

Mooring Options and Total Installed Cost for a Commercial Scale Wind Farm

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ACTEON

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Quest Offshore



The Westin Houston, Memorial City 28-29 June 2021

A MARINE ENERGY AND INFRASTRUCTURE SERVICES PARTNER FOR THE ENERGY TRANSITION

ACTEON



Our aim is simple: to be the **preferred engineering, services and technology partner** for all our customers



Through a focus on technical improvement and customer service, **we are enabling the energy transition** across marine infrastructure



Delivering strong **commercial and environmental benefits** in a complex and rapidly changing market.

Presentation Contents

Project Highlights and Drivers

Mooring Types

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Mooring Analysis Results

Total Installed Cost

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Project Highlights



Hannibal Wind Farm



Location: Offshore Sicily



Developers: 7 Seas Wind Power, NiceTechnology and Copenhagen Infrastructure Partners



Floating Foundation: TetraSub - Stiesdal Offshore Technologies



Turbine Size: 12MW



Number of Turbines: 21



Study water depth: 200m

Project Drivers

Minimize Environmental Impact

- Minimize mooring footprint
- Minimize seabed impact

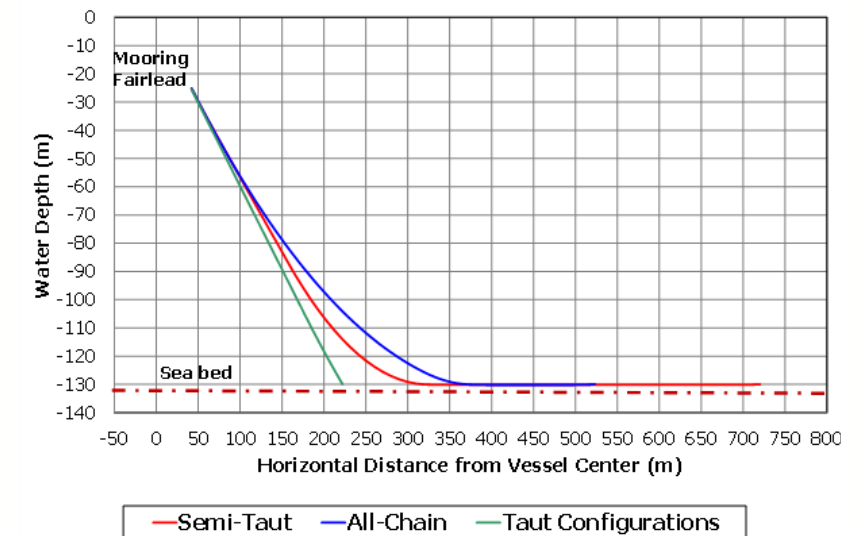
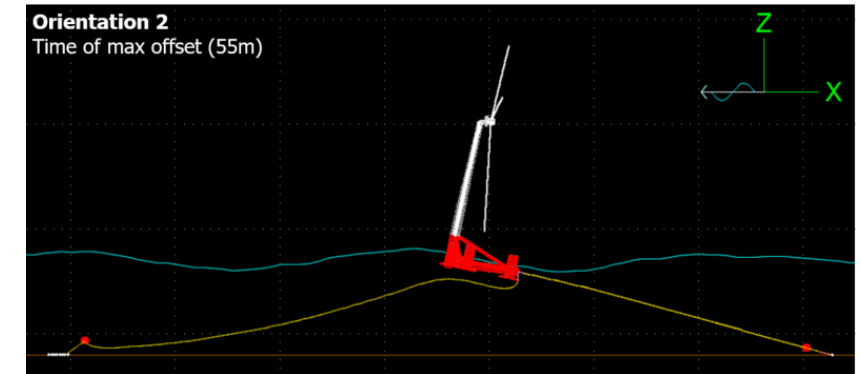
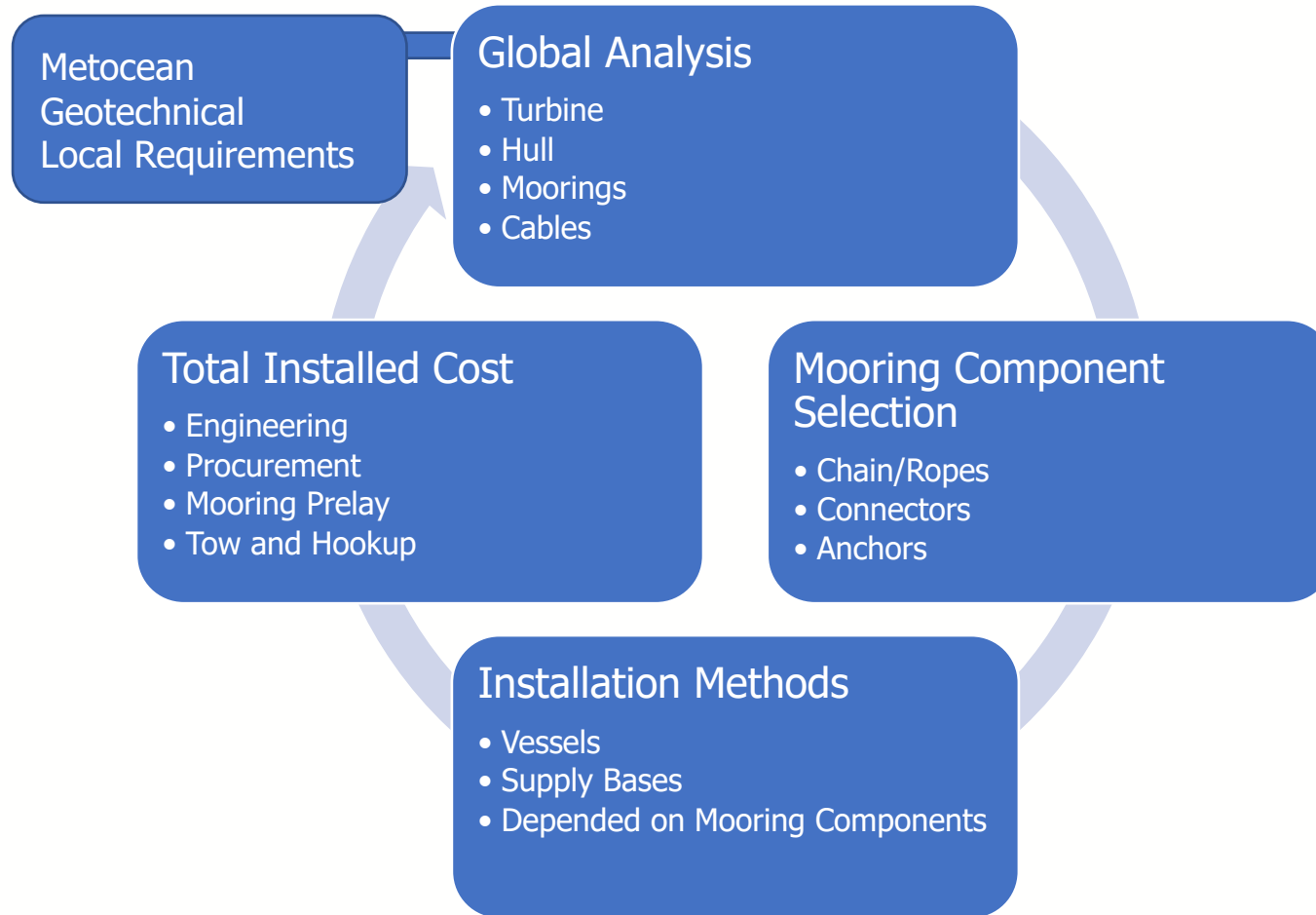
High Bankability

