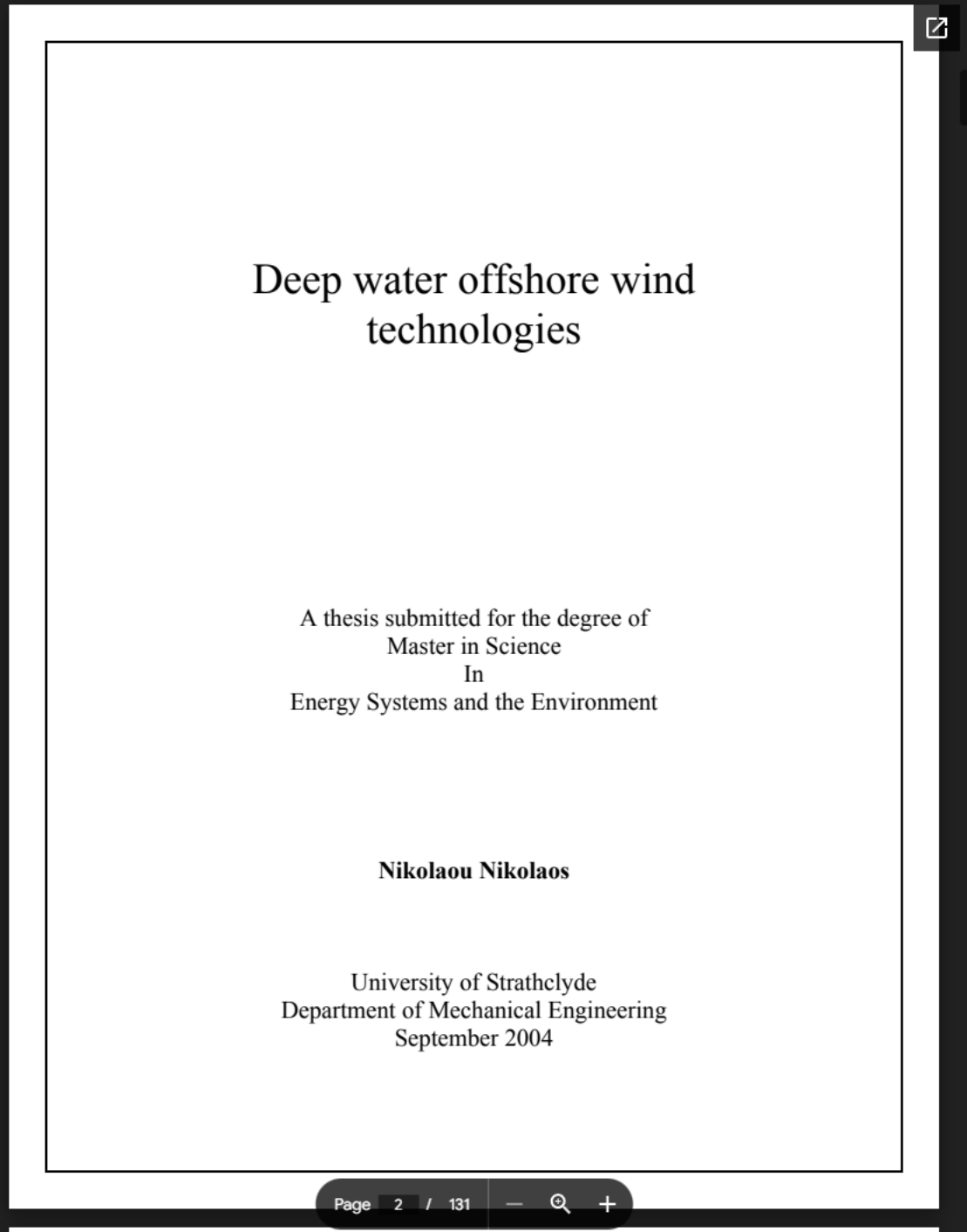
Renewables, Europe - Timeline



Deep water offshore wind technologies

A thesis submitted for the degree of
Master in Science
In
Energy Systems and the Environment

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University of Strathclyde
Department of Mechanical Engineering
September 2004

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1990

WORLD FIRST OFFSHORE WIND TURBINE IN NOGERSUND IN SWEDEN

In 1990, the first offshore wind turbine was raised 250m offshore of the fishing village of Nogersund in southern Sweden. The turbine was constructed and installed by the company World Wind and consisted of a single 3-bladed Danish wind turbine with a hub height of 37.5m and rated ouput of 220kW. The wind turbine was installed at 7m water depth.

The Vindeby legacy

1991

THE WORLD´S FIRST OFFSHORE WIND FARM BUILT IN VINDEBY, DENMARK

Built between 1990 to 1991, the Vindeby offshore wind farm (OWF) is the first of its kind to ever be built. It consisted of eleven 450 KW Bonus wind turbine generators and totalled 5MW, covering the annual consumption of 2,200 Danish households.

