.0 tools active: Twitter, Facebook, YouTube channel, LinkedIn and Blog, with more than 500 subscribers/followers together, being Twitter the more active and Blog the less one, with almost no activity. Website also includes links to several projects and entities, as a result of the networking activity developed.

Modifications regarding planning stated in the proposal:

The execution deadlines were modified according to the request for extension of the schedule included in the Amendment to the Grant Agreement.

Perspective for continuing the action after the end of the project

After the end of the Project and included in the regular activities of the partners, the consortium is undertaken to continue with dissemination and networking activities.

F.5 Post-Life communication plan

Foreseen start date: 01/06/2018 Actual start date: --
Foreseen end date: 30/06/2019 Actual end date: --

Summary activities undertaken and outputs achieved:

In the last stage of the project, an After Life plan was developed in order to plan future actions to continue disseminating the Project. Plan developed is attached to this document as Annex 9.1.62 and can be downloaded from website http://www.life-demowave.eu/en/.

6.2. Main deviations, problems and corrective actions implemented

Deviation/Problem	**Nature**	**Assessment Impact**	**Correction**
Delay from the foreseen end date. Milestone: Installation Permits	Incoherence with actual procedure	Although no action was impacted. Contingency plan was nearly activation.	Permits already granted.
Delay from the foreseen end date. Deliverable: Report simulation results	Technical. Change in the regulation system	No action is impacted.	No correction needed
Delay from the foreseen end date. Milestone. Panel of Experts Reunion I:	Technical-Stakeholders availability	A1 was highly dependent of this action	Panel of Experts already held
Delay in the construction of the buoy	Technical	Reduction of the demonstrative stage	Chronogram extension application.
Communications fail	Technical	Maintenance woks. Reduction of the demonstrative stage	Equipment withdrawal and maintenance woks. Evaluation of performance based on registered date.
Overruns	Financial	Without impact on execution	The consortium assumed unbudgeted expenses with own resources

6.3. Evaluation of Project Implementation

In order to evaluate the project implementation, an external evaluator was hired to assess methodology, results, effectiveness of the dissemination, etc… Detailed information is included in Annex 9.1.56 Final evaluation report, but a summary of this document is shown below.

Methodology applied is adequate sorting out the objectives of the project based on importance and their effects. Lists of indicators have been set to quantify the performance, and the results and these indicators were compared against the objectives and expected results foreseen in the proposal.

The operational, intermediate and global objectives were classified in a tangible way, and with them the expected effects as products, short-term results (within the project), and expected impact.

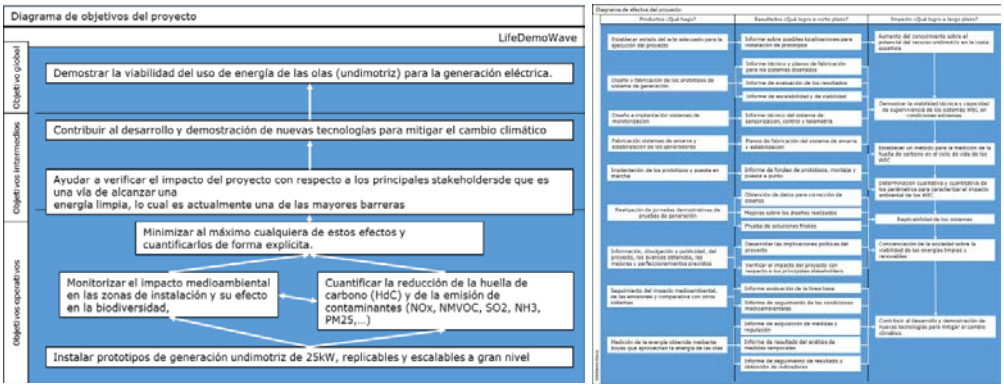


Figure 21: diagrams with project objectives

Two prototypes, designed in order to be easily scalable for future commercial exploitation, were installed for demonstration. That was done by means of:

- A study of the state of the art of WEC technology and of possible locations. As a result, it was got a report that implied an increase about knowledge of technology and resource, especially in the Galician coast.
- The design and development of prototypes of Power Take Off systems and floating buoys, design and installation of control and monitoring systems, and design and construction of mooring systems. The technical dossiers related and the deployment and installation activities resulted in the demonstration of technical feasibility and a proven ability of surveillance for the devices develop.

