Final report

1.1 Project details

Project title	Deutsche Bucht Demonstrator
Project identification (program abbrev. and file)	Demowind 1: 646517
Name of the programme which has funded the project	ERA-NET Cofund DemoWind-1, Frederikshavn demonstrationsprojekt
Project managing company/institution (name and address)	
Project partners	Universal Foundation (DK) Harland & Wolff (UK) SIF (NL)
CVR (central business register)	26046246
Date for submission	

1.2 Short description of project objective and results

1.2.1 English project description

The academic goals for this project are reflected in increased wave heights (+19m), deep water (+40m), more "offshore" conditions compared to the original demonstration project in Frederikshavn (as the Deutsche Bucht location is further from shore), optimal seabed conditions, the possibility of two larger bucket foundation rather than several smaller ones and the possibility of installing the, at that time, largest wind turbine in the world, the 8.4MW Vestas wind turbine.

The DBU site has been evaluated to be the perfect test location for the Mono Bucket Foundation, based on the following criteria, all of which fulfils the desired purpose of this foundation.

- Installation of the, at that time, largest wind turbine, the 8.4MW Vestas turbine
- Installation at +40m water depth
- Environmental site conditions of +19m waves
- Acquire BSH-approval

1.2.2 Danish project description

De faglige mål for dette projekt udmønter sig i højere bølgehøjder (+19 m), dybere vand (+40 m), mere "offshore" i forhold til det oprindelige Frederikshavn demonstrator projekt (da det er længere fra land), gode bundforhold, mulighed for to større mono buckets frem for flere mindre, og dermed ligeledes eventuel installation af verdens daværende største vindturbine (8,4 MW Vestas vindmølle).

DBU-sitet er blevet evalueret til at være den perfekte test lokation for Mono Bucket Fundamentet, baseret på de følgende kriterier, som også alle opfylder de ønsket formål med fundamentet:

- Installation af den (daværende) største vindturbine 8,4 MW Vestas vindmølle
- Installation på vanddybde 40 meter
- Forhold med bølgehøjde +19 meter
- Opnå BSH-godkendelse

1.3 Executive summary

Just before entering 2017, DeBu was given notice that German authorities, BNetzA, had decided to make grid connection available for the specific demonstration of the Mono Bucket foundation. During the summer 2017, budgets for the project was being developed in parallel with UF getting the Basic Design in place for the DeBu Demonstrator project.
The detailed design was finalized during 2018 as planned and the fabrication was commenced, with support from Universal Foundation on technical matters. In the second half of 2018, Universal Foundation started the planning and preparation for offshore activities and installation training of the offshore personnel, which was intended to perform the installation of the two Mono Bucket Foundations in the Deutsche Bucht.
This year was also when one of the larger milestones was achieved, namely the BSH approved and certified design.
During the beginning of 2019 it was officially announced that H&W had difficulties in keeping the agreed timelines and securing quality of the performed work. This together with the inability to come up with solutions to the problems lead to a decision of relocating the partly manufactured MBF's to Bladt Industries at Lindø. UF supported with structural integrity calculations and analysis for the relocation and handling process of the two foundations. Besides the supporting activities for manufacturing of the foundations, UF internally prepared for the offshore activities that was upcoming later that year. Certificates needed to be acquired and maintained, installation training was executed, including an offshore campaign off the coast of Frederikshavn, where the installation teams were training with an 8x8 meter bucket, before the Deutsche Bucht installation campaign commenced. 2019 was the beginning of the installation campaign of the first of two MBF's. The installation was unfortunately halted before completion of the installation of MBF33 due to unforeseen circumstances, and at the end of 2019 the installation was still halted.
The project partners are still investigating, with third part support, the circumstances for the failed installation and a root cause is being investigated. No conclusion has yet been determined, and since it has taken more time than expected, the project developer Northland Power has decided not to complete the project, since their financing agreement and permit timeline did not allow them to complete the project.

The outcome of the project and the current situation, where a firm root cause is still not determined makes it difficult to utilize the results from this project. When a firm root cause has been determined, it will be clear which data and results can be utilized in other future projects.

