Final report

1.1 Project details

Project title	Wavepiston – Next Generation Wave Power
Project identification (program abbrev. and file)	ForskEL – project no. 2015-1-12275
Name of the programme which has funded the project	ForskEL
Project managing company/institution (name and address)	Wavepiston A/S Kronborg 1, DK-3000 Helsingør
Project partners	Technical University of Denmark (DTU) Vryhof Anchors (Vryhof) Fiellberg, former Nurmi Cylinders (Fiellberg)
CVR (central business register)	35680829
Date for submission	26 March 2019

1.2 Short description of project objective and results

The project covers a demonstration of the Wavepiston wave energy concept. Numerical tools for estimation of structural design loads and absorbed power for the concept were developed, together with a tool to model the motion of the complete string structure. A 1:2 scale installation was designed, built and installed in the North Sea. With several iterations made on the detailed design during the tests conducted at sea, the reliability and power performance of the concept were improved considerably. The power output from the installation confirmed the predictions of the numerical tools. A business analysis was carried out using the numerical tools and wave data for reference sites selected according to the large attention from potential customers to the concept. The business analysis supports a viable market launch plan for Wavepiston.

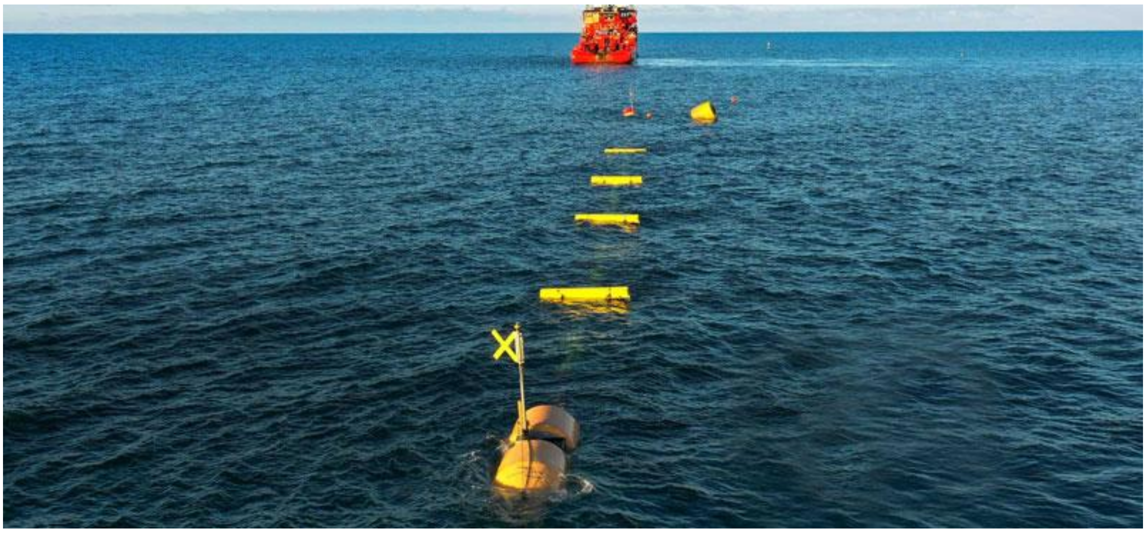

Figure 1. Wavepiston installed in the North Sea

Projektet omhandler en demonstration af Wavepiston bølgeenergikonceptet. Numeriske værktøj for estimering af strukturelle design laster og produceret effekt for konceptet blev udviklet. Et anlæg i skala 1:2 blev konstrueret, bygget og installeret i Nordsøen. Flere iterationer på det detaljerede design blev gennemført for at forbedre pålidelighed og produceret effekt i forsøgene til søs. Den producerede effekt bekræfter de numeriske værktøjer. Der blev gennemført en forretningsanalyse baseret på det analytiske værktøj og på bølgedata for referenceområder valgt i henhold til den store opmærksomhed fra potentielle kunder til konceptet. Forretningsanalysen understøtter en holdbar markedsføringsplan for Wavepiston.

1.3 Executive summary

The project covered a joint effort by DTU, Vryhof, Fiellberg and Wavepiston to demonstrate the Wavepiston concept at 1:2 scale in the North Sea near Hanstholm.

