

Final report

1.1 Project details

Project title	Weptos Offshore #1
Project identification (program abbrev. and file)	Energinet.dk project no. 2015-1-12318
Name of the programme which has funded the project	ForskVE
Project managing company/institution (name and address)	Weptos A/S, Prins Georgs Kvarter 11, 7000 Fredericia
Project partners	AAU, Kuni, Rasgaard Group
CVR (central business register)	15649089
Date for submission	26.11.2017

1.2 Short description of project objective and results

1.3 Executive summary

1.4 Project objectives

1.5 Project results and dissemination of results

1.6 Utilization of project results

1.7 Project conclusion and perspective

Annex

Relevant links

1.2 Short description of project objective and results

This project has aimed at testing the Weptos WEC for the first time in an uncontrolled - real sea environment. It has operated as an autonomous system, just like a conventional power plant, and produced power, which was delivered to the grid. The Weptos WEC has demonstrated the ability to produce power to the grid and shown performance as expected according to previous testing of models. During testing the Weptos WEC has been operated and controlled remotely by wireless internet connection.

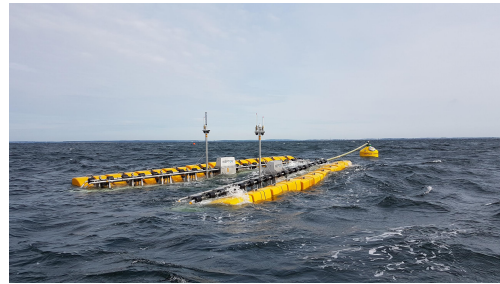
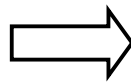
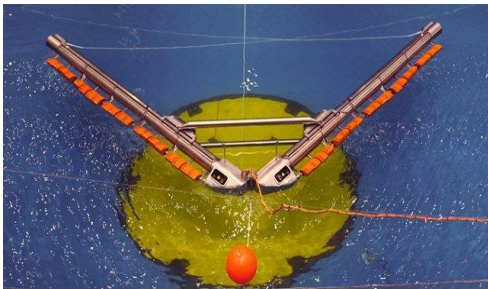
1.3 Executive summary

The Weptos project was prospectively divided into 3 phases, and project plans and budget have been made until the ending of phase 3, where a decision on further commercial development can be made.

Phase 1: Construction and testing of WEPTOS Lab. model

Phase 2: Engineering and construction of large-scale test model

Phase 3: Putting at sea and test of large-scale test model Weptos Offshore #1



Phase 1: Model tests providing detailed power performance data

Phase 2: Detailed engineering providing reliable cost data

Phase 3: Construction and full scale testing and demonstration

All solutions have been designed and built with regards of scalability as the next step towards commercial deployment will be an upscaled version. Additionally to the original project plan, design, manufacturing and installation of an automatic system to operate the angle of the WEC were included. This include all mechanical details as well as PLC programming to run the angle adjustment automatically. The commissioning and sea trials with the Weptos WEC has proven that the technology is a valid candidate to commercial development.

1.3 Project objectives

The project consists out of 3 main successive and complementary phases. They are more precisely:

- *A first design & engineering phase. Here, the device and all its sub-systems are designed following marine engineering guidelines, cost optimised and brought to the level where they can be constructed*

This phase was planned to end in July 2016 but due to delays and difficulties mainly addressed to the work done by the project partner Rasgaard Group, it was not finished before the end of Januar 2017. Rasgaard Group left the project and closed their company in October 2016. Weptos A/S finished the work in cooperation with an external engineering firm.

In August/September 2016 an additional funding was applied for, and granted, for the project.

The reason for this was primarily that the initially planned test area for the plant did not prove suitable and the location was moved to a position north of Brandsø in Lillebælt. The new location caused significant changes in electrical installations, changes in commissioning and the need for sea marks. In addition to changes in the location, was found that the plant must be equipped with an automatic adjustment of the angle, ensuring that measurements can be made in all relevant weather without risk.

- *The construction and commissioning phase, where the model and all its sub-systems will be built, assembled, installed and preliminarily tested.*

Construction has been undertaken by Weptos A/S and Kuni and started Februar 2016. This phase has been demanding due to the delays and difficulties mentioned above. The quality requirements were not compromised, so the Weptos WEC was not ready for launch before July 2017.



