

Hywind experiences from operations and heavy maintenance

Herbjørn Haslum, Equinor

FER FORUM, Saint-Cyr-Sur-Mer, France, 20.11.2024

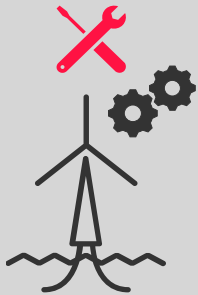
AGENDA

- Main component exchange priorities
- Hywind Scotland MCE 2024 – tow to shore, mooring disconnect, cable disconnect
- Full scale measurements of windfarms
- Access to turbines – CTV/SOV/Helicopter
- Noise / sustainability measurements

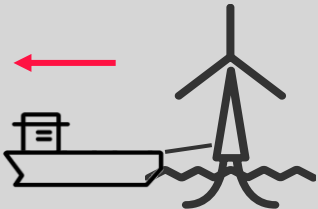


Heavy maintenance / main component exchange (MCE)

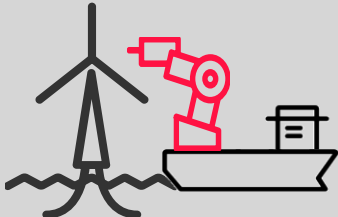
Equinor priorities for main component exchange



1. Up-tower repair and nacelle crane solutions for floating



2. Efficient tow to shore



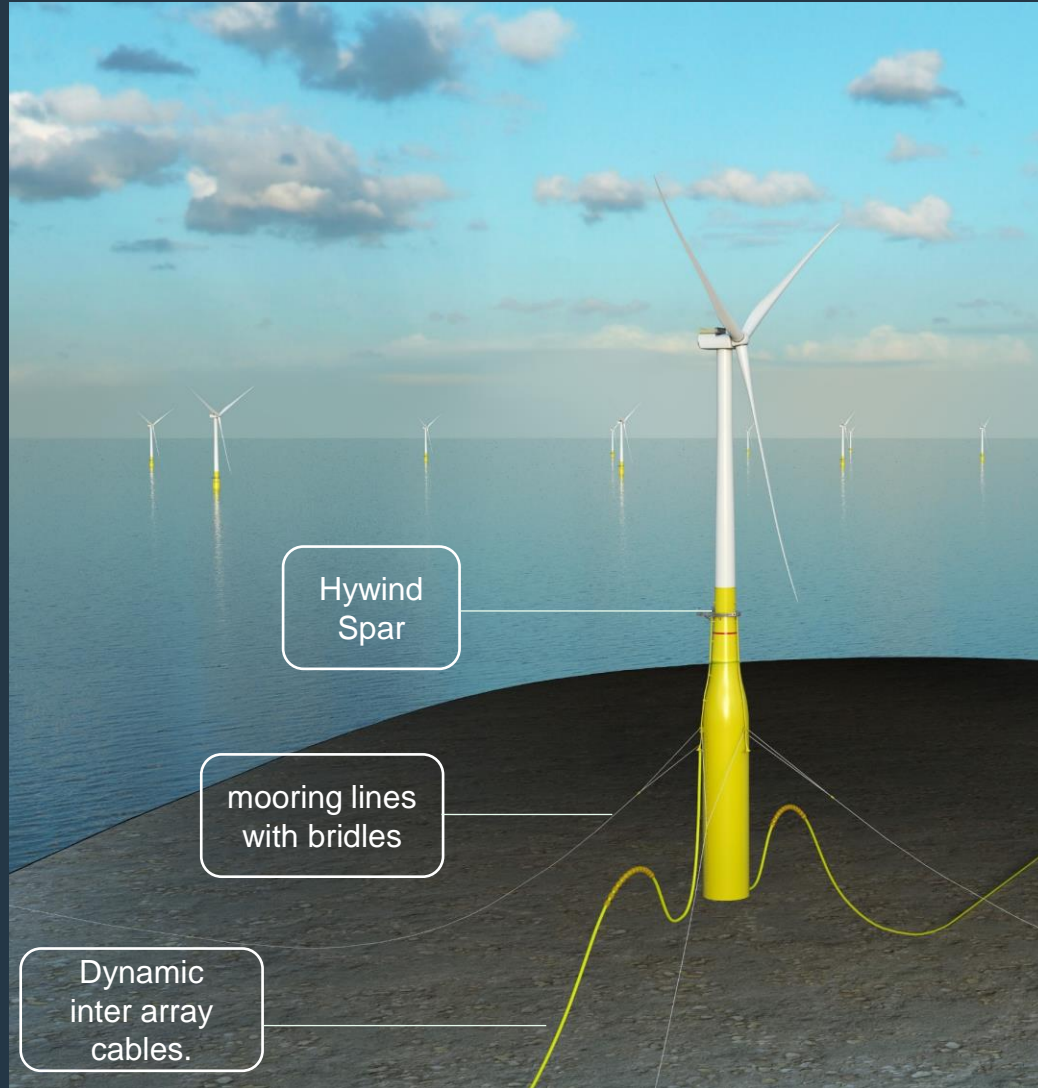
3. Market watch for offshore floating2floating component replacement

Hywind Scotland

Floating to floating WTG installation



WTG installation



Hywind Scotland major component exchange (MCE) Summer 2024

- World first MCE project at scale for a floating windfarm successfully executed
- No major HSE incidents
- All WTGs back in Scotland in one season
- All 5 main bearing replaced
- All 15 blades repaired and upgraded
- Blade bearing replacement
- Cranes repaired
- Repairs after fishing vessel collision