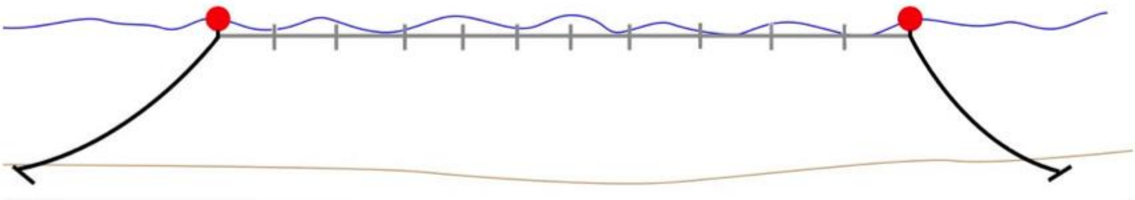

Figure 2. Conceptual drawing of Wavepiston. The red buoys carry the load from the black anchors with chains. The grey string consists of a number of energy collectors (EC) hinged together just below the surface.

Wavepiston was the overall project manager and system designer. The energy collector (EC), which is the key element in the concept, was developed and tested in four consecutive versions. The development of the EC resulted in three different versions of the string assembly. A maximum of four energy collectors were tested on the string at the same time. Two versions of the buoys at the ends of the string were developed and tested.

> The testing at 1:2 scale indicates that:
> - The side length of energy collector plates is half the length of full-scale plates
> - The arrangement of ECs along the string and the stroke length for pumps in the ECs are the same as for full scale as the wave lengths and periods are the same

DTU developed three numerical software tools: the loads tool, the energy tool, and the visualisation tool. The loads tool calculates the wave-induced loads exerted by regular waves on stationary plates. In combination with wave-climate information, the energy tool allows calculation of the absorbed energy in irregular waves at any given location. The visualisation tool models the two-dimensional loads on, and motions of, the full cable system.

Vryhof designed and supplied the mooring system and supported the system design. The same mooring was used in all the string configurations.

Fiellberg designed and supplied the pumps in the energy collectors and supported the system design. The pumps were adapted to the four versions of the energy collectors.

The business analysis under the project was based on predictions of power produced by the Wavepiston energy tool, developed by DTU. The Wavepiston concept has a competitive business case for both electricity generation, and production of fresh water from desalination through reverse osmosis directly from the pressurised sea water.

The original maximum power target was 12 kW for the string with 8 ECs. This target was not verified in the test due to various issues with malfunctioning of the ECs and the consequences of a strong cross current at the site. The maximum power produced by one EC was of the order of 1.7 kW and this confirms that the power target set for a string is achievable.

The positive outcome of the conducted tests and business analysis were the key factors for receiving the European Commission’s financial support for further two projects for demonstrating the Wavepiston wave energy concept in full scale. This funding was granted by the end of the project.

The press releases and conference presentations from the project have helped Wavepiston to establish contact with a larger number of potential clients and partners for the system across the world. The site-specific information on wave climate, seabed and logistic costs for these clients creates the basis for further system design optimisation and business analysis. Wavepiston has built a sustainable market launch plan based on the project.

1.4 Project objectives

Three project objectives were defined in the application:

Objective 1: Development of a refined hydrodynamic model.
Objective 2: Construction and test of a small-scale demonstration structure.
Objective 3: Determination of the power production efficiency.

The following sections first describe the details of these three objectives, and later present the time line together with the challenges and opportunities experienced in reaching the objectives.

1.4.1 Details of Objective 1: Development of a refined hydrodynamic model.

A fast, accurate hydrodynamic model is required to quantify the loads acting on the Wavepiston device, together with the energy absorption that can be expected at any given site. This information is necessary to create a reliable and cost-effective electricity generator. Building on an earlier model created by Wavepiston, DTU have created linear and weakly-nonlinear numerical models, in the time and frequency domains, that allow these calculations to be performed. These models are designed to provide fast results for rapid design cycles, and allow the modification of numerous design variables, to allow assessment of a large design space. The performance of the energy tool has been verified by field measurements made on the 1:2 scale demonstrator.

1.4.2 Details of Objective 2: Construction and test of a small-scale demonstration structure.

The plan was to build and install demonstration installations to gain experience of the different installation and service operations offshore, the reliability of the system design, and the power performance. From the beginning it was realized that several iteration steps would presumably be required to improve the design to reach the set characteristics and performance.

During the budget negotiations with ForskEL, the original scope of the application was modified. It was agreed not to implement a tailored turbine/generator and connect it to the grid. Instead, the power take-off was simplified to a throttle valve with pressure and flow measurement to estimate the generated power.

Figure 3. Position of the test site near Hanstholm

Figure 4. Four versions of the energy collectors tested during the project in chronological order*. Total plate area on first version is 4 m² and for last version it is 8.5 m².*

Figure 5. String of energy collectors tested with version 4. Distance between plates is 14 m.

For further details of the system design please see Annexes 1 & 2.

