出國報告（出國類別：考察）

比英離岸風電海洋機械產業暨航空高值化考察

服務機關：經濟部工業局
姓名職稱：林育萱　技士
派赴國家：比利時、英國
出國期間：108 年 6 月 17 日至 27 日
報告日期：108 年 9 月

摘要

為推動離岸風力發電產業發展，本局責成金屬工業研究發展中心規劃比利時及英國行程，考察當地離岸風力發電產業發展現況與創新技術，同時針對離岸風電產業使用無人機進行風力機葉片運維進行多方面的技術交流，進一步建立航空高值化智慧產業鏈與智慧維修產業推動，強化我國離岸風電產業智慧化及創新技術之在地化發展。

本次比利時離岸風電產業拜會對象包含海上變電站商 Engie Fabricom，參觀其位於安特衛普港的海上變電站製造工廠，瞭解海上變電站製造過程及運送實務經驗。並前往比利時最重要的離岸風電安裝運維港口，與多家離岸風電產業標竿廠商，包含海事工程統包商 DEME、Jan De Nul 進行產業及技術交流。行程主軸以離岸風力機運維為主題，拜會多家公司，包含 REBO 公司、Otary 公司，以瞭解奧斯坦德港自漁港轉型成為離岸風電運維港的過程、港埠基礎設施規劃建置及其提供的風力機安裝運維服務，瞭解其監控中心運作模式及其運維供應鏈建置規劃。除產業界的拜會，於學術方面本參訪團參觀位於根特大學附近的 Flanders Maritime Lab.海事工程實驗室以及奧斯坦德港外離岸 1 公里之研究測試平台，瞭解比利時法蘭德斯政府如何鏈結產官學資源，提供中小企業可優化其產品的研發測試環境。並透過與比利時兩大離岸風電業者聯盟的產業交流會，媒合團員與比利時業者交流離岸風電發展實務經驗，促進雙方未來的合作機會。

在英國離岸風電產業廠商拜訪方面，本次參訪位於英國懷特島上的 MVOW 葉片工廠，實務考察風力機葉片製造生產流程，以及與 James Fisher & Sons 交流其執行離岸風場風力機、水下基礎、海纜檢測等實務經驗。最後，以參觀參觀英國倫敦「2019 Renewable UK 離岸風電展」畫下句點。該展覽參展廠商涵蓋風力發電各層面，除前述相關運維業者及風場開發商，亦包含以無人機運維監控、無人測量船、水下無人載具等新興技術於離岸風場建置時之應用廠商。透過此次的拜會提供了參訪團員良好的商機媒合機會，瞭解離岸風電產業最新發展技術趨勢和國際離岸風電業者動態，綜觀離岸風電產業發展全貌，亦瞭解與掌握無人機產業應用於離岸風場運維及施作之方式。

目錄

壹、前言（出國目的）

有鑑於今年起陸續有新建離岸風場完工商轉，預計 2025 年將完成離岸風力發電 5.7GW 之目標設置量（包含示範風場設置量），對於下一階段離岸風電產業如何達到提高營運效率、降低成本等目標，或提升機具內涵智慧及注入創新技術能量，成為推動整體產業成長的動能，比利時及英國等歐洲國家發展離岸風電多年之經驗，值得作為推行產業政策時的參考案例。

本局為推動離岸風力發電產業發展，責成金屬工業研究發展中心帶領國內離岸風電產業相關業者前往比利時及英國考察當地離岸風力發電產業發展現況與創新應用，促進臺灣與比利時、英國業者之合作機會，進一步強化我國離岸風電產業智慧化及創新技術之發展。

比利時及英國為全球風力發電產業標竿國家，除擁有完整的風力發電機製造、安裝運維產業鏈、以及健全的港埠基礎設施規劃外，多家離岸風電產業設備商、研究機構等持續研發及投資最創新及智慧化的材料和設備，值得我國業者學習和積極尋求進一步洽談合作之機會。因此，本考察團前往拜會離岸風力發電產業標竿業者，針對風力發電機製造、安裝、運維和國際供應鏈合作等多個面向進行交流；並參觀「2019 英國離岸風電展」，增進業者接軌國際之機會。

本次參訪活動感謝比利時台北辦事處法蘭德斯外貿投資局、我國駐歐盟兼駐比利時代表處、英國在台辦事處於籌備及活動過程中的接洽與協助，以及金屬工業研究發展中心的主導安排，使本次考察行程圓滿完成、收穫滿盈。

貳、行程表

一、 參訪總行程表：

本次行程自 108 年 6 月 17 日至 27 日止，每日安排之行程與拜會對象如下表所示：

日期	時間	活動
6/17(一)	全日	去程（自台北出發至比利時布魯塞爾）
6/18(二)	上午	自比利時布魯塞爾機場移動至市區
	13:30	拜會 Engie Fabricom（海上變電站 EPCI 統包商）
6/19(三)	12:30	拜會 Jan De Nul（海事工程 EPCI 統包商）
	16:30	參加 Greenbridge Oostende 離岸風電產業交流會（Seminar/B2Bs） 團員與比利時兩大離岸風電產業聯盟(Blue Cluster 和 Belgian Offshore Cluster)會員廠商進行交流
6/20(四)	09:30	拜會 REBO（奧斯坦德運維港港務公司）
	13:00	參觀 Jan De Nul 離岸風電海事工程船舶
	15:00	拜會 Otary（風場開發及運維管理公司）
6/21(五)	09:30	參觀離岸 1 公里之研究測試平台
	13:00	拜會 DEME（海事工程 EPCI 統包商）
	14:30	參觀 Flanders Maritime Lab. 海事工程實驗室
6/22(六)	全日	市政參訪：布魯日
6/23(日)	全日	交通移動：比利時布魯日至英國普次茅斯
6/24(一)	15:30	拜會 MHI Vestas 葉片工廠
6/25(二)	09:00	參觀 2019Renewable UK 離岸風電展
6/26(三)	10:00	拜會 James Fisher &Sons（海事工程及運維公司）
	下午	離境準備
6/27(四)	全日	返程（自英國倫敦返回台北）(+1 日)

二、 產業交流會議程：

Greenbridge Oostende 離岸風電產業交流會

June 19th, 2019

會議地點：Greenbridge Oostende

會場地址：Wetenschapspark 1, 8400 Oostende, Belgium

主辦單位：比利時台北辦事處法蘭德斯外貿投資局(Flanders Investment & Trade)
Blue Cluster (DBC)
Belgian Offshore Cluster (BOC)

時間	活動	講者
16:30 16:40	主辦單位致詞歡迎本考察團 Welcome	Ann Overmeire, Blue Cluster(DBC)
16:40 16:50	開幕致詞 Opening Remark	林育萱技士 經濟部工業局 Lin, Yu-Hsuan Industrial Development Bureau(IDB), Ministry of Economic Affairs(MOEA)
16:50 17:00	離岸風電產業供應鏈推動 Taiwan Offshore Wind Energy Development and Opportunities	張家豪博士 金屬工業研究發展中心 Dr. Chang, Chia-Hao ,MIRDC
17:00 17:10	臺灣離岸風電港口規劃與發展現況 TIPC’s Port Planning and Development for Offshore Wind Power	唐柏芬資深副處長 港務公司 Tang, Po-Fen, Senior Vice Director, TIPC
17:10 17:30	我國業者公司簡介 Pitch Presentation	本考察團貴賓 Delegates form Taiwan Companies
17:30 19:00	本考察團與比利時兩大離岸風電產業聯盟會員廠商自由進行交流 B2Bs and Reception with Members of the Blue Cluster and Belgian Offshore Cluster	

參、工作內容（包含過程與心得）

一、拜會 Engie Fabricom（海上變電站 EPCI 統包商）

(一)時間：108 年 6 月 18 日星期二，13:30~16:00

(二)地點：Leo Bosschartlaan 1, 2660 Hoboken, Belgium

(三)與會人員：

1、 本參訪團成員(經濟部工業局林技士育萱、臺灣港務公司熊處長士新等 3 人、金屬中心張博士家豪等 4 人、國內離岸風電相關業者 5 人，共計 13 人)

2、 比利時法蘭德斯外貿投資局科技參事(Science and Technology Counsellor)Mr. Ralph Moreau

3、 Blue Cluster 代表

4、 Engie Fabricom 區域業務經理(Area Sales Manager)Mr. Patrick Vincent、離岸海外商務總監(Commercial Director Offshore International Operations Offshore)Mr. Hans Leerdam、離岸商務招標經理(Tendering Manager Offhore Services)Mr. Sam Worthy

(四)過程摘要：

參訪過程：

由 Engie Fabricom 進行業務簡報後，由該公司經理帶領本參訪團團員實地參觀其海上變電站製造產線，講解過程中可自由提問交流。

公司簡介：

1、 比利時商 Engie Fabricom 是法國 Engie 集團旗下企業，隸屬該集團荷比盧地區事業體，該集團業務領域包括：電力、天然氣及能源服務，業務遍及全球 70 個國家 2017 年營收達 650 億歐元，EBITDA (Earnings Be fore Interest, Taxes, Depreci ation and Amortization)為 93 億歐元，擁有超過 153,000 名員工。

2、 Engie Fabricom 已有 70 年營運經驗，於全球擁有 6,000 名員工，專精於建築與基礎建設之電力工程、工業用電力與管線之安裝與維護、離岸或岸上油氣平臺與管線安裝等。在歐洲離岸風電產業開始發展後，該公司亦投入離岸風場海上變電站之製造，範圍涵蓋海上變電站設計、製造、施工及管理運維(EPCI)，迄今已完成 20 座海上變電站，在歐洲離岸風場海上變電站市占率約達 40%。

3、 參觀廠區主要分成在戶外露天的框架前置製造階段及在廠房內堆疊組裝兩個部分，廠房內可同時製造三座大型海上變電站或四座小型海上變電站。在戶外的執行工程，主要是鋼構件的銲接組立以及相關線槽和固定件的施作。在海上變電站的主體結構件組立完成後，會視客戶需求及天氣條件決定於廠內或戶外進行電器類組件的安裝，電器類組件包含變壓器、開關設備及配電盤等。海上變電站的製造時程為 4~6 個月工期，依據容量不同會有不同的層數、重量、尺寸等等。其所製造最大的海上變電站為重量 4,100 噸，具有 4 層結構之站體。

(五)討論議題：

1、 **問題：**海上變電站工廠設置所需碼頭設施(承載力)、製造設施(廠房面積、儲存區面積、天車載重、產能規劃)與人力品質需求為何？

回復：碼頭設施承載力為每平方公尺 20 噸及足夠的碼頭長度(最小 35 公尺)。廠房面積必須有足夠的室內場地滿足製造需求，現有廠房約為長 300 公尺、寬 50 公尺、高 30 公尺。儲存場地面積約 12,000 平方公尺，吊車承載力為 40 噸。至於人員需要各種人才，像是專案經理、電銲組立、表面塗裝、高壓電氣設備安裝、電纜安裝連結及吊裝的操作員等。

2、 **問題：**海上變電站的運轉有哪些須監測的項目？ 如何監測海上變電站異常狀況 ？營運維護人力要如何配置？

回復：需要監測的項目像是電氣設備的性能及輔助與安全系統的運作確認，包含溫度監測與消防及安全措施的確認。可透過 SCADA 系統也就是 Supervisory Control and Data Acquisition Software 進行監測，系統會針對訊號進行分析狀況是否異常。最後若有必要，才再根據須執行的工作內容，進行工作人員的派工。

3、 **問題：**針對海上變電站營運維護，何種備品零件更換次數最頻繁？

回復：主要是耗材類，但不易取得之組件、特殊規格品與輔助和安全設備等物料搬運設施像是吊架及起重機，在營運維護風場時也會需要準備。

4、 **問題：**海上變電站安裝於海洋上，如何防護海洋環境的腐蝕？腐蝕反應的發生對於電力設備造成何種影響？

回復：針對鋼材腐蝕的防護，透過抗海洋環境的塗料及犧牲陽極等方法來防護。至於電力設備的防護，則是透過防水設計要求、材料選擇像是碳鋼、不銹鋼或 FRP 等材料及利用箱體進行環境控制。

5、 **問題：**海上變電站安裝於海洋上，變電站中變壓器所使用的絕緣油有何特殊要求？

回復：一般使用傳統礦物油與酯類絕緣液體，還透過滴水盤、油水分離器及水槽的設計避免水氣滲入。也可以使用可生物降解絕緣油，但仍需要防止滲漏。

(六)拜會心得：

Engie Fabricom 業務從海上變電站的設計(包含站體結構、電氣設備等)到製造組裝一條龍服務。在製造廠區中，會依據客戶需求先進行海上變電站的鋼構結構製造及相關電氣設備的組裝。其中為了減重的需求，選擇 C 型或 H 型的玻璃纖維強化塑膠(FRP)結構件做為變電站中的電纜支架，且廠內也有專門的部門進行 FRP 的標準件製造，可以看出 Engie Fabricom 的製造技術能力及多元性。

(七)影像紀錄：

圖 1：本參訪團成員聽取 Engie Fabricom 公司簡介及參觀安全講習

圖 2：安全裝備著裝準備進入工廠參訪

圖 3：本參訪團成員於 Engie Fabricom 公司門口合影

二、拜會 Jan De Nul（海事工程 EPCI 統包商）

(一)時間：108 年 6 月 19 日星期三，12:30~15:00

(二)地點：Tragel 60, 9308 Aalst, Belgium

(三)與會人員：

1、 本參訪團成員

2、 比利時法蘭德斯外貿投資局代表

3、 Blue Cluster 代表

4、 Jan De Nul 業務發展經理(Business Development Manager)Mr. Jef Monballieu、Mr. Carl Heiremans、離岸再生能源營運經理(Operations Manager Offshore Renewables)Mr. Koen Marchand、市場分析師(Market Analyst)Mr. Pranav Tetali

(四)過程摘要：

參訪過程：

會前於 Jan De Nul 總部，本參訪團團員與該公司人員進行簡單餐敘交流及參觀該公司船體模型簡介，正式拜會時由 Jan De Nul 公司進行簡報後自由談話交流。

公司簡介：

1、 Jan De Nul(JDN,楊德諾)是一間比利時的海事工程公司，總部位於 Aalst，水下工程施作佔其承接之業務總量百分之七十五，為家族企業，因此在資金調度上具有充分的自主性。在全球有 6,500 餘位員工、700 多位工程師且平均年齡為 37 歲，在非洲、南美及歐洲都有建設實績，2018 年營業額達 270 百萬歐元，主要業務包含海底電纜、離岸風場、天然氣與石油供應管線及其他設施之海洋工程，是國際標竿的海事工程公司，在業界具有領導地位的角色，全世界共有 20 餘地(包括臺灣)設有服務據點及業務。

2、 楊德諾具有離岸風場安裝和海底電纜鋪設工程、設計、建造等經驗，擁有各種專業海事工程施工機具及人員，可直接承攬相關工程之規劃、設計及施工業務。曾承攬比利時最早開發之風場，其他實績包括巴拿馬運河拓寬工程、杜拜棕梠島、香港赤臘角機場等，另具有約 50 位工程師從事船舶設計，船舶幾乎都為自有製造，為符合臺灣政府在地化需求，船舶須向外租賃。

3、 在海洋工程部分從事包港灣建造及維護、港灣疏濬及護灘工程，離岸工程包括海床鑽探、拋石、海纜鋪設、離岸再生能源設置及重件裝卸作業等，土木工程類包括基礎建設、基礎土木工程及水下基礎裝設，環境工程部分包括清除汙泥及土壤、地下水、廢棄物處理與處理中心，建設過程公司很重視環境與海洋的保護，風場建置及水下基礎裝設、風力機吊裝及波浪與潮汐發電，海床整平及人工島嶼建置，海纜佈放埋設等。

4、 2022 年即將建成之最大安裝船 VOLTAIRE 號，吊掛能力 3,000 噸、水深 80 公尺、安裝風力機機艙高度 165 公尺、葉片長度 125 公尺，另還有新造 VOLE AU VENT

及 TAILLEVENT 等兩艘新船。目前 JDN 最大之鋪纜船 Willem de Vlamingh 5.400t capacity 已來台，將協助臺灣風場進行海纜鋪設。

5、 楊德諾已承攬臺灣台電一期、上緯海洋二期及海能風場 EPCI 水下基礎及海纜鋪設工程。過去楊德諾在離岸風電 EPCI 經驗包括比利時 Bligh Bank phase 2 風場 51 支單樁式水下基礎及 50 座風力機 (Vestas 3.3MW)的運送安裝、英國 Burbo/Race Bank 風場運送安裝 2 條輸出海纜 (71 公里)及 1 條陣列海纜、芬蘭、丹麥、德國歐洲各國風場建置等。

(五)討論議題：

1、 **問題：**在進行風力機預組裝作業時，水下基礎之儲放方案為何？例如：以駁船載運儲放或於陸上儲放？

回復：考量吊裝搬運成本、搬運風險及運送效率，須儘量避免搬運次數，故可能由數艘駁船進行運送，需視實際限制條件決定。

2、 **問題：**由於臺灣地理環境條件特殊多颱風且海床屬於軟泥土層，在進行風力機安裝及運維時，有無針對颱風因素對於工作船及風力機任何安全建議及因應措施？

回復：對於颱風侵襲部份我們有一系列的處理作法，最有把握的就是將船舶駛離可能受侵襲的區域，或進入安全的港口避風。

3、 **問題：**依據 JDN 過去離岸風場海事工程統包經驗，對選用在地既有之船隻有何規範或具體協助之作法？

回復：需依照施工國家的規範選用船隻，在臺灣的經驗因為有船舶生產地的限制，故需要特別避免使用中國大陸製造的船隻，同時也要符合相關的法令要求。

4、 **問題：**水下基礎安裝的過程中，如何減少對海洋生物及環境的衝擊？

回復：這是一個很大的問題，可能可以採用減噪或是提前進行相關海底生物棲息或環境影響調查，預為因應來避免干擾海洋生物及減少對環境的影響。

(六)拜會心得：

JDN 特別著重企業員工施工細節及作業安全的企業文化，對於施工細節及作業安全須知等出自員工自我要求或習慣。我國國內業者對於施工安全之認知意識較為薄弱，需要較長的時間進行充分的教育訓練，以達成歐洲離岸風電產業製造的高規格標準。

美中不足的是，JDN 業務目前仍以石化產業的鑽油平台工程為大宗，有鑑於全球目前重視環境永續發展，現階段 JDN 積極參與環境建設工程，雖然只佔公司整體 3~4%的營業額，但仍積極投入發展並持續推動在離岸風電海事工程業務。該公司同時也關心潮汐及波浪發電的發展趨勢，發揮推動再生能源以減少溫室氣體排放的社會企業責任也值得國內企業借鏡。

(七)影像紀錄：

圖 1：JDN 以模型介紹其 Cutter Suction Dredger (CSD)吸泥船

圖 2：JDN 向本參訪團成員致歡迎詞並進行公司簡介

圖 3：雙方經驗分享與意見交流

三、參加Greenbridge Oostende離岸風電產業交流會（Seminar/B2Bs）

(一)時間：108年6月19日星期二，16:30~19:00

(二)地點：Wetenschapspark 1, 8400 Oostende, Belgium

(三)與會人員：

1、 本參訪團成員

2、 比利時法蘭德斯外貿投資局代表

3、 Blue Cluster(DBC)及Belgian Offshore Cluster(BOC)會員廠商

4、 駐歐盟兼駐比利時代表處經濟組經濟秘書行健

(四)過程摘要：

參訪過程：Blue Cluster與Belgian Offshore Cluster代表及本參訪團代表簡單致詞致意表示歡迎後，由雙方成員代表分別進行簡報說明比利時與臺灣建置離岸風電之概況與本參訪團成員所屬公司業務內容，期望於會後自由交流時可進一步洽談相關合作。（整體流程詳見貳、流程表二、產業交流會議程。）

交流情形：

1、 本參訪團代表致詞，感謝Blue Cluster與Belgian Offshore Cluster協助本參訪團之比利時拜會行程聯繫以及今日交流會活動，提供一個臺灣業者與比利時標竿業者進一步交流離岸風電產業之新興資訊及洽談合作商機的平台。並說明臺灣政府積極推動智慧新創產業發展的決心。本次參訪團團員包含海事工程，水下調查，港口及水深調查、大型公共基礎設施和能源法律諮詢服務等方面的專業人員，期望透過本次與比利時業者的專業技術交流，使比利時業者瞭解臺灣離岸風電產業，並協助國內業者掌握國際發展趨勢，建構臺灣離岸風力機產業鏈智慧化及創新技術能量，鏈結國際。

2、 Blue Cluster (DBC) 社群經理Ms. Overmeir致詞時，以簡報向與會人員簡介比利時離岸風電現況，提供雙方會後自由交流時間可進一步洽談合作之相關資訊。