The wind turbines were founded on concrete gravity based foundations of 8 to 9m diameter.

1998

BOCKSTIGEN - THE FIRST SWEDISH OFFSHORE WIND FARM FOUNDED ON DRILLED MONOPILE FOUNDATIONS

Commissioned in 1998, the Swedish offshore wind farm Bockstigen was built as a demonstration project with drilled monopiles in limestone. Its five 550 kW turbines were repowered in 2018 and the towers maintained.

2001

THE ALM AND HAMRE SRD METHOD

Alm and Hamre with their iconic papers of 1998 and 2001 introduced a CPT based for assessing the soil resistance to driving (SRD), incorporating the pile driving fatigue theory introduced previously by Heererma (1976).

Although, the method was developed based on data from the Oil and Gas industry it is widely used as a reference method for the prediction of pile installation in the offshore wind industry.

2002

HORNS REV 1 - FIRST FULL SCALE OFFSHORE WIND FARM FOUNDED ON MONOPILE FOUNDATIONS

Horns Rev 1 Offshore Wind Farm was the first wind farm to use monopile foundations. Built by the Danish energy company Elsam (later known as DONG Energy and currently as Orsted) it is located in the North Sea approximately 30 km west of Esbjerg.

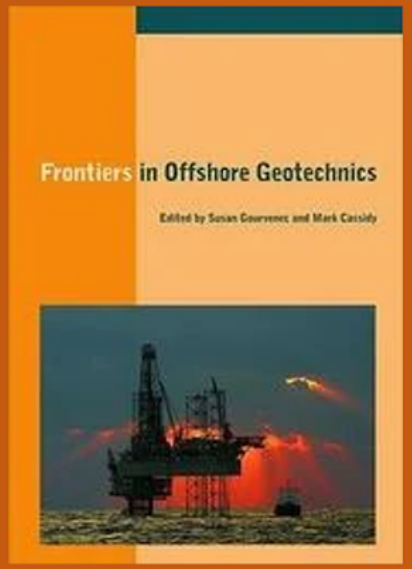
It consists of 80 Vestas V80-2.0 MW type wind turbines with a total rotor nacelle assembly weight of 105.6 t. The monopile foundations have an outer diameter of 4.0 m and a transition piece with outer diameter of 4.34 m. The water depth at the site is 6–14 m and monopile peneration is approximately 20m.

2002

THE FREDERICKSHAVN DEMONSTRATOR WORLD'S FIRST WTG FOUNDED ON SUCTION CAISSON

In October 2002 a prototype suction caisson wind turbine foundation was installed in the offshore research test facility in Frederikshavn, Denmark. The prototype has a diameter of 12 m and a skirt length of 6 m with a steel construction mass of pproximately 140 t.

The operational water depth is 4 m and as the site is in a basin, no wave or ice loads are applied. The installation period was about 12 hours, with the soil penetration time being 6 hours. The Vestas V90 3.0 MW turbine was erected on the foundation in December 2002.



Proceedings of the International Symposium on Frontiers in Offshore Geotechnics (ISFOG 2005), 19-21 Sept 2005, Perth, WA, Australia

2005

THE CPT BASED METHODS FOR AXIAL CAPACITY DESIGN

At the 2005 ISFOG conference a total of four new empirical methods for the evaluation of axial pile capacity of open ended piles based on CPT results were published. The methods became known as the ICP, the UWA, the NGI and the Fugro methods after the affiliations of the their publishers gradually replaced the obsolete API and became the main methods for calculating the axial pile bearing capacity in the years to come for numerous offshore wind farm developments in the North Sea.

The four (ICP, NGI, Fugro and UWA) empirical methods for the evaluation of axial pile capacity of open ended piles enabled the offshore wind industry to perform far more effective designs for WTG and OSS jacket foundations which resulted in significantly lower L/D pile and thus significant cost savings.

2007

BEATRICE WIND FARM DEMONSTRATOR PROJECT FOR JACKET FOUNDATIONS - FIRST WTG FOUNDED ON A JACKET SUBSTRUCTURE WITH PIN PILE FOUNDATIONS

The Beatrice Wind Farm Demonstrator Project is located approximately 22 kilometres from shore off the coast of north-east Scotland. It comprises two 5MW Senvion turbines supported on piled jacket substructures, which sit in approximately 45m of water. It was a joint venture between SSE and Talisman Energy (UK) and its purpose was to build and operate an evaluation wind farm in the deep water close to the Beatrice Oil field that Talisman Energy.