Environmental impact and effects on biodiversity were monitored as well, and at the same time, it was quantified the carbon footprint and emissions of GHGs. This was done by means of the development of a method for quantification of carbon footprint and the design of protocols aimed to measure quality water parameters in order to quantify the impact of prototypes on them, developing an evaluation between the baseline and the same parameters during and after implementation.

Demonstrative days were developed, and generation data collected, in order to analyse the ability for the use of these devices for power generation, as well as the study of improvements and future scalability and replicability.

It was monitored as well the impact on stakeholders, from industry and fishing community to public bodies; and networking and dissemination activities were performed. This way, policies implication were studied while the project contributed to the social awareness about climate change and the use of green energy in order to mitigate it.

The conclusion is that the project was concluded as expected, while it is true with an extension requested in the Amendment to the Grant Agreement. It can be said that, by means of the activities developed, the results short-term and the study of the impact, the project fulfil the main objectives: to demonstrate de feasibility of wave energy converters as a way to generate power energy; and to contribute to development and demonstration of new energy sources aimed to the mitigation of climate change.

The effectiveness of the dissemination is considered correct, with more than 30 dissemination events performed, more than 90 media releases, different dissemination material (panels, leaflets and Layman report), active website and 2.0 tools, meetings with entities and projects related, and panels of experts involving public bodies and industries that could increase their business towards renewable energies, others such as fisheries that may be affected,

The Policy impact in the different areas involved is shown in Point 6.4, detailing for each case the challenge addressed and the contribution made from LifeDemoWave. In this case, the impact is not immediate, but must be assessed in the future. But it should be noted that LifeDemoWave addressed several challenges and directives. It was quantified the power potential of one of the areas within the EU with the highest energy per meter of wave front (Galician Coast), helping the EU to calculate the quota that these equipment could hold in the future for energy consumption, aligned with Directive 2009/28 / EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources. It was also analyzed the environmental impact on the ecosystem by measuring noise, pollution in the water column and effect on the seabed, aligned with Blue Energy Action needed to deliver on the potential of ocean energy in European seas and oceans by 2020 and beyond /* COM/2014/08 final */. And it was monitored the environmental impact of WECs on fishing sector, aligned with EU Water Framework Directive - "Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy".

Regarding replication efforts, they are more detailed in Point 6.4 of this document.

6.4. Analysis of benefits

Benefits are analyzed taking into account several aspects like environmental and economic ones. Following are shown the results.

Environmental benefits

- Reduction of greenhouse gas emissions. A study of the LCA was carried out to be able to compare to other devices. It is important to consider that there is not too much information at regards experimental devices of WECs, neither from energy production, nor for LCA calculation. Nevertheless, PB3 from PowerBuoy (one of the initiatives with the greatest investment so far) declares productions of 1MW since installation (source: https://marineenergy.biz/2019/05/17/ watch-eni-deploys-opt-powerbuoy-in-adriatic-sea/), while LifeDemoWave prototypes, have generated 5,76 MWh. And although LCA calculation of PB3 is not available, weight should be a good indicator; and PB3 is about 8,3 Ton while LifeDemoWave weights about 13 Ton. That means an improvement of 300% of the ratio production / carbon footprint to the WECs with higher TRL (technology readiness level), which is a scale that shows the level of development of a particular technology, from basic principles to systems tested successfully in real environment.
- Ecological status - water pollutants. Environmental status - marine and coastal waters.

The measures developed in the evaluation of the baseline, and later in the days of data collection in the final phase of the demonstrations, all of them referred to bathymetry, wave parameters and measure of contaminants in the water, reflect a null impact on the area where prototypes have been installed. As for the noise levels, unfortunately it was not possible to record the noise generated directly during operation, but data was extrapolated from the site as a baseline mixing all equipment noise measured in operation in lab. The impact was assessed with a level of error, but the low values measured compared to the levels that could affect to the fauna allow us to conclude that the noise level is within the range of any oceanographic buoy in operation and far from dangerous levels for the ecosystem.

- Long term sustainable technology: As was detailed in this document, the technology is adjusted to international regulations.
- Transfer of the methodology implemented: The procedure used for the TDR was adopted by INEGA for future applicants, helping LifeDemoWave to INEGA in order to speed up new projects in the area.
- Future impact on EU environmental policy and legislation: experimentation area (Punta Langosteira) has high fishery activity and is very sensible to new offshore operations. The feedback got from fishery associations could lend to policies to not harm this market so the two industries can coexist.

