Survey of Swedish suppliers to a floating wind turbine unit equipped with pumps for oxygenation of the deepwater

BOX WIN

Technical report no.7

Holger Eriksson &
Thomas Kullander

C101
Rapport
Gothenburg 2013

Department of Earth Sciences
University of Gothenburg

GÖTEBORGS UNIVERSITET

Naturvetenskapliga fakulteten

UNIVERSITY OF GOTHENBURG
Department of Earth Sciences
Geovetarcentrum/Earth Science Centre

Survey of Swedish suppliers to a floating wind turbine unit equipped with pumps for oxygenation of the deepwater

Technical report no.7

Holger Eriksson &
Thomas Kullander

ISSN 1400-383X

C101
Rapport
Gothenburg 2013

Mailing address	**Address**	**Telephone**	**Telefax**	
Geovetarcentrum	Geovetarcentrum	031-786 19 56	031-786 19 86	Geovetarcentrum
S 405 30 Göteborg	Guldhedsgatan 5A			Göteborg University
				S-405 30 Göteborg
				SWEDEN

Abstract

This report serves to present a selection of Swedish suppliers which are potential candidates to involve in the realization of a floating Demonstrator wind turbine and pumping unit located in the Bornholm Basin of the Baltic proper. The presentation, which does not cover all but some Swedish suppliers, is based on open information and the suppliers are selected for their proven experience and shown capability to deliver services and goods to the offshore and marine industry, and to manage, engineer, construct, transport, install, operate and maintain a Demonstrator.

We conclude that there are potential Swedish suppliers of services and products to the Demonstrator with respect to Management of the project and all phases of realization of the substructure, but none is experienced enough to perform the Engineering, Construction and Transportation /Installation of the total wind turbine assembly.

There are companies in Sweden which have the experience and capability to design, construct and transport the substructure, and to import services and materials that are unavailable. Considering the wind turbine, technology is basically the same for the Demonstrator as for other wind turbines located in Sweden irrespective of whether they are based on land or resting on the sea bottom. The wind turbine is principally assembled from three integrated parts: the tower, nacelle and turbine blades. There is only one Swedish supplier of towers while nacelle and turbine blades have to be imported. On the contrary, there are several companies in Sweden which are building and operating wind turbine farms located in Sweden onshore and resting on the sea bottom offshore. Regarding pumps, these can be designed and fabricated in Sweden and there are established suppliers of imported pumps and pump equipment.

Marine operations, preferably within the transport, installation and mooring sector, are provided by a limited number of companies represented in Sweden. To assemble the wind turbine, heavy-lift vessels are usually required, and these are normally provided by foreign companies. Some specific areas of competences and components also need to be imported.

Sammanfattning

Denna rapport presenterar ett urval av svenska företag som har förutsättningar att kunna delta i förverkligandet av en Demonstrator, ett flytande vindkraftverk med pumpar för syresättning av djupvattnet, placerad i Bornholmsbassängen i Östersjön. Presentationen, som inte gör inte anspråk på att vara komplett, bygger på öppen information och redovisar ett urval av svenska företag som har erfarenhet och kapacitet att leverera varor respektive tjänster till den marina industrin inom områdena projektering, byggnation, installation, underhåll och drift av en Demonstrator.

Slutsatsen är att det finns möjlighet att i svensk regi leda och genomföra ett projekt i syfte att konstruera, bygga, transportera, installera, driva och underhålla en Demonstrator.

I Sverige finns företag som kan konstruera, bygga och transportera undervattenskroppen samt köpa in de tjänster och produkter som inte finns tillgängliga i Sverige. För själva vindkraftverket gäller samma förutsättningar och tekniska grundlösningar som för övriga vindkraftverk i Sverige oavsett om dessa är baserade på land eller till havs. Vindkraftverket består i princip av tre separata delar: tornet, nacellen (maskinhuset) och vingarna (turbinbladen). Det finns emellertid endast en tillverkare av torn i Sverige, medan nacelle och vingar måste importeras. Däremot finns ett flertal företag som bygger eller äger både land- och havsbaserade bottenfasta vindkraftparker i Sverige. Beträffande pumpar kan dessa konstrueras och tillverkas i landet, och det finns också några få etablerade leverantörer som importerar pumputrustning.