The turbines were installed in August 2006 and by July 2007 were the largest offshore wind turbines in the world; the first jacket substructure; the first to be installed in a single lift from a floating vessel; and the first wind turbine in international waters, furthest from shore and in the deepest water.

2009

FIRST FLOATING WIND TURBINE INSTALLED AT HYWIND OFFSHORE WIND FARM

The first full scale demo floating wind turbine is installed at the Hywind Offshore Wind Farm in the Amoy Fjord off Stavanger in Norway by Statoil (Equinor). The WTG is a Siemens 2.3MW and the water depth is 220m.

Anholt Offshore Wind Farm

2012

FIRST MONOPILES TO BE VIBRO-INSTALLED AT AN OFFFSHORE WIND FARM - ANHOLT OFFSHORE WIND FARM

Two full-scale demonstration tests of vibro-driven monopiles were conducted at Anholt Offshore Wind Farm in 2012. The two monopiles were vibrated 18 and 19 m below seafloor before impact driving was applied to the remaining 2 m and 1 m, respectively , with the use of three 200 kJ vibrohammers from PTC.

2012

BORKUM WEST II OFFSHORE WIND FARM - FIRST WIND TURBINES FOUNDED ON TRIPOD FOUNDATIONS AND PIN PILES

The Borkum West II Wind Farm was developed by Trianel Windkraftwerk Borkum GmbH in the North Sea, approximately 45km offshore northern Germany. The first phase of the project included the construction of forty 5MW turbines supported by tripod structures in water depths of 26m to 33m. The steel tripods, which have an outer footprint diameter of 28m are founded on 2.48m diameter driven pin piles and support a central column to which the turbine tower is connected.

This was the first full scale offshore wind farm founded on pin piles.

MODIFICATION OF THE API P-Y FORMULATION OF INITIAL STIFFNESS OF SAND

D Kallehave, C LeBlanc Thilsted and MA Liingaard
DONG Energy A/S, Fredericia, Denmark

Abstract
Monopiles are currently the preferred concept of support structures for offshore wind turbines. However, experiences from operating offshore wind farms indicate that the current design guidelines (e.g. American Petroleum Institute (API)) under-predict the soil stiffness for large-diameter monopiles. Due to the structural dynamic of a wind turbine, it is unconservative to both over-predict and under-predict the soil stiffness. Only an exact prediction is conservative. The objective with this paper is to introduce an approximate method for determining the soil stiffness of sand regarding large-diameter monopiles by modifying the initial stiffness of the API *p-y* formulation. The modification introduces both a stress level and a strain level correction derived on basis of sound theoretical considerations without introducing new empirical parameters. It has been shown by benchmarking with full-scale measurements from Walney offshore wind farm that the modified approach provides a more accurate determination of the total soil stiffness, although it is still under-predicted.

1. Introduction

The *p-y* curves evolved primarily from research in the oil and gas industry, as the demand for large pile-supported offshore structures increased during the 1970s and 1980s. Research has included testing of full-sized piles in sand under both static and cyclic loading conditions. The *p-y* curves for piles in sand described by Reese et al. (1974) and O'Neill and Murchison (1983) led to recommendations in the American Petroleum Institute (API) standards for oil and gas installations (2011). In 2004 these recommendations were adopted in the Det Norske Veritas (DNV) standard (2004), which represents the current state of the art for design of monopiles in the offshore wind industry. The *p-y* curves for piles in sand were developed based on full-scale load tests on long, slender and flexible piles with a diameter of 0.61m (Reese et al., 1974). In addition, they have been widely applied to relatively shorter and stiffer piles with diameters up to 6.0m in the offshore wind turbine industry.

The impacts of applying *p-y* curves empirically developed outside the verified range can now be observed. Nacelle measurements from DONG Energy's offshore wind turbines show that the fundamental frequencies are much higher than best-estimate predictions using the API *p-y* formulation for piles in sand. This may be due to an under-prediction of the soil stiffness. For example, full-scale measurements for three randomly chosen offshore wind turbines located in sand profiles in the Walney offshore wind farm (see Figure 1) reveal an under-prediction of the wind turbine structures' fundamental frequency of ~5–7%. Figure 1 shows the relative frequency deviation (Δf_{Rel}) being the difference between the measured and predicted frequency relative to the predicted frequency. Each dot represents a 10min average measured value in the period 15 August 2011 to 26 September 2011. The measured frequencies are seen to drop slightly at high wind speeds, which is most likely due to an increased load cycle amplitude at such wind speeds.

Under most circumstances and particularly for static structures, under-predicting the stiffness is conservative. However, because of the structural dynamic of a wind turbine, both over-predicting and under-predicting the soil stiffness is unconservative. Only an exact prediction is conservative. It must be emphasised that the *p-y* curves have never been developed with the objective to accurately predict the soil stiffness for large-diameter piles.

