Improving the installation of foundations for offshore wind turbines by realistic testing

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Fraunhofer IWES

Short profile of Fraunhofer IWES North-West

Research spectrum	Wind energy from material development to grid connection
Managing Director	Prof. Dr.-Ing. Andreas Reuter
Operational budget 2015	€ 15 million
Staff	150 employees
Locations	Bremerhaven, Oldenburg, Bremen, Hannover
Previos investments in the establishment of the institute	€ 60 million
Forschungsverbund Windenergie	Strategic Association with ForWind and the German Aerospace Center (DLR)

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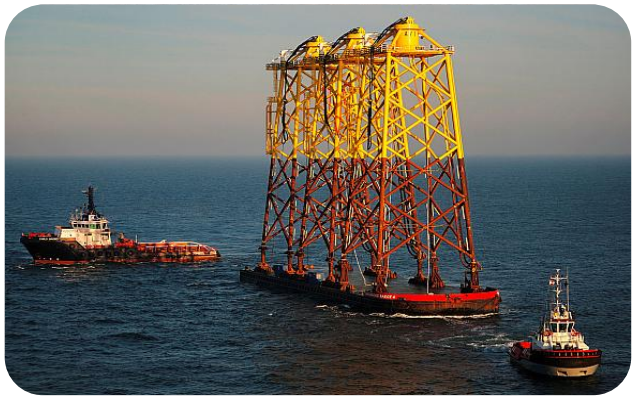
Examples of bottom-fixed substructures

4-legged-jacket



Tripod

rave.iwes.fraunhofer.de

Monopile

fino3.de

Tripile

© BMWi/Holger Vonderlind

Gravity foundation

mhp.pnl.gov

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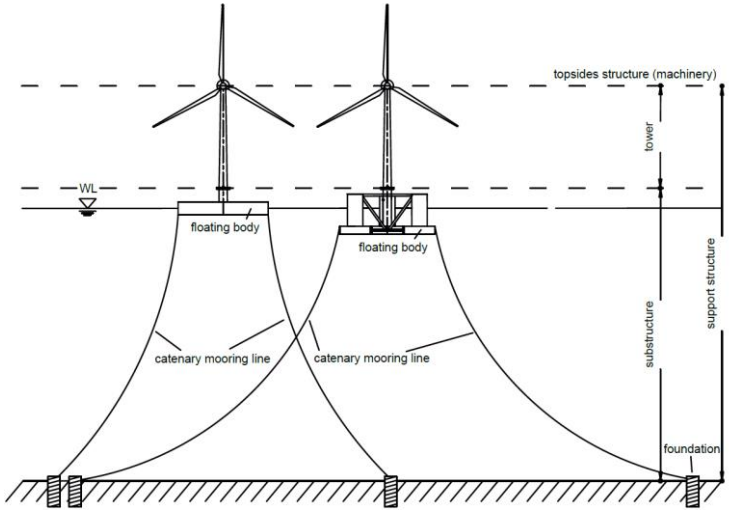
Examples of floating support structures
suitable for high sea depths

WindFloat

EWEA, 2013



GL, 2012

Hywind

statoil.no

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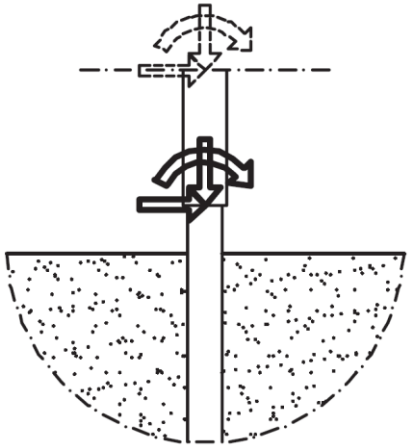
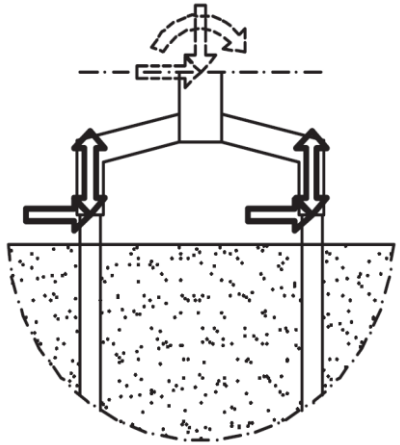
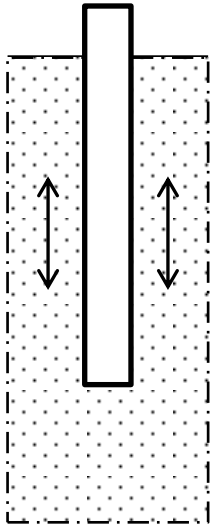
Load transfer