1.4.3 Details of Objective 3: Determine power production efficiency.

In the last part of the project, the power production efficiency in the form of the Levelised Cost of Energy (LCoE) is estimated based on the collected data. The LCoE are the expenditures for design, manufacturing and installation (CAPEX) and expenditures for service and maintenance (OPEX).

The AEP and the amounts of desalinated water can be translated to annual financial yield with prices relevant for the different sites.

The CAPEX for business case analysis was estimated based on scaling of the financial figures for the activities in the present project. The scaling considered the physical size of the EC as well as the number of manufactured units for both EC modules, buoys and anchor systems.

The OPEX was based on the same type of scaling as for the CAPEX. The use of local technicians and technical support from Wavepiston in Denmark was addressed.

The discount rate was set to 5% in the LCoE analysis.

1.4.4 Timeline with challenges and opportunities in reaching the three objectives

The below table is a summary of the project timeline. Critical events are listed, and the challenges and opportunities connected with the events are explained.

Table 1, Project timeline

Time	**Event**	**Challenge/Opportunity**
Feb. 2015	Project kick-off meeting	Convenient agreements for scheduling, communication and alignment between the partners
Feb. 2015	Detailed design of 1:2 scale installation and the site lay out. The initial version of the design pump cylinders had a linear response.	Good collaboration with DANWEC in Hanstholm on the site layout and consent process with Energistyrelsen
June 2015	Consent from Energistyrelsen	
Aug. – Sept. 2015	Installation of the first anchors and the string without ECs https://vimeo.com/137988380	Observation that the buoys in each of the string were not stable in their position due to their design. This would imply wear and fatigue.
15 Sept. 2015	A trawler accidentally deviated from the navigational restrictions that were set to avoid traffic in the area of the installation. The trawler collided with the first installation and severely damaged it. The project needed extra budget and time to continue.	Revised time schedule and small amount of additional funding for additional instrumentation to improve monitoring agreed with ForskEL
Sept. 2015	A case against the owner and the insurance company for the trawler was started to claim compensation for the accident.	A lot of manpower for R&D was lost in order to support the case with technical evidence.
Dec 2015	Decision to redesign pump to avoid strokes hitting the ends. Detailed design of telescopic pump with a non-linear response that reduce the number of strokes hitting the ends.	New telescopic pump design and patent application
Dec. 2015	Decision to redesign buoys by the end of the string to keep them more stable in their position.	New buoy design
Jan 2016	Bankruptcy of the original partner in the project Nurmi Cylinders	Efforts to continue the collaboration with the same specialists in a new company.

Aug. 2016	Re-installation of wire string without ECs	
Sept. 2016	One anchor out of position. Vryhof suggested that this was due to disturbance at the collision with the trawler.	Repositioning of anchor needed
Sept. 2016	First version of Wavepiston energy tool with multiple plates and waves from multiple directions.	The tool now supported the LCoE estimation.
Oct. 2016	Fiellberg officially takes over the role of Nurmi cylinders in the project	Fiellberg takes on the responsibility to deliver the new telescopic pumps.
Oct. 2016	Repositioning of anchor	Unsuccessful due to bad conditions (heavy cross current and insufficient manoeuvring capacity of the vessel)
Nov. 2016	Minor damage to the string due to wrong position of anchor and loss of pretension.	String towed to harbour for updates and repairs.
Dec. 2016	A storm caused severe damage to the Wavepiston equipment in Hanstholm harbour.	New parts needed.
May 2017	Re-installation of the string, anchors and first EC https://vimeo.com/218783960	Instrumentation not working, and had to be repaired.
May-2017	New events where ships approach the installation by accident	Together with DanWEC, communication campaigns were initiated and the Danish Maritime Authorities added two AIS-Atons (virtual warning signals in the electronic sea charts).
Aug. 2017	Replacement of EC with new version.	Instrumentation is not working so there is no power-performance data.
Nov. 2017	Installation of two new ECs - EC3 and EC4	
Nov. 2017	First results for power production.	Power production confirms the analytical simulations by the Wavepiston energy tool.
Mar. 2018	Replacement of EC3 and EC4 with EC5 - a v3.1 module. Also, replacement of instrumentation.	
Apr. 2018	EC v3.1 tested successfully up to Hs = 3.5 m	
Apr. 2018	Large deflections due to heavy cross current	Test with fewer modules as originally planned. Four instead of eight.
May 2018	Wire rope broke due to fatigue. Retrieval of string and ECs	Redesign with hinged ECs for v4 started to avoid issues with robustness of wire string.
July 2018	Lack of time to test v4 of EC	ForskEL accepted postponing the project end to March 2019.
Oct. 2018	Several revisions by DTU to the Wavepiston energy tool	Better support of detailed structural design and power estimation for business analysis
Nov. 2018	Installation of a string with four ECs v4 https://vimeo.com/307470243	
Nov. 2018	Loss of contact to parts of the instrumentation due to hose from string to buoy breaking loose (assembly error by supplier)	No performance data from EC v4
Dec. 2018	Error fixed and contact to the instrumentation re-established	Performance and load data