Marina operationer, företrädesvis inom transport, installation och förankring, utförs av ett mindre antal företag representerade på den svenska marknaden, tunglyftsfartyg saknas dock i Sverige. I tillägg får även en del specifika kompetenser, tjänster och komponenter importeras.

Table of Contents

Abstract 2

Sammanfattning 3

Table of Contents 4

List of figures 5

List of tables 5

Preface 6

1. Introduction 7

2. Data 8

3. Suppliers 8

3.1 Project Management 8

3.2 Engineering 9

3.2.1 Wind Turbine 11

3.2.2 Substructure 11

3.3 Construction 12

3.3.1 Wind Turbine 12

3.3.2 Substructure 13

3.4 Marine Operations 14

3.4.1 Transport / Wet Towing 14

3.4.2 Installation 16

3.4.3 Anchoring / Hook-up 16

3.4.4 Removal / De-commissioning 16

3.5 On-Site Operations 17

3.5.1 Operation 17

3.5.2 Maintenance 18

3.5.3 Use 18

4. Conclusion 18

5. Discussion 19

6. Acknowledgements 19

7. References 20

List of figures

Figure 1. Side view of the Demonstrator concept........13

Figure 2. Wet towing of a FTWU substructure........15

Figure 3. Anchoring and Hook-up operation........15

Figure 4. Assembling a nacelle by a Crane Vessel........16

List of tables

Table 1. Number of Swedish suppliers........18

Preface

In 2008, Formas and Naturvårdsverket (Swedish EPA) announced available funding for research on the possibility to use deepwater oxidation as a mean to combat eutrophication in the Baltic Sea. Two projects, BOX, "Baltic deepwater OXygenation" and PROPPEN were funded at the end of December 2008. These projects have shown that phosphorus leakage from anoxic bottoms in small coastal basins may be stopped by oxygenation. BOX has shown that this also is true for the Baltic proper. The BOX-WIN project "wind driven oxygenation by pumping and generation of electrical power" builds on BOX.

Results from the BOX-WIN project will be presented in a series of reports from the Department of Earth Sciences at the University of Gothenburg. A wide range of subjects are covered by BOX-WIN. Technological, environmental, economical and legal facts and circumstances must be considered to develop and locate a full-scale Demonstrator composed of a self-supporting, floating wind turbine unit with a generator producing electric power for deepwater oxygenation by pumping and for delivery to the grid. The Demonstrator will be developed for the Bornholm Basin, which at times has anoxic water in its deepest parts. The Demonstrator developed by BOX-WIN will hopefully be built to conduct tests in the Bornholm Basin. This would be an important step towards installation of a regional system of full-scale floating wind turbine units with pumps in the Bornholm Basin. An updated list of BOX-WIN reports is included at the end of the report.

The present report "BOX-WIN Technical report no. 7 – Survey of Swedish suppliers to a floating wind turbine unit equipped with pumps for oxygenation of the deepwater" is written by Holger Eriksson and Thomas Kullander. The work is funded by the Swedish Agency for Marine and Water Management.

Gothenburg 22 May 2013

Anders Stigebrandt

1. Introduction

This report serves to present a selection of Swedish suppliers which are potential candidates for engagement in the realization of the design, construction, installation, operation, maintenance and decommissioning of a floating Demonstrator wind turbine and pumping unit located in the Bornholm Basin of the Baltic proper.

The objective of this report is to provide an indication of to which extent Swedish industry is available and capable to realize the Demonstrator project and to identify products and services required by the Demonstrator that lack Swedish suppliers.

The feasibility study of a Demonstrator is based on the proven design of the Floating Wind Turbine Unit (FWTU) named Hywind, which has been moored in the Norwegian Sea west of Bergen, Norway at 500 m of water depth and operated continuously since 2009. The Hywind FWTU is referred to as Hywind I herein. Its design has been modified to accommodate a water pumping device for deepwater ventilation on an assigned location in the Bornholm Basin of the Baltic proper. The report is thus applicable for the proposed locations presented in Technical Report no. 2 (Ödalen and Stigebrandt, 2013)[1] of the BOX-WIN series of reports, where water depth is approximately 100 m and seabed soil is pre-dominantly clay and sand.