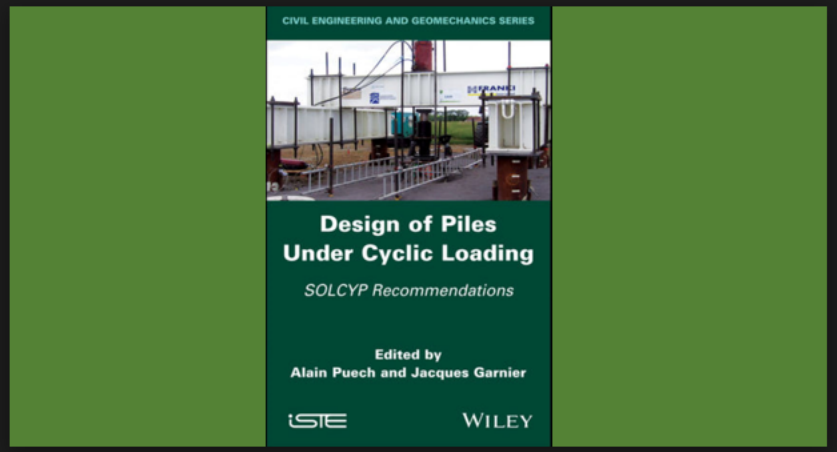
The objective of this paper is therefore to present modifications to the current *p-y* curves that result in a better prediction of the soil stiffness. From a commercial point of view, under-predicting the soil stiffness increases uncertainties, adds additional but unnecessary costs to the industry and decreases the feasibility of the monopile foundation. Moreover, in the worst case it could have a negative influence on the structural lifetime.

2012

MODIFICATION OF API P-Y CURVE STIFFNESS FOR LARGE DIAMETER EFFECTS - DEMONSTRATING THE INADEQUACY OF API P-Y CURVE FORMULATIONS TO PREDICT INITIAL STIFFNESS OF LARGE DIAMETER PILES

Nacelle measurements from DONG Energy's (currently known as Orsted) offshore wind turbines showed that the fundamental frequencies are much higher than best estimate predictions using the API p-y formulation for piles in sand. The paper, Modification of the API p-y formulation for initial stiffness in sand, introduced a modification on the formulation to accoount for large diameter effects.

The proposed modification was used in the design of numerous windfarms prior to the PISA JIP method.



2012

THE SOLCYP PROJECT - INTRODUCING A DETAILED METHODOLOGY FOR THE DESIGN OF AXIAL PILES USED UNDER CYCLIC LOADING

As stated in the Puech et al. 2012 paper "The SOLCYP project" (French acronym for piles under cyclic solicitations) was launched in 2008 with the objectives of: understanding the physical phenomena conditioning of the response of piles subject to vertical and horizontal cyclic loads; defining a methodology to assess the behaviour of cyclically loaded piles; developing design methods and initiating pre-normative actions with a view to introducing new methodologies in national (and international) codes or professional guidelines.

The project had a total budget of approximately €5 million, financed by Agence Nationale de la Recherche (ANR) and Ministry for Ecology, Sustainable Development, Transports and Housing (MEDDTL) and private companies from the civil engineering and energy sectors.

2013

THE PISA JIP - CREATED A NEW SET OF SOIL REACTION CURVES SIGNIFICANLTY IMPROVING THE WAY THAT MONOPILES ARE MODELLED AND DESIGNED

In 2013 the Pile Soil Analysis (PISA) Joint Industry project commenced. PISA was a research project aimed at investigating and developing improved design methods for laterally loaded piles, specifically tailored to the offshore wind sector.

The project was a JIP run through the Carbon Trust's Offshore Wind Accelerator program end executed in collaboration with the University of Oxford, Imperial College London and the University College of Dublin, under the lead of Orsted. The project was completed in 2019.

2014

BORKUM RIFFGRUND 1 OFFSHORE WIND FARM - FIRST SUCTION BUCKET FOUNDATION INSTALLED

The first suction bucket foundation was installed at the Borkum Riffgrund 1 Offshore Wind Farm in the North Sea, 55km from the north-western coast of Germany. One of the 78 WTG was founded on a three-legged jacket structure with 8m diameter suction buckets with skirt penetration of 8m (L/D=1).

The remaining foundations were founded on monopile foundations.

2015

YTTRE STENGRUND - FIRST OFFSHORE WIND FARM TO BE DECOMMISSIONED

In November 2015 the Yttre Stengrund Wind Farm in Sweden, operated by Vattenfall, was decommisioned. The wind farm consisted of five 2 MW NEG Micon turbines.