Key success factors

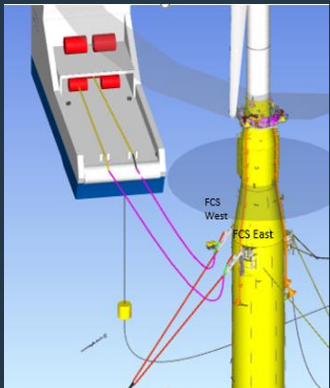
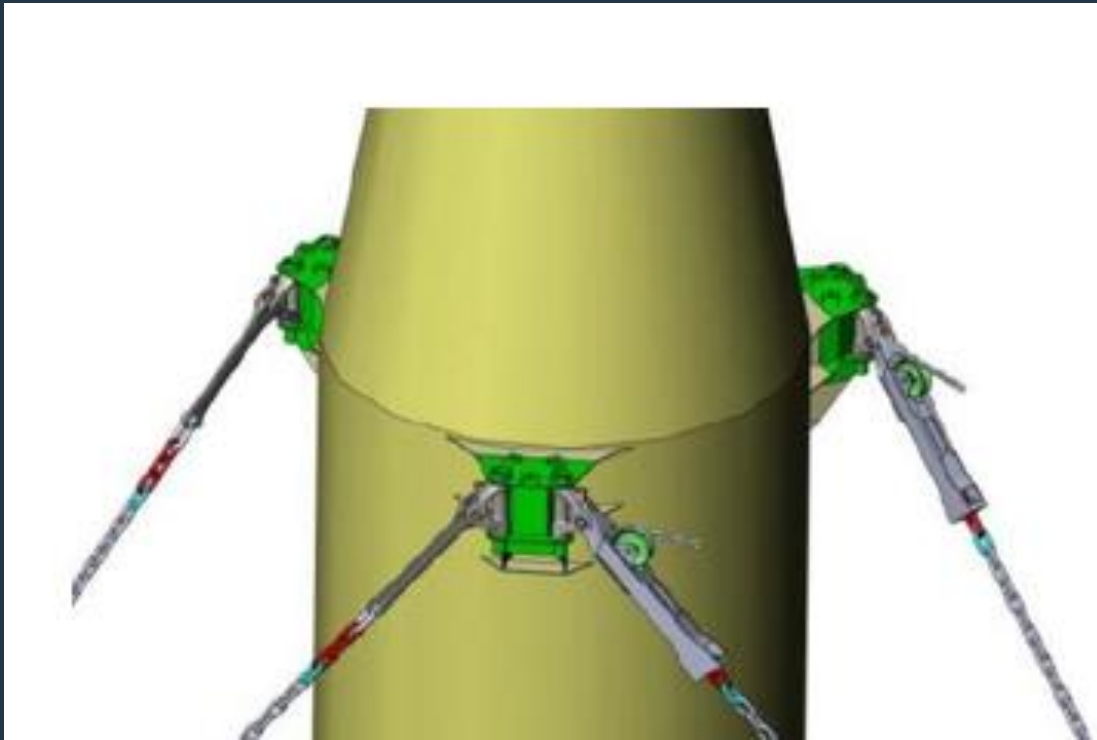
- Strong and shared HSE culture
- Strong cooperation across teams
- Flexible contractors and contracts
- A “one team” problem solving attitude
- Steep learning curve with parallel activities