3、 復由金屬中心張博士向比利時業者介紹臺灣離岸風電政策目標、執行策略、與外商合作現況及實例，包含風力機運轉維護管理、風力機智慧監控等，期望未來可能與比利時合作。接著由臺灣港務公司唐資深副處長介紹臺灣離岸風電港口規劃與發展現況，以及由本參訪團成員介紹其所屬公司專長技術、產品及服務。

4、 會後進行自由交流，交流媒合情況概述詳(五)討論議題紀錄。

(五)討論議題：

1、 IMDC產品經理Mr. Samadov與海歷企業，針對離岸風電海事工程服務領域進行討論交流，希望能夠提供海洋地形及氣象等探測技術及儀器等服務，並與港務公司討論有關港口土地規劃的歐洲開發經驗，以及港區地形監測等可能合作議題。

2、 Smulders業務發展經理Mr. Finé與金屬中心張博士交流表示仍期望與臺灣廠商在大型鋼構件的製造技術(如，銲接工法、表面處理及銲接檢測等)能有合作機會。

3、 安全設備吊具廠商 K2 Profshop 公司代表 Mr. Binst 與團員海歷企業及大陸工程交流，洽談未來雙方在高空操作人員安全設備提供及高空安全操作準則制定合作可能性，作為臺灣風場運維工程從業人員的安全防護。

4、 其餘自由討論內容眾多，恕不詳列入本報告中。

(六)拜會心得：

此次參與產業交流會的比利時業者，除具有專業的海事施工及統包承攬、水下基礎製造等技術能力外，亦有離岸風電運維作業安全設備供應商及國際工程和諮詢公司共同參與。藉由離岸風電產業交流會的舉辦，提供我國海事工程業者、港埠單位以及規劃切入離岸風電產業之國內業者，廣泛的與比利時業者接觸與交流的機會，促進我國業者全面瞭解比利時離岸風電水下基礎製造及海事工程產業發展。針對水下監測數據採集方法、水下監測儀器設備使用，以及波浪、水流、沉積物對水下基礎結構影響等作進一步交流，增進未來企業雙方商業合作的機會。

(七)影像紀錄：

圖 7：IMDC 產品經理與本參訪團成員針對港口規劃等領域進行討論

圖 8：本參訪團成員與劉行健秘書交流

圖 9：本參訪成員團、劉行健秘書與比利時業者於交流會後合影

四、拜會 REBO（奧斯坦德運維港港務公司）

(一)時間：108 年 6 月 20 日星期四，09:30~11:30

(二)地點：Slijkensesteenweg 2, 8400 Oostende, Belgium

(三)與會人員：

1、 本參訪團成員

2、 比利時法蘭德斯外貿投資局代表

3、 Blue Cluster 代表

4、 Haven Oostende 行銷主管 Mr. Laure Martroye

5、 Port Oostende 業務發展經理 Mr. Wim Stubbe

(四)過程摘要：

參訪過程：

本次拜會先由臺灣港務公司唐資深副處長進行簡報後，再由 REBO 介紹奧斯坦德港的離岸風電港埠發展策略、行動方案、安裝運維碼頭之基礎建設，並概述比利時的離岸風場概況等。

公司簡介：

1、 奧斯坦德(Oostende)港因比利時政府發展離岸風電之需求，於 2010 年成立 REBO(Renewable Energy Base Oostende)公司，結合了 PMW(股份佔 40%)、Oostende 港務當局(15%)、Geosea(15%)、 DEME Blue energy(15%)、ARTES(15%)等五家公司組成 REBO 公司，專責經營港口離岸風電業務。可為已營運的 6 座離岸風場(共 274 部風力機)，及 3 座正在建設中的大型離岸風場，提供完整的風力機安裝及運維服務。

2、 奧斯坦德港規劃的安裝及運維碼頭，可存放機艙、轉接段、葉片等進行預組裝作業，另設有一特殊船席，可供西門子 RORO 船 Rotra Vente 號直接使用自走式模組化運輸車(Self-Propelled Modular Transporter, SPMT)運送風力機機艙，港口規劃用於離岸風電風力機安裝及運維區域總佔地約 40-50 公頃，碼頭水深 8 公尺，碼頭面承載力達每平方公尺 20 噸重。

3、 REBO 已為多個離岸風場提供港埠服務，包含：Nobelwind(水下基礎轉接段)、Belwind (Haliade 150 水下基礎及風力發電機組)、Rentel(風力電機組)等，現持續提供比利時 6 座離岸風場的日常運維。

(五)討論議題：

1、 **問題：**REBO 公司有承接拖船(Tugboat)和人員運輸船(Crew transfer vessel, CTV)服務或之業務嗎？

回復：REBO 公司營運旨在強化港埠基礎設施設及船席的建設，有關人員運輸船的業務，僅設有線上軟體系統作為船體靠泊的分配輔助工具，該軟體可使船舶找到可停泊位置，每一艘人員運輸船可發布訊息在該線上系統，由該系統可知該船體的停泊位置、運輸船上的船員、以及需航行至哪個風場維修等；對 REBO 公司

來說每天都要規律追蹤這些資訊。

2、 **問題：**在奧斯坦德港進行風場營運維護人員大約有多少人？港口發展下創造多少人數的就業機會？

回復：截至 2017 年，在奧斯坦德港從事運維的人員總數為 466 人；在 2013 年僅 204 人，由於比利時風場建設陸續完工，4 年內風力機運維人員增長率達 228%；而奧斯坦德港的發展目標在 2020 年達到 50 企業進駐港埠，並創造 800 個就業機會。

3、 **問題：**奧斯坦德港人員運輸船的泊位數量？投資金額？

回復：運維港埠建設方面，繫船區(Mooring spaces)第一階段的運維船席已於去(2018)年 10 月完工，有 9 個小型人員運輸船船席、5 個大型人於運輸船船席，總投資約為 60 萬歐元(約 2,160 萬台幣)。第二階段將再建置 12 個大型船席，預計於 2019 年夏季完工，投資 1.5 百萬歐元(約 5,400 萬台幣)。

4、 **問題：**奧斯坦德港每年人員運輸船的停靠數量？

回復：人員運輸船停靠數從 2015 年 2,129 艘次，增長至 2017 年 3,234 艘次，營運服務船(Service Operations Vessel, SOV)在 2017 年則有 57 艘次。

(六)拜會心得：

REBO 公司由比利時政府單位及多家民營企業合資成立，負責離岸風電安裝及運維碼頭管理與基礎設施興建。然而其投資發展離岸風電的信心則來自於比利時政府 2020 年 2.262GW 明確的風力發電產業目標，以及鄰近離岸風場開發地區的區位優勢(距離最近離岸風場僅 22 公里)。區位條件優勢再加上政府政策，不僅吸引比利時離岸風電業者進駐，更有多家英國業者投資該港口進行英國離岸風場運維。我國臺中港具有相同的發展條件，距離彰化離岸風場近且腹地大，在碼頭基礎設施的建置與規劃，除有賴政府長期的發展決策與決心外，還需與產業界溝通與討論，規劃出風場運維所需的各項軟硬體服務。

(七)影像紀錄：

圖 10：REBO 業務發展經理 Mr. Wim Stubbelur 簡報奧斯坦德港口發展

圖 11：可供西門子 RORO 船使用 SPMT 運送風力機機艙之碼頭一景

五、參觀 Jan De Nul 離岸風電海事工程船舶

(一)時間：108 年 6 月 20 日星期四，13:00~15:00

(二)地點：Tijdok, 8400 Oostende, Belgium

(三)與會人員：

1、 本參訪團成員

2、 比利時法蘭德斯外貿投資局代表

3、 Blue Cluster 代表

4、 Jan De Nul 業務發展經理(Business Development Manager)Mr. Jef Monballieu、Mr. Carl Heiremans

(四)過程摘要：

參訪過程：

於安全中心聽取簡報、穿戴相關安全裝備後，前往碼頭。原定登船參觀，惟因臨時進行檢修作業，僅於碼頭船側近距離參觀與講解。一側並有儲放於碼頭邊的長達 64 公尺之葉片。

公司簡介：

1、 楊德諾的自升式平台船(Jack-up vessel) TAILLEVENT 號於 2011 年建成，可進行離岸風電重件吊裝維護及施工作業，總長 138.55 公尺、寬 40.8 公尺，具有 DP2 動態定位系統，自升式系統(Jack-up System)共有 6 隻腳，長 73.27 公尺，最大作業水深達 40 公尺，主吊臂吊裝能力為 25 公尺、吊裝 1,000 噸貨品，甲板最大乘載能力為每平方公尺 10 噸重，最大承載貨物重量為 6,000 噸，船艙可容納 112 人。

2、 自升式平台船選用需考量吊裝能力，隨離岸風電風力機逐漸大型化，故目前楊德諾正建造符合更大型風力機所需的自升式平台船 VOLTAIRE 號，惟亦委由中國大陸中遠集團建造，預計於 2022 年建造完成，吊裝能力可達 3,000 噸，可吊裝機艙高度 270 公尺高的風力機及 120 公尺長的葉片 ，新船的甲板空間將比現有 TAILLEVENT 號增加一倍以上。

3、 TAILLEVENT 號停泊的碼頭旁存放有準備裝載上船以前往風場安裝的風力機葉片，葉片長度為 64 公尺長，為保障葉片在碼頭儲放時的安全及吊裝便利，葉片使用專用的夾具以及角架支撐，可確保葉片儲放不致滑落或遭受碰撞，並利於裝載上船運送。

(五)討論議題：

昨(6 月 19 日)已拜會該公司並於會上討論，港邊風大不易紀錄，恕敬略參觀過程中之提問與回答。

(六)拜會心得：

雖然因 JDN 船舶臨時檢修作業需要未能登船參觀十分可惜，但能近距離觀察已是相當寶貴的經驗。在聽取說明和介紹後，充分了解奧斯坦德港已由原先作為一個漁港，逐

步轉變為海事工程運維基地的過程，未來離岸風電與臺灣在地的漁民及漁港也可借鏡奧斯坦德港之經驗，創造漁港新風貌及發展新契機。

另外參觀了儲放在碼頭邊的葉片，長度雖然僅 64 公尺(相較於未來 MVOW V164 9.5-MW turbine 葉片長度超過 80 公尺)，但仍然非常巨大具有震撼力。離岸風力機持續持朝大型化發展，未來臺灣在考慮自建工作船時應考量下一世代風力機的研發趨勢，進行做最有效的規劃，以因應急速成長的市場。

(七)影像紀錄：

圖 12：本參訪團成員在 TAILLEVENT 號自升式平台船前合影

圖 13：奧斯坦德港是 JDN 重要運維母港之一
(後方為 JDN Alexander von Humboldt 號挖泥船)

圖 14：TAILLEVENT 號為檢修需在港內抬升船體(已可見船尾螺旋槳)

圖 15：JDN 介紹其碼頭葉片存放及吊裝作業

六、拜會 Otary（風場開發及運維管理公司）

(一)時間：108 年 6 月 20 日星期四，15:00~17:00

(二)地點：Buskruitstraat 3, 8400 Oostende, Belgium

(三)與會人員：

1、 本參訪團成員

2、 比利時法蘭德斯外貿投資局代表

3、 Blue Cluster 代表

4、 Otary 運維經理 Mr. Tiemen Maebe

5、 e-BO 執行長 Mr. Christophe Dhaene、產品策略經理 Mr. Ronny Dewaele

(四)過程摘要：

參訪過程：

先由 Otaty 與 e-BO 公司進行簡報，介紹 Otary 成立背景過程與比利時離岸風電市場發展概況，以及該公司風場開發與運維的計畫。後 Otary 帶領本參訪團成員參觀其正在建置之運維中心，可一次監控風場所有整體狀況。

公司簡介：

1、 Otary 於 2011 年由八間比利時公司(包含 DEME)共同成立，總部位於奧斯坦德(Oostende)的風場開發和運維公司，員工約 50 位，專注於開發和建設三個比利時離岸風場 Rentel (309MW)、Seastar (252MW)、Mermaid (235MW)，總計 796MW。其中，Rentel 風場是第一個開發並已於 2018 年投入營運的項目。

2、 比利時目前共有九個離岸風場，其中六個已商轉，預計到了 2020 年總裝置容量將達到 2.262GW，電力足可供應比利時 50%的家庭。近十年比利時致力於將其於離岸風電領域的專業推廣到全世界。目前已商轉之 Rentel 離岸風場位於比利時北海海域，共計有 42 座 SGRE 的 SWT-7.0-154 風力機，裝置容量共計 308M，可供應約 30 萬戶比利時家庭用電，風場面積約 22.72 平方公里，

3、 Otary 運維監控室主要任務包含狀況認知(situational awareness)、警報管理(alarm management)、工作安全系統(safe system of work)、資產監控(Asset Monitoring)及資產運營(Asset Operations)等。如何降低風場營運成本，進而降低能源價格為運維工作的重要目標;未來挑戰包含如何將可再生能源生產單元整合到現有能源結構中、大規模儲存、電網互連及智能數據和智能電網等範疇。

4、 e-BO 為遠程控制系統的專業軟體工程公司，負責提供 Otary 運維系統軟體。其所提供之離岸風電運維之智慧管理系統、e-Wind O&M platform、Drone detection、eBO-Vision 等通訊系統與資安軟體，已被使用於比利時、荷蘭與德國等多個離岸風場的運維管理，期待可進入臺灣離岸風電運維市場。e-BO 的 e-Wind 風場管理平台提供海事、資產及風場等方面的智慧化管理功能，包含即時監控(人員、船隻、設備)、庫存管理、工作安排、功率損失計算、風力機數據及警訊處理等，另外風險管理、承包商績效報告、時間序列分析、歷史數據報告及人資管理之功

能介面亦涵蓋在內。強調能以地圖和圖表等可視化工具，客製化設計界面呈現工作計畫，並依照風場建造期程分為佈纜、安裝及商轉三階段來管理。

(五)討論議題：

1、 **問題：**如何與離岸風場開發商或海事工程統包商搭配合作？ 一般離岸風場運維的人力數量如何評估？ 如何配置？

回復：主要取決於和各家廠商的簽約內容分工，例如四份 EPC 合約，分別為風力機、水下基礎、海上變電站及電力輸出，假設所簽合約中，系統商負責風力機全面性監控、檢測、數據管理及維修等，Otary 只負責品質管控(quality control)；與海上變電站的合約中，Otary 則負責大部分的維護作業。人力數量配置取決於風場規模大小及擁有資產的多少，理論上，以一個擁有三個海上變電站的風場來說，運維中心的運維工作人員配置約計為 40 名，但不含施工作業技術人員。

2、 **問題：**離岸風場開發管理運維有哪些須監測項目？ 如何監測？ 如何進行轉接段、水下基礎與海上變電站的維修保養工作？

回復： 風力機零組件品項眾多，每項皆有嚴謹的監控流程，通常由 Otary 負責監控，海事工程統包商做後續的維修工作。轉階段及水下基礎的檢查與監控，例如 破損及腐蝕問題，由 Otary 負責，而由 DEME 負責於風場現場進行維修；或者是海上變電站的檢測與小範圍維修由 Otary 負責，但大型維修工作則由 Engie Fabricom 進行。

3、 **問題：**離岸風場在運維階段，主要更換的風力機零組件是哪些？更換頻率是？

回復： 運維階段最不希望要更換的零組件應該是齒輪箱 (Gearbox)，而且齒輪箱維修相當昂貴，可能需要自升式平台船(Jack-up vessel)及花費各種物流成本；另也會有葉片等大型部件更換等需求，但多數仍為細部小零組件較常需要作更換。

4、 **問題：**針對離岸風場營運維護，如何進行備品管理，和在地備品供應鏈合作經驗與案例？

回復： 備品管理由其他部門負責，主要備品包含存放在離岸的輸出海纜(Export cables)和海底電纜(Seabed cables)等，因目前還在五年保修期內，Otary 還不需負責更換備品。

(六)拜會心得：

本次拜會主軸集中於離岸風力機智慧化運維，透過開發商 Otary 說明其營運 Rentel 風場的情況，以及參觀風力機運維監控室的軟硬體設備，對運維進行實地參訪，也使本參訪團成員對於風力機系統商於風力機保固期間內的運維模式，有進一步瞭解。運維監控部分，如破損檢測等影像辨識，皆須仰賴大量影像資料及運轉資料集成的大數據庫，才能建立優良的辨識結果，例如某系統商位於西班牙總部的運維中心，與分布於全球的兩萬多台自家風力機皆有連線，形成的數據庫非常龐大，得以進行後續數據分析。Otary 的運維經理 Mr. Tiemen Maebe 表示，目前是 Rentel 風場商轉的第一年，

初期由風力機系統商SGRE提供部分數據資料,後續Otary也將會自行進行數據蒐集，再針對監控系統設定進行優化。有鑑於我國離岸風場建置完成後,風力機運維(例如：營運維修工具、檢測設備、安全設備等)將有更多的市場業務釋出，運維周邊硬體設備亦需強力的支援。台灣資通訊產業發達，若能透過瞭解開發商需求，結合國外軟體系統建置經驗，將可增加雙方合作機會，強化離岸風電在地供應鏈之建置。

(七)影像紀錄：

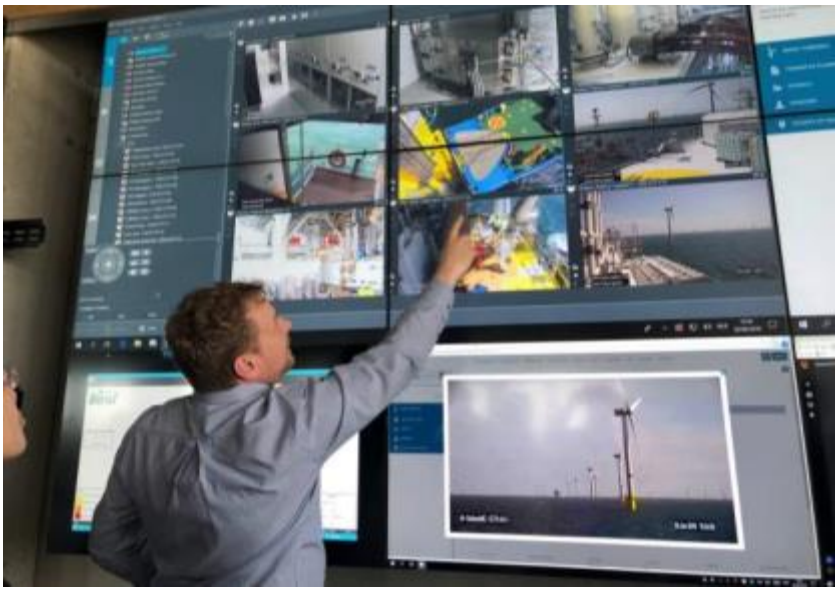


圖 16：Otary 運維經理 Mr. Maebe 於監控中心解說

圖 17：本參訪團成員現場提問情形

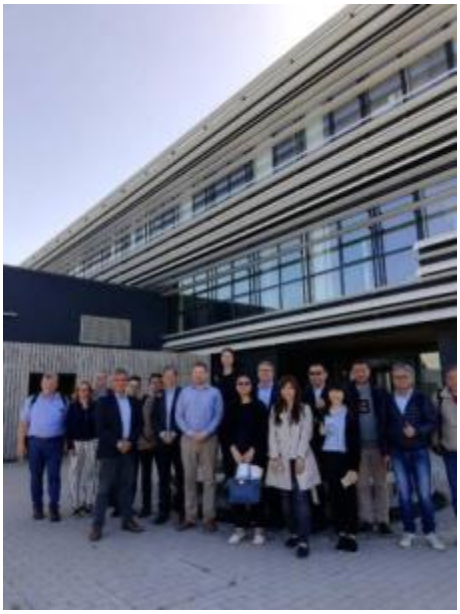


圖 18：本參訪團成員與 Otary 及 e-BO 代表於其公司大門口合影

七、參觀離岸 1 公里之研究測試平台

(一)時間：108 年 6 月 21 日星期五，09:30~11:30

(二)地點：Oosterstaketsel, haven Oostende, 8400 Oostende, Belgium

(三)與會人員：

1、 本參訪團成員

2、 比利時法蘭德斯外貿投資局代表

3、 Blue Cluster 代表

4、 比利時台北辦事處法蘭德斯經貿組吳組長良鈺

5、 比利時西法蘭德斯政府藍色能源專員(Coordinator Blue Energy)Ms. Sarina Motmans

(四)過程摘要：

參訪過程：

步行至於近岸外海海堤岸邊，可遠眺離岸 1 公里之研究測試平台 Blue Accelerator Platform 的地方，由 Coordinator Blue Energy 向本參訪團成員，對該設施進行介紹與解說。

