

ABSTRACTS

International Conference on

Noise mitigation for the construction of increasingly large offshore wind turbines

Technical options
for complying with noise limits

22nd - 23rd November 2018, Auditorium Friedrichstraße, Berlin



Federal Agency
for Nature
Conservation

Marine Nature Conservation Directorate

**Noise mitigation for the construction
of increasingly large offshore wind turbines
Technical options for complying with noise limits**

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ABSTRACTS

Welcome and introduction

Reflection and outlook on the development of offshore wind energy in Germany	4
Impact of Noise Pollution on Fish and Invertebrates with an Emphasis on Pile Driving	5

The threshold value from different perspectives

Impact of underwater sound on harbour porpoises	6
Monitoring of compliance with the threshold value of 160 dB	7
Overview of the efficiency of previously applied noise mitigation systems and outlook	8

Combinable Noise Mitigation Methods

Offshore Pile driving noise: Capability of numerical prediction models and ways to consider new technologies	9
BLUE Piling	10
Vibration-Pile-Driving - A promising alternative to conventional installation methods	11
Environmental impact optimization by smart solutions: IHC Noise Mitigation System	12
Hydro-Sound-Dampers: Effective offshore piling noise mitigation with big monopiles	14

Alternative foundation variants

Foundation Drilling for Offshore Wind - Less Noise and Suitable for Hard Soil	15
Push-in and helical piles - two concepts for silently driven piles	16
The use of Suction Bucket Jackets for Offshore Wind Turbines	17
Suction Mono Buckets - noise free and bankable foundations	18
Gravity base foundation, a noiseless foundation technology	19
Semi-submersible floating wind turbines	20
Minimal noise emission by floating offshore wind foundations - a tension leg platform as one example	21

Welcome and introduction

Tuesday, 22nd November 2018, 13:20h

Reflection and outlook on the development of offshore wind energy in Germany

Thomas Merck

Federal Agency for Nature Conservation (BfN), Vilm / Germany

The development of offshore wind energy in Germany began about 20 years ago. In 2002, the German government developed the Strategy for the Use of Wind Energy at Sea. Guiding principles were that offshore wind energy should be used in an environmentally sound way following a stepwise approach and accompanied by research of environmental aspects. A large number of applications for offshore windfarms have been received. The licensing procedures regulated in the Marine Facilities Ordinance (SeeAnlV) have been repeatedly adjusted since then, taking the requirements of spatial planning and the needs for nature conservation into account. In 2017, the Wind-Energy-at-Sea-Act (WindSeeG) enabled sectoral planning. Since then federal institutions decide on if, where and when suitable areas will be developed as offshore wind farm sites. At the same time it was switched from previously fixed subsidies per kW/h of wind energy to a tender model.

To fulfill the requirements of environmental impact assessments, a Standard Investigation Concept (StUK) was developed and has been revised three times since then (StUK 4 now in place). It includes baseline, construction phase and operation phase studies with respect to noise impact and various protected resources (e.g., marine mammals and birds). The Federal Nature Conservation Act (BNatSchG) implements the EU Habitats and Birds Directives. In order to fulfill their requirements (i. a. prohibition to injure, kill or significantly disturb wild living specimen of specially protected species) a dual legal threshold value for impulsive noise (190 dB SPL/160 dB SEL at 750 m) was developed. To avoid injury (e.g., TTS in harbour porpoises), among other measures, state-of-the-art noise mitigation measures have to be applied and a noise mitigation concept be provided 12 months before construction. The following options are available for this purpose: Primary noise reduction measures change the excitation of the pile by adjusting impulse parameters or pile driving method whereas secondary measures reduce the noise in the transmission path. Further, a number of low-noise foundations are available.

The application of noise mitigation measures and complying with the noise threshold helped to significantly reduce impact zones for injury and disturbance of marine mammals. Depending on various parameters such as pile diameter and water depth, various noise mitigation measures may have to be used in combination. The development of increasing wind turbines and their deployment at increasing depth requires a critical review whether it will be possible to comply with the noise threshold in the future.

