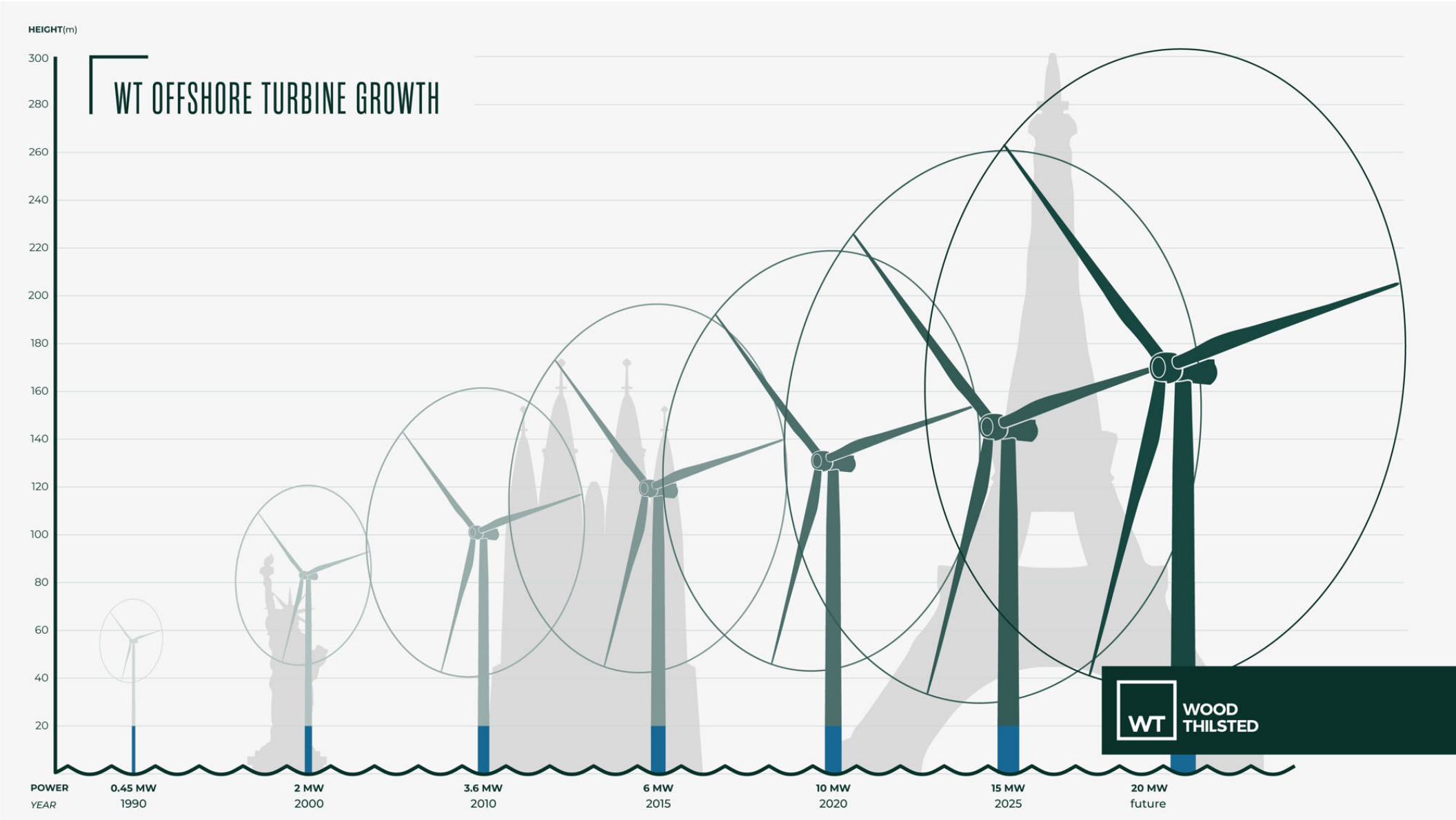
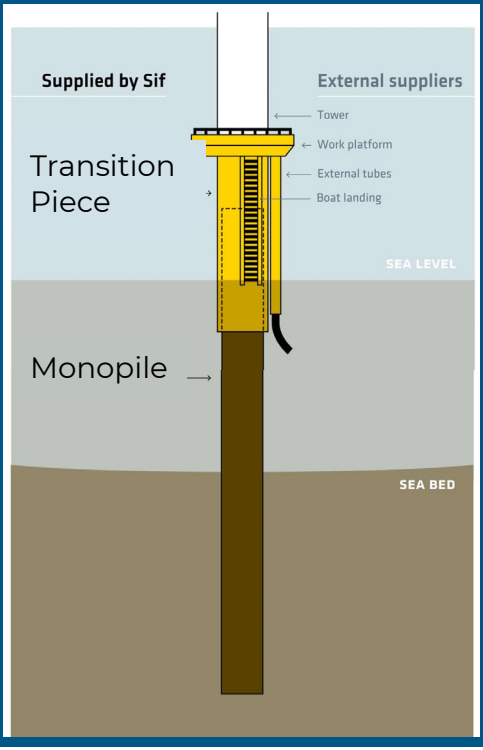
AUSTRALIAN WATER SCHOOL

