

出國報告（出國類別：其他）

## 赴德國布萊梅產業交流訪問

服務機關：核能研究所

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派赴國家：德國

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## 摘 要

本次國外公差為核能研究所研究員黃金城奉派參加由經濟部能源局主辦之 2017 年赴德國布萊梅產業交流訪問團，於中華民國 106 年 5 月 16 ~ 19 日訪問德國布萊梅(Bremen)離岸風電產業及技術發展現況，並藉由國內來自不同產業界代表及研發領域的專家與德國離岸風電產業經濟發展機構、主要廠家以及研究機構之間的相互交流，建立未來台德雙方在離岸風電產業發展合作及聯繫的管道。台灣與德國於能源議題交流密切，自 105 年經濟部能源局代表政府與德方簽署「台德能源轉型合作意向共同宣言」，作為未來能源議題深化交流合作之基礎。本次組團赴德訪問即為具體落實能源議題的交流活動之一，由能源局蘇主任秘書金勝擔任領隊。由於出發前能源局的縝密規劃與聯繫，舉行兩次的籌備會議，除蘇主秘及職來自政府單位，其餘 15 位則皆為來自法人單位及國內外離岸風電產業界的代表共計 17 人參加此次台德於離岸風電產業交流活動。藉由此次 4 天於德國布萊梅離岸風電產業園區相關機構的訪問交流，對於德國離岸風電的發展現況有了更深的了解，而對於未來國內重要的離岸風電建設與德國的實質合作與交流值得期待。

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## 一、目的

政府於中華民國 101 年 7 月頒布風力發電離岸示範獎勵辦法，並在 102 年 1 月核定由兩家民間離岸風電開發商上緯公司及永傳能源公司，以及台灣電力公司率先啟動離岸風電示範，並藉由補助兩台離岸風機的設置進而推動離岸風電示範風場的建立。去年(105 年)9 月由上緯公司預計建立的海洋(Formosa)離岸風場率先完成兩台離岸風機的設置，採用西門子(Siemens)4MW 離岸風機及單樁(Monopile)支撐結構，正式啟動台灣離岸風力發電的新紀元。也是近來行政院推動「風力發電四年推動計畫」以及未來台灣因應能源轉型，將於 2025 達成非核家園，加速推動綠能電力開發，非常關鍵之風電建設重要的一環。

有鑑於離岸風電起始於 1990 年代的歐洲北海及波羅的海等鄰近國家，例如丹麥、德國及荷蘭等國。其中尤其是德國，約在 1990 年代初期，德國既以其重工業的雄厚基礎及縝密規劃與實事求是的民族性，跨足離岸風電產業及搭配完整的離岸風電技術標準(如風機國際標準 GL Guidelines 等)逐步建立德國的離岸風電產業技術，而目前已具世界上最完整離岸風電產業鏈結的地位，而且藉由其技術研發、測試驗證、整機系統整合、設計製造組裝、海事工程施工等由示範實驗離岸風場，建立經驗、改正錯誤到建立標準導則與程序，整體的離岸風電學習曲線(Learning Curve)，非常值得政府及國內離岸風電產業界學習及借鏡。

經濟部能源局與德國在台協會自民國 104 年開始連續兩年在台舉辦能源論壇，以進行能源議題對話與交流。去年雙方更進一步簽署「台德能源轉型合作意向共同宣言」，宣示進一步合作之意願，並做為深化能源領域合作之基礎架構。而在此基礎之下，台德雙方同意於今年安排台灣訪問團訪德，以具體落實上述共同宣言下之合作活動，促進台灣與德國產官學研間雙邊能源轉型議題之交流。因此，今年經濟部能源局特別接受德國布萊梅政府邀請，規劃本次 2017 年赴德國布萊梅產業交流訪問團，並以離岸風電為主題，由能源局主辦並邀集國內離岸風電工程技術研發相關法人研究單位、國內主要離岸風電相關廠家、港務公司台中分公司、國內主要財務規劃公司及德國在台離岸風電相關公司代表等。本次赴德訪問團由能源局蘇主任秘書擔任領隊，除蘇主秘及職為政府單位，其餘皆為來自上述各單位之代表，涵蓋產官學研不同領域專家與業界代表。而此次參訪德國布萊梅港區(Bremerhaven) 亦為其主要的離岸風電產業聚落所在包括 SENVION 風機公司研發製造及組裝、佛朗恩霍夫(Fraunhofer)研究院之風能及能源系統研究所 IWES (Institute for Wind Energy and Energy System)、興建中

的北海 Nordergrunde 離岸風場及布萊梅港務公司及港口基礎建設與離岸風電重裝設備物流 (Logistics) 等產業。此次赴德參訪，能源局於出發前的縝密規劃，透過德方布萊梅離岸風電產業相關單位的安排，所擇定的各參訪機構皆是布萊梅主要的離岸風電重要產業鏈結聚落。職很榮幸奉派代表核能研究所參加此次由能源局主辦以離岸風電為主題之 2017 年赴德國布萊梅產業交流訪問團。由於自 102 年起，職即擔任核能研究所離岸風力計畫主持人並主持科技部能源國家型科技計畫離岸風力主軸計畫，主要從事國內離岸風機及支撐結構整合系統抗颶耐震設計驗證技術建立，因此藉由參加此次赴德參訪團，特別注意德國離岸風電技術研發與產業整合所建立的學習曲線。其次，本次參訪由於安排參訪機構較多，且都為不同領域涵蓋政府經濟投資機構、風機製造產業鏈及水下施工工程管理、研究機構、港務公司及風電設備碼頭運輸等，以配合離岸風電產業複雜多元的角色，而參訪團成員也都來自產官學研不同單位，經過與德方 4 天於離岸風電不同的領域交流，對於目前國內推動的離岸風電計畫，無論在產業發展、風電開發，甚至技術研發及德國相關產業技術現況都已留下深刻的印象，對於未來在上述領域的台德雙方合作上，應會具有相當的助益。

## 二、過程

此次 2017 年赴德國布萊梅產業交流訪問團一行共計 17 人，然而來自不同機構，為符合各單位不同規劃需求，行程較為複雜。其中部分團員於參訪前已先行抵達布萊梅並於結束訪問團行程後，另有安排其他事項辦理，因此行程安排上並無法共同出發及返回，而整體參訪行程安排及聯繫就顯得格外重要，本次赴德參訪團團員名冊如附錄一。於 106 年 5 月 15 日(週一)由桃園機場搭機經阿姆斯特丹機場轉機前往德國布萊梅，約在 5 月 16 日早上 10:30 抵達所預計下榻之大西洋酒店(Atlantic Grand Hotel)。由於該日下午即安排前往拜會布萊梅市政府經濟廳及布萊梅商會，整體行程緊湊。因為上述機構皆位於布萊梅市政廣場附近，因此就近也參觀了布萊梅的市政廣場，體驗這個以格林童話著名的古老城市及歷史古蹟。

德國布萊梅市的市政府，是歐洲最重要的哥德式建築之一，2004 年與布萊梅羅蘭像一起入選聯合國教科文組織的世界文化遺產名錄，布萊梅市政府建築現在是布萊梅市市長和議會主席的所在地。市政府位於老城廣場，而與其議會及商會毗鄰。訪問團一行拜會布萊梅經濟廳由其廳長 Mr. Martin Günthner 親自接待並致歡迎詞，而蘇主秘亦代表訪問團致詞感謝此行的安排與接待，如圖 1-3 所示，並簡短說明台灣目前的能源轉型政策與正推動離岸風電，



期望與德國加強交流，學習德國發展的經驗。雙方代表並交換禮物做為紀念，而訪問團全體則與該機構相關人員進行相關議題交流。離開布萊梅經濟廳後，由德方人員引導前往位於鄰近古老建築的布萊梅商會，這個市政府位於的老城廣場為主要的政經中心，市政府、議會、商會等皆位於一處，周圍還有古蹟教堂等，相當具有特色。於拜訪布萊梅商會主要由其商會代表接待並介紹位於古蹟的商會建築，歡迎訪問團蒞臨也期待台德雙方未來更加強在商務經貿的來往，也期待台灣發展離岸風電，未來可以多藉助德國已累積超過 20 年的成功經驗。



圖 1 蘇主秘金勝於布萊梅經濟廳代表訪問團致感謝詞



圖 2 布萊梅廳長 Mr. Günthner(左)與蘇主秘金勝(右)互贈禮品



圖 3 布萊梅市政府經濟廳會議

5月16日訪問團應 ONP 管理公司邀請，參加於下榻之酒店舉行歡迎晚宴，ONP 管理公司主要從事離岸風場開發及工程規劃與承作等離岸風場統包事業，由其資深工程經理 Mr. Stefan Muller 主持餐會。德方出席人員尚包括布萊梅離岸風電產業機構如布萊梅經濟事務、勞工及港口部之國際外貿推動事務主任 Mr. Christian Gutschmidt 及布萊梅投資公司亞洲區主任 Mr. Matthias Hemen 等。藉由餐會安排每位團員交錯與德方人員有充分交談機會，並了解布萊梅離岸風電產業專區過去及現在推動情形，以及目前德國離岸風電發展之現況。

5月17日依據行程規劃移動至布萊梅港(Bremerhaven)，其為德國離岸風電主要的產業聚落。因而清晨 Check-out 離開飯店，由布萊梅前往布萊梅港，約1小時巴士行程抵達離港區不遠已預定之 Haverkamp 飯店，由於當日行程安排緊湊於飯店完成 Check-in，隨即依規劃集合並搭巴士前往港區參訪主要風機製造公司如 SENVION 等，其實在離港口不遠之風機零組件包括風機葉片、輪殼及機艙等裝配區，有 Adwen 及 SENVION 等風機公司進駐，由於港區都有出入限制並無法靠近，而允許就近拍照如圖 4。如圖 5 則為目前於港區進行運轉測試之全世界最大額定功率達 8MW 的 Adwen AD8-180 風機。隨後訪問團抵達位於港區之 Fraunhofer/IWES 風能及能源系統研究所，聽取行程介紹後，首先前往參觀其風機葉片測試 (Blade Testing) 實驗室，如圖 6 所示。其為目前歐洲最大的風機葉片測試實驗室，上述目前世界最大的 Adwen AD8-180 8MW 風機葉片也是於該研究所進行測試其葉片長度達 85m，而測試項目包括靜態強度測試及葉片動態疲勞強度測試等，主要依據國際標準如 IEC 61400-13 等涵蓋的靜動態的葉片測試進行，而 IWES 此項技術研發及測試主要是服務風機製造廠家，尤其是布萊梅港為離岸風電產業專區，對於巨大的風機葉片有實際運輸的困難，地區性考量有其必要性及效益性。此外，訪問團一行隨後亦前往風機機艙動態 (Dynamic Nacelle Testing) 實驗室參觀風機轉子驅動軸 (Drive train) 及主要零組件之模擬測試 (嚴禁拍照)，本報告為資料分享，由網頁翻拍公開資訊說明該實驗室風機機艙設備實驗裝置，如圖 7。而整個實驗室佔地很大，實驗區有相關硬體設施並連線至主控制室。實驗區的硬體設備如動態加載裝置、油壓系統風機驅動主軸連同軸承及齒輪箱與笨重的發電機等都可由主控制室進行操控運作，且依據不同的設計條件或嚴苛條件都可由主控制室進行實驗區的設備操作模擬及測試，並記錄與分析相關數據，以進行測試驗證與研究評估。中午返回 IWES 於港區的主要辦公室進行簡單午餐並聽取其單位之簡報，以讓訪問團更加了解 Fraunhofer/IWES 研究機構。



圖 4 布萊梅港風機零組件(機艙)裝配區



圖 5 世界最大風機 Adwen AD8-180 8MW



圖 6 IWES 研究機構參觀風機葉片



圖 7 IWES 風機機艙動態實驗室(DyNaLab)

(<http://www.windenergie.iwes.fraunhofer.de/en/test-centers-and-measurements/drive-train-and-grid-integration.html>)

5 月 17 日下午前往布萊梅港會議中心(Bremerhaven Conference Center)參加布萊梅離岸產業媒合與發展研討會，會議由布萊梅經濟事務、勞工及港口部之國際外貿推動事務主任 Mr. Christian Gutschmidt 主持，德方參加人員踴躍，來自德國風能相關之產官學研各界，會晤人員如表 2。此會議由德國風能協會(Wab)，首先進行德國離岸風力概況的簡報，以讓我方訪問團再次了解目前德國發展離岸風電的現況及未來推動策略等。而我方參訪團則由領隊蘇主秘擔任主席，全員參加研討會並進行各單位參與離岸風力工作說明及規劃，如圖 8 所示。

此外，也由工研院綠能所呂威賢經理進行台灣離岸風電推動現況及產業發展規劃等，透過簡報以介紹台灣目前面臨能源轉型以及因應 2025 達成非核家園的政策目標，將加速推動國內離岸風電建設。另外，會議進行議題討論主要尚包括碼頭基礎建設，電網營運及離岸風電計價等。雙方討論熱烈，透過議題交流，也使得台德雙方在彼此離岸風電產業及技術發展獲得更多的了解及訊息，對於未來的深化交流與合作，將有一定的幫助。會後，於會議中心由德國風能協會主辦邀請晚宴，歡迎本訪問團的造訪及促進雙方的交流。



圖 8 布萊梅離岸產業媒合與發展研討會

5 月 18 日早上抵達布萊梅港，先前往位於港區的 SENVION 風機公司如圖 9，進行參訪，聽取該公司之業務簡報，簡單介紹其公司沿革與目前主要的風機製造能量與規格，也帶領訪問團參觀其風機機艙內各關鍵零組件的裝配，包括風機轉子驅動軸上的各關鍵零組件如輪殼、剎車、軸承、轉向器及齒輪箱與發電機及其他附屬配件等，特別商請於遠方進行其裝配線拍照，並獲得許可，如圖 10 所示。SENVION 其實前身為 Repower 風機公司，近年來因整併，由印度 Suzlon 風機公司投資經營。SENVION 風機市場仍相當大，除歐洲外，南美如巴西、智利及阿根廷也為其主要市場。一行人受邀參觀其風機生產裝配，對於巨大的零組件與每個裝配區分開測試裝配組裝，留下深刻印象。於 SENVION 午餐後，訪問團即前往布萊梅港區碼頭，登上接駁船前往位於北海離岸約 16 公里興建中的 Nordergrunde 離岸風場，如圖 11-12 所示。此風場為 WPD 所開發，採用 18 台 SENVION 6.2MW 離岸風機及單樁支撐結構。目前離岸風

