OFFSHORE MONOPILE DECOMMISSIONING ON A SCALED BASIS

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EU5-Market development till 2040

- Decommissioning
- Repowering
- New development

[Prognos, 2011]
German North Sea development till 2040

[Prognos, 2011]
Development of OWF in Europe

- suitable areas
  - limited resources
- repowering
- decommissioning
Offshore Wind Substructures

- Monopile: 76.60%
- Schwergewicht: 8.97%
- Jacket: 5.55%
- Tripod/ Tripile: 5.10%
- Sonstige: 3.44%
- Floating: 0.32%

[Schaffarczyk, 2016]
[Achmus, 2009]
Current decommissioning solution – cutting

- external jet-cutting
  - dredging or excavating
  - external cutting
  - recovering of the pile

![Diagram showing steps of decommissioning](image)

1. Initial situation: turbine and TP removed
2. Sand dredging or excavating
3. External cutting
4. Pile removal and natural sand refill

- Mudline
monopile decommissioning preparation

1. [Sequence of actions]
2. [Sequence of actions]
3. [Sequence of actions]

[m]
monopile decommissioning preparation

1. [Diagram: Monopile structure with sections labeled 1, 2, and 3, and depth of 8.0 meters indicated.]
jet cutting

8.0 [m]

underwater camera
jet cutting nozzle
torch
monopile recovery

78.0 mm
Alternative decommissioning methods

I. Vibrator
   - Crane-uplift
   - Monopile
   - Shaft resistance $F_s = 0$
   - Bulking zone

II. Crane-uplift
   - Monopile
   - Shaft resistance $F_s$
   - Lance guidance
   - Jetting lance

III. Crane-uplift
   - Monopile
   - Shaft resistance $F_s$
   - Ballast ring

IV. Crane-uplift (or without)
   - Sealed pile head
   - High pressure pipe
   - Buoyancy force
   - Inflatable floating body

V. Crane-uplift
   - Sealed pile head
   - High pressure pipe
   - Hydraulic press
   - Lifting movement

VI. Crane-uplift
   - Monopile
   - Shaft resistance $F_s$
Vibratory Extraktion

- excitation of surrounding soil
- "free fall" of soil particles $\gamma \approx 0$
- skin friction drastically reduced
- extraction by lifting (pile + vibro)
Internal Dredging

- reducing the inner shaft resistance
- loose pile toe area
- bulking zone – hydraulic heave
- reducing outer shaft resistance
Internal Dredging

- reducing the inner shaft resistance
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- reducing outer shaft resistance
Air-Pressure / over-pressure

- Buoyancy force
- Inflatable floating body
- Shaft resistance $F_s$
- Crane uplift
- Sealed pile head
- High pressure pipe
- Pressure

- Load cell
- Pressure sensor
- Air/water pressure
- Strain transducer
Air-Pressure / over-pressure

Crane-uplift
sealed pile head
air pressure

IGB-TUBS
Conclusion and Outlook

- steady increase of OWF worldwide
- decommissioning of the turbine and tower $\rightarrow$ construction steps in reverse order
- jet-cutting is an approved method for offshore decommissioning:
  - low risk $\rightarrow$ remote operating

- the need for sufficient decommissioning methods
- alternative methods need to be researched, developed and approved
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**hydraulic/jetting lance equipment**
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Thank you for your attention!