PRESENTATION
August 2023

WOOD THILSTED


HEIGHT(m)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
WT OFFSHORE TURBINE GROWTH
WT
WOOD
THILSTED
POWER
YEAR
0.45 MW
1990
2 MW
2000
3.6 MW
2010
6 MW
2015
10 MW
2020
15 MW
2025
20 MW
future

MONOPILES


Supplied by Sif
External suppliers
Tower
Work platform
External tubes
Boat landing
Transition Piece
SEA LEVEL
Monopile
SEA BED

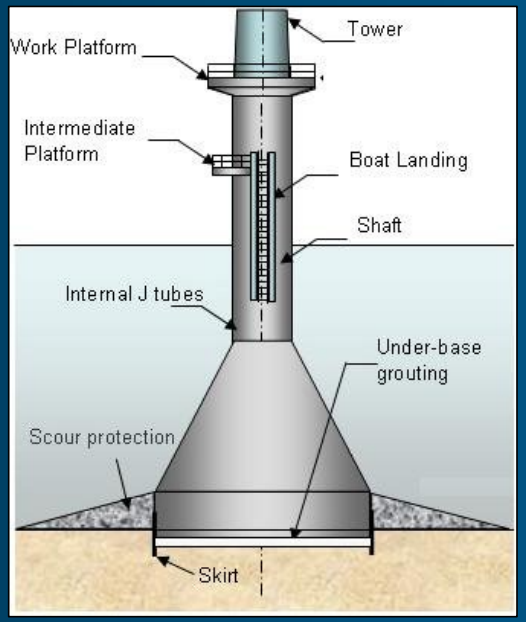
JACKETS

Water depth: 40-80 m
Diameter: 0.8-3.0 m

WT WOOD THILSTED

GRAVITY BASED STRUCTURES (GBS)

Water depth: <40 m
Diameter: 6-30 m



WT WOOD THILSTED

FOUNDATION DESIGN

Floating Substructures and Anchors

TENSION-LEG PLATFORM

Pros	Cons
Limited motion of floater and turbine	Inherently unstable without mooring in case of anchor failure
Allows for submerged platform with little wave loading	Not suited for high current speeds
Simple floater construction	Not suitable for shallow water or large water level variation
Small seabed footprint	Relatively high OPEX for hull-tendon connection

SEMI-SUBMERSIBLE

Pros	Cons
Assembly onshore or in dry-dock	Sensitive to wave loading
Suitable for most water depths depending on mooring configuration	Relatively complex floater structure
Potential to use a concrete hull, allowing for increased local content	Large motions within anchor spread

SPAR BUOY

Pros	Cons
Inherently stable, also without mooring	Large water depth (typically >100m) required – both in-place and during turbine installation
Simple floater structure	Some motions within anchor spread
Limited motion of turbine	

WT

FOUNDATION DESIGN

Floating Substructures and Anchors

DRAG ANCHOR / DRAG-EMBEDDED PLATE ANCHOR

Pros	Cons
Off-the-shelf solution	Inaccuracy with positioning / drag – additional mooring chain required
Empirical design approach – limited design & SI costs	Empirical design approach – high proof load required on site
Installation spread – only anchor handler tug required	

SUCTION ANCHOR

Pros	Cons
Accurate positioning of anchor	Relatively high CAPEX for anchor
No proof loading required	Installation spread – crane vessel required
Allows for shared anchor solution	Sensitive to scour