Welcome and introduction

Tuesday, 22nd November 2018, 13:40h

Impact of Noise Pollution on Fish and Invertebrates with an Emphasis on Pile Driving

Lindy Weilgart

Ocean Care, Wädenswil/Switzerland and Dalhousie University, Halifax/Canada

Most marine fauna depend on sound for almost all vital functions. To date, around 100 fish and invertebrate species have been shown to be impacted by human-caused noise. These impacts include decreases in growth, body condition, feeding, productivity, abundance, immune competency and nutrition, and catch rates. Noise can also cause permanently damaged ears/sensory organs, developmental delays and malformations, increased stress, and death. Impulsive noise, such as piling, and continuous noise have been shown to impact ecological services such as water filtration, sediment mixing, and bio-irrigation which is key to nutrient cycling. In particular, piling noise impacts abundance, growth, body condition, anti-predator defense, school coordination and cohesion, and caused masking, barotrauma injuries, and stress. Management implications include the apparent inefficacy of ramp ups, intermittent sounds producing slower behavioral recovery, and drilling likely being less impactful than piling, especially if periods of rest between sessions are allowed. Impacts from particle motion, through the seabed or water, also need to be assessed.

The threshold value from different perspectives

Tuesday, 22nd November 2018, 14:20h

Impact of underwater sound on harbour porpoises

Michael Dähne, Josephine Züchner, Jakob Tougaard

German Oceanographic Museum, Stralsund / Germany

In recent years the knowledge about porpoise behaviour during noise impacts has increased drastically. This is partly due to needs developed from having to assess the effects of pile driving noise on the individual and on the population. This talk will give some insight into the history of how noise effects are currently addressed using thresholds for emissions and whether modelling population consequences of disturbance will be used in the future to develop a clearer picture of the long-lasting effects on harbour porpoises. The talk will give some more insight from the Dantysk wind farm that was built in 2013 using noise mitigation throughout the construction period. At this wind farm it was shown, that employed bubble curtains worked as expected by reducing the zone of responsiveness to 12km distance and 5 hours duration after piling. The initial deterrence using seal scarers, thought to protect porpoises from a temporary threshold shift, however showed similar displacement radii as pile driving using bubble curtains. This result highlights, that acoustical deterrence still needs adjustment and may result in a higher population impact of disturbance. Using illustrative noise measurements as an example, the possible role of frequency weighting is explored with respect to different noise mitigation methods. It is furthermore necessary also to focus on the direct behavioural reactions of porpoises to pile driving using noise mitigation. At Dantysk, elevated swimming speeds and increased feeding activity after cessation of pile driving demonstrated, that porpoises were probably not able to feed during piling operations and the lost opportunities for feeding had to be compensated for. This indicates long term energetic consequences of disturbance, even when using noise mitigation.

Research shows that noise mitigation measures can contribute much towards porpoise and seal conservation in windfarm construction areas.

The threshold value from different perspectives

Tuesday, 22nd November 2018, 14:45h

Monitoring of compliance with the threshold value of 160 dB

Manfred Zeiler

Federal Maritime and Hydrographic Agency, Hamburg/ Germany

There has to be a balancing between the national and European greenhouse emission targets and the protection of the marine environment when it comes to the effect of the installation of offshore wind energy facilities on marine mammals. By doing this, Germany is aiming at reducing noise emissions from pile driving at their source. Therefore, a threshold for noise emissions has been introduced by BSH as the authority in charge which has to be met by the developers of offshore wind energy projects in the German Exclusive Economic Zone (EEZ).

The talk focusses on the procedural issues and their implementation from the perspective of BSH. An overview will be given on the development of noise mitigation as well as on the recent regulations during the design and construction of offshore installations for wind energy.