機及支撐結構皆已完工，然而由於海上變電站承包商倒閉，已造成整體工程的延宕。對於本訪問團多數團員都是首次搭船到外海參訪離岸風場，感覺新鮮之餘其實也承受暈船的痛苦，然而抵達風場踏上甲板，欣賞壯闊的海上風場，確實可以感受離岸風電工程的浩大及困難，國內目前已由上緯公司於海洋風場位於苗栗後龍外海完成兩台西門子 4MW 離岸風機及單樁支撐結構的安裝，在不久的將來相信苗栗及彰化外海的離岸示範風場完成之後，對於國內目前再生能源的規劃將可邁入新的紀元。接駁船於靠近 Nordergrunde 風場停留讓所有團員就近拍照及感受離岸風場的壯觀後，隨即加速，乘風破浪經過約 1 小時後，順利返回港口。



圖 9 SENVION 公司參觀



圖 10 SENVION 公司風機機艙內  
關鍵零組件裝配線現場



圖 11 參觀興建中的 NORDERGRUNDE 離岸風場



圖 12 訪問團於布萊梅港碼頭合影

5 月 18 日晚上則依計畫前往布萊梅港會議中心與離岸風電產業界進行聯合餐會，主辦單位為 K2 Management、Green Giraffe 及 Global Renewables Shipbrokers。餐會開始由台德雙方人員互換名片交談，並由此三家德國公司進行業務簡報，說明其公司業務內容及主要成績，涵蓋離岸風電系統、工程興建及電力併網規劃施工等系統化的工程服務，也積極與訪問團中來自國內之離岸風電開發商如台電公司及台灣綠能公司，以及主要工程承包公司如世

紀鋼鐵等進行詢問，以了解國內離岸風電規劃及推動現況，並都表達意願期望參與國內離岸風電建設。

5月19日為本次參訪的最後一天，早上安排前往布萊梅港務公司拜會，聽取其主任 Mr. Robert Howe 的業務簡報以及其他專業技術說明，如圖 16 所示。隨後，訪問團一行即前往參觀碼頭基礎建設，以及忙碌碼頭裝卸貨物與運送，如圖 13 所示。布萊梅港為歐洲第四大港，而汽車進出口則為第一大港，相當忙碌。由於布萊梅港為德國離岸風電產業專用港，且已形成非常著名及獨特的離岸風電產業聚落，國內未來發展離岸風電主要離岸風電專區應為台中港區以鄰近彰化之主要離岸風場，應可學習借鏡其開發經驗。於布萊梅港區作業參觀，港區幅員遼闊，主要較集中於離岸風電專用碼頭，如圖 14 所示。訪問團到達其風電專用碼頭，迎面而來為一批即將運往阿根廷的 SENVION 風機系統正放置待運，如圖 15。而港務公司人員也說明，台灣上緯公司訂購之兩台西門子離岸風機去年也是從此港口運送至台灣。其次，到達碼頭離岸作業平台，恰好碰到吊裝風機葉片，如圖 18。經過詢問，因為德國第一個離岸風場 Alpha Ventus，近來有風機葉片損壞問題，此風場共計 12 台風機其中 6 台是 SENVION 5MW 使用 Jacket 支撐結構，而 6 台則為 Adwen 5MW 使用 Tripod 支撐結構。Alpha Ventus 不僅是德國第一個離岸風場，從 2010 年完成開始運轉，也是結合示範、測試研究及發電的多功能風場，尤其所建立的學習曲線涵蓋許多層面，不僅透過兩支海氣象塔實際蒐集北海實際風速及海氣象數據，以及配合德國之產學研研究聯盟(Research Alliance)如 Forwind 以及國際合作計畫實際對於離岸風機及不同支撐結構系統之設計運轉及安全等，進行系統化的研究並且實際回饋至控制運轉端增進北海風場的發電效率，職於參訪 Nordergrunde 離岸風場時，曾提問其開發商 WPD，德國目前有超過 80%的離岸風場位於北海，而平均各風場之年容量因子(Capacity factor)約多少？其回覆約為 50% 並表示其容量因子數據非常好，代表其運轉及妥善率都相當高。不過，其有 Alpha Ventus 離岸風場位於北海做為離岸風機及支撐結構系統之所有設計、測試及運轉的研發改進樞紐，個人覺得針對北海離岸風場條件之掌握對於風機及風場整體設計與營運精進有一定之影響。中午回到布萊梅港務公司午餐，並聽取布萊梅港碼頭營運管理及離岸風電產業專區相關簡報，而領隊蘇主秘與港務公司代表也互贈禮物如圖 17，其餘團員則交流相關的議題。



圖 13 布萊梅港碼頭



圖 14 布萊梅港區離岸風電專用碼頭



圖 15 碼頭上待運之 SENVION 風機系統





圖 16 布萊梅港務公司會議



圖 17 蘇主秘(右)與布萊梅港務公司代表(左)互贈禮物



圖 18 布萊梅港碼頭葉片吊裝船

5月19日下午則安排本次訪德緊湊行程的最後一站 Flack Safety Service 安全服務公司，此公司其實離港區也不遠，搭巴士前往約15分鐘，抵達後，映入眼簾的是模擬海域安全測試模擬演練的設施，如圖19所示。訪問團一行首先於會議室聽取 Flack Safety Service 公司的業務簡報，以了解此公司主要為接受證照要求，代為訓練各項專業人員於其職業相關領域必要的安全技能，因此未來離岸風電相關作業人員，於進入有安全顧慮的場所，因應場地負責單位要求，例如船舶、吊運等都需要先接受訓練才能執行工作，而此訓練課程一般都有相關的國際標準或國家標準去遵循。然而此部分國內似乎尚缺少相應的法規，如因應國際標準，經討論最快速及經濟的方法可以其駐新加坡分公司代訓為處理方式。結束參訪，訪問團一行與 Flack Safety Service 公司合照，如圖20。



圖 19 模擬海域安全測試模擬演練

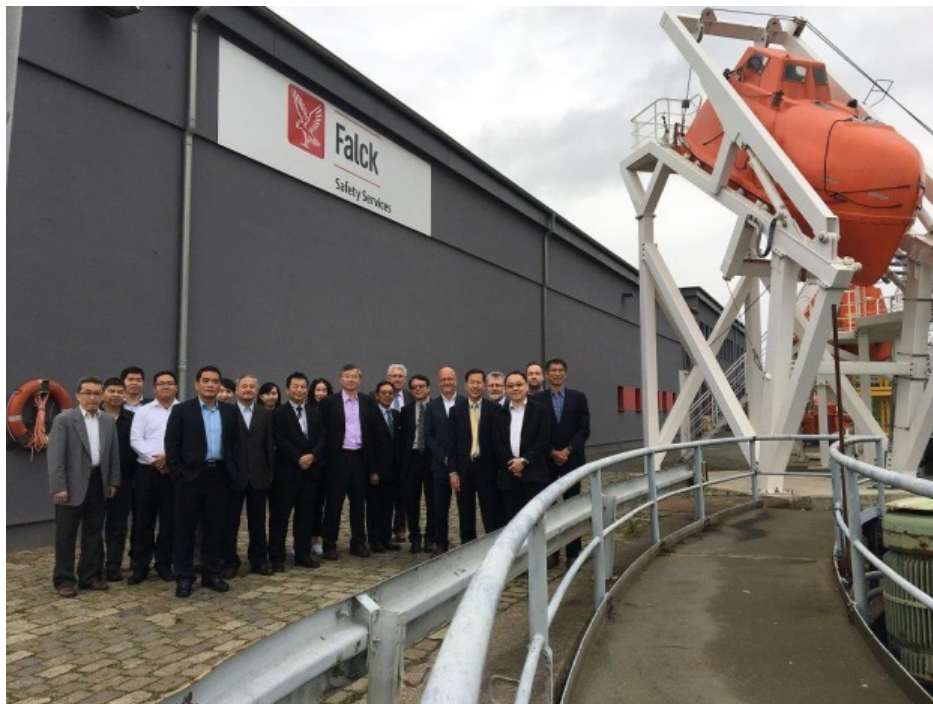


圖 20 Falck Safety Service 安全服務公司團體照

5月19日晚上由駐德代表處為本次赴德訪問團餞行，由沈副代表文強主辦，本訪問團則由領隊蘇主秘率領大家出席。不過由於部分團員於歐洲尚有其他行程且時間緊湊，因此除提早離開者之外，全員出席，包括蘇主秘、職與來自工研院綠能所及船舶中心、台灣電力公司、台灣綜合研究院、港務公司及勤業國際等代表。另外，駐德代表處沈副代表也盛情邀請德方主要承辦人員出席，特別代表政府感謝他們的安排與協助。沈副代表於餐會開始先致歡迎詞除感謝德方的安排外，亦說明國內目前正面臨能源轉型，而為達成2025年非核家園的政策，

政府正加速積極推動離岸風電建設，感謝德方協助此次離岸風電產業的參訪安排，並祝福此次經濟部能源局主辦之 2017 年德國布萊梅產業交流訪問團一連 4 天的密集拜會，滿載回國，並期許未來台德雙方在離岸風電產業領域繼續深化交流，藉由德國非常成功發展離岸風電的經驗一定可以協助台灣早日完成離岸風電的國家級再生能源建設。隨後，德方代表布萊梅經濟事務、勞工及港口部之國際外貿推動事務主任 Mr. Christian Gutschmidt 也致詞答謝，歡迎本次訪問團的蒞臨參訪，本次訪問主要目的為考察離岸風電產業，德國於離岸風電已發展超過 20 年，也獲得許多寶貴的技術、工程、產業等離岸風電開發的經驗，此部分的經驗一定可以協助台灣未來成功的推動離岸風電，而這幾天安排許多布萊梅離岸風電專區相關的業者以及德國風能協會代表廠家，都表達對於台灣離岸風電開發的高度興趣，期待未來台德雙方的進一步交流與合作，如圖 21 所示。雙方餐會代表致辭並互贈禮物後，隨即開始氣氛輕鬆的晚宴，並交流幾天來於參訪與拜會行程的所見所聞，對於德國離岸風電整體涵蓋風機研發、工程施工、碼頭吊運及產業發展等等大家都留下很深刻的印象。



圖 21 駐德代表處沈副代表文強(左一)邀請台德雙方出席晚宴

回國後，5月26日接到德方轉寄布萊梅地方報紙刊登此次台德離岸風電產業交流訪問的有關消息，如圖22。說明布萊梅政府經濟廳熱烈歡迎並希望藉由參訪交流，促進台德雙方未來在離岸風電的進一步合作。



圖 22 布萊梅地方報紙報導台灣離岸風電產業交流訪問團

本次公差自 5 月 15 日至 5 月 21 日，為期共 7 天。

表 1 行程表

日期	公差地點	工作內容	備註
5 月 15 日(一)	德國布萊梅	桃園機場搭機經阿姆斯特丹機場轉機前往德國布萊梅	
5 月 16 日(二)	德國布萊梅	1. 參觀布萊梅市政府 2. 拜會布萊梅市政府經濟廳 3. 拜會布萊梅商會 4. 參加ONP管理公司主辦晚宴	
5 月 17 日(三)	德國布萊梅港	1. 參觀港區風機重件裝配區 2. 參訪 Fraunhofer 風能及能源系統研究所 (IWES) 3. 參加布萊梅離岸產業媒合與發展研討會 4. 德國風能協會 (Wab) 主辦晚宴	
5 月 18 日(四)	德國布萊梅港	1. 參訪 SENVION 離岸風力公司 2. 參觀布萊梅港離岸風力園區及 Nordergründe 離岸風場 3. 與離岸風電產業界進行聯合餐會，由 K2 Management、Green Giraffe 及 Global Renewables Shipbrokers 主辦	
5 月 19 日(五)	德國布萊梅港	1. 拜會布萊梅港務公司 2. 布萊梅港區設施參觀 3. 參訪 Flack Safety Service 安全服務公司 4. 參加駐德代表處主辦晚宴	
5 月 20-21 日 (六-日)	德國布萊梅港	布萊梅機場搭機經阿姆斯特丹機場轉機返回桃園機場	

表 2 德國公差行程會面之專業人員彙整表

單位名稱	姓名	職稱
中華民國駐德代表處	沈文強	副代表
中華民國駐德代表處	何元奎	組長
中華民國駐德代表處	楊禮騰	秘書
Bremen Economic Affairs	Martin Günthner	Senator
ONP Management GmbH	Stefan Muller	Senior Engineering Manager
ONP Management GmbH	Martin Rahtge	Managing Partner
Freie Hansestadt Bremen	Christian Gutschmidt	Director Foreign Trade Promotion and International Affairs
Bremeninvest	Matthias Hempen	Director Asia
K2 Management GmbH	Axel Juhnke	Managing Director
Green Giraffe	Nathan Richter	
Global Renewables Shipbrokers	Philippe Schonefeld	Managing Partner
Global Renewables Shipbrokers	Simon Werner	Offshore Broker
Bremenports	Robert Howe	Managing Director
Bremenports	Uwe WILL	Senatsrat a.D.
MELCHERS TECHEXPORT GMBH	Thomas Kochems	Director
IHK	Torsten Grunewald	Graduate in Business Administration & Economics Department International Affairs
Bremerhaven University of Applied Sciences	Holger Lange	Prof. Dr.-Ing.