The height of the Demonstrator is approximately 90 m above the sea surface and it extends a further 90 m below the surface. The Demonstrator displacement is approximately estimated to 5500 tonnes, whereof steel is about 2000 tonnes; ballast 3000 tonnes; and the wind power unit 500 tonnes. The wind turbine is rated 3.0 MW. The Demonstrator concept has been developed in the BOX-WIN project and will be presented in an upcoming Technical Report in the BOX-WIN series.[2]

There are companies in Sweden that are capable to construct this type of steel design; nowadays mainly repair yards, which are the sturdy remnants from the previous large new-building ship yards of which most were closed down. This study clarifies which these companies are and what they might be able to contribute with in the realization of the Demonstrator project.

This survey is based on open information from suppliers with proven experience and capacity to deliver products and services to the offshore and marine industries.

2. Data

Design data and conceptual design drawings form the basis for the products and services of the Demonstrator. Some design data are published in Technical Report no. 4 of the BOX-WIN series of reports.[3] The conceptual design drawings and other design data will be published in the upcoming report "Plan and Cost Estimate for a Demonstrator – a floating wind turbine unit equipped with pumps for oxygenation of the deepwater, and associated patents and immaterial rights", which will also be a Technical Report in the BOX-WIN series.[2] That report will also include investigations of patent and immaterial rights and a preliminary cost estimate for the construction of the Demonstrator.

3. Suppliers

The Demonstrator project constitutes five phases, of which some may be concurrent or overlapping:

- Project Management
- Engineering
- Construction
- Marine Operations
- On-Site Operations

In addition, a client and/or lender organization will be set up for steering, sanctioning and approval of the overall project performance and financial control, and for contracting of all suppliers to the project. The customer may, at lenders discretion, decide to delegate his responsibility and authority to one of the main contactors.

These phases are further described and Swedish suppliers to each of these phases are identified in the sections below. [4,5,6,7]

3.1 Project Management

Procurement of suppliers and assignment of contractors comes essentially in a variety of forms depending on the policy, preference and attitude to risk of the client or owner, for example a turn-key engineering-procurement-construction-installation (EPCI) project for attaining minimum risk. In general, the responsibility for delegation of procurement activities varies during the distinct phases of the project according to the operative form being chosen. Depending on the experience and capacity, the engineering resources of the client or owner may be integrated into the organization of the project as managed by the project manager; this is often the model chosen for large international offshore projects. The project manager may occasionally be the client representative.

In this conceptual stage of the Demonstrator project, the owner and client organizations are not yet defined and no further directions are reasonable.

There are a number of large Swedish companies which have the capacity, resources and experience from managing complex construction projects, mainly onshore but also bottom-resting units offshore, for example Sweco, AF, Swepro, Semcon, WSP and the specialized construction companies Skanska, NCC and PEAB, as well as the diversified manufacturing and installation giant ABB .

The main challenge for project management is to correctly include the requirements of rules and regulations, statutory requirements, laws, national standards and practice used for floaters in Danish territorial waters and to compensate, as necessary, for those mandatory for Hywind in Norwegian waters.

The project management phase will last over the entire period of time of the project.

3.2 Engineering

Marine and offshore engineering is international in approach and not adapted to Swedish engineering practices onshore. A documented technical description (TD) or design outline specification is enough to kick-off a project team for the Demonstrator. The TD should indicate the flag state and rules and regulations to be followed, and whether a classification society is required for third party approval of the Demonstrator. The latter is mandatory for floating offshore units on the continental shelf in the North Sea and may be required by lenders or clients in order to be able to insure the vessel.

Marine and offshore engineering is usually performed sequentially in four phases:

i. Pre-FEED (Front End Engineering Design)
ii. Basic Design, or FEED
iii. Detail Design
iv. Work Shop Drawings

Normally the Pre-FEED and FEED phases are assigned to a naval architectural and marine engineering consultant company specialized in fulfilling the design basis in a cost-efficient way, while the detail design and shop drawings are performed by a ship yard. Smaller yards may show lack of specialized design knowledge or engineering capacity, so these tasks may occasionally be assigned to the naval architect designer, too.

Pre-FEED is mainly aimed at finding the optimum design under given presumptions and includes a number of design loops to meet this purpose. This process requires some time. For example, one year is typically the time required to develop an acceptable semisubmersible mega-design for tapping huge oil reservoirs below sea bottom at water depth of 3000 m or more.