The threshold value from different perspectives

Tuesday, 22nd November 2018, 15:10h

Overview of the efficiency of previously applied noise mitigation systems and outlook

Michael Bellmann, R. Kühler, R. Matuschek, M. Müller, J. Schuckenbrock, S. Gündert and P. Remmers
itap GmbH – Institute for Technical and Applied Physics, Oldenburg / Germany

Underwater noise caused by impact pile-driving during the installation of offshore foundations is potentially harmful to marine life. Therefore, in several nations (e. g. Germany, The Netherlands, Denmark, Taiwan, etc.), noise limiting values were developed to prevent injury of marine life. The experience over the last years shows, that underwater noise produced during pile-driving, depending on many parameters and measurements, shows values, which exceed the national underwater noise limiting value by up to 20 dB. Therefore, Noise Mitigation Systems (NMS) are required to significantly minimize the underwater noise. Since 2011, NMS must be applied during all noisy offshore construction work in Germany, several other nations followed over the last years. The Institute for Technical and Applied Physics GmbH (Itap) was involved in many international offshore wind farm (OWF) projects with pile driving activities (> 1,000 pile installations without and with different NMS in the North and Baltic Sea with water depths of up to 45 m). Based on these underwater noise measurements, the tested NMS were evaluated in accordance to the DIN SPEC 45653 and the ISO 18406.

In this paper, a general overview of the existing and tested NMS, including various tested system configurations as well as combinations of different NMS, is provided. Monopiles with diameters of up to 8 meters and pin piles of up to 3.5 m have been investigated. Focused on the three most often used NMS (Hydro Sound Dampers, Noise Mitigation Screen and Big Bubble Curtain), the measured data and factors influencing the noise reduction are discussed. Based on data measured under offshore conditions, the level of effect of single or multiple NMS and the main limiting factors for the noise reduction are demonstrated. Possible boundaries of currently available NMS in relation to future deep water projects as well as projects using XL or XXL monopiles will be discussed. It will be explored what implications the development towards larger foundations can have for the state of the art in noise mitigation

Combinable Noise Mitigation Methods

Tuesday, 22nd November 2018, 16:20h

Offshore Pile driving noise: Capability of numerical prediction models and ways to consider new technologies

Stephan Lippert

Hamburg University of Technology, Hamburg / Germany

The foundations of offshore constructions, like e.g. wind turbines, are normally attached to the seabed by huge steel piles. Due to the high hammer energies that are needed to drive the piles into the soil, a considerable amount of noise is emitted into the water column. Subsequently, many countries have introduced legal restrictions for the underwater noise to protect marine wildlife. Reliable and accurate prediction models to enable a prognosis of the noise levels prior to construction are therefore necessary to assess the noise emission and configure possible mitigation measures.

Numerical prediction models have proven to be especially capable for this task, as they allow for a detailed consideration of the applied hammer technology, the pile geometry, possible noise mitigation measures as well as the specific propagation conditions in both water column and soil. This contribution explains the general setup of state-of-the-art numerical prediction models and illustrates the possibilities to consider new technologies, like e.g. optimized hammer procedures or new pile designs. Furthermore, also the necessary requirements for a reliable prognosis and the limitations of numerical approaches are addressed.

Combinable Noise Mitigation Methods

Tuesday, 22nd November 2018, 16:45h

BLUE Piling

Jasper Winkes

Fistuca, Delft/The Netherlands

BLUE Piling uses a large water mass to generate the driving force. Sea water inside the hammer is pushed upwards by igniting a gas mixture in a combustion chamber below. The resulting pressure increase generates a downward force and lifts the water column at the same time. A second downward force pulse is produced when the water falls down again. This increases the pulse duration and decreases noise emissions without the need for external noise mitigation methods. Further advantages are a gradual force build-up, a low tension stress and also cost-effectiveness.

The presentation on BLUE Piling will deal with the latest advancements on the development of the BLUE Piling Technology. Following an offshore test with a pile diameter of 6.5 m in summer 2018 the BLUE Hammer has shown to reduce underwater noise levels significantly at the source. In this presentation the results will be discussed.

Combinable Noise Mitigation Methods

Tuesday, 22nd November 2018, 17:10h

Vibration-Pile-Driving - A promising alternative to conventional installation methods

Jens Meyer

innogy SE, Hamburg / Germany

Vibratory pile driving, in combination with conventional hammering, has been used for foundation installation at several offshore wind projects. Foundation installation only by vibratory pile driving has been conducted at offshore wind park projects outside of Germany, and also on test-piles on- and offshore. The experiences from these projects show that vibratory pile driving appears to be a promising technology to lower underwater noise emissions and to shorten installation times. The experience with the sole use of vibratory pile driving for full scale foundation installations in Germany is however limited until now and before this technology can be seen as mature as conventional impact pile-driving by hammering, there are still questions that are to be clarified. We would here like to introduce the Kaskasi project, a full scale 325 MW-project within German waters in the North Sea with a planned installation start in 2021, where we intend to exclusively use vibro-piling thus providing a valuable opportunity to investigate possible effects of vibratory pile-driving on the marine environment to mature this installation method.