公司簡介：

1、 Blue Accelerator 是一個離岸研究測試平台，距離奧斯坦德港約 1 公里。該實驗室規劃在實際海洋條件下測試各種海洋相關創新項目，像是進行波浪能轉換、防腐蝕、電纜操縱，電阻抗性、材料、氣象測量及無人機等技術測試，可同時提供研究成果予科學研發機構與海事工程公司等商業公司使用。2010 年 NEMOS 是第一個使用平台，並進行波浪能轉換測試之公司。平台本身具有 15 年期限之使用執照。

2、 此創新計畫在比利時西法蘭德區的社會經濟政策自治機構 POM 支持下開發，POM 主要關注藍色能源等新創議題，並協助在地新創企業在國際市場中探索新商機，透過參加國際展覽、B2B、歐洲地區計劃等建立國際夥伴關係並進行合作，在此研究測試平台計畫中扮演主要聯繫和協調窗口。

3、 Blue Accelerator 離岸研究測試平台主要特色在於其公有屬性，使用者可經由簡單的申請程序獲得使用許可，且鄰近奧斯坦德港，交通便利，也和其他藍色能源相關單位，如法蘭德斯海洋研究所、Blue cluster、GreenBridge 及法蘭德斯海洋實驗室等聚落相鄰。

(五)討論議題：

1、 **問題：**Blue Accelerator 測試平台的大小以及內部附有那些裝備？

回復：平台長 7.1 公尺、寬 3.1 公尺、高 3.3 公尺，會隨潮汐的變化，平均高出海平面 13 到 18 公尺不等。平台上裝設可乘載 1,600 噸之起重機、導航燈、霧號及對外通訊和網路等裝置，亦附有可用電源、CCTV 及安全逃生等設備。

2、 **問題：**Blue Accelerator 測試平台籌備資金以及未來所需花費來源為何？

回復：主要資金來源為歐洲區域發展基金(European Regional Development Fund)、佛蘭芒政府(FlemishGovernment)和西佛蘭德省(Province of West Flanders)，並且是以使用者付費的方式營運。

(六)拜會心得：

臺灣的離岸風場從今(2019)年開始將陸續完工，隨著能源均化成本(Levelized cost of electricity, LCOE)逐年降低，下一階段離岸風電產業如何持續提升營運效率、降低成本，將成為帶動產業邁向新技術發展成長的動能。比利時重視離岸風電產業技術創新，透過海上測試平台，提供中小企業良好的研發測試環境(例如：海上結購物防腐蝕、無人機運維設備、海上監視器 CCTV 等技術建立。)，以持續優化其產品。為因應離岸風場運維需求，可借鏡比利時政府推動海上測試平台，自策劃、實施到完成，以及資金來源等面向之經驗，建構出優良的研發測試環境，持續輔導國內中小企業優化其離岸風電產業相關產品。藉由推動產學研合作補足國內產業技術落差，透過技術提升增加我國業者產業競爭優勢，將有助打造我國成為亞太離岸風電產業樞紐。

(七)影像紀錄：

圖 19：Ms. Sarina Motmans 於近岸外海海堤岸邊簡介 Blue accelerator

圖 20：離岸 1 公里之 Blue Accelerator 研究測試平台

圖 21：本參訪團成員與離岸研究測試平台合影

八、拜會 DEME（海事工程 EPCI 統包商）

(一)時間：108 年 6 月 21 日星期五，13:00~13:30

(二)地點：Scheldedijk 30, 2070 Zwijndrecht, Belgium

(三)與會人員：

1、 本參訪團成員

2、 比利時法蘭德斯外貿投資局代表

3、 Blue Cluster 代表

4、 比利時台北辦事處法蘭德斯經貿組吳組長良鈺

5、 DEME 採購及物流經理(Procurement & Logistics Manager)Mr. Tom Saelens Deme Offshore、業務經理(Commercial manager)Mrs. Justine Thiry

(四)過程摘要：

參訪過程：後續擬參觀 Flanders Maritime Lab.，就近於 GreenBridge Oostende 會場與 DEME 交流，由 DEME 進行簡報後，即由 Flanders Maritime Lab.負責人進行簡報，並步行至附近實驗室參觀與解說。

公司簡介：

DEME 集團是比利時具有百年歷史的海事工程公司，主營離岸海事工程包括石油及天然氣等化石能源開採，並發展離岸風電風力機及水下基礎運送及安裝等海洋工程。旗下子公司 GeoSea 成立於 2005 年，與台船公司 JV 合資成立台船環海(CSBC-DEME WIND ENGINEERING Co. Ltd., CDWE)，目前已取得 CIP 及 NPI 的海事工程訂單。我國可借鏡 DEME 集團過去在歐洲的開發經驗和專業團隊，進行密切的良好合作。

DEME 在簡報中建議，因離岸風電零組件均為大型組件，在運送時需要準確地計算貨物重量、直徑及運送距離，必須選用適當的船舶和機具，透過適當的船機以面對各種在海上的氣候條件，方可提供快速、安全的運送及安裝服務，同時也需要考量具有適當條件的港口及腹地，以儲放大型組件，便於提供風場建置良好的服務。

(五)討論議題：

1、 **問題：**臺灣常遭遇颱風侵襲，請教如何規劃與因應？

回復：需透過氣象資料的蒐集與判斷，儘量將船機等及早駛離颱風可能侵襲的路徑範圍，或者將船機停泊於港內。另外以安放在港內的貨品，也需要妥善固定。

2、 **問題：**若需建造具 50 座的風力機風場需要多久時間？

回復：這個問題牽涉較為廣泛，須配合風力機系統廠的製造交貨時程，在安裝期間則需考量風場與港口間的距離、使用船隻規格及數量、相關的建置限制(惡劣天候或其他)等因素。

3、 **問題：**DEME 擁有許多的不同工作船，應如何選用？

回復:需考量風場的地質條件等要素,並考慮價格的經濟性等因素作為選用依據,也要考慮船期配合，來選擇最合適的船。

4、 **問題：**有關 DEME 各式工作船的製造地為何？

回復：目前持有的船舶係依照各船廠之製造能力及船舶特性來自不同國家，有來自克羅埃西亞、中國大陸、德國、荷蘭、馬來西亞、西班牙等地建造的工作船。已知中國大陸製船舶到臺灣作業曾有案例有狀況，但中國大陸製船舶外尚有許多歐洲製船舶可供選擇，屆時會一併考量。

(六)拜會心得：

DEME 已與台船合組台船環海公司(CDWE)並承攬 CIP 及 NPI 海事工程業務，GeoSea 擁有 7 艘自升式平臺船、3 艘浮式起重船、以及 3 艘駁船。該公司過去已多次參與英國、德國及比利時等國之大型離岸風場建設。期待未來能借重 DEME 在歐洲的豐富經驗及多樣船機，對我國離岸風電海事工程注入充分能量，使我國海事工程產業在地化發展具有更穩固的基礎。

(七)影像紀錄：

圖 22：DENE 介紹其風場建置設備運輸及物流相關議題

圖 23：比利時 SeaMade 計畫建置概況簡報

九、參觀 Flanders Maritime Lab. 海事工程實驗室

(一)時間：108 年 6 月 21 日星期五，14:30~16:30

(二)地點：Wetenschapspark 1, 8400 Oostende, Belgium

(三)與會人員：

1、 本參訪團成員

2、 比利時法蘭德斯外貿投資局代表

3、 Blue Cluster 代表

4、 比利時台北辦事處法蘭德斯經貿組吳組長良鈺

5、 Flanders Maritime Lab. Manager of Physical Research Infrastructure Mr. Stefan Geerts

(四)過程摘要：

參訪過程：並述於八、拜會 DEME(四)、過程摘要，參訪過程中。

公司簡介：

1、 Flanders Maritime Lab(法蘭德斯海事工程實驗室)，為比利時法蘭德斯政府與兩所大學共同合作，投資 2,800 萬歐元建設。整合產、官、學界資源進行離岸風電相關研究，有利於掌握未來全球離岸風電創新研究方向。

2、 該實驗室設有一造浪池及一大型拖船池可進行無因次水力模型研究，造浪池長 30 公尺、寬 30 公尺、深 1.4 公尺，以混凝土結構組成。其特色之處在於可以產生波浪、水流和風，用以測試及研究海上結構物、沿海保護結構、浮動式風力機的設計受波浪、水流以及風作用的影響，進一步研究如何降低海上結構物損害之風險。第一次實驗計劃已於 2019 年開始，可為離岸風電開發商、風力機系統商、海事工程商提供大量優化離岸風電產業可能性。

(五)討論議題：

1、 **問題：**Flanders Maritime Lab.的創立，如何連結學校及企業資源進行離岸風電相關研發及測試？

回復：本實驗室由根特大學與 Agoria(比利時科技產業聯盟)發起建置，針對水動力流體相關研究，積極鏈結產業界及學術界，透過實驗室的模擬水槽進行實驗排除設計錯誤，縮短施工時程。此外，該實驗室也歡迎全球對於水動力流體研究相關的單位進行合作。

2、 **問題：**針對離岸風電產業，除研究波浪對船泊的影響外，是否針對水下基礎型式進行研究？若有，那是甚麼樣型式的水下基礎？ 研究成果將如何應用於離岸風電產業實務上？

回復：該實驗室有進行浮動式基礎結構分析，且與日本相關研究單位合作，運用福島的浮動式風力機實驗計畫，主要的實驗項目包括浮動式基礎、固定錨及繫泊纜繩。

3、 **問題：**除了波浪對海上結構物的影響，Flanders Maritime Lab.未來還有可能規

劃的研究項目為何？

回復：除了針對固定結構物(港灣、風力機)的研究外，未來規劃了潮汐及波浪能應用，研究項目將越來越充足。

(六)拜會心得：

Flanders Maritime Lab 實驗室設有一造浪池及一大型拖船池，目前已經完成凝土結構的製造，將在 2020 年完成相關的電機及機械設備建置完成，屆時將開放全球對於水動力流體研究相關的單位進行合作，如海上結構物、沿海保護結構、浮動式風力機等受波浪、水流以及風作用的影響等。

該實驗室的硬體專注於水動力流體相關研究之需求，採用大水量泵浦供水的方式做為造波及造流的來源，可提供不同流速、流量及浪高的模擬水流滿足研究需求，並裝置有大型天車(載重 20 噸重)以進行大尺寸的模型試驗。規劃時即預留硬體空間及設備的能量可滿足未來更大型化的實驗需求。該研發中心對全球合作計畫採開放態度，國內廠商若有相關的研發需求可與之洽談合作，該研發中心的國際合作相當活躍，致使研發能量相當豐富。藉由實地走訪實驗室並在與 Mr. Stefan Geerts 談話中發現該計畫在初期即有縝密設計，小細節上也有許多用心之處，例如即使實驗室尚未完全建造完畢，但為幫助相關推廣活動能同步進行，實驗室內設置一艘 JDN 模型船，有助來訪貴賓對未來實驗進行也能產生畫面連結，不因施工期而暫停與外單位進行交流，細心之處值得臺灣相關單位參考。

(七)影像紀錄：

圖 24：Mr. Geerts 介紹 Flanders Maritime Lab.的研究實績及成果

圖 25：參觀尚在興建的研究場域 Towing Tank Oostend

圖 26：本參訪團成員聽取 Flanders Maritime Lab.的硬體建置現況介紹

十、拜會 MHI Vestas 葉片工廠

(一)時間：108 年 6 月 24 日星期一，15:30-17:30

(二)地點：MHI Vestas Offshore Wind Blades UK LTD, Stag Ln, Newport PO30 5TR

(三)與會人員：

1. 本院另一參訪團貴賓
2. 本參訪團成員
3. MHI Vestas 副總經理兼英國區域經理(Vice President and UK Country Manager)：Mr. Julian Brown

(四)過程摘要：

參訪過程：聽取該公司發展歷程介紹簡報及安全講習簡報後，分為兩組實地參訪其葉片工廠內部。

公司簡介：

1. MHI Vestas Offshore Wind(MVOW)是由 Vestas(50%)和日商三菱重工 MHI(50%)組成的合資企業。該公司於 2014 年成立，業務範疇包含離岸風力機之設計、製造、安裝及維修。
2. 位於懷特島(Isle of Wight)的研發設施於 2011 年成立，由 MVOW 承租，主要用於風力機大型葉片開發，該工廠包括兩個 170 米長、50 米寬的生產空間，一個用於測試和驗證，一個用於葉片生產。MVOW 風力發電機組 V164-8.0 MW 的原型機葉片即在懷特島工廠設計、製造及測試，因此 MVOW 開發了製造葉片所需的關鍵技術和製程，且具連續製造(Serial produce)風力機葉片的生產能力。
3. 實地參訪其產線時，可以發現整個葉片的生產流程需要大量的人力來執行，如葉片玻璃纖維(碳纖維)布的鋪疊工作、葉片成形後的表面粗糙位置的研磨及氣孔存在位置的替換維修等。係以人力為主進行製作，僅用少數的自動設備(如，氣動研磨機、樹脂澆鑄機台等)作為輔助，完成長達數十公尺之風力機葉片。

(五)討論議題：

1. **問題：**葉片完成全尺寸型式測試後，要進入正式量產。期間若是更換葉片製造所使用材料(不同材料)或廠牌(同材料但不同廠牌)(如樹脂、預浸材料、黏著劑…等)，是否葉片需要重新型式測試？

   回復：葉片的原材料如有更換(供應商、種類、芯材等)，MVOW 葉片廠需要對新的供應商進行認證，針對葉片的機械性能、壽命穩定度、製程參數等。如果沒有涉及葉片原始設計，則不需進行型式測試。
2. **問題：**葉片型式測試，除了全尺寸測試外，是否還有其他測試要求？雷擊測試是必要的嗎？臨場測試是可被接受的嗎？

   回復：葉片在製造過程中，會進行樹脂與玻璃纖維(碳纖維)布的結合力、表面塗裝的附著力、雷擊導電系統測試等。
3. **問題：**目前 MVOW 最大機種風力機(V164-10.0MW、V164-9.5MW)，每製造單一支葉

片需投入多少人力及時間？未來葉片之發展趨勢？

回復：葉片的製造速度大約是一週生產 1 到 2 支，由約 20 至 30 人進行葉片玻璃纖維(碳纖維)布的鋪疊工作。對於未來葉片的發展趨勢，在尺寸上會朝向長度增加，但是重量不增加的趨勢發展，會朝向選用碳纖維來替代玻璃纖維，達到重量輕量化的目的。

4. **問題：**當葉片遭遇雷擊時，如何確保葉片的功能正常？

   回復：當雷擊發生時，葉片表面上會安裝金屬圓餅狀接頭(直徑大約 40mm)及葉片尾端安裝金屬板，用來傳導雷擊的電流接地。

5. **問題：**在生產製造風力機葉片的過程當中，是否有投入自動化及智慧化的生產製造應用？

   回復：在工廠參觀過程中，看到葉片的製造需要大量的人力來執行，如葉片玻璃纖維(碳纖維)布的鋪疊工作、葉片成形後的表面粗糙位置的研磨及氣孔存在位置的替換維修等，僅有使用少數的自動設備(如，氣動研磨機、樹脂澆鑄機台等)。表面的塗裝工作有機會投入自動化設備，但其中的製程仍是仰賴人工執行。

6. **問題：**當初 MVOW 選擇在懷特島建置葉片廠的因素為何？ 是與上游材料供應策略有關，還是與下游葉片成形組裝相關？整體供應鏈規劃策略為何？

   回復：因英國在推行離岸風電產業有在地化要求的因素，加上本葉片廠的現址當時為 Vestas 閒置的舊有廠房，因此順勢將舊有廠房更新為葉片廠，投入葉片研發及製造。目前已經在懷特島當地建立相關的供應鏈體系，供應葉片原料及生產設備維修等。

7. **問題：**MVOW 在懷特島設葉片廠提供的就業機會有多少？帶動的就業機會有哪些類型？

   回復：懷特廠葉片的產線人員透過與當地的政府及大學合作，進行葉片相關研究及人才培養，該廠員工多數依此模式進用，整場的人數大約為 400 人。新進人員產線訓練約 2 週即可上手，產線可依產品進行調整，約 2 至 3 週可完成更換。

(六)拜會心得：

葉片製造主要是以人工進行，葉片模型分上下模，在模型上堆疊玻璃(碳)纖維布(一般約有 19 層)後，再灌注樹脂進行固化，各自成形後再組合成為一支完整的葉片。過程中需時時針對葉片尺寸、表面粗糙度、氣泡排除等瑕疵進行修整。一週大約能生產 1~2 支葉片，一個工班依現場人數估算約有 20~30 名專業技術操作人員。為了確保葉片的品質，該公司還透過與當地的政府及大學合作，進行葉片相關研究及人才培養，藉此保證人員的素質及降低人員流動率。此外，該公司亦於懷特島當地建立生產設備維修服務(如：模具維修、研磨設備、真空澆注設備)等業務，業已形成在地供應鏈體系，產生製造業與在地多元的連結模式。參訪 MVOW 葉片工廠是個不可多的經驗，除實地了解風力機重要零組件的製作過程及產線規劃，如何將 MVOW 於懷特島當地形成在地供應鏈體系的經驗(如：產線規劃、原物料引進、人力配置及產業聚落形成等方

面。)，轉化為協助我國業者建置供應鏈的能量，是個值得思考的問題。

(七)影像紀錄：

圖 27：MVOW 公司針對其懷特島的葉片廠進行簡報

圖 28：本參訪團成員於 MVOW 懷特島的葉片廠門口合影

十一、參觀 2019Renewable UK 離岸風電展

(一)時間：108 年 6 月 25 日星期二，09:30-17:00

(二)地點：Royal Victoria Dock, 1 Western Gateway, Royal Docks, London E16 1XL

(三)與會人員：

(四)過程摘要：

參訪過程:本案訪團成員自由於展場中,了解與詢問各自有興趣之主題,並相互交流。

展會簡介：

1. Renewable UK Global Offshore Wind 2019 為英國離岸風力發電展盛會, 主辦單位為 Renewable UK。去年(2018)展會在曼徹斯特舉辦, 吸引了超過 100 家廠商參展，超過 150 位學者專家進行講座以及論壇活動，本屆展會在倫敦舉辦，預計吸引來自全球 80 多個國家、400 家參展商、約 1 萬名與會者參加，如金融投資業者、海事工程商、水下基礎製造商、風力機系統商以及開發商之單位等。另外該展覽亦有邀請超過 200 位專家進行論壇演講發表,藉此促進產業資訊交流以及增進商業合作機會。
2. Renewable UK Global Offshore Wind 2019 展會集結了許多領域之標竿廠商，依據類型可分為：開發商(例如：Orsted、Innogy、Equinor 等)、風力機系統商(例如：MHI Vesta、Siemens Gamesa、GE 等)、水下基礎製造商(例如：Sif Group、EEW Special Pipe 等)、海事工程商(例如：DEME Group、Van Oord Offshore wind、Seajacks)四大類。

參訪摘要：

1. 本次展會參訪，以離岸風電產業水下基礎智慧化製造、離岸風力機及水下基礎運維新興技術(例如：無人機葉片運維、無人測量船、水下無人載具)等相關項目為重點進行資訊蒐集與趨勢探討。
2. 展場中，有數家水下無人載具(Remotely operated vehicle, ROV)設備商展出實體設備模型。其中，ROVOP 公司於展場中，展示其 Schilling HD 系列之 ROV，該設備四面及機械手臂上皆裝設攝影鏡頭,可經由人員在母船上透過繫纜直接控制 ROV，用於地質、海纜監控、水下基礎監控，移動速度每小時達 4 英里(約 6.437 公里/小時)，共設有 4 個定位系統，可使用聲納定位，掃描半徑達 80 公尺的距離，可提供完整的服務(Total solution)。

圖 29：ROVOP 公司展示其水下無人載具

3. 除了水下無人載具相關業者外，展場中亦有無人機設備業者。其中，ReroEnterprise 公司展出的無人機設備，機體重量達 21 公斤(目前最大機體可乘載重量為 25 公斤)、鏡頭重 5 公斤，每次飛行時間達 30 分鐘，並可在每秒 14 米的風速下進行檢查，一天約可檢查 2 至 4 部風力機。無人機配備數位相機及紅外線熱像儀，風力機檢修人員可利用數位影像檢測塔架、機艙、轉子葉片、螺栓連接的視覺故障和損壞；利用紅外線熱成像檢測轉子葉片表面溫度變化，進而察覺葉片結構缺陷。

