8th Communication Platform Conference of Taiwan Offshore Wind Energy Industrial Cooperation

Thousand Wind Turbines Project Office, Taiwan Energy Bureau

OWEC TOWER

Foundations for Offshore Wind Turbines & Taiwan Offshore Wind Industry Solutions

Taipei, May 2017

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Content of the presentation

1. Introduction 簡介

2. Track record:

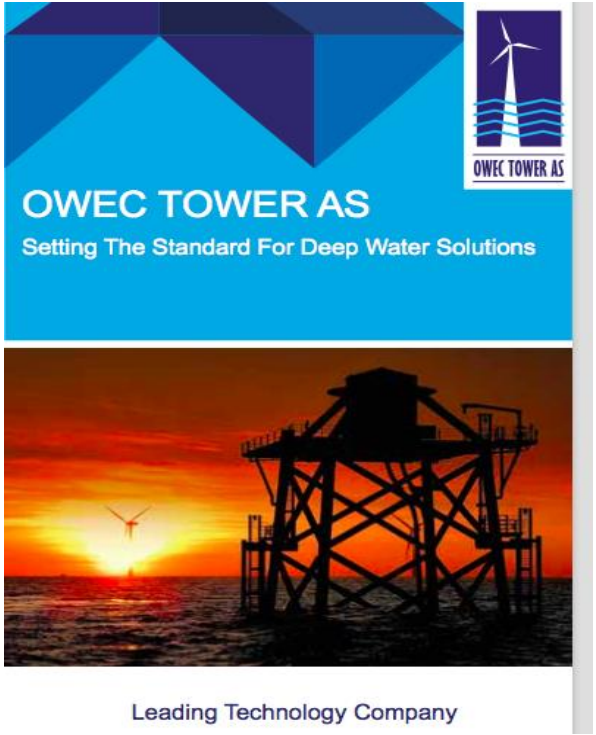
- **Concept, FEED, basic design, etc.** 概念、FEED、基本設計...等
- **Projects Installed** 安裝案件

3. Optimization through Innovation
優化:經由 創新

4. Optimization through Flexibility & Expertise
優化:經由 靈活性與專業知識

5. Taiwan 台灣情況

- **Challenges & Solutions:** 挑戰與解決方案
- **Our commitments** 我們的承諾



Introduction 簡介

- **OWEC is a leading Design & Engineering** company developing foundation solutions for offshore wind farms
- Invested **16 years into developing offshore windfarm foundation solutions**
- **Pioneer and Leader** in developing **Jacket Substructures**
- Delivery of **Concept Designs and FEED** for >50 offshore wind farms
- Experience of detail engineering:
  - **for around 100 Jacket structures**
  - **4 full scale installed wind farms**,
  - All fully certified, installed in time and within budget

Ormonde OWF, UK

Thornton Bank OWF, Belgium

Track Record 實績 : Concept, FEED, basic design

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- Studies for >50 offshore wind farms in Europe, US, Asia:
  - ✓ Benchmarking including all foundation types
  - ✓ Concept designs, FEED and basic design for Project owners
  - ✓ Tender designs for Yards (EPC) or Installation Companies (EPCIs)
- R&D studies with:
  - ✓ Yards,
  - ✓ Steel Suppliers,
  - ✓ WTG-suppliers, etc.

wpd · IBERDROLA RENEWABLES · VATTENFALL · electrawinds · GDF SUEZ · Statoil · Statkraft · Eneco · POWEO · NASS&WIND OFFSHORE · CARBON TRUST · RWE The energy to lead · EDF energies nouvelles

Track record 實績: installed OWEC Quattropod®

OWEC Quattropod®, 4-Legged Jacket Solution:

- This is a complete WTG support structure, which includes:
  - ✓ A transition piece (**midsection**),
  - ✓ **Jacket** substructure
  - ✓ **Pile Stoppers** (pre-piling) or pile sleeves (post-piling)
  - ✓ Secondary steel