- Use mature mooring technology
- Low risk installation

Economics

- Keep costs low while considering points above

Mooring Selection Process



Floating Wind Solutions

Main Design Criteria

50-year storm conditions

- $H_s = 6\text{m}$
- Wind = 42.5m/s at hub height
- Current = 0.5m/s

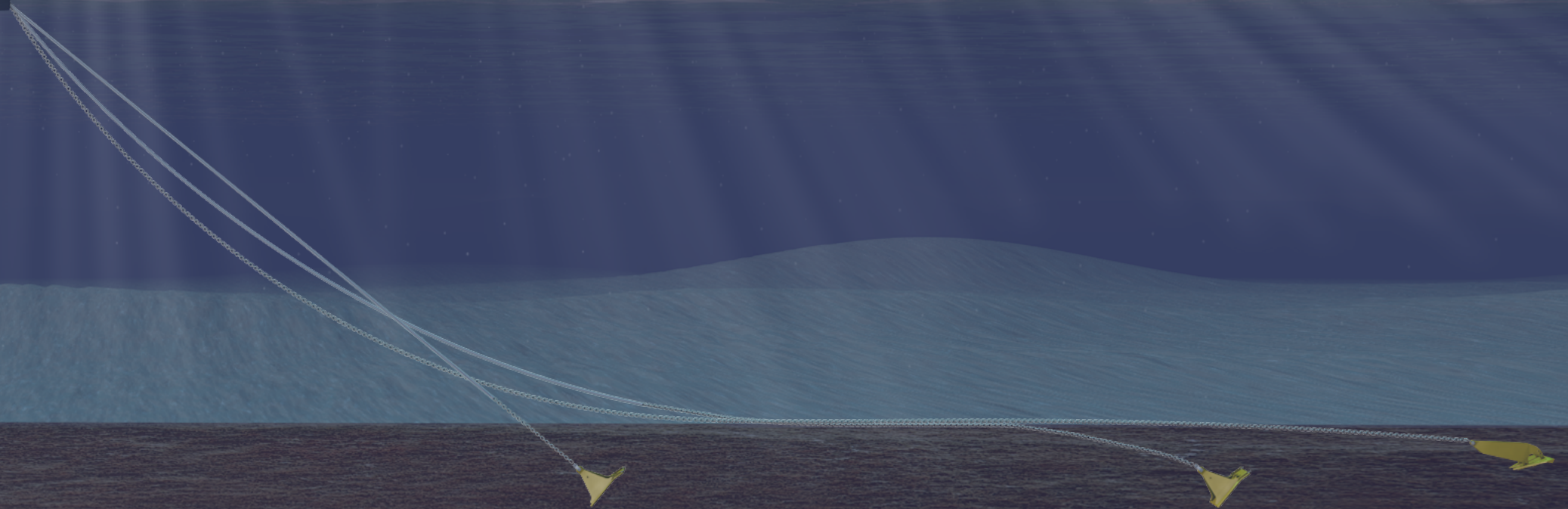
Use DNV-ST-0119

Strength utilization < 0.95
(consequence class 1)

Offset $< 50\text{m}$ (25% WD)