The purpose of the basic design is to arrive at an approved design. The basic design is based on the outcome of the Pre-FEED and consists of drawings of the proposed design and calculations to support the design, which are normally submitted for approval by the client, national (flag) authorities and classification societies. These drawings and calculations may occasionally first be preliminarily submitted for main scantling approval, enough to order material with long lead time and book slots at steel mills. Later on, when the design has settled and arrangements become locked, final basic design calculations of structural strength, intact and damage stability, hydrodynamic motions and loads, mooring analyses, piping, machinery, electricity, HVAC, fire protection, safety, navigation and control systems are subject to review and approval by the classification society. Additional to these, a number of reports are submitted to authorities, e.g. risk analysis (HAZID, HAZOP; FMEA), dropped object study, sea bottom survey (cable route finding, anchoring), towing analysis, environmental study (MKB), diving program, etc. For purchasing, installation and operating the Demonstrator various procedures, e.g. assembly, installation, commissioning and maintenance, are issued by the basic design team of engineers in cooperation with the suppliers.

The detail design phase is a further refinement of the design models developed by the basic design, but now adapted for practical use. The documents produced by the detail design phase easily outnumber those of the basic design. For the previously mentioned semisubmersible mega-design projects, ship yard personnel work in close cooperation with the basic design team for more than a year to be able to prepare for a detail design which meets the ship yard standards.

Procurement activities and purchasing documents may be included in the basic design of the floater in order to specify, define and support the procurement activities in practice during the normally hectic final of the project before handover. The purchasing documents include main arrangement drawings and material take-off (MTO) lists and form the basis for the request for quotation (RFQ), purchase order (PO), technical inquiry specifications (TIS) and technical procedure specification (TPS). In addition, the procurement department may need assistance from specialized consultants to prepare the documents of the PO.

Engineering basically includes design drawings, design specifications, material take-off for procurement, test specifications, approval by client, national authorities and classification societies, already from start of first design.

The engineering of the Demonstrator is split into concurrent design of the wind power plant and of the substructure. Concurrent engineering makes it possible to reduce the total period of time needed to start procurement of long lead items and proceed with construction work.

The plant consists principally of a standard wind tower 90 m high, nacelle, rotor and rotor blades, plus control systems and equipment for transformation and transport of the generated electrical effect. The substructure comprises an approximately 100 m long and 20 m wide reinforced steel cylinder with three steel cylinders of approximately 4 m diameter each welded thereto. The steel weight of this construction is about 2000 tonnes.

Engineering also includes marine operations, such as load-out, sea-fastening and towing calculations, anchoring and hook-up procedures, lifting at sea, ballasting, anchoring system design and power cable design. The details on marine operations are given in section 3.4.

It is of utmost importance that the design of the wind power plant matches that of the floating unit, for example transfer of structural loads, intact and damage stability, hydrodynamic loads, anchoring loads, weight management, access to nacelle, routing of power and control lines and so on. In practice, the project will form a joint team with the engineers of the wind turbine designer.

The Demonstrator is designed to stay on location for the entire period of on-site operation.

3.2.1 Wind Turbine

The engineering design process of the wind power plant is not anticipated to deviate from that of Hywind, except for the implementation of Danish national requirements as described above. There are a few Swedish designers of wind turbines, primarily Vattenfall Power Consultants and Triventus Consulting, but none with experience from 3 MW turbines of their own make.

3.2.2 Substructure

There are some Swedish marine engineering companies which have the capacity, resources and experience to manage marine and offshore projects, for example GVA Consultants, Bassoe Technology, FKAB and Saltech Consultants. The scale of their projects often comprises steel designs ten times the size of the Demonstrator and anchored at large water depth, from 500 to 2000 m. In addition, there are a large number of specialists in smaller engineering design companies as well in the large Swedish multi-engineering design companies, such as SEMCON, ÅF, Sweco, etc. which possess special competent resources occasionally allocated to projects managed by the few major marine design companies listed above.

The work shop drawings are tailored to the specific production equipment of the ship yard and are not necessarily identical between different ship yards. In addition, particular attention is to be paid to meet the physical configurations and constraints on lifting range, lifting height, equipment and control systems used for steel cutting machines and rollers; all required in order not to unnecessarily delimit the dimension and weight of steel sections.

A site team is often established at the ship yard to coordinate and respond to problems encountered by the ship yard during fabrication; to assure all rules and regulations approved in the basic design are being met and not overseen; and to approve directly on site any design changes proposed by the ship yard. The site team, as organized by the client, is assembled of the prominent lead engineers from the design companies and is responsible to coordinate the client, classification society, authority's requirements and questions regarding the design, function, capacity and performance of the floating vessel.

