HO CHI MINH CITY 2022

The Second Vietnam Symposium
on Advances in Offshore Engineering

SUSTAINABLE ENERGY AND MARINE PLANNING

UNDER THE AUSPICES OF THE ISSMGE (TC-308, TC-209) AND VSSMGE

OCTOBER 24
2022
HO CHI MINH CITY
VIETNAM

ORGANISERS

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CONTENTS

VSOE2021 – The Second Vietnam Symposium on Advances in Offshore Engineering
Sustainable Energy and Marine Planning
24 October 2022, Ho Chi Minh City, Vietnam

https://vsoe2021.sciencesconf.org/

Organisers

Patronages

The Ministry of Natural Resources and Environment (MONRE)

The Vietnam National University Ho Chi Minh City (VNUHCM)

Under the Auspices of:

VENUE

Morning Session (Oct 24th)	Lunch and Afternoon Session (Oct 24th)
https://oisp.hcmut.edu.vn/en/	https://saigon.newworldhotels.com/en/
	
268 Ly Thuong Kiet Street, Ward 14, District 10, Ho Chi Minh City, Vietnam.	76 Le Lai Street, District 1, Ho Chi Minh City, Vietnam

INTRODUCTION

Following the success of the first Vietnam Symposium on Advances in Offshore Engineering (VSOE2018), the second Symposium, VSOE2021, which was delayed due to the COVID19, will be held in Ho Chi Minh City, Vietnam in 24 October 2022. The second VSOE event is being organised by the Association of Vietnamese Scientists and Experts (AVSE Global) in collaboration with Ho Chi Minh City University of Technology (HCMUT) and the Vietnam Administration of Seas and Islands (VASI). The event is organised in parallel with the Joint International Conference on Environment, Earth Science and Sustainability (ICES).

Focusing on the theme of "Sustainable Energy and Marine Planning", VSOE2021 aims to enhance the sustainable use of our marine resources while ensuring the health of the ecosystem as well as the effective management of marine activities including energy production and infrastructures.

VSOE2021 continues providing a platform for all participants to exchange knowledge and experience gained recently in offshore engineering, technology innovations, and marine spatial plan to achieve the goal of economic, reliable and sustainable solutions for offshore energy development, and ecosystem-based management of the marine environment. VSOE2021 intends to bring together researchers, practitioners, policymakers, and entrepreneurs to discuss and promote technology and policy changes toward renewable energy, as well as to generate business opportunities in offshore energy, both domestically in Vietnam and globally.

We have received a tremendous amount of support from a diverse group of participants all over the world. More than 170 abstracts were submitted in the first phase and 100 full papers were submitted in the second phase. Despite our tough review process in which each paper was reviewed by at least two relevant experts, 60 papers have been accepted and published online by the international publisher Springer as a volume in the Lecture Notes in Civil Engineering series, indexed by SCOPUS.

We would like to acknowledge the wonderful support of the scientific committee and the invited experts, who have all spent their valuable time and made tremendous efforts to review the papers. We are grateful to the valuable support from our sponsors: FECON Corporation (Vietnam), NUCE (Vietnam), Sarathy Geotech (SGES) (India) and CTE WIND (Vietnam).

You are cordially invited to attend VSOE at HCMUT premises (morning session), and at New World Saigon Hotel (afternoon session) on October 24th, 2022.

We believe that the symposium will provide attendees with the recently collected and valuable knowledge from experts on topics that include offshore engineering, technology innovations, and offshore wind.

Please visit our website for registration and further details: https://vsoe2021.sciencesconf.org/

We wish you good heath, success and prosperity.

Dr Hong DOAN (EDF, France) & Prof. Van Thang LE (HCMUT, Vietnam)
& Dr Khoa D.V. HUYNH (NGI, Norway)
On behalf of the VSOE Organising and Scientific Committees
Website: https://vsoe2021.sciencesconf.org/
E-mail: vsoe@avseglobal.org

PROGRAM

8h00 onwards	REGISTRATION (24-Oct-2022 @HCM Uni. of Technology)
8h30	Welcome & Opening Address: VSOE/AVSE + HCM Uni. of Technology + VASI + Trent Uni. + IIES Director
8h30	Keynote: Representatives from MONRE and from MOIT (TBC)
8h50	Keynote : Ambassador Hilde Solbakken, The Norwegian Ambassador to Vietnam *Accelerating transition to net zero through ocean-based solutions: lessons learned and good practice*
9h05	Keynote : Prof. Ong Choon Nam, Saw Swee Hock School of Public Health, National University of Singapore *Multidisciplinary Research for a Sustainable Environment*
9h50	BREAK / EXHIBITION / POSTER SESSION (@HCM Uni. of Technology)
10h00	Keynote: Prof. Margaret Graham, The University of Edinburgh
10h45	Keynote: Ha Duong Minh, Vietnam Initiative for Energy Transition (VIET) *Planning, policy and integration for sustainable development of offshore wind energy in Vietnam 2022 - 2050*
11h15	Photo sessions, Exhibitions, Poster and Coffee Break (@HCM Uni. of Technology)
11h30	TRANSPORT TO NEW WORLLD SAIGON HOTEL & LUNCH
13h00	PLENARY SESSION & PANEL DISCUSSION (New World Saigon Hotel - Club Boardroom)
13h00	Keynote : Prof. Phil Watson, The University of Western Australia *Innovative research to support offshore renewable energy*
13h20	Keynote: Maarten Vanneste, Norwegian Geotechnical Institute *Data-driven ground models: the road to fully-integrated site characterization and design*
13h45	Panel Discussion: Vietnam Offshore Energy Moderators: Hang Dao, Clean Energy Investment Accelerator Vietnam & Ha-Duong Minh, VIET *Denzel Eades, Managing Director, Pioneer International Consulting, Singapore* *Dung Vu Viet, Director, Power Plant Operation and Management Center, PECC2* *Riccardo Felici, Country Manager, OWC Vietnam* *David Donaghy, Technical Manager - Geotechnics, Ocean Infinity* *Dien Tran Quoc, Deputy General Director, PECC3* *Hung Nguyen Viet, CEO, CTV Wind*
15h15	BREAK

15h30	TECHNICAL PRESENTATIONS (New World Saigon Hotel - Club Boardroom)
15h30	Daniele Bertalot, Geowynd, UK *Installation risks and opportunities for future WTG foundations*
15h40	Pham Thanh Dam, Duy Tan University *Potential Development of Floating Offshore Wind Turbine in Vietnam offshore*
15h50	Amir Moghaddam, School of Engineering, RMIT University *An AI-based framework for predicting liquefaction-induced deformation of Offshore Wind Turbines*
16h00	Indrasenan Thusyanthan, Managing Director Gavin & Doherty Geosolutions, Ireland *Role of geotechnics in risk management of Offshore Windfarm Projects*
16h10	Le Viet Hung, Technische Universität Berlin, Germany *Investigation of the long-term cyclic behaviour of monopile foundation by impact and vibratory installation*
16h20	Muhammad Bilal Mumtaz, Fugro Survey Middle East (UAE) *Optimisation of Predictions for Driven Piles Performance in Carbonate Silts for Offshore Structures*
16h30	Mai Cao Tri, Hanoi University of Civil Engineering *Experimental Investigation of Wave Scattering Around a Large Vertical Circular Cylinder*
16h40	Sumanth Haribhat Chandrashekhar, Sarathy Geotech and Engineering services pvt Ltd., India *Case studies on Mitigating Pile Foundation Refusals*
16h50	Pham Duc Huyen, FECON, Vietnam *Tra Vinh no.3 Windfarm: CBOP Package - Lessons Learned*
17h00	Ahmed Elkadi, Research Program Manager: Energy Transition, Deltares, Netherlands *Highlights from R&D on innovative monopile installation and decommissioning*
17h15	Closing Ceremony: VSOE/AVSE + HCM Uni. of Technology + VASI Representatives
18h45	GALA DINNER (Floating Restaurant *Indochina Junk* - Cruise along Saigon River)