Track record 實績: Beatrice – UK - 2 WTG - 10MW

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- First 5MW turbine deployed offshore
- First application of a jacket substructure for offshore wind
- Still today deepest jackets supporting a WTG

The Scottish GREENENERGY Awards 2005 success in renewable energy

General
- Project owner: Talisman Energy / SSE
- 22km off the northeast cost of Scotland
- 2 WTG Repower (now Senvion) 5MW
- est. Project costs: 41Mio € (35 Mio £)
- Fabrication yard: Burntisland Fabrications Ltd

Environment
- Water depth : 45 m (tidal range: 8m)
- Soil profile: Sand

Jacket / piles:
- Height / Footprint: ca. 70 m, 19x19m
- Weight: ca. 750 t (jacket & associated equipment)
- Piles: 120 t each; length: ca. 45m

Track record 實績: Alpha Ventus – Germany – 6WTG – 30 MW

- First German offshore wind farm
- First jacket design approved by GL and BSH (German administration)
- Pre-pilling applied for the first time
- Innovative grouted connection / piles stopper

General
- Project owner: DOTI (EWE, E.ON, Vattenfall)
- 6 Repower (now Senvion) 5MW
- est. Project costs: 250Mio €
- Fabrication yard: Burntisland Fabrications Ltd

Environment
- Water depth: 28 m
- Soil profile: sand

Jacket / piles:
- Height / footprint : ca. 56 m, 20x20m
- Weight: ca. 500 t
- Piles: OD 72'', length: ca. 20-40m

Track record 實績: Ormonde – UK– 30WTG – 150 MW

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- First serial production and installation of jackets
- First commercial deployment of steel jacket foundations
- “Built in record time, Ormonde was the first large project using jacket foundations and 5MW turbines in the UK”

renewableUK ENERGY AWARDS 2012

General
- Project owner : Vattenfall (prev. Eclipse)
- 30 Repower (now Senvion) 5MW
- est. Project costs:552 Mio €
- Fabrication yard: Burntisland Fabrications Ltd

Environment
- Water depth :17-21m (tidal range: 9m)
- Soil profile: sand, clay, mudstone

Jacket /piles:
- Clusters: 2 (slight reinforcement main steel)
- Height / footprint:: ca. 47 m, 20x20m
- Weight jacket: ca. 450 t
- Piles: OD 72’’, length: 20-45m

Track record 實績: Thornton Bank – Belgium – 48WTG – 300 MW

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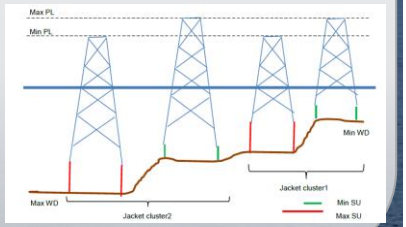
- Largest project-financed wind farm in Europe
- Fast track (<12 months between start design and start installation)
- Sand dunes, breaking waves
- Parallel design for OTS
- 5 clusters:
  - same footprint
  - same Midsection



General
- Project owner: C Power (DEME, RWE, EDF, etc.)
- 48 Repower (now Senvion) 6,15MW & 1 OTS
- est. Project costs: 1,3 Mrd € (incl. Phase 1)
- Fabrication yard: Smulders

Environment :
- Water depth :**15-27m**
- Soil profile: dense sand, clay

Jacket / piles:
- Clusters: 5 (same footprint and same Midsection)
- Height / footprint:: ca. 44-54 m, 18x18m
- Weight jacket: <500t (average total operational weight), 800t (OTS)
- Piles OD 72'', length: ca. 20-50m

Track record 實績: Le Carnet – France – onshore proto Haliade Ge – 6 MW

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- First jacket for the Haliade (prototype) , turbine under development
- Large forces
- New developed Midsection, without cast