3.3 Construction

The construction phase is split into two parallel activities of fabrication: the wind turbine including tower, nacelle and rotor blades; and the substructure of the floater. Procurement of sub-suppliers and testing of their equipment are included in both activities.

Fabrication of large steel designs by a ship yard generally follow these steps of execution: detail design drawings, work shop drawings, procedures for fabrication, erection and assembly of steel sections, production planning, schedule for main equipment, section preparation, numerical steel cut program, piping, steel straightening, painting, lifting, load-out and installation, tests, commissioning sea trial, and handover. All these prior to installation, are also applicable to the Demonstrator.

As compared to land-based designs, which are ruled by national onshore authorities, the floating Demonstrator is typically designed for operation offshore as regulated by international rules issued and enforced by a classification society in order to guarantee the technical function to insure the vessel. In addition, the national authority like the Swedish Maritime Administration or the corresponding authority of the country where the vessel will be registered (the flag state), will also be present to regularly inspect and survey the design, fabrication and operation of the vessel.

The Demonstrator is produced according to standard offshore design where a lot of the installation work is performed already in the sections, before they are assembled into a larger vessel; that is to minimize production time, lead time, risks and transport ways during construction.

3.3.1 Wind Turbine

The fabrication of the wind turbine for a floating Demonstrator is principally the same process as for land-based and bottom-rested wind turbines of tower, nacelle and turbine blades with electrical, control and automation systems. The tower is assembled in 3 – 4 separate sections of about 25 m of length or delivered as an all-welded section. From a fabrication point of view, there is no major difference between the Demonstrator and a land-based wind turbine.

Today, Sweden has only one experienced manufacturer of wind turbine towers, Enercon in Malmö. There are no manufacturers of complete nacelles in Sweden. Turbine blades are not regularly produced in Sweden, although some have been made by Marström Composite. In general, existing equipment and services are provided by Swedish entrepreneurs for constructing foundations to land-based wind turbine towers, assembly of equipment produced by suppliers, completion of various systems and commissioning of a wind turbine. These services are also available as applicable to the Demonstrator.

3.3.2 Substructure

The substructure comprises several steel sections, each sections being marked on a section drawing. The drawing in Figure 1 shows the side view of the conceptual design of the Demonstrator, where the main central cylinder is designed to embody the necessary displacement and ballast to provide the stability of the vessel. The pumping units are shown as three additional steel cylinders welded onto the central cylinder, where the pumps are removable from atop the separation roof. Below the roof is a lattice work to protect the water inlet and prevent drifting nets, timber, seals, etc. to intrude into the pumping device. At the bottom, the water is pumped out through a nozzle in the end of each pump cylinder.

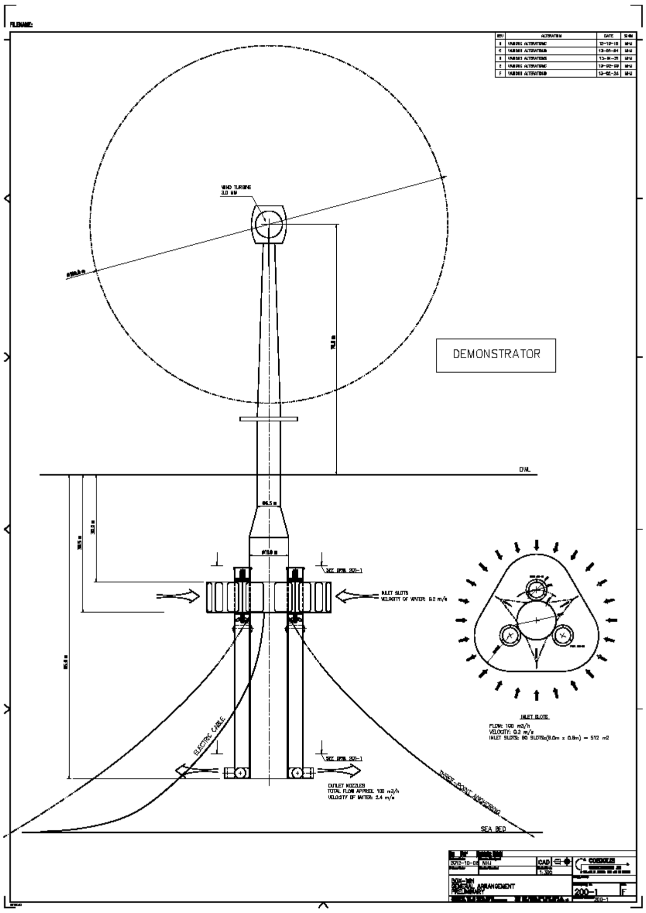

Figure 1. Side view of the Demonstrator concept.