DRIVEN PILE ANCHOR

Pros	Cons
Relatively low CAPEX	Decommissioning
No proof loading required	Installation spread – crane vessel required
	Relatively deep embedment – not suited for shallow bedrock

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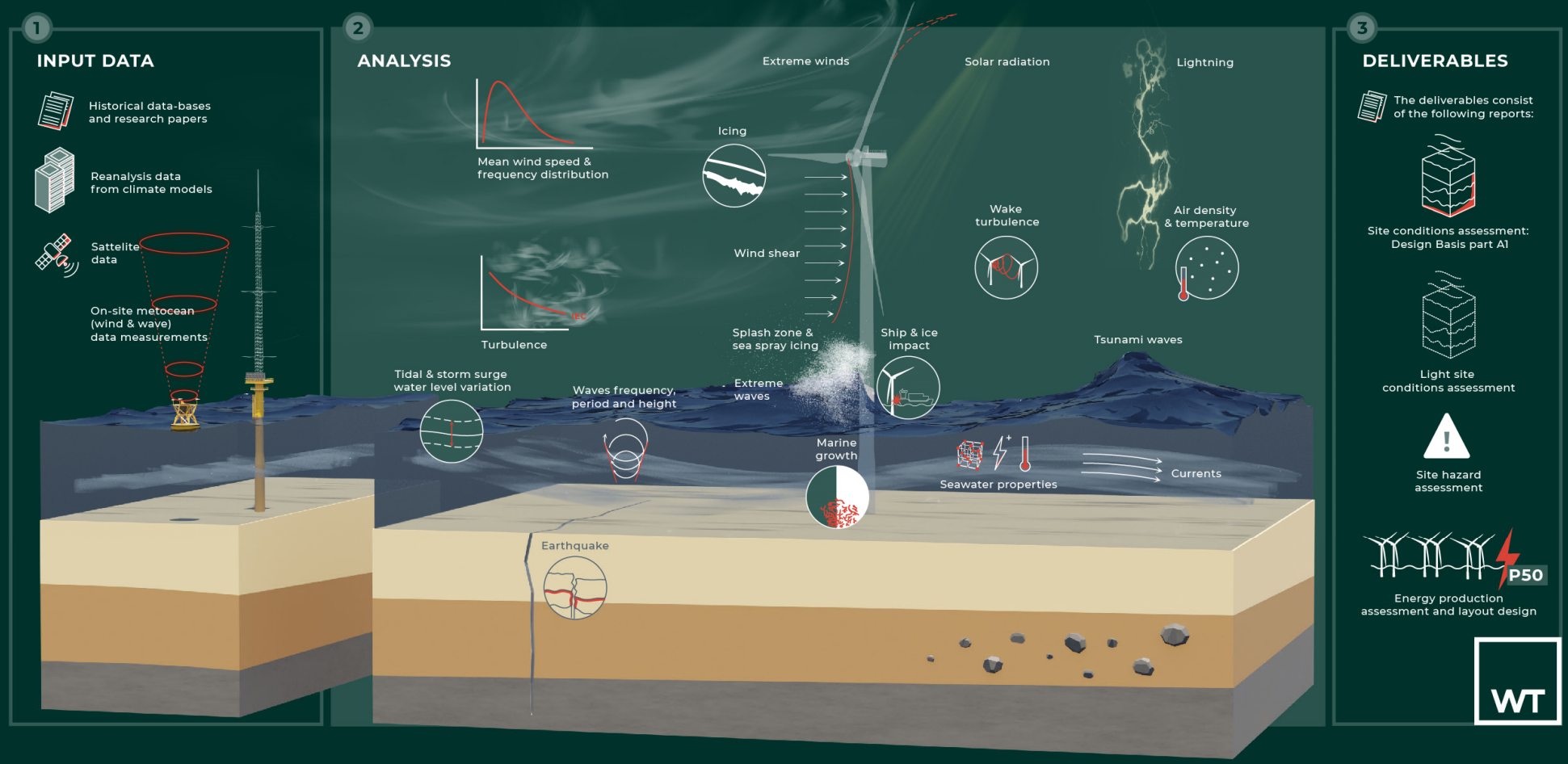
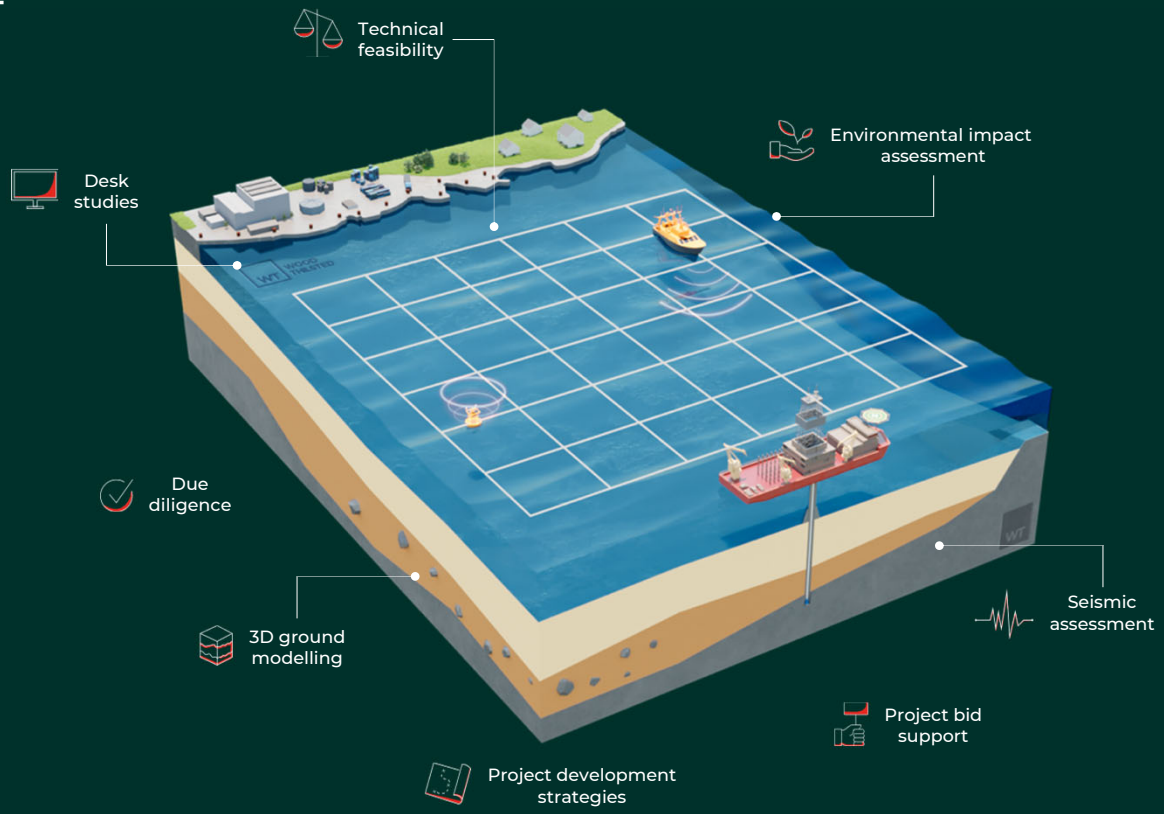
OFFSHORE ENVIRONMENT