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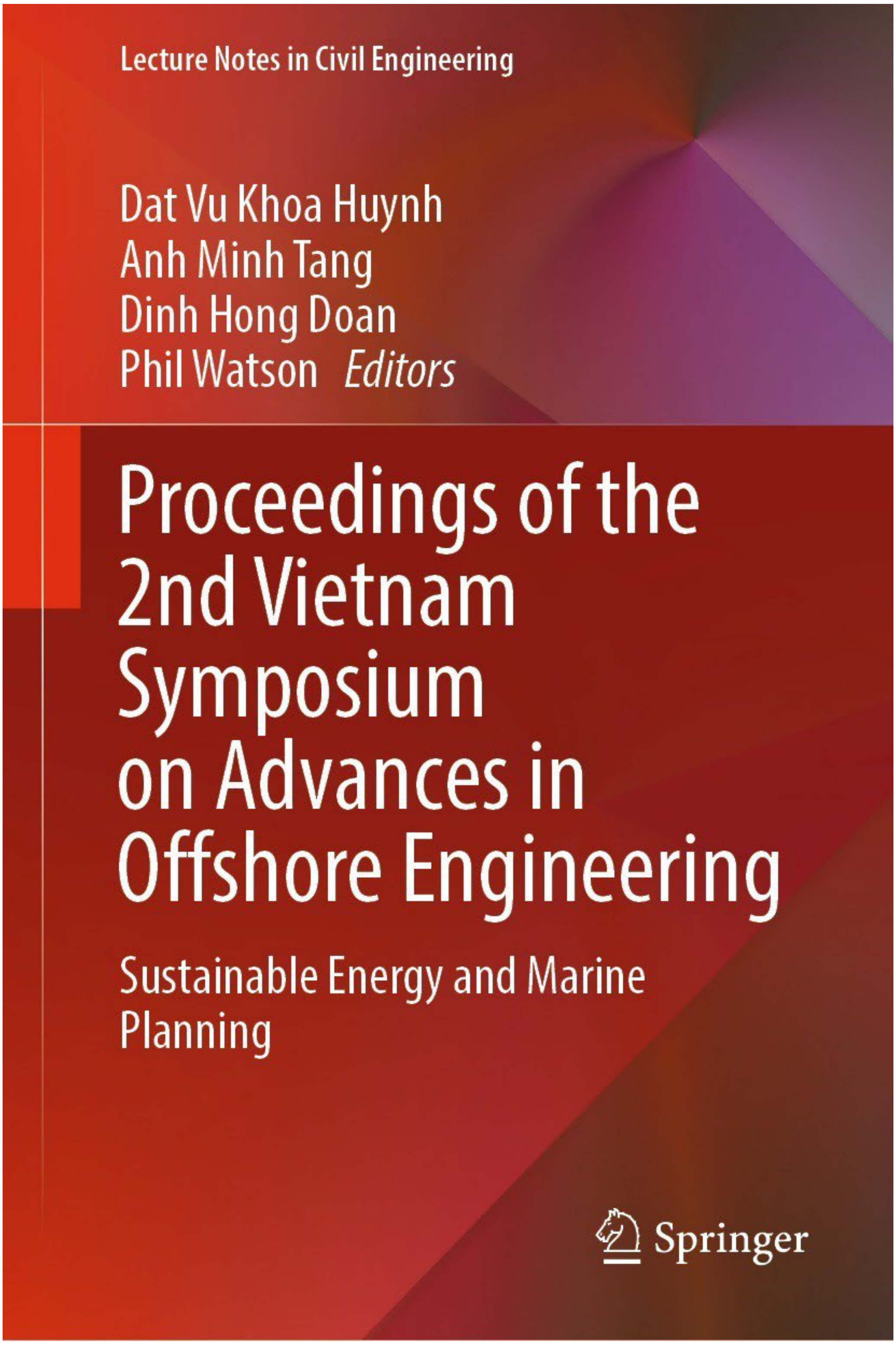
PRESENTATIONS



https://link.springer.com/book/10.1007/978-981-16-7735-9

Accelerating transition to net zero through ocean-based solutions: lessons learned and good practice

Hilde Solbakken
Norwegian Ambassador to Vietnam
The Royal Norwegian Embassy in Hanoi

Norway's economic reliance on its oceans is pivotal, with ocean-based industries contributing significantly to its welfare and export earnings. As a leading figure in ocean research, responsible marine resource management, and a major player in shipping and seafood export, Norway is actively transitioning from traditional oil and gas production to renewable energy. This keynote speech, presented against the backdrop of COP26 and Vietnam's ambitious net-zero goals, shares Norway's experience and best practices in leveraging ocean-based solutions to combat climate change. It explores how such strategies could contribute one-fifth of the necessary annual greenhouse gas emissions reductions by 2050, keeping global temperature rise below 1.5 degrees Celsius.

The speech delves into five key ocean-based climate action areas: investing in nature-based solutions, harnessing ocean-based renewable energy, decarbonizing ocean industries, securing sustainable future food sources, and implementing carbon capture and storage in the seabed. The Norwegian experience in developing offshore wind power is highlighted, showcasing the country's ambitious targets and the synergies between the maritime and energy sectors in this green transition. The role of integrated ocean planning is emphasized as a crucial framework for balancing environmental, industrial, and societal needs.

Overall, the speech underscores the criticality of a healthy ocean in the global fight against climate change, presenting a comprehensive approach that combines policy, industry innovation, and sustainable practices to achieve a prosperous, environmentally-resilient ocean-based economy.

Planning, policy and integration for sustainable development of offshore wind energy in Vietnam 2022 - 2050

Ha Duong Minh
Vietnam Initiative for Energy Transition (VIET), Vietnam

Planning, policy and integration for sustainable development of offshore wind energy in Vietnam 2022-2050

Dr. Minh Ha-Duong

2022 Vietnam Symposium on Avances in Offshore Engineering
Ho Chi Minh City, 24 October 2022

Regulations
Planning
Biomass
Wind
Grid

VIET

an active
INDEPENDENT THINK TANK
since 8/2018

Research
Expertise
Consultancy
Training

Dialogue
Scenarios
Modeling
Economics
Integrated assessment
International experience