### 三、心得

本次職奉派代表核能研究所參加由經濟部能源局主辦之 2017 年德國布萊梅產業交流訪問團，一方面為台德雙方以「台德能源轉型合作意向共同宣言」為基礎，深化能源議題之交流，另一方面則是本次訪問以德國布萊梅離岸風電產業專區為主要目標。行前經過縝密安排，透過德國駐台外商如美最時(MELCHERS)公司等居中積極聯繫以獲德方離岸風電產業相關公司最即時協助。而台灣駐德代表處何組長元奎及楊秘書禮騰的聯繫協調更使得此行整體安排更為順利及有效率，非常感謝。由於本團於行前，由能源局邀集舉行兩次籌備會議，充分討論相關交流議題，而團員皆為來自不同單位之代表如附錄 1 所述，關切議題相當廣泛也呼應離岸風電確實是相當複雜、牽涉不同專業領域既深且廣。職過去 5 年來主要於核研所擔任離岸風力研發領域之負責人，而且同時主持科技部能源國家型科技計畫離岸風力主軸計畫超過 4 年，因而在離岸風力整體包括技術研發、工程施工及產業發展已具有相當之熟悉技術背景，而透過本次參訪與不同領域交流，包括德國不同機構的產官學研代表及國內不同單位的代表，確實更增進對於離岸風電的整體研發及產業，有更深入的了解。以下列出本次參訪之重要心得：

(一)德國的沿海海域分為從海岸開始的 12 海哩區和毗鄰的專屬經濟區 (EEZ)。聯邦政府在海岸 12 海哩的範圍內批准，而聯邦政府則配合聯邦運輸和數字基礎設施部的分支機構之水文局(BSH)，負責專屬經濟區之離岸風場審核。大多數離岸風場計畫遠離海岸，因為專屬經濟區有更多的空間且其位置可確保敏感的沿海生態系統得到有效的保護。而在專屬經濟區內的離岸風場審核主要依據德國「離岸設施條例」而其具有「聯合國海洋法公約」和「德國聯邦海事責任法」的法律依據。德國 BSH 為專屬經濟區內的所有離岸風電場計畫進行規劃及審核，其決策則是基於一個全面的考量包括政府及私人利益的權衡。BSH 規劃核可主要考量以下情況：(1)風廠不影響交通的安全和效率，國家和國防的安全；(2)既不危害海洋環境也不危及鳥類遷徙；(3)滿足「海上設施條例」與其他要求相關之規定。BSH 核可離岸風場計畫申請也規定施工必須開始的期間甚至打樁時的聲音限制，安全施工作業和使用基礎等要求。一般規定核可使用期限為 25 年，而離岸風場申請核可所需作業時間約兩年半至三年，海洋環境評估方面則需至少一年。此外，BSH 依據審核需求，也一起制定了三項標準如生態，基礎及岩盤和施工標準，以支持離岸風場開發計畫。

(二)本次參訪團參加由德國風能協會安排與德國離岸風電相關的產官學研相關單位會晤進行交流，也獲得部分最新有關德國風場的資訊，如圖 23 為目前德國最新位於北海及波羅的海離岸風場的地圖(2017)，可以看出離岸風電總計裝置容量約 4.16GW，其中超過 80 % 都裝置於北海的海域達 3.82GW，裝置於波羅的海海域則約 338MW。由於北海海域距離海岸 12 海浬許多區域屬文化保留區，無法開發。因此，由圖中也可以觀察多數的離岸風場規劃為坐落於 EEZ 的經濟專屬開發區域。如圖 24 顯示德國北海主要的離岸風場規劃及分布，其中最近布萊梅港的 Nordergrunde 離岸風場就是此行參訪團到訪的興建中的離岸風場其距離海岸約 16 公里，最大水深約為 10 公尺，總裝置容量為 112MW，共計 18 台 SENVION 6.2MW 的風機及單樁支撐結構，由於目前海上變電站承包商倒閉，造成整體工程延宕，依據說明將儘速解決並恢復施工。如圖 25 所示為來自德國風能協會最新的德國離岸風場統計資料(2017)，目前於北海海域運轉的離岸風場共計 16 個，在波羅的海海域則有 3 個。北海海域為德國主要的離岸風場海域其中 13 個離岸風場(超過 80%)是在 2014 以後開始運轉發電。依據德方規劃在 2020 年之前，將會有 9 個離岸風場的建置，總裝置風機數量為 422 台，裝置容量約 2.69GW，全部將採用單機容量 6MW 以上的離岸風機轉子。



圖 23 最新德國離岸風場地圖(2017, from Wab, 德國風能協會)





圖 24 德國北海離岸風場規劃及分布(2017, from Wab, 德國風能協會)

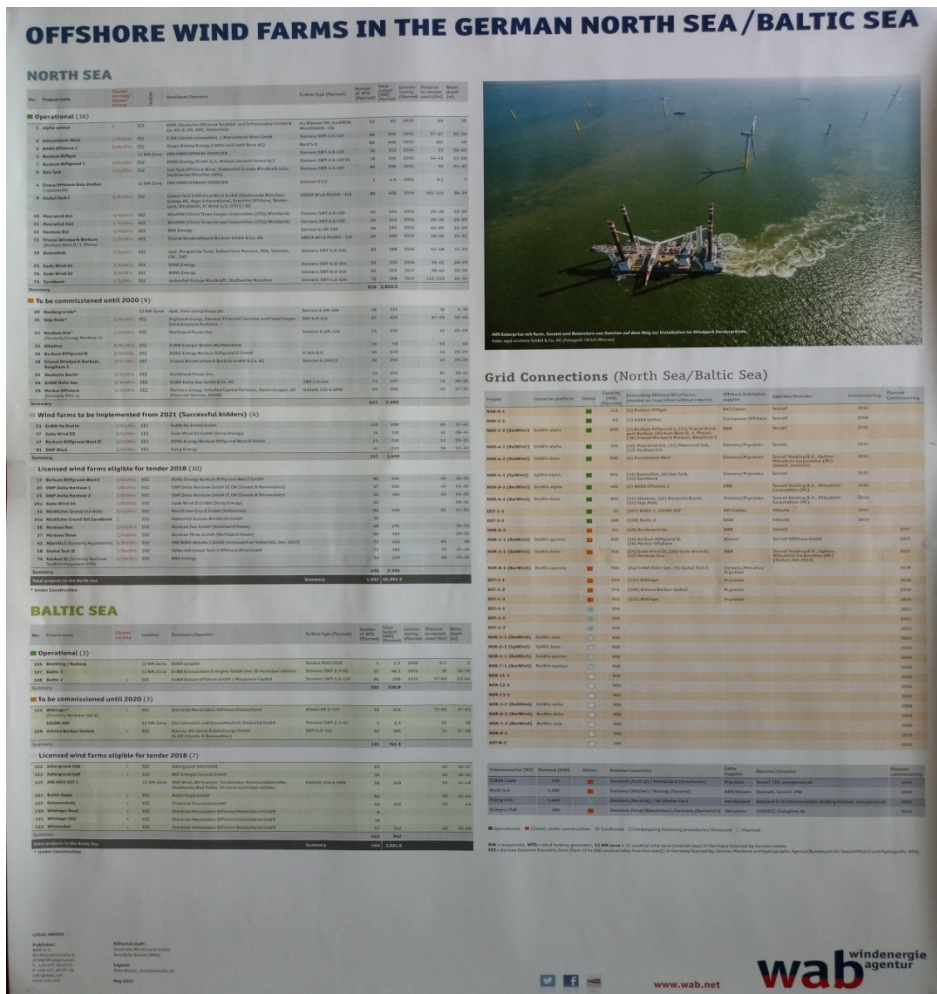
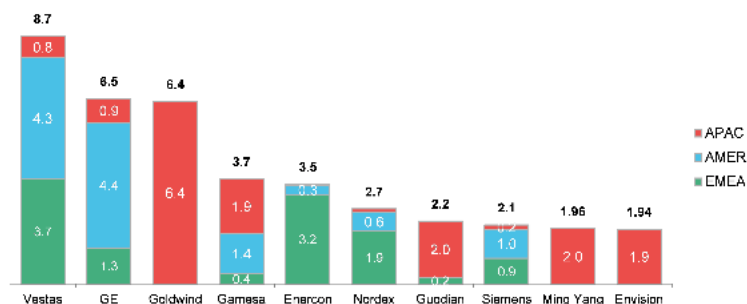


圖 25 最新德國離岸風場統計資料(2017, from Wab, 德國風能協會)

(三)離岸風場採用的風機大型化為是必然的，近年來甚有加速的趨勢。由於海上風速條件優於陸域，平均風速高及具較低的紊流影響，因而於適當海域設置離岸風場可以獲致較高的發電效益。此次參訪 Nordergrunde 離岸風場採用 SENVION 6.2 MW/126 風機及單樁支撐結構，共計 18 台，總安裝容量達 112MW。SENVION 6.2 MW/126 於 2008 年首次安裝於離岸風場，當時即為超過 5MW 之最大的離岸風機。而於此次參訪在布萊梅港離岸風電專區看到 Adwen 8MW AD8-180 風機轉子直徑達 180 公尺，目前為世界上最大的風機功率即為 8MW，AD8-180 也正於廠區進行原型機測試運轉，如圖 5 所示。不過，除上述風機，MHI Vestas V164-8MW 及 Siemens SWT-8.0-154 也同樣為目前最大的風機。此外，依據 SENVION 最新的資訊其將在 2017 年 6 月歐洲離岸風能研討會(WindEurope)發表世界上最大的 10MW 離岸風機，可見風機廠家的競爭非常激烈且技術愈臻成熟。風機大型化的趨勢，藉由風機系統設計的技术精進，與日俱增有加速與驚人的發展，值得關注。

(四)2016 及 2017 年也是世界前十大風機製造廠家整併非常活躍的年代，如圖 26 所示分別為依據彭博能源財務所公布 2016 年陸域及離岸風機前 10 大風機製造廠家及其安裝容量。而最新的風機製造廠家整併是今年(2017)4 月的 Siemens 及 Gamesa，因而造就市場所謂的「Big Four」，也就是由陸域看位居第 4 的 Gamesa 與 Siemens 結合後將大大增加其風機市場，尤其是 Siemens 風機為離岸風機的主要廠家遙遙領先其他風機廠家。此外，過去日本 MHI 及 Vestas 的合併，GE 及 ALSTON 的合併，都代表整個風機市場走向集團化的時代。而本次參訪的 SENVION 其前身為德國 Repower 風機製造公司，改組後則由印度最大風機製造廠 Suzlon 投資成立。

**Top 10 onshore turbine manufacturers, 2016 (GW)**



Top 10 offshore turbine manufacturers, 2016 (MW)

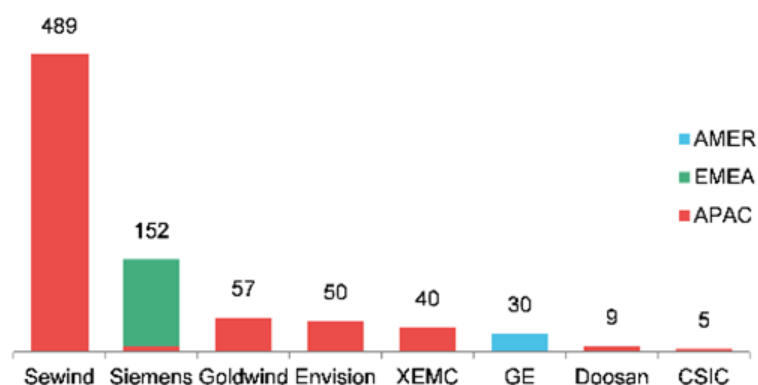


圖 26 2016 年陸域及離岸風機前 10 大風機製造廠家及其安裝容量

(五)依據全球風能委員會(GWEC)統計數據，從 2011 ~ 2015 年，歐洲為離岸風電開發主要市場，以每年平均增加 7GW 持續成長，而世界累計離岸風電已超過 12GW(截至 2015 年)。2015 年英國新增離岸風電達 566 MW，仍為目前世界最大離岸風電國家其離岸風電累積容量已超過 5GW，佔歐盟 45%。而 2015 年則為德國離岸風電安裝爆炸的一年，年安裝達 2.3 GW，德國目前是全球第二大的離岸風電裝置容量國家達 3.3 GW(截至 2015 年)。而如以整體風電而言，目前德國總計安裝容量為約 45.2 GW，排名世界第三，僅次於排名第一的中國(148 GW)及第二的美國(74 GW)。

(六)德國於 2010 年首座離岸風場 Alpha Ventus 併聯發電，為結合示範、測試研究及發電的多功能風場，此風場共計 12 台風機，總安裝容量 60MW，其中 6 台是 SENVION(前身 Repower) 5MW 使用 Jacket 支撐結構，而 6 台則為 Adwen(前身 Areva) 5MW 使用 Tripod 支撐結構。依據統計，Alpha Ventus 離岸風場截至 2015 已發電量達 1.5 兆瓦小時，平均容量因子可達 50%。其實，此風場由於位於北海也是德國 80%以上的離岸風場所在，因此初期德國即規劃海氣象塔實際蒐集北海實際風速及海氣象數據，配合風機實際運轉數據，利用這些寶貴的數據進行相關的研究及測試並成立長期研究計畫 RAVE(Research at Alpha Ventus)，建立學習曲線以回饋至產業界與研究領域及精進技術。此外，配合德國之產學研研究聯盟(Research Alliance)如 ForWind 以及國際合作計畫，實際對於離岸風機及不同支撐結構系統之設計運轉及安全等，無論德國或國際提供寶貴的研究平台。Alpha Ventus 作為德國先導的離岸風場並以結合技術研發及測試運轉及發電的多用途示範離