Key figures

- Project owner: Alstom (now GE)
- near Saint-Nazaire (France) on the shores of the estuary.
- 1 Alstom Haliade 150, 6MW
- 1 onshore proto , Alstom Haliade 6,2MW
- Fabrication yard: STX

Jacket :

- Height / footprint: ca. 25m, 16x16m
- Weight jacket: ca. 350 t

Track record 實績: Knowledge gained - covering the entire OWF Lifecycle

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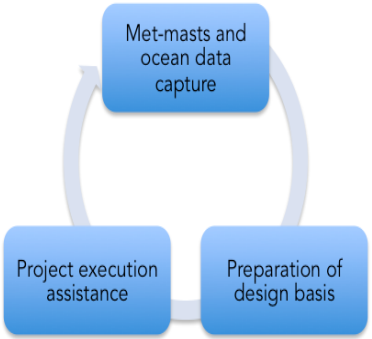
- **Benchmarking and parametric studies**, comparing all possible different substructures for :
  - OTS and
  - WTG up to 15MW

- Consideration for all **Wind Farm Life Cycle Phases:**
  - Planning,
  - Fabrication
  - Transport/Installation
  - Operation / Maintenance
  - Decommissioning

OWEC delivers comprehensive knowledge that covers the entire offshore wind project lifecycle and can offer:

In general:

- Met-masts and ocean data capture
- Preparation of design basis
- Project execution assistance



Focused on the sub-structures:

- Feasibility, Screening & Initial Studies for various types of sub-structures
- Geotechnical Interpretation /Pile Design
- Benchmarking (monopile, jacket, GBS etc.)
- Conceptual Design
- Detailed engineering (including certification)
- Interface Management
- Fabrication & Installation Management Grouted Connection
- Ship Impact Analysis
- Third part review / Due diligence
- Supply Chain Analysis
- Support to fabrication
- Support to transport / installation
- Support to decommissioning

Optimization through Innovation: Midsection
優化經由創新

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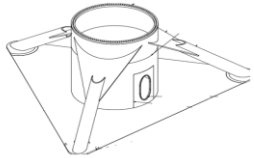
- Achievement of 16 years development, including input from several leading turbine suppliers, and yards
- Replaces 6-8 m of the tower section
- Most efficient interface tower/jacket, allowing to design a lighter jacket



- Version 3: Le Carnet.
- NO cast sections

- Version 2: Alpha Ventus, Ormonde, Thornton Bank.
- Smaller cast sections

- Version 1: Beatrice.
- Heavy cast pieces with complicated welding

Optimization through Innovation: Pre-Piling
優化經由創新

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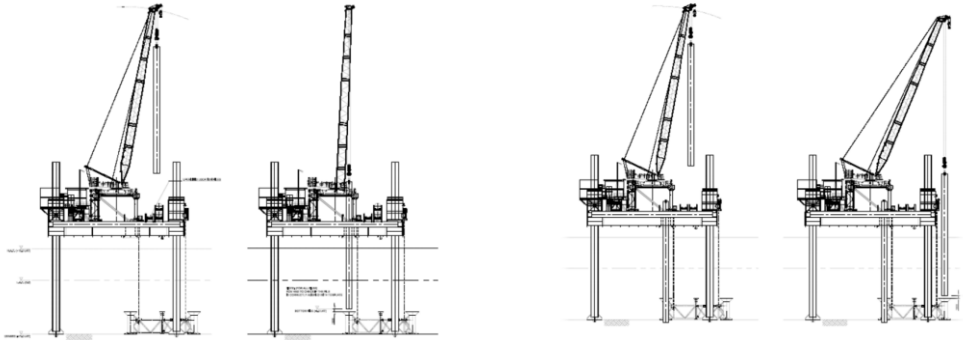
3 independent steps :

1. Seabed preparation

2. Pre-piling: driving of 3 (or 4) piles
    1. Lowering template to sea bottom
    2. Upending of pin piles
    3. Positioning of the pile into template
    4. Stabbing & driving of the piles

