

SeeOff:

Windfarm decommissioning Elements of foundation removal

June10, 2021

Major *technical* context

- Why?
 - Construction 😳
 - \circ Aborted installation (pile buckling, driving problems,...)
 - o NPV
 - i. Low repair value/high repair cost
 - ii. Value of physical location (old vs new 15MW)
 - End-of-life ⊗
- HSE
 - Class-leading Renewables ethics vs "junkyard" ethics
- Legislation
 - $\circ~$ Remove everything vs. "let it crash"
 - o Removal depth



Windfarm Decom overview

- Preparation
- Turbine removal
- Monopile foundation removal (no industry experience w/OWF diameters)
 - Dredging
 - Sub-bottom cutting
 - Lifting & transport to base
- OSS removal (Lots of experience w/ similar jacket removal)
 - \circ Dredging
 - Sub-bottom cutting
 - Lifting & transport to base
- Land based operations

Foundation/OSS removal

- Pile geometry
 - Diameter/length/wall thickness
 - \circ Weight
- Soil conditions
 - Soil friction can be surprisingly high

Lifting capacity ~ VESSEL SELECTION~ technical solution



600 t cap

2x7,000 t cap



Hightech subsea services















CLEANING

DECO experience

- Pile cutting 1440+
- Hole cutting 850+
- Pile dredging 750+
- Cutting depths up to 130 m
- Typical wall thickness 38–130 mm (up to 440 mm)
- 2019 15 jackets
- 2020 17 jackets
- Various other structures (OWF piles, OSS piles, OWF Met masts, salvage,...)

Jacket removal









CUTTING

- UHP abrasive water jet cutting
- Diamond wire cutting
- Classic cut technologies







AWJ advantages

- Nothing in cut: no pinching (disk, wire, milling)
- Multi-layer capabilities: TP/Grout/Monopile
- Precision: kerf = 2-5 mm
- Temporary stability: beveled cuts or castellated cuts
- Can be built into relatively small tools
- Remote operation
- Divers only in exceptional cases



Abrasive Waterjet Cutting: method 1

Slurry method – Simple!

• Mix sand&water in barrel,

pressurize to 600-1500 bar

- Heavy mixing barrel
- Batch operations
- Simple umbilical + nozzle
- high sand consumption
- Umbilical wear (hrs)
- Nozzle wears out (hrs)

Abrasive -Slurry



Abrasive Slurry Jet

Abrasive Waterjet Cutting: method 2

Nozzle mixing method - Powerful

- 3000 bar water
- Mixing after jet formation
- sand consumption 1/3rd
- High energy jet
- Continuous cutting
- Little wear on umbilical
- Superior nozzle life long cuts



AWJ mixing method advantages

	Slurry method	Mixing method
Cutting Power	+	+++
Umbilical wear&tear	heavy, hrs	minimal
Nozzle life	2-6 hrs?	>100 hrs?

+Patented Cut confirmation system: no test lifts...



AWJ advantages (mixing)

- Fast
- Continuous cutting, electronic monitoring
- Reliable: interrupted cut is <u>extreme exception</u>
- Cut confirmation system: we know the cut is complete
- Mature cutting system, we focus on tool design

• Σ : Leads to small weather window with little risk or uncertainty

CL2 Clar types: 200 mm - 1900 mm Already used on OWF's and OSS's (Helwin-Borwin, Wikinger,...)







CL2 Chris Lehouck; 10.06.2021

ToolsHamburger types: 1800 mm - 4000 mmAlready used on OSS's (HKZ, Merkur, Hornsea, St Nazaire...)



Tools

OWF type: 4800 mm - 11000 mm



Tools

OWF type: 4800 mm - 11000 mm













Tools: ICT vs ECT

	Internal cutting	External cutting	ECT, diver installed
Diameter range	2-3 times tool dia	Radius - 500 mm?	unlimited
Technical complexity	Standard	<mark>High to v. high</mark>	Depends
Deck space	Reference	Large tool	Low
Installation procedure	Simple	<mark>Complex</mark>	Difficult
Installation fragility	Robust	Fragile	Can be difficult
Weather exposure	Low/none	High	<mark>v. High</mark>

Yellow items: More risk, ultimately more cost, hence few ECTs

- Example: Passat project budgets (removal of very large test piles)
 - Diver installed ECT was cheapest at first sight
 - ICT build was very expensive
 - Budget&Risk analysis favoured ICT build

Pile Cutting: results

Tool design&proper operations: no spiral cut problems



Pile Cutting: situation









DREDGING

- Pile dredging
- Difficult (Rock/Clay) dredging
- Simple granular material dredging
- Mostly jetting-based









High performance dredging:

- Limestone 116 Mpa
- Grout 135 Mpa
- Granite 184 Mpa
- Maerl
- Clay= worst







DREDGING

Results





Work zones – monopile removal steps



Nett cutting time for 10m dia pile = 4-8 hrs

Work zones – alternative steps



A few caveats (1)

- Reverse installation fallacy
 - Crane capacity may have to be larger than during installation
 - Soil conditions may have changed locally
 - Soil conditions dictate dredging solution
 - Soil/pile wall interaction: influence on extraction?
 - Unexpected objects and situations
 - ✓ Scaffolding
 - ✓ Rope
 - ✓ Cables
 - ✓ Grout

A few caveats (2)

- Temporary work conditions
 - Tool breakdown near end of cut
 - Feasibility of restarting a cut
 - Heavy weather conditions forcing vessel to leave
 - All about stability, safety
- Pile handling! (vessel&transport)
 - \circ **Downending**
 - \circ transport

Risk: time and budget (1)

- Vessel (spread) cost: between 25,000 and 1,000,000 EUR/day
- Weather Windows for critical operations=

Minimum period of good weather, allowing for operations + mitigation + restoring to safe situation in case of incident

• Wind/Wave/Wave period/Current/...

Risk: time and budget (2)



- Min weather window 6 hrs: 5 opportunities
- Min weather window 12 hrs:4 opportunities
- Min weather window 13 hours: 2 opportunities

Risk: time and budget (3)

- Consequence of incidents (e.g. tool breakdown, unexpected situation,...)
 - Knock-on effects:
 - Losing just 1 hour may push the vessel into 2 wks weather delay if vessel has to abort operations
- Reliability of service provider (=DECO focus)
 - Loads of testing & R&D
 - **Project preparation with Main Contractor**!
 - Reliability has a cost and no immediate upside
 - Redundancy has a cost and no immediate upside
 - Spreadsheet blindness&gamblers ☺

Risk: time and budget (4)

• Harsh contracts: LDs do not deal with the real problem

- Service provider "only destroys value" for vessel
 - A cut is a cut is a cut
 - No points for a nice cut
 - Delay destroys value
 - "We live in a negative space"

Thank you.

For more info :Chris Lehouck at

info@deco-subsea.be +32 50 31 10 92