1.4 Project objectives

The demonstration project was, according to the original Stage II application, to be made through a project named Frederikshavn Demonstrator. But according to dialogues between UF and DemoWind, the application was adjusted to reflect a demonstration to be made in the Deutsche Bucht project instead.
The background for changing project for the demonstration from Frederikshavn to Deutsche Bucht went on throughout 2014 and 2015 where large efforts by the Consortium had been put into the Frederikshavn Demonstrator project to develop the project in collaboration with EDF Énergies Nouvelles (EDF), who would install, take over and operate the small windfarm upon completion.
In early 2016 UF unfortunately received the message that EDF failed in securing an offshore tariff for the project, and hence the business case for EDF led them to cancel the project in Frederikshavn.
As it is of key importance for the Consortium to do the full-scale demonstration to unlock the market for the Mono Bucket foundation, it was immediately decided to start pursuing alternative potential demonstration sites in Northern Europe. This is a very challenging and time demanding task, and UF have been helped by the support from EUDP/DBEIS/RVO, which has provided the comfort, that UF would still be able to benefit from the grant, of course depending on the exact scope and costs of such alternative demonstration projects.
During the process, UF explored a short list of seven potential demonstration sites, which was further shortlisted to 4 potential projects during the late summer 2016. During autumn 2016 UF had to narrow this number down to 1 preferred demonstration project.

1.4.1 The Deutsche Bucht Demonstrator

Due to demanding noise restrictions for installation of offshore foundations in Germany, the biggest market potential for the Mono Buckets. And hence UF was pleased to have caught the attention of British Wind Energy, who is building the Deutsche Bucht (DeBu) Project in the German part of the North Sea. Based on intense discussions with DeBu throughout 2016, UF and the partners came to the joint agreement to make DeBu the preferred demonstration project as the DeBu windfarm was evaluated to be a perfect demonstration site for the Mono Bucket foundation, based on the following facts:

- Deployment of the world's largest wind turbine generator – the 8.4 MW turbine from Mitsubishi-Vestas Offshore Wind (MVOW)
- The site is in ~40m water depth
- The site is exposed to ~19m of maximum wave height
- Possibility to obtain BSH-approval by the observation method
- Very suitable soil conditions for the Mono Bucket foundation
- Possibility to focus on the core-demonstration of the Mono Bucket and avoid expensive and challenging deliveries outside UF's normal scope (cabling, Turbine Installation & Transformer)
- Possibility to do a two position (two foundations) demonstration instead of six (Frederikshavn)
- A site in Germany, which is currently the biggest market for the Mono Bucket foundation due to very strict noise restrictions.

Just before entering 2017, DeBu was given notice that German authorities, BNetzA, had decided to make grid connection available for the specific demonstration of the Mono Bucket foundation on the condition that DeBu would provide the infrastructure necessary to make the grid connection feasible (transformer station capacity, array/export cable connection, approval of BSH etc.).

Therefore, the first months of 2017 was used by the Consortium and DeBu to commonly explore what would be required from both parties to realize the DeBu Demonstrator. This included detailed discussions on technical feasibility, interfaces, requirements for complying with German regulations/authorities as well as establishing a cost budget for the demonstration.
During the summer 2017, budgets for the project was being developed in parallel with UF getting the Basic Design in place for the DeBu Demonstrator project, but as the realization of the project is completely relying on ability to transfer relevant parts of the original grant from Frederikshavn Demonstrator to the DeBu Demonstrator UF needed to seek the support from DemoWind to transfer relevant parts of the grant according to applicable EU funding rules, which also was done during 2017.

The overall project was being progressed as planned during 2018. Of main activities which was finalized was the detailed design for the two Mono Bucket foundations. Also, preliminary planning for fabrication and installation activities was initiated and performed in the first half of 2018. The second half of 2018 was focused on fabrication support to Harland and Wolff for the fabrication of the two Mono Bucket Foundations. Further, the period was used to initiate the preparation for the installation teams, including assigning the overall team setup, responsibilities and to secure that the candidates had sufficient certificates for the offshore activities and planned training with the installation equipment. The internal preparation for mobilization and installation was commenced and followed the predefined time schedule.
The project progressed according to schedule, which, among other milestones, meant that the Detailed Design process, which was one of the important milestones, was also finalized according to the milestone schedule.
Further, during 2018 an ongoing coordination of work tasks was made towards the German authorities, namely BSH, due to the German noise- and environmental requirements but was also concluded upon during the summer.

In 2019 the two foundation were relocated to Bladt Industries as Harland and Woolf did not manage to reach their deadlines and was not capable of providing a fulfilling plan for completion of the two foundations, which involved UF in supporting VOOW on structural integrity for the relocations and handling process of the two foundations.
During 2019, there was several larger areas of work. The overall workload was on supporting activities for the fabrication, first Harland & Wolff in production activities, the moving activities, and finally on supporting Bladt for the final part of the fabrication of the two foundations.
Further, the mobilization and installation activities were of high importance and demanded a lot of planning and alignment, as a new jack-up installation vessel was chosen for the installation, instead of the floating OIV Aegir. The installation was decided to be carried out by the jack-up vessel Scylla.
Beside from the structural support to VOOW during the fabrication and installation activities, UF was also working internally on preparing the offshore installation team, including the required offshore certificates, SCADA training, teambuilding activities and offshore preparation in general. One of the training activities was an offshore installation campaign in the spring of 2019, at the coast of Frederikshavn, Northern Jutland, to prepare and train the teams for the Deutsche Bucht installation. Further, the period of 2019 was the beginning of the installation campaign of the first of two MBF's, which was mobilized at Lindø, Denmark. The installation was unfortunately halted before completion of the installation of MBF33 due to unforeseen circumstances, and at the end of 2019 the installation was still halted.