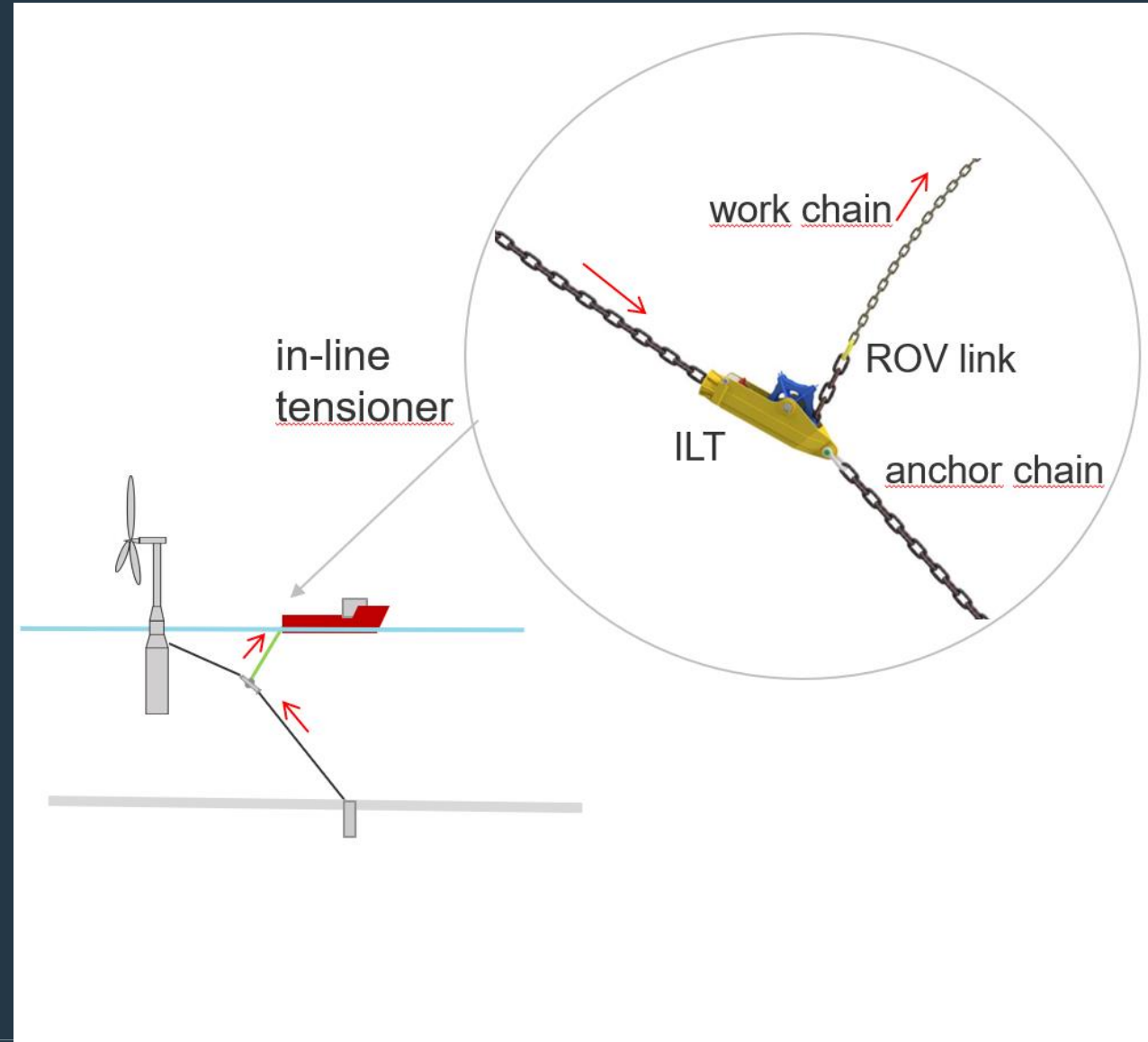
Mooring disconnect / re-connect

Mooring components