Combinable Noise Mitigation Methods

Tuesday, 22nd November 2018, 17:50h

Environmental impact optimization by smart solutions: IHC Noise Mitigation System

Accurate and efficient installation methods contribute with less environment impact

Henk van Vessem and Bob Jung

IHC IQIP B.V., Sliedrecht / The Netherlands

General summary

To limit the environmental impact during installation of offshore wind farms it's important to overview the total scope of activities. Currently the focus is set on noise mitigation in a wide range of frequencies. A closer look at all involved activities might have some "collateral benefits" for the environment.

Method

Noise mitigation is currently partly executed by passive and active systems. To prevent Harbor Porpoise presence deterrent devices must be applied and soft start piling actions need to be executed. Legislation is subscribing that "Harbor Porpoises have to be scared away in advance of piling operations". However during piling campaigns with the NMS it is recorded that Harbor Porpoises return to the site during piling activities when deterrent devices are shutdown. This kind of behavior "could mean" that this mitigation method is very efficient. To enable the developments in offshore wind and secure the energy demand of Europe legislation has to be adjusted to the biological needs in the local environment.

Results

The presented topics contribute to less impact on the environment. (noise/CO₂ emission and duration of the project)

- The Noise Mitigation System (NMS) contributes with a consistent and reliable 360 degrees mitigation during piling activities. This efficient solution mitigates up to 98–100% of the water born noise. At the frequency of 10.000 Hz (re 1 μPa) noise reduction up to 45 dB is reached which is equal to the back ground noise level of 110 dB and of high importance for the Harbor Porpoises. Due to proven, consistent and reliable operation of our NMS it's an accepted solution by Governments. Benefits are the reduction of the overall installation time and costs.
- The PULSE system is a new way of limiting the noise emission directly at source and in many cases is eliminating the need of "Big Bubble Curtains". In this way the passive noise mitigation system reduce the CO₂ emission and protect the environment. The system is not only reducing under water noise, but also limiting air born noise. Introducing a new technique often introduce new challenges, however the PULSE system can be integrated into our current hammer ranges and there by securing the contractor's need to execute the project in time.
- The Combi Lifting Tool CLT contribute by speeding up operations again with safe, accurate and efficient installation execution. A shorter installation campaign is limiting the environmental impact on CO₂ emission and perhaps even more importantly "exposure".

Combinable Noise Mitigation Methods

Conclusions

The offshore wind industry is looking for ways to limit the environmental impact during offshore wind installations in combination with the reduction of installation costs in order to lower the market cost of energy to the market.

NMS – PULSE – Combi Lifting Tool are helping to achieve these goals by speeding up the installation process, improving safety, more accurate, reliable and optimized installation sequences. To reduce the environmental impact we need to look at all activities with a broad view during offshore installations.

Minimizing active noise mitigation systems where possible will have a significant impact on CO₂ emissions.

We solved all challenges at hand and work on the future.

Learning Objectives

Delegates will be given an insight of the installation process and where significant improvements are achieved and allow for opportunities to limit the environmental impact without neglecting safety, efficiency and cost.

Combinable Noise Mitigation Methods

Tuesday, 22nd November 2018, 18:15h

Hydro-Sound-Dampers: Effective offshore piling noise mitigation with big monopiles

Karl-Heinz Elmer

OffNoise-Solutions GmbH, Neustadt/ Germany

OffNoise-Solutions GmbH has developed a noise mitigation method to reduce the noise level of underwater pile driving without energy supply and without influence of tide current.

This HSD-System provides a net with special sound mitigating damping HSD-elements of PE-foam and of air filled balloons. The net is installed around the whole monopile and covers its full height under water. Radiated piling noise can be mitigated directly at the source of noise. The distribution and the sizes of the HSD-elements are variable. It is therefore possible to tune the HSD-nets to the noise frequencies that shall be mitigated.