岸風場進行離岸風機及支撐結構系統之運轉的研發改進樞紐，對於德國離岸風場建置與整體風電產業條件之掌握及推動，具一定之影響。

(七)德國離岸風電今年 4 月最大的新聞之一就是經過電價競標出現零補助(Zero-Subsidy)的結果，震撼德國離岸風電業者。3 個德國 Dong Energy 的風場及 1 個 EnBW 的風場，經過電費競標，以零補助得到開發權。整體歐洲新興風場投資仍然往上成長，金額相較於去年同期也上漲幅度超過五分之一以上。但隨著政府補貼政策的修訂以及收購價格的下跌，一般預估 2017 年之後新興風場的投資活動將會趨緩。由於目前歐洲各國，由原先政府電力收購制度(Feed-in Tariff, FIT)逐漸轉向拍賣(Auction)制度，因此，歐洲風電市場在 2017 年預估會大幅放緩。上述德國於 4 月份宣布拍賣結果，也將影響到未來英國、荷蘭、法國等海上風場投標。而低利率情形將刺激離岸風場計畫開發商及相關業主包括風機製造商及工程公司等尋求更精準地整體設計及分析評估以降低資本的成本為重要的考量之一。

(八)布萊梅港為歐洲的第 4 大港，汽車進出口則為第一。位處德國北方領土之北海濱具優良地理位置，其由早期的漁港逐漸轉型為貿易量繁重的多功能港口。過去近 20 年來更因應地理位置配合荷蘭、丹麥甚至英國等的關係，開發離岸風電產業專區以因應離岸風電的開發，尤其目前德國為世界第二大離岸風電安裝國家，而其 80%以上的風場位於北海的專屬經濟區 EEZ，其餘則位於波羅的海海域。布萊梅港離岸風電產業專區，擁有離岸風電設備必要的重裝碼頭，吊裝船等，以方便離岸風電相關設備如風機系統如風機葉片及轉子、機艙及重要零配件與塔架結構與次結構(Substructure)等的吊運、組裝及運送。其次，在此專區也有主要的風機製造廠家進駐例如 Adwen 及 SENVION 等大型離岸風機系統廠家，當然主要原因之一為因應大型的風機零組件製造組裝有運送問題，設置於港區有其一定的必要及便利性。而比較驚訝的為 Fraunhofer 研究院之風能及能源系統研究所(IWES)在港區也設置布萊梅港的研究所分部(IWES-Bremerhaven)，也是此次參訪的重點之一，包括其風機葉片的強度測試及動態疲勞測試實驗室以及風機驅動軸及零配件性能及耐久性實驗室，都令人留下深刻印象。而觀察以目前為歐洲最大研究機構 Fraunhofer，擁有超過 60 個不同科技應用的研究所在布萊梅港區設立分部也有其因素，主要針對風機轉子及葉片，其巨大的結構本體機械系統以及各大主要風機系統廠也

在附件音為主要原因。因此，整個布萊梅港離岸風電產業專區，如今已鏈結風機系統廠及零配件產業、工程施工公司及研究機構與其他附屬必要的公司例如在本參訪最後一日拜訪之 Flack Safety Service 公司也在港區不遠，其主要提供接受證照要求代為訓練各項專業人員於其職業相關領域必要的安全技能，以因應未來離岸風電相關作業人員，進入有安全顧慮的場所，符合場地負責單位要求，例如船舶、吊運等都需要先接受訓練才能執行工作。此外，Flack 公司也可針對各特定離岸風場進行危險因素的評估，以作為運轉及維修作業的參考，以提昇安全性並降低維修成本，增進效益。因此，針對以上關於在布萊梅港離岸風電產業專區整體的規劃及營運，或許國內台中港配合未來離岸風電需求，為最重要的風機系統及支撐結構的組裝、吊裝、測試及運送碼頭規劃，此刻也正在進行相關規劃及強化改建工程，應有需許多值得參考及借鏡之處。

#### 四、建議事項

- (一)目前核能研究所執行能源國家型離岸風力主軸計畫並與中鋼公司進行產學合作計畫，共同規劃及執行離岸風力技術研發，以配合國內離岸風電設置及技術本土化。近年來，主要技術研究方向以建立國內自主化離岸風機及支撐結構整合設計驗證及工程分析技術，並針對台灣獨特之環境條件如颱風及地震等極端條件之影響，進行必要的分析與評估。此行綜觀德國離岸風電產業專區，雖以布萊梅港為重點，但由其過去的學習曲線歷程及討論可以得到德國於離岸風電過去發展 20 多年以來的技術累積與經驗研發，結合技術研發及產業開發應用的重要性，尤其如離岸風電等綠能產業。本所未來執行離岸風力計畫仍應以有限技術研發資源，結合其他法人與產業界建立共同建立整合技術研發平台持續加速推動。
- (二)經濟部能源局規劃 4 年風電開發計畫，2020 年完成開發陸域風電 800MW，離岸風電 520MW，2025 年完成開發陸域 1.2GW，離岸風電 3GW 的累積風電容量目標。而目前完成台灣離岸風場區域開發規劃並發布在彰化近海的 21 個區域開發廠址，以配合為未來離岸風電建置在 2025 年之前達到 3GW，及在 2030 年達到 4GW 的政策目標。此外，最近彰化縣政府配合中央政府是項再生能源發展政策，積極對外推動有關的合作開發，例如丹麥單能風力 (Dong Energy) 開發公司，已簽訂合作開發 4 座離岸風電區域，而由加拿大北陸電力

(Northland Power Inc.)及新加坡玉山能源合組的海龍離岸風電開發等，於今年 4 月也申請兩座離岸風場域，其他多家國際離岸風電開發集團如澳洲麥格理及德國 WPD 等也都表示高度興趣，規劃提案申請。此外，由於將來台電的離岸風場以及永傳能源的離岸風場等與上述國外廠家主要都以開發彰化近海為主。而綜合能源局已公布的 36 座離岸風電區塊開發，其中彰化近海即佔有 21 座。有鑑於，此次參訪布萊梅港離岸風電產業專區，發展之初，因預測北海的環境條件包括年平均風速與海的深度與海床非常適合建立離岸風場，從 2010 年迄今超過 80%德國的離岸風電容量皆設置於北海海域。因此，從首座 Alpha Ventus 離岸風場於 2010 開始發電，既規劃此風場為結合技術研發、測試實驗及發電的綜合性風場，並於北海所設置的兩支海氣象觀測塔進行資料蒐集並配合風機運轉，成立一系列的研究團隊計畫進行包含歐盟及德國等國內及國際的研究活動，精進離岸風電技術及藉由其北海的真實數據，研究改良與增進德國的離岸風電技術研發與產業相關技術。此種前瞻性的做法，建立所謂的技術學習曲線，非常值得借鏡參考。由於未來於彰化海域也將陸續有為數不少離岸風場的設置，而離岸風機系統可靠性及運維與實地量測數據息息相關，學習德國的經驗，建立彰化離岸風場技術研發及實驗與量測整體研發平台，應為一個值得思考的方向。

(三)本所參與能源國家型離岸風力主軸計畫主要在建立本土化離岸風機及支撐結構整合設計驗證及工程技術，並以國際參考風機及支撐結構針對本土極端條件如颱風及地震進行結構系統整合分析及評估，目前已累積相當的計畫研究成果。而自今年 2 月也加入經濟部標檢局規劃未來於台中港離岸風電專區的離岸風機測試驗證平台建置團隊。然而，目前正值中央機關關於綠能科學城計畫推動重新盤點之際，離岸風電系統及零組件示範場域可能以台中港港區規劃執行。建議本所離岸風力技術團隊應以目前建立之本土化參考離岸風機系統相關技術，積極參與及協助標檢局之可能離岸風電系統測試驗證示範場域規劃與執行，以建立風機系統及零組件測試驗證技術及共同提昇國內離岸風電產業技術能力。

(四)此刻正值國內大力推動離岸風電建設，應持續蒐集國際離岸風電產業與技術發展最新資訊，並加強引進及學習國外技術，尤其在風機系統可靠性、系統動態量測及運維技術等，本所應持續與德國、荷蘭、英國及丹麥等離岸風電技術較為新進的歐洲國家交流合作，以達事半功倍的效益。

## 五、附 錄

### 附錄一、團員名冊

項 次	單 位	姓 名	職 稱	備 註
1	經濟部能源局	蘇金勝	主任秘書	
2	原能會核能研究所	黃金城	專案主持人	
3	船舶中心	周顯光	海洋產業處處長	
4	工研院綠能所	王人謙	副所長	
5	工研院綠能所	呂威賢	經理	
6	港務公司臺中分公司	陳慧穎	資深事務員	
7	台灣綜合研究院	陳建緯	研究二所所長	
8	臺灣電力公司	林明成	再生能源處副處長	
9	臺灣電力公司	鍾年勉	綜合研究所 能源研究室主任	
10	台灣綠色電力公司	李建勳	總經理	
11	台灣綠色電力公司	吳曉玲	秘書	
12	德商美最時	古曰肅	離岸風力發電部門協理	
13	世紀鋼鐵	李建成	執行長	
14	世紀鋼鐵	林明弘	顧問	
15	世紀鋼鐵	賴俊成	特助	
16	歐風能源	白兆梅	專案助理	
17	德勤財務顧問公司	朱韻儒	協理	

## **The Delegation of Taiwan (17 人)**

### **Chief Delegate**

- Mr. Jin-Sheng Su (蘇金勝)  
Secretary General (主任秘書)  
Bureau of Energy, MOEA (經濟部能源局)

### **Delegates**

#### Institute of Nuclear Energy Research, Atomic Energy Council, R.O.C.

##### 行政院原子能委員會核能研究所 (1 人)

- Mr. Chin-Cheng Huang (黃金城)  
Director (專案主持人)

#### Ship and Ocean Industries R&D Center 船舶暨海洋產業研發中心(1 人)

- Mr. Shean-Kwang Chou (周顯光)  
Director, Marine Industrial Department (海洋產業處處長)

#### Industrial Technology Research Institute(ITRI)工業技術研究院(2 人)

- Dr. Ren-Chain Wang (王人謙)  
Deputy General Director, Green Energy and Environment Research Laboratories (綠能所副所長)
- Mr. Wei-Hsien Lu (呂威賢)  
Manager, Green Energy and Environment Research Laboratories (綠能所經理)

#### Taiwan Research Institute (TRI) 台灣綜合研究院 (1 人)

- Mr. Chien-Wei Chen (陳建緯)



Director of Second Research Division (研究二所所長)

Taiwan Power Company 臺灣電力股份有限公司 (2人)

- Mr. Ming-Cheng Lin (林明成)  
Deputy Director, Department of Renewable Energy (再生能源處副處長)
- Mr. Nien-Mien Chung (鍾年勉)  
Director, Energy Research Laboratory (綜合研究所能源研究室主任)

Port of Taichung, Taiwan International Ports Corp., LTD 臺灣港務股份有限公司臺中港務分公司 (1人)

- Ms. Hui-Ying Chen (陳慧穎)  
Senior Clerk (資深事務員)

Taiwan Green Power Co., Ltd. 台灣綠色電力股份有限公司 (2人)

- Mr. Chien-Hsyun Lee (李建勳)  
General Manager (總經理)
- Ms. Charlene Wu (吳曉玲)  
Secretary (秘書)

Melchers Trading GmbH (Taiwan Branch) 德商美最時貿易股份有限公司 (1人)

- Ms. Peko Ku (古曰肅)  
Director, Offshore Wind Department (離岸風力發電部門協理)

Century Iron & Steel Industry Corporation 世紀鋼鐵股份有限公司 (3 人)

- Mr. Chien-Chen Li (李建成)  
CEO (執行長)
- Mr. Ming-Hung Lin (林明弘)  
Consultant (顧問)
- Mr. Chun-Chen Lai (賴俊成)  
Special Assitant (特助)

EOLFI Greater China 歐風能源股份有限公司 (1 人)

- Ms. Chao-Mei Pai (白兆梅)  
Project Assistant (專案助理)

Deloitte & Touche Financial Advisory Corporation 德勤財務顧問股份有限公司(勤業眾信集團) (1 人)

- Ms. Chu, Yun-Ju (朱韻儒)  
Senior Manager (協理)



Welcome

## WIND . ASSURING CONFIDENCE THROUGH COMPETENCE

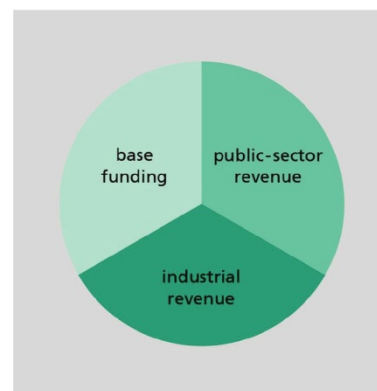
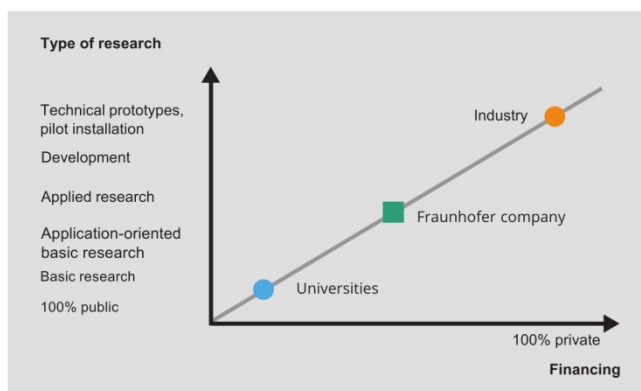
*Dr. Antje Wagenknecht*

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### Fraunhofer's business model: Focus on industry as a factor for success

- 67 Fraunhofer institutes in Germany
- More than 24,000 employees
- € 2.1 billion annual research budget