The period from the installation was stopped to Q3 2020 the foundation has been standing offshore, waiting for the retrieval, which is scheduled for Q3 2020. This period has been focused on a root cause analysis to make it clear why the installation was not completed. No clear indication of the circumstances that lead to the stopped installation has yet been revealed.

As the installation of the two foundation did not finalise according to plan, the need to abandon site and as the root cause for the failed installation is still not concluded upon, it is difficult to conclude on unexpected problems, as it was not expected, not to finalise the installation.

1.4.2 Original timeline for the DeBu project

The following timeline reflects the original agreed timeline. Indications have been made for each milestone if it has been reached or not, including a comment if applicable.

1. Initiate Basic Design [01-03-2017] - *(Reached according to schedule)*
2. Initiate Detailed Design [01-08-2017] - *(Reached according to schedule)*
3. Hand-in BSH 2nd release [01-02-2018] – *(Reached with a small delay)*
4. Initiate Fabrication at H&W [01-03-2018] – *(Reached according to schedule – not a UF responsibility)*
5. Initiate Fabrication at SIF [01-08-2018] – *(Reached according to schedule – not a UF responsibility)*
6. Final Acceptance Test, Belfast [15-01-2019] – *(Delayed until Q3/Q4 2019 – Moved from H&W before foundation was ready for FAT. Completed at Bladt)*
7. Ready for load-out, Germany [01-02-2019] – *(Delayed until Q4 2019 with changed location – Completed at Bladt)*
8. Installation [2nd Quarter 2019] – *(Delayed until Q4 2019 – Installation and site was abandoned. Root cause for failed installation is still being investigated)*
9. Project close-out [3rd Quarter 2019] – (*Delayed and not reached at present)*

1.4.3 Project risks

Based on the size and form of the Deutsche Bucht project, the major risks identified in the initial phases of the project was divided into the following areas HSE risks, General risks, Pre-ops, Load-out and transit and Phases during installation. These were the risk areas that were used as guidelines for work related to the installation and preparation itself, including recourses throughout the project scope.

When looking at the overall project related risks, the risk of a failed installation, either due to site refusal or damaged, was the main project related risks that were managed by UF. But also the strict timeline and a winter installation to catch up for the delay effects of Harland and Wolff bankruptcy were significant risks.

1.5 Project results and dissemination of results

1.5.1 Technical results

Universal Foundation have during the project had technical activities within concept development, detailed design and verification, certification and support to fabrication in regard to alignment and optimisation. In the early stages starting with forming the basis for the project in Design Basis and Design Briefs. Hereafter generating several concepts which then is narrowed down to a final concept as input for the detailed design. The entire design work has been an interdisciplinary process with interaction between Geotechnical, Structural and Process Engineering. First the Geotechnical Engineers found the main dimensions of the soil embedded part (skirt) of the MBF based on the acting loads and the soil profile. The Structural Engineers use that as a basis for the design of the primary steel. The result is then used as input for an iterative process of load optimisation. When the load levels are optimised the detailed design process initiate and the structure is designed to fulfil the requirements, codes and standards and thereafter follows the whole certification phase, which leads to further design iterations and more detailed and advanced methods of validation.
To be able to install the MBF several piping systems has been developed together with a unit containing all process control elements like pumps, ejectors, valves, and censors. Other secondary item that has been developed is the airtight platform as the interface level between MBF and the above structure. De technical activities also include a complete corrosion protection system, being a combination of surface treatment (paint), ICCP (electrical corrosion protection), and sacrificial anodes.
During the fabrication phase Universal Foundation has contributed with support to understanding of design, optimisation of processes and discussions with certifying party.