The steel design of the Demonstrator substructure comprises a shell design traditionally used offshore, for ships and other marine designs. The stressed membrane design is mainly composed of steel plates supported by frames, webs and bulkheads, and is a most weight and stress efficient design.

The floater is designed as a cylinder of approximately 100 m of length and up to 20 m of diameter. The cylinder is constructed with its axis parallel to the ground. Construction and hanging of large steel sections is performed in sequence from the ground and up. The yard required for assembling of the cylinder should be located close to the launching facilities, i.e. a dry dock, floating dock or slipway. Before leaving the ship yard, the substructure including pumping devices is assembled and tested, mechanically complete, and finally painted to prevent corrosion at sea. Depending on the launching or berthing facilities, procedures may vary between ship yards.

Several ship yards are still established in Sweden and capable to construct all, parts or sections of the Demonstrator substructure unit: Götaverken Damen, Gotenius Varv, Djupviks Varv, Falkvarv, Öresund Heavy Industry, Kockums Varv, Damen Oskarshamn and Stockholm Ship Repair Yard. In addition, some companies specialized in welded steel designs may be used for particular steel sections or steel equipment such as ladders, platforms, pumping cylinders, etc.

3.4 Marine Operations

There are relatively few ships and specialized vessels equipped for transport and installation of wind turbines in Europe and those are not routinely available in Sweden. For example, special crane vessels are effective for lifting and positioning and for holding the tower sections, nacelle, hub and rotor and turbine blades in place when bolting them together. Traditional offshore supply vessels are used very seldom in Sweden, but the company Transatlantic operates some large offshore supply vessels equipped for anchor handling and diving operations in the North Sea, which could also be used in the Baltic Sea. [8,9,10]

3.4.1 Transport / Wet Towing

The term ”transport” includes all forms of activities required from the float-out at the ship yard quay to installation of the Demonstrator completed on-site in the Bornholm Basin. It includes lifting, loading, unloading, under-water installation, ballasting, mooring system hook-up, diving, wet towing, wind tower assembly, nacelle and rotor system assembly, turbine blades assembly, installation of sea power cable from the Demonstrator to onshore, mechanical completion tests, commissioning tests and handover of complete Demonstrator. Tugs for towing and transport of sections, equipment and materiel are available at the largest sea ports in Sweden, through companies such as Bohus Tug and Svitzer Sverige. Wet towing of a substructure to a FWTU is shown in Figure 2. [8]

Special equipment and vessels required for transport of pre-assembled wind turbines and blades are not available in Sweden. The same applies for heavylift vessels and crane vessels which usually operate on the global or European market by international companies.

Figure 2. Wet towing of a FTWU substructure. [8]

Figure 3. Anchoring and Hook-up operations. [8]

3.4.2 Installation

When located on-site, the Demonstrator is ballasted down with rock and water to obtain enough stability for installing the wind tower, lifting and loading on the nacelle and turbine blades. As compared to bottom-resting wind turbines, where a jack-up type of crane can be used, the Demonstrator requires a crane vessel floating in about 100 m of water depth. Anchoring and Hook-up operations are shown in Figure 3.[8] Assembling of a nacelle by a Crane Vessel is shown in Figure 4. [8]

There are a few Swedish companies which have the capacity, resources and experience to manage the manufacturing and installation of offshore submarine cables, for example ABB Cables and Nexans.

Figure 4. Assembling a nacelle by a Crane Vessel.

3.4.3 Anchoring / Hook-up

As described in Technical Report no. 4,[2] the Demonstrator will be moored by a three set of mooring lines each of about 300 – 400 m total length. The pre-laid anchors and mooring lines will then be picked up by an anchoring or supply vessel and hooked up to the pad eyes.

Mooring wire lines and chain are readily available in offshore standards, while chain size is well within the product register of Ramnäs Bruk who supply 50,000 – 80,000 m of chain each year.

There are a few Swedish companies which have the capacity, resources and experience to manage anchoring operations, for example Transatlantic and Stena.