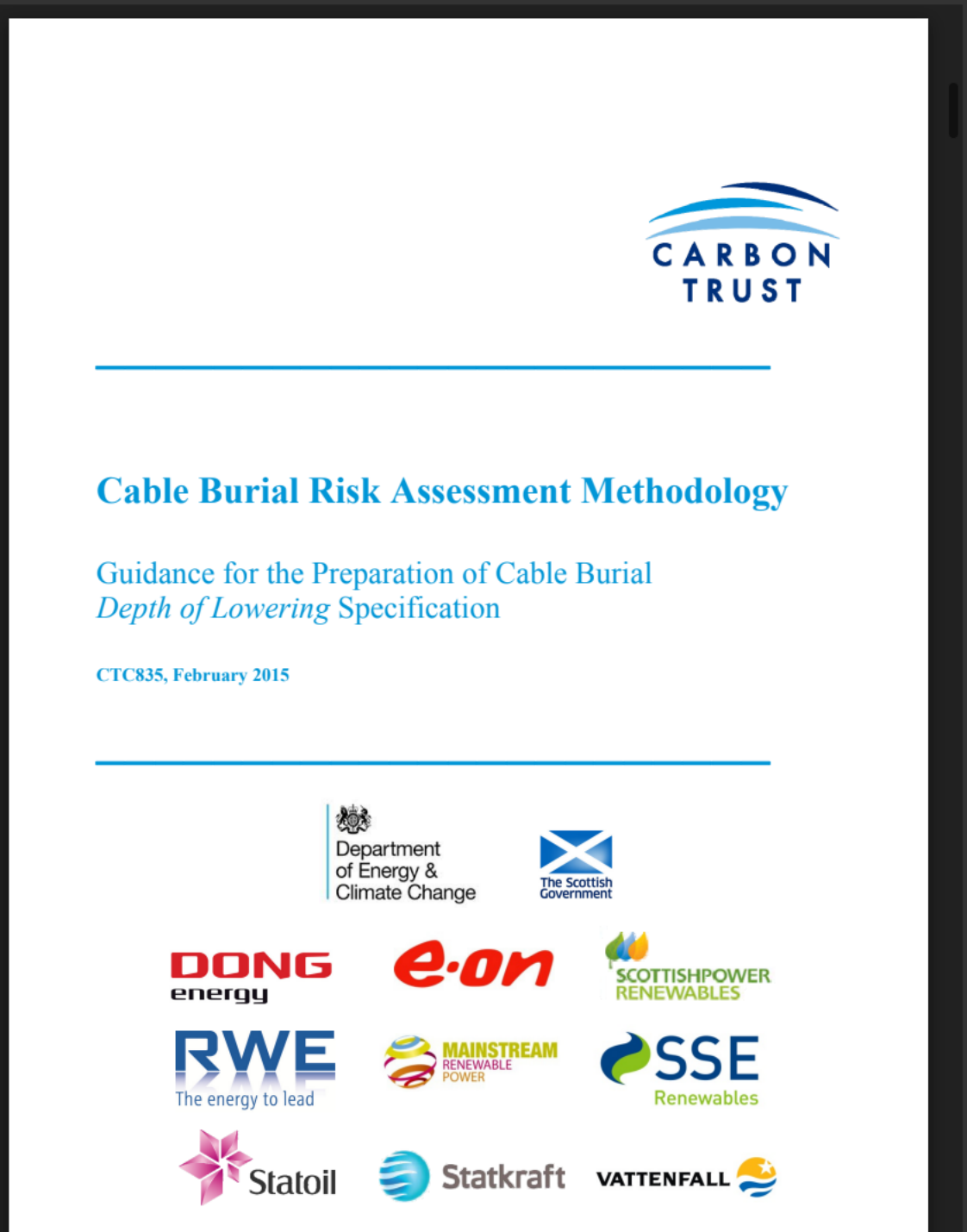
2015

WIKINGER OFFSHORE PILE LOAD TEST - FIRST OF ITS KIND AT AN OFFSHORE WIND FARM

The Wikinger Offshore Wind Farm in the German Baltic Sea was developed by Iberdola and it consists of seventy wind turbine generators and one offshore substation with a 350 MW total installed capacity. The wind turbines are supported by four legged jackets founded on driven open ended piles with diameter of 2.667m while the OSS is supported by eight legged jackets founded also on driven piles with diameter 3.66 m.

As part of the Wikigner Offshore Wind Farm development, Iberdola commissioned, in advance of final design, offshore dynamic and static pile load tests to evaluate the behaviour of piles in Chalk. The pile testing campaign comprised the installation of a total of nine 1.5m piles (six test piles and three reaction piles) with penetrations of up to 31m, at three different WTG locations. The first phase of the test campaign consisted of the installation and dynamic monitoring of all piles and the second phase of the campaign, executed 10 weeks after phase I, consisted of 3 static tension tests (one at each location) and re-strikes at an adjacent reaction pile.