Economic benefits,

- A reduction of CAPEX compared to other similar technologies due to low submerged mass, a better production/weight, a new hybrid mooring system, no phase control required to keep the balance, installation similar to oceanographic buoys.
- A reduction of OPEX due to easy maintenance and access, transport viable from dock-site full-assembled, no undersea operations or machinery, no unreliable mooring system.

Social benefits

The project was able to involve shipyards to manufacture the buoys and interest themselves in the development of future commercial devices, expanding this way its current market (naval industry is shrinking) triggering positive effects on employment with a clean energy solution.

Replicability, transferability, cooperation:

- Design adjusted to international regulations of DNV.
- Manufacturing with international certification.
- TDR in the same format as it is required in the strictest sites.
- Water flume correlation and simulations developed to replicate different conditions.
- A dedicated water flume for the project to test different emplacements as required.
- Devices able to operate in are with different depths thanks to the design of the mooring system.
- Devices able to work in a wide range of wave conditions thanks to the dynamic resistive body based in water column isolation (more amplitude more relative dynamic between bodies). The same prototype can work in different locations without adjustments.
- Equipment easily scalable to higher power.
- Area with high fishery market. Proof of concept of coexistence of both markets with no interference.
- Contact s with other site managers: EMEC and BIMEP.
- Local and regional administrations involved.

Best Practice lessons:

- The procedures developed, together with INEGA, for the placement of equipment of these characteristics in the marine environment are currently used by the site manager as protocols for future procedures.
- At the level of mechanical design, the modularity of the system reduces assembly and maintenance time and this design premise will be kept for future developments.
- The communication protocols used, the data management logic and the web application that allows to know and act on the prototypes, serves as base document for new developments.
- Environmental and wave monitoring systems are a standard and are being used in several locations thanks to the participation of HCTech in the project.
- Regarding mechanical design, the modularity of the system allows to reduce assembly and maintenance cost. This design premise will be kept for future developments and, given the hardness of operation environment, it should be transferred to many other equipment operating in difficult to access environments.

Innovation and demonstration value:

The project was able to demonstrate the feasibility to install the devices developed, as well as to prove the survival ability in hard conditions. The hydraulic PTO has proven its ability to generate energy, even it was with a low performance. It is thought that the main reason for this performance is the design of the inertial body, but in any case, the project can be considered as a proof of concept of a new technology for clean energy production.

Policy Implications:

- Compliance with national Climate Change Mitigation plans (Spanish Renewable Energy Plan 2011-2020). LifeDemoWave will contribute to this plan by providing a technical demonstration, as well as a socio-economic and environmentally viable solution for WEC, for a commercial solution in the plan by 2026.
- Alignment with Directive 2009/28 / EC of the European Parliament, which sets a common framework for the promotion of energy got from renewable sources by 2020 (20%). In the long term, the "energy strategy 2050" sets 30% of renewable energy sources for 2030. LifeDemoWave will offer a solution for member countries to comply with those requirements and policies.
- Contribution to the action plan "Blue energy: necessary action to harness the potential of ocean energy in the European seas and oceans by 2020 and beyond" by the European Commission. LifeDemoWave will provide technical support to unlock wave energy potential.
- Compliance with the Water Framework Directives (2000/60/EC) and Directive 2008/56/EC for the installation, operation and monitoring of environmental impact. LifeDemoWave was intended to preserve the environmental state of water and facilitate international replicability.
- Support for the preparation and development of legislation in terms of renewable energy and climate change mitigation policies. LifeDemoWave will provide documentation, knowledge and experienced members to the competent authorities.
- Blue Energy Action needed to deliver on the potential of ocean energy in European seas and oceans by 2020 and beyond /* COM/2014/08 final */. LifeDemoWave through the A1 action, in collaboration with the Galician Energy Institute (INEGA) has contributed to the creation of the procedural documentation that will be required for future installation of wave energy converters in one of the regions with highest potential

marine energy. Guidelines have been obtained to facilitate the application of relevant legislation and to assist in the management of maritime space in Galicia and which will serve as a basis for the future.