Mooring Types

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Taut

Semi-taut

Catenary

Selected Systems

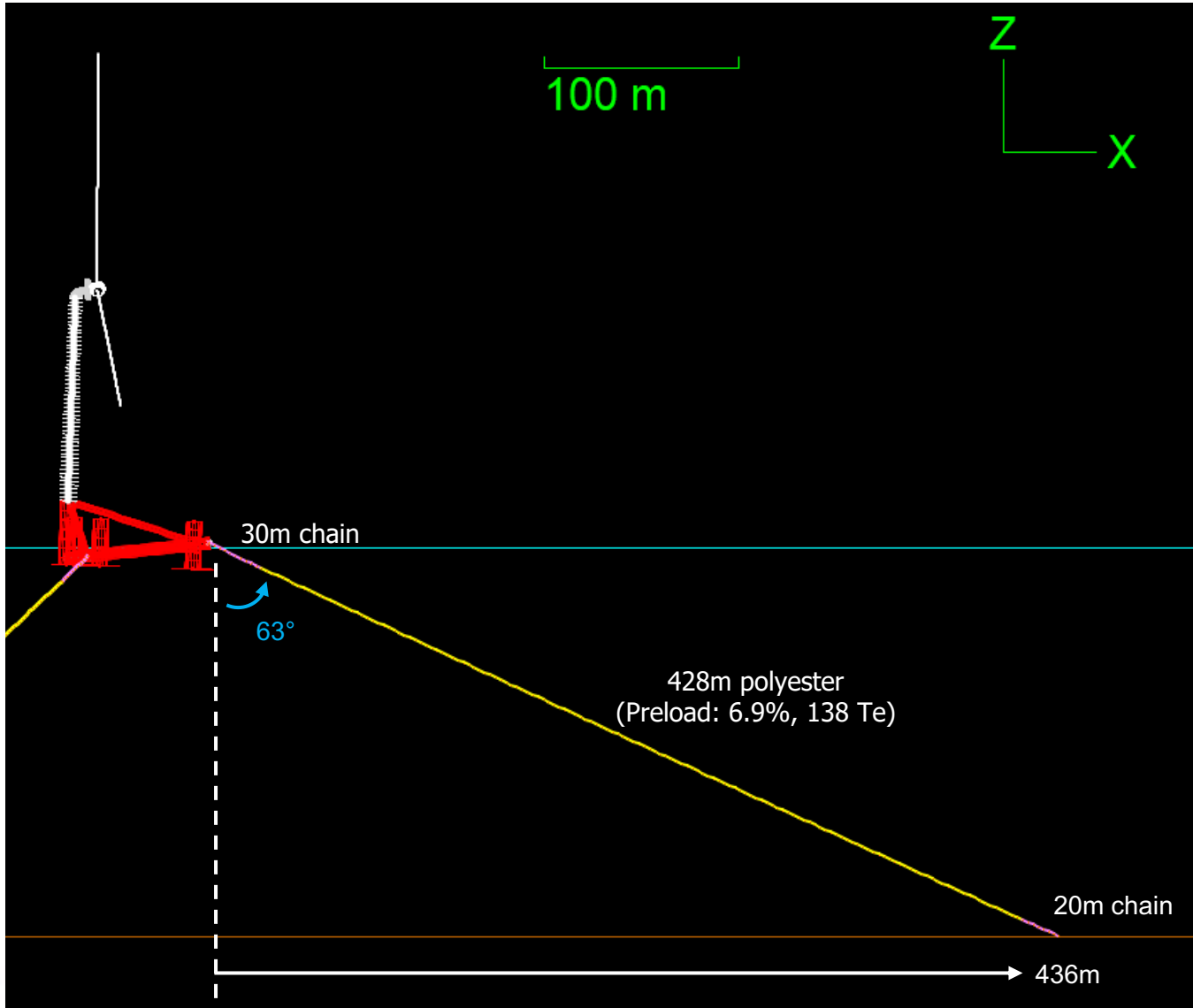
Option 1: Polyester Taut Leg

Option 2: Chain Catenary

Option 3: Polyester Semi-Taut

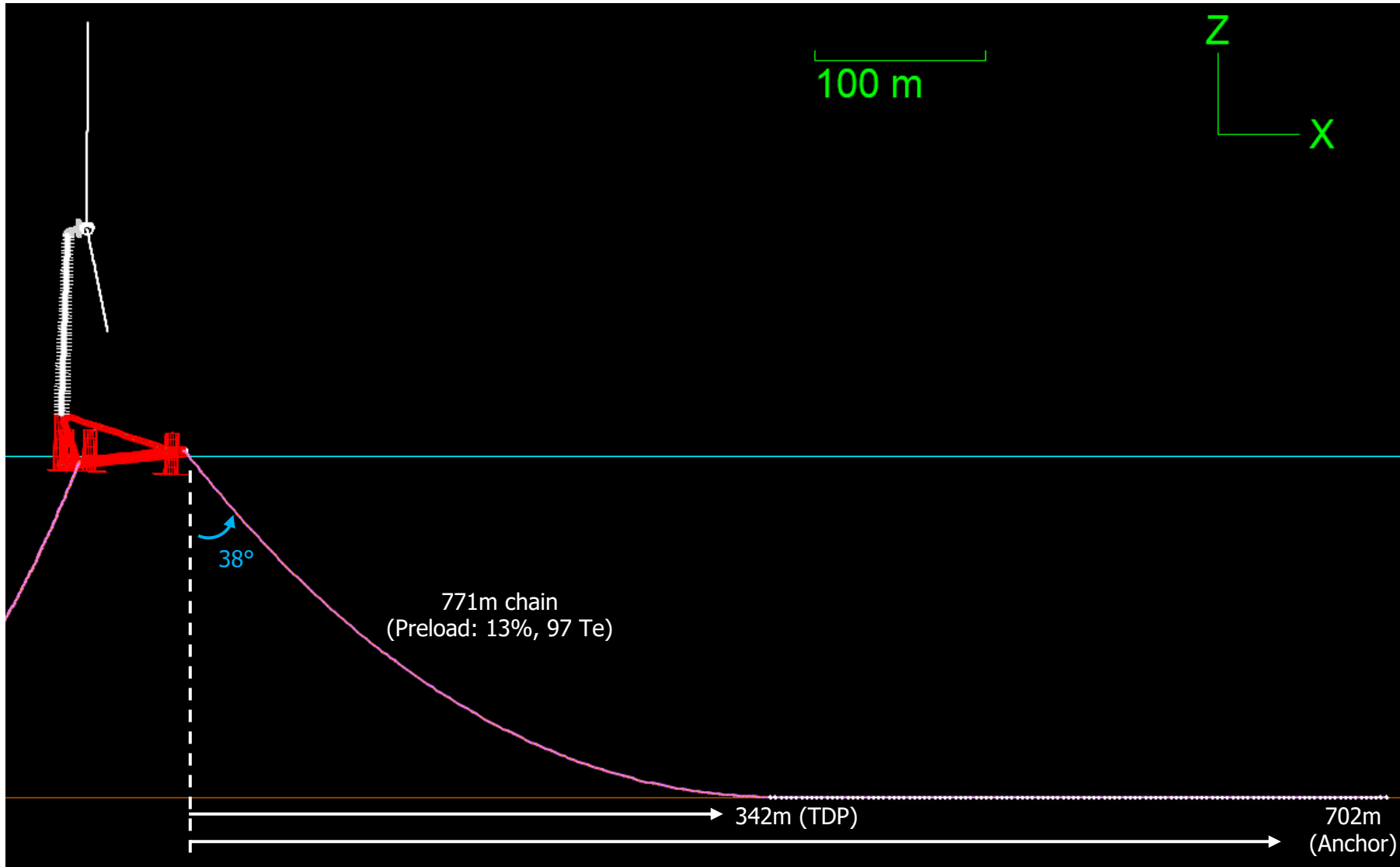
Option 4: Nylon Taut Leg

Polyester Taut Leg



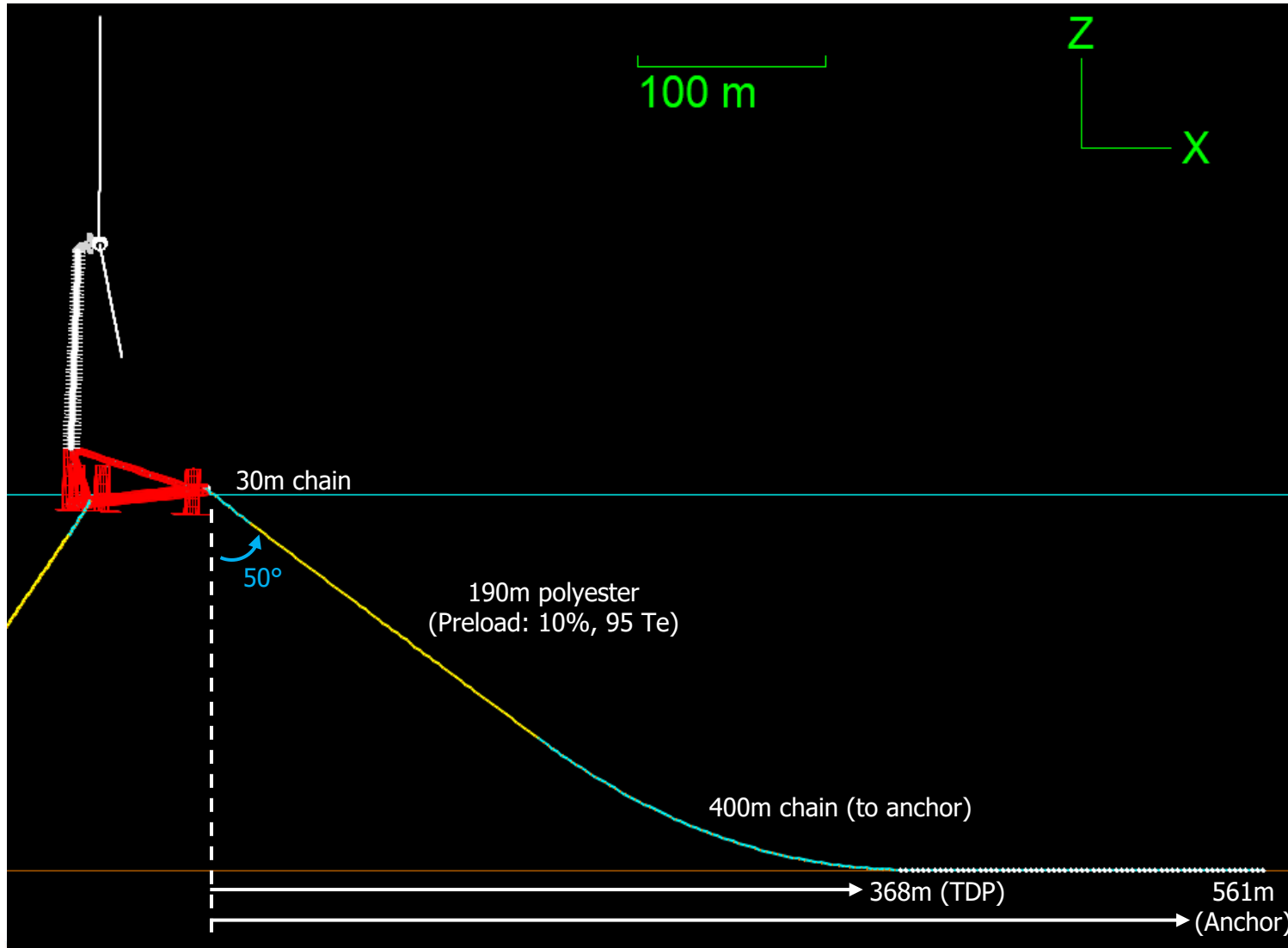
- Components (Total Length: 478m):
 - Top Chain (30m):
 - 145mm R5 studless chain
 - 2,024 Te MBL when considering 8mm corrosion
 - Polyester Rope (428m unstretched):
 - 2000 Te MBL
 - Bottom Chain (20m):
 - 145mm R5 studless chain
 - 2,024 Te MBL when considering 8mm corrosion

Chain Catenary



- Components (Total: 771m):
 - Chain (771m):
 - 103mm R3 studless chain
 - 747 Te MBL when considering 8mm corrosion