圖 30：ReroEnterprise 展示無人機風力機運維設備

4. 展場中，另有離岸風電相關研究專區，展出多篇離岸風電產業發展創新研究成果，例如：「CTV 未來的設計發展」、「水下基礎自動化製造趨勢」、「離岸風場運維數位化應用」、「如何優化離岸風電纜埋設」等研究。針對未來人員運輸船 CTV 的創新和設計，CWIND 現已開發全球第一艘混合動力(Hybrid Powered SES)CTV 船，命名為 Hybrid SES；未來將持續優化電池技術、採氫氣燃料電池(Hydrogen Fuel Cells)、新型檔泥板系統(Bow fender system)，並發展離岸充電增加續航力，朝降低燃料消耗和二氧化碳排放發展。未來新型全電動(Full Electric SES)及混合動力(Hybird Powered SES)船舶設計，將可兼顧風力機維修人員作業安全、維修作業效率及保護海洋環境。

(五)討論議題：參展過程人員分散、問題眾多，本部分討論議題敬略。

(六)拜會心得：

我國離岸風場自今(2019)年起陸續商轉後，將邁入下一階段長達 20 至 25 年風力機運維期。未來在運維產業發展上，除可參考國外經驗持續優化無人機葉片檢測技術外，在水下無人載具 ROV 運維方面，現行 ROV 所配備的機械手臂及攝影鏡頭已可執行更精密海纜檢修作業。惟國內 ROV 設備製造正處發展階段，未來可持續借鏡國外 ROV 精密機械技術及水下作業經驗，發展屬於台灣的 ROV 運維自主能量；在人員運輸船 CTV 創新技術方面，全電動及混合動力船舶將成為未來船舶設計的新趨勢，為台灣產業關聯方案前置期船舶製造下，新造 CTV 船舶可借鏡的新技術方向。

(七)影像紀錄：

圖 31：2019 年英國 Renewable UK 離岸風電展區圖

圖 32：參訪團於 2019 英國離岸風電展會門口合影

十二、拜會 James Fisher & Sons（海事工程及運維公司）

(一)時間：108 年 6 月 26 日星期三，10:00~12:00

(二)地點：Royal Victoria Dock, 1 Western Gateway, Royal Docks, London E16 1XL

(三)與會人員：

1. 本參訪團成員
2. 英國在台辦事處蘇組長韻如
2. James Fisher & Sons 國際發展部部長：Mr. Dan Greeves
3. James Fisher & Sons 國際營運工程師：Mr. Adam Tucker

(四)過程摘要：

參訪過程：雙方於英國離岸風電展場內商談室會面，由 James Fisher & Sons 進行簡報與提問討論後，前往其於會場中之攤位參觀。

公司簡介：

1. James Fisher & Sons(JFMS)提供之服務眾多，包含整體運維系統控與前置測量探勘方面的服務：像是離岸風電管理系統(Offshore Wind Management System, OWMS)是一種最先進以網路為基礎的海事管理系統，可提供資產營運商即時的營運數據，以減少營運支出、提高安全性並優化效率；海事和經濟風險管理支援，在前置的工程設計階段，透過軟體模擬營運的條件來改進案規劃以利辨識並協助減輕海上作業期間的天氣停機時及多變地風險；且 JFMS 具有測量能力提供給沿海、近海和離岸市場使用該資料庫；淘刷預防及資產保護—在海底電纜和風力機基礎等中提供淘刷預防解決方案的廣泛專業知識經驗，包括安裝石袋、仿植(Frond mats)等。
2. 風場運維方面的服務包含：水下遙控載具(ROV)設備及專業技術人員—JFMS 擁有 14 組不同規模和尺寸的 ROV，可以精確地滿足業主的需求由，並利用各種釋放和回收系統快速部署；潛水及水下遙控載具服務—JFMS 的海底部門在提供再生能源、核能及石油天然氣市場有關潛水和水下遙控載具的服務及設備有多達 40 年的經驗；葉片檢查及修復—Rotos 360 採用最新的技術創新，為陸上和海上環境中的轉子葉片之檢查、修復整提供解決方案。
3. 輸電電線電纜運維方面的服務包含：電纜維護、埋設及去除埋設—JFMS 為輸出、陣列間(風機間)、島嶼間和海底電纜的維護、埋設和去除埋設提供專業且整合的電纜解決方案，並包括案件及船舶管理；電纜安裝及引入作業—JFMS 在安裝和岸端電纜引入作業方面擁有成功且出色的記錄，包括提供電纜團隊、船舶、絞車(捲揚機)和作業前調查(測量)；電纜檢查及修復—轉門技術用於去除埋設或重新埋設電纜的沖埋設備、潛水和水下遙控載具調查及測量解決方案，可用於海底電纜的介入、故障查找和維修服務。

(五)討論議題：

1. **問題：**離岸風場營運維護常使用的水下維修技術及相關水下探勘設備有哪些？維

修對象為何？

回復：一般來說水下運維可透過潛水員或是水下遙控載具進行測量、檢查以及維修。水下遙控載具 ROV 具備有攝影機和量測設備以進行檢查和測量，而潛水員考量風險和額外的成本，較常見於緊急維修。維修或檢查的對象則包括水下基礎，電纜，J 管及海床等，細部的部分包括如銲縫，灌漿密封，海生物生長，塗層，陰極防蝕及裂縫或缺陷檢查。

2. **問題：**JFMS 已有和臺灣離岸風電產業與港口經營單位合作，目前合作現況如何？

   回復：JFMS 已與臺中港務分公司簽署了 MOU，並計劃在臺中港建立一個運維中心；另外也與穩晉港灣工程合作承攬臺澎海纜鋪設工程，其他合作對象包括銓日儀以及上緯等。

3. **問題：**於臺灣海峽進行風力機安裝及運維時，有無針對颱風因素對於工作船及風力機有任何安全建議及因應措施？

   回復：透過天氣預報系統可以預先規劃惡劣天氣之因應策略，以減少因為惡劣天氣造成的風險及工作延宕，同時 JFMS 擁有在全球惡劣天氣條件地區營運所需之工具、軟體和經驗(包括曾經承攬臺灣海洋示範風場的工程)。

4. **問題：**使用潛水人員進行水下基礎檢修的頻率？潛水人員須具備的證照有哪些？像是銲接技術、非破壞檢測、潛水證照之類的？

   回復：水下基礎需要維護的頻率，可能會因諸多因素而有很大差異，例如：水下基礎類型有單樁、套筒式基礎等不同、塗裝類型、海床移動性、有無陰極保護、沖刷保護以及防蝕保護的類型等而有不同。開發商一般會向水下基礎運維商提出所需服務的時間表和營運維護的類型建議，以便達到預期結果的解決方案。舉例來說，JFMS 曾在丹麥 Anholt 離岸風場和英國 Galloper 離岸風場上進行陰極防蝕、海洋生物生長厚度評估、陽極損耗估計、水下基礎結構完整性—包含塗裝、碎片、損壞檢查，電纜保護系統檢查和線路檢查、沖刷調查，包括岩石堆放等的水下基礎維護。在水下基礎維護人員認證方面，通常需具備的證照主要為非破壞檢測執照，另水下無人載具操作或潛水員水下調查也須遵循當地的標準認證，如 International Marine Contractors Association, IMCA 或 DNV-GL 等。

5. **問題：**依照 JFMS 專業，離岸風電運維港應具備哪些條件？像是港口的條件、距離風場最適距離範圍、水深要求、碼頭及其後線腹地等)？

   回復：運維港選擇的綜合考量因素包括：運維項目、風場距離—因要減少運輸時間及燃油成本還有與其他運維港距離以及到風場限制等、適當的地點—要能適合人員運輸船停靠、良好的生活機能、船舶燃料補給及廢棄物處理、完善的通訊設備、基礎建設—包含鐵、公路及機場等、產業供應鏈、緊急救助服務等。由於需要評估的各種因素太多，故沒有適用於所有港口的解決方案。

(六)拜會心得：

由於 JFMS 已與臺灣港務公司、穩晉、銓日儀等在地公司展開各種合作洽談且實際參

與許多臺灣海事工程業務，對於我國海事工程作業環境具有一定了解，對於我方的問題和意見提供了完整且實際的說明，協助本參訪團成員充分了解其在海事工程方面的實績及經驗。我國期在未來 5~10 年內穩健踏實、逐步完成離岸風場建置，預計於 2025 年達成 5.7GW 的裝置容量。在商轉後的 20 年內，與離岸風場運轉維護的相關產業將會是下一波海洋機械可在地化的範疇。該公司在包括葉片檢修、水下基礎檢修技術、水下無人載具及海纜檢修等項目均已具有實際經驗，值得我國業者學習，以了解歐洲業者如何將海洋機械相關領域導入離岸風電產業，並掌握未來產業發展趨勢及市場脈動。

(七)影像紀錄：

圖 33：JFMS 介紹其主要業務及目前與臺灣合作情形

圖 34：經驗分享與意見交流

肆、結論

比利時擁有多家國際海事工程知名業者，如 Jan De Nul 及 DEME，並且對於港口、近岸或離岸工程都有相當實績，除船舶製造外亦具有良好的海洋機械製造、營運等工程經驗。並已早先投入展開離岸風電開發，對於我國剛起步的離岸風電海事工程及海洋機械環境建構極具參考價值。英國業已投入離岸風電超過 10 年，裝置容量位居歐洲前三大，其中有意願參與臺灣離岸風電建置之國際風力機兩大系統廠—西門子歌美颯(SGRE)及菱重維特斯(MVOW)業已於該國設置風力機葉片工廠。結合英國風場建置需求並借重其既有的工業基礎技術，搭配良好的工業基礎建設，促使各國業者爭相前來參與倫敦離岸風電展，希望能拓展商機。英國的再生能源產業尤其是離岸風電供應鏈建置的開發經驗值得我國借鏡，。

在參團人員方面，本參訪團成員包括我國政府委託諮詢之法律事務所法律顧問謝律師、國內積極參與大型公共建設且具有豐富經驗的工程專家林先生與許先生、海事工程專家侯先生、臺灣港務公司等相關單位人員參團，對於提升發展海洋機械之跨領域交流有相當的助益。成員除了在自己的專業領域外，亦於行程中了解海洋機械對各行各業的相關議題，並研討如何讓臺灣成為亞太地區離岸風電的先驅者。並藉由參訪期間長時間交流，獲取我國業者最新資訊，交換平常較不易獲得之離岸風電供應鏈下游廠商參與實際情況、以及蒐集國內外業者投資意願及期望我國政府協助之處，進而期望離岸風電產業政策的推動，可使我國經濟發展建立充足能量。

伍、建議

本次參訪期間透過與業者的交流，相關建議供國內後續推動政策之參考如下：

(一)鼓勵我國業者展開國際合作、進軍國際市場：

我國政府近年來致力於風力發電產業發展，本土廠商在技術能力上與國際大廠互有長短，可透過參加國際風能展覽、拓展商機。目前政府正積極推動離岸風電產業發展，我國業者將受惠於離岸風力發電產業的推動切入國際供應鏈，離岸風電之在地產業鏈指日可待，政府亦應鼓勵業者以打入國際離岸風電市場全球供應鏈為發展目標，持續協助業者展開國際合作、進軍國際市場。

(二)強化台灣與比利時及英國雙邊智慧化運維軟體系統合作：

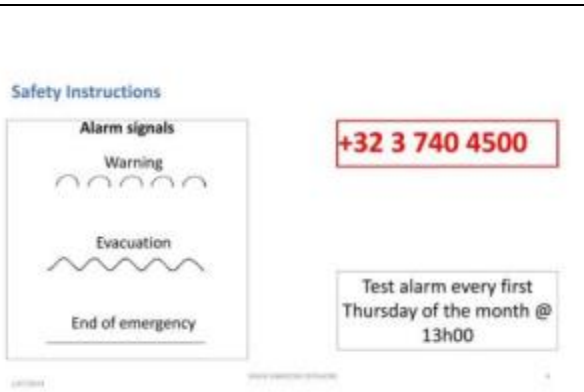
離岸風力機安裝完成後進入運維階段，岸上與離岸需仰賴資通訊科技的聯繫，此次拜會的 e-BO 公司及英商 James Fisher & Sons 皆具離岸風場運維軟體系統供應能量，該系統整合與離岸風場所有的營運維護管理可執行運維規畫、存貨管理、海氣象預測、風場運維船舶及人員的追蹤等，亦可透過儲存歷史資訊、輸出報表持續優化決策。奠基於台灣資通訊科技(ICT)產業能量，未來離岸風場進入運維階段，我資通訊業者可借鏡比利時及英國業者具離岸風場運維系統建置經驗，切入離岸風電運維產業，共同爭取離岸風電運維產業新商機。

(三)推動主題式國際參訪深化交流，有助減少國際落差增強投入信心：

本次參團的國內業者多已對政府推動離岸風電產業關聯方案政策有初步了解，且部分已與我國離岸風電一級供應商或國際業者積極展開接洽和洽談合作，但仍期望藉由國際參訪團加強平日較難快速建立的夥伴關係，以及獲取平日不易獲得之產業資訊，例如本參訪團工程專家許先生之公司已參與某前置期風場之水下基礎之測量工程作業，藉本次參訪奧斯丹港所見國外探測船的設備配置，表示獲益良多；本參訪團另一位工程專家林先生亦透過此次參訪團了解我國離岸風電的政策及產業動態，回國後已向各相關業者展開密切洽詢，以進行從事離岸風場工程設計、規劃、施工與監造等領域之評估。建議未來可依國內離岸風電產業發展進程推動主題式國際參訪，協助我國業者於外商所在國家進行深度交流。透過國際實地考察減少國際落差，並增進業者投入信心，強化臺灣離岸風電產業發展。

陸、附錄

一、ENGIE Fabricom 公司簡報



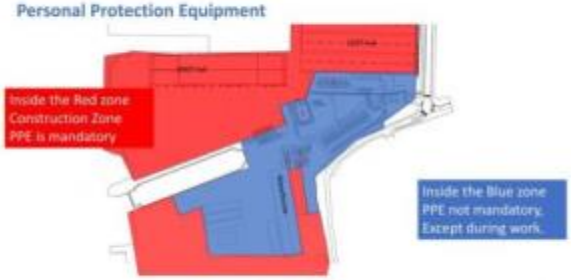
Personal Protection Equipment

Minimum mandatory standard PPE in the workplace:

- Hard hat
- Visitor high visibility vest
- Trousers, long sleeves
- Safety glasses
- Safety shoes: high type (S3)

- Shoes, Visitors vest, Safety glasses and hard hat can be obtained through your ENGIE contact

Personal Protection Equipment



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Smoking is only permitted in the smoking area

HAVE A SAFE VISIT

1/07/2019 YARD INTRODUCTIE rev 5.1 11

ENGIE Fabricom

Movie

ENGIE Group profile

Activities in **70** countries: a global player

Expertise in **4** businesses: electricity, natural gas, energy services and renewable projects

150 000 colleagues worldwide

Turnover **66** Bio € EBITDA **9,3** Bio €

22 Bio € of growth investments over the period of 2016-2018 of which **1,5** Bio € in innovation & digital

ENGIE

ENGIE Offshore

ENGIE Fabricom (incl. subsidiaries)

€1.27 billion 5 900 employees

ENGIE


ENGIE OFFSHORE
Offshore Wind Division Mission Statement
We are an integrated solutions provider specialising in the areas of
Engineering, Procurement, Construction and Installation of Offshore High Voltage Substations.
Full Monitoring and Maintenance Services for offshore wind farms.
We seek to work closely with major partners to deliver value added solutions to our clients.
By combining the competences of our people, we are able to offer world class technical expertise to our customers.


ENGIE OFFSHORE
Mission & Vision Offshore Wind
To ensure the Safety and Wellbeing of workers, costumers, partners and other stakeholders
engie

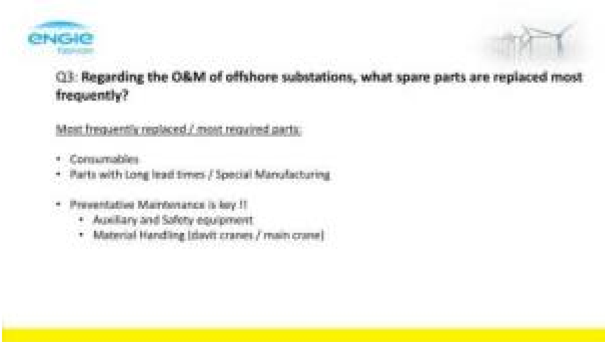

ENGIE OFFSHORE
engie


ENGIE OFFSHORE
Strategy for Taiwan
engie


ENGIE OFFSHORE
Our approach for supply chain localization in Taiwan
Development
Construction
Monitoring & Maintenance
Challenges
engie


engie
Q1: What are the requirements of port facility (load capacity), manufacturing facility (space for factory and storage area, crane capacity, production capacity planning) and human resources for the manufacturing of offshore substations?
Port Requirements:
Load bearing Capacity: 20 t/m²
Sufficient Quayside length for Loadout (min 35 m)
Sufficient Water depth and distance sea-level to quayside.
Manufacturing Requirements:
Crane Capacity: 40t
Sufficient covered manufacturing facility for completed topside
Spray / blasting area large enough for completed topside (or large sections)
Clear access for transport (SPMT)
Sufficient height for topside and to lift in items (transformer)
Human resources requirements:
General
Steelwork
Fitters
Electrical
Specialists
High Voltage
Commissioning / Operations
Engineering
Project Management
SCADA


engie
Q2: What parameters have to be monitored in the operation of an offshore substation? How to identify abnormalities of an offshore substation? How to assign staff for O&M?
To be monitored:
Electrical Performance
Availability of Auxiliary / Safety systems
HVAC
Fire Fighting
Handling Equipment
How to identify:
SCADA (Supervisory Control and Data Acquisition Software)
Analysis of information (interpretation)
Visual Inspection
Staff are assigned dependent on the work to be performed


engie
Q3: Regarding the O&M of offshore substations, what spare parts are replaced most frequently?
Most frequently replaced / most required parts:
Consumables
Parts with Long lead times / Special Manufacturing
Preventative Maintenance is key !!
Auxiliary and Safety equipment
Material Handling (davit cranes / main crane)

Q4: **As offshore substations are installed in the sea, how to protect against seawater corrosion? How does corrosion affect power facilities?**

Steel corrosion protection:

- Offshore Spec Paining
- Sacrificial Anodes

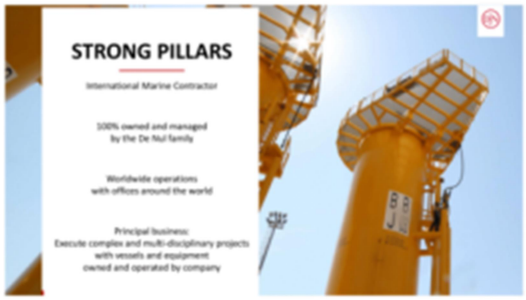
Equipment corrosion protection:

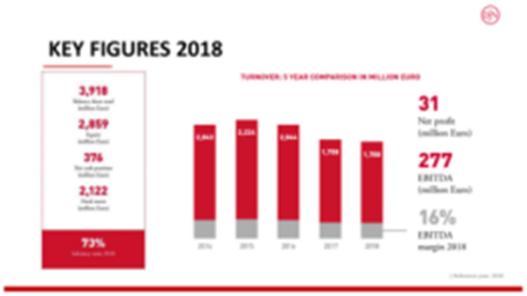
- Design specifications
- Material choice (stainless steel, GRP)
- Enclosed and conditioned areas.