Credibility
Excellence
Happiness
Responsibility
Interdependence

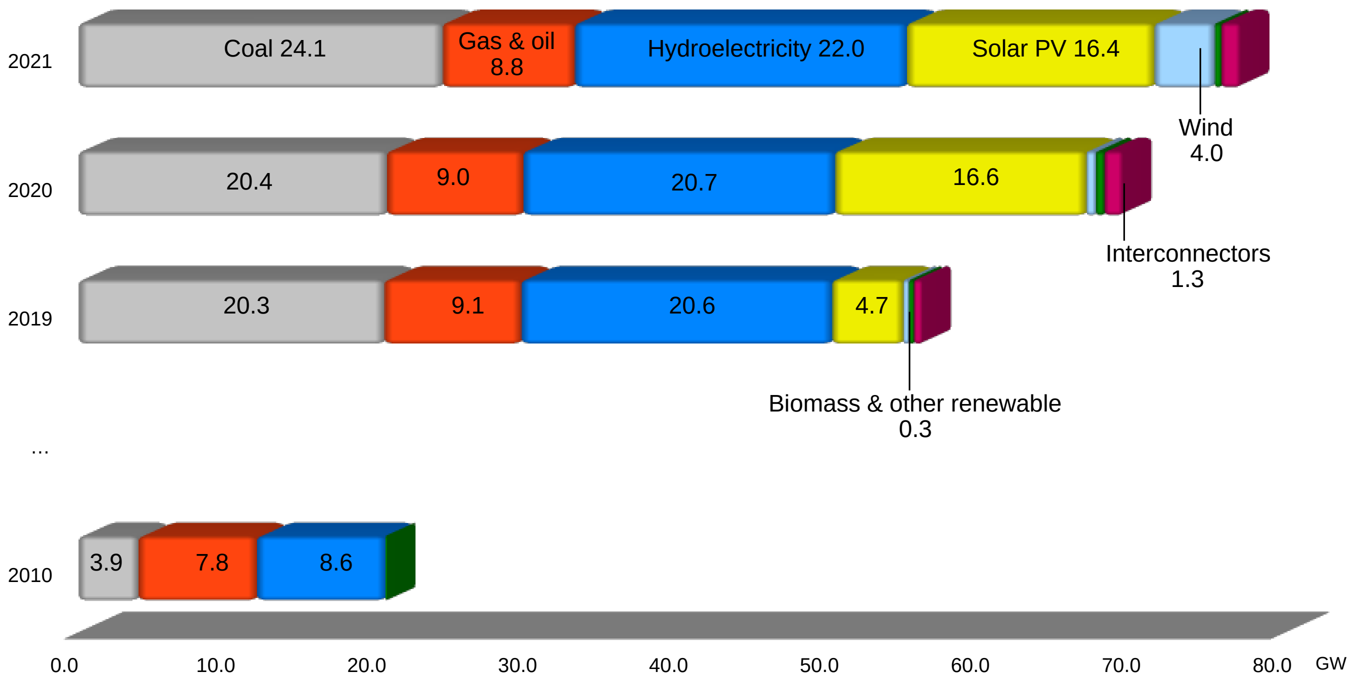
1. Wind power in Vietnam today

88 projects operating

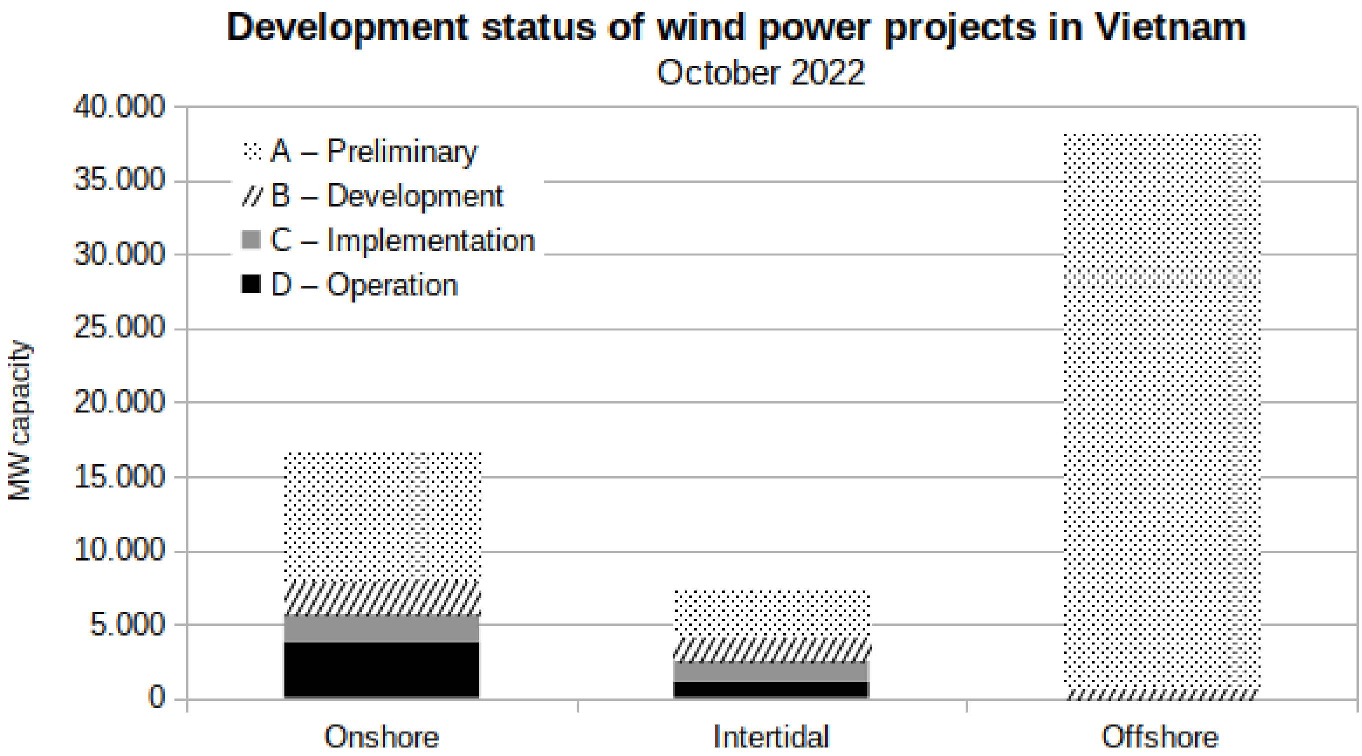
4.2 GW installed capacity

No “real” offshore under construction

Vietnam installed 40GW of power generation capacity in 2010-2021



Source: author, data EVN.



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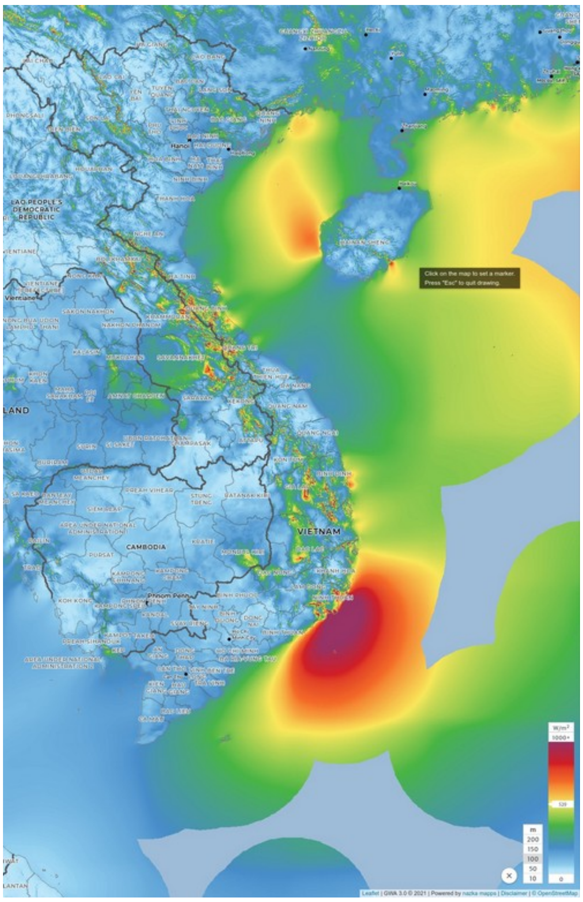
Source: Author.
Dataset available at Zenodo.org



Mean wind power density for Vietnam at 100m, color scale from 0 to 1000+ W/m2

Source: Global wind atlas 3.1

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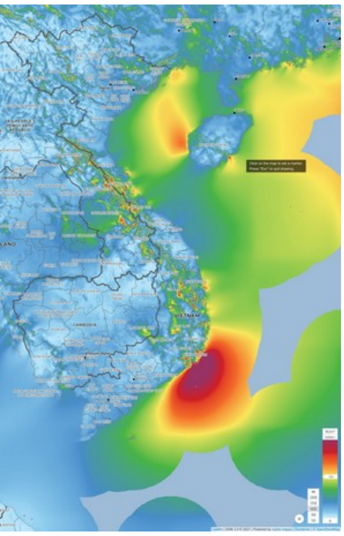