Dec. 2018	Storm, Hs 7 m / Hmax 12 m, caused mechanical damage to one plate on the EC lying highest in the water, and minor damage to another plate.	No weather windows allowing for detailed inspection
Jan. 2019	No performance data from sensors due to malfunctions.	No further performance data
Jan. 2019	Loss of contact to load shackle (sensor) due to cable becoming unplugged (damaged)	No further load data
Feb. 2019	Final LCoE model established based on the Wavepiston energy tool. Business analysis and review of market launch plan	Key project types for market launch identified
Feb./Mar. 2019	Decommissioning of installation	Detailed inspection of EC v4, string, buoys and mooring. Preparing for follow-up test at the DanWEC site (another project)
15 Mar. 2019	Project closing meeting in Helsingør.	Review of results and planning future collaboration

On top of the events listed in the table there have been general challenges with the robustness of the instrumentation and the accessibility due to poor weather conditions.

1.5 Project results and dissemination of results

The project results are here summarised for the three different project objectives listed in Section 1.4.

1.5.1 Results for Objective 1: Development of a refined hydrodynamic model.

The key results for Objective 1 are the Wavepiston load and energy tools. These tools allow both design loads and annual power production to be calculated for any site where the water depth and records for significant wave height, peak period and wave direction are available. The tool calculates the power based on an optimum or specified hydraulic pressure in the delivery pipe connected to each EC. The captured energy can be used in the business case for both electricity generation and desalination of pressurised water through reverse osmosis.

> The Wavepiston load and energy tools are based on the following approach:
>
> - Linear potential flow in the frequency domain
> - WAMIT analyses provide hydrodynamic coefficients
> - Linearised forces and damping to represent nonlinear power take-off and viscous drag
> - Weakly nonlinear time-domain model includes exact PTO and drag forces

The calculation methods used in the Wavepiston load and energy tools were published in a conference paper Read, R., & Bingham, H. "*Time- and Frequency-domain Comparisons of the Wavepiston Wave Energy Converter*". The paper was presented at the 33rd International Workshop on Water Waves and Floating Bodies in Guidel-Plages, France in 2018. This paper is enclosed the present report as Annex 3.

The Wavepiston energy tool does not address the effect of current or the effect of storm protection mechanisms on the ECs. However, these effects can be taken into account with an empirical approach in the LCoE estimations.

Measurements of wave height, peak period and mean propagation direction typically come from hindcast models or wave buoys. The Wavepiston energy tool can process power simulations based on records of the significant wave height, peak period and directions on typically a half hourly basis, and results can be summarised in annual distributions of power, see Figure 5. Alternatively, the annual wave data can be made available as correlated distributions and simulated power for each reference sea state can be used to determine annual production, according to the frequency for each reference state.

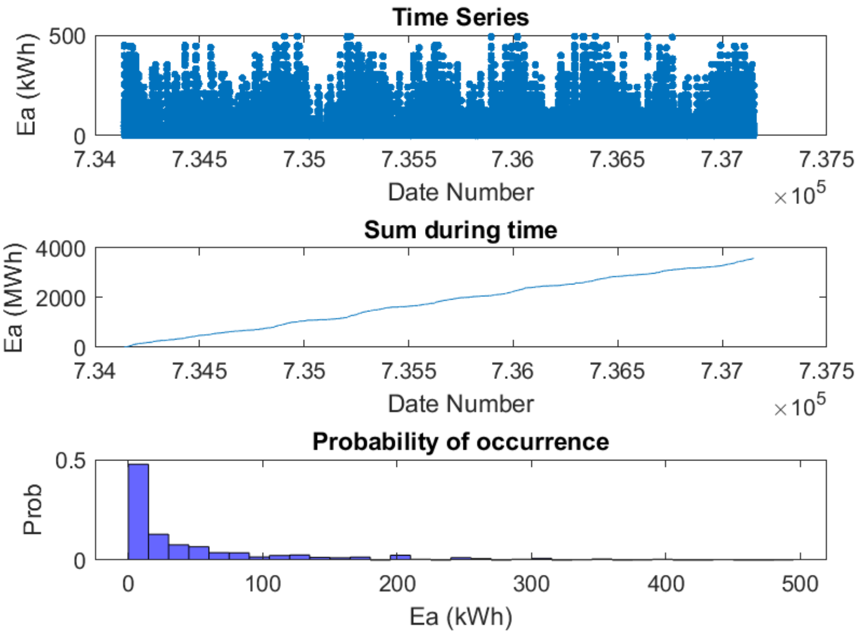

Figure 6. The Wavepiston energy tool allows the power production to be simulated for typically every half hour according to registrations from a wave buoy (top). The cumulative absorbed energy can be calculated over a specified period (middle). The Power can be plotted in terms of a probability of occurrence over the period (bottom).