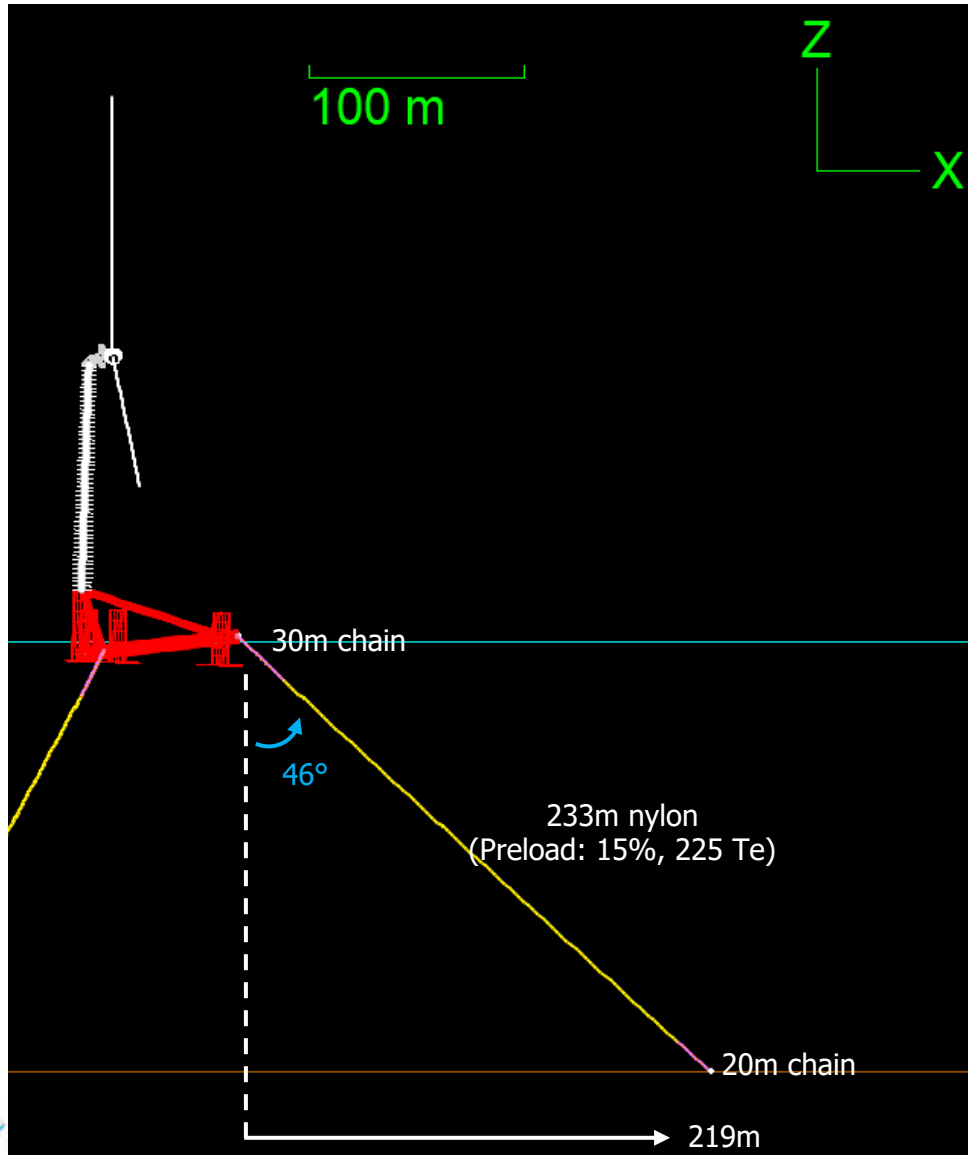
Polyester Semi-Taut



Components (Total Length: 620m):

- Top Chain (30m):
 - 111mm R4 studless chain
 - 1,060 Te MBL when considering 8mm corrosion
- Polyester Rope (190m unstretched):
 - 1000 Te MBL
- Bottom Chain (400m):
 - 124mm R3 studless chain
 - 1,062 Te MBL when considering 8mm corrosion

