

Final report

1.1 Project details

Project title	Upgrading and relocation of the Wavestar prototype
Project identification (program abbrev. and file)	Energinet.dk project no. 2009-1-10306
Name of the programme which has funded the project	ForskEL
Project managing company/institution (name and address)	Wave Star A/S
Project partners	
CVR (central business register)	29838879
Date for submission	01/05-2016

1.2 Short description of project objective and results

English version

The project included an upgrade and development of the Wavestar wave energy converter (WEC) in Hanstholm and since relocation to a new site with bigger waves.

The facility was successfully removed from the previous location and drawn into the port of Hanstholm. Here it was examined thoroughly in terms of wear and maintenance requirements.

The major and crucial development has been conducted on the PTO system, which has resulted in an increase of efficiency from 60% to approximately 80%.

Two additional floats was to be added with a diameter of 6 meters instead of 5 meters increasing the effect with 200 kW.

The project did not reach the final goal, and the facility was not expanded with the new PTO system and more floats. Wavestar has been forced to give up to find self-financing to continue the business, and all activities were stopped by the end of March 2016.

Danish version

Projektet omfattede en opgradering og videreudvikling af Wavestar bølgeenergianlægget i Hanstholm og efterfølgende flytning til et nyt site med større bølger.

Maskinen blev succesfuldt fjernet fra den tidligere placering og trukket ind i Hanstholm Havn. Her er det blevet gennemgået grundigt i forhold til slid og krav til vedligeholdelse.

Den største og afgørende udvikling er blevet gennemført på PTO-systemet, som har resulteret i en stigning i effektiviteten fra 60% til ca. 80%.

To yderligere flydere skulle tilføjes med en diameter på 6 meter i stedet for 5 meter, hvilket ville øge effekten med 200 kW.

Projektet nåede ikke endeligt i mål, og anlægget blev ikke udvidet med det nye PTO-system og flere flydere. Wavestar har set sig nødsaget til at opgive at finde selvfinansiering til at fortsætte virksomheden, og alle aktiviteter blev stoppet ved udgangen af marts 2016.

1.3 Executive summary

The aim of the project was to upgrade the wave energy plant in Hanstholm and since relocate it to a new site with bigger waves.

The first phase included a temporary location inside the harbor, where a review and extension could be made. Afterwards, the updated wave energy converter (WEC) was intended to be located further out in the sea in bigger waves and in a more realistic environment.

The upgrade of the system was primarily concentrated on a new and more efficient PTO system, which is the backbone of the system. This should increase production and reduce cost of energy. Extensive development work has been made together with Aalborg University. The implementation of the new hydraulic PTO system developed and tested at Aalborg University was expected to increase the efficiency from 60% to approximately 80%, which is close the efficiency known from wind turbines.

The WEC was planned to be expanded with two additional floats with a diameter of 6 meters, which would increase the total capacity with approx. 200 kW. One of the new floats were planned to be constructed in CRC concrete for the test of an alternative material.

A new bearing system for the machine's arms was also to be tested.

The expansion of the number of floats and the new location was supposed to increase the electricity production and allow examining the interaction between a larger series of floats. It would also make it possible to verify the production from floats increased from 5 to 6 meters in diameter.

Finally, the over-all review and renovation of the machine would give a crucial insight into the impact of the sea forces in relation to lifetime and maintenance.

RESULTS

It was essential for the road to commercialization that the WEC was tested with a new Power Take-Off system and expanded with more floats to be as close to a full scale machine as possible. With the new location the machine would further more operate in a wave environment with large waves much closer to the conditions in the open sea.

The major and crucial development has been done on the PTO system (power take-off). Operational data from Hanstholm has been analyzed and the power matrix used on a test bench. Many resources were allocated to the programming of the management and control of the test bench in relation to the planned implementation in Hanstholm.

Extensive tests in wave basins in both Aalborg and Plymouth Universities had been performed in the project period. There have been power measurements and measurements of energy absorption and the control strategies developed in Hanstholm has been tested and verified in the basin.