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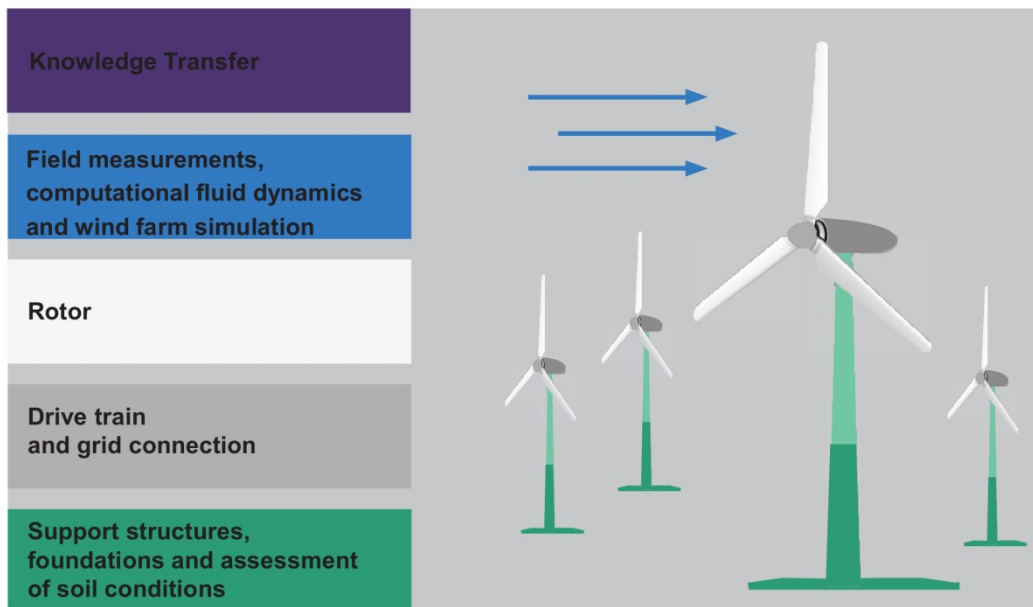
## Short profile of Fraunhofer IWES North-West

<b>Managing Director</b>	Prof. Dr.-Ing. Andreas Reuter
<b>Research spectrum</b>	Wind energy from material development to grid connection
<b>Operational budget 2016</b>	€ 15 million
<b>Staff</b>	150 employees
<b>Located in</b>	Bremerhaven, Oldenburg, Bremen, Hanover
<b>Investments to date in the establishment of infrastructure</b>	€ 60 million
<b>Research Alliance</b>  Wind Energy	Strategic Alliance with ForWind and the German Aerospace Center (DLR)

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## Research with added value



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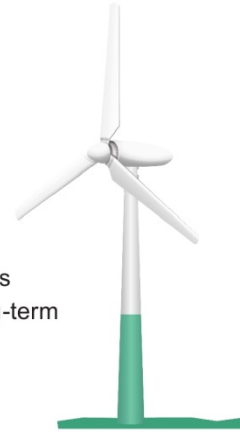




## Support structures, foundations and assessment of soil conditions

### Support structures & foundations

- Experimental model testing on foundation elements and substructures
- Scale 1:10 to 1:3.5
- Numerical calculation and simulations
- Development and testing of environmentally friendly construction methods
- Simulation of the structure's dynamic and fatigue behavior under the long-term cyclic influence in "time lapse"



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 **Fraunhofer**  
IWES



## Drive trains and grid connection

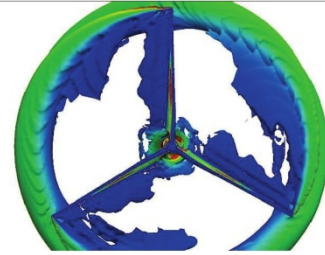
### DyNaLab with 10 MW drive performance / peak 15 MW

- Nominal torque: > 8.6 MNm
- Rotor load application unit for dynamic bending moments, thrust and radial forces
- Artificial grid: 44 MVA installed inverter power
- Technical reliability of mechatronical systems
- Planning and implementation of system tests, accelerated lifetime tests
- Model validation



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## Rotor

### Qualification of composite materials and components

- 70- and 90-meter testing facility certification approval
- Accredited testing of specimens and components

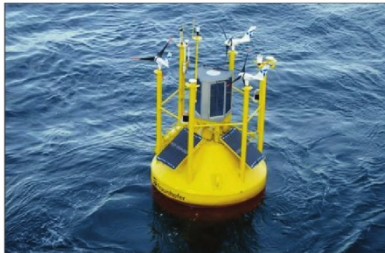
### Industrialized manufacturing

- Experimental tests in the "BladeMaker" demonstration center
- Validation testing of manufacturing processes and materials
- CNC-controlled production cell with 2 cooperating 6-axis gantries



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## Site assessment, CFD simulation and field measurements

### Site assessment onshore and offshore

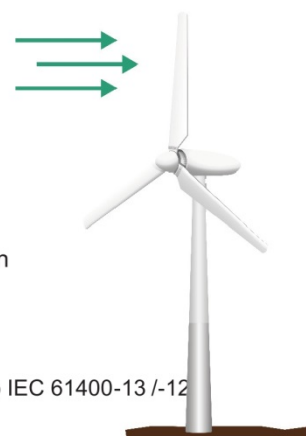
- Wind speed measurements with LiDAR devices up to 200 meters
- High-resolution, spatial geophysical analysis of planning areas

### CFD simulation and wind farm modeling

- Numerical simulations (CFD) for site assessment in complex terrain
- Optimization of entire wind farms with flapFoam

### Accredited measurements of operating turbines

- Measurement of mechanical loads and power performance according to IEC 61400-13 /-12
- Analysis of component dynamics, loads and operating behavior



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## References



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## Acknowledgements

### Fraunhofer IWES is funded by the:

**Federal Republic of Germany**

**Federal Ministry for Economic Affairs and Energy**

**Federal Ministry of Education and Research**

**European Regional Development Fund (ERDF):**

**Federal State of Bremen**

- Senator of Civil Engineering, Environment and Transportation
- Senator of Economy, Labor and Ports
- Senator of Science, Health and Consumer Protection
- Bremerhavener Gesellschaft für Investitions-Förderung und Stadtentwicklung GmbH

**Federal State of Lower Saxony**

**Free and Hanseatic City of Hamburg**



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**Thank You For Your Attention**

Any questions?

*[antje.wagenknecht@iwes.fraunhofer.de](mailto:antje.wagenknecht@iwes.fraunhofer.de)*

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## Introduction to Senvion Offshore

prepared for Taiwanese Wind Energy Delegation

May 18th, 2017

**SENVION**  
wind energy solutions

## Agenda

**SENVION**  
wind energy solutions

### 9.00 a.m.: Presentation

1. Senvion in facts & figures
2. German offshore framework conditions
3. Senvion's approach for successful offshore projects
4. Q&A

9.45 a.m.: Visit of nacelle production facility

11.00 a.m.: Lunch snack

11.30 a.m.: Transfer to harbour



## 1. Senvion in facts & figures

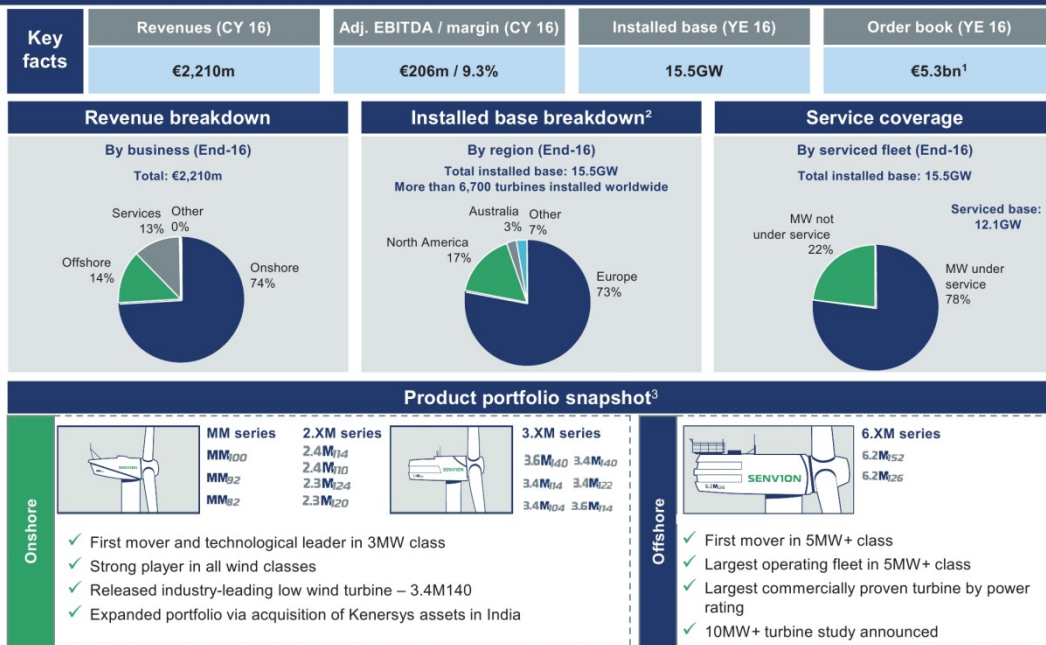
*Senvion was founded in 2001 by a merger of various companies*

**SENVION**  
wind energy solutions



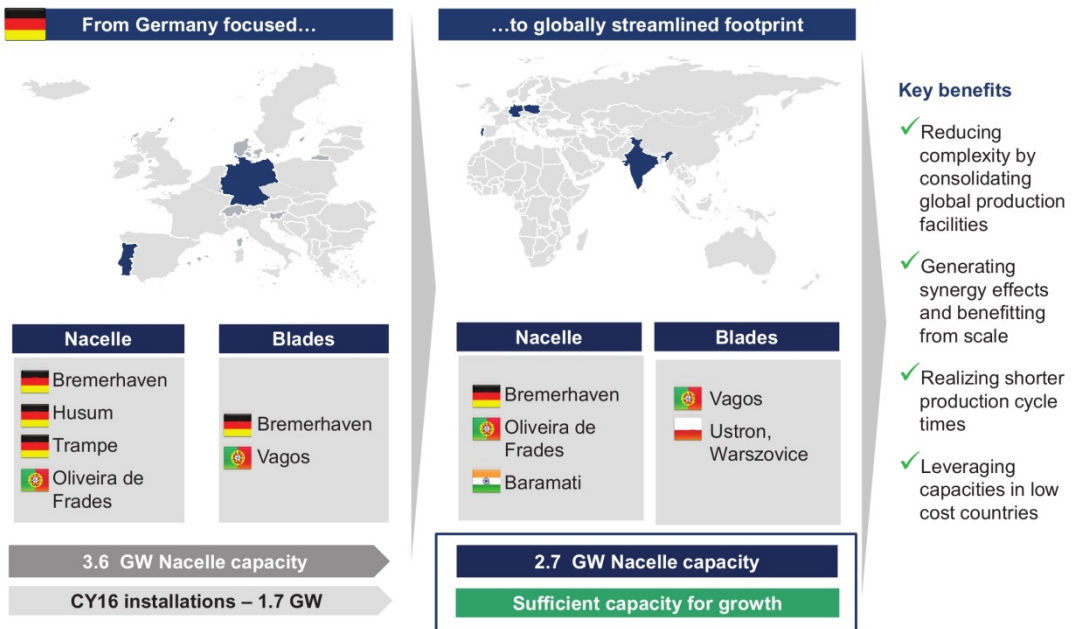
<sup>1</sup> BNEF, Global wind turbines manufacturing market trends, 22 February 2017

# Senvion is a leading global player in wind energy



Notes:  
 1. Includes net firm orders, signed contracts and service order book  
 2. Europe: Germany, France, UK, Italy, Belgium, Poland, Portugal; North America: Canada, USA; Other: Netherlands, China, Japan, Austria, Hungary, Czech Republic, Spain, Sweden, India, Greece, Russia, Korea, Switzerland.  
 3. Selected products  
 Source: Company information

# Senvion continuously improves production footprint to serve key and emerging markets





## 2. German offshore framework conditions

*With a solid industrial basis, the policy goals were switched from promotion to market integration*

**SENVION**  
wind energy solutions



- Stable expansion targets
- Solid remuneration of renewable energy
- R&D investments for enhanced technology

## Offshore wind auctions and expansion policies will shape the industry in future years

### Previous framework

If BSH-permit is granted and grid-connection confirmed, the project owner executes windfarm project and receives EEG tariffs/subsidies

#### Transitional period

- Commissioning 2021 - 2025
- 2 auctions, April 1st 2017 & 2018
- 2 x 1550 MW
- Max. 12 ct/kWh
- "Existing projects" (6,500 MW) eligible for participation

#### Surprising results in 1<sup>st</sup> auction round

- 1,490 MW awarded, average price:  
0,44 €ct/kWh  
3 projects: 0 ct/kWh

#### Centralised Model

- Commissioning 2026 onwards
- Yearly auctions, starting 2021
- 700 - 900 MW
- Lowest bid last transitional period auction
- Projects pre-developed by governmental authorities;  
step-in right for existing projects without award in transitional period

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### 3. Our approach for successful offshore projects

## WTG are most decisive for an offshore windfarm's commercial success

**SENVION**  
wind energy solutions

Approx. 40% of windfarm CAPEX are spent for WTG



### Rotor

12 % Rotor (hub, blades, pitch system)

### Nacelle

20 % Nacelle (drivetrain, converter, transformer)

### Tower

8 % Tower (steel, switchgear & electrical systems)

→ Proven WTG technology required for reliable energy yield at lowest LCOE

Source: EWEA / The Crown Estate

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## Our offshore WTG is based on proven and reliable technology

**SENVION**  
wind energy solutions



- First generation 18th December 2014
- Test run completed at 99.6% availability

### Certification status and timeline

- 2014-11-06: Type Certificate (prototype)
- 2016/Q2: IEC Type Certificate
- 2016/Q4: Update of Type Certificate to 6.33 MW rated power

**Senvion's next generation offshore WTG will set a new market standard...**



... but it's too big to show on this slide



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**Senvion features a 10 year track record in 5/6MW offshore projects**