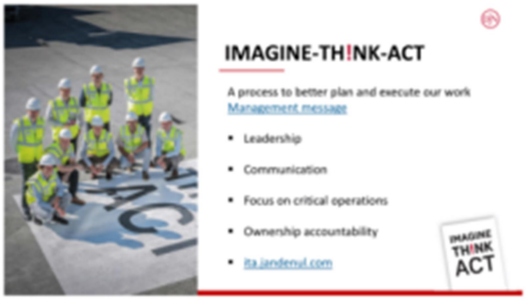
Q5: **Offshore substations are installed in the sea. What are the specific requirements for the insulating oil used in transformers of a substation?**

- Traditional mineral oil vs Ester insulating liquid:
- Drip tray + Oily water Seperator + sumpa tank
- Bio-degradable but still need for containment (insurance)

二、Jan De Nul 公司簡報







OUR MAIN ACTIVITIES




DREDGING AND MARITIME WORKS

- Port infrastructure and port maintenance
- Capital and maintenance dredging
- Coastal defence and riverbank protection
- Land reclamation and beach restoration

OFFSHORE SERVICES

- Seabed intervention
- Rock installation and bolstering
- Subsea cable and umbilical installation
- Offshore renewables
- Heavy lifting and decommissioning

CIVIL ENGINEERING

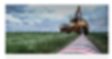
- Infrastructure works
- Maritime engineering
- Buildings
- Foundation and piling works
- Major earth works

ENVIRONMENTAL WORKS

- Environmental dredging and sediment treatment
- Soil and groundwater remediation
- Waste treatment and valorisation
- Soil and sediment treatment centres

OFFSHORE SERVICES






OFFSHORE RENEWABLES

- Entire wind farm realisation
- Wind Farm Foundations
- Wind Turbine Generators
- Tidal, wave and current energy
- video

SEABED INTERVENTION

- Trenching
- Pre-sweeping
- Seabed levelling
- Boulder clearance
- Land- and outfalls
- Artificial islands

SUBSEA CABLES AND UMBILICALS

- Power Cables (MV, HV, AC, DC)
- Umbilicals
- Inter-Array Cables
- Cable Burial
- Pull-ins

ROCK INSTALLATION AND BALLASTING

- Gravel beds
- Foundation layers
- Burial of cables/pipelines
- Scour protection
- Concrete mattresses
- Ballasting

SOME OF OUR MILESTONES


Dubai – Palm Jebel Ali


Panama – 3rd set of locks


Belgium – Nobelwind Offshore Wind Farm


Hong Kong – Chep Lap Kok airport

OFFSHORE CONSTRUCTION FLEET

OFFSHORE WIND EQUIPMENT


Vole Au Vent Jackup 1500t crane vessel


Taillevent Jackup 1000t crane vessel

VOLTAIRE (NEWBUILD COMPLETE 2022)

EQUIPMENT (THROUGH SCALDIS)


Gulliver 4000t floating crane vessel


Rambiz 3300t floating crane vessel

OFFSHORE CABLES EQUIPMENT

Willem de Vlamingh 5.400t capacity

Isaac Newton 10.700t capacity

JDN OWF PROJECTS IN

① **Formosa 1 Phase 2**
- 120 MW
- 20x monopile foundations
- EPCI contract for foundations and subsea cables incl. scour protection

② **TPC Changhua**
- 109.2 MW
- 21x pre-piled jacket foundations
- 21x 5.2 MW Hitachi wind turbines
- Turnkey contract incl. 5 years O&M

③ **Formosa 2**
- 376 MW
- 47x pre-piled jacket foundations
- EPCI contract for foundations and subsea cables incl. scour protection

FORMOSA OWF 1 – PHASE 2

Fase 1
- 2 WTG's 4MW installed in 2015 as demonstration

Fase 2
- 120 MW
- Turbines: 20 x 6MW Siemens
- Water depth 15 to 32 m
- 1-2 nm from the coast
- Marshalling harbour: Taichung
- 4 cables connected to the coast
- No offshore substation

FORMOSA 1 PHASE 2

FORMOSA 1 PHASE 2

FORMOSA 1 PHASE 2

FORMOSA 1 PHASE 2

FORMOSA 1 PHASE 2

FORMOSA 1 PHASE 2 (5/5)

EPCI CONTRACTOR

Procurement and Construction

- Monopiles
- Transition Pieces
- Gravity Based Foundations
- Cables

Engineering

- Design, maintain and modify own equipment
- Geotechnical engineering
- Foundation and piling techniques
- Formwork
- Heavy lifting and transport
- Mechanical production and electrical drawings

Installation

- Project Management
- Subcontractor/Interface Management
- Installation of foundations, turbines, cables, scour protection

PAST PROJECTS

Bligh Bank phase 2 - Belgium

- 2016-2017
- EPCI of 51 monopiles and T&I of 58 Turbines (Vestas 3.3MW)
- Installation of Scour protection

Burbo/Race Bank - UK

- 2016-2017
- T&I of 2 export cables (71km) and 1 inter-link cable
- Pre-sweeping
- Post Lay trenching

Takholuoto OWF - Finland

- 2016-2017
- T&I Gravity based foundations and turbines (10 x 4MW Siemens)
- Management of cable subcontractor
- Sea-bed preparation and scour protection

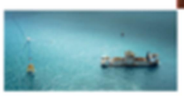
PAST PROJECTS

Blight Offshore Demonstrator - UK

- 2017
- T&I of 5 x V164 8.4 MW Vestas WTG's
- In-house design of sea fastening

Borkum Riffgrund II - Germany

- 2018
- T&I of 36 monopile foundations
- Installation of scour protection for suction buckets



Karehamn - Denmark

- 2012
- EPCI contract 16 x gravity based foundations for Vestas V112 3MW WTG's

FUTURE PROJECTS

Changhua - Taiwan

- 2019-2020
- Full wind farm scope: BOP + turbine procurement

Formosa - Taiwan

- 2019
- Soil investigation
- EPCI of 21 foundations, cable installation and scour protection

Northwester 2 - Belgium

- 2019
- EPCI of 23 x 9.5MW Turbines, foundations and cables

INNOVATION

Horizon 20/20

Applied as partner in consortium to develop 10+MW turbine

Work package: Installation of future turbines

Research projects

Current project ongoing with DNV-GL and University of Brussels

In House R&D

Development of Monofish & Sunfish. Won Best Young Engineer Award.

In house design of most of the fleet

CONTACT

Luxembourg

Belgium

Mauritius

三、REBO 公司簡報

GOAL

Become the most important hub for offshore activities in the Southern Northsea.

STRATEGY

1. Have a performing terminal available for current installations and further heavy maintenance.

STRATEGY

2. Develop the Operations & Maintenance site as a true cluster of offshore companies.

ACTION

Develop infrastructure

Easy access & mooring

Training & education

R&D

Offshore wind farms

PHASES of an OFFSHORE WIND FARM

Offshore wind farms

BELGIAN WINDFARMS CONNECTED

C-Power	54 turbines (5 – 6 MW)
Rentel	42 turbines (7 MW)
Belwind	55 turbines (3,3 MW) 1 turbine (6 MW)
Northwind	72 turbines (3,3 MW)
Nobelwind	50 turbines (3,3 MW)
TOTAL	274 turbines

Offshore wind farms

PROJECTS CLOSE TO OSTEND

Wind farm	MW	Type of turbine	Country	Phase
Norther	44 x 8 = 352 MW	8 MW MHI Vestas	BE	Under construction
Seastar	246 MW	7 MW Siemens	BE	Preparation
Mermaid	266 MW	7 MW Siemens	BE	Preparation
Northwestern	224 MW	9,5 MW MHI Vestas	BE	Preparation
Borselle 1&2	752 MW	Siemens	NL	Preparation
Borselle 3&4	680 MW	MHI Vestas	NL	Preparation
	2 176 MW	250 à 300 turbines	INVESTMENT	+/- € 8 billion

Offshore wind farms

DISTANCE TO THE PORT

Offshore wind farms

NEW CONCESSION AREA

Offshore Wind

INSTALLATION

OPERATIONS & MAINTENANCE

Installation

RENEWABLE ENERGY BASE OOSTENDE

rebo
Supporting the winds of change

FOUNDED 2010

Installation

SHAREHOLDERS

PUBLIC FUNDS

40% PMV

15% PORT OF OOSTENDE

15% GEOSEA

PRIVATE FUNDS

15% DBE

15% ARTES

PMV

Provides finance for promising businesses, from their very start through their various growth stages and even on to operating internationally.

Port of Oostende

is closely involved with the development and operation of wind farms in the North Sea.

GeoSea Maintenance

offers a wide range of services including maintenance of offshore installations.

DEME Blue Energy

is a part of the DEME Group and was created to develop offshore wind farms, wave and tidal energy projects.

Artes Depot

as general contractor, primarily active in the field of Buildings, Civil engineering and Water Works.

Installation

KRIEGERS FLAK – JAN DE NUL - 2017

Installation

ARRIVAL MONOPILES: GE turbine (Haliade150)

Installation

ARRIVAL TRANSITION PIECES: Nobelwind

Installation

ARRIVAL BLADES AND TOWER ELEMENTS: Rentel – vessel Rotra Mare

Installation

ARRIVAL NACELLES SIEMENS: Rentel – vessel Rotra Vente

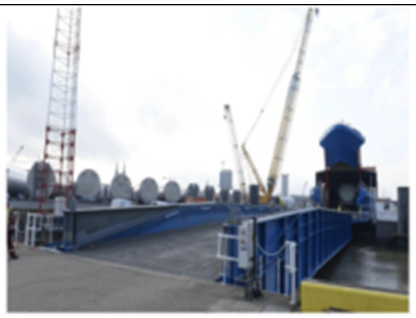
Installation

UNLOADING NACELLES SIEMENS via RORO: Rentel – vessel Rotra Vente

Installation

UNLOADING NACELLES SIEMENS via RORO: Rentel – vessel Rotra Vente

Installation



UNLOADING NACELLES SIEMENS via RORO: Rentel – vessel Rotra Vente

Installation

LOADING: Nobelwind – vessel Vole au Vent

Installation

LOADING: Nobelwind – vessel Vole au Vent

Installation

LOADING: Nobelwind – vessel Vole au Vent

Installation

LOADING: Nobelwind – vessel Vole au Vent

Installation

ASSEMBLY: Belwind – GE (Haliade 150)

Installation

DEPARTURE: Belwind – GE (Haliade 150) – vessel Bold Tern

Installation

READY FOR LOADING: Rentel – vessel SeaInstaller

Installation

LOADING OF BLADES: Rentel – vessel SeaInstaller

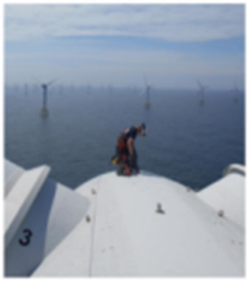
Installation

DEPARTURE: Rentel – vessel SeaInstaller

Installation

INSTALLED AT SEA: Rentel – vessel SeaInstaller

Operations & maintenance



DAILY MAINTENANCE: C-Power, Belwind, Northwind, Nobelwind, Rentel, Norther

Operations & maintenance

1. BUILDINGS > REBO-terminal


Deme – GE – Parkwind - MHI Vestas


Siemens


Rely On Nutec


Servion


Multitech


Hangaar 17

1. BUILDINGS > Oosteroever


Otary


C-Power

1. BUILDINGS > Sloepenstraat en Vismijnlaan


Geosyz


Geosyz


Survitec


Hangaars Sloepenstraat


Hangaars Vismijnlaan

2. TYPES OF SHIPS

Crew Transfer Vessels (CTV)

2. TYPES OF SHIPS

Crew Transfer Vessels (CTV)

2. TYPES OF SHIPS

Service Operation Vessel (SOV): Olympic Intervention

2. TYPES OF SHIPS

Service Operation Vessel (SOV): Eswagt, with Walk to Work

Operations & maintenance

2. TYPES OF SHIPS

Stone Dumping Vessel: Simon Stevin (Jan De Nul)

Operations & maintenance

2. TYPES OF SHIPS



Thor | Bold Tern | Neptune



Goliath | Vole au Vent | Seainstaller

Operations & maintenance

OFFSHORE RELATED TRAFFIC

	2015	2016	2017
Crew Transfer Vessels	2129	2652	3234
Service Operation Vessels			57

Operations & maintenance

3. WANTED: MOORING SPACES

Current mooring space for CTV's

Operations & maintenance

3. WANTED: MOORING SPACES

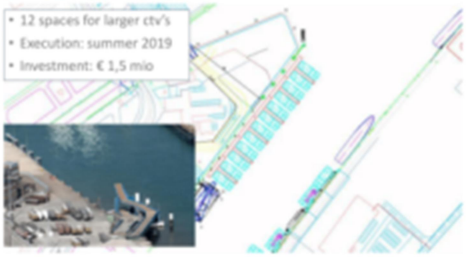
- 9 spaces for smaller ctv's
- 5 spaces for larger ctv's
- Execution: october 2018
- Investment: € 600 000

Overnight mooring for CTV's > RYCO

Operations & maintenance

3. WANTED: MOORING SPACES

- 12 spaces for larger ctv's
- Execution: summer 2019
- Investment: € 1,5 mio



Overnight mooring for CTV's > quay 202

Operations & maintenance

BUNKERING STATION: Monjasa

Operations & maintenance

BUNKERING STATION: Monjasa

Operations & maintenance

3. WANTED: MOORING SPACES

Fisheries Dock

Operations & maintenance

3. WANTED: MOORING SPACES

Fisheries Dock

Operations & maintenance

3. WANTED: MOORING SPACES

Demeysluis & Vlotdok

Operations & maintenance

4. Offshore companies active in Oostende

Operations & maintenance

LOCAL EMPLOYMENT

	2013	2014	2015	2016	2017
PERMANENT	204	179	280	339	466
	100%				228%

Operations & maintenance

GOAL 2020

Oostende > the reference in O&M for offshore windfarms

- +/- 50 companies
- +/- 800 jobs

Port of Oostende

TRADITIONAL ACTIVITIES

Bulk & general cargo

PROJECT CARGO

Transport, assembly and storage of heavy parts.

Recent project

Silos constructed in Menen for Sint-Petersburg, Bulgaria, ...

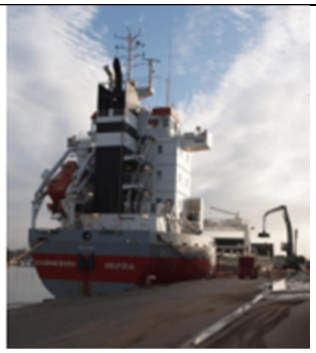
Bulk & general cargo

BULK

Mostly sand & gravel

Annual ton

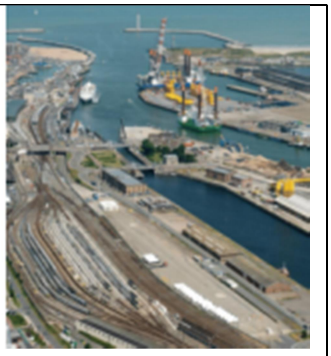
1,2 – 1,5 mio ton



Ferry port

FERRY's

Successful period in 2000 - 2013 with Ferryways and Transeuropa Ferries.



Ferry port

Passenger traffic & cruises

CRUISES

Completely different market.
Promotion campain with Zeebrugge.

Limit Oostende < 200 m length

2018

15 cruise calls

Industrial area

PLASSENDALE 1

Available area for:
- R&D
- Shipping repair
- Circular economy

2017 - 2018

Construction coastal ocean basin and towing tank

Industrial area

PLASSENDALE 1

AIM recycling

Since May 2015

Joint venture of Waste Management (Gistel) and 'American Iron & Metal' (Canada)

Port of Oostende

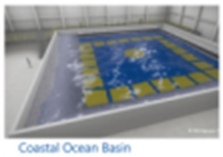
UGENT – campus Oostende

UGENT – campus Oostende

Science park

UGENT – campus Oostende

Maritime Science Center



Coastal Ocean Basin

Towing tank

Contact us

www.portofoostende.be

www.reboostende.be

四、Blue Accelerator 計畫簡報

FABRIEKEN VOOR DE TOEKOMST
INNOVATIEVE CREATIE

Blue Energy Cluster

POM

POM

FABRIEK VOOR DE TOEKOMST
BLUE ENERGY

Blue Energy

POM

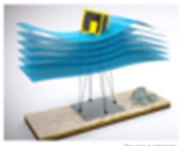
1. Blue energy

Source: De Tijd

POM

- 2020: 2200 MW
- 2030: 4000 MW
- Socioeconomic importance
  - 50% Belgian renewable energy produ goals
  - 15.000-16.000 jobs (direct & indirect, Belgian & export)
  - Added value of ca. € 1 billion/y

POM



- Development phase
- Blue energy cluster:
  - Support innovation
  - Platform/networking
  - R&D infrastructure

POM

2. Cooperation

POM

3. Partners

tuawest
howest
KU LEUVEN
vlaio
vlaams

POM

4. Actions

Product & process

Research & testing

Internationalisation

4.1. Product and process

- Focus: how to optimise product and process, latest trends and technologies, access to the sector
- Quick wins
  - Short-term and practice oriented cooperation projects between min. 2 companies, focused on innovation
  - Editions in 2016 and 2018; new call to be launched
  - Funding: € 22.500,00 per project, max. 50% (2018)

"Thanks to the Quick Win project, we were able to design and build a safe and reliable underwater coupling"

Steven Nauwelaerts, CEO Laminaria, Quick Win Laminaria – Multitech 2016

4.2. Internationalisation

- Focus:
  - Help companies internationalise, explore new markets and opportunities
  - Create international partnerships and cooperations
- How
  - International exhibitions and B2Bs
  - European projects
  - International partnerships

European projects:

Expand innovation capacity and improve access to the offshore wind industry for SMEs by connecting offshore wind businesses and facilitating access to test facilities.

Development of International Standards and Certification Schemes for Marine Energy Technologies

Eco-innovative concepts for the end-of-life for offshore wind energy farms

COASTAL

Exhibitions, fairs and B2Bs

- Belgian Offshore days
- Windenergy
- Ocean Energy Europe

Promotion and partnerships

4.2. Research and testing

- Focus: boost innovation in companies and knowledge institutions
- How: facilitate access to
  - Test facilities
  - Expertise
  - Supporting network

Testing zone Oostende	
Wave flumes	
OWI-Lab Climate Chamber VIS OWOME databank	sirris
VIS trillingsonderzoek	
Drivetrain structural analysis CMS HALT chamber	KU LEUVEN
XIAK – 3D – Sizing servers	howest
Simon Stevin Belgica	

Blue Accelerator

Source: Nemos GmbH

- Partners:

FABRIEK VOOR DE TOEKOMST BLUE ENERGY

VLIZ

vives

UNIVERSITEIT GENT

tuawest

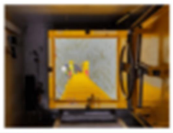
vito

- Funding: European Regional Development Fund, Flemish Government and Province of West Flanders

Living lab

- Chain of test facilities
- Supportive framework
- Innovation program drones
- Innovation platform blue energy

- 500m Ostend
- Target group
  - Knowledge institutions
  - Private companies
  - Belgian and international
- Functions:
  - Blue energy (wind, wave, tidal, floating,...), corrosion/abrasion, drones, boatlanding, meteo, cabels, erosion...
- Exploitation
  - Concessionnaire
  - Open, non-discriminatory access
  - User fee
  - 15 years

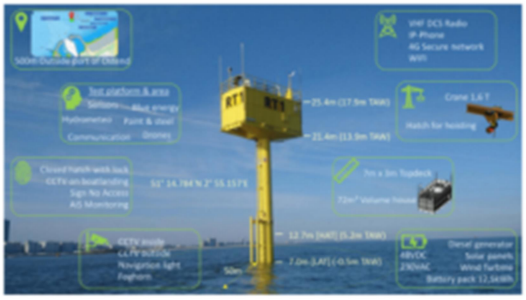


- USPs
  - Open access for industry, knowledge institutions and consortia
  - Public owned
  - Easy and simplified permitting procedure for users
  - Easy and fast access from Port of Ostend
  - Proximity of large blue growth network and expertise: Flanders Marine Institute, Blue Cluster, GreenBridge, Flanders Marine Laboratory,...

©NEMOS

- Role POM:
  - Realisation test platform
  - Front office role
  - Communication
  - Coordination project
  - Contact: eddy.dewinter@pomwvl.be
- Status:
  - Permit for 15 years acquired
  - Platform installed
  - Technical due diligence ongoing
  - Formal take-over: August 2019
  - Selection concessionaire and start exploitation: fall 2019

©NEMOS

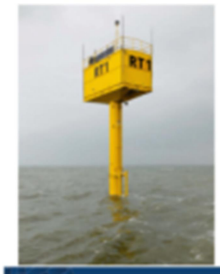


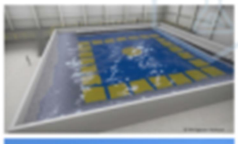
- First use case: NEMOS wave energy convertor (WEC)

NEMOS

- System for generating electricity from ocean waves
- Testing since 2010, in 2019: large scale offshore installation
- Blue Accelerator as a control and monitoring hub for WEC trials
- 2019 WEC prototype: 8 x 2 m floater and a 16 m long substructure

Chain of test facilities in a blue growth hub

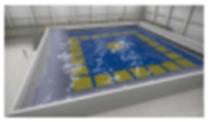





GreenBridge

- Incubator
- Focus blue growth

Flanders Maritime Laboratory

- New onshore test infrastructure:
  - Coastal and Ocean Wave Basin
  - Towing Tank
- At Ostend Science Park/GreenBridge
- Operational: 2020 -2021

Ostend Science Park

- Science park:
  - R&D intensive and innovative products and services in blue economy
  - Bridge between companies and knowledge institutions
- Reconfirmation of Ostend as hightech hub in blue economy
- Initiative POM West Flanders, University of Ghent and Port of Ostend

- By and with support of:
  - Lead of POM West Flanders in blue energy cluster
  - Expertise of University of Ghent in blue research
  - Port of Ostend as energy port
  - Presence of and cooperation with other knowledge institutions, such as Flanders Marine Institute
  - Chain of test facilities (Blue Accelerator, Flanders Maritime Laboratory)
  - Presence of and cooperation with The Blue Cluster and Belgian Offshore Cluster
  - Activities of TIJA West

FABRIEKEN VOOR DE TOEKOMST
INNOVATIEVE CREATIE

Thank you for your attention!