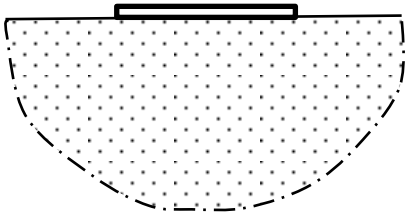


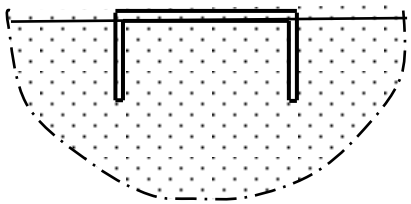
Substructure with monopod foundation



Substructure with multipod foundation







Shallow foundations

The type of substructure dictates the design method for foundations

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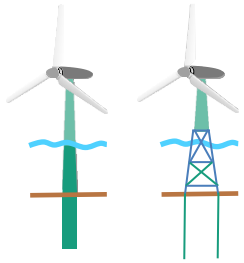
Installation of piled foundations

- state of the art -



Impact driving

Umweltschutzamt, 2006

Drilling

Underwater drill system Seabed Drill BSD 3000
www.bauer-renewables.co.uk

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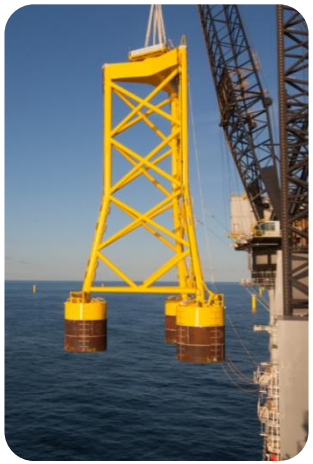
Alternative solutions for the foundation installation

- Impact driven XL-piles
- Vibratory driven piles
- Suction Buckets
- Pile Groups
- Drilled piles
- Pushed piles

XL-Monopile / EEW

Vibro project / rwe.com



Suction Bucket Jacket / dongenergy.com

Universal Foundation

Vallourec.com

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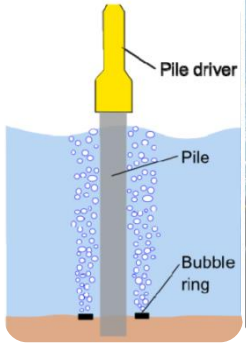
Noise mitigation systems

In Germany:

- Sound exposure level SEL < 160 dB
- Sound pressure level SPL < 190 dB

} at 750 m from the source

Bubble curtain

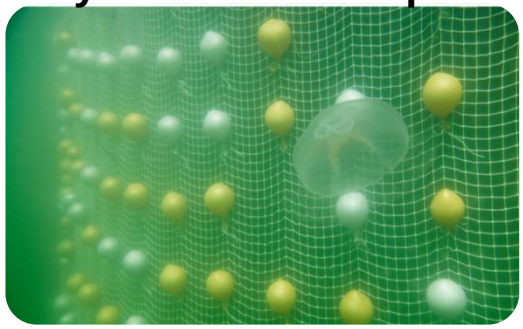


Betke, 2008

Double-wall steel tube with inner bubble curtain

© Patrice Kunte

Hydro sound damper



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Improving the logistic chain
-self-installing foundations -

Seatower Cranefree Gravity®

Seatower

Bucket-based solutions

Universal Foundation

sptoffshore.com

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Challenges in offshore pile installation

- Short weather windows available for installation
- Tight time schedule (1 day vessel operation up to 250.000,00 €)
- Logistic coordination (vessel availability is limited)
- Geotechnical issues (pile refusal, rock layers, boulders, etc…)
- Noise mitigation measures
- Verticality of pile
- Installation effects / set-up effects on pile capacity
- Scour protection and scour evolution

Experimental experiences

Test Center Support Structures Hannover

- Impact driven piles
- Vibratory driven piles
- Pushed piles
- Suction Buckets
- Shallow foundations
- Pile groups (ongoing)