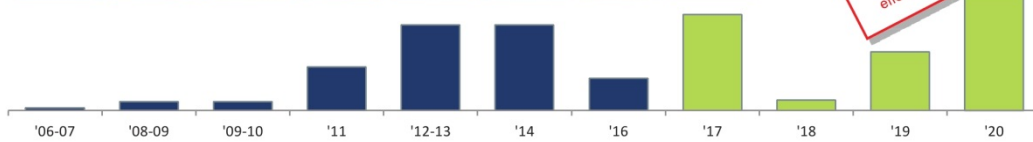


	Beatrice	Thornton Bank I	Alpha ventus	Ormonde	Thornton Bank II/III	Nordsee Ost	Nordergründe	Nordsee One	TBA	TWB II	TBA
Capacity	2x 5M (10 MW)	6x 5M (30 MW)	6x 5M (30 MW)	30x 5M (150 MW)	48x 6.2M126 (295 MW)	48x 6.2M126 (295 MW)	18x 6.2M126 (111MW)	54x 6.2M126 (332 MW)	6.2M152 & 3.XM series	32x 6.2M152 (203 MW)	6.2M152 & next gen.
Depth & distance	45m 23km	17-23m 30km	26-29m 56km	17-21m 9km	12-28m 26km	22-25m 57km	3-11m 18km	26-34m 47km	--	Trianel EWE	--
Customer	SSE	C-Power	e.on EWE Vattenfall	Vattenfall	C-Power	RWE	wpd	Northland Power / RWE	--	Trianel EWE	--
Country									--		--
Comments				Winner of the Renewable UK prize for Best Large Project '12	Before schedule delivery		Successfully delivered in 2016	Currently under construction	Floating & nearshore project		



2 x Single preferred bidder

Contract effective



**Fleet size of 158 turbines and 923 MW installed offshore  
Contracts signed for 86 WTGs and 535 MW**

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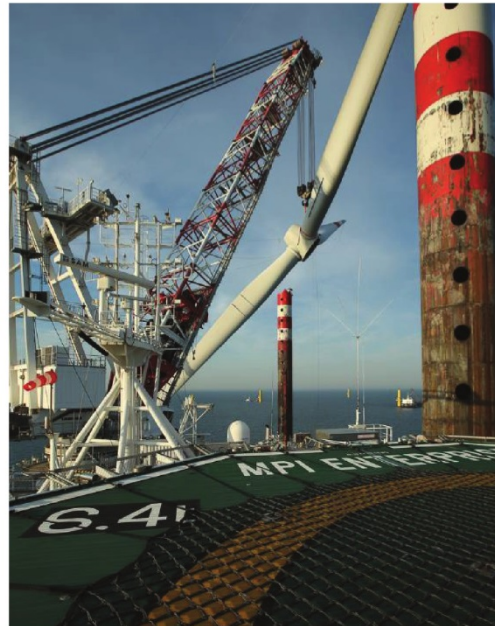
## Nordergründe: reduced LCOE + improved overall economics

SENVION  
wind energy solutions

- **Location:** approx. 34 km north of Wilhelmshaven
- **Water depths:** 3 – 11 m
- **Typ of turbine:** Senvion 6.2M126
- **Total output:** 111 MW with 18 turbines
- **Production:** approx. 400 GWh per year
- **Operator:** OWP Nordergründe GmbH

### Nordergründe, Germany

- **Nordergründe** is a great example of how Levelized Cost of Energy can be reduced. **Cooperation with the client** and the other contractors lead to **creative solutions** to improve the overall economics of this wind farm consisting of 18 x 6.2M126 turbines.



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## Nordsee One: successful reduction of interfaces

SENVION  
wind energy solutions

- **Location:** 40 km north of the island of Juist in the North Sea
- **Water depths:** 26 – 34 m
- **Typ of turbine:** Senvion 6.2M126
- **Total output:** 332 MW with 54 turbines
- **Production:** 1,200 GWh per year
- **Operator:** Nordsee One GmbH

### Nordsee One, Germany

- **Senvion** manages and takes **responsibility for the whole value chain** of the wind turbine generator package: from engineering to commissioning. This includes all transports, harbor logistics and construction vessels for this scope. The reduction of interfaces was a major supporting element of the project finance for this €bn1,5 wind farm.



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## Senvion is deeply involved in latest technological developments

**Floating foundations** are another step to globally available, standardized and economic wind energy

### Project description

- Part of French government's calls for proposal of 4 offshore floating foundations projects
- 4 x 6.2M152 WTG planned on Ideol designed concrete floating foundations, commissioning in 2020
- Site located in the Mediterranean Sea 16km offshore, water depths of 55m

### Senvion scope of work

- Co-Engineering regarding the floater and WTG design
- Modification and provision of wind turbines 6.2M152 as well as O&M
- Harbour installation works, offshore commissioning (in cooperation)



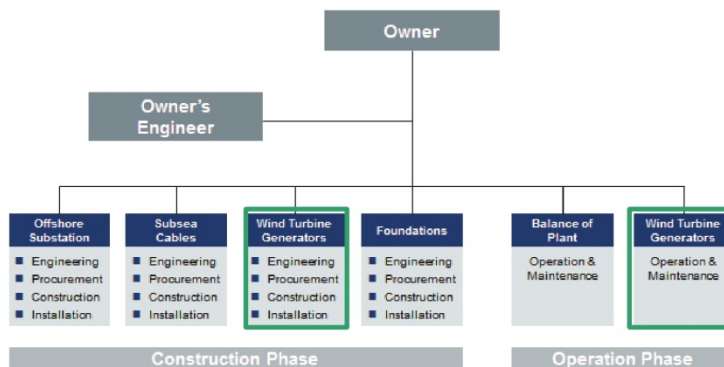
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## Senvion offers tailor-made solutions to customers

The structuring of offshore windfarm projects evolved from multi-contracting to 3 - 4 main work packages, allowing

- risk allocation fitting to contractors competences,
- limited interface management at owners and a
- reduction of contingency budgets and cost overruns.

➔ **Senvion's role developed from WTG supplier to EPCI contractor.**



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## 4. Q&A

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**SENVION**  
wind energy solutions

ANY VESSEL ANYTIME

GLOBAL RENEWABLES SHIPBROKERS






YOUR FIRST POINT OF CONTACT FOR ALL OFFSHORE LOGISTICS

WIND | WAVE | TIDAL ENERGY

GLOBAL RENEWABLES SHIPBROKERS

Who we are

- Founded 2011 by Matthias Mross and Philippe Schönefeld
- Specialised ship broking services for renewable energy:
  - Offshore wind energy
  - Offshore wave energy
  - Offshore tidal energy
- Team of 15 brokers with different focus areas and backgrounds
- Offices in Hamburg, Aberdeen and Paris



1



### What a shipbroker does

- Maintaining permanent contact with all market participants:
  - shipowners
  - charterers / clients
  - shipyards
  - marine service providers
- Having an overview on latest market developments / rates / availabilities
- Assisting with experience from past projects / enquiries / contracts
- Help avoiding uncovered risks and pitfalls in contract negotiations
- Using software tools & databases to provide fast market overviews
- Help clients defining their project requirements

2



### Why work with a shipbroker

Independent partner to give clients a fast and transparent market access

Non-binding service:

- if we don't perform to clients' expectations – no obligation to work with us

Forced to perform:

- we only get paid in case of success
- thus, our highest aim to provide the best offer
- follow on business only if we have added actual value

Free of charge:

- no direct contractual relationship necessary
- no invoices from GRS to clients
- commission paid by the ship owner
- no price increase through our commission ▶ Owners value our service (technical & commercial guidance, offering new business opportunities)

3



### GRS' Services in Detail - Chartering

- Helping our clients to define the optimal requirements for their scope (technically, commercially and operational)
- Assist in defining project budgets and tender processes
- Provide market overviews at a glance
- Boosting competitive bidding situation leading to reduced prices



Use our experience in vessel selection and contract negotiations as we do nothing else all day long!

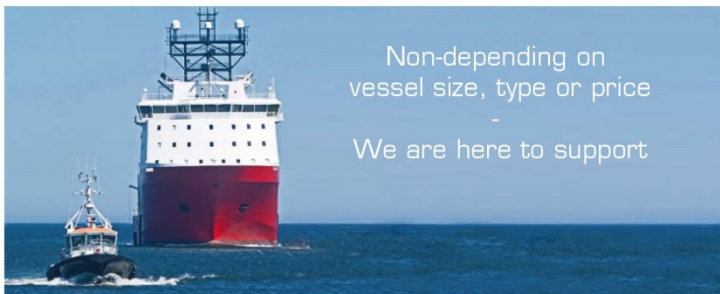
Find out more at <http://www.grs-offshore.com/en/any-vessel-any-time/charter/>

4



### GRS' Services in Detail – Sale and Purchase

- Matching supply and demand in a complex market landscape
- Help sellers identifying key markets
- Guidance and execution of closing meetings including sales contracts and accompanying documentation
- Assisting during insolvency sales of assets



Non-dependent on  
vessel size, type or price  
-  
We are here to support

Find out more at <http://www.grs-offshore.com/en/any-vessel-any-time/salepurchase/>

5



### GRS' Services in Detail – Turnkey Solutions

- Excellent market knowledge & experience through involvement into numerous offshore wind projects
- Sourcing the best service providers according to scope of work and develop a lead contractor to offer a one interface solution
- Close cooperation with clients' procurement department to reduce workload and risk while easing project coordination
- Bring additional contractors to clients' attention and thus increase competition



Find out more at <http://www.grs-offshore.com/en/any-vessel-any-time/turnkey-solutions/>

6



### GRS' Services in Detail – Others

- Cargo runs / supply services
- Vessel financing
- Tailor-made market intelligence
- Recommendations on other specialised service providers (legal advisers, agency services, consultants, etc.)



Find out more at <http://www.grs-offshore.com/en/any-vessel-any-time/cargo-runs-v2/>

Do you have other  
service needs that  
could fit our expertise?

—  
Just get in touch and  
we take it from there!

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## GRS team & their areas of expertise



<b>Management Team</b>	 <b>Matthias Mroß</b> Managing Partner	 <b>Philippe Schönefeld</b> Managing Partner		
<b>Hamburg Brokers</b>	 <b>Tim Börner</b> Offshore Broker Accommodation Vessel, WZV, CTV	 <b>Simon Werner</b> Offshore Broker Turnkey Contracting, Guard, Survey & Standby Vessel	 <b>Merlin Kuchmeister</b> Offshore Broker Jack-Up, Construction Vessel, Sales & Purchase	
	 <b>Jens Guhke</b> Offshore Broker DSV, OSV, Cable Lay Vessel, Heavy Lift, Turnkey Contracting	 <b>Niels Vogt</b> Offshore Broker Sales & Purchase	 <b>Alexander Gentsch</b> Offshore Broker Sales & Purchase	
	 <b>Henning Leverkus</b> Offshore Broker Cargo Run, CTV, AHTS, Tug, Workboat	 <b>Ralph Schnee</b> Offshore Broker Jack-Up, Cable Laying Construction Vessel	 <b>Bruno Bartel</b> Offshore Broker Guard, CTV, Workboat, Sales & Purchase	
	 <b>Caspar Blum</b> Offshore Broker DSV, OSV, WZV, PSV Accom. Vessel, Equipment	 <b>Lorena Fernandez</b> Offshore Broker DP Vessels, SV, ROVSV, OSV	 <b>David Fogg</b> Offshore Broker CTV, Guard, Survey, Tug, Workboats	
	 <b>François Richard</b> Offshore Broker			
	 <b>Bernd Meyer</b> Accounting & Marketing	 <b>Sina Ingber</b> Marketing	 <b>Claudia Franz</b> Documentation & Database	 <b>Maxi Saalbach</b> Office Admin. & Marketing
<b>Aberdeen Brokers</b>				
<b>Paris Broker</b>				
<b>Back-Office</b>				

## Some Clients of Global Renewables Shipbrokers






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**ANY VESSEL ANYTIME**

**GLOBAL RENEWABLES SHIPBROKERS**



**YOUR FIRST POINT OF CONTACT FOR ALL OFFSHORE LOGISTICS**

**WIND | WAVE | TIDAL ENERGY**

**What a shipbroker can achieve for your daily business**

**GLOBAL RENEWABLES SHIPBROKERS**

**GRS BENEFIT**



**1. Definition of your enquiry**

**2. Clarify technical issues & collect binding offers**

**3. Negotiations, closing & post-fixture**

CLIENT

Vessel 1 Vessel 2 Vessel 3

Vessel X

MARKET OVERVIEW

CONSULTANCY

VALUE ADDED SERVICES

SAVE EFFORT

SAVE TIME

SAVE MONEY

**1**

## Where to use GRS for your Offshore Wind Projects

GLOBAL  
RENEWABLES  
SHIPBROKERS

GRS  
SERVICES

### Charter Brokerage

Get access to vessel data base with > 80,000 vessels

Guidance on market conditions

Soliciting offers from vessel owners

Accompany and conduct contract negotiations

Work out of Charter Parties

Providing post fixture follow-up services

### Sale & Purchase

Advice on vessel availability and market price

Conduct contract negotiations and legal terms

Administer the closing and finalizing documentation

Consulting of alternative financial structures

Brokerage of technical ship management etc.

Identifying key markets for sellers

### Turnkey Services

Sourcing the market for competitive and experienced contractors

From geological pre-investigation to route clearance to re-occurring inspections & decommissioning

Reducing your interface management and workload

Increasing competition and thus reducing cost

*"Independent & comprehensive support to keep you focused on your business"*

2

## Our experience guarantees you comprehensive services

GLOBAL  
RENEWABLES  
SHIPBROKERS

THE  
GRS  
KEYS

### Vision

*"Becoming the international leading Renewables Shipbroker and leading advisory between and to involved parties"*

### Our Key Success Factors

'First Mover' of pure brokerage in the global offshore renewables market

Going beyond traditional shipping and developing individual renewable solutions

Deep market knowledge and research studies

Worldwide network of all kind of charterers, which leads to the highest market penetration.