3. Installation of jacket foundation
    1. Sand excavation / cleaning of piles
    2. Positioning of the jackets on piles
    3. grouting of connection jacket pinpiles



Optimization through Innovation: Pre-Piling / Pile-Stopper
優化經由創新

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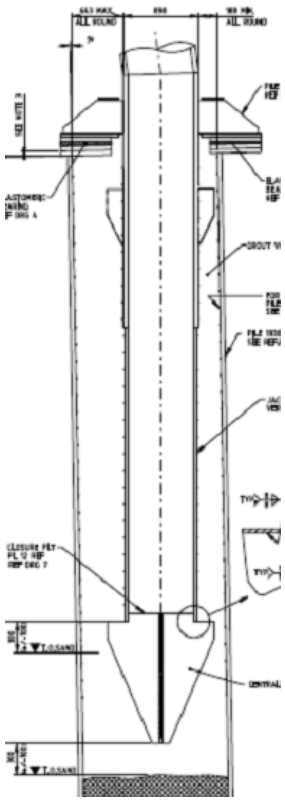

- Innovative, best cost-efficient solution for pre/piling allowing:
  - High impact velocity
  - High tolerances for fabrication and installation
  - Optimized weather window for installation
- Certified by DNV, GL, etc.
- Successfully used on all OWEC's projects since Alpha Ventus
- And other (ex-Wikinger)
- Continuous improvement to ensure compliance to new requirements, etc.

Optimization through Innovation: Hybrid solution
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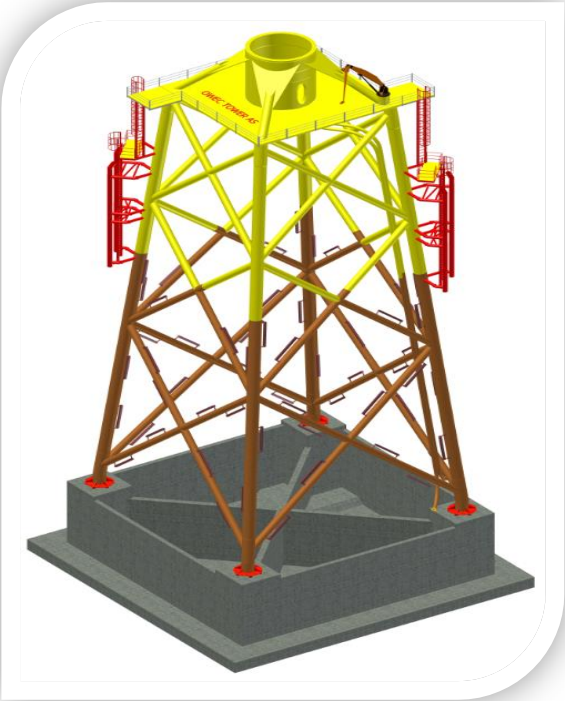
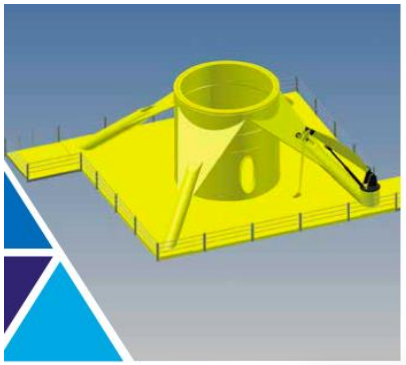


- Innovative solution for specific site conditions
- Combines advantages of
  - Jacket:
    - Keeps the jacket concept for substructure shaft
    - Transparency to sea loads
  - Gravity based solution:
    - Using a GBF for the foundation
    - Stability and load transfer to soil at surface levels due to weight

Optimization through Flexibility & Expertise: Dedicated Design
優化經由靈活性&專業知識

OWEC Engineered Solutions:

- Jacket
  - OWEC Quattropod®, 4-Legged
  - OWEC Trepod® , 3-Legged Solution
  - OWEC Hybrid ®, Hybrid jacket
- Monopile
- Gravity based, GBS
- Pile / Suction bucket
- Offshore Transformer & Accommodation Platform Solutions
- Met-Mast Design



Optimization through Flexibility & Expertise : Steel Supply, Fabrication,Transport
優化經由靈活性&專業知識

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Steel Supply

Challenges:

- Supply Chain not prepared for mass production
- Guidelines not adequate
- Balance to define between standardization & optimization
- Beveling, logistic, storage also to consider

Expertise:

- With major steel suppliers
- R&D related to:
  - Steel improved fatigue.
  - Automatized welding

Fabrication

Challenges / Expertise:

- Constraints yards (size / welding)
- Few yards prepared
- Serial production
- Different fabrication method statement

Transport

Challenges / Expertise:

- Deck arrangement
- Transport analysis
- Grillage / sea fastening

Optimization through Flexibility & Expertise : Pile & Jacket Installation
優化經由靈活性&專業知識

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Pile Installation (post / pre-piling)

Challenges / Expertise:
- Tolerances x-y / z
- Pile-top elevation metrology, accuracy
- Levelling
- Noise reduction
- Monitoring
- Standardization (footprint, stick-up)
- Shimming

Jacket Installation

Challenges:
- Lifting weight
- Foot print (3 vs 4 legs) & CoG
- Weather window
- Impact velocity, etc.
- Installation turbine, etc.

Expertise
- Pre/post piling,
- Various installation vessels
- Heavy lift / Jack-up
- DP2 /DP3
- On-bottom stability / pile stopper
- Grouting procedure

Optimization through Flexibility & Expertise: OTS
優化經由靈活性&專業知識

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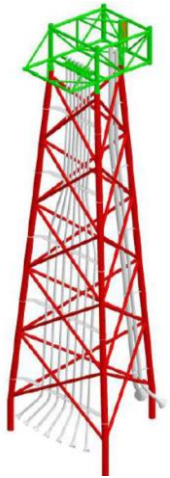
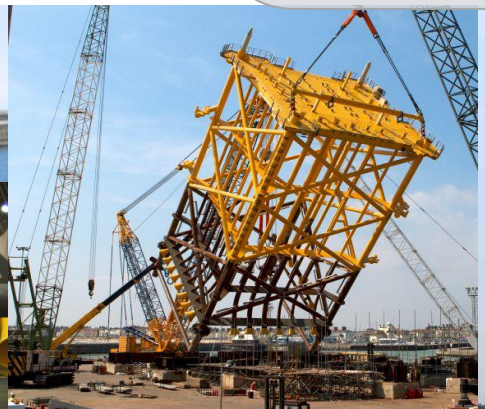


Key Features:

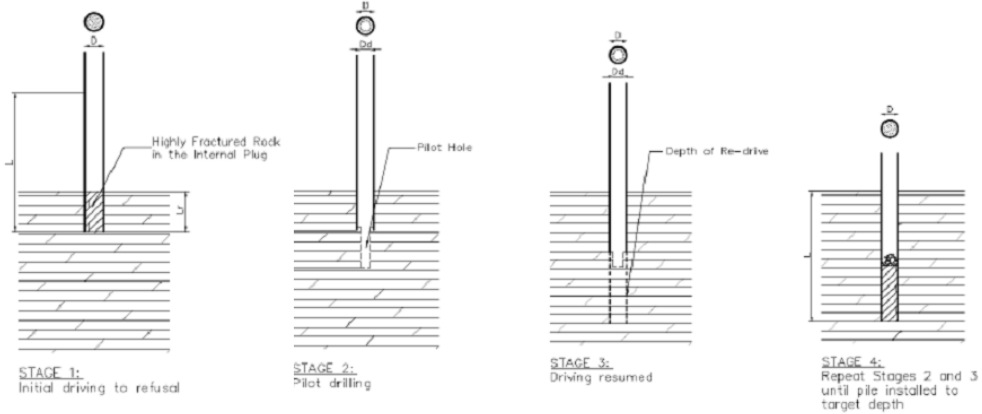
- Light design
- Extensive experience with cable interfaces.
- Optimized connection for J-tubes
- Allows same installation as jacket for WTGs:
  - Same footprint
  - Even for 3 legged
  - Possible pre-piling