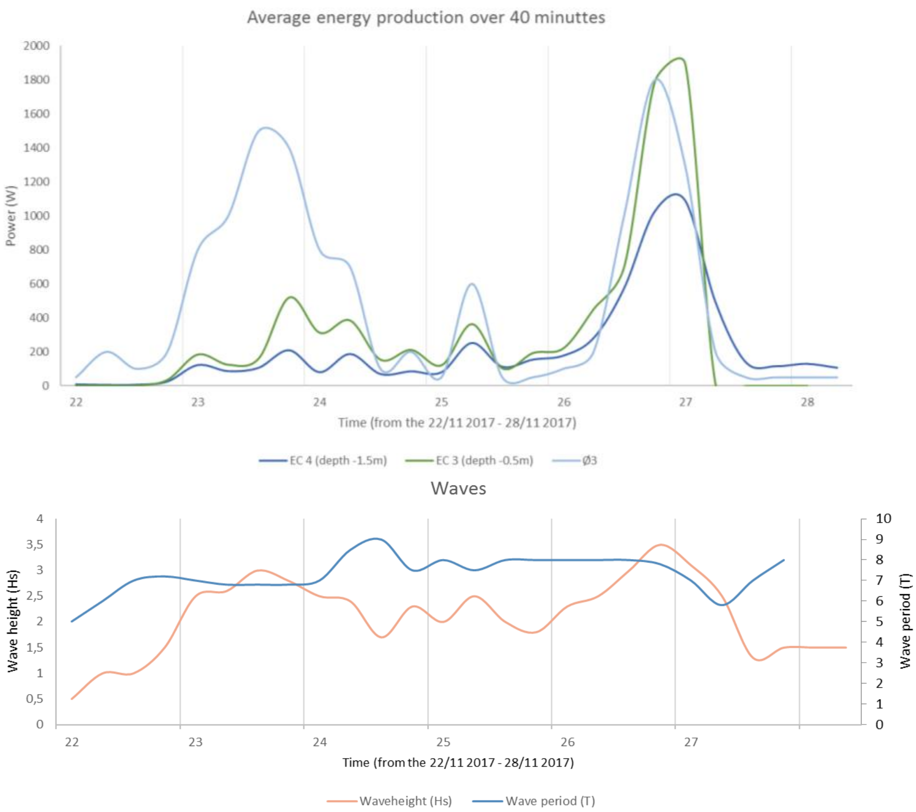

Figure 7. A Wavepiston energy tool power simulation for a Ø3 m plate compares well with measurements for 7 m² EC plates on EC3 and EC4. There is an issue with air disturbing the pump action during the first 4 days. EC4 is submerged to -1.5 m and produces less power than EC3 submerged to - 0.5 m as assumed in the Wavepiston energy tool.

The main conclusion from analysis with the Wavepiston energy tool is that the capacity factor, in the form of the mean produced power relative to the maximum power for the Wavepiston system, is a key parameter that indicates a competitive levelized cost of energy. To achieve a high capacity factor, deployment in wave climates with small directional spreading and a rather constant height is needed. The analysis confirms that several of the potential sites relevant for market launch satisfy these conditions well. The capacity factor is of the order of 20 % - 40 % for these sites.

1.5.2 Results for Objective 2: Construction and test of a small-scale demonstration structure.

The key results for Objective 2 are

- Detailed design and test of four consecutive versions of the energy collector ECs for the Wavepiston system
- Detailed design and test of two consecutive versions of the buoys at each end of the string
- Detailed design of string assembly in three different versions
- Invention and detailed design of telescopic pump solution in the ECs. This was published as a patent application in the patent WO2018108220 (A1) — 2018-06-21, “Wave Power Device”
- Verification of the power performance simulated with the Wavepiston energy tool
- Verification of installation, service, and decommissioning procedures at sea
- Lessons learned about measures to control navigation and avoiding collisions with foreign vessels.
- Lessons learned about inspection of mooring systems and vessels after collisions
- Lessons learned about the importance of sea current in site analysis and for the detailed design of the mooring system
- Lessons learned about the robustness of instrumentation systems at sea