Site Conditions Assessment

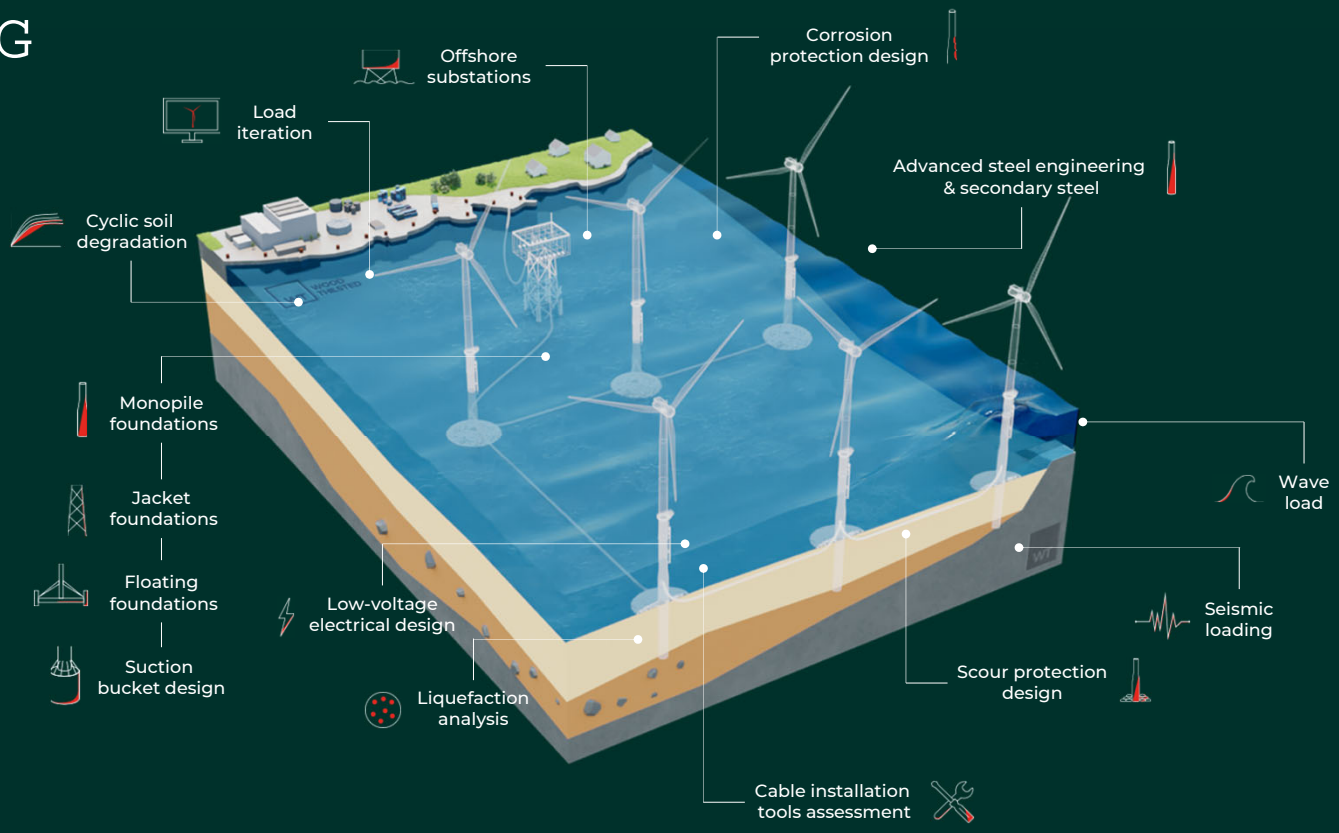


EXPLORATION



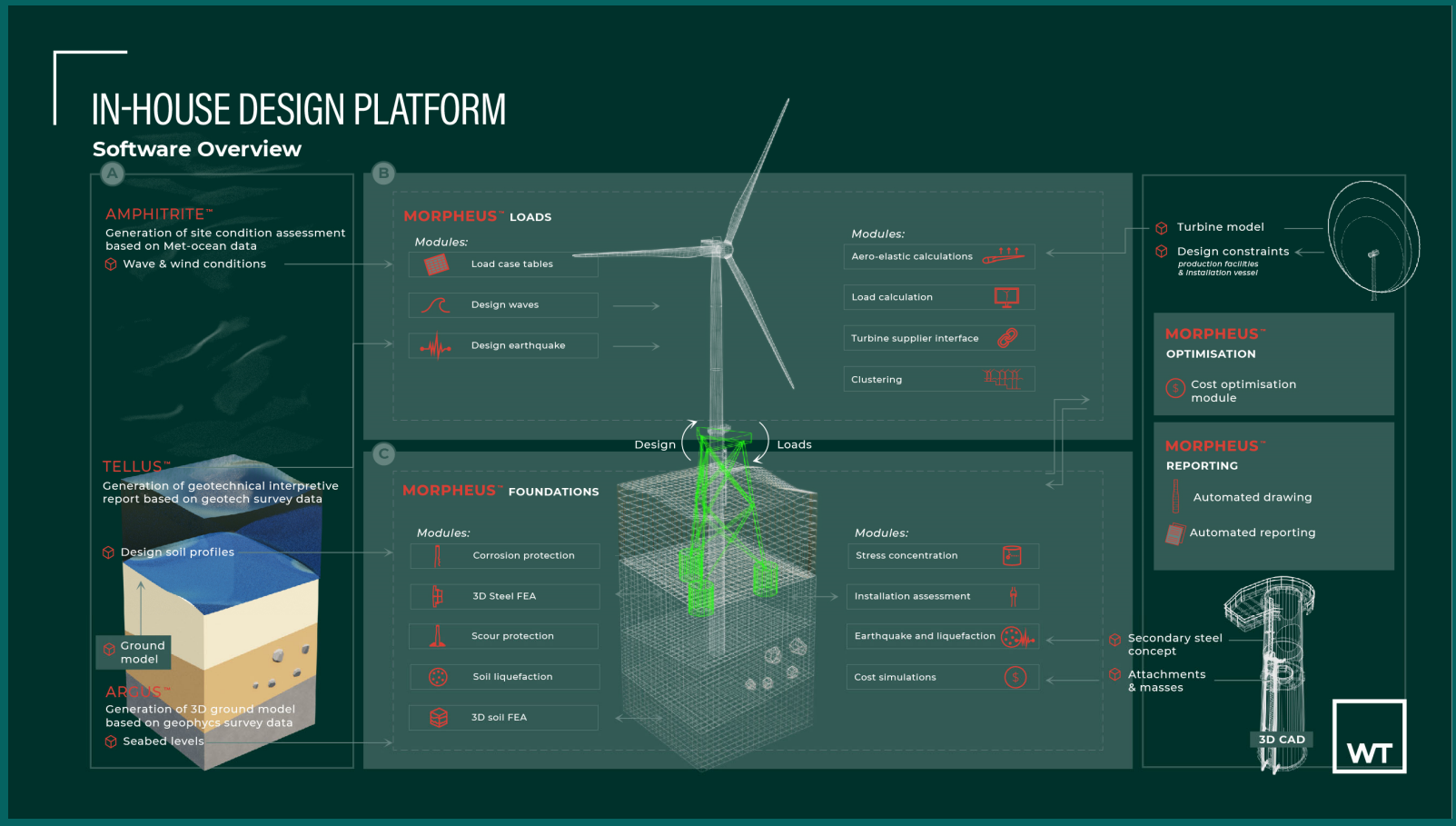
Project Exploration is defined as a phase where initial engineering works is performed. The boundary conditions (e.g. wind, wave, geology, etc.) of the project site are investigated and critically reviewed. This identifies risks and hazards that may be potential threats to the project. Wood Thilsted has wide experience in evaluating, planning and undertaking high-quality engineering assessments.

ENGINEERING



Wood Thilsted deliver cost-effective foundation designs for offshore wind projects through our holistic approach to design – understanding all the inputs to the design and supply chain constraints results in efficient structural design and project cost savings.
Many of the worlds largest offshore wind farms are currently being designed by Wood Thilsted.