Impact driven pile

Vibration driven pile

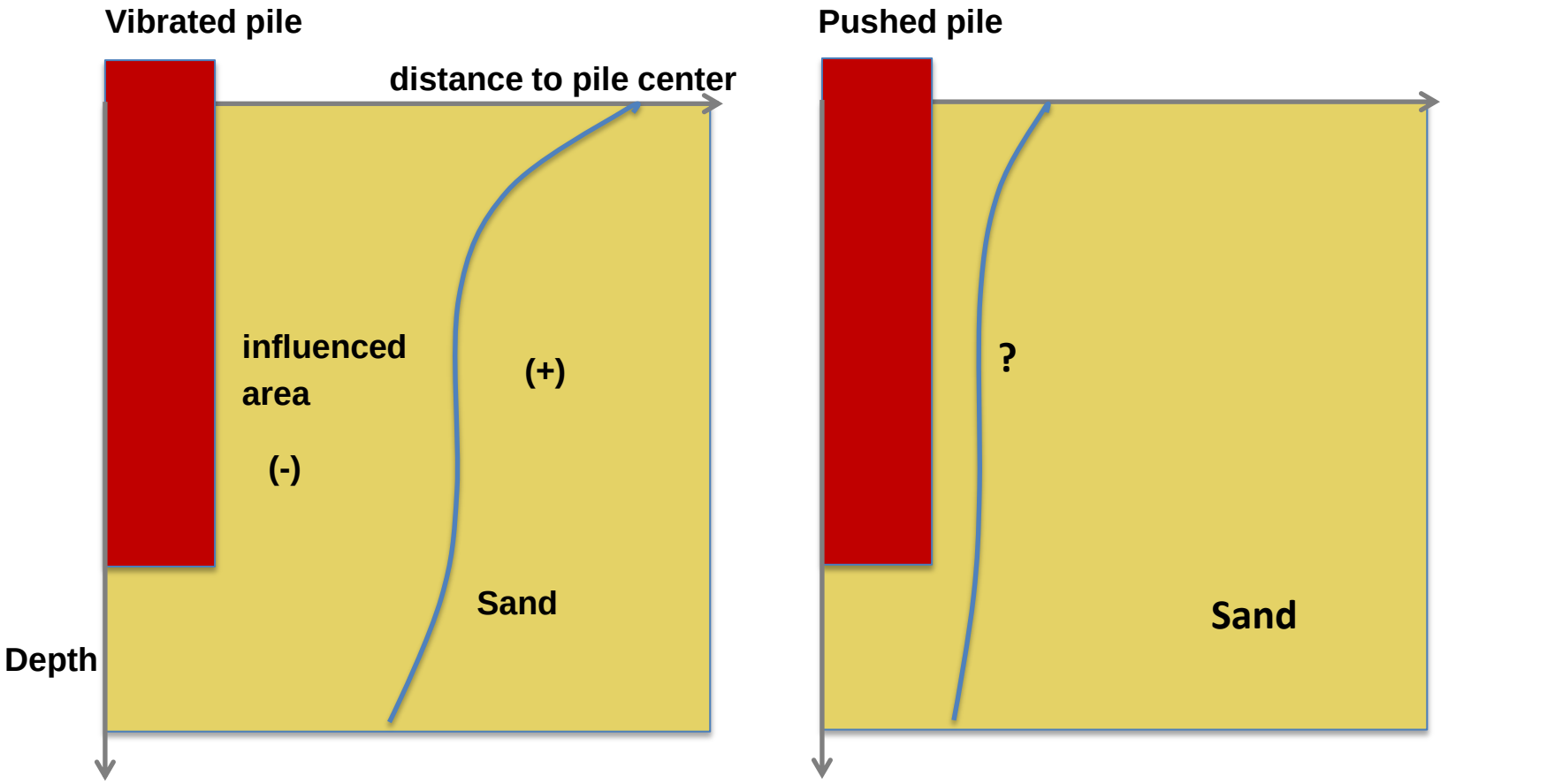
Suction Bucket

Shallow foundations

Experimental experiences

Test Center Support Structures Hannover

Installation effects



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Summary

Improving the foundations installation by realistic testing

- Simulation of different installation scenarios
- Optimization of innovative installation methods
- Evaluation of installation effects
- Pile set-up effects
- Prototype tests: new installation technology and monitoring systems
- Model validation
- Reproducibility

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Federal Ministry of Education and Research

Federal Ministry of Education and Research

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- Senator für Wirtschaft, Arbeit und Häfen
- Senatorin für Bildung und Wissenschaft
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Lower Saxony

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THANK YOU FOR YOUR ATTENTION

Questions?

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