In the demonstration, a high maturity was achieved for:

- Structural integrity of string and mooring concept
- Buoy design
- Mooring design
- Installation

The demonstration indicated solutions well in progress - but more maturity needed for:

- Efficiency of EC pump modules
- Storm protection of EC plates
- Service and maintenance operations

The following items were not covered by the demonstration:

- Export pipe from string to shore
- Power generation or desalination with pressurized water from string through export pipe

The results of objective 2 were presented at 3 conferences

- Marine Energy Week, Bilbao, March 2017
- International Conference on Ocean Energy 2018, Cherbourg in Normandy, June 2018
- Ocean Energy Europe 2018, Edinburgh, October 2018

The last presentation is attached to the present report as annex 2. The other two are not attached since the last presentation is a development of these.

Vryhof designed and supplied the mooring solution for the demonstration:

- The available site and soil data were analyzed to determine the suitable anchor solution
- Mooring design and offshore installation procedures
- The engineered and manufactured anchor for the project is 1 mT Stevpris Mk6 anchor - http://www.vryhof.com/pdf_2010/VRYHOF-STYLE2011Brochure-Mk6.pdf
- The mooring, from anchor to the surface buoy, consisted of bottom chain and wire rope with suitable connectors (shackles).
- The anchors and mooring system were preset by using a tug with sufficient bollard pull capacity
- The mooring system for Wavepiston technology is relatively simple, easy to install, maintain, service, and recover. This increases the feasibility of the total concept at remote locations with limited marine facilities and fleet services.

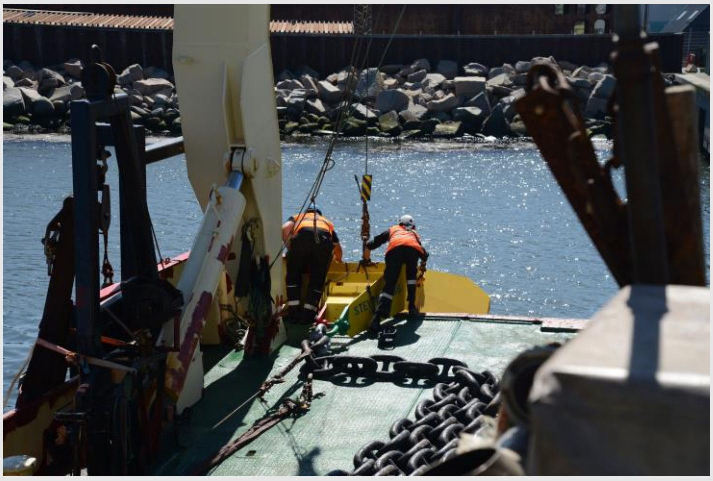

Figure 8. Vryhof anchor and chain made ready for Wavepiston installation in Hanstholm

Fiellberg designed and supplied the pump solution for the demonstration:

- The pump solution is based on a three-stage telescopic pump
- Each stage has a guide that slides on the EC structure
- There are two pumps on each EC. When one pumps pressurized water, the other sucks water in
- Various pump models were manufactured. There were different kind of bottom valves and different types of solutions to tackle telescopic tube opening/closing sequences. The latter remains as one of the further development areas in future projects