- Directive 2009/28 / EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources. LifeDemoWave has contributed to quantify the potential of one of the areas within the EU with the highest energy per meter of wave front, the temporality and the space suitable for the installation of this equipment. With a greater installation factor, it will help the EU to calculate the quota that these equipment could hold in the future for energy consumption.
- Blue Energy Action needed to deliver on the potential of ocean energy in European seas and oceans by 2020 and beyond /* COM/2014/08 final */. LifeDemoWave, in collaboration with the Port of A Coruña, has carried out a plan to expedite the authorization and licensing procedures in the future deployment of wave equipment in one of the regions with the greatest marine energy potential. As well through action D2, has analyzed the environmental impact on the ecosystem in different phases of use by measuring noise, pollution in the water column and effect on the seabed.
- EU Water Framework Directive - "Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy". LifeDemoWave through action D2 has carried out environmental monitoring quantifying the impact of these equipment and influence on the local fishing sector. This and other elements identified will serve for an extension of the measures and data collection that should be written in future directives for the protection of the marine environment.
- Spanish National Plan of Renewable Energies 2011-2020. LifeDemoWave has provided data for future deployment of commercial devices in Galicia and its power potential, as well as easing the effect on restrictions due to fisheries and maritime traffic sectors.
- Galician Strategic Plan 2015-2020. LifeDemoWave in collaboration with INEGA and through the realization of events and diffusion work, has managed to expose the wave energy power in Galicia to the public and researchers that would suggest a diversification in energy with a low effect on the natural environment.

As general conclusion, it can be said that LifeDemoWave has shown promising results, with high survival behaviour in extreme wave conditions, a compact and non-aggressive anchoring system; low costs in both CAPEX and OPEX (thanks to its ease of access for maintenance and minimal submerged mass); and competitive returns at generation level compared to similar technologies for a TRL 5.

This project has been another step towards obtaining alternative clean energy, future versions that can be optimised thanks to hydrodynamic behaviour correlated with sea simulations and trials. The goal is to increase the scale of production and create wave energy parks to obtain in future iterations the desired TRL 9 with a competitive LCOE compared to other energy sources.

7. Key Project-level Indicators

Following are shown the identified indicators applicable for the LifeDemoWave project:

INDICATOR	1.5.	Project area/length:		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0	1	0	ha

Comments: The area affected by the project is limited to the extension of the site during the demonstration months, and no affected are is identified once the prototypes are withdrawn.

INDICATOR	1.6.	Humans (to be) influenced by the project:		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0	100	40	Others regularly present in the project area (employees, students)
	0	200	300	Persons concerned by the project independent of the project area
	0	400	500	Visitors to the project area

Comments: Population resident in the project area is considered not to be directly influenced by the project. Visitors include professionals operating in the area.

INDICATOR	2.2.	Aquatic extent affected by the pressure or risk addressed		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0	0	0	ha

Comments: The affected area is limited to the extension of the site, but the project did not imply any risk within it.

INDICATOR	2.3.6.	Point source pollution		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0	0	0	g/year

Comments: The presence of hydrocarbons in the marine environment, measured through NTUs before and after installation, has not suffered any change.

INDICATOR	4.1.3.	Renewables production		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0	5670	5670	kWh/year

Comments: Based on the production data it is got the generation ability of the prototypes, and production tables were drawn up according to the waves recorded. The resulting energy production capacity is 5670 kW/year/prototype. This value was limited by issues related with the relative movement between flotation and inertial body. Future implementations already planned are aimed to get 94.68 MWh/year/prototype through the technical models updated.

INDICATOR	5.2.2.	Noise level frequency – under water noise		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	90	110	90	dB re µPa RMS (1/3 octave band 125 Hz centre frequency)

Comments: As for the noise levels, unfortunately it was not possible to record the noise generated directly during operation, but data was extrapolated from the site as a baseline mixing all equipment noise measured in operation in lab. The impact was assessed with a level of error, but the low values measured compared to the levels that could affect to the fauna allow us to conclude that the noise level is within the range of any oceanographic buoy in operation and far from dangerous levels for the ecosystem (See Wave energy and underwater noise: State of art and uncertainties DO - 10.1109/OCEANSE.2009.5278302 for more details).