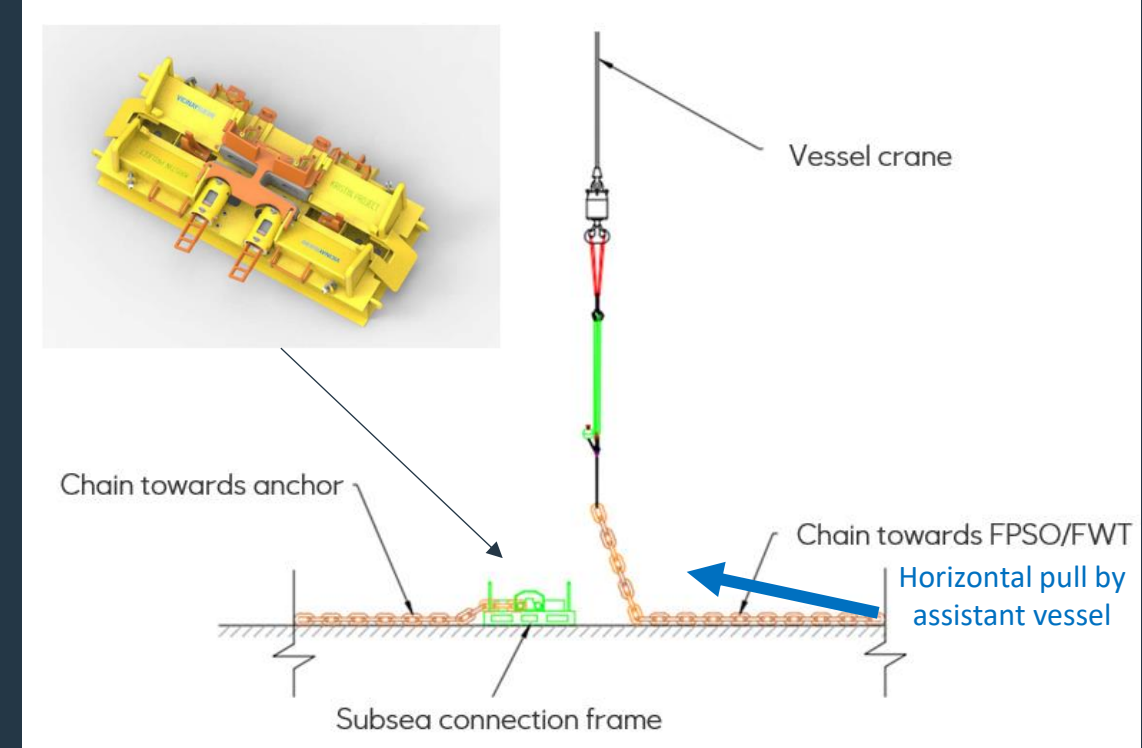
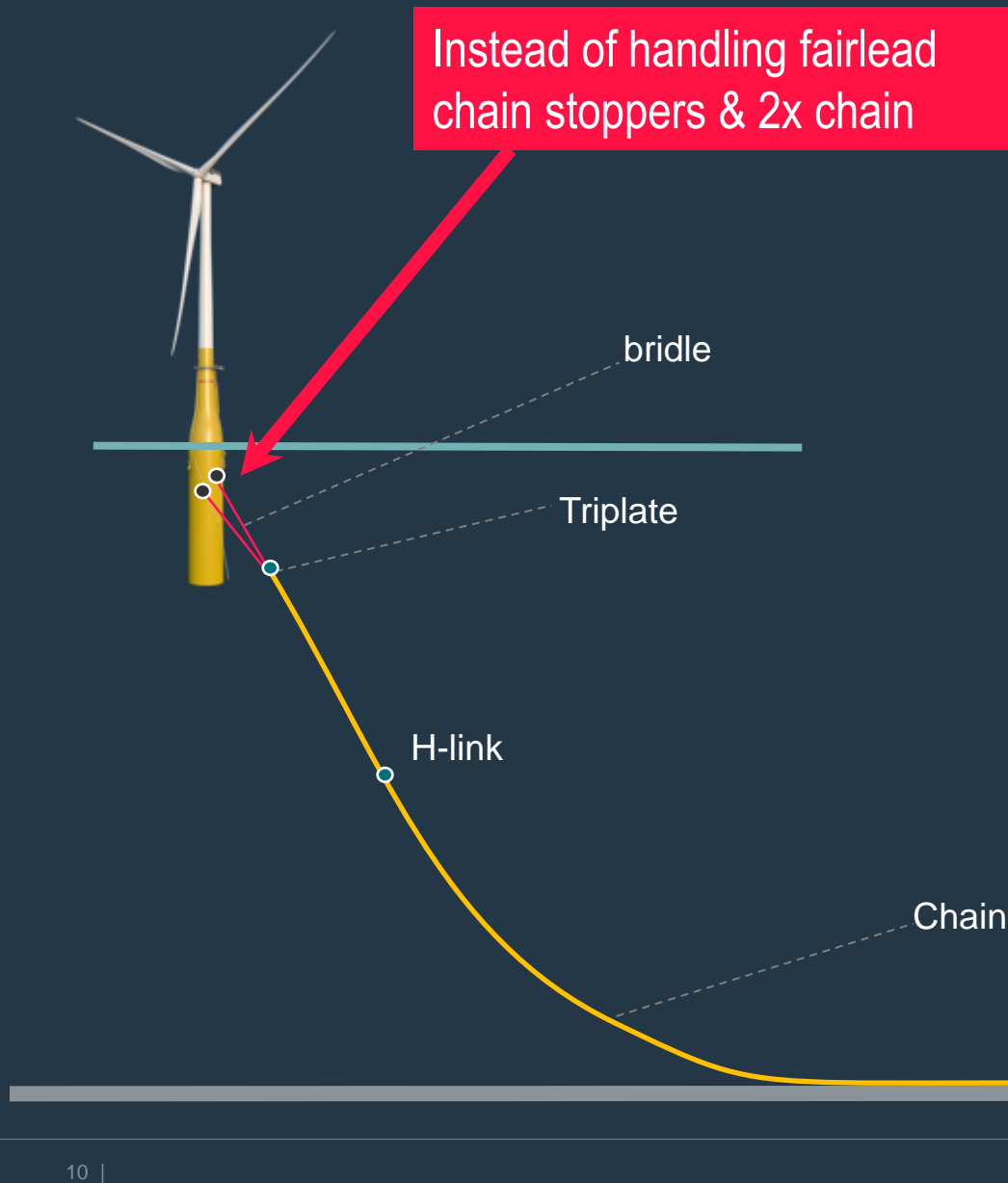
Hywind Scotland: Fairlead chain stopper