Questions? Sarina.motmans@pomwvl.be

五、DEME 公司簡報

Topics of today

1. Project Description
2. Project Organisation & Set-up
3. Scope & Working Methods
4. Required Equipment and Planning

SeaMade Project description

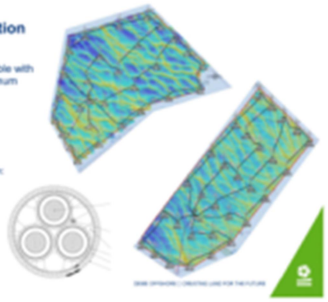
- Mermaid site:
  - 50 km off the Belgian coast
  - 27-36 m water depth
  - 28 turbines x 8.4 MW = 235.2 MW
  - 1x Offshore Substation (OSS)
- Seastar site:
  - 40 km off the Belgian coast
  - 20-36 m water depth
  - 30 turbines x 8.4 MW = 252 MW
  - 1x Offshore Substation (OSS)

→ (58 + 2) x foundation: monopile (MP) + transition piece (TP)

  - Offshore installation in 2019 – 2020
  - Exploitation for 25 years

SeaMade Project description

- Infield Cables: 33 kv submarine cable with cross section of 3x 800 mm² Aluminum
  - 64 Infield Cables
    - 31 Mermaid ~ 32.8 km
    - 33 Seastar ~ 39.2 km
  - Total length of 78 675 meter (including spares and cable for offshore trials)
  - All cables have the same cross section:
    - 16 cm diameter (approx.)
    - 35 kg per meter (approx.)
- Six strings per offshore site
- Looped configuration (every 2 strings interconnected as contingency)



SeaMade Project description

- Export Cables: 220 kv submarine cable with cross section of 3x 800 mm² Aluminum
  - 2 integrated Fibre Optic cables
- From Mermaid & Seastar OSS to the Elia MOG Substation (OSY):
  - MERMAID ~ 22 km
  - SEASTAR ~ 8 km
  - Spare cable: 1.5 km

Concession Holder / Employer

SeaMade LOT division

- LOT 1: Wind Turbine Generator (WTG) package excluding provision of main installation vessel;
- LOT 2: EPCM package;
  - LOT 2G: General works LOT 2: site demarcation, object removal,...
  - LOT 2A: Foundation (FND) design, supply and installation
  - LOT 2B: Infield cable (INC) design, supply and installation
  - LOT 2C: WTG provision of main installation vessel for Transport & Installation
- LOT 3: Electrical package
  - LOT 3A: Export cable (EXC) submarine export cable
  - LOT 3B: Offshore Substation (OSS)

SeaMade LOT division

DEME Offshore

DEME OFFSHORE

DEME Offshore – Equipment

►3. Scope & Working Methods

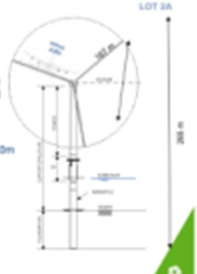
Foundations – Design Set-up

LOT 2A

Foundations – Key fact and figures

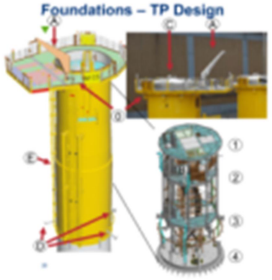
LOT 2A

	Seamade	Rentel
► CONNECTION	Bolted	Conical grouted
► MONOPILES		
› Diameter	8.0m	7.5 – 8.0m
› Max weight	1150t	1253t
► TRANSITION PIECES		
› Top flange diameter	6.0m	6.0m
› Weight (estimated)	310t – 350t	327t



Foundations – TP Design

LOT 2A



Transition Pieces

- ► 1 external work platform ②
- ► 4 internal platforms ① ... ④
- ► Free issued items:
  - › Service crane (+ accessories) Ⓐ
  - › GIS skid (+ accessories) Ⓑ
  - › Smaller items: navigation lights, fog horns, CCTVs...
- ► Temporary structures:
  - › Aluminum TP cover Ⓒ
  - › TP Lifting lugs (bolted on the flange to lift the TP)
  - › Cable hang-off
- ► ICCP system for corrosion protection of TP Ⓓ
- ► Grout pipe Ⓔ
- ► ICCP cells (to be lowered inside MP)

LOT 2A

Foundations – Scour Protection Design

- Single Layer Design
- Model tests completed in May 2018

LOT 2B

Infield Cables – Fabrication

- Cable fabrication:
  - By JDR
  - Final assembly in Hartlepool, UK
  - Components from Teleforika (Poland)
  - Cable accessories: Cable Protection System (by Tekmar), Cable Hang-Offs…
- Cable transport:
  - Load-out at Hartlepool with cable lay vessel (Living Stone)
  - Double load-out on both cable drums in parallel
  - Transport to SeaMade OWF

LOT 2B

Infield Cables – T&I Engineering

- Cable routes
  - Based on outcome geophysical surveys
- Soil model based on geotechnical + geophysical surveys
  - Developed in house
  - Approx. 90 % SAND, 10 % CLAY (@ 1m below seabed)
- Slope assessment on final cable routes
- Cable pull-in Wind Turbines (WTG) & Offshore Substation (OSS)
  - Pull-in concepts
  - Design pull-in equipment
  - Temporary cable storage
  - Cable routing & clearing concepts
- Interfacing on OSS / WTG

LOT 2A

Foundations – Fabrication

- Intermediate transports during fabrication
  - MP cans (and MP sections)
  - Primary TPs
  - Internal Cages
  - Secondary steel items

LOT 2A

Foundations – Fabrication

- **Monopiles**: Sif
  - Rolling of cans and longitudinal welding
  - Circumferential welding of cans
  - Coating of MPs
  - Mechanical completion

LOT 2A

Foundations – Fabrication

- **Transition Pieces**: Smulders/Sif
  - Primary steel
  - Production of secondary steel
  - Welding secondary steel
  - Blasting and coating
  - Final assembly

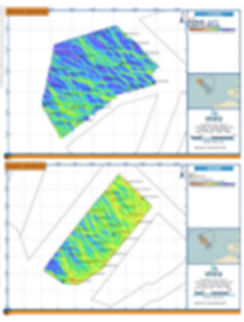
LOT 2A

Foundations – Logistics

- TP load-out at Smulders Hoboken
- Transport to marshalling harbour Rotterdam by barge

Soil Investigation

- Geotechnical / Soil investigation with Omalius

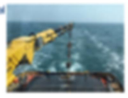
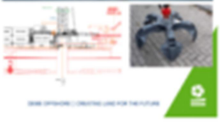


LOT 2G

Site Preparations

- Geophysical site investigation & surveys
- Object & Unexploded Ordnance (UXO) inspection and removal campaign with Omaltius
- Out of Service Cable Removal & Pre-Lay Grapnel Run

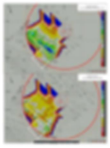
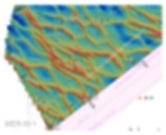
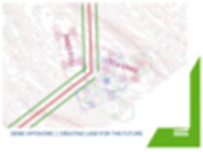


LOT 2G

Site Preparation – Pre Sweeping / Dredging

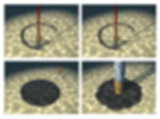
- Steep slopes of sand dunes problematic for jack-up vessel positioning
- Pre-sweeping campaign:
  - For both Foundation & Turbine installation vessel
- Vessel: trailing suction hopper dredger Lange Wapper

LOT 2A+B

Foundations – Rock Placements

- Scour protection of foundations (1 layer)
- Cable crossings & Cable stability berms
- DP2 Fallpipe Vessel (Flintstone, Rollingstone or Seahorse)


LOT 2A

Foundations – Transport & Installation

- Vessel Innovation
  - Marshalling harbour Rotterdam (SF terminal Maasvlakte II)
  - TPs loaded from barge by Innovation crane
  - MPs loaded from quay by Innovation crane


Foundations – Transport & Installation




LOT 2A

Foundations – Transport & Installation

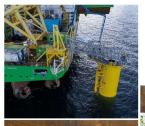
- Installation of MP & TP




- Flanged MP upending tool
- Hydrohammer with capacity of 4000 kJ
- Shock absorber
- TP lifting spread

LOT 2A

Foundations – Transport & Installation

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LOT 2A

Foundations – Transport & Installation

- Noise mitigation
  - Double Big Bubble Curtain (DBBC)
- Noise monitoring
  - Real-time (Online) Underwater Noise Monitoring @ 750 m


Infield Cables – Transport & Installation

- Cable load-out (at Hartlepool)
  - Directly on installation vessel Living Stone

LOT 2B

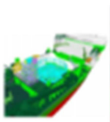
Infield Cables – Transport & Installation

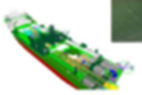
- Cable installation (laying + pull-in)
  - Living Stone + support vessels to access foundations
- Post-lay trenching
  - Living Stone + Cable Burial Tool 1100

LOT 2B

Infield Cables – Experience Vessel Conversions

- Detailed conversion engineering by Tideway:
  - Fallpipe vessel Flintstone converted to cable installation vessel on Rentel project
  - Flintstone on Thornton Bank
  - Olympic Taurus on Northwind
  - Neptune on C-Power export cable

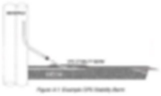




LOT 2B

Infield Cables – Transport & Installation

- Termination & Testing
  - CTVs and/or DP2 Walk To Work-vessel for transfer of personnel to foundations
- Rock placements
  - Export Cable crossings
  - Cable stabilisation berm



LOT 3B

Offshore SubStation

Joint Venture:

Engie (Fabricom & Tractebel)

- Engineering, Design, Procurement, Installation and Commissioning of the electrical outfitting topside

Smulders

- Engineering, Design and Fabrication of steel structure topside with foundation

GeoSea

- Engineering / transport and installation of foundation
- Engineering / transport and installation of topside
- Including barge transportation to Marshalling Harbour
- Including offshore installation

LOT 3B

OSS – Transport & Installation

- Design Specifics:
  - MP/TP Connection: Bolted & Grouted
  - J-tube Cage installation
  - OSS weight: approx. 1,100 mT

LOT 3B

OSS – Transport & Installation

- DEME direct scope:
  - Topside:
    - Transportation on barge to Zeebrugge / Flushing
    - Installation by HLV Gulliver

LOT 3A

Export Cables

Hellenic Cables

Tideway

1. Cable & accessories design & manufacturing
2. Site Survey & Site Preparation works
   - Out of service cable removal
   - PLGR
   - Object removal
   - Pre-sweeping (TSHD)
3. Route optimisation
4. Sea trials
5. Crossings Design & Execution
6. Load-out, Seafastening & Transport (Greece-Site)
7. Cable Installation (lay & burial) & Pull-in
8. Routing & Termination (Core & FO)
9. Accessories Installation
10. Testing
11. Post-Installation Survey

LOT 1A

Export Cables – Design & Fabrication

- 220 kv submarine cable with cross section of 3x 800 mm² Aluminum
- 30 km total length
- 30 years design lifetime
- Cable manufacturing and load-out @Sousaki, Greece
  - Loaded directly on installation vessel Living Stone

LOT 1A

Export Cables – Transport & Installation

- Cable Pull-in at Offshore Switchgear Yard (OSY)
  - Diverless, only using Remotely Operated Vehicle (ROV)
  - Existing cables to be protected
- Cable Laying
  - ROV touch down monitoring
- Cable Pull-in at OSS
  - Diverless, only using Remotely Operated Vehicle
- Cable Burial
  - Post lay trenching, immediately after laying
- Cables Crossings
  - Pre-lay and post-burial rock berm installation

LOT 2C

Wind Turbine Generators

- Main dimensions of WTG components
  - Tower (incl. shell plate, flanges and internals)
    - Gross weight: 492 t
    - Length: 87.7 m
    - Bottom diameter: 6 m
  - Nacelle incl. generator & hub
    - Gross weight: 378 t
    - Dimensions (approx.): 20 m x 6 m x 6 m
  - Blade
    - Gross weight: 35 t
    - Length: 81.5 m

LOT 2C

Wind Turbine Generators – Transport & Installation

- Main installation vessel Apollo
- WTG single blade installation

LOT 2C

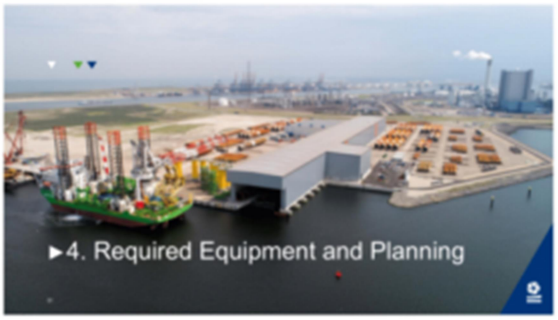
Wind Turbine Generators – Transport & Installation

- Base port Ostend

LOT 2C

Operations & Maintenance

- Maintenance & Repairs
- Survey & Inspection Services
- Transportation & Logistics
- Monitoring & Maintenance Management
- Major Repairs, Retrofits & Decommissioning



Vessel timeline

- All LOTs

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DEME
Dredging, Environmental & Marine Engineering

Efficient Offshore Wind Logistics

Tom Saelens

Procurement & Logistics Manager
Deme Offshore

Mission Statement DEME OFFSHORE P&L

ENSURE GOODS AND SERVICES ARE PROCURED AGAINST THE APPROPRIATE PRICE AND DESIRED QUALITY, DELIVERED AT THE RIGHT SPOT, ON TIME, AND ALWAYS IN ACCORDANCE WITH DEME OFFSHORE'S QHSES POLICY.

ACT AS DEME OFFSHORE'S INTERNAL CONSULTANT TO ANSWER ALL KIND OF QUESTIONS RELATED TO PORTS, TRANSPORT MEANS, LOGISTICS, PROCUREMENT OF GOODS AND SERVICES.

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Efficient Offshore Wind Logistics

Offshore wind logistics

- Logistics of foundations
- Wind Turbine Generator (WTG) logistics

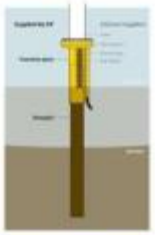
Efficient Offshore Wind Logistics

Efficient Offshore Wind Logistics

Automotive logistics

1 car = +/- 30.000 parts

Efficient Offshore Wind Logistics



Efficient Offshore Wind Logistics

Offshore Wind Foundation logistics

Complete windfarm = 300 foundation parts

Efficient Offshore Wind Logistics

Challenges

- Dimensions & weight

Efficient Offshore Wind Logistics

Challenges

Efficient Offshore Wind Logistics

Challenges

Efficient Offshore Wind Logistics

Efficient Offshore Wind Logistics

Challenges

- Dimensions & weight
- Distances
- Weather restrictions

Efficient Offshore Wind Logistics

Challenges

- Dimensions & weight
- Distances
- Weather restrictions
- Ports & Terminals

Efficient Offshore Wind Logistics

Challenges

- Dimensions & weight
- Distances
- Weather restrictions
- Ports & Terminals

Limited transport modi

Efficient Offshore Wind Logistics

Transport vessels

- Transport & Installation vessel

Efficient Offshore Wind Logistics

Transport vessels

- Transport & Installation vessel
- Tug & barge

Efficient Offshore Wind Logistics

Transport vessels

- Transport & Installation vessel
- Tug & barge
- Geared heavy lift vessel

Efficient Offshore Wind Logistics

Transport vessels

- Transport & Installation vessel
- Tug & barge
- Geared heavy lift vessel
- Deck carriers

Efficient Offshore Wind Logistics

Challenges

- Equipment

Efficient Offshore Wind Logistics

Challenges

- Equipment

  Heavy cranes

Efficient Offshore Wind Logistics

Heavy cranes

Efficient Offshore Wind Logistics

Challenges

- Equipment
  - Heavy cranes
  - Self Propelled Modular Transporters

Efficient Offshore Wind Logistics

Self propelled Modular Transporter

Efficient Offshore Wind Logistics

Self propelled Modular Transporter

Efficient Offshore Wind Logistics

Challenges

- Equipment
  - Heavy cranes
  - Self Propelled Modular Transporters
  - TP-carrier

Efficient Offshore Wind Logistics

TP-carrier

Efficient Offshore Wind Logistics

Challenges

- Equipment
  - Heavy cranes
  - Self Propelled Modular Transporters
  - TP-carrier
  - Lifting tools

Efficient Offshore Wind Logistics

Lifting Tools

Efficient Offshore Wind Logistics

Lifting Tools

Efficient Offshore Wind Logistics

Lifting Tools

Efficient Offshore Wind Logistics

Lifting Tools

Efficient Offshore Wind Logistics

Challenges

- Equipment
  - Heavy cranes
  - Self Propelled Modular Transporters
  - TP-carrier
  - Lifting tools

Efficient Offshore Wind Logistics

Challenges

- Equipment
  - Loadspreading

Efficient Offshore Wind Logistics

Loadspreading

Efficient Offshore Wind Logistics

Loadspreading

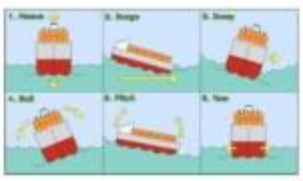
Efficient Offshore Wind Logistics

Challenges

- Equipment
  - Loadspreading
  - Cradles & seafastening

Efficient Offshore Wind Logistics

Cradles & seafastening



Efficient Offshore Wind Logistics

Cradles & seafastening

Efficient Offshore Wind Logistics

Cradles & seafastening

Efficient Offshore Wind Logistics

Cradles & seafastening

Efficient Offshore Wind Logistics

Challenges

- Equipment
  - Loadspreading
  - Cradles & seafastening
  - Onshore stillages

Efficient Offshore Wind Logistics

Craddles & seafastening

Efficient Offshore Wind Logistics

Challenges

- Equipment
  - Loadspreading
  - Cradles & seafastening
  - Onshore stillages

Efficient Offshore Wind Logistics

Challenges

- Dimensions & weight
- Distances
- Weather restrictions
- Ports & Terminals

Limited transport modi

Efficient Offshore Wind Logistics

Ports

- Vicinity offshore wind farm
- Unrestricted access 24/7
- Quay availability
- Priority regime installation vessel
- Jacking vessels

Efficient Offshore Wind Logistics

Ports

- **Fabricators' ports**
  - Incoterms
    - FAS
    - FOB
- **Base ports**
  - Terminal handling & storage
  - Floating storage

Efficient Offshore Wind Logistics

Terminal for handling & storage

- Ground bearing capacities
- Availability storage area
- Timing / booking of space
- Experience

Efficient Offshore Wind Logistics

Goal

- Fabrication schedule

Optimum cost efficient logistical solution

- Installation schedule

六、Edulis 淡菜養殖計畫簡報

Supported by Government of Flanders

North Sea Aquaculture

GHENT UNIVERSITY ILVO Belwind C-Power COLRUYT GROUP DEME Lobster Fish mus-eum SIOEN

Framework

EDULIS VALUE @SEA

- Europe and Flanders invest in aquaculture
- Feasibility study AquaValue: seaweed and shellfish culture in offshore wind farms is economically feasible
- Learning from the past: technical feasibility
- Interest from private investors

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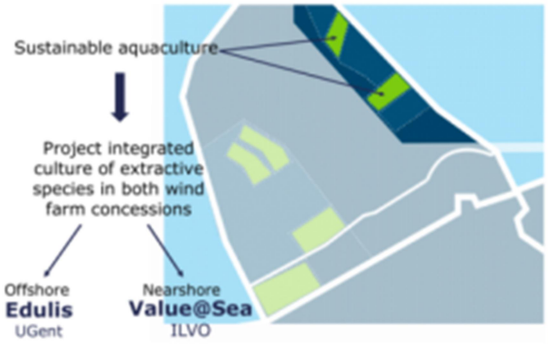
Marine Spatial Plan

EDULIS VALUE @SEA



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Integrated culture of extractive aquaculture species

VALUE @SEA

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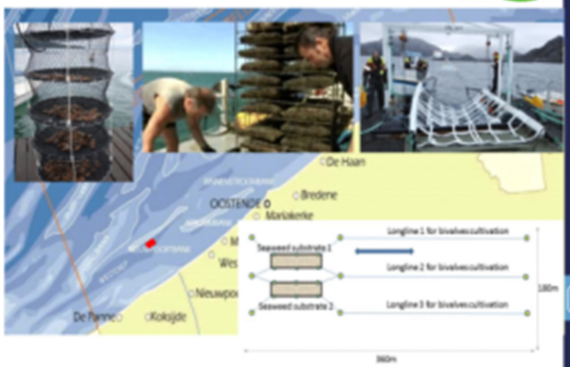
Location & systems

VALUE @SEA



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Goals

VALUE @SEA

- Biological & technical feasibility
- Evaluation of a unique integrated culture system
- Determining the bioremediation potential
- Sustainability analysis for each species
- Market research and economical feasibility

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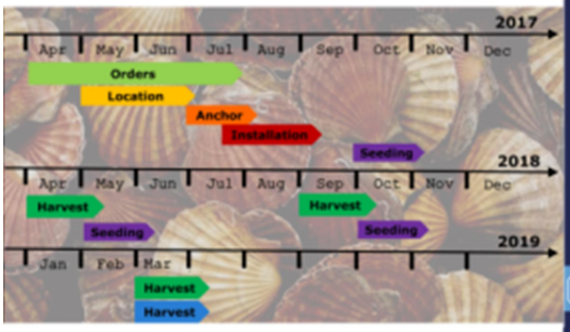
Timeline

VALUE @SEA



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Results

VALUE @SEA

Culture systems for sugar kelp, flat oysters and scallops, adapted to the conditions of the open sea in the Belgian part of the North Sea

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Offshore mussel culture in wind farms

Source picture: www.nieddittas.it/en/1-ie-alleviamo-nel-nostro-mare

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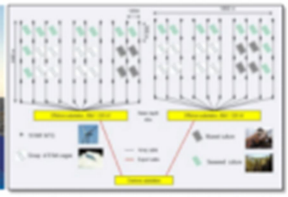
Why now?