WHAT MAKES US UNIQUE? OUR SOFTWARE

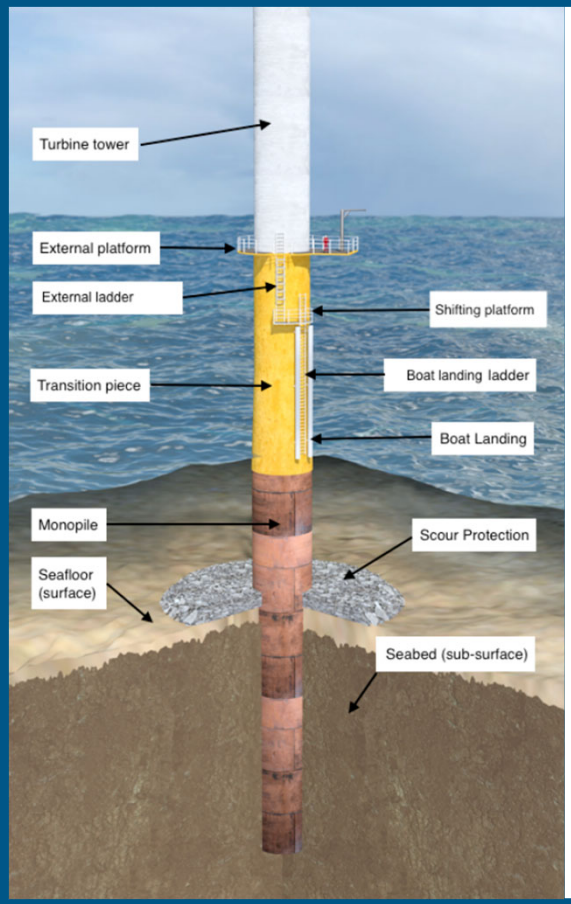


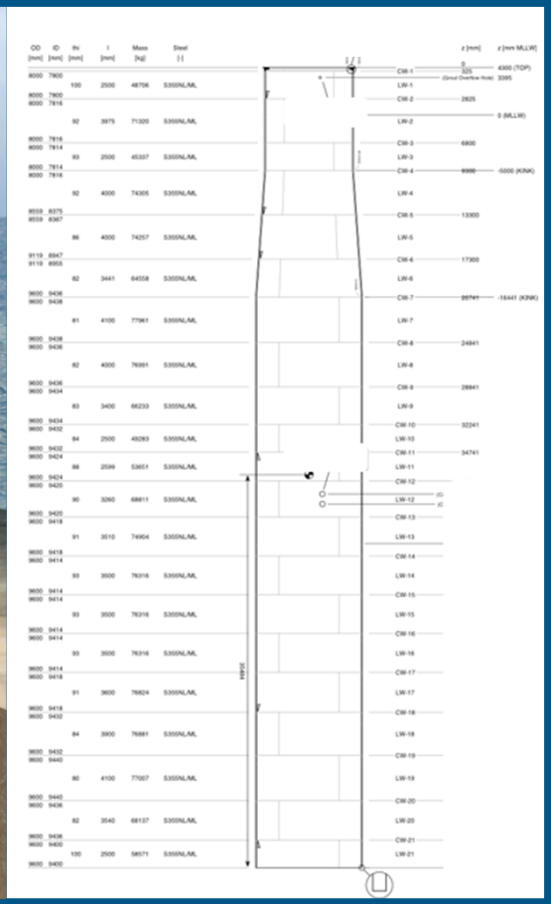
WT has highly developed design processes for substructure and foundation design.

Our software platform is a comprehensive tailor-made tool developed specifically for offshore wind foundations, including MPs and Jackets.

It includes modules for efficient site characterisation (wind, wave, soil etc.), for load assessment, structural design, optimization and for reporting.

KEY DESIGN CONSIDERATIONS





- Ultimate Limit State (ULS)
- Fatigue Limit State (FLS)
- Natural Frequency Analysis (NFA)
- Accidental Limit State (ALS)
- Service Limit State (SLS)
- Corrosion Protection (CP)
- Secondary Steel (SS)

- Integrated Load Analysis (ILA)

EXAMPLE OF A HIGH LEVEL LCT

DLC Table [IEC 61400-3-1]

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	DLC	DLC Description	Wind speeds considered	Wind model	Sea State Model	Water level	Current model	Wind Wave misalignment	Yaw misalignment	Partial safety factor for Ultimate design load assessment	No. Combinations
Fatigue	1.2	Power production	[Vin:Vout] 3:1:31	NTM (operating in Fatigue) - m=5	NSS	SWL_NSS_FLS	CS_NSS	MIS, MUL -30 ; 30 ; 60	-8° ; 0°; +8°	1.35	5220
	6.4	Parked (standstill or idling) outside WTG operation wind speed range	[< Vin] and [Vout:Vhwo] 1:1:2 and 32:1:34	NTM (operating in Fatigue) - m=5	NSS	SWL_NSS_FLS	CS_NSS	MIS, MUL -30 ; 30 ; 60	-8°; 0; +8°	1.35	900
	7.2	parked and fault conditions (WTG yaw angle is aligned with wind direction)	[Vin:Vout] 3:1:31	NTM (operating in Fatigue) - m=5	NSS	SWL_NSS_FLS	CS_NSS	MIS, MUL -30 ; 30 ; 60	-8°; 0; +8°	1.35	5220
Ultimate	1.4	Power production + gust + wind direction change	Vr +/-2m/s 9, 11, 13	ECD	NSSULS	SWL_NSS_ULS	CS_NSS	COD, UNI	0°	1.35	9
	1.6	Power Production + severe sea state + Normal current & water levels	[Vin:Vout] 3:1:31	NTM (operating in Ultimate)	SSS + SWH	SWLR_SSS	CS_NSS	MIS, MUL limited to -30° ; 0°; +30°	-8° ; 0°; +8°	1.35	261
	6.1	Idling + 50 yr wind, waves, current, water levels	V50 50.9	EWM	ESS50 + EWH50	SWLR_ESS50	CS_ESS	MIS, MUL limited to -30° ; 0°; +30°	-8° ; 0°; +8°	1.35	108
	I.1	Idling + 500yr cyclone wind, waves, current, water levels	V500 cyclone 64.9	EWM	ESS500 + EWH500	SWLR_ESS500	CS_ESS	MIS, MUL limited to -30° ; 0°; +30°	-8° ; 0°; +8°	1.0	108
	I.1-PLUNG	Idling + 500yr cyclone wind, waves + plunging breaker wave (a slamming force is added), current, water levels	V500 cyclone 64.9	EWM	ESS500 + EWH500	SWLR_ESS500	CS_ESS	COD, UNI	-8° ; 0°; +8°	1.0	36
											11862