Hywind Tampen: Inline tensioner



Hywind Scotland MCE mooring disconnect / re-connect



Cut & re-connect @ seabed using ROV operable H-link

Cable pull-in

Cable pull-in, Hywind Tampen

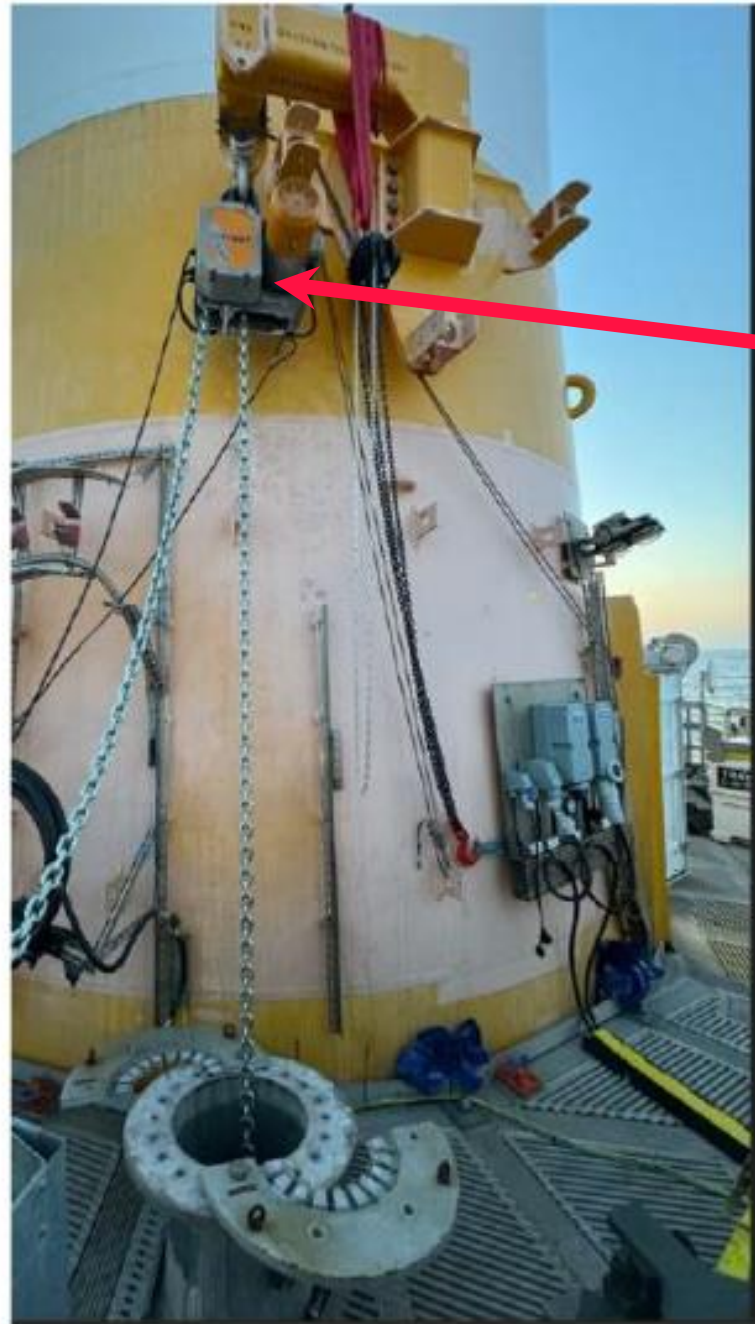


Cable pull-in arrangement, Tampen



Hywind Scotland MCE

cable
lowering &
pull-in



Full scale measurements

Windfarm instrumentation - Demo Phase (2006-2015)

- Development of aero-hydro analysis tools
 - Development of motion controller
 - Validations with model tests
 - Validations with full-scale measurements
- } now state of the art

instrumentation: [motions, tower bending moments, mooring line tensions, power production, rotor speed and blade pitch angle]

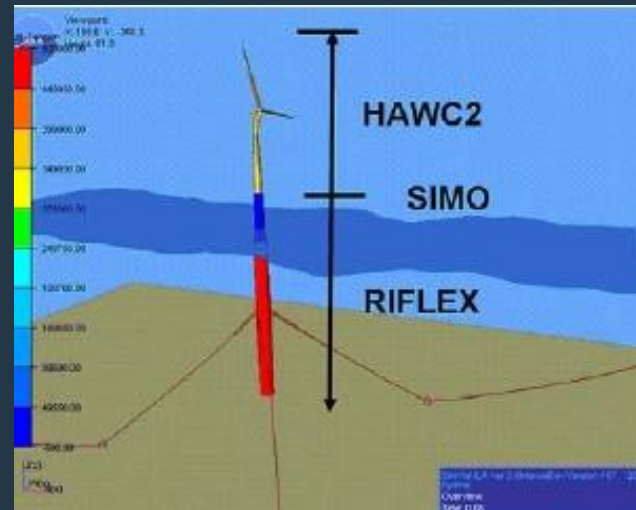
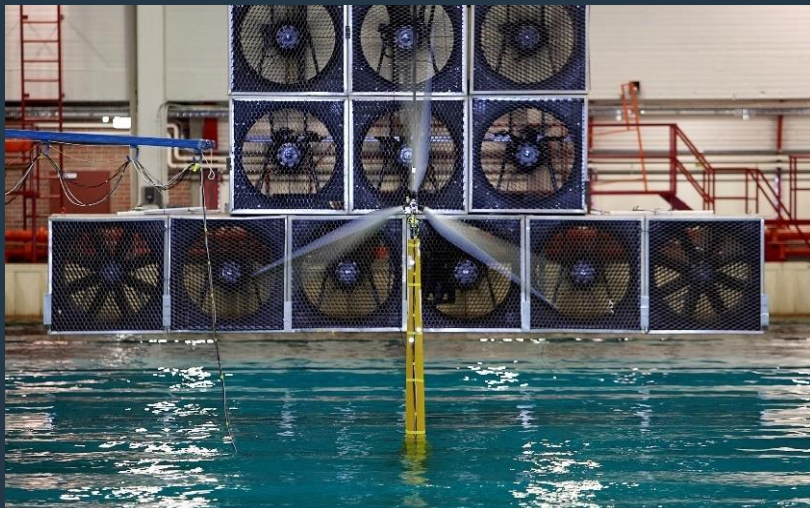
REFERENCES

Nielsen, Hanson, Skaare, OMAE 2006
“Integrated dynamic analysis of floating offshore wind turbines”

Skaare, Hanson, Nielsen, OMAE 2007
“Importance of control strategies on fatigue life of floating wind turbines”

Hanson, Skaare et al, EWEA (2011)
“Comparison of measured and simulated responses at the first full scale floating wind turbine Hywind”

Skaare, Nielsen et al, Wind Energy 2015
“Analysis of measurements and simulations from the Hywind Demo floating wind turbine”



Windfarm phase – Hywind Scotland and Hywind Tampen (2017-)