3.4.4 Removal / De-commissioning

De-commissioning, removal and finally scrapping include all activities required in relation to de-assembling and de-ballasting of the floater after final use, including the substructure, wind turbine, mooring system, sea power cable and all other equipment installed to operate the Demonstrator.

There are no experienced Swedish companies with vessels suitable for removal of such a long steel structure as the Demonstrator. However, there are dredging and heavy lift companies in Holland who are capable to remove the rock ballast and wind turbine unit before removal off the site. The Demonstrator can then by towed in horizontally floating position to a scrap yard nearby.

3.5 On-Site Operations

On-site operations stretch from handover to de-mobilization and constitute the main period of use of the Demonstrator, assumingly 20 years of continuous operation, maintenance and use.

A very good accessibility to the Demonstrator, serviceability of the main equipment and availability of service and maintenance personnel are fundamental to maintain the optimum operational availability of the Demonstrator as vital to the generation of energy and the total efficiency of the plant.

Service and maintenance are normally provided on a continuous basis, stand-by or called in during certain times. This service potentially includes some remote operational monitoring and control, manning on-site and technical support as well as store keeping of goods and materials expendables and inventory of parts. In addition to this service comes freight and shuttle service to and from the Demonstrator, preventive maintenance operations and minor repairs.

There are a few Swedish companies which have the capacity, resources and experience to manage transportation for maintenance and site operations, for example Northern Offshore Service, Blekinge Offshore and Triventus Energiteknik.

3.5.1 Operation

Different modes of operation can be installed on-board by means of the submarine power cable, if equipped with umbilical lines for hydraulic control of valves, etc. The Demonstrator can then be regularly operated from ashore. This mode is frequently used in harsh environments and hurricane infested waters, e.g. of the Gulf of Mexico. This mode is applicable for control of the wind turbine as for counter-ballasting of the Demonstrator, as applicable.

3.5.2 Maintenance

A reliability regime centred on preventive maintenance is recommended since the Demonstrator is an unmanned installation with potentially reduced accessibility at stormy and icy weather conditions.

3.5.3 Use

The Demonstrator is primarily used for transporting dissolved oxygen from waters above the halocline to the deep waters above the sea bottom, but also to supply energy to the pumps used to transport the water. In addition, the Demonstrator may be used in duty as a platform hub for research and development to:

- register metrological and climatic parameters over time.
- register wind direction and speed.
- register water parameters over time and depth, such as temperature, salinity and oxygen content.
- measure biological parameters over time, such as occurrence of plankton, cod spawn, etc.
- survey bird tracks.

The Demonstrator is not equipped with hostel facilities that allow for personnel to stay on-board.

4. Conclusion

The range of number of experienced Swedish potential suppliers of services and products to the Demonstrator are compiled in Table 1.

Table 1. Range of number of potential Swedish suppliers.

	Wind Turbine 3 MW	Substructure
Project Management	3 - 8	5 - 15
Engineering	0	3 - 4
Construction	0 (only Tower)	3 - 8
Transport/ Installation	0	1 - 2
On-Site Operation	1 - 2	1 - 2

The conclusion is that there are potential Swedish suppliers of services and products to the Demonstrator with respect to Management of the Project and all phases of realization of the substructure, but none is experienced enough to perform the Engineering, Construction and Transportation/Installation of the total wind turbine assembly.

It is also obvious that the supplier of the wind turbine will need to develop the design, fabricate and transport/install the wind turbine in close cooperation with the Project team as organized by the Project Management.

Marine operations, preferably within the transport, installation and mooring sector, are provided by a limited number of companies represented in Sweden. To assemble the wind turbine, heavy-lift vessels are usually required, and these are normally provided by foreign companies. Some specific areas of competences and components also need to be imported.

5. Discussion

The realization of a Demonstrator will generate jobs in Sweden to a non-negligible amount, the extent of which is however not estimated by this report.

Vestas is a Danish producer of wind power plants who has long experience from designing and producing bottom-rested wind power plants for location offshore. They also supplied the wind turbine for the floating Hywind unit. Cooperation with Danish suppliers, research organizations and universities should come into effect as the Demonstrator is proposed to be located in the Danish exclusive economic zone (EEZ).

Considering a life time of 20 years of continuous operation of the Demonstrator, the on-site operations will be a critical factor for success and potential new market for Swedish entrepreneurs offshore.