WHERE ARE OUR PROJECTS?

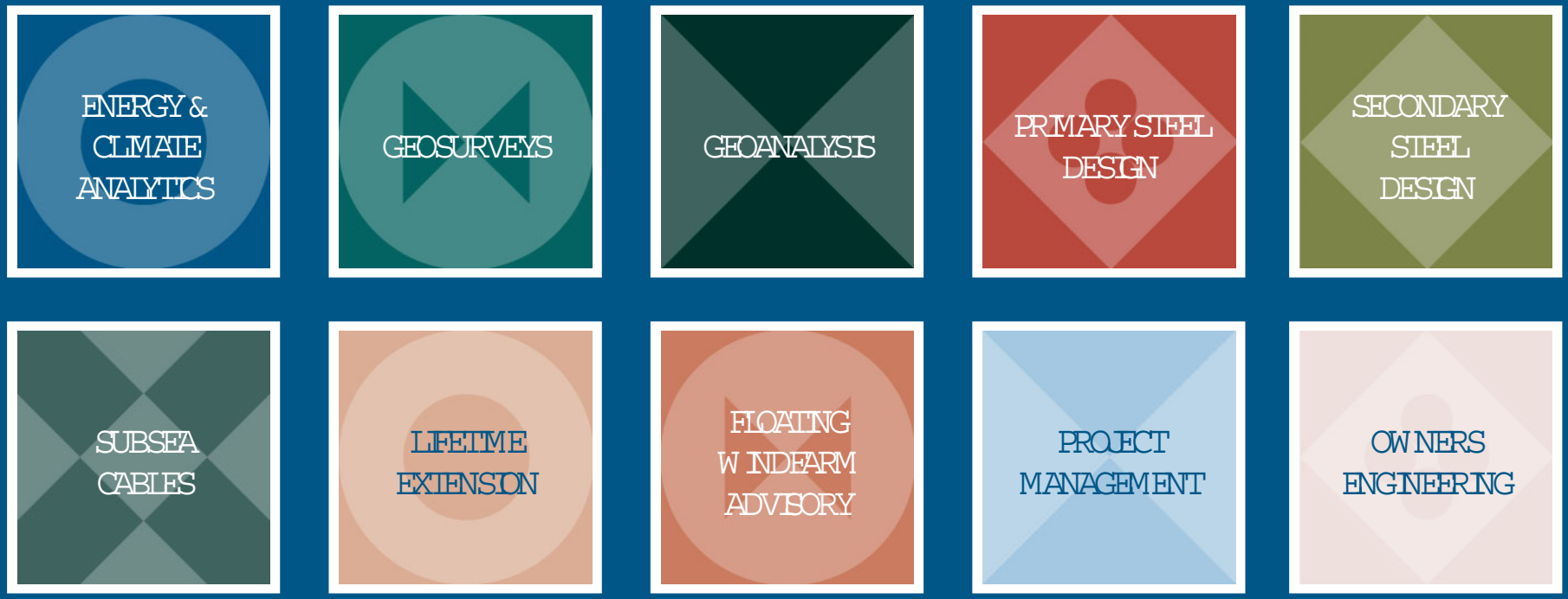
WT Projects:

- Australia
- Denmark
- Germany
- Greece
- Ireland
- Korea
- Poland
- Japan
- UK
- USA

OUR EXPERIENCE

With our unique experience and track-record in offshore wind we deliver the largest and most complex offshore wind projects globally, annually delivering the detailed foundation design of 3 GW worldwide.

WHAT SERVICES DO WE OFFER?



THANK YOU

WOOD THILSTED

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