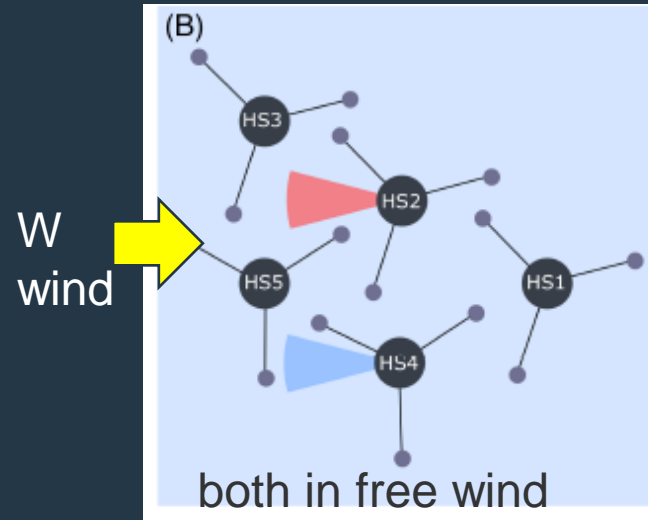
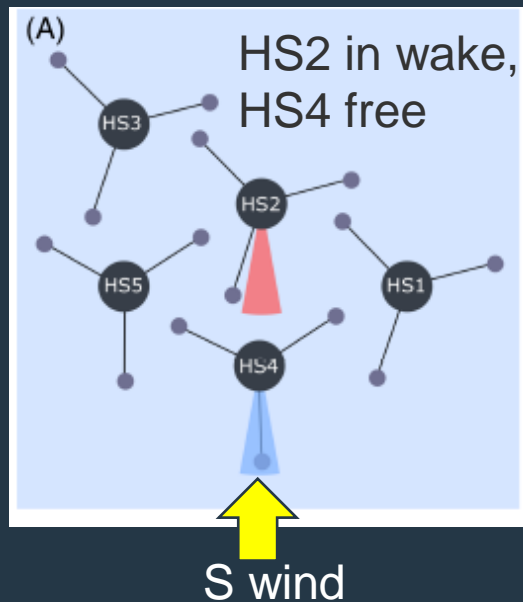


Hywind Scotland

- Park effects
- Production
- Tower stress/fatigue
- Mooring loads
- VIM



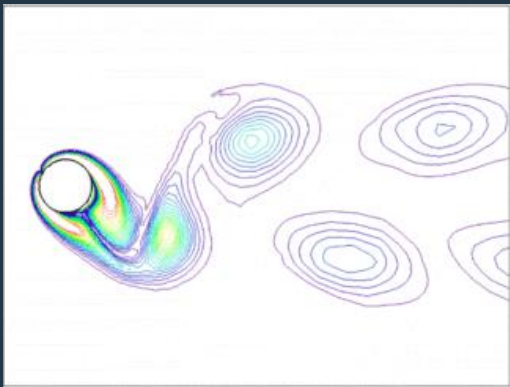
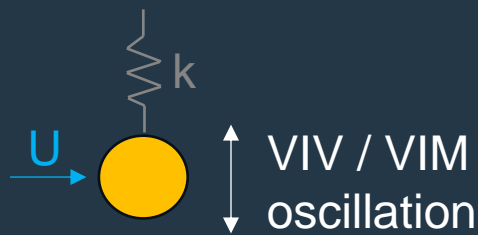
Hywind Tampen



REFERENCES

Jacobsen, Godvik (2021)
Influence of wakes and atmospheric stability on the floater responses of the Hywind Scotland wind turbines
Wind Energy. 2021;24:149–161.

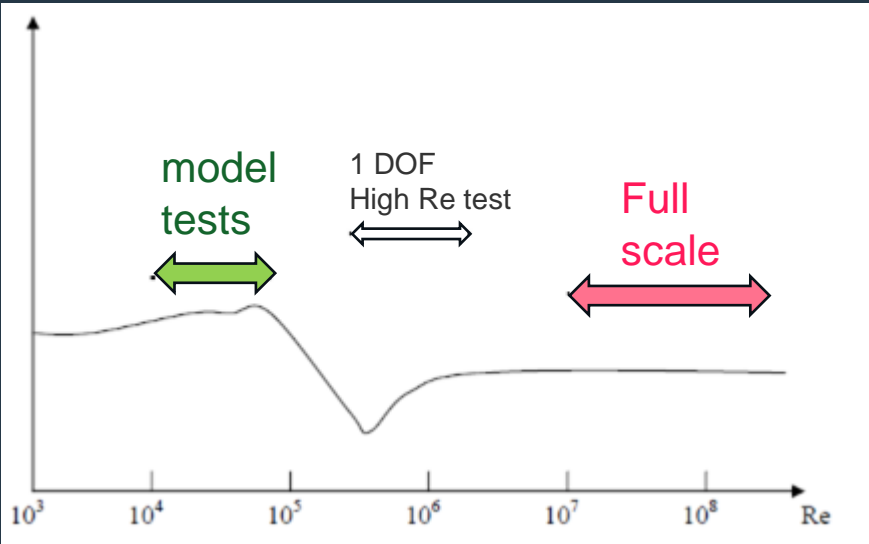
Vortex induced motions (VIM) of spar platforms, general challenge