6. Acknowledgements

This work was funded by the Swedish Agency for Marine and Water Management. Oresund Heavy Industry AB, IUC, KSB Mörck Pumps, Bergs Propulsion and Statoil division for Unconventional Wind are acknowledged for providing the necessary data for this study. The authors thank Malin Ödalen very much for suggesting many improvements and for essential assistance in proof reading, editing and layout of the report.

7. References

1. Ödalen, M. & Stigebrandt, A., 2013. Factors of potential importance for the location of wind-driven water pumps in the Bornholm Basin, BOX-WIN Technical Report no. 2, Report C97, ISSN 1400-383X, Dept. of Earth Sciences, University of Gothenburg.

2. Eriksson, H., Kullander, T., 2013. Plan and Cost Estimate for a Demonstrator – a floating wind turbine unit equipped with pumps for oxygenation of the deepwater, and associated patents and immaterial rights, BOX-WIN Technical Report series. (in prep.)

3. Eriksson, H., Kullander, T., 2013. Assessing feasible mooring technologies for a Demonstrator in the Bornholm Basin as restricted to the modes of operation and limitations for the Demonstrator, BOX-WIN Technical Report no. 4, Report C98, ISSN 1400-383X, Dept. of Earth Sciences, University of Gothenburg

4. Edvardsson E., 2010/2011. Swedish Shipping, The past, the present and the future. Horns forlag AS.

5. Slutrapport, Kartläggning och Tillväxtanalys av SMF inom Havsmiljöområdet, IUC Sverige AB.

6. Hedman, M., Svensson, L., Hansson, Ö., 2012. SEK Samhällsekonomisk kalkyl, Havsbaserad Vindkraft, IUC Sverige AB.

7. Blekinge Offshore AB, retrieved 15 February, 2013, from <http://www.blekingeoffshore.se/>

8. Statoil.com. 2009. *"Hywind: Putting wind power to the test."* Published 10 December 2010, Retrieved 24 December, 2012, from <http://www.statoil.com>.

9. Ny Teknik. Published August 7, 2012, retrieved 26 February, 2013, from <https://www.nyteknik.se>

10. StatoilHydro. Published June 10, 2009, retrieved February 15, 2013, from <http://www.siemens.com>

BOX-WIN Technical Reports Series

1. Ödalen, M. & Stigebrandt, A., 2013. Hydrographical conditions in the Bornholm Basin of importance for oxygenation of the deepwater by pumping down oxygen saturated water from above the halocline, BOX-WIN Technical Report no. 1, Report C96, ISSN 1400-383X, Dept. of Earth Sciences, University of Gothenburg.

2. Ödalen, M. & Stigebrandt, A., 2013. Factors of potential importance for the location of wind-driven water pumps in the Bornholm Basin, BOX-WIN Technical Report no. 2, Report C97, ISSN 1400-383X, Dept. of Earth Sciences, University of Gothenburg.

3. Stigebrandt, A., Kalén, O., 2012. Improving oxygen conditions in the deeper parts of Bornholm Sea by pumped injection of winter water, *Ambio*, 41, no. 8, Dec 2012, doi: 10.1007/s13280-012-0356-4 (BOX-WIN Technical Report no. 3)

4. Eriksson, H., Kullander, T., 2013. Assessing feasible mooring technologies for a Demonstrator in the Bornholm Basin as restricted to the modes of operation and limitations for the Demonstrator, BOX-WIN Technical Report no. 4, Report C98, ISSN 1400-383X, Dept. of Earth Sciences, University of Gothenburg.

5. Eriksson, H., Kullander, T., 2013. Assessing important technical risks from use of a floating wind turbine unit equipped with pumps for oxygenation of the deepwater, BOX-WIN Technical Report no. 5, Report C99, ISSN 1400-383X, Dept. of Earth Sciences, University of Gothenburg.

6. Hellström, T., Ödalen, M., 2013. Long-time behaviour of mustard gas dumped in the Bornholm Basin, BOX-WIN Technical Report no. 6, Report C100, ISSN 1400-383X, Dept. of Earth Sciences, University of Gothenburg.

7. Eriksson, H., Kullander, T., 2013. Survey of Swedish suppliers to a floating wind turbine unit equipped with pumps for oxygenation of the deepwater, BOX-WIN Technical Report no. 7, Report C101, ISSN 1400-383X, Dept. of Earth Sciences, University of Gothenburg.