The project was initially delayed because of the planned expansion of Hanstholm port and problems getting permissions to a new appropriate site. At a later point Wavestar was been forced to give up to find self-financing to continue the business, and all activities were stopped by the end of March 2016 with a view to liquidation of the company.

There has nevertheless been made important basic research at Aalborg University, which other wave energy developers could benefit from in the future.

1.4 Project objectives

Phase 1 of the project, which included the moving of the WEC into the port was carried out successfully. The plant was fully examined in relation to corrosion, wear and maintenance requirements.

Development and testing of the new PTO system at Aalborg University took place as planned and showed potential to increase efficiency as expected from 60 to over 80%.

Design and testing of materials was also conducted, but did not have to be implemented at the plant. The new location of the plant farther out in the ocean appeared to be delayed due to the conversion of Hanstholm Harbour and problems with the approval of an appropriate location.

At the beginning of 2016 was Wavestar granted a very large amount from the EU Horizon 2020 program for the construction of a 1 MW WEC in Belgium. The rebuilt machine in Hanstholm should have played a major role in this regard to the testing of materials and technology.

Unfortunately, it proved impossible to find the necessary self-financing, and as a consequence of this, Wavestar decided to completely abandon all activities and close the company.

1.5 Project results and dissemination of results

Wavestar reached a long way down the road to meet the expectations of the project. The new digital PTO system showed promising results that could improve the economics of wave energy.

It was managed to move the plant in Hanstholm and prepare it for a new and more realistic position further out in the ocean.

The project has opened the way for a major support from the EU Horizon 2020 of more than 20 million EUR for the construction of a crucial 1 MW plant associated with an offshore wind farm. Together, the two projects display the possible interaction with wave and wind energy, which could create a more stable green electricity production in the future.

Unfortunately, the project did not reach being fully realized as the money ran out.

The basic ideas will live on, and have been widely presented at conferences, two Ph. D. dissertations, in papers and through teaching at Aalborg University.

1.6 Utilization of project results

If Wavestar had continued its activities, the results of this project would have been essential for the commercialization process. Cost of Energy is the crucial challenge for wave energy in general, and the increased efficiency in the new PTO system, would have contributed to improve the competitiveness significantly.

Wavestar was selected by the EU Horizon 2020 for support of the construction of a 1 MW facility in an offshore wind turbine park. The facility in Hanstholm would have had a great importance in preparing for this, to test and demonstrate the technology.

The goal was to show the combination of wind and waves in the future CO₂-free energy production.

Wavestar has over the years worked closely together with Aalborg University (AAU), which also includes in this project and the PTO development.

Wavestar and AAU has jointly installed a large and sophisticated test bench at the university, that students have access to and AAU retain afterwards.

There are made two Ph.D. theses based on Wavstar (read more details in the technical report). One about control strategies and one about hydraulic PTO.

Students are being taught at AAU on the basis of Wavestar, and it is expected that other wave energy developers will benefit from the university's knowledge in the future.

Finally, there have also been offered training courses based on Wave Stars technology.

1.7 Project conclusion and perspective

If it had been possible for Wavestar to provide self-financing for the EU Horizon 2020 project, this ForskEI project would have had a decisive impact on the road to commercialization of wave energy.

The next necessary step was to increase efficiency and to test the technology on a larger scale and in a wave environment with bigger waves in the open sea.

Unfortunately, it was not possible to reach the last crucial piece of road. However, it is our firm belief that AAU and other wave energy inventors will be able to work further with the results obtained and the massive development that Wavestar has conducted and documented over the years.

Annex

This final report is included the following documents:

Technical Report

Appendix I_AAU Testbench - 20150305 Valve Opening Characteristics - Iteration 1

Appendix II_AAU testbench report - 2015 01 19

Appendix III_AAU testbench report - 2015 04 08

Appendix IV_AAU testbench report - 2015 09 29

Appendix V_EWTEC2015_Different Reliability Assessment Approaches for Wave Energy Converters