Vortex-induced vibration - Wikipedia



typical spar model test

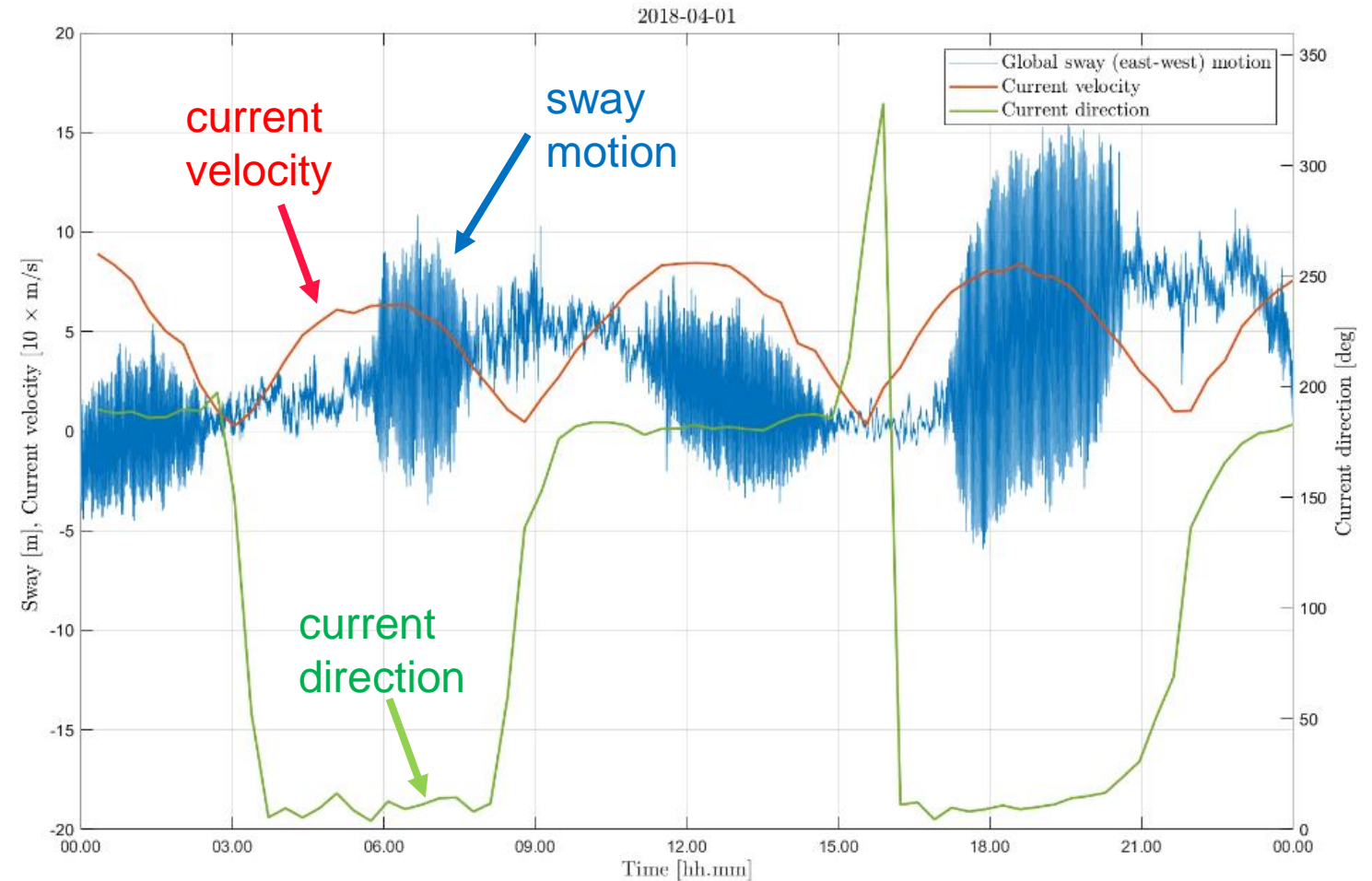
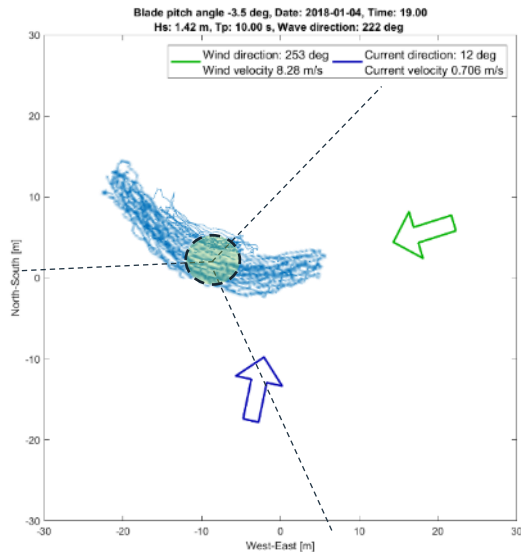
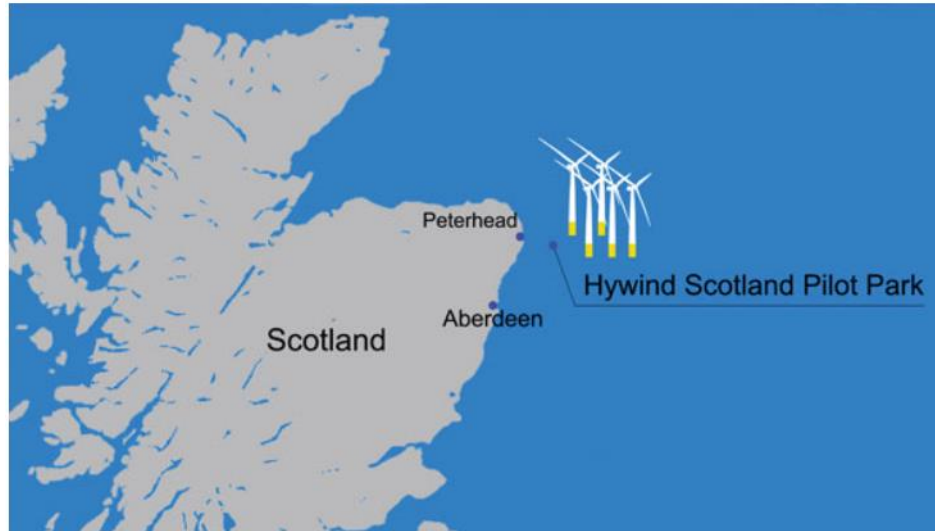