INDICATOR	8.1.1.	CO2		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0,246	0,246	0,246	Kg CO2/kwh
	0,00	0,00	0,00	Tons of CO2/year

Comments: In 2017, the reference for emissions in the Factor Mix of Energy Production in Spain was 0,246 Kg CO2/kWh (see annex 9.1.52 Monitoring Report). Regarding emissions, energy generation was lower than expected (5670 kWh/year/prototype), and generated electricity was not utilised. Therefore the project had no actual impact on CO2 emissions reduction and values under climate action of the LIFE KPI database are set to zero both at the beginning and after the end of the project.

Note: The weighted value with the Total of Spain will be negligible, so only it was used as an indicator.

INDICATOR	8.1.2.	CH4		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0,04	0,04	0,04	Kg GHG/kwh
	0,00	0,00	0,00	Kg GHG/year

INDICATOR	8.1.2.	N20		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0,0027	0,0027	0,0027	Kg GHG/kwh
	0,00	0,00	0,00	Kg GHG/year

Comments: Kg/kWh is the national average used only as reference, as the production will be negligible.
Regarding emissions, generated electricity was not utilised and therefore the project had no actual impact on emissions reduction. Due to that, values under climate action of the LIFE KPI database are set to zero both at the beginning and after the end of the project.

INDICATOR	10.1.2.	Regional authorities involved		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0	6	6	Number of bodies involved

INDICATOR	10.2.	Stakeholders involved		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	2	5	5	Number of stakeholders involved; other
	0	8	14	Number of stakeholders involved; private for profit
	1	6	6	Number of stakeholders involved; public bodies
	0	1	2	Number of stakeholders involved; NGOs

INDICATOR	11.1.	Website		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0	15074	18000	Number of unique visits
	0	3213	5000	Number of individuals
	0	647	1000	Number of downloads
	0	3	2	Average visit duration (minutes)

INDICATOR	11.2.	Other tools for reaching/raising awareness of the general public		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0	10	10	Publications / reports
	0	8	8	Posters / panels
	0	30	32	Print media
	0	11	11	Other media (video)
	0	1	1	Hotline / information centre
	0	8	10	Events / exhibitions

INDICATOR	12.1.	Networking		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0	8	14	Professionals

INDICATOR	12.2.	Professional training or education		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0	100	220	Professionals

INDICATOR	13.	Jobs		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0	6	6	Number of FTE

INDICATOR	14.1.	Running/operating costs during the project and expected in case of continuation		
Indicator Values	At the beginning	At the end	Beyond 5 years	Units
	0	1893197	2250000	€

INDICATOR	14.2.2.	Operation expenses expected in case of continuation
Indicator Values	Beyond 5 years	Units
	315000	€

INDICATOR	14.3.	Beneficiaries' own contribution
Indicator Values	Beyond 5 years	Units
	150000	€

INDICATOR	14.4.2.	Entry into new sectors
Indicator Values		D3511 – Production of electricity

Comments: future development of the project must involve the introduction of partners in the energy sector, in addition to those to which they already belong.

INDICATOR	14.4.3.	Entry into new geographic areas
Indicator Values		United Kingdom - Scotland

Comments: future developments are intended to be tested in EMEC facilities.

8. Comments on the financial report

8.1. Summary of Costs Incurred

PROJECT COSTS INCURRED				
	Cost category	Budget according to the grant agreement in €*	Costs incurred within the reporting period in €	%**
1.	Personnel	1.211.775,00 €	1.362.284,10 €	112,42 %
2.	Travel and subsistence	62.562,00 €	16.399,19 €	26,21 %
3.	External assistance	101.600,00 €	102.987,47 €	101,37 %
4.	Durables goods: total non-depreciated cost			
	- *Infrastructure sub-tot.*	19.400,00 €	42.255,55 €	217,81 %
	- *Equipment sub-tot.*	18.350,00 €	24.806,90 €	135,19 %
	- *Prototype sub-tot.*	135.600,00 €	157.398,49 €	116,08 %
5.	Consumables	26.600,00 €	19.316,00 €	72,62 %
6.	Other costs	34.900,00 €	49.784,09 €	142,65 %
7.	Overheads	112.751,00 €	117.965,86 €	104,63 %
	TOTAL	1.723.538,00 €	1.893.197,65 €	109,84 %

*) If the EASME has officially approved a budget modification through an amendment, indicate the breakdown of the revised budget. Otherwise this should be the budget in the original grant agreement.
**) Calculate the percentages by budget lines: e.g. the % of the budgeted personnel costs that were actually incurred

Calculation methodology for the daily rates was based in real costs. Unit rates calculation is specified in the financial annex.