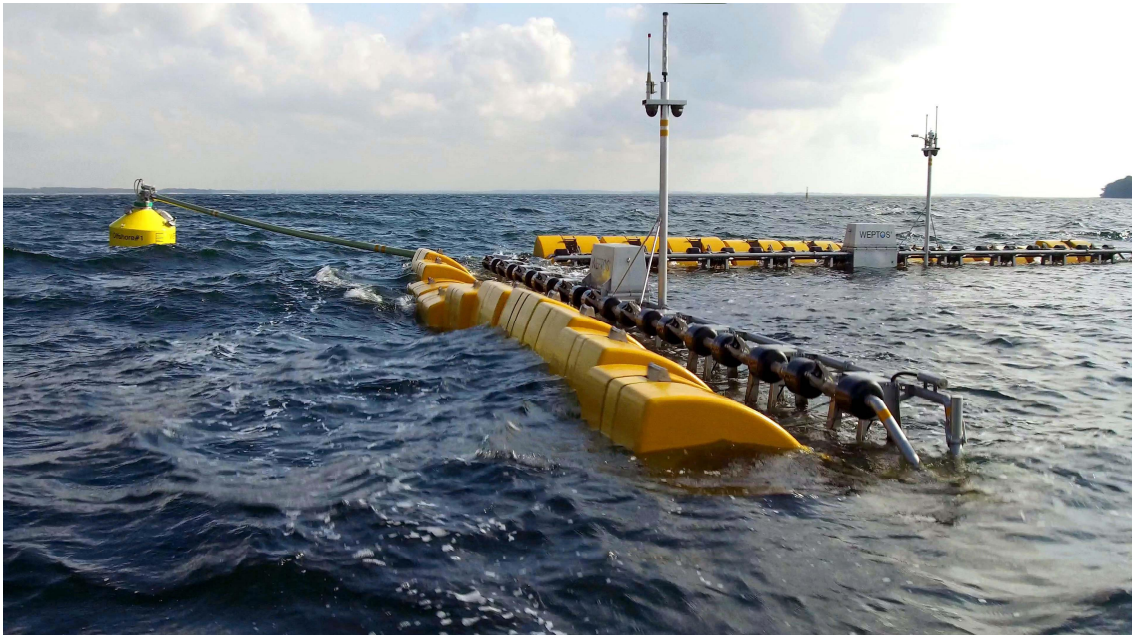
The installation of the Weptos WEC was completed on the 22th of July 2017 and testing of functions was started. Unfortunately, a few days later, water penetration was detected in the generator houses and the plant was disconnected, dragged back to the harbor and lifted out of sea. Here a design error in the main axles was found and reparation of the water damages was made and the error was corrected.

- The second operation and test phase, where the device will be operated as an autonomous offshore power plant. During this phase, the device will undergo several test campaigns, which will be looking at different matters. There will for example be a period in which the focus will be set on the optimisation of the control of the power take off (PTO) system. Other test campaigns will also include the assessment of structural loads for different opening angles and the measurement of structural loads during extreme wave events.

As the wave conditions are not controllable, compared to laboratory conditions, the various test campaigns will be performed whenever the conditions allow it. However, as the system will be connected to the grid and have internet connection, much of the supervision and PTO control will be able to be done remotely.

On August 10 2017 the Weptos WEC was back in position and ready for operation. During the following period, measurements and system monitoring were performed. Attempts with different settings of the generator loads led to damage to one of the inverters due to overvoltage. It was removed on site and sent for repair and reinstalled.

Despite a number of initial difficulties, the successful installation and operation where the plant has produced electricity to the grid has documented the method and potential of the Weptos technology. The PTO system has worked smoothly and it is proven that operation with conventional generators is possible.



After a period of regular operation the project was unfortunately affected by a major incident on the October 10 as the Weptos WEC was found stranded at the coast of Brandsø.



The tether tube was broken and mooring buoy, hawser connection and WEC were transported for safe storage in port. Fortunately, no major damage to the WEC itself has been detected.