Reynolds number regime	Flow regime	Flow form	Flow characteristic
$Re \rightarrow 0$	Creeping flow		Steady, no wake
$3 - 4 < Re < 30 - 40$	Vortex pairs in wake		Steady, symmetric separation
$30 < Re < 80$ $40 < Re < 90$	Onset of Karman vortex street		Laminar, unstable wake
$80 < Re < 150$ $90 < Re < 300$	Pure Karman vortex street		Karman vortex street
$150 < Re < 10^5$ $300 < Re < 1.3 \cdot 10^5$	Subcritical regime		Laminar, with vortex street instabilities
$10^5 < Re < 3.5 \cdot 10^6$ $1.3 \cdot 10^5 < Re < 3.5 \cdot 10^6$	Critical regime		Laminar separation Turbulent reattachment Turbulent separation Turbulent wake
$3.5 \cdot 10^6 < Re$	Supercritical regime (transcritical)		Turbulent separation

Proceedings of MMS/OTRC VIM Workshop, 2003

H. Schlichting, «Boundary-Layer Theory»

Vortex Induced Motions (VIM) – Full scale measurements from Scotland



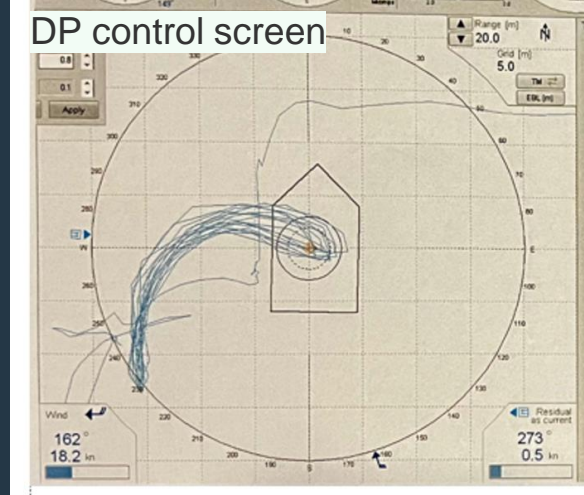
Access to windturbine

Access during VIM events

CTV pushing against Hywind & follow



SOV must follow Hywind



DP Capability studies
when chartering vessel

More results & analysis will
be presented by Equinor on
DP TEKNA 2025

Access systems for O&M

CTV Hywind Scotland



SOV, walk2work, Hywind Tampen (motion compensated gangway)



Helicopter access to nacelle @Hywind Tampen



Full scale monitoring cont'd

... environmental impact / marine life

Noise measurements at Hywind Demo, Scotland and Tampen

Acquire data, learn how continuous noise from wind turbines affects life in the ocean



Mooring system noise

Turbine related noise

Background noise



Seals



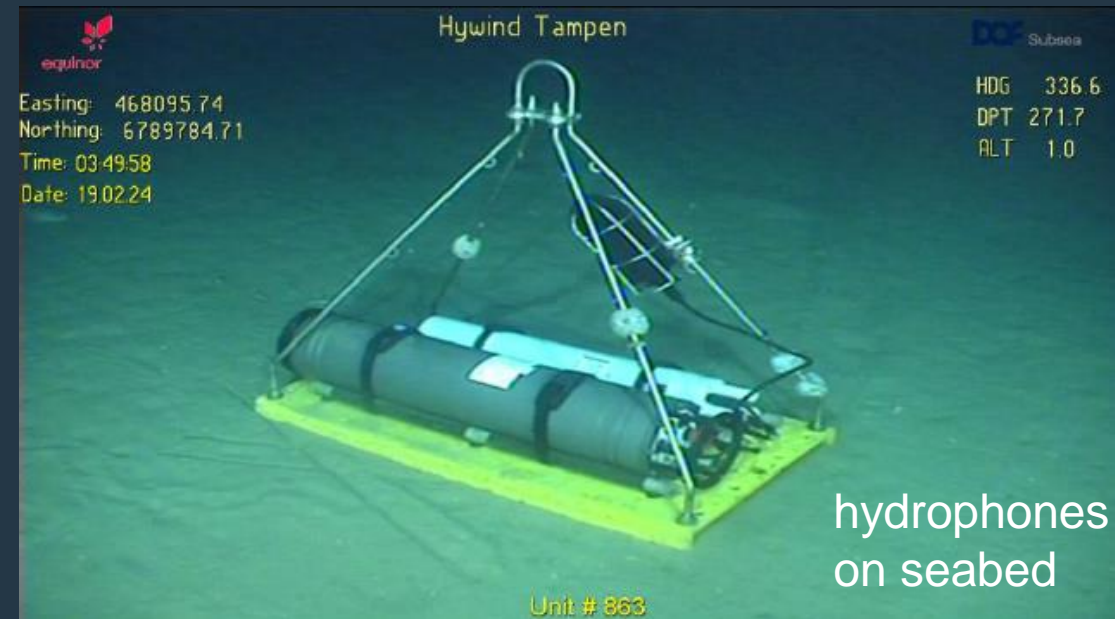
Whales



Fish



Invertebrates



hydrophones
on seabed

REFERENCES

'www.equinor.com/sustainability/impact-assessments-hywind-scotland-pilot-park'

WindSys project – **Havforskningsinstituttet**



Photo: Hofshagen, Equinor

Sunrise for floating wind



Photo: Hofshagen, Equinor

Hywind experiences from operations and heavy maintenance

Herbjørn Haslum, Senior Advisor Floating Offshore Wind, Equinor
hhasl@equinor.com