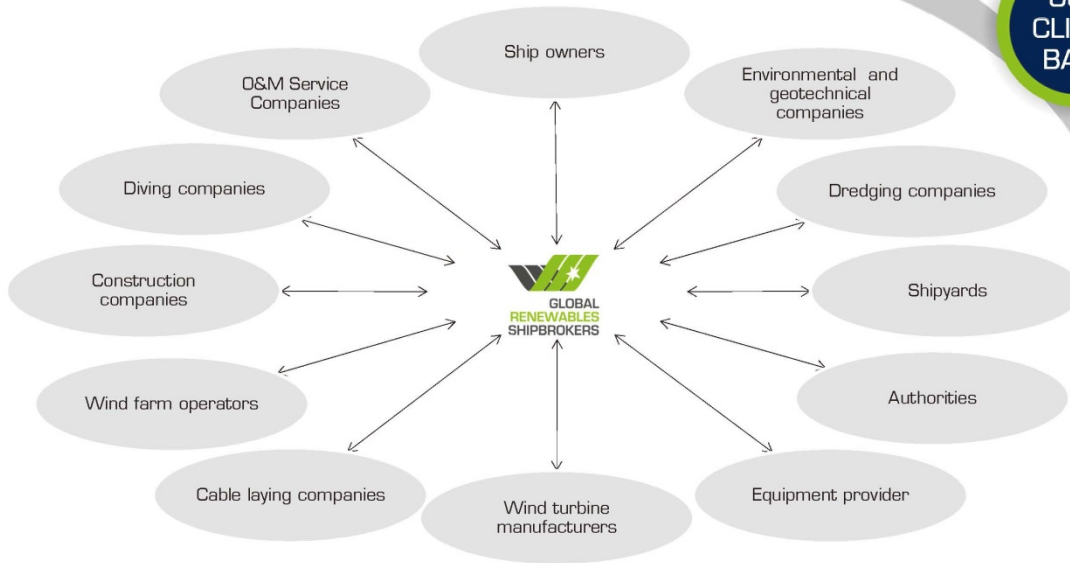
Non exclusive business relationship – acting completely independently

Supporting offshore renewable projects with a variety of technical and administrative services

3

With whom GRS is working in the offshore renewables

OUR CLIENT BASE



*"GRS is the independent shipbroker for the renewables market and supports small to very large customers from all divisions, in all phases of a renewables project"*

Some Clients of Global Renewables Shipbrokers






CLIENTS



## Exemplary Vessels out of the GRS Database

OUR  
VESSEL  
BASE

*"Which Vessel or Equipment or Service may we source you for Taiwanese Offshore Wind Project"*

			
Wind Turbine Installation Vessel	Multicat	Workboat	Crew Transfer Vessel
			
Survey Vessel	Accommodation Vessel	Platform Supply Vessel	Jack Up Accommodation Unit
			
DP (I, II, III) Construction Vessel	Barge	Dive Construction Vessel	Anchor Handling Tug
			
Tug	Cable Layer	DP (I, II, III) Support Vessel	ROV
			Please have a look to our <b>exemplary 3D-vessel portfolio</b> . GRS would be happy to promote your vessel as well.
Crane Vessel	Guard Vessel	Helicopter	



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## Who is GLOBAL RENEWABLES SHIPBROKERS

GRS IN  
PERSON

### Management Team



**Matthias Mroß**  
Managing Partner



**Philippe Schönefeld**  
Managing Partner

### Hamburg Brokers



**Tim Börner**  
Offshore Broker  
Accommodation Vessel,  
W2W, CTV



**Simon Werner**  
Offshore Broker  
Turnkey Contracting, Guard,  
Survey & Standby Vessel



**Merlin Küchmeister**  
Offshore Broker  
Jack-Up, Construction  
Vessel, Sales & Purchase



**Jens Guhlke**  
Offshore Broker  
DSV, OSV, Cable Lay Vessel,  
Heavy Lift, Turnkey Contracting



**Niels Vogt**  
Offshore Broker  
Sales & Purchase



**Alexander Gentsch**  
Offshore Broker  
Sales & Purchase



**Henning Leverkus**  
Offshore Broker  
Cargo Run, CTV, AHTS,  
Tug, Workboat



**Ralph Schnee**  
Offshore Broker  
Jack-Up, Cable Laying  
Construction Vessel



**Bruno Bartel**  
Offshore Broker  
Guard, CTV, Workboat,  
Sales & Purchase

### Aberdeen Brokers



**Caspar Blum**  
Offshore Broker  
DSV, OSV, W2W, PSV  
Accom. Vessel, Equipment



**Lorena Fernandez**  
Offshore Broker  
DP2 Vessel, SV, ROVSV,  
OSV



**David Fogg**  
Offshore Broker  
CTV, Guard, Survey, Tug,  
Workboats

### Paris Broker



**François Richard**  
Offshore Broker

### Back-Office



**Bernd Meyer**  
Accounting &  
Marketing



**Sina Ingber**  
Marketing



**Claudia Franz**  
Documentation &  
Database



**Maxi Saalbach**  
Office Admin.  
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# - THANK YOU VERY MUCH -

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## Track record of "extended services" brokered by GRS

### • Sourcing the right Turnkey Contractor

#### Turnkey Service Contracts

- Transport monopiles > OWP Nobelwind
- Dredging campaign > OWP Nordergründe
- Scour protection campaign > OWP Nordergründe
- Subsea IMR campaign (air dive & ROV) > Alpha Ventus & Riffgat
- Remedial cable burial > OWP Northwind + Belwind
- De-commissioning of gen sets > OWP Meerwind S/E
- Turnkey contractor geological pre-investigation > Guanyin & Taoyuan OWP Taiwan
- Grouting support campaign > OWP Amrumbank West
- Cable repair & UXO clearance > OWP Riffgat
- Offshore supply runs ("Cargo Runs") as shared runs and on a lumpsum basis > Various OWP's

### • Developing the Lead-Contractor

### • Arranging all subordinated contracts

#### Extended Brokerage Chartering

- Buoy maintenance framework-contracts > Nordsee One, Nordsee Ost, Riffgat
- Selection of modular pontoons & full cable laying spread for cable laying job in the "Königssee"
- Upgrade of vessel with offshore equipment (i.e. Crane, W2W-System, TLQ's, Boatlanding) > Bard
- Longterm charter of two ROV's on a jack up vessel for foundation installation & grout inspection
- Ultimate short notice arrangement of a sublet to recover a sunken boatlanding

### • Follow up, and accompany the client throughout & thoroughly

#### Extended Brokerage S&P

- Vessel sale including simultaneous brokerage of a Charter Party and a Shipman
- Contract for crewing and technical management, both for several years.

9



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**VESSEL  
PORTFOLIO**



**ANY  
VESSEL  
ANYTIME**



**YOU THINK OFFSHORE –  
WE FOLLOW YOUR THOUGHTS!**

A vessel for construction works at sea? An installation vessel for wind turbine generators or a sale and purchase deal for offshore tonnage? We make your enquiry to our challenge. As independent shipbrokers we are able to focus always and only onto our customers' needs.

GRS is familiar with the world market and can rely on longstanding contacts throughout the marine industry, thereby GRS offers a full service in brokerage for offshore tonnage, either for wind, wave or tidal renewable energy. Independent and comprehensive!

**OUR SERVICES –  
YOUR ADVANTAGE!**

- **Chartering**  
The right vessel for any set of requirements
- **Sale & Purchase**  
Success-oriented negotiations between Buyers and Sellers
- **Maritime Services**  
More time for your core business
- **Equipment**  
The right offshore equipment for any set of requirements
- **Cargo Run**  
Decrease your offshore supply trip costs by up to 30% with the GRS-Cargo-Run.

**ANY  
VESSEL  
ANYTIME**



**WE HAVE THE VESSELS –  
YOU HAVE THE CHOICE**

Experience and know-how turn GRS into your charter specialist for offshore tonnage and equipment in the field of renewable energy. Our independence is your advantage! As Global Renewables Shipbrokers neither owns vessels nor is associated with any ship owners we are free to create an individual solution for our customers.

**Our Chartering services for you:**

- Guidance on current market conditions
- Recommendation of alternative charter options, such as trip, time and bare boat charter
- Assisting and conducting contract negotiations
- Preparing charter contracts and all related contract documentation

**Our Sale & Purchase Service:**

- Advice on vessel availability and market prices
- Accompany and conducting contract negotiations
- Concluding all required contractual agreements
- Suggesting alternative financial structures
- Tendering of shipmanagement services

**ANY  
VESSEL  
ANYTIME**





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**CRANE VESSEL**

Vessel for lifting/transporting heavy offshore structures

Heavy lift crane vessels are mainly used as work ships to transport and install offshore structures and come in various dimensions and crane capacities that far exceed 12,000 t, depending on each offshore project's requirements. The vessels are often designed as multihulls to ensure a stable position in the water. Usually, their deck has ample space and is very strong in order to carry heavy, bulky parts and components.

Request your Crane Vessel at [www.grs-offshore.com](http://www.grs-offshore.com)

**Hotspots**

- 1 HELICOPTER DECK
- 2 DP 2
- 3 CRANE
- 4 SPACIOUS ACCOMMODATION
- 5 LARGE DECK
- 6 BALLAST TANKS



**INSTALLATION VESSEL**

Jack up crane vessel for installing wind turbines

Installation vessels are specialised for installing foundations and offshore wind turbines. Main features are a heavy lift crane with a load handling capacity of 300 to 1,500 tonnes and a jacking system that enables the crane vessel to carry out tasks regardless of swells. Installation vessels these days are around 130 m long and 40 m wide. Using its jacking system with legs, this type of vessel can work in water depths of 45 m and more.

Request your Installation Vessel at [www.grs-offshore.com](http://www.grs-offshore.com)

**Hotspots**

- 1 HEAVY LIFT CRANE
- 2 JACKING SYSTEM
- 3 DP 2
- 4 SPACIOUS ACCOMMODATION
- 5 HELICOPTER DECK
- 6 LARGE DECK

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### GUARD VESSEL

Vessel for securing offshore construction sites

Guard vessels secure the site during the construction stage of an offshore wind farm, a substation platform or a cable route. The vessel constantly monitors marine traffic near the construction site visually and with radar and AIS and guides external vessels how to safely get past the site. Guard vessels' essential features include being able to stay offshore up to 30 days and longer and great seaworthiness combined with high service speeds.

Request your Guard Vessel at  
[www.grs-offshore.com](http://www.grs-offshore.com)

### Hotspots

- |   |                            |
|---|----------------------------|
| 1 | POWERFUL ENGINE            |
| 2 | FAST RESCUE BOAT           |
| 3 | EXTENSIVE BRIDGE EQUIPMENT |
| 4 | VERY LONG SEA ENDURANCE    |

**WIND | WAVE | TIDAL ENERGY**

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### PLATFORM SUPPLY VESSEL (PSV)

Vessel for transporting construction materials and equipment

PSVs typically transport construction materials and equipment. In the offshore wind market PSVs are frequently used to transport individual wind turbines and foundation parts and are involved in supply and waste disposal for offshore transformer stations. The vessels have various tanks and powerful pumps for all liquid goods as well as a large open cargo deck which can be used to stow unwieldy cargoes and containers.

Request your PSV at  
[www.grs-offshore.com](http://www.grs-offshore.com)

### Hotspots

- |   |                                    |
|---|------------------------------------|
| 1 | LARGE CARGO DECK                   |
| 2 | STORAGE TANK CAPACITIES UNDER DECK |
| 3 | DP 2                               |
| 4 | FIRE FIGHTING EQUIPMENT            |

**WIND | WAVE | TIDAL ENERGY**

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### CONSTRUCTION VESSEL

Multifunctional construction vessel for offshore operations

Construction vessels are used for subsea construction projects such as laying cables and installing foundations or tidal power plants. These vessels are usually equipped with a DP system and a helicopter deck for offshore crew changes. The AHC-crane onboard can be used to load heavy components in deep water and swells or maintain wind turbines and foundations. Also diving and ROV tasks can be carried out with these vessels.

Request your Construction Vessel at  
[www.grs-offshore.com](http://www.grs-offshore.com)

### Hotspots

- |   |                        |
|---|------------------------|
| 1 | HELICOPTER DECK        |
| 2 | DP 2                   |
| 3 | AHC-CRANE              |
| 4 | SPACIOUS ACCOMMODATION |
| 5 | ROV HANGAR             |
| 6 | LARGE DECK             |
| 7 | STREAMLINED BOW SHAPE  |
| 8 | POWERFUL ENGINE        |

**WIND | WAVE | TIDAL ENERGY**



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### ANCHOR HANDLING TUG (AHT)

Tug for assisting and towing drilling platforms

These all-purpose vessels are mainly used for towage, anchoring and installation operations as well as supply services and also as dive support vessels. AHTs are often equipped with a dynamic positioning system that enables them to maintain precise positions in offshore locations over long periods and under a wide range of weather conditions. Powerful winches serve to tow drilling platforms and recover large drilling platform anchors offshore.

Request your AHT at  
[www.grs-offshore.com](http://www.grs-offshore.com)

### Hotspots

- 1 DP 2
- 2 SPACIOUS ACCOMMODATION
- 3 OFFSHORE CRANE
- 4 TOWING GEAR

**WIND | WAVE | TIDAL ENERGY**

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### CABLE LAYING VESSEL

Specialist vessel for laying sub-sea cables

Cable laying vessels are used for laying sub-sea cables and are also able to retrieve broken or damaged sub-sea cables and repair them on board. Sub-sea cables are buried in the sea floor by the cable layer using a special plough. A DP system enables the vessel to remain in a precise position above the defined cable route. Today, the largest cable layers can stow and lay up to 7,000 tonnes of cables on board, usually stowed spirally in a cable carousel (horizontal rotating table).

Request your Cable Laying Vessel at  
[www.grs-offshore.com](http://www.grs-offshore.com)

### Hotspots

- 1 CABLE CAROUSEL
- 2 LARGE DECK
- 3 A-FRAME
- 4 DECK CRANE
- 5 DP 2
- 6 SPACIOUS ACCOMMODATION

**WIND | WAVE | TIDAL ENERGY**

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### SURVEY VESSEL

Vessel for geological, visual, biological underwater investigation

Survey vessels are deployed prior and during the construction of offshore wind farms for a wide variety of hydrographic and geophysical soil investigations. These vessels are equipped with e.g. firmly installed measuring and sonar systems, multibeam, special mounts for measuring devices, laboratory workstations, outdoor workplaces, fishing gear, cranes, fast winches and in some cases a DP system that guarantees safe working close to offshore structures.