The pile testing campaign was the first of its kind at an offshore wind farm.



2015

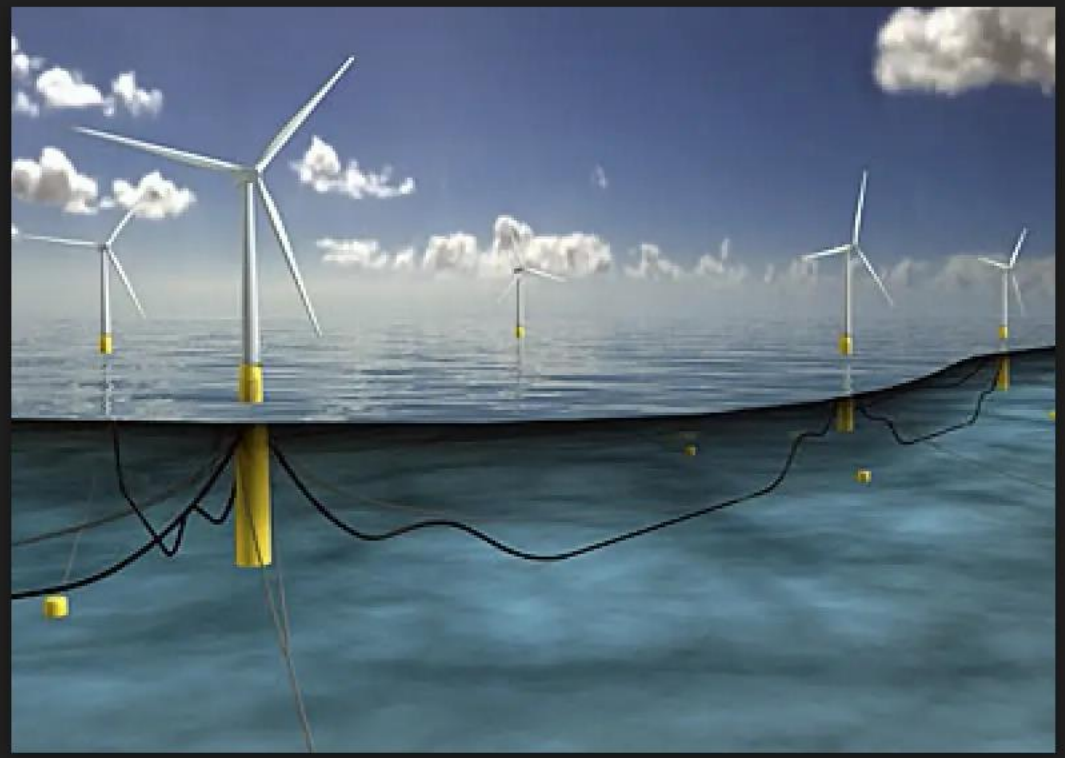
CABLE BURIAL RISK ASSESSMENT METHODOLOGY BY CARBON TRUST - A GUIDANCE METHOD TO IMPROVE CONSERVATIVE ESTIMATES OF RESIDUAL RISK AND REDUCE THE INSTALLATION AND INSURANCE COSTS FOR SUBSEA CABLES WITHIN THE OFFSHORE WIND INDUSTRY

In February 2015 the Offshore Wind Accelerator (OWA) program of the Carbon Trust issued the Cable Burial Risk Assessment (CBRA) Guidance, which offered the offshore wind industry a standardised, repeatable and qualitative method to improve risk management of subsea cables for offshore wind farms.

2016

VIBRATION PILE VALIDATION (VIBRO) - PROVIDING IMPORTANT KNOWLEDGE ON THE INSTALLATION AND IN PLACE BEHAVIOR OF MONOPILES WITH VIBRODRIVING

The VIBRO joint industry project (JIP) was a Carbon Trust project lead by RWE with the aim to evaluate the installation of monopiles with the vibro driving technique as an alternative to traditional impact driving.



2017

HYWIND SCOTLAND WIND FARM - FIRST COMMERICAL FLOATING WIND FARM

In 2017 the world's first commercial floating wind farm was commisioned by Hywind Scotland Limited (a JV of Equinor and Masdar) 29km of the coast of Peterhead in Scotland.

The wind warm consists of five 6.0MW Hywind WTGs summing a total of 30MW capacity.

2017

ALPACA CHALK JIP - INTRODUCED A NEW DESIGN METHOD FOR PILES INSTALLED IN CHALK FORMATIONS

The ALPACA (Axial-Lateral Pile Analysis for Chalk Applying multi-scale field and laboratory testing) Joint Industry Project (JIP), developed a new design guidance for piles driven in chalk, through extensive field testing of 36 piles installed at a well-characterised low-to-medium density test site.