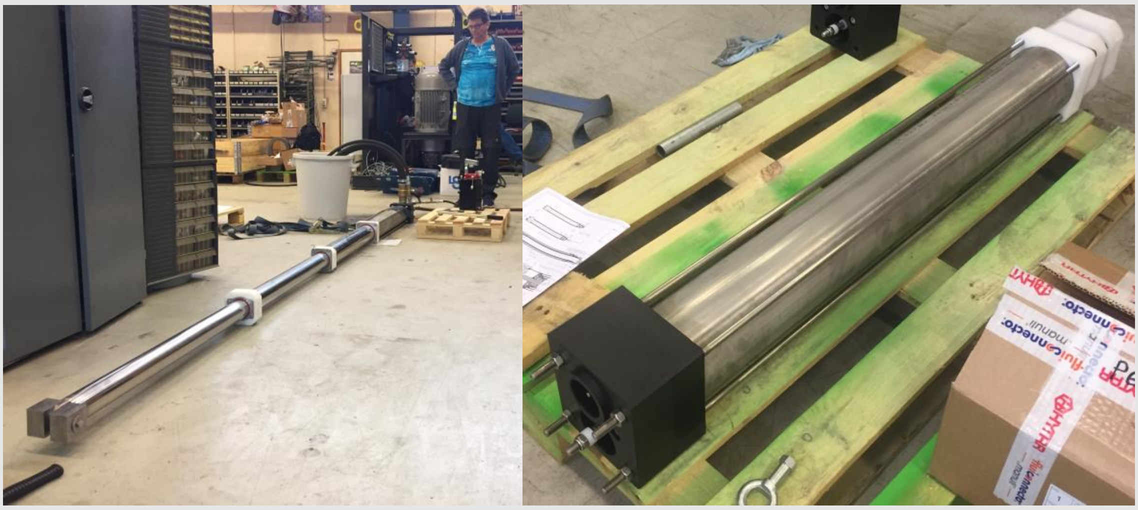

Figure 9. Fiellberg telescopic pumps that were integrated in the ECs

1.5.3 Results for Objective 3: Determine power production efficiency.

As explained in section 1.5.1 the Wavepiston Energy tool supports business case analysis by calculating the annual energy production AEP or amounts of desalinated water according to wave data and water depth from any type of site.

The levelised cost of energy LCoE model developed in the project is a key result. It calculates yield based on the results from the Wavepiston energy tool. The CAPEX and OPEX in the LCoE is based on simple scaling of the financial figures from the present project taking account of the physical scale and the scale of the manufactured and installed volume. As such, the financial account for the different project activities is also a key result.

Typical values for the LCoE from the business case analysis are in the range of 0.2 EUR/kWh for the first smaller installations in isolated communities. Over time the potential is estimated to be 0.03 EUR/kWh for very large installations.

The business cases analysed for the different potential sites suggest that:

- Desalination of water is an important market for the technology.
- The capacity factor is key for commercial success with projects as explained in section 1.5.1. Wave climates that have a predominant wave direction (mainly the same direction), with a more or less constant height/period each day, will result in the highest capacity factors.
- The technology will compete with other sources of power and water supply. In the first step, the technology competes well in isolated communities with an annual demand in the range of 5 - 40 GWh/year.

1.6 Utilization of project results

As explained in 1.5.2 many of the project results have been utilised already in the design modifications under the project. This was made possible as several iterations of the design could be tested, and there was a strong collaboration between the project partners as well as with external partners on the design iterations and their implementation in the demonstration.

One patent has been granted to Wavepiston for a pump cylinder with a non-linear response. This is a key solution to effectively utilise the Wavepiston concept.

The development of the Wavepiston energy tool continues after the project ends in coordination between DTU and Wavepiston. Two Master students are continuing development of the software tools. The first is extending the multiple-plate, irregular-wave, frequency-domain model to the time domain. The second is developing the visualisation tool to incorporate recent design changes to the energy-connector backbone.

The first Master student has assisted Wavepiston in integrating the results from the Wavepiston energy tool into the business analysis. The tool is now an important part of Wavepiston design and business planning.

The positive outcome of the tests in Hanstholm and the business analysis under the project are considered as key factors for the European Commission granting financial support to further two demonstration projects at full scale by the end of the project period:

1. Competitive Wave Energy on Islands, SME Instrument under Horizon 2020 project at the PLOCAN facility, Gran Canaria
2. Wave to Energy and Water, Fast Track to Innovation under Horizon 2020 project at Isola Piana, Sardinia

The first full scale demonstration project at PLOCAN has a preliminary maximum capacity of 200 kW. The preliminary design involves one string with 24 ECs. Wavepiston and Fiellberg are already well in progress in preparing the design of the ECs, and Vryhof are preparing updates on the mooring. First installation is expected by the end of 2019.

The second full scale demonstration project at Isola Piana has a capacity of 100 kW for electrical power and is also to demonstrate desalination of the pressurised sea water from Wavepiston with reverse osmosis. The detailed design has not yet started.

The two full scale demonstration projects have made it necessary to increase the number of Wavepiston staff by three full time employees, and the company will issue additional shares to fund the industry part of the two projects.

A lot of attention has been received by the presentations and press releases at various conferences and on the internet. For further details of this information see Annex 2. Many types of sea climates and conditions for integrating electrical power and desalinated water have been suggested by potential clients. The business analysis conducted for these potential clients suggests that the first commercial implementations will be of a few MW at sites where electrical power today is supplied with diesel generators today and/or where the installations shall be used for desalination of seawater. The two full scale projects supported by the European Commission represent such opportunities well.

1.7 Project conclusion and perspective

The 1:2 scale prototype funded by ForskEL in the present project supported both the technology push and the market pull to the Wavepiston concept.