- International policy to develop aquaculture further from the coast (offshore)



Artistic interpredation
Source: Lacroix and Pioch, 2011

Source: He et al. 2015

but mainly desktop studies!

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Why now?

- Favorable political policy in Belgium
- Wind farms worldwide are only recently considering alternative activities in their concessions:
  Belgium is frontrunner

© C-Power NV

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Why now?

- Knowledge & expertise present in Flanders

Partner	Role
Ghent University	Design longlines & modeling of forces and mussel growth
Belwind, C-Power	Sampling & monitoring
DEME	Design & installation of longlines
Colruyt	LCA & marketing
Brevisco	Sampling & management of mussel longlines
ILVO	Biology & processing of samples
OD Natuur	Supply of biological & physical data

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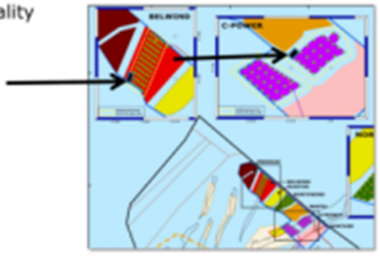
Why in wind farms?

- Safety
- Multiple use of space & profitability
- Exploring synergies between both activities
- Water quality



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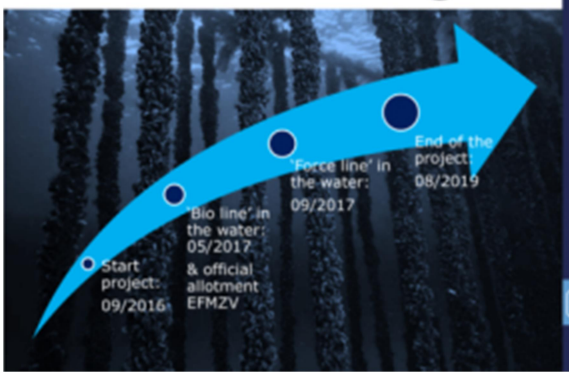
Timeline



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'Bio line' at C-Power

- Are there enough mussel larvae in open sea?
- Which type of rope works best?
- Do the mussels grow well?

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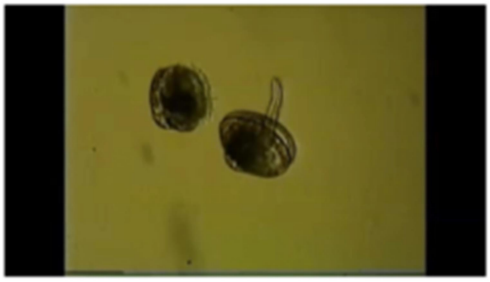
'Bio line' at C-Power



Source: University of Delaware https://www.underthescope.udel.edu/who-am-i/clam-zooplankton

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'Bio line' at C-Power

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Ready for the water

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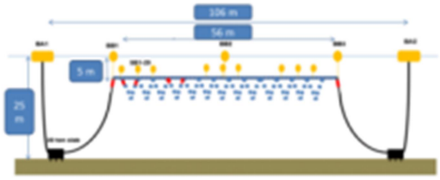
'Force line' at Belwind

- September 2017
- Longline with mature mussels, hung in short V's
- Design validated through simulations (cfr. demo)
- Equipped with force meters



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'Force Line' at Belwind

- What forces are being exerted on the longline by the sea?
- Basis for design of commercial culture system

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Result

- Mussel culture systems for use on open sea
- Validated models for mussel aquaculture in open sea
- Increasing social support of aquaculture in wind farms, hereby demonstrating the multifunctional nature of wind farms

© Parkwind NV

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Valorisation

- Belgian sustainable production & marketing of shellfish and seaweed
- Development of a new industry
- Export of expertise
- Marketing of specific technical products
- Bioremediating effect of extractive aquaculture

North Sea Aquaculture

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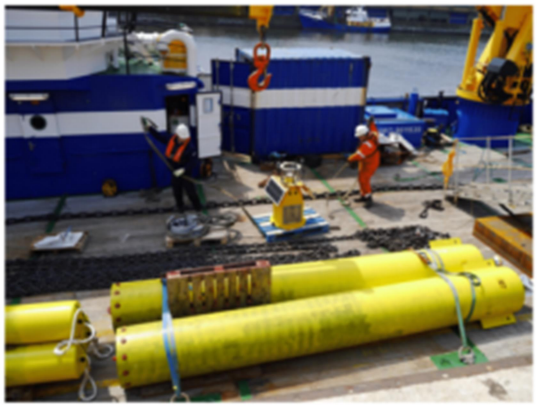

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Danforth anchor

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Off we go!

© David Vuylsteke, ILVO

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Bio line at C-Power

© Gust Lesage, DEME Group

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Force line at Belwind

© Gust Lesage, DEME Group

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First Belgian wind farm mussels

© Gust Lesage, DEME Group

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Video of Edulis

https://www.youtube.com/watch?v=gbWNNiXjhzE

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七、Flanders Maritime Lab簡報

Towing Tank Ostend

- **scale factor 95 -> 55**
- **fully automated, unmanned operation (as TT1)**

		Antwerp	Ostend	Ratio
year		1992	2019	-
Length	m	87.5	174	2
Width	m	7.0	20	**3**
max. water depth	m	0.50	1.0	2
ship model length	m	3.5-4.5	3.5-8.0	1-2

9

Towing tank Ostend: new benefits

- **Observation** tunnel and windows
- Minimal **steering** in **4 DOF** (horizontal plane + roll), preferably **6 DOF** (hexapod)
- Ship **sizes**
- State of the art **wave maker**
- Commercial availability on **short term**
- Application for **ITTC Advisory Council**

10

Background and funding

- **Gen4Wave project**
  - → Initiated by UGent + AGORIA - Generaties
  - → Organised by UGent + KU Leuven + FHR
- **Hercules foundation project (now under FWO)**
  - → Large research infrastructure only
  - → Wavemaker and current generator
- **VLAIO (formerly IWT)**
  - → Research infrastructure and personnel
- **Department of Mobility and Public Works**
  - → Housing and concrete structures for COB
- **Network of innovative companies**
  - → Contractors, consultancy, developers, ...

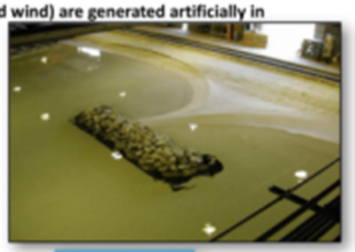
fwo Opening new horizons

AGENTSCHAP INNOVEREN & ONDERNEMEN

11

What is a wave basin?

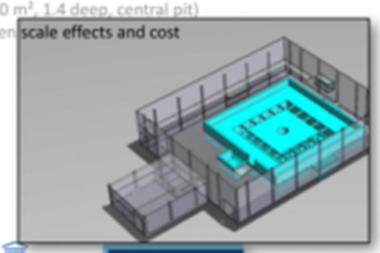
- **Water basin to subject a scale model of a coastal/offshore structure to wave and current loading**
- **Waves and currents (and wind) are generated artificially in water basin**
- **Similitude laws provide correct scaling of loading and response as in reality**
- **Example applications:**
  - → Blue energy
  - → Coastal defense
  - → Offshore engineering



12

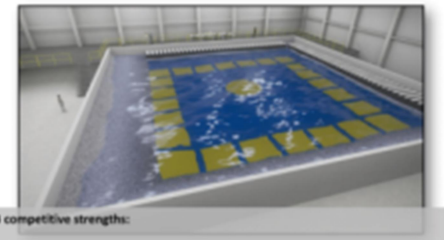
Coastal and Ocean Basin

- **Unique European research facility**
  - → Generation of waves and currents and wind
  - → Midsize (30 x 30 m², 1.4 deep, central pit)
  - → Balance between scale effects and cost



13

Coastal and Ocean Basin



COB competitive strengths:

- variable **water depth** (0.4 – 1.4 m)
- modular multi-directional **wave generator** in L lay-out (H_{max} = 0.55 m)
- **currents** up to 0.4 m/s
- **wave-current** interaction in any direction
- **wind** up to 15 m/s in 2 x 2 m flow section
- exceptional quality **velocity profile** (< 10%) based on numerically design of inlet grid vanes

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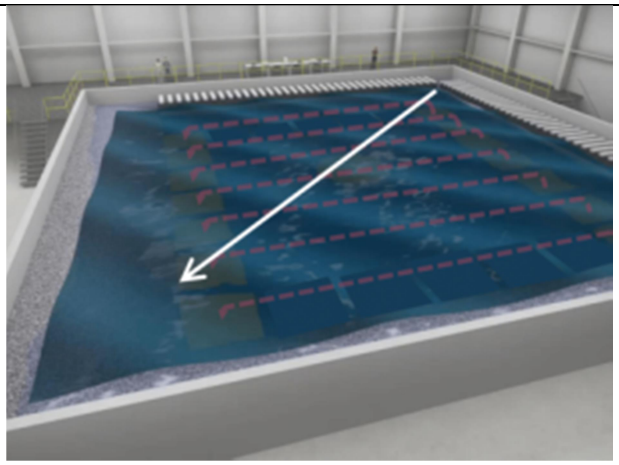

Coastal and Ocean Basin

- **Coastal engineering applications**
  - → Wave wind interaction
  - → Breakwaters
  - → ...
- **Offshore structure applications**
  - → Wave structure interaction
  - → Anchors and mooring lines
  - → ...
- **Interaction with vegetation**
  - → Water dissipation by vegetation
  - → Deterioration of vegetation
  - → ...

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Coastal and Ocean Basin

- **Offshore wind applications**
  - → 3D modelling of offshore wind structures
  - → Floating offshore wind devices
  - → …
- **Tidal energy applications**
  - → 3D modelling of different tidal energy devices
  - → Development of new devices
- **Wave energy applications**
  - → 3D modelling of different wave energy devices
  - → Interaction of multiple devices
  - → …

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Flanders Maritime Laboratory

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Flanders Maritime Laboratory

Construction budget

- 20 M euro concrete (foundation, walls, facilities)
- 10 M euro steel (carriage, wave maker, basin facilities)

http://www.maritiemetoegang.be/projecten/maritiem-onderzoekscentrum

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Requirements for the construction

- Max 0,1mm deflection in the floor.
- Max 1mm settlement difference

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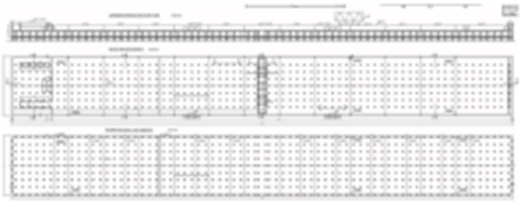
20

Towing Tank

- 178m length with joints every 12,5m in the measuring zone.
- Design based on inverted immersed tunnel.



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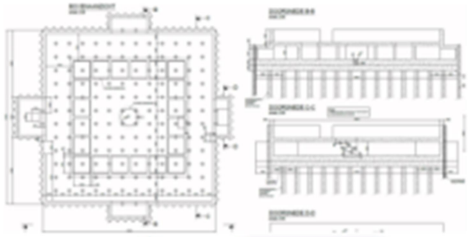
Wave Bassin

- Square of 31 x 31m, no joints.
- Dead weight compensates uplift.



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22

Flanders Hydraulics Research

- Founded in 1933
- Department of Mobility and Public Works
- Centre of expertise for research and advice on hydraulic, coastal, nautical, sediment-related and hydrological topics
- Provides consultancy services for
  - government of Flanders
  - other domestic and foreign government services
  - private sector

Flanders
State of the Art

3

Research goals

- Safety against flooding and water shortage
- Safe Vessel Traffic
- Safe waterborne infrastructure
- Efficient investments of the government
- Improvement of the environment

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4

Flanders Hydraulics Research

- Approximately 80 employees + insourcing

① ▫ ▫ ④ halls for model tests

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5

Instruments & equipment

- Physical (research) installations
  - wave bassin, towing tank, flumes, sediment test tank, ...
- Ship manoeuvring simulators
- Numerical models and supporting IT infrastructure
- Measurement network for continuous monitoring of hydrological and physical parameters on and along navigable waterways
- Instruments for measurement campaigns
- Sedimentological laboratory
- Documentation centre for literature research and desktop studies

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Flanders Martime Laboratory

- New research facilities in Ostend
  - Towing tank *for manoeuvres in shallow water*
  - Coastal & Ocean Basin (COB): *wave, current & wind*
- Operational in 2020

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What we do

8

Research at FHR

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9

Activities

- Study & advice
  - scientific and technical support in the field of hydraulic and naval engineering by conducting research and providing advice
- Research & development
  - development of dynamic and state-of-the-art research tools and specific expertise
- Operational services
  - Hydrological Information Centre (HIC)
  - sedimentological laboratory
  - ship manoeuvring simulators
    - Available to masters, pilots and skippers for education & training

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Our research areas

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Research areas

- Harbours & waterways
- Hydraulic structures
- Water management
- Hydraulics & sediment

Driven by
- Support team Physical Research Installations
- Hydrological Information Centre (HIC)
- Supportive administration

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Harbours & waterways

- Accessibility
  - ship manoeuvring simulators
  - numerical models and software
- Manoeuvres
  - scale models
  - calculations & in situ measurements

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Hydraulic structures

- Locks
  - levelling system design
  - bank and bottom protection design
- Flood defences
  - riverine
  - coastal
- In- and outlet sluices
- Fish passes

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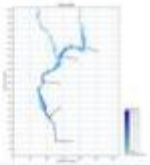
Water Management

- Flood risk management
- Water availability
- Salt intrusion
- Policy support



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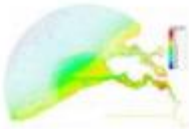
Hydraulics & sediment

- Riverine, estuarine & coastal hydrodynamics
- (Non-)cohesive sediment transport
- Morphodynamics



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Research & Innovations at FHR

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Importance of sediment dynamics

- Port accessibility
  - maintenance dredging
  - manoeuvring above/through mud
- Safety against flooding
  - wave propagation
  - tidal propagation
  - Levees
- Nature
  - ecological functioning (primary production)

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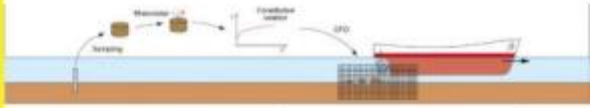
Examples

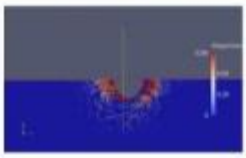
patrik.peeters@mow.vlaanderen.be

19

CFD Nautical Bottom



- CFD calculation of the experiment
- Validation against physical model test
- Conclusion: technique is feasable
- Follow-up project under way



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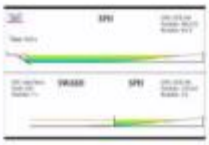
Accessibility of port of Delfzijl

- Simulation study
  - manoeuvring above mud
  - local pilots
- Validation with in situ measurements

Wave transformation and overtopping



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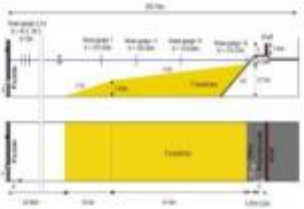
Study of Wave Loads on Walls (WaLoWa)

- Research on wave impact on a wall on a dike in a shallow foreshore



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Impact of Changing Foreshore on Flood Defence Performance (ICODEP)

- Analysis of the influence of bed mobility on wave overtopping and wave loads on a flood defence structure
  - use of large Wave Flume (GWK) at Leibniz University Hannover
  - experimental investigation of overtopping and forces at a nearly vertical battered seawall at the back of a sandy foreshore

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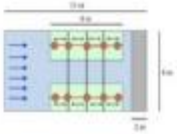
HYdrodynamics at coastal Wetland Edges (HyWEdges)

- Coastal wetlands provide coastal protection
- Propagation of combined waves and currents
- Physical model will be conducted at DHI wave facility



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Integrated management plan of the Upper-Seascheldt river

- **Effect of scenario's in Upper Sea Scheldt**
  - Improve navigability
  - Increase nature value
- **Integrated Modelling approach**
  - Scaldis model (HD, sand, mud)
  - Ecotope Model
  - Models for fish and [illegible]
  - Hyperturbid[illegible]

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IMDC

INSTITUUT NATUUR- EN BOSONDERZOEK

NIOZ

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Operational services

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Operational services

- Development of forecasting & warning systems
- Sedimentological research
- Ship manoeuvring simulators

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Knowledge & information management

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Knowledge & information management

- Open FHR archive
  www.waterbouwkundiglaboratorium.be
- Networking & cooperation
  - Knowledge centre 'manoeuvring in shallow and confined water'

  www.shallowwater.be

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八、MVOW 公司簡報

MHI Vestas 5 Safety Principles

Site Rules – Visitors & Guests

Your safety while at West Medina Mills and St Cross is our primary concern. Please observe the following simple rules. If you have any questions please ask, we will be more than happy to help.

- **Smoking** - only permitted in designated area using the zebra crossing to gain access – your guide will advise / accompany you.
- **Mobile Phones** may be used – please stand in safe area at all times.
- **Photographs** – please ask permission to take photographs, we will make it safe for you to get any authorised photographs you would like to take.
- **If you hear any alarm** - listen to your guide who will escort you to safety.
- **Vehicles** - Please ensure your vehicle is reverse parked in the correct space and the Speed Limit of 30 mph is adhered to on Stag Lane.

If you need assistance please ask

Site Rules

- Personal Protective Equipment (PPE), Visitors and Contractors must wear the following basic PPE.

MVOW Blades IoW Staff - MVOW Visitors

External Visitor / Contractors

- Further PPE will be required and made available to view a specific process.

Designated Boot Room

- Production area is only to be accessed through the designated changing area.
- Safety shoes are only to be put on once you have passed through the doors into the Production Hall and into the green zone.
- Safety shoes, protective suits and gloves must be removed and disposed of prior to crossing into the red zone and into the Boot Room from the production hall.
- If work wear / garments have become contaminated, they must be removed before entering the clean administrative or communal areas.
- Any issued safety shoes and glasses must be returned.

Emergency Arrangements

First Aid

- MHI Vestas Offshore Wind have first Aid boxes and eye wash stations within manufacturing areas and first aid boxes in the offices by the main entrance. We also have AED's on site.

Fire Arrangements

- In the event of fire, the alarm will sound.
- Vacate the building via the nearest emergency exit as directed by the Fire Marshal.
- Go to the Emergency Assembly Point (EAP) immediately and await further instructions!

This information is available on the Safety Boards

Emergency Assembly Point (EAP)

Assembly point

At the assembly point a line will be formed by each department. Please join the relevant line.

Wait at the muster point with your guide until the **'MVOW Fire Controller'** or **'Nominated person'** advises the appropriate action.

At the assembly point the MVOW Fire Controller will be identifiable by wearing a red high visibility vest and hard hat.