Optimization through Flexibility & Expertise : Pile
優化經由靈活性&專業知識

Piles design & installation:

- Steel & concrete piles
- Driven
- Drilled
- D-D-D (drive-drill-drive)
- Grouted socket
- Etc.



Optimization through Flexibility & Expertise, with Partners:
優化經由靈活性&專業知識

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Engineering and Consultant Companies	Geotechnical Companies	Fabricators	Steel Suppliers & specialists	Installation Companies	WTG Suppliers
DR. TECHN. OLAV OLSEN	NGI	Keppel FELS	EUROPIPE	Boskalis	SIEMENS Siemens Wind Power
DNV·GL	CATHIE ASSOCIATES	SMULDERS	ERNDTEBRÜCKER EISENWERK	DEME Dredging, Environmental & Marine Engineering	GE Energy
NIRAS	MENCK	FAB	SALZGITTER MANNESMANN LINE PIPE	Jan De Nul GROUP	Adwen
SEMAR	BAUER	OFFSHORE	TATA STEEL	SEAFOX	MHI VESTAS OFFSHORE WIND
TRELLEBORG		stx	OCAS	Seaway Heavy Lifting	SAMSUNG HEAVY INDUSTRIES
KCI THE ENGINEERS		Navantia		DAELIM	SENVION wind energy solutions
COWI		BLADT INDUSTRIES		SAMSUNG HEAVY INDUSTRIES	MINGYANG WIND POWER 明阳风电
LIC ENGINEERING A/S		Lamprell		Van Oord	
		Keppel Nantong 吉宝南通			
		Keppel AmFELS			
		ZPMC			
		harland and wolff heavy industries ltd			

Taiwan, Challenges & Solutions: Supply Chain
台灣，挑戰與解決方案

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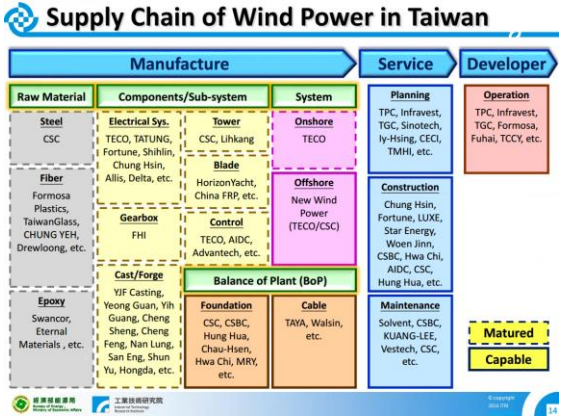

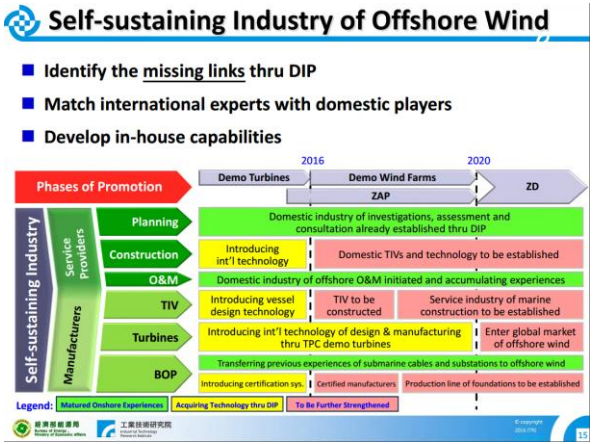

Courtesy of ITRI

Domestic competences:

- ✓ **available,**
- ✓ **but limited regarding wind offshore, (similar to Europe as we have started 15 years ago)**

We propose to help the local supply chain to develop faster:

- ✓ **As pioneer in Europe, we know this process**
- ✓ **We know well all interfaces**
- ✓ **We are already oriented toward the future (working on 15MW turbines)**

In-house Fabrication Capabilities. Keppel FELS.