First Offshore Wind Turbine in Mediterranean Stands

WIND FARM UPDATE (HTTPS://WWW.OFFSHOREWIND.BIZ/TOPIC/WIND-FARM-UPDATE/)

February 11, 2022, by Adnan Durakovic

Van Oord's jack-up MPI Resolution has installed the first wind turbine at the Beleolico wind farm offshore Italy.

This is the first wind turbine to be installed on a commercial offshore wind farm anywhere in the Mediterranean sea.

Source: Renexia SpA

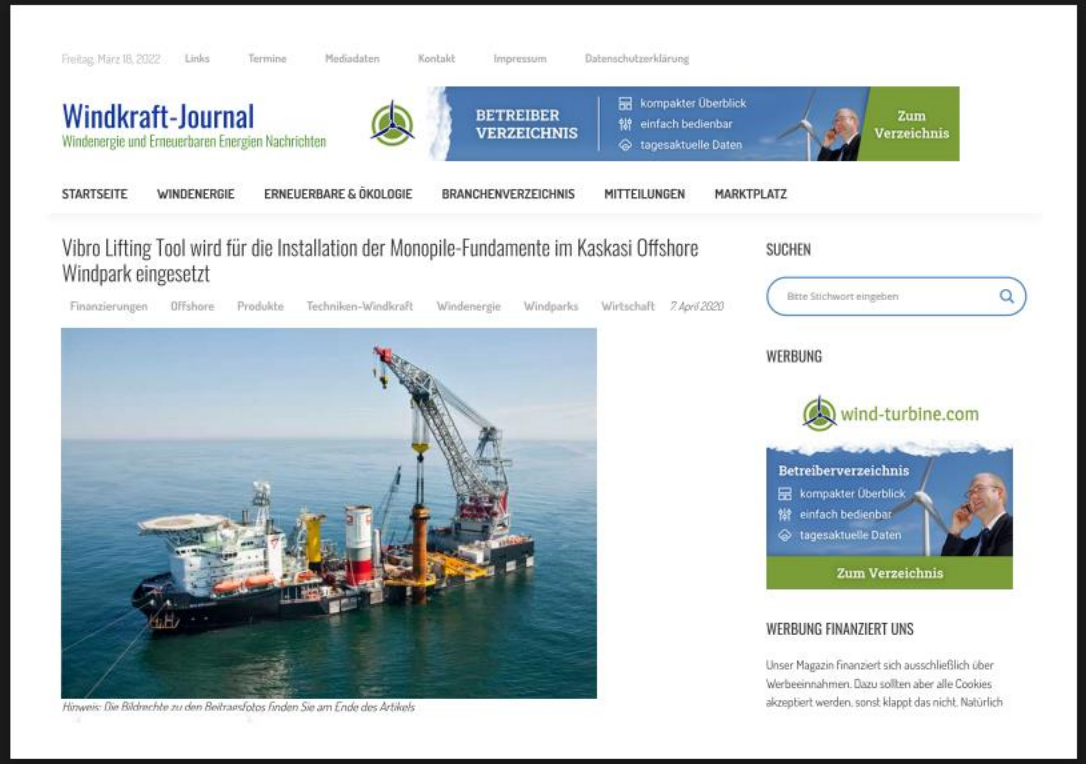
The 30 MW Beleolico, also known as the Taranto offshore wind farm, will comprise 10 MySE 3.0-135 wind turbines provided by MingYang Smart Energy and installed on monopile foundations.

2022

BELEOLICO OFFSHORE WIND FARM - FIRST OFFSHORE WIND TURBINE IN MEDITERRANEAN SEA

The first offshore windfarm in the Meditteranean Sea installed in the Apulia Region of Italy, off the port of Taranto. The Beleolico Offshore Wind Farm consists of ten 3MW (MySE 30.135) wind turbines and when fully commisioned will provide electricity to 18,500 households.

The wind farm is founded on monopile foundations.



Freitag, März 18, 2022 Links Termine Mediadaten Kontakt Impressum Datenschutzerklärung

Windkraft-Journal
Windenergie und Erneuerbaren Energien Nachrichten

STARTSEITE WINDENERGIE ERNEUERBARE & ÖKOLOGIE BRANCHENVERZEICHNIS MITTEILUNGEN MARKTPLATZ

Vibro Lifting Tool wird für die Installation der Monopile-Fundamente im Kaskasi Offshore Windpark eingesetzt

Finanzierungen Offshore Produkte Techniken-Windkraft Windenergie Windparks Wirtschaft 7 April 2020