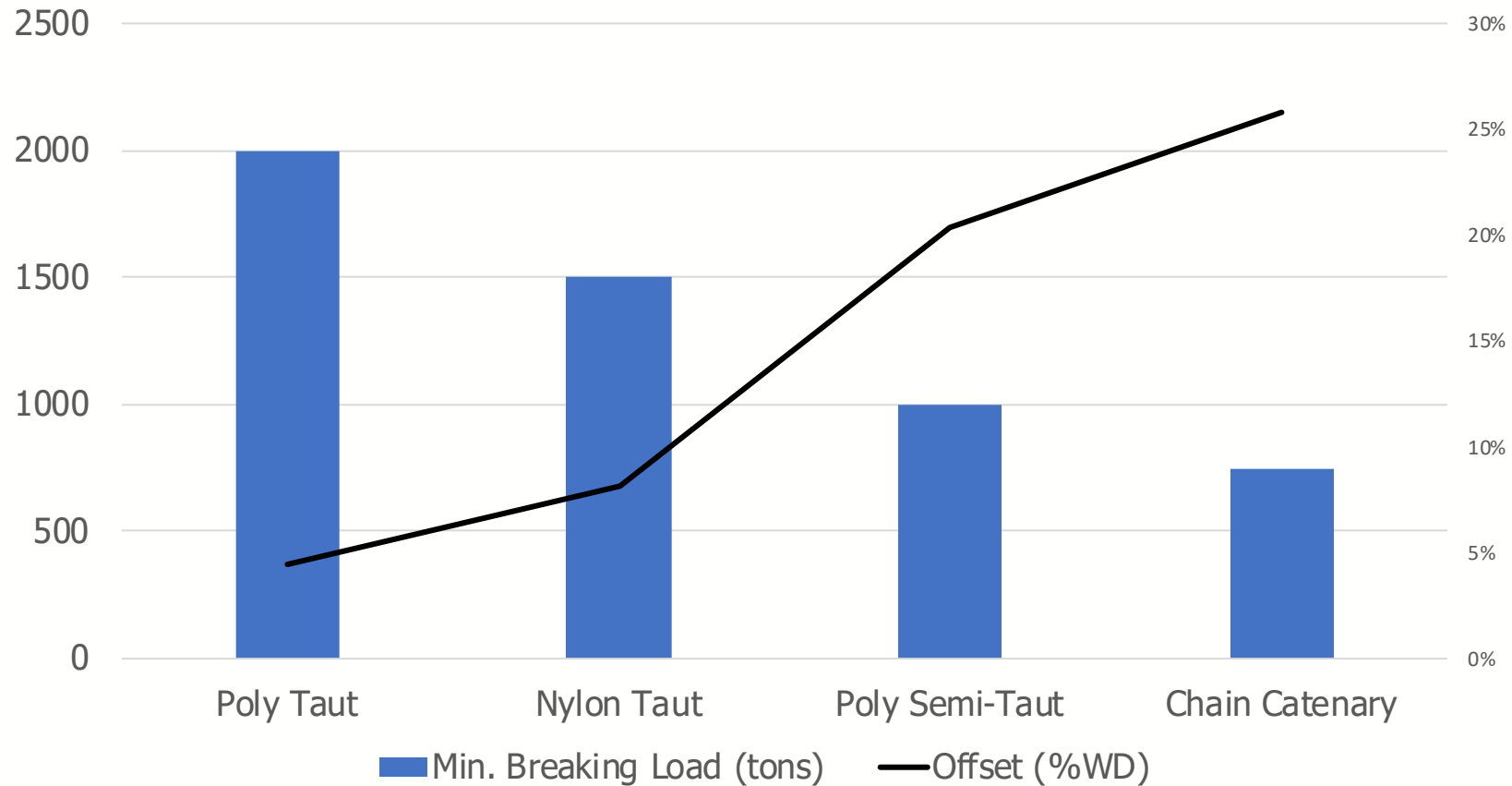
Nylon Taut Leg



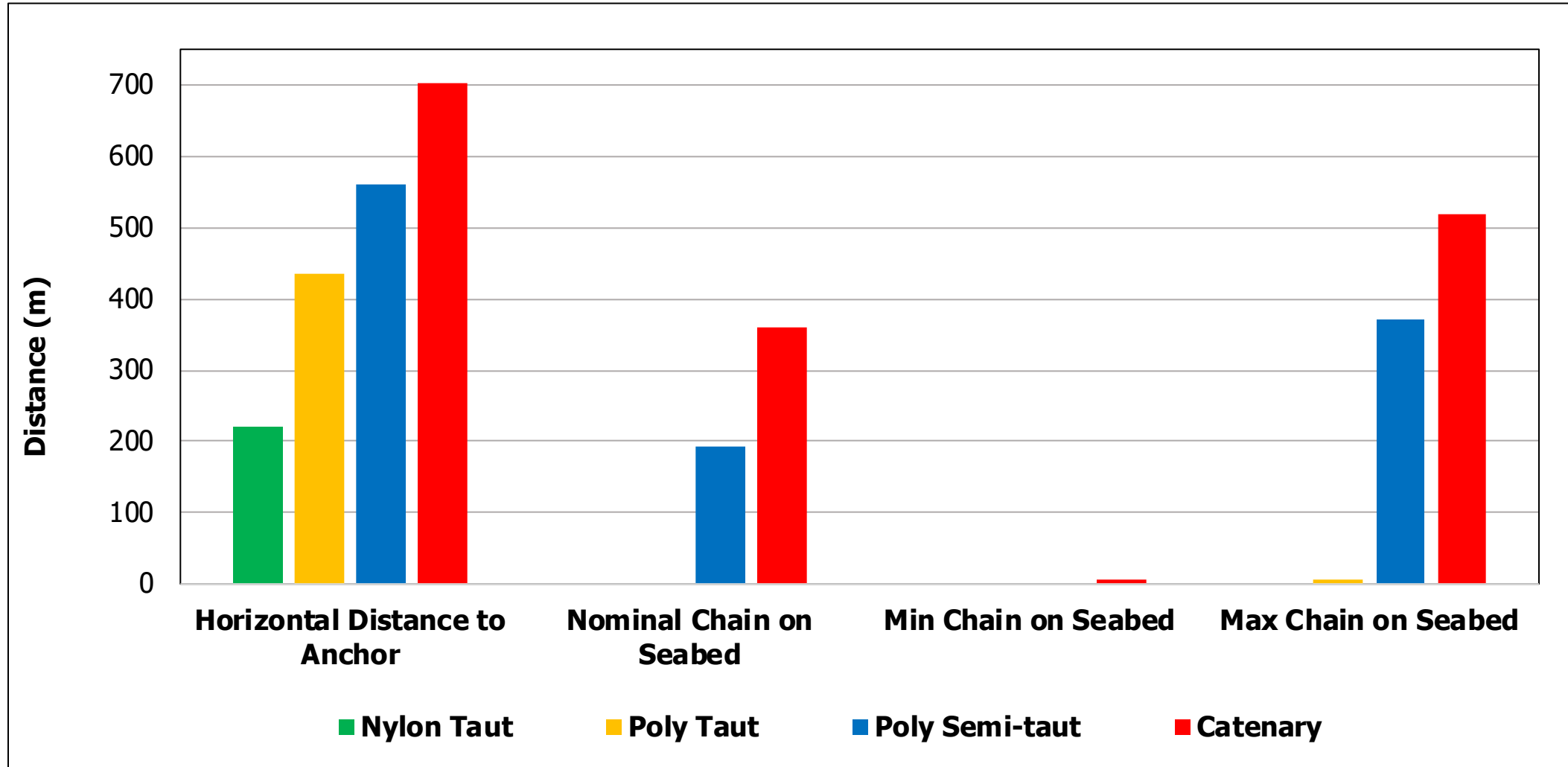
- Components (Total Length: 283m):
 - Top Chain (30m):
 - 175mm R4 studless chain
 - 2,567 Te MBL when considering 8mm corrosion
 - Nylon Rope (233m unstretched):
 - 1500 Te MBL
 - High stiffness for in-line (30xMBL)
 - Low stiffness for between-line (10xMBL)
 - Bottom Chain (20m):
 - 175mm R4 studless chain
 - 2,567 Te MBL when considering 8mm corrosion