1.5.2 Commercial results and expectations

The project has enabled UF to position towards our commercial pipeline. 3 major utility developers in Europe, 4 major utility developers with projects in the US, 3 utility developers in Japan have engaged us for conceptual studies on the prospect of the Deutsche Bucht pilot project. All developers have indicated that it can be a condition that Deutsche Bucht is successfully deployed, which naturally given the current context has been hard to defend. Regardless of this, all but two developers have continued their work with Universal Foundation and have kept the option open to use Mono Buckets in their projects. All are still awaiting the final root cause that led to the installation failure at Deutsche Bucht, and hence there is the real risk that our commercial pipeline does not materialize either due to the root cause or as a result of the fact that the root cause lengthy process means us missing crucial development decision milestones with the developers in question.

The complications during the fabrication process in the project, i.e. the bankruptcy of Harland and Wolff and the subsequent transfer of half-finished foundations to Bladt Industries, negatively impact the perception of the competitiveness of the technology. The commercial implication is that the technology might be penalized on the risk profile, ultimately affecting the cost of capital for the commercial projects. Such impact on cost of capital can prove devastating on the competitiveness, and hence all our future commercial focus is towards developer clients who have a detailed understand of the technology, and who are comfortable enough to not restrict the technology by such increase in risk profile impacting the cost of capital.

The commercial activities of Universal Foundation continue with reduced organization, that has a sole focus on the abovementioned commercial pipeline, but no new projects are considered until a final conclusion on the root cause is available.

1.5.3 Realization of project objectives

Universal Foundation managed to fulfil the objectives in regard to certification of design, development of installation equipment, preparation and training for offshore installation activities and all linked approvals etc. During the installation, a technical issue occurred when the first foundation was halfway installed. The client decided to leave the offshore site after days of problem solving and later cancellation of the project.

UF has investigated the opportunity to complete the project with new partner/developer who has the ability and willingness to complete the Deutsche Bucht project, but this has not turned out positive.

A Root Cause Analysis was initiated in February, heading by an independent 3. Party, this work is expected to be concluded over the late summer months of 2020. Planning of the retrieval process are ongoing and is expected to be concluded during June/July 2020.

1.6 Utilization of project results

The obtained learnings from the project, even though the installation did not succeed, will be used to secure the success for further projects, if any projects are to be realized. The utilization of learnings from the Deutsche Bucht also depends on the root cause, which are still to be determined, to establish if the failed installation did occur due to failed design, installation or external conditions, such as soil and or environmental impacts.

1.6.1 Commercial activities

Due to the current situation, no commercial activities are being planned, as the root cause for the failed installation is still being investigated and concluded upon.
Further use of the philosophy of a suction foundation can be utilised in several other aspects of the offshore industry, e.g. suction anchors for oil/gas or for floating wind turbine installations.

1.6.2 Patents

Universal Foundation is currently sitting on the patents for the method used for installation of the suction bucket foundation for offshore wind.

1.6.3 Ph.D results

The Ph.D results, used for this project has not been used for other research projects at the moment. As the project is still not officially closed down, due to the ongoing root cause analysis and retrieval operations of the foundation, no results will be published for other research projects at this time.
Due to an NDA it has not been possible to use the research or results for other purposes than the Deutsche Bucht project, prior to project close down. When the project officially has been closed down, scour related research data will be published. This date and results will have a positive influence for the scour field in relation to field surveys.

1.7 Project conclusion and perspective

As the project did not manage to be concluded as expected, due to a unsuccessful installation attempt, based on, at the time unknown circumstances and as the project did not chase the second installation due to financial obligations towards the complete project scope of Deutsche Bucht's 31 other monopiles. The concluding parts of the DeBu scope for the two Mono Bucket Foundation is within project and stakeholder management, design and engineering and the ability to prove the philosophy of a controlled installation of the MBF by the means of the used installation method.
The project managing aspects of this project, including the ability to manoeuvre around between all the involved entities and project stakeholders has proven a success throughout this project, both in relation to keeping timelines and deliver within the agreed deadlines. But also, in the quality of the work performed throughout the organization.
Further, the approved and certified BSH design exhibits the quality of the engineering work which was one of the larger milestones to overcome for UF.

The construction of an MBF in this scale was also carried out and by doing this, many difficulties in handling and welding was discovered and lessons was learned on this basis. Further elaboration of conclusions from manufacturing must be found with the project partner H&W and/or Bladt Industries.

1.7.1 Further development

For further projects involving an MBF, material selection and handling is of crucial importance and parallels to soil capabilities and samples must be more fulfilling than for a monopile. Further, a more fulfilling monitoring system must be in place for the installation of a structure, this scale.

Annex

https://www.owf-deutsche-bucht.de/pilot-project/default.aspx
https://www.owf-deutsche-bucht.de/default.aspx
https://www.offshorewind.biz/2020/02/26/northland-power-might-halt-deutsche-bucht-demonstrator-project/