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OFFSHORE WIND FABRICATION CAPABILITIES

- In depth study and planning has been conducted to ensure the possibilities of producing jackets and monopiles on time on budget.
- Future studies on serial production method is currently being done to optimize our fabrication methods

Current Capacity (Monopile):
- 12 to 16 per batch
- 6 months per batch
- 5 weeks between batches
- 1000t (MP & TP), MP: 80m/TP:15m, 8m diameter

Future Capacity:
-Ongoing production planning

Current Capacity(Jackets):
- 12 jackets per batch
- 6 months per batch
- 5 weeks between batches
- 800t jackets, 80m, 25m x 25m footprint

Future Capacity:
-Ongoing production planning

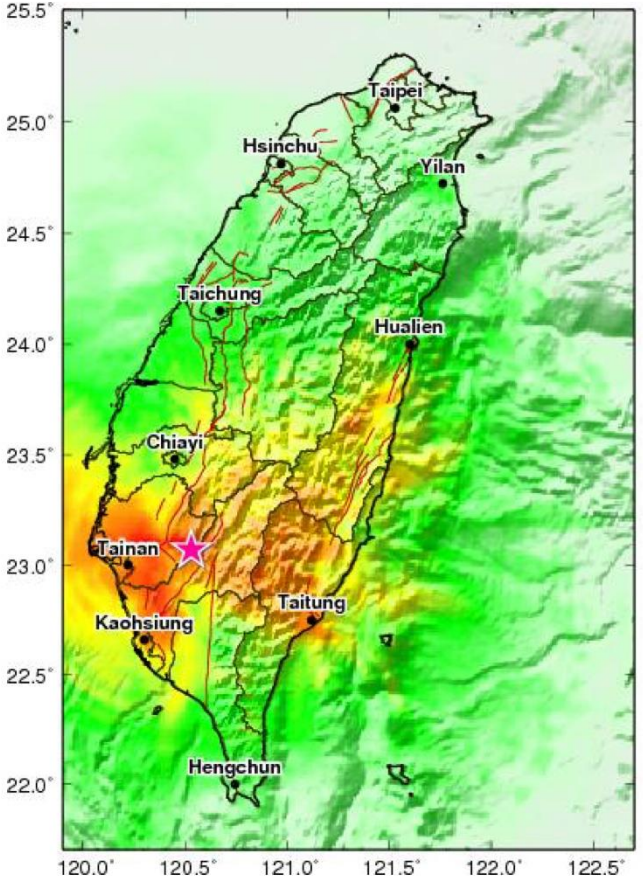
Taiwan, Challenges & Solutions: Earthquake / Soil Liquefaction
台灣，挑戰與解決方案

We propose Structural and Geotechnical Earthquake Engineering:

- **PILES**
  - ✓ **Establishment of earthquake response spectra in the horizontal and vertical directions**
  - ✓ **Assessment of soil liquefaction (scour protection / allowance)**
  - ✓ **Confirmation / update Design Soil Profile**
  - ✓ **Proper handling of earthquake loading**
  - ✓ **Structural pile design**
  - ✓ **Damping effect**