HSD-nets show high buoyancy forces under water caused by air filled HSD-elements. To compensate these buoyancy forces and to unfold and gather the main net around a monopile, the weight of the HSD-net basket of steel on the sea bottom is used. To install very long monopiles the basket with the included HSD-net is openable.

Characteristics:

- effective near field noise mitigation,
- even of the very low frequencies of today's big impact hammers,
- optimum cooperation and perfect enhancement of double big bubble curtains (DBBC),
- no compressed air and no energy supply required,
- low weight, low space required, no time delay,
- independent from water flow current,
- for water depth up to 60m and wave heights of more than 2.5 m,
- for pile diameters up to 13m and more, for all pile lengths.

Alternative foundation variants

Friday, 23rd November 2018, 9:05h

Foundation Drilling for Offshore Wind - Less Noise and Suitable for Hard Soil

Paul Scheller

BAUER Spezialtiefbau GmbH, Ismaning / Germany

The standard way to install foundation piles – monopiles or jacket pin piles – for offshore wind structures is pile driving. The resulting noise can be dangerous for sea mammals and, as a consequence, must be reduced using expensive and complex methods. This presentation shows, that drilling methods can be used to overcome these issues.

BAUER has developed over the last 10 years several offshore foundation drilling techniques for different soil conditions. In particular, the following methods are described:

- MIDOS pile for predominantly sandy soils – the soil is mixed with cement and simultaneously the structural pile member is installed into the seabed.
- Dive Drill for installation of drilled and grouted piles – a temporary casing is installed through any type of soil or rock using the Bauer Dive Drill and a casing oscillator. Once the borehole is finished, the pile is installed, grouted and then the temporary casing is recovered.
- BSD 3000 for drilling piles in rock. A seabed mounted drilling rig installs a borehole in rock using a full face roller bit. The pile is installed and grouted afterwards.

All three presented methods can be executed from floating or jack up vessels. These methods reduce the dependence on pile driving.

Alternative foundation variants

Friday, 23rd November 2018, 9:30h

Push-in and helical piles - two concepts for silently driven piles

Marco Huisman and Marius Ottolini

Heerema Marine Contractors Nederland SE, Leiden / The Netherlands

The installation of conventional offshore platform and wind turbine foundations by impact pile driving is increasingly being challenged by noise restrictions during pile driving, and for good reasons – it is recognized that the effects of man-made sound at sea can be significant, and can affect the marine environment to a substantial degree. Although noise mitigation for pile driving is possible, it involves substantial cost and operational effort, and with foundation sizes and water depths increasing we are closing in on technical boundaries. Heerema has therefore started a development project with the aim to reduce or completely eliminate piling noise, which could start by developing a complete different type of foundation.

Two concepts are being presented here, that can both serve as an alternative for jacket foundation piles and are therefore suitable for substations as well as deep water wind turbine foundations: a push-in pile foundation, which uses a static force to drive piles into the seabed, and a helical pile foundation, which uses a rotating motion to drive piles fitted with several helical blades into the soil. Both concepts are fully silent, but will require special tools and in the case of the helical pile, an interface with the installation vessel.

Alternative foundation variants

Friday, 23rd November 2018, 10:05h

The use of Suction Bucket Jackets for Offshore Wind Turbines

Avi Shonberg and Andreas Beeken

Ørsted Germany, Hamburg/ Germany

The presentation will give an overview of the use of suction bucket foundations outside and inside the wind energy industry. It will provide a historical context and background information regarding the original use as foundation solution in the oil & gas industry to a use in wind energy industry. It will explain the most important differences between both applications and the experience Ørsted gained so far using suction bucket jacket foundations (SBJ) within the Borkum Riffgrund 1 and 2 offshore wind farms. Finally it will show the opportunities but also the challenges of a SBJ foundation, including a brief reflection about underwater noise during the installation process.