Mooring Analysis Results

Min. Breaking Load and Offset



Mooring Footprint and Chain on Bottom



ANCHOR TYPES FOR FLOATING WIND

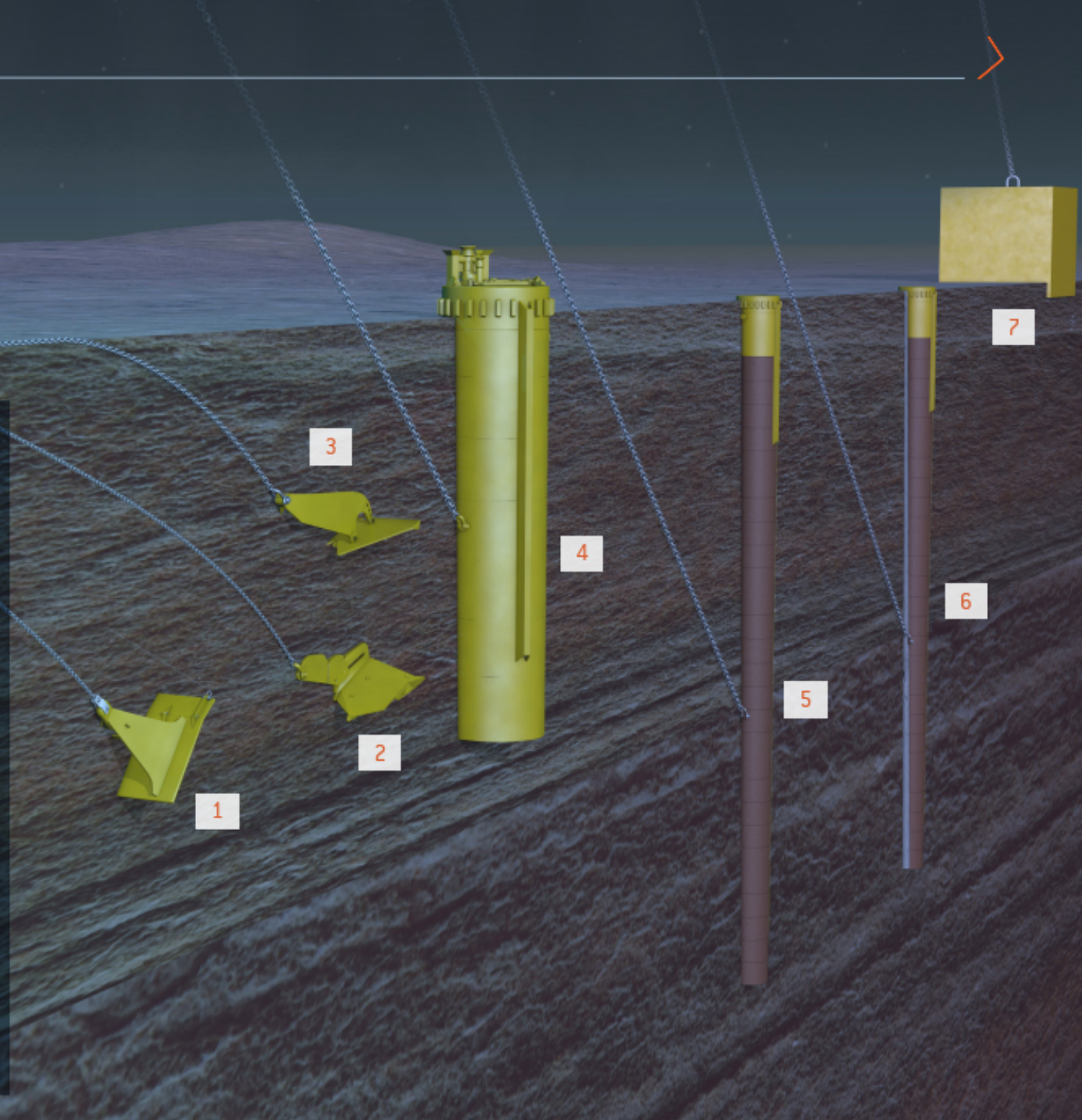
PERFORMANCE OF VARIOUS ANCHOR TYPES IN DIFFERENT SOILS AND THEIR POSITIONING ACCURACY

Anchor type	Soil				Vertical load capable	Precision/accuracy
	Clay	Sand	Hard	No sediment		
1/ Suction embedded plate anchor (SEPLA)	***	*			***	***
2/ Drag VLA	***				***	*
3/ Drag anchor	***	***	**			*
4/ Suction anchor	***	*			***	***
5/ Driven anchor	***	**	***		***	***
6/ Drilled and grouted anchor	*	*	***	***	***	***
7/ Gravity (clump weight)	*	*	*	*	*	***

*fair **better ***best

Many variables are taken into consideration when choosing anchoring options, including:

- soil and geotechnical properties
- required precision of the embedment location
- installation vessel capabilities
- type of asset and mooring system
- metocean conditions and environmental regulations
- cost and availability of mooring components.