1.5 Project results and dissemination of results

During the project, a Weptos model has been constructed and afterwards tested in an uncontrolled real sea environment. This provided the opportunity to check the extensive findings from the previous investigations (based on model tests and subsequent analyses) and to assess the additional factors related to an offshore environment (e.g. marine fouling and offshore operations). It has operated as an autonomous system, just like a conventional power plant, and produced power, which was delivered to the grid. So, all aspects of an autonomous offshore operating renewable energy power plant have been addressed and tested. Furthermore, the device was produced following marine guidelines and installed and tested in a real offshore environment, which have set the development to new standards of operation.

The test model designed for this, is as small as physically possible, including all vital parts of the WEC. Although some parts, such as the bearing structure, might have a different design than the one envisaged for a full-scale WEC, it is representative of the complete full-scale WEC in a real offshore environment.

The overall dimensions are two legs of 13.5 m length each and 20 rotors with a circular diameter of 0.9 m. The weight is in total 13.5 ton.

It was intended to be tested in Nissum Bredning, the Danish offshore sheltered wave energy test station. But after investigation the test area did not prove suitable for the plant and the chosen location became a position north of Brandsø in Lillebælt.

Referring to the attached reports, INSTRUMENTATION DATA PROCESSING, INITIAL REAL SEA TEST REPORT and OMAE 2018 PAPER the project illustrates that the performance of the prototype is able to match the data from the former laboratory experiments.

Highlights are that the Weptos technology has proven to be able to operate regular generators normally used in windturbines. It was also able to produce power from the very beginning of the seatrials. Furthermore the test results indicates possibilities of even more powerproduction than former model tests have shown.

The dissemination of this project are multifaceted and will target different audience i.e. general public, wave energy sector and developers, scientists, stakeholders and potential investors. Overall, the dissemination of the commercial aspects of the project will be communicated by Weptos, while the research related aspects will be presented by Aalborg University.

The results of the project will be made available through the following channels:

- At the Weptos website i.e. www.weptos.com
- Publications in scientific journals, popular press and peer-reviewed articles and magazines as the attached draft to OMAE 2018 PAPER
- Issuing of press releases to local, national or international press
- Participation in conferences and industry exhibitions
- Participation in the biannual meetings in the organization 'Partnerskab for bølgekraft'
- Brochures, flyers, online video spots.

- Aalborg University VBN website
- Energy supply.dk

The data and results will be presented in order to contribute to the wider scientific and wave energy developers community. Especially a lot of data gathered during the test campaign can be of great interest to validate numerical and mechanical models, which can be used on the further development of this technology, but also for a wide range of similar applications.

The dissemination is an ongoing process and will continue forwards.

1.6 Utilization of project results

The overall objective of the Weptos project is the vision to develop the first commercial viable wave energy converter for power generation. The present project and results show that Weptos technology is a valid candidate to commercial development.

The further development and utilization of the project results is now focused on finding a partner that can supply resources and capital to begin industrialization of the technology. The process is started with an external corporate finance institution. Possibilities of supplements from public funding sources are also being pursued.

During the present project Weptos has been granted approved patents in EU, China and USA.

1.7 Project conclusion and perspective

The project is in accordance with the three focus points of the Danish energy policy, namely security of supply, climate impact and cost effectiveness. The activities of the current project contribute directly to the objectives by developing a technology which can promote the viability and the potential of wave energy as a competitive form of renewable energy with specific advantages in terms of supply security given the potential of Danish wave resources.

Furthermore, it is in line with the Government's vision of a Denmark which is independent of fossil fuels in 2050 and in order to fulfill this goal, a mix of renewable energy sources is necessary. One of the advantages of wave energy is that electricity generated is more predictable than other variable renewable energy sources like wind energy and photovoltaic. Furthermore, because wave energy is delayed in time compared to wind generated energy, a combination of wind-wave power will have significantly smaller variability than wind alone which is important for the grid balance.

Wave Energy can contribute significantly to the Danish renewable energy mix and security of supply, as its potential has been assessed to provide 15 % of the Danish electricity consumption. In a long term perspective, the plan is to build 3-8 MW full-scale Weptos WECs and the Weptos technology can form basis for a significant contribution to the Danish energy production.

Annex

www.weptos.com

OMAE 2018 Paper, Real Sea Testing of a Small Scale Weptos WEC Prototype