Hinweis: Die Bildrechte zu den Beitragsfotos finden Sie am Ende des Artikels

SUCHEN

Bitte Stichwort eingeben

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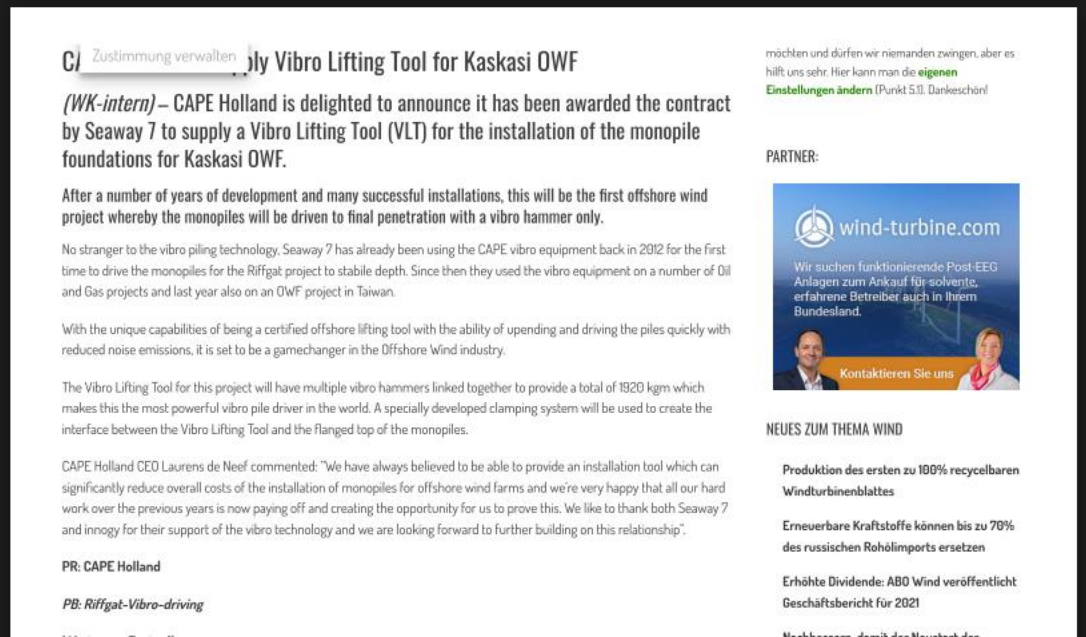

C… …ly Vibro Lifting Tool for Kaskasi OWF

(WK-intern) – CAPE Holland is delighted to announce it has been awarded the contract by Seaway 7 to supply a Vibro Lifting Tool (VLT) for the installation of the monopile foundations for Kaskasi OWF.

After a number of years of development and many successful installations, this will be the first offshore wind project whereby the monopiles will be driven to final penetration with a vibro hammer only.

No stranger to the vibro piling technology, Seaway 7 has already been using the CAPE vibro equipment back in 2012 for the first time to drive the monopiles for the Riffgat project to stabile depth. Since then they used the vibro equipment on a number of Oil and Gas projects and last year also on an OWF project in Taiwan.

With the unique capabilities of being a certified offshore lifting tool with the ability of upending and driving the piles quickly with reduced noise emissions, it is set to be a gamechanger in the Offshore Wind industry.

The Vibro Lifting Tool for this project will have multiple vibro hammers linked together to provide a total of 1920 kgm which makes this the most powerful vibro pile driver in the world. A specially developed clamping system will be used to create the interface between the Vibro Lifting Tool and the flanged top of the monopiles.

CAPE Holland CEO Laurens de Neef commented: "We have always believed to be able to provide an installation tool which can significantly reduce overall costs of the installation of monopiles for offshore wind farms and we're very happy that all our hard work over the previous years is now paying off and creating the opportunity for us to prove this. We like to thank both Seaway 7 and innogy for their support of the vibro technology and we are looking forward to further building on this relationship".

PR: CAPE Holland

PB: Riffgat-Vibro-driving

möchten und dürfen wir niemanden zwingen, aber es hilft uns sehr. Hier kann man die **eigenen Einstellungen ändern** (Punkt 5.1). Dankeschön!

PARTNER:

NEUES ZUM THEMA WIND

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- **Erhöhte Dividende: ABO Wind veröffentlicht Geschäftsbericht für 2021**

2022

KASKASI II - FIRST OFFSHORE WIND FARM WITH MONOPILE FOUNDATIONS INSTALLED BY VIBRO-DRIVING

Seaway 7 will carry out the transport and installation of the offshore substation foundation. 38 wind turbine monopile foundations will be installed by vibro-driving. For the installation multiple vibro hammers will be linked together to provide a total of 1,920 kilogram-metres and a specially developed clamping system will be used to create an interface between the Vibro Lifting Tool and the flanged top of the monopiles.