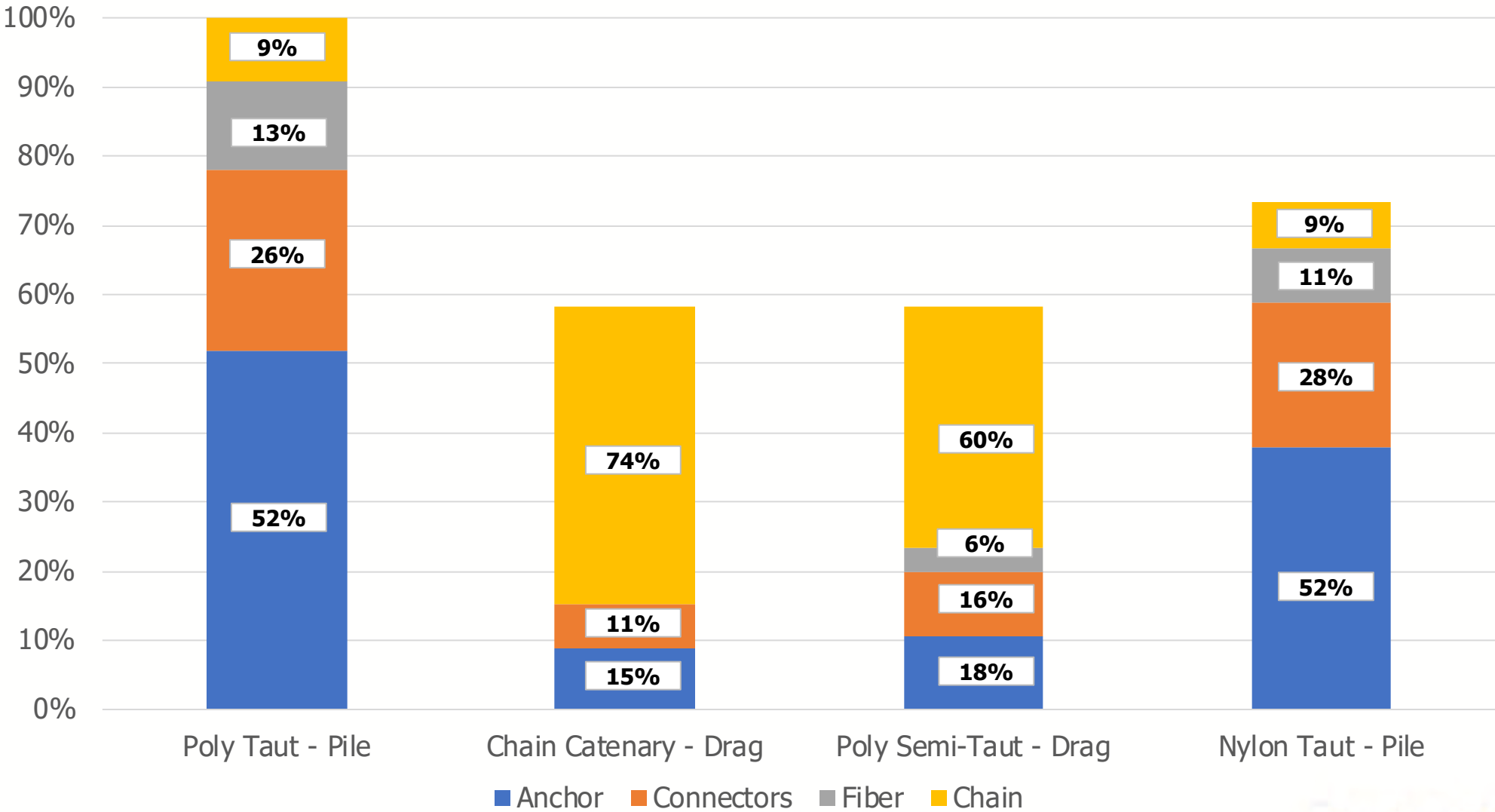


Anchor sizes for costed options

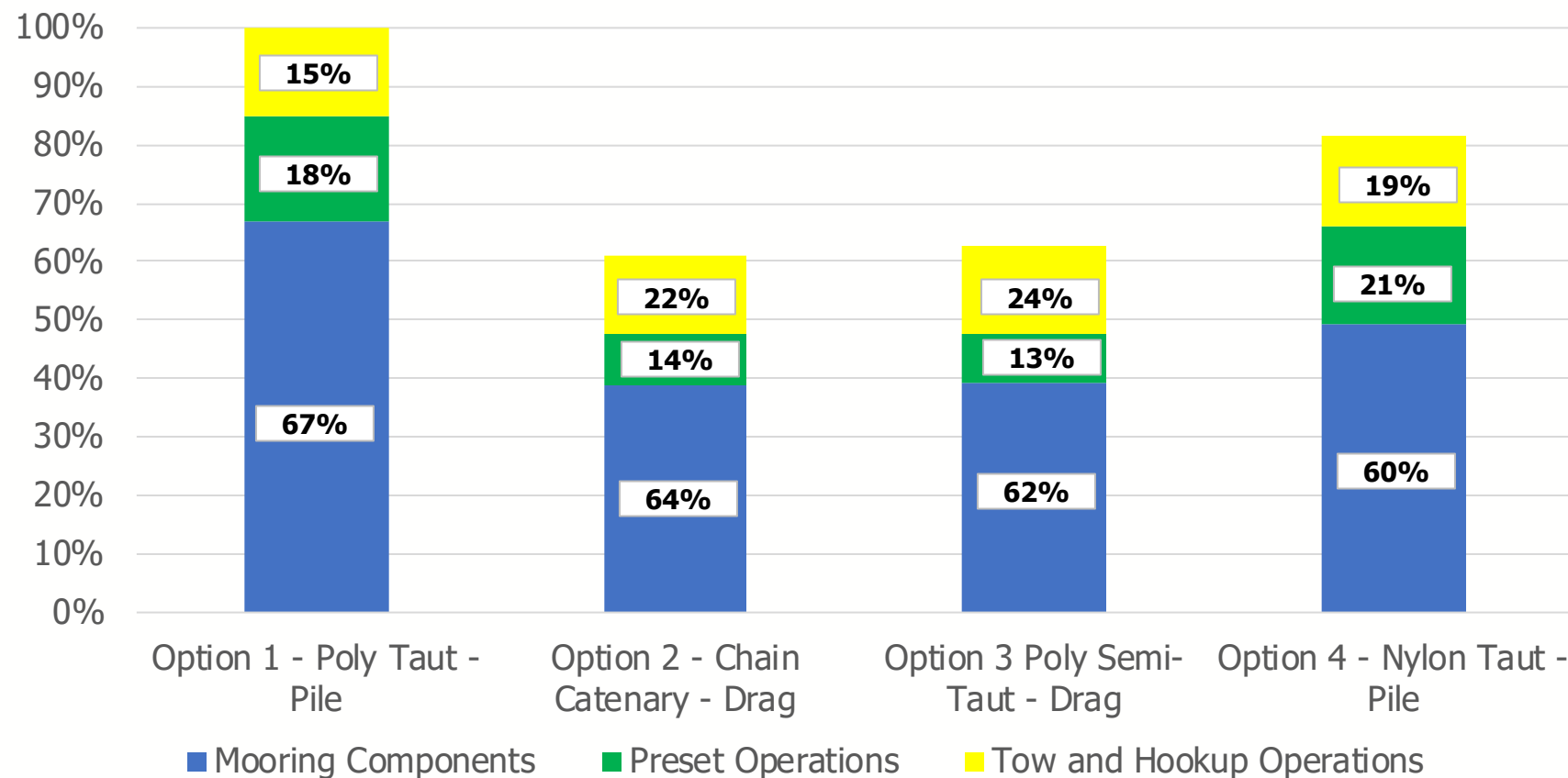
Options	Driven pile	Drag anchor
Polyester Taut	2.1m dia x 60m long, 137mt weight	Not applicable
Chain Catenary	1.5m dia x 42m long, 65mt weight	Bruce FFTS GP – 15mt
Polyester Semi-taut	1.5m dia x 39m long, 72mt weight	Bruce FFTS GP – 18mt
Nylon Taut	2.1m dia x 40m long, 105mt weight	Not applicable

Total Installed Costs

Mooring Procurement Breakdown



Total Installed Costs



Includes:

- All mooring components (including shipping allowance)
- Vessels w/fuel
- Project equipment
 - Pile hammer
 - Survey
 - ROV
 - Handling Equip
- Project crews
 - Marine supervisors
 - Engineers
 - Technicians for equipment listed

Does not include

- Base port services
- Weather downtime
- Mechanical downtime
- Unforeseen complications

For reference, a 40 unit floating wind farm, total installed mooring costs can range from \$85-150m

Floating Wind Solutions

Conclusions

Multiple designs were determined technically feasible

Taut legs designs were preferable from an environmental standpoint

Polyester was preferred over nylon due to vast experience with polyester in long term oil and gas moorings

Total installed cost ranged from \$85m to \$150m for 40 turbine farm

Project requirements, local conditions and technical feasibility can all impact total installed costs

Floating Wind Solutions

THANK YOU!

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