Alternative foundation variants

Friday, 23rd November 2018, 10:30h

Suction Mono Buckets – noise free and bankable foundations

Kristian Ascanius Jacobsen

Universal Foundation, Aalborg / Denmark

A mono bucket foundation is a monopile foundation with a suction bucket seabed interface suitable for sandy soils, clay or combinations hereof. Due to the technical design of the Universal Foundation standalone scour protection is normally not needed. The installation needs no pile driving, therefore there are no emissions of impulsive noise, and thus noise mitigation is not required. The structure is fully retrievable. This results in less environmental impact and – together with fast installation cycles – also in lower cost.

The Mono Bucket foundations have been rigorously tested since 2002, when a still operational 3.0 MW wind turbine (height 89m) on a mono bucket foundation (Ø 12m, height 6m, weight 135t) was successfully installed in marine sediments at Frederikshavn/Denmark. Several mobile met mast on mono buckets have been installed in the North Sea. Installation tests and decommissionings were successfully conducted. The installation of two pilot mono bucket foundations carrying the largest commercially available wind power generator (V164 8.4 MW) is underway for the OWF Deutsche Bucht in the second quarter of 2019. The certified technology is accepted by financiers and insurance companies and the Universal Foundation is now ready for commercial projects being deployed from 2021 forward.

Alternative foundation variants

Friday, 23rd November 2018, 11:35h

Gravity base foundation, a noiseless foundation technology

Katarina Halldén

Seatower AS, Oslo/Norway

As with all energy production, offshore wind power affects the environment to some degree. It is therefore crucial to mitigate the negative impacts in order to conserve the aquatic ecosystem and biodiversity in areas where offshore wind projects are planned or constructed. One of the most pressing issues is the potential effects on marine species from construction noise, especially the noise stemming from pile driving. There are various methods and foundations designs that minimise the exposure to this intense construction noise. One such solution is the use of gravity base foundations, which is an almost noiseless technology since pile driving is not needed during the construction phase. The crane-free gravity based foundation is fast and efficiently towed out to the placement location by two tug boats. It is then deployed by letting seawater fill the hollow foundation and it is thereafter fixed to the seabed by its own ballasted weight. Construction of gravity base foundations therefore not only mitigate the negative impacts of pile driving, it eliminates it altogether and so avoids intense noise pollution.

Alternative foundation variants

Friday, 23rd November 2018, 12:00h

Semi-submersible floating wind turbines

Alda Martins

Principle Power, Lisbon / Portugal

The WindFloat is a floating support structure that allows offshore wind farms to be sited in deep waters, accessing higher capacity and superior wind resources.

The environmental monitoring set for the prototype demonstration was focused on the main receptors and stressors expected for offshore wind projects: seabirds, bats, fish, marine mammals, platform colonisation, water properties, visual impact and underwater noise. The results show no negative impacts.

The WindFloat was able to validate the design, fabrication and installation approach, as a feasible and viable source of clean energy contributing towards the environment and demonstrating the improved social acceptance of deep offshore energy systems.

The very successful 5-year deployment, in the open ocean of the Atlantic, has proven that the technology can meet its promise and is ready for commercialization. In July 2016, having completed all of its project objectives, Principle Power initiated the WindFloat decommissioning process. This was the first time an offshore wind turbine had been dismantled from a floating structure and it demonstrated the procedures to be used in commercial projects in the event of unanticipated major component failure. The turbine has now been transferred to another project and the inspections reveal that the WindFloat foundation itself is in excellent condition.

Principle Power is the most advanced offshore wind company from both Technical and Commercial point of view, thanks to its successful demonstration project WF1 in Portugal, being the leader in floating wind with three projects totaling 99 MW under contract: LEFGL project in France, WFA project under construction in Portugal, and most recently was selected for an additional 50 MW for the KOWL project in Scotland.

Alternative foundation variants

Friday, 23rd November 2018, 12:25h

Minimal noise emission by floating offshore wind foundations - a tension leg platform as one example

Daniel Walia

University of Rostock, Endowed Chair of Wind Energy Technology, Rostock/Germany

Floating foundations do not rely on a fixed connection to the seabed. Rather, different anchor types such as gravity anchors, suction buckets or also drilled or driven piles can be used to hold the floating substructure and the wind turbine on top in place. In a floating substructure with a lowerable gravity foundation the noise emission during installation and lifetime is reduced to a minimum.