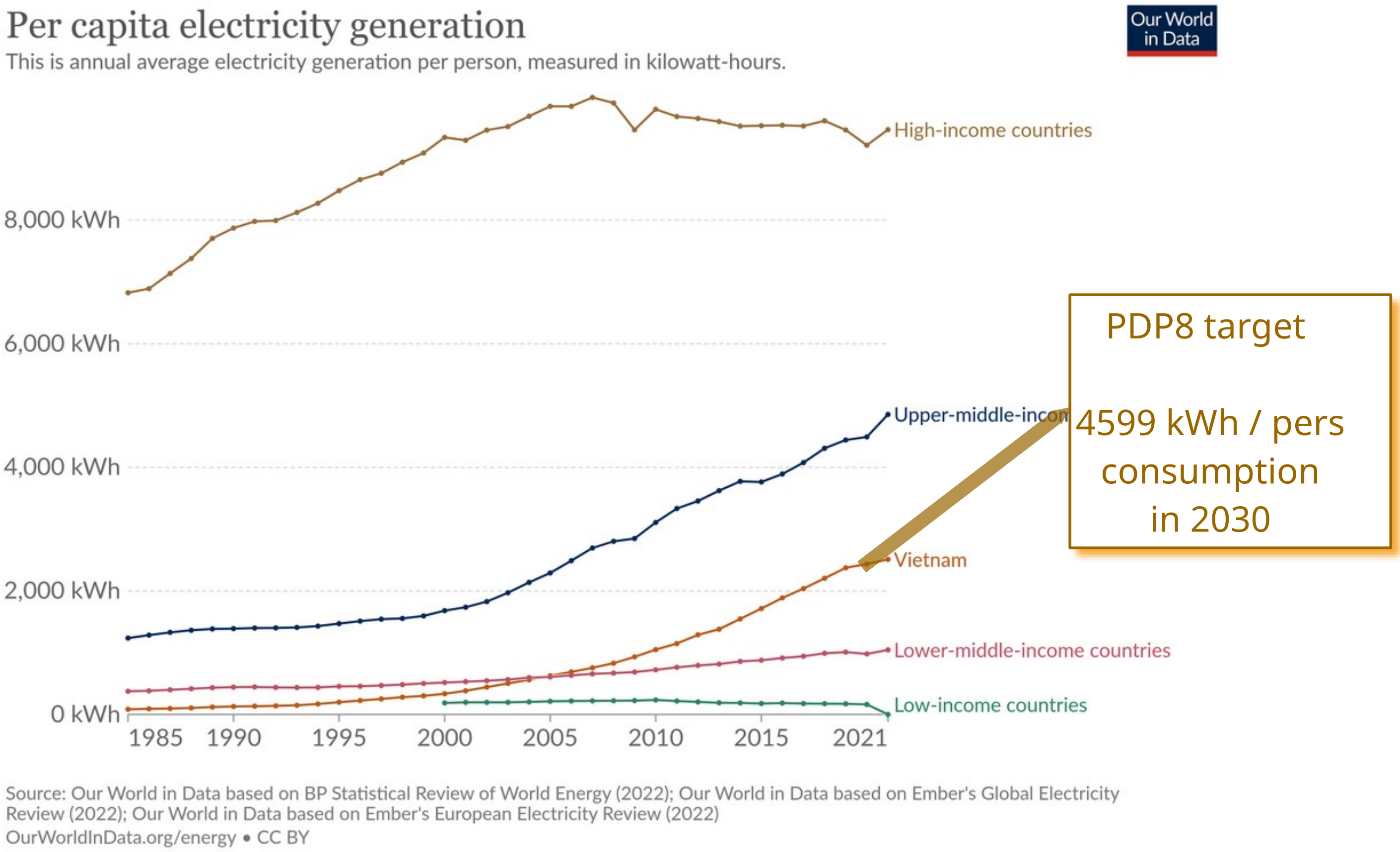
Wind farms in Vietnam

Source: pgis.vietse.vn

2. Vietnam needs more electricity

And wind is the #1 clean, affordable solution

Vietnam Initiative for Energy Transition



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EVN TẬP ĐOÀN ĐIỆN LỰC VIỆT NAM VIETNAM ELECTRICITY

Introduction | Cooperation Information | Media | EVN and Customers

Press Releases

Information about failures of some substations in the North on 4 July 2022

According to information from the National Load Dispatch Center, at 13:00 on 4 July 2022, voltage fluctuations appeared on the Northern power system, affecting some customers' power supply in the North.

The initial cause was determined hot weather, which increased power consumption and some generator units failed causing voltage fluctuations, then power supply interruption resulted in some customers in the North.

Immediately after the failure occurred, the National Load Dispatch Center actively coordinated with power generation and grid operating units to troubleshoot the problem and restore power supply to customers as quickly as possible.

By 15:00 on the same day, all customers who were affected by power disruption had been restored to the power supply and the Northern power system have returned to stable operation.

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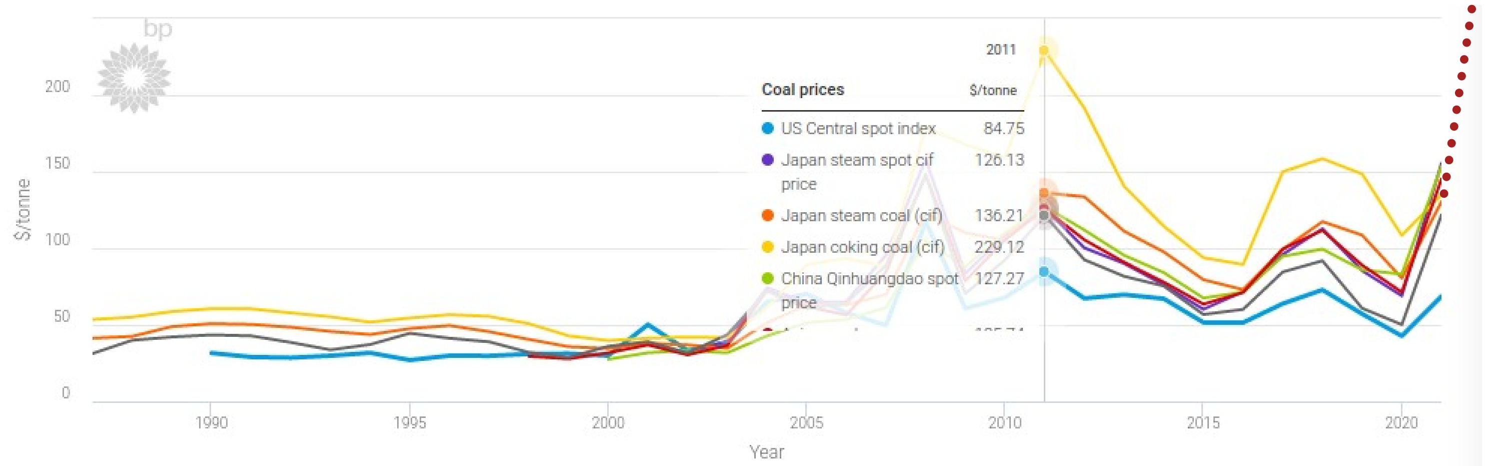
to 400 $/t

Prices of coal, 1985-2021

Steam coal was 50-150 $/t

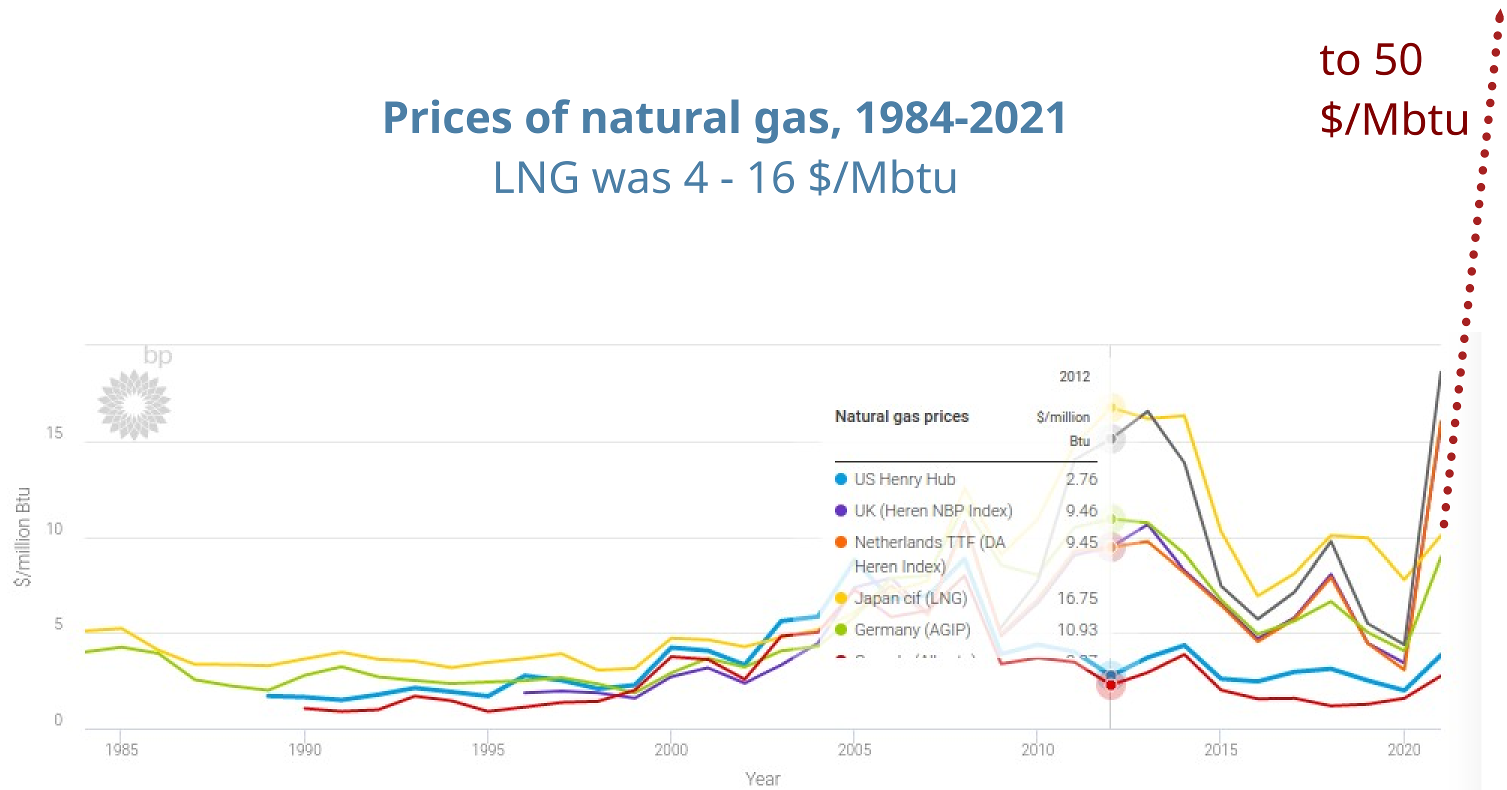


Undeflated prices. bp Statistical Review of World Energy June 2022 charting tool.