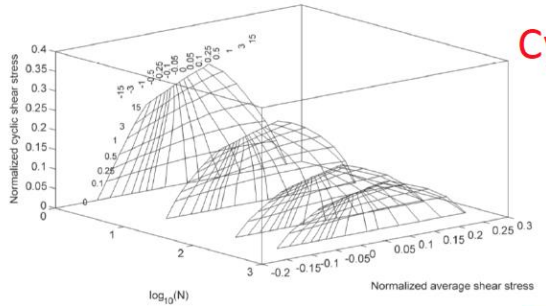
Ref to Kaynia (2017) to be presented BY NGI at the 3rd Int. Conf. on Performance, Design in Geotech. Earthquake Eng. in Vancouver in July 2017

- **JACKET**
  - **Acceleration / displacement due to earthquake to consider**
  - **Influence of higher frequency modes, including local brace vibrations**

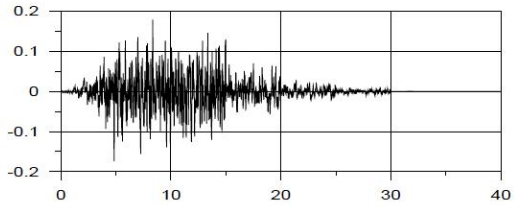


Taiwan, Challenges & Solutions: Earthquake / Soil Liquefaction
台灣，挑戰與解決方案

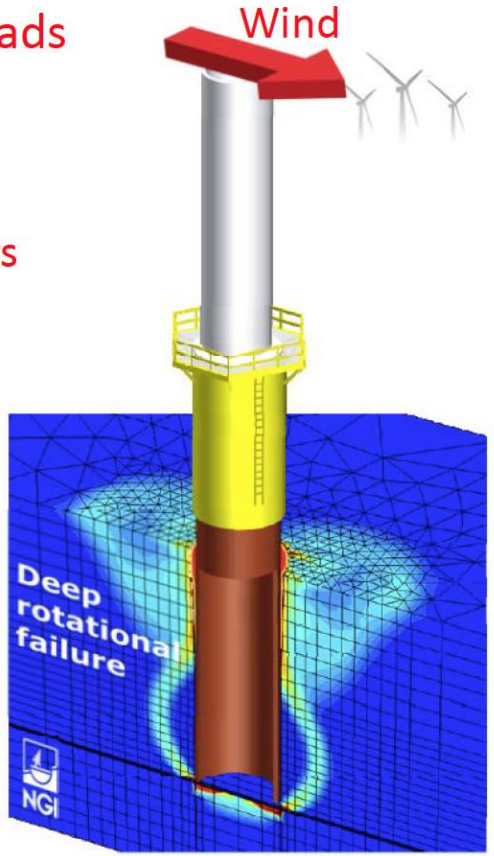
Cyclic data + Wind/Earthquake Loads
= Cyclic foundation behaviour



Cyclic contours
(lab tests)



Earthquake



Taiwan – Our Commitment
台灣, 我們的承諾

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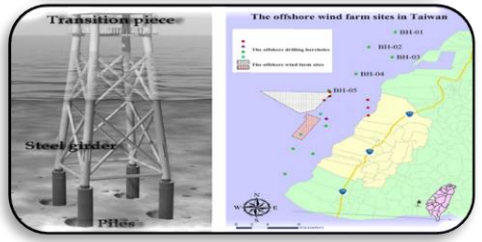
To be the BEST PARTNER to develop A ROBUST INDUSTRY STRUCTURE in TAIWAN:

- We bring 16 years of **offshore wind experience& know-how**
- An **unique TRACK RECORD: HIGH QUALITY, ON TIME and COST**
- **In-house FABRICATION CAPABILITIES**
- **Interface Management** competence:
  - **WIND TURBINE**
  - **STEEL SUPPLY**
  - **FABRICATION**
  - **TRANSPORT & INSTALLATION**
  - **CABLES**
- We bring innovations to solve challenges.
- OWEC is prepared to present soon THE best solution for **the local site conditions,** also for future turbines, considering**:**
  - **EARTHQUAKES**
  - **TYPHOONS**



Thank you

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