Main Site Hazards

- Be aware of chemical substances whilst in the manufacturing areas.
- Your guide will ensure that you will not be exposed to substances

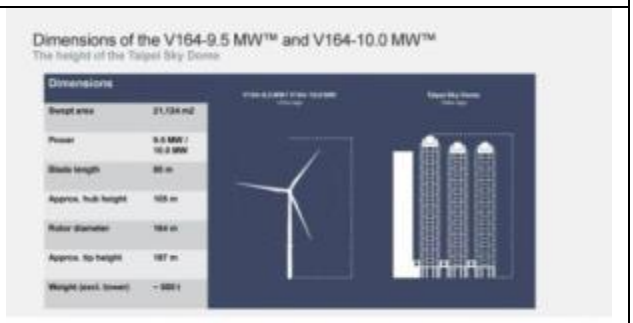
Main Site Hazards

Heavy Lifting Operations

- Keep Clear of Lifting Operations
- Do Not Work or Walk under Suspended Loads
- Moving Cranes (Look for flashing lights and listen for alarms)
- Cranes will be wearing red hard hats and Banksman will be wearing white hard hats.
- Follow Banksman Instruction
- Risk of falling objects

Vehicle Movements

- Fork Lifts
- Scissor Lifts
- Delivery Vehicles (HGVs)



MHI Vestas Offshore Wind Blades UK

History of the IOW West Medina Mills (WMM)

- WMM was developed for the new generation of Wind turbine blades 100m +
- Developed, prototyped and tested blades from 2013 to current day
- Currently Building V164 9.5 MW blades
- Increase in production has seen us grow from 350 employees to 600 in the last 5 months.
- Operating 24/7
- Currently supplying blades for export for European projects.
- Blade leave the site on our barge which docks next to our Blade storage area

Solent Hub for Offshore Wind

Hampshire & Isle of Wight, UK

Economic Impact

2018 Solent Expansion, UK

When fully operational in 2020, the introduction of a 9th mid blade mould will result in the following impact for the region

MHI Vestas Workforce	Training Investment	Supply Chain Jobs	Additional Regional Value Added
+380	+£780K	+>700	+£42m pa

MHI Vestas supports the local supply chain

Composites expertise in the region means opportunities for local businesses

MHI Vestas has worked with local suppliers to grow together since 2015

- Global Wind Turbine Services
  - Actively increasing headcount to meet MVOW demand
- Incom
  - Significantly grown dedicated FTEs and investing in new kit
- MSA Manufacturing
  - Introducing new technologies to support expansion

New suppliers introduced to support expansion

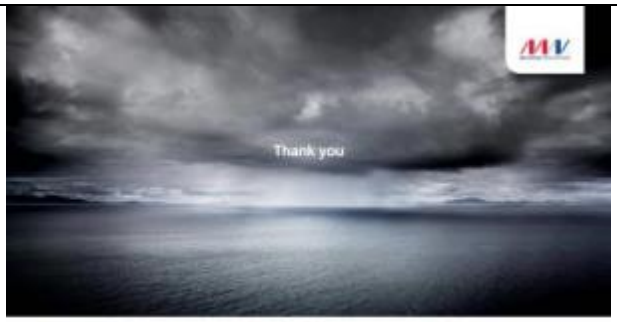
- Williams Shipping
  - Transporting blades in a newly designed 75m transport barge
- MMD Shipping Services
  - Safeguarding 47 FTEs and diversification into offshore wind

WILLIAMS SHIPPING

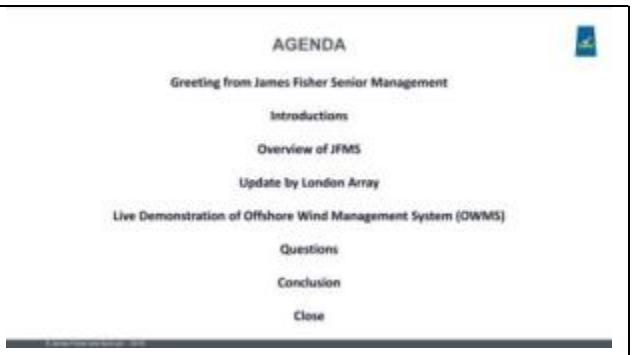
MHI Vestas Offshore Wind Blades UK

Working with Solent LEP to develop skills

- Approximately £1m investment in skills programme over 4 years: supporting a loyal & productive workforce
- Strong partnership with Isle of Wight College & CECAMM
- 108 blade operatives have opportunity to be trained in NVQ level 3 in composite engineering
- Through this investment in our training and development we were awarded Employer of the year 2017 by Composites UK
- All new staff will undertake their Core Skills Training at CECAMM, helping CECAMM to invest in new facilities including a new mould



九、James Fisher & Sons 公司簡報

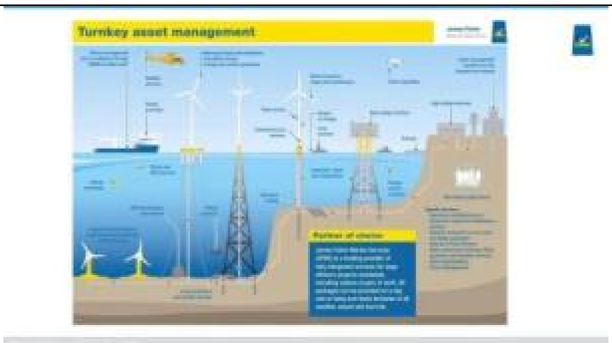



A LITTLE HISTORY – 公司沿革
ORE & RAIL - 礦石及鐵道
DIVERSIFICATION - 多元化經營
MARINE SERVICES - 海事服務
NUCLEAR - 核能
EXPANSION - 擴張


OUR GLOBAL LOCATIONS – 我們全球據點


SAFETY AT OUR CORE – 安全是首要核心


James Fisher Marine Services - 英商費舍海洋服務公司
DNV-GL


Turnkey asset management


INTEGRATING MARINE SOLUTIONS – 整合式的海事解決方案
Turnkey asset management services
Service 服務
Innovation 創新
Integration 整合


OUR PEOPLE - 我們的人員
COMPETENCY ASSURANCE MANAGEMENT - 能力保障之管理


Corporate & Social Responsibility
– 企業與社會責任
ACCREDITATIONS - 認證
MEMBERSHIPS - 會員資格
IMCA

RECENT NEWS – 最新消息

- James Fisher Subsea Excavation (JFSE) recently completed its first project in Taiwan by deploying the Twin R2000 tool to de-bury and relaunch a cable for maintenance at the Formosa 1 offshore wind farm.
- JFMS has been appointed by London Array to deliver Balance of Plant (BoP) Operations and Maintenance (O&M) services. £35 million / 5 years
- JFMS has been awarded the ten year PBB Terminal Management Contract of the Tetney Monobuoy (oil terminal) in the Humber Estuary. £50 million / 10 years
- JFMS delivered the Innogy Galloper Offshore Services Contract (OSC) on time & on budget with first power in November 2017. £36 million / 2 years
- Scottish Power Renewables (Iberdrola) recently awarded JFMS an Integrated Marine Package to supply a range of Construction Support Services on the East Anglia One OWF. £20 million / 3 years
- EON awarded JFMS a global contract to implement our proprietary Offshore Wind Management System OWMS™ across all their Offshore Wind Farms. £6 million / 5 years
- JFMS acquired Rotos360 in 2017 giving us a world leading blade inspection & repair capability based around UV fast cured resins, aluminium blade access cradles & temperature and humidity controlled repair habitats.
- JFMS acquired the EDS Energy Group in 2017 giving us market leading capability in High Voltage engineering, fault diagnosis, cable fault location and repair, termination & testing services and the only company in the world to have worked on 66 kVA infrastructure offshore.
- Siemens have chosen JFMS to manage and deliver the largest offshore blade repair campaign ever conducted and also to provide the management and delivery of the largest ever offshore gearbox and hydraulic oil change campaign £15 million / 4 years.

RECENT NEWS – 最新消息

- James Fisher Subsea Excavation (JFSE)最近完成了其在台灣的第一個項目，部署了Twin R2000工具，用於在Formosa 1離岸風電場中進行電纜維護的埋設去除及再埋設作業。
- JFMS已獲London Array風場委任，提供電力其他系統(BoP)及運維服務(O&M)服務，3.5億歐元/ 5年
- JFMS已獲得在Humber Estuary的Tetney Monobuoy(石油碼頭)十年PBB碼頭的管理合同，5,000萬英鎊/ 10年
- JFMS於2017年11月在首次授權下完成按時和按預算交付Innogy Galloper海上服務合約(OSC)，3,600萬英鎊/ 2年
- 蘇格蘭電力可再生能源公司(Iberdrola)最近授予JFMS綜合式海事包裝合約，以East Anglia One OWF提供一系列的建造支援服務，2,000萬英鎊/ 3年

JFMS SERVICES – JFMS服務

- UXO investigation and disposal on a turn-key basis
- Offshore marker buoy installation, maintenance and demobilisation
- Guard vessels
- Offshore maintenance planning & hardcover
- Offshore temporary generation and turnkey offshore cable laying service
- Offshore Emergency Response Teams (ERT), medics and onshore co-ordination services (multi-skilled)
- Skilled personnel supply
- Subsea IRM support - local standby diving services
- Subsea IRM support - local standby ROV services
- Ad-hoc and planned survey services
- Service Operation Vessel
- Boulder relocation and removal
- High Voltage Services
- Marine Economic Risk Management AID (MERMAID)
- Temporary telecommunications
- Marine co-ordination facilities and services (CWIREI)
- Blade inspection and repair services
- Personal Protection Equipment (PPE) provision
- Crewboat / port welfare facilities
- Crewboat gangway co-ordination
- Crewboat stores and equipment management
- Permit to Work
- Chemical monitoring
- Waste management and environmental spill response
- Wave & Tidal installation, O&M and decommissioning
- Offshore cable repair, replacement, recovery and disposal
- Pontoon design and construction
- Fully integrated Balance of Plant Services both topside and subsea

JFMS SERVICES – JFMS服務

TAIWAN

Our business model is based on offering a range of high quality marine services predominantly to large multinational customers and governments around the world on a local basis, and key to our strategic expansion in the offshore renewable energy market is Taiwan.

Wherever we operate we focus on the local supply chain and aim to create a legacy and as such our efforts to develop our business in Taiwan will be centred around:

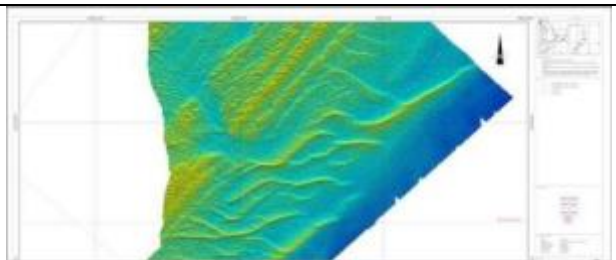
- Offering our complete range of skills and services "In Country" with a high local content
- Building on the existing joint venture partnerships
- Relocating Richard Beattie, our Regional Director to Taipei
- Incorporating a new company in Taipei to be called "James Fisher Taiwan"
- Offering up to 8 x Taiwanese offshore technicians UK working placements on our existing offshore wind operations in 2018 / 2019
- Awarding 2 James Fisher Taiwan Scholarships to high performance Taiwanese graduates in the UK to learn about managing our business with the opportunity to attend the prestigious EF language school in Cambridge [home of the world famous Cambridge University]
- Relocating strategic equipment in country
- Setting up marine operations control rooms and communication hubs in our customer's strategic locations

OFFSHORE WIND MANAGEMENT SYSTEM™ - 離岸風電管理系統

OWMS™ is a state-of-the-art web-based marine management system providing real-time operational data to reduce operational expenditure, increase safety and optimise efficiency for asset operators – OWMS™是一種最先進以網路為基礎的海事管理系統，可提供實時操作數據，以減少運營支出，提高安全性並優化效率。

MARINE & ECONOMIC RISK MANAGEMENT AID: Mermaid® - 海事和經濟風險管理支援

A software suite that identifies and helps mitigate against weather driven time and variable risk during marine operations at FEED stage by simulating operational conditions to improve project planning – 該軟體套件，在前置的工程設計階段，透過模擬運營條件來改善項目規劃，以利降低與天氣有關的時間和變動風險。



Surveying capability – 測量能力


SCOUR PREVENTION & ASSET PROTECTION – 淘刷預防及資產保護
Extensive expertise and experience in delivering scour prevention solutions for offshore cable and turbine assets including installation of rock bags, frond mats and concrete mattresses, using efficient


Blade inspection and repair – 葉片檢查及修復


INSPECTION, REPAIR & MAINTENANCE (IRM) – 檢查、修復及維護 (IRM)
JFMS has in-house expertise and assets that can be used to provide Clients with a range of IRM solutions including UWILD surveys, pile wrapping, underwater jetting and cathodic protection inspections –


ROV FLEET AND PERSONNEL – 水下遙控載具(ROV)及人員
JFMS has a fleet of 14 ROVs of different classes and sizes to precisely suit our Clients requirements, operated by skilled, experienced personnel and rapidly deployed by various launch and recovery systems


DIVING & ROV SERVICES – 潛水及水下遙控載具服務
James Fisher's subsea division has over 40 years' experience in providing diving and ROV services and equipment to the renewables, nuclear and oil and gas markets – James Fisher

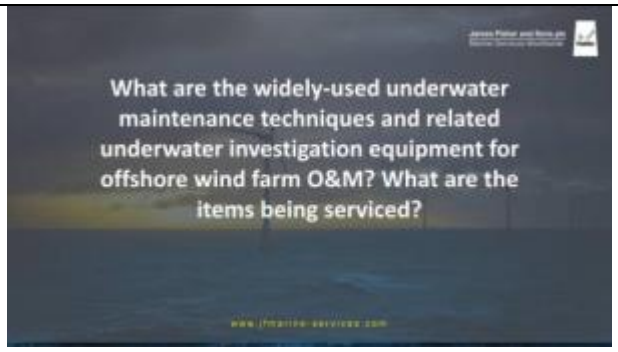

CABLE MAINTENANCE, BURIAL & DE-BURIAL – 電纜維護、埋設及去除埋設
James Fisher provides a specialist integrated cable solution for the maintenance, burial and de-burial of export, inter-array, interconnector and subsea power cables including project management and

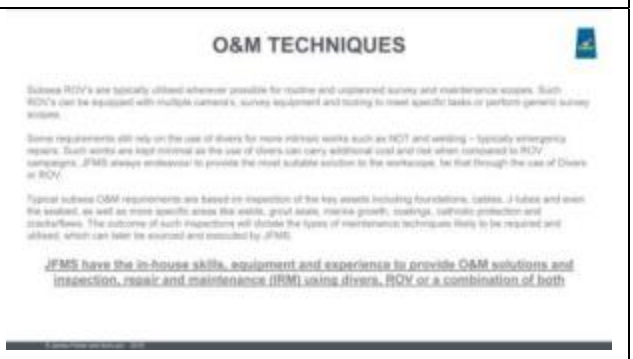

CABLE INSTALLATION AND PULL-IN OPERATIONS – 電纜安裝及引入作業
James Fisher has an excellent proven track record for the installation and shore-end cable pull-in


CABLE INSPECTION AND REPAIR – 電纜檢查及修復
In-house mass flow de-burial/reburial, diving and ROV survey solutions for intervention, fault finding and repair services on subsea cables –


LONDON ARRAY UPDATE

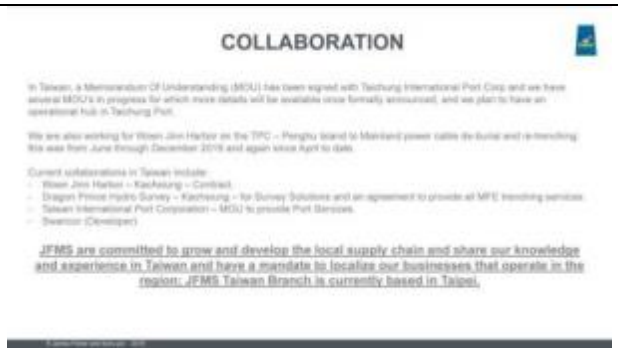

JAMES FISHER & SONS plc


What are the widely-used underwater maintenance techniques and related underwater investigation equipment for offshore wind farm O&M? What are the items being serviced?


O&M TECHNIQUES
JFMS have the in-house skills, equipment and experience to provide O&M solutions and inspection, repair and maintenance (IRM) using divers, ROV or a combination of both


INSPECTION, REPAIR & MAINTENANCE (IRM)
JFMS has in-house expertise and assets that can be used to provide Clients with a range of IRM solutions including UWILD surveys, pile wrapping, underwater jetting and cathodic protection inspections


In the offshore wind industry, how is JFMS collaborating with port operators?


COLLABORATION
JFMS are committed to grow and develop the local supply chain and share our knowledge and experience in Taiwan and have a mandate to localize our businesses that operate in the region: JFMS Taiwan Branch is currently based in Taipei.


合作意向書簽署典禮
James Fisher Marine Services (JFMS) has signed a Memorandum of Understanding (MoU) with the harbour port management company, Taiwan International Ports Corporation Ltd (TIPC), to explore port services in the country.

During installation and O&M work of wind turbines at the Taiwan Strait, are there any safety tips or suggested measures in handling work vessels and turbines, specifically addressing the typhoon issue?

TAIWAN STRAIT O&M

Preparation and planning are key to ensuring operations are executed in a safe, timely, successful and efficient manner. JFMS operates under a management system certified to ISO 9001:2015, ISO 14001:2015 and OHSAS 18001:2007 to ensure all operations are planned and managed to the highest standards.

Use of weather prediction and monitoring software such as JFMS's Mermaid® allows for planning around adverse weather (such as typhoons) as much as possible to minimise HSE risks and interruption to work.

A key part of offshore operations is the vessels and it is the policy of James Fisher Marine Services (JFMS) to ensure that vessels selected to support our services and operations are suitably assessed and audited to ensure they are suitable for the planned operations, will provide a safe place of work for our workforce and are operated in accordance with all statutory and company safe working practices.

The following list of capabilities identifies aspects of a support vessel that are commonly reviewed during an initial assessment to determine suitability:

- Free Deck Space
- Deck Equipment
- Available Accommodation
- Deck Loading Capacity
- Mooring Capability
- Helideck
- Crane Curves
- DP System – Class 1, 2 or 3

JFMS has the tools, software and experience from operating globally in regions experiencing severe weather conditions – including trenching operations in Taiwan on Formosa 1 – to ensure projects are managed and operated safely and successfully.

MARINE & ECONOMIC RISK MANAGEMENT AID: Mermaid®

A software suite that identifies and helps mitigate against weather down time and variable risk during marine operations at FEED stage by simulating operational conditions to improve project planning

How often are divers sent for foundation maintenance and servicing? What are the required certifications for this task (e.g. welding, nondestructive testing, diving certification)?

FOUNDATION MAINTENANCE

The intervals at which foundations require servicing and maintenance can vary widely depending on many factors such as:

- Foundation type (e.g. monopile, multi-leg jacket, etc)
- Coating type
- Seabed Mobility
- Cathodic protection – is there any? Type?
- Scour protection – is there any? Type?

It is standard practice for the developer to advise JFMS on the schedule and type of services required allowing us to develop a solution to achieve the desired outcome such as the following executed on the **Anholt and Gulliver Offshore Wind Farms:**

- Cathodic protection readings, Marine Growth thickness assessment, Anode wastage estimates, Structural integrity/coatings/debris/damage inspections, Cables protection system inspection and route checks, Scour surveys (including rock dumps)

Types of services / certifications required would typically include:

- Non-destructive testing (NDT)
- ROV or diver survey following local approved accreditations (e.g. IMCA, DNV, etc)

JFMS have the in-house skills and experience to manage foundation maintenance from start to finish, and can incorporate this element with topside O&M to provide a cost efficient complete solution

PROJECT MANAGEMENT

James Fisher has world-class assets, personnel, a proven track record and heritage to engineer, plan, manage and deliver a range of topside, marine or subsea projects

According to JFMS' professional experience, what makes an ideal offshore wind O&M port (infrastructure requirements, such as optimal distance to wind farm, draft, port and storage yard, etc.)?

O&M PORT

Many factors need to be addressed when selecting an ideal O&M Port including the following:

- What O&M activities will be run from the base?
- Proximity
  - Base to OSW? – **Closer is beneficial to reduce transit times, fuel burn, etc**
  - Base to other O&M bases (where applicable, e.g. if a temporary base is used during construction)
  - From open sea – **transit times may be impacted if vessels have to transit to open sea via restricted channels**
- Space
  - Sheltered Berthing for CTV's
  - Offices, control rooms, induction rooms, laydown areas, stores, waste disposal, Car parking, etc
  - Bunded area for vessel fuel and waste liquid handling
- Communication Networks – **e.g. fixed or temporary VHF and UHF connections**
- Security
- Infrastructure – Road, Rail, Airways
- Supply chain availability
- Emergency services
- Many more!

There is no one size fits all solution due to the number of varying factors which all need to be assessed. JFMS have the expertise and experience to manage port assessment, selection and development


SHORE-SIDE SUPPORT BASE SET-UP
James Fisher is an industry leader in the set-up of both temporary and permanent shore-side support bases, including the ability to provide vessel mooring, bunkering and operational base solutions


James Fisher
Marine Services
感謝
THANK YOU