The technology push consisted of

- Simulation tools for produced power and design loads
- Detailed design of mooring systems
- Detailed design of buoys
- Detailed design of pumps and energy collectors
- Verification of reliability at both component and system level
- Verification of power performance
- Verification of installation procedures
- Verification of service and maintenance procedures
- Verification of decommissioning

The market pull consisted of

- Contact to several potential clients for the system and collaboration on the business analysis
- Funding from the European Commission for two full scale demonstrations
- Establishment of an Industry Follow Group with some of the largest industrial players in the energy sector to assist and follow Wavepiston in the next phase

The technology push matured the technology to a level where it is considered ready for testing at full-scale before market launch. A limited number of details with insufficient maturity have been observed. These details are still to be corrected. However, the project has supported a considerable evolution of the major part of the detailed design to a satisfactory maturity.

The market pull confirms the maturity of the market launch plan at Wavepiston. Key projects have been identified where both commercial and technical risks are modest. The detailed design for these projects will be developed during the next phase, 2019 - 2021.

Annex 1 – Publicly available information from the project:

Wavepiston homepage:

- http://www.wavepiston.dk

Read, R., & Bingham, H. (2018). Time- and Frequency-domain Comparisons of the Wavepiston Wave Energy Converter. Paper presented at 33rd International Workshop on Water Waves and Floating Bodies, International Workshop on Water Waves and Floating Bodies, 2018), Guidel-Plages, France. (enclosed as Annex 3)

- http://orbit.dtu.dk/files/148170140/report.pdf

Patent for telescopic pump solution developed in the project, Patent WO2018108220 (A1) — 2018-06-21, Wave Power Device:

- https://dk.espacenet.com/publicationDetails/originalDocument?CC=WO&NR=2018108220A1&KC=A1&FT=D&ND=4&date=20180621&DB=&locale=dk_DK#

Youtube:

- Wave Energy: Deployment of Resinex buoys for WavePiston project - Resinex Trading
- 'Esvagt Connector' helps test Wavepiston's wave power prototype

Energy Supply:

- https://www.energy-supply.dk/article/view/636586/dansk_bolgeenergi_gor_sig_klar_til_gran_canaria
https://www.energy-supply.dk/article/view/607373/fra_prototype_til_demomodel
- https://www.energy-supply.dk/article/view/553569/wavepiston_har_skiftet_fokus
- https://www.energy-supply.dk/article/view/480022/tredje_gang_var_lykkens_gang
- https://www.energy-supply.dk/article/view/221986/bolgeenergianlaeg_pasejlet_ved_hanstholm#.Vg0A_PntlBc
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Ingeniøren:

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- https://ing.dk/artikel/pilot-boelgekraftanlaeg-lagt-ud-ved-hanstholm-igen-186339
- https://ing.dk/artikel/boelgekraftanlaegget-wavepiston-testes-i-haardt-havmiljoe-ved-hanstholm-174018

Marineenergy.biz:

- https://marineenergy.biz/2017/05/25/video-wavepiston-deployment-at-danwec/
- https://marineenergy.biz/2018/07/23/wavepiston-bags-multi-million-wave-demo-grant/
- https://marineenergy.biz/2018/12/06/wavepiston-upgrades-prototype-signs-up-wave-desalination-scheme/
- https://marineenergy.biz/2018/12/21/video-wavepiston-v4-installation-offshore-denmark/
- https://marineenergy.biz/2018/03/12/wavepiston-equips-wave-system-with-new-energy-collector/
- https://marineenergy.biz/2017/07/03/wavepiston-ponders-relocating-as-denmarks-support-stalls/

Danwec:

- http://www.danwec.com/dk/nyheder_og_presse/nyheder/wavepiston-in-the-water.htm

TVMidtVest:

- 9. august 2018: https://www.tvmidtvest.dk/nyheder/09-08-2018/1825/1820-09-aug-2018?v=0_temfesiq
- 17. november 2016: https://www.tvmidtvest.dk/nyheder/17-11-2016/1930/tror-stadig-pa-dansk-bolgeenergi?autoplay=1#player
- 15. juli 2015: https://www.tvmidtvest.dk/artikel/150-meter-langt-bolgeanlaeg-til-hanstholm

Diverse:

- Artikel: Patent & Varemærke, november 2018, Indstik i Mediaplanet
- Radio: DR, Radioavisen 27. oktober 2017

Annex 2 – Ocean Energy Europe 2018, Edinburgh, October 2018 presentation of the results from the project.

Annex 3 – Read, R., & Bingham, H. (2018). Time- and Frequency-domain Comparisons of the Wavepiston Wave Energy Converter.

Paper presented at 33rd International Workshop on Water Waves and Floating Bodies, International Workshop on Water Waves and Floating Bodies, 2018), Guidel-Plages, France