9. Annexes

9.1. Deliverables

The following deliverables are attached to this report as digital files:

9.1.1. F1 Minutes of the kick-off meeting*
9.1.2. E4 Dissemination Plan (Logo)*
9.1.3. F1 Management and Contingency Plan*
9.1.4. E4 Project leaflet*
9.1.5. E1 LifeDemoWave project website*
9.1.6. F1 Minutes of meetings of the project committees (I)*
9.1.7. A1 Possible locations for the installation of wave energy uptake on the Galician coast*
9.1.8. F4 Distribution list and project networking links*
9.1.9. E4 Project newsletter (I)*
9.1.10. E2 Life informative panels*
9.1.11. F4 Project presentation*
9.1.12. E5 Report on opening event*
9.1.13. F2 Evaluation Plan*
9.1.14. F4 Project blog, LinkedIn and Twitter*
9.1.15. F1 Minutes of meetings of the project committees (II)(III)*
9.1.16. E4 Project newsletter (II)*
9.1.17. D2 Evaluation Report on the base line in the selected zones for the installation of the wave energy converters*
9.1.18. C1 Technical Design Report (TDR) and manufacturing drawings*
9.1.19. E4 Media appearances*
9.1.20. F1 Minutes of meetings of the project committees (IV)*
9.1.21. E4 Project newsletter (III)*
9.1.22. C2 Regulation and Control of Electric Power Systems*
9.1.23. C6 Initial awareness session. Minutes and audio-visual data*
9.1.24. F3 Audit Report*
9.1.25. F2 Midterm Evaluation Report*
9.1.26. C3 Telemetry & Monitoring System*
9.1.27. F1 Minutes of meetings of the project committees (V)*
9.1.28. E4 Project newsletter (IV)*
9.1.29. D1 Questionnaire model*
9.1.30. F1 Minutes of meetings of the project committees (VI)*
9.1.31. E4 Project newsletter (V)*
9.1.32. C5 Mooring and commissioning report*
9.1.33. C2 Simulation results*
9.1.34. F1 Minutes of meetings of the project committees (VII)*
9.1.35. E4 Project newsletter (VI)*
9.1.36. E5 Report of Life Week attendance*
9.1.37. C4 Mooring and stabilization technical report*
9.1.38. C1 Scalability report
9.1.39. C6 Minutes and videos of the intermediate demonstration days*
9.1.40. E4 Media appearances*
9.1.41. C1 Prototypes results evaluation report
9.1.42. D3 Measurement acquisition and regulation report

9.1.43. D3 Temporal measures results report
9.1.44. C6 Minutes and videos of the final demonstration days
9.1.45. E4 CD-ROM with project´s results
9.1.46. F1 Minutes of meetings of the project committees (VIII)
9.1.47. D2 Monitoring report on environmental conditions
9.1.48. F1 Minutes of meetings of the project committees (IX)
9.1.49. E4 Project newsletter (VII)
9.1.50. F4 Project visits report
9.1.51. D1 Minutes of meetings of Panels Experts
9.1.52. D3 Monitoring report
9.1.53. E4 Specialized publications
9.1.54. E3 Layman's Report of the project
9.1.55. F3 Audit Report
9.1.56. F2 Final evaluation Report
9.1.57. E5 Media coverage of the events
9.1.58. E5 Closure project event report
9.1.59. E5 Report on the scientific community events
9.1.60. E4 Project newsletter (VIII)
9.1.61. E4 Press releases of the end of the project
9.1.62. F5 After-LIFE Plan

9.2. Other documents

9.2.1. F1 Information or clarifications, requested in previous letters from the EASME
9.2.2. E4 Corporate identity*
9.2.3. A1 Bathymetry site Punta Langosteira*
9.2.4. A1 Installation Permit granted by INEGA*
9.2.5. F1 General project evolution
9.2.6. F1 Changes in University of Vigo management team*
9.2.7. A1 State of the art of relevant WEC technologies*
9.2.8. C1 Photographic report of equipment installed in prototypes
9.2.9. D1 Communications with fishery sector*
9.2.10. E4 Animations

9.3. Financial documentation

(*) Marked Deliverables and Documents were already sent in previous reports.