Request your Survey Vessel at  
[www.grs-offshore.com](http://www.grs-offshore.com)

### Hotspots

- 1 MOUNTS FOR SURVEY EQUIPMENT
- 2 SPACIOUS ACCOMMODATION
- 3 LABORATORY WORKSTATIONS
- 4 A-FRAME

**WIND | WAVE | TIDAL ENERGY**

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### FIELD SUPPORT VESSEL

Survey vessel for maintenance and operation of offshore structures

These vessels offer multiple flexible services in the area of underwater support, ROV operations, accommodation facilities, stand by services, fast rescue craft services and the usual supply functions. A field support vessel is equipped with a very stable platform and with excellent dynamic positioning capabilities. A vast range of built-in functions allows charterers to meet changing requirements without expensive modifications.

Request your Field Support Vessel at  
[www.grs-offshore.com](http://www.grs-offshore.com)

### Hotspots

- 1 FAST RESCUE CRAFTS
- 2 SPACIOUS ACCOMMODATION
- 3 DP 2
- 4 FIRE-FIGHTING EQUIPMENT
- 5 WINCH DECK
- 6 MID-SIZED CARGO DECK

**WIND | WAVE | TIDAL ENERGY**

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### DIVE SUPPORT VESSEL (DSV)

Vessel for installing and servicing offshore structures

DSVs are mainly used as installation and maintenance ships for offshore structures and combine construction and diving tasks. Equipped with dive systems, these vessels can be deployed in both coastal waters and deep sea areas and are able to remain in the exact position due to multiple point anchoring or a DP system. On many DSVs diving bell, diving lifts, ROVs and hyperbaric chambers and cranes are permanent fixtures.

Request your DSV at  
[www.grs-offshore.com](http://www.grs-offshore.com)

### Hotspots

- 1 HYPERBARIC CHAMBERS
- 2 DP 2
- 3 AHC-CRANE
- 4 SPACIOUS ACCOMMODATION
- 5 HELICOPTER DECK
- 6 ROV HANGAR

**WIND | WAVE | TIDAL ENERGY**

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### TUGBOAT

Vessels used for towage, transport and assistance

Tugs have a powerful propulsion system and are used in the offshore market for towing and positioning pontoons and installation vessels. Furthermore, tugs are deployed for salvaging and dredging works. The power of a tugboat varies according to type. An essential measure is known as bollard pull, which is measured in tonnes. The range spans from 30 tonnes to large offshore units with bollard pull capacities of up to 250 tonnes.

Request your Tugboat at  
[www.grs-offshore.com](http://www.grs-offshore.com)

### Hotspots

- 1 BOLLARD PULL
- 2 WINCHES
- 3 POWERFUL PROPULSION SYSTEM
- 4 FIRE FIGHTING EQUIPMENT

**WIND | WAVE | TIDAL ENERGY**

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### MULTICAT

Multi-purpose workboat for offshore works, transport, dredging

Multicats are all-purpose vessels and used for a variety of tasks in the offshore sector. Key tasks are towing offshore construction vessels and handling anchors and navigable water buoys. The vessels are equipped with powerful winches, one to two offshore cranes as well as a spacious flat deck. More and more Multicats are being equipped with DP in order to extend their flexible range of operations. Due to their low draught Multicats are able to operate in shallow-water.

Request your Multicat at  
[www.grs-offshore.com](http://www.grs-offshore.com)

#### Hotspots

- |   |                  |
|---|------------------|
| 1 | VERY LOW DRAUGHT |
| 2 | CRANES           |
| 3 | DP SYSTEM        |
| 4 | WINCHES          |

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### SHOALBUSTER

Multi-purpose workboat for offshore work, transport and wet dredging

Shoalbusters are multi-purpose vessels, used for a variety of tasks in the offshore sector. The vessels are equipped with powerful winches, an offshore crane and a wood-planked deck. A powerful propulsion system enables the vessel to safely manoeuvre even in strong ocean currents. Key tasks are towing offshore construction vessels, handling anchors and navigable water buoys. Shoalbusters can operate in shallow-water due to their low draught.

Request your Shoalbuster at  
[www.grs-offshore.com](http://www.grs-offshore.com)

#### Hotspots

- |   |              |
|---|--------------|
| 1 | BOLLARD PULL |
| 2 | CRANE        |
| 3 | WINCHES      |
| 4 | BOW FENDERS  |

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### CREW TRANSFER VESSEL (CTV)

Vessel for transporting personnel and spare parts offshore / to wind parks.

CTVs are mainly used to transport offshore personnel and smaller cargo units. A small to medium-sized deck crane and a fuelling system for wind turbine aggregates add to the versatility of this vessel type. The fender system at the bow helps the vessels to approach the access ladder of a wind turbine or an accommodation vessel and facilitates safe boarding. Depending on the design, CTVs achieve a speed of between 20 and 30 knots and can transport 12 to 24 passengers.

Request your CTV at  
[www.grs-offshore.com](http://www.grs-offshore.com)

#### Hotspots

- |   |                          |
|---|--------------------------|
| 1 | 12- 24 PASSENGERS        |
| 2 | CARGO DECK               |
| 3 | FENDER FOR SAFE BOARDING |
| 4 | CRANE                    |
| 5 | TRANSFER SYSTEM          |
| 6 | HIGH TRANSFER SPEED      |

**WIND | WAVE | TIDAL ENERGY**
**WIND | WAVE | TIDAL ENERGY**
**WIND | WAVE | TIDAL ENERGY**

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### ACCOMMODATION VESSEL

Accommodation vessel for housing offshore workers at sea

Offshore accommodation vessels are used as hotel ships in direct proximity to the construction site. Separate landing platforms allow offshore workers to board the CTVs and a helicopter deck is available for crew change. The vessels frequently serve as a construction office at sea with various communication and conference rooms. Many vessels also provide sufficient storage for offshore spare parts and workshops for various types of repair works.

Request your Accommodation Vessel at  
[www.grs-offshore.com](http://www.grs-offshore.com)

#### Hotspots

- 1 COMFORTABLE ACCOMMODATION
- 2 BOAT LANDINGS
- 3 HELICOPTER DECK
- 4 OFFICES AND CONFERENCE ROOMS
- 5 STORAGE AREA
- 6 VERY LONG SEA ENDURANCE

**WIND | WAVE | TIDAL ENERGY**

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### ACCOMMODATION PLATFORM

Offshore accommodation platform for personnel and equipment

Accommodation platforms are used during installation and commissioning of offshore substation platforms. These type of accommodation can help to provide good working and living conditions for offshore personnel for months. Along with this, the platform is equipped with catering areas, sanitary facilities, workshops, storage areas, offices and space for leisure activities. Almost all offshore accommodation platforms are equipped with helicopter landing decks.

Request your Acco Platform at  
[www.grs-offshore.com](http://www.grs-offshore.com)

#### Hotspots

- 1 SPACIOUS ACCOMMODATIONS
- 2 CRANES
- 3 HELICOPTER DECK
- 4 JACKING SYSTEM

**WIND | WAVE | TIDAL ENERGY**

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### MINI CTV

Small crew transfer vessels

Mini-CTVs are used for the rapid transport of offshore personnel and smaller spare parts or tools. These boats can transport up to 12 passengers and achieve a speed of between 30 and 40 knots. The fender system at the bow enables the passengers to embark safely. The vessels can be loaded on board a field support vessel offshore and launched into the water by crane or launch system. The superstructures provide good protection for passengers in a wide range of weather conditions.

Request your Mini-CTV at  
[www.grs-offshore.com](http://www.grs-offshore.com)

#### Hotspots

- 1 FENDER FOR SAFE BOARDING
- 2 POWERFUL PROPULSION SYSTEM
- 3 12 PASSENGERS
- 4 SUITABLE FOR A VARIETY OF TASKS

**WIND | WAVE | TIDAL ENERGY**

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# EQUIPMENT PORTFOLIO

## WE HAVE THE EQUIPMENT - YOU HAVE THE CHOICE

Which type of offshore equipment may we source for you?  
GRS is your independent offshore equipment broker for chartering and sale & purchase, specialized in the offshore renewables market.

Get in touch with us for your offshore equipment enquiry!



ANY EQUIPMENT ANYTIME



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### RIGID INFLATABLE BOAT (RIB)

Boat for personnel transport

RIBs are mainly used for the rapid and flexible transport of offshore personnel and for rescuing castaways. These boats can transport up to 10 people and achieve speeds of between 30 and 50 knots. A fender system can be installed on the bow to enable the boat to approach the access ladder of a wind turbine or accommodation vessel. The buoyancy of air tubes makes this type of vessel extremely seaworthy and allows it to be safely manoeuvred even in choppy seas.

Request your RIB at [www.grs-offshore.com](http://www.grs-offshore.com)

#### Hotspots

- 1 POWERFUL PROPULSION SYSTEM
- 2 SUITABLE FOR A VARIETY OF APPLICATION TASKS
- 3 JOCKEY SEATS
- 4 SMALL CARGO DECK

WIND | WAVE | TIDAL ENERGY

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### BARGE/PONTOON

Pontoon for transporting large / heavy elements

Barges, flat top barges and pontoons for heavy loads are used for shipping and interim storage of wind turbines, rotor blades, monopiles, jacket foundations and all other large and heavy elements in the offshore sector. In addition to standard flat top barges, the market offers different special barges for heavy load, floating loads and barges for launching steel constructions or jacket foundations.

Request your Barge at [www.grs-offshore.com](http://www.grs-offshore.com)

#### Hotspots

- 1 BALLASTABLE
- 2 FLEXIBLE LOCKS & LASHINGS
- 3 REINFORCED DECK
- 4 MULTIFUNCTIONAL

WIND | WAVE | TIDAL ENERGY

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### REMOTELY OPERATED VEHICLE (ROV)

Dive robot for underwater operations

ROVs are used for a variety of underwater tasks and inspections on offshore structures in water depths of a few meters up to thousands of meters. These robots are launched from a vessel or a platform and are remotely controlled with an umbilical cable. Smaller ROVs are equipped with cameras for visual inspections and bigger ROVs also have flexible tools. Typically, a ROV is operated and maintained on board by a team of up to six members.

Request your ROV at  
[www.grs-offshore.com](http://www.grs-offshore.com)

### Hotspots

- 1 POWERFUL THRUSTERS
- 2 MANIPULATORS
- 3 CAMERAS/SONAR
- 4 UMBILICAL CABLE

**WIND | WAVE | TIDAL ENERGY**

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### HELICOPTER

Helicopter for offshore personnel and equipment transfer

Specially equipped helicopters transfer personnel and equipment to offshore wind farms. Above all, helicopters are the fastest and safest means of transport for rescue operations. A service speed of 250 to 300 km/h and an operating range of 800 km result in particular benefits in respect of time. Moreover, a helicopter is still able and allowed to fly at wind speeds where accessing the turbine from the service vessel is no longer possible.

Request your Helicopter at  
[www.grs-offshore.com](http://www.grs-offshore.com)

### Hotspots

- 1 6 - 24 PASSENGERS
- 2 LENGTH OF 10 - 19 METRES
- 3 ROTOR DIAMETER 10 - 17 METRES
- 4 HIGH TRANSFER SPEED

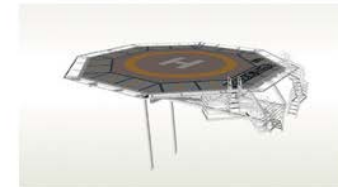
**WIND | WAVE | TIDAL ENERGY**

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### ACCOMMODATION MODULES

For creating more living space on vessels:  
mobile, flexible to use and stackable.



### HELICOPTER DECK

For creating more transfer flexibility on vessels, jack ups or substations: new or second hand helicopter decks for sale or rent.



### GANGWAY

Fixed or telescopic gangways between 10 and 40 meters long and available in different configurations.

**WIND | WAVE | TIDAL ENERGY**

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### TRANSFER SYSTEM

On high seas, these systems will safely transfer both staff and cargo from a ship to a fixed platform.



### A-FRAME

New or second hand A-frames with lifting capacities up to 350 tons and a working radius tailor made to suit any vessel design.

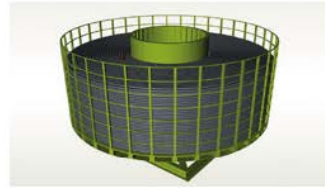


### INSTALLATION EQUIPMENT

All kind of cable installation equipment: for loading, unloading or laying of subsea cables.

WIND | WAVE | TIDAL ENERGY

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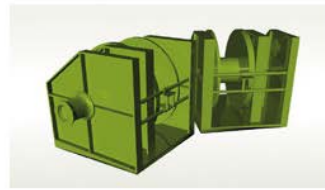
### CAROUSEL SYSTEM

Cable carousel for transportation or storage, available in different sizes for sale and rent.



### CRANE

New build or second hand offshore cranes are available in various sizes and can be modified for specific customer requirements.



### MOORING SYSTEM

Mooring systems for mooring lines, anchors and connectors, used for station keeping of a ship or floating platform.

WIND | WAVE | TIDAL ENERGY

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## CARGO RUN

### TANGIBLE ADVANTAGES - GRS CARGO RUN

Decrease your offshore charter costs by up to 30% with the GRS-Cargo-Run.

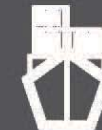
- INDIVIDUAL CARGO RUN
- TEAM CARGO RUN
- JUMP ON CARGO RUN
- GRS CARGO RUN SERVICES

#### YOUR BENEFITS:

- Significant cost and time savings
- Securing of tonnage availabilities
- Greater flexibility
- Less environmental impact.



ANY VESSEL ANYTIME





# MARKET INTELLIGENCE

MARKET INTELLIGENCE - GRS GUIDES YOU THROUGH THE MARKET

- UP-TO-DATE DATA REPORTS
- CUSTOMISED STUDIES
- DETAILED MARKET ANALYSES

Send us your individual request and we will provide you with your tailor-made study or report.



ANY VESSEL ANYTIME  



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3D 360° 

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