to 50 $/Mbtu

Prices of natural gas, 1984-2021

LNG was 4 - 16 $/Mbtu



Undeflated prices. bp Statistical Review of World Energy June 2022 charting tool.

https://vsoe2021.sciencesconf.org/

Energy sector CO2 emissions must peak before 2035

No new coal after 2030

Control methane emissions

Carbon neutrality by 2050

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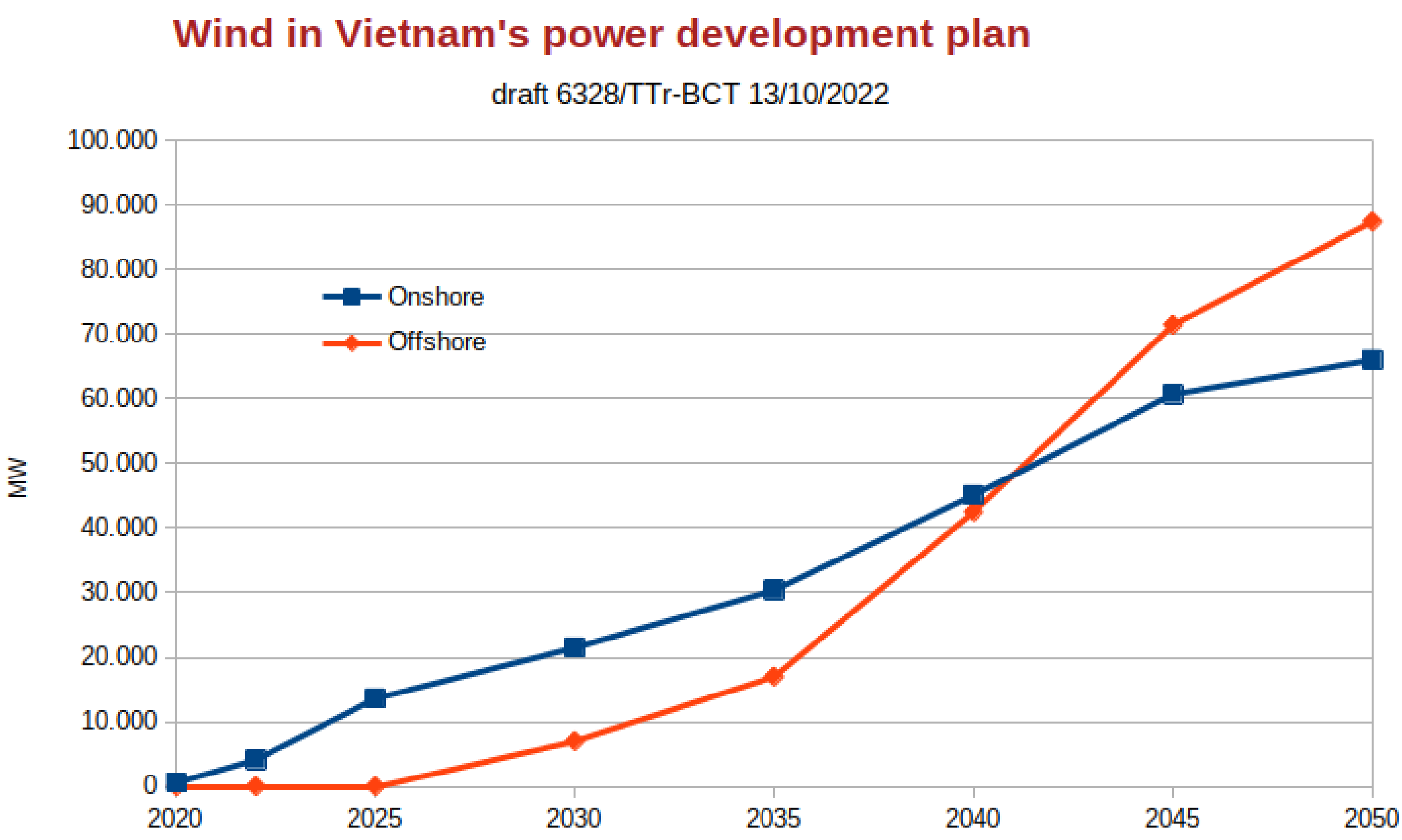

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3. Challenges ahead

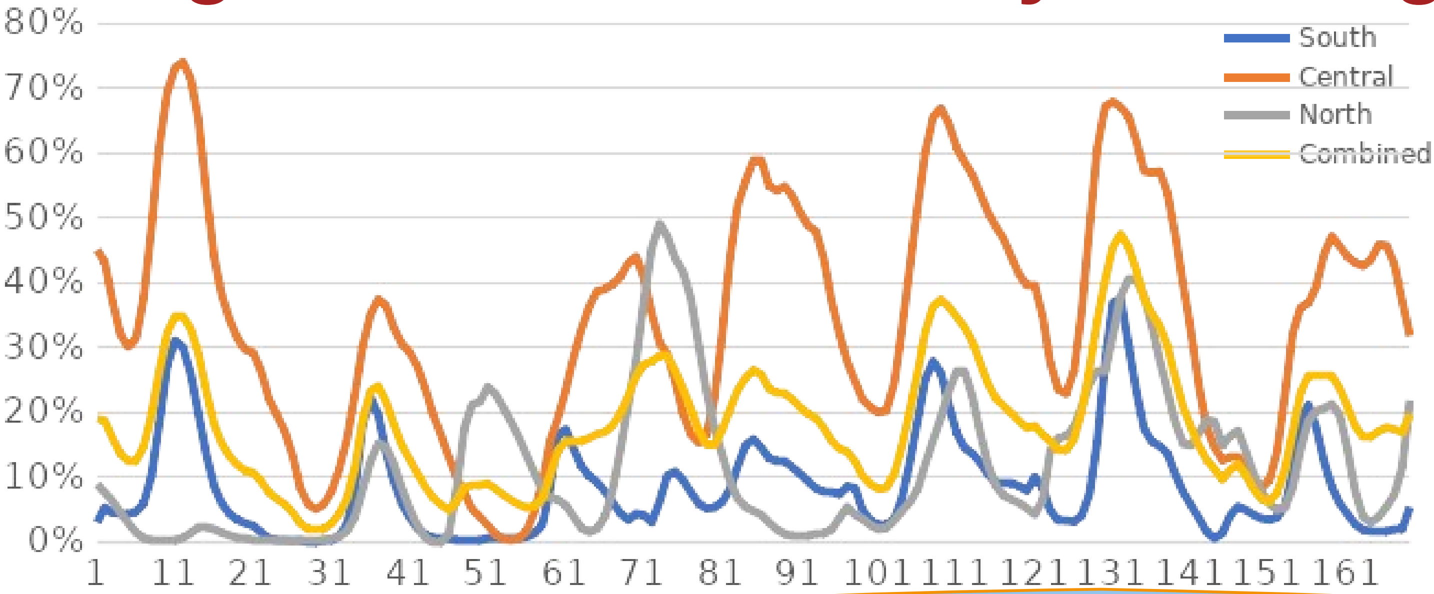
Integrate, manage variability

Finance, find capital

Connect, build the transport infrastructure

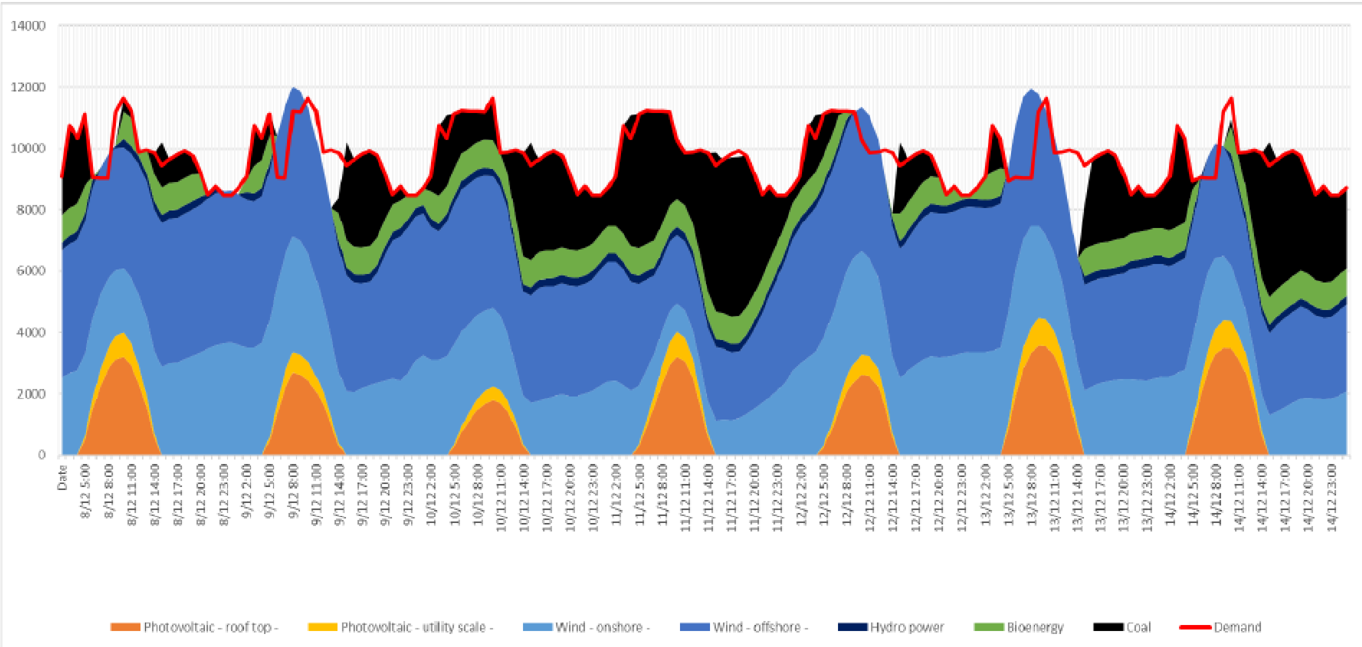
Vietnam Initiative for Energy Transition

Wind generation variability challenge



Regions of Vietnam, first week of January, generation profile from Renewable Ninja.

Power mix simulation for the Red river delta (2030) in a very windy week and high renewables scenario



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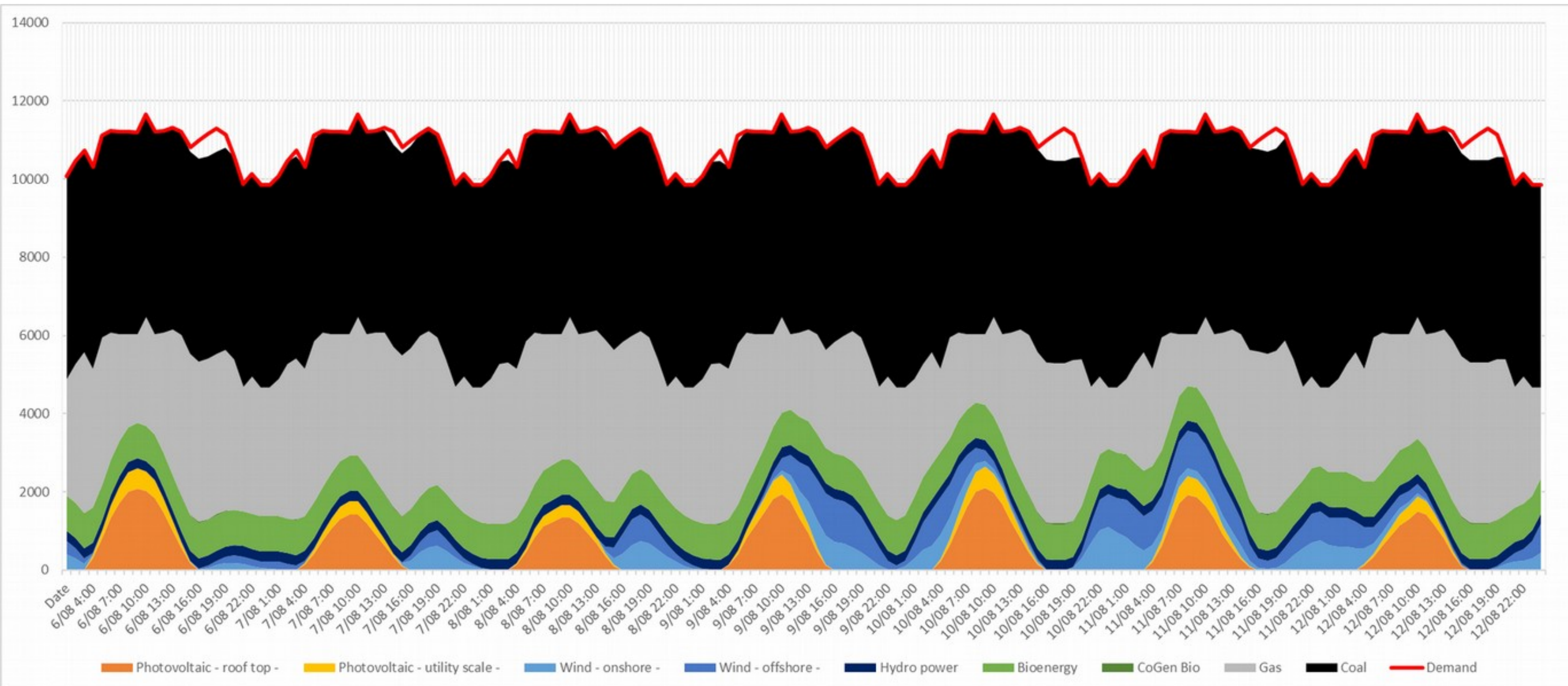
Windless week → Thermal power here in 2030



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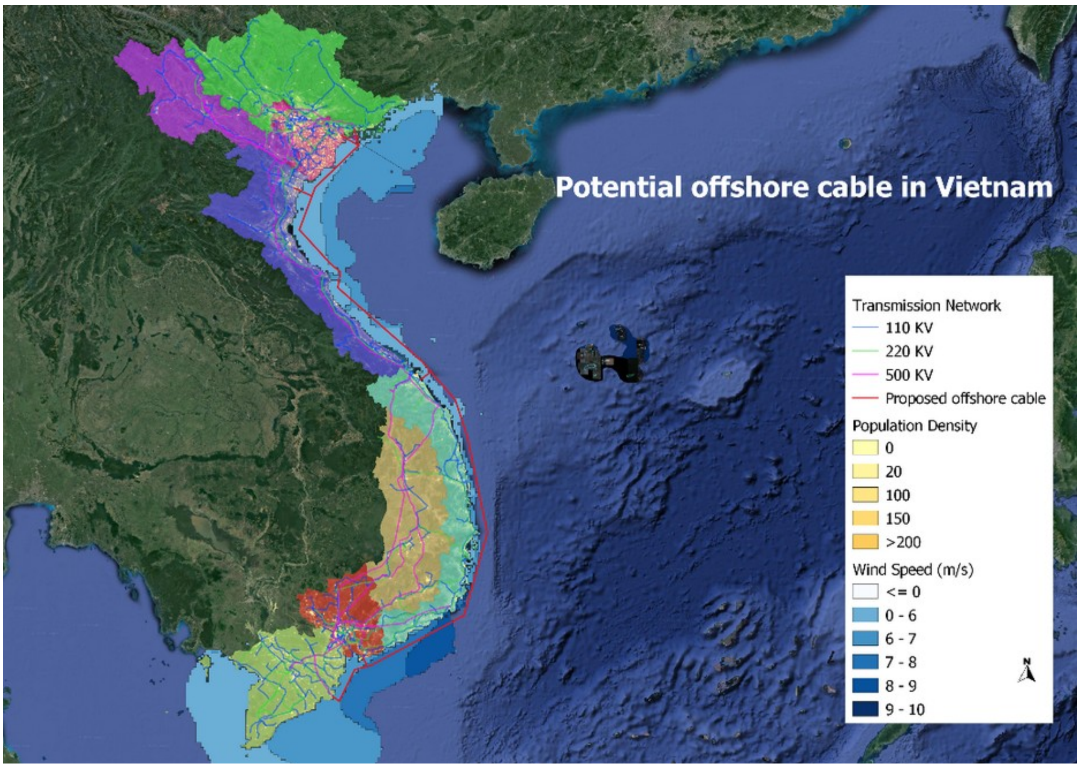
Power sector capital challenge

9.0 - 12.6 billion USD for generation sources
+
1.5 - 1.6 billion USD for the grid

per year, over 2021-2030

According to 5709/TTr-BCT 23/09/2022

Infrastructure challenge



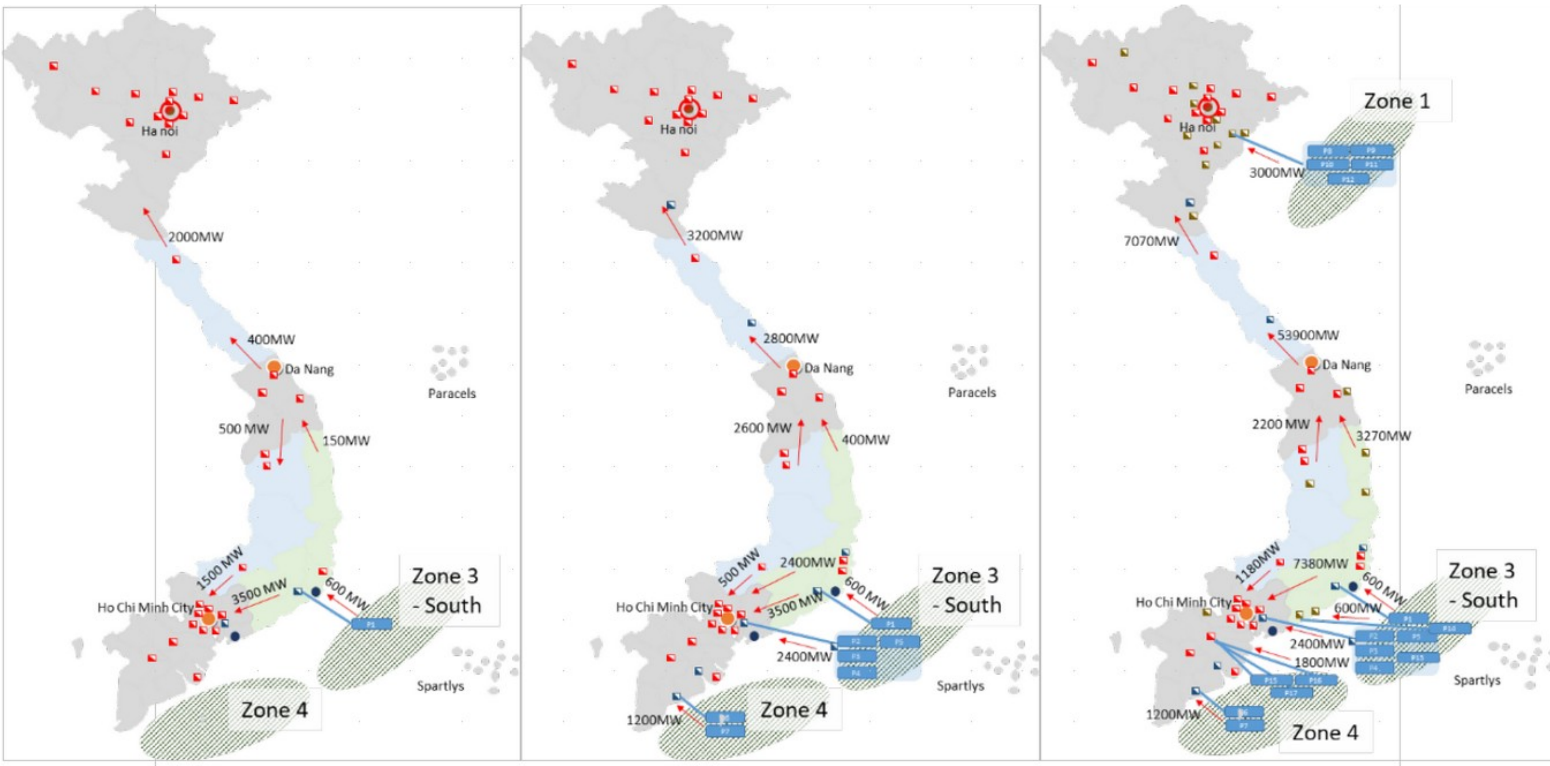


Fig. 1. Load flow snapshot in 2023, 2025 and 2030 (from left to right) - Cases of high renewable sources including max capacity from OWFs.

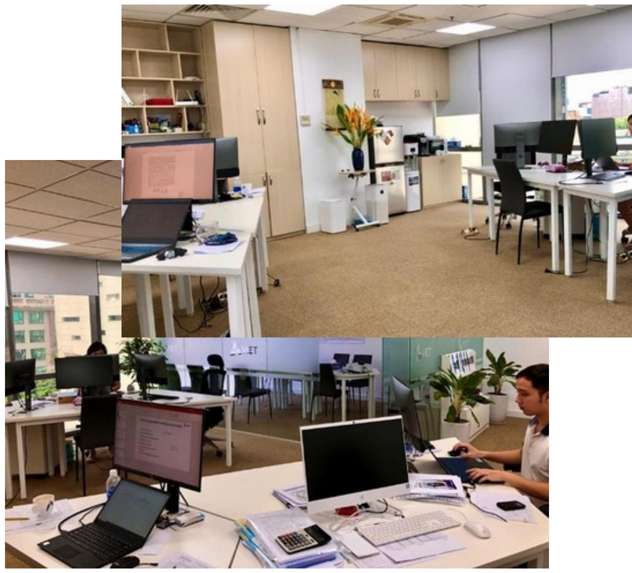
Conclusion

Vietnam ♥♥ Offshore wind

- Future of domestic power supply
- Hydrogen production potential
- Growth sector with a global supply chain

More info at https://vietse.vn

Thank you!



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Innovative research to support offshore renewable energy

Phil Watson
The Centre for Offshore Foundations Systems (COFS)
The University of Western Australia

Innovative research to support offshore renewable energy

Phil Watson – *The Centre for Offshore Foundations Systems (COFS)*

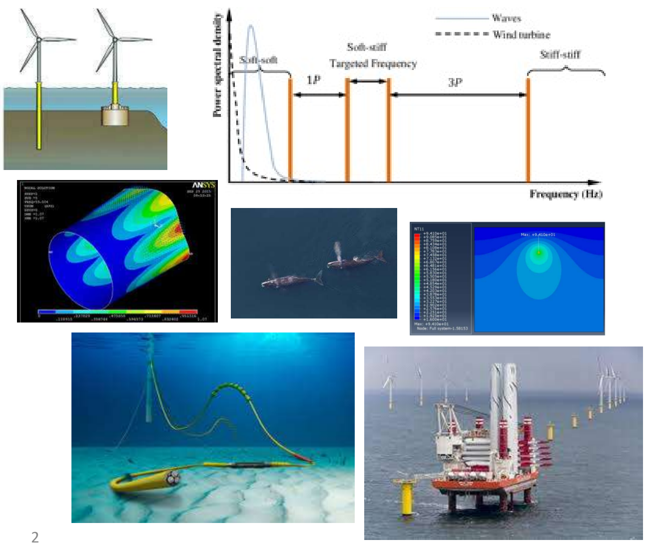
with input from …

Fraser Bransby, Christophe Gaudin, Britta Bienen, Conleth O'Loughlin, Mike O'Neill, Alessio Mentani plus PhD students as acknowledged on individual slides

New challenges …

- Foundations
  - Dynamically sensitive (stiffness)
  - Low V/M ratio
  - New regions (soils)
- Field layout
  - Spatial variability
  - Shared anchors (floating)
- Installation
  - Noise
  - Low t/D ratios
  - Highly loaded spudcans
- Seabed
  - Scour
  - Cables (thermal)

… and much, much more!



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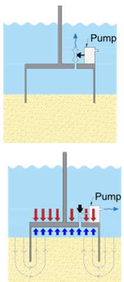
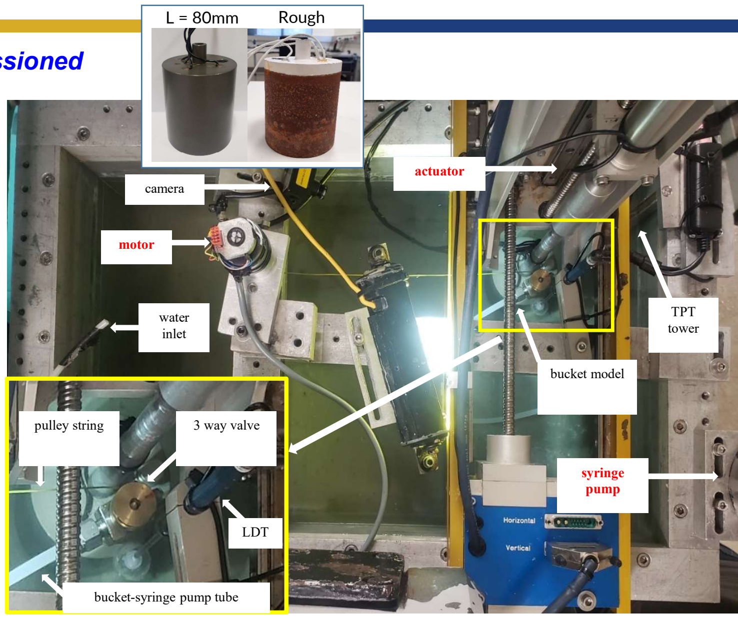
Foundations

Suction buckets

Fast installation, low noise, can be decommissioned

Model full installation process and in-service





Suction buckets

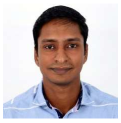
Innovative installation strategies

Challenges:

- Cavitation limit
- Buckling limit

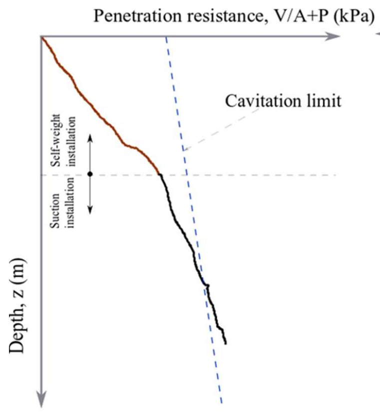
Strategies:

- Pressure cycling
- Tip water injection

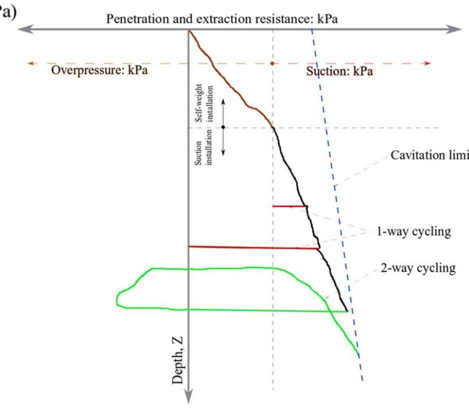


Senthen Mani

Cavitation can halt installation



Pressure cycling to get beyond limit



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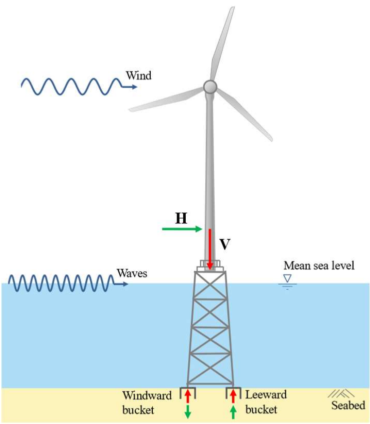
Suction buckets

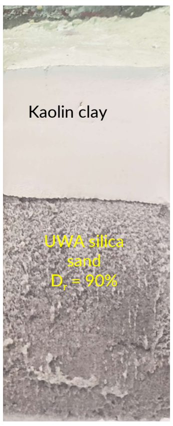
In-service loading

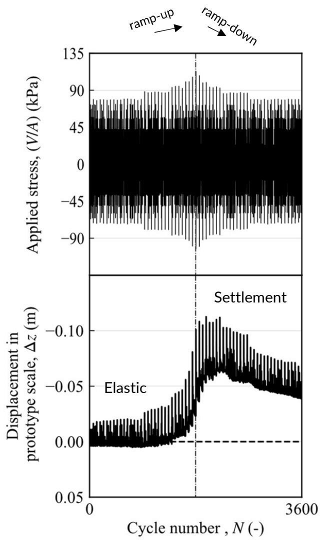
Environmental load resisted by push-pull effect



Layered soils

Often encountered, not widely studied





Francisco Pereira

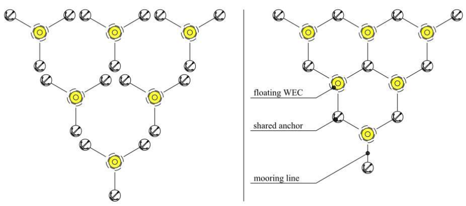
Also explored by many other researchers …

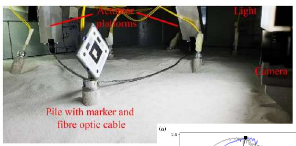
https://vsoe2021.sciencesconf.org/

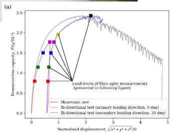
Other examples of ongoing modelling

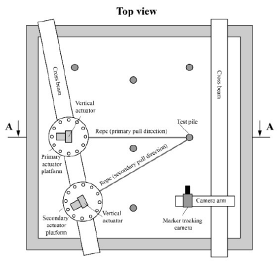
COFS CENTRE FOR OFFSHORE FOUNDATION SYSTEMS — THE UNIVERSITY OF WESTERN AUSTRALIA

Multi-directional loading / shared moorings



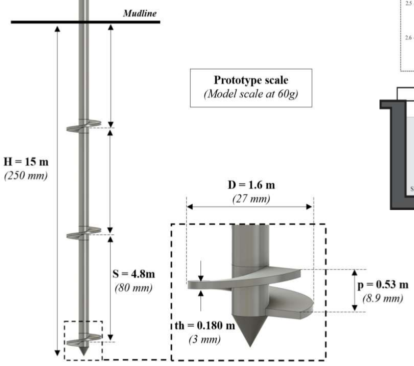


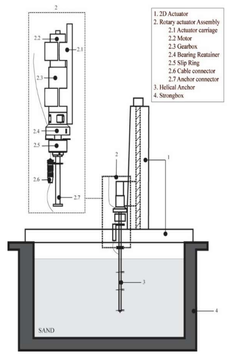


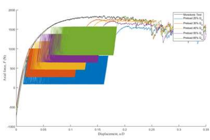


Helical piles

Pierre Duverneuil







New design tools

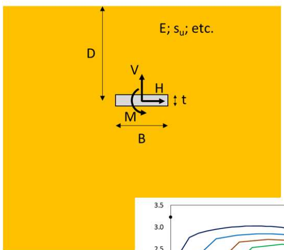
COFS CENTRE FOR OFFSHORE FOUNDATION SYSTEMS — THE UNIVERSITY OF WESTERN AUSTRALIA

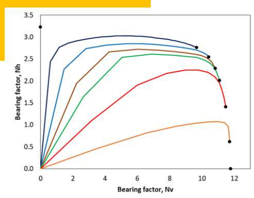
A numerical tool that embeds the response of advanced FE model but at low computational cost - through use of metamodels (MM)

SEAFLOWER for floating wind energy

1. Define problem position

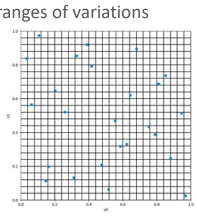
Select the problem input and identify the output





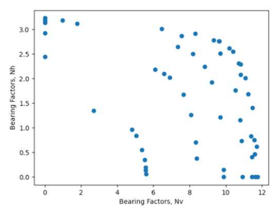
2. Sampling

Sample the input into relevant ranges of variations



3. FE test programme

Run FEM for the sampled combo's



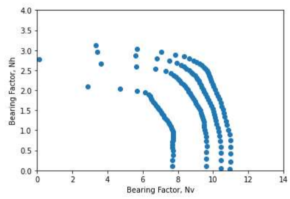
4. MM calibration & validation

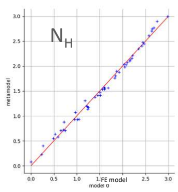
Input-output combinations are used to calibrate the MM, which is then validated against a different dataset

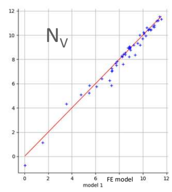
input + output

5. Exploit MM

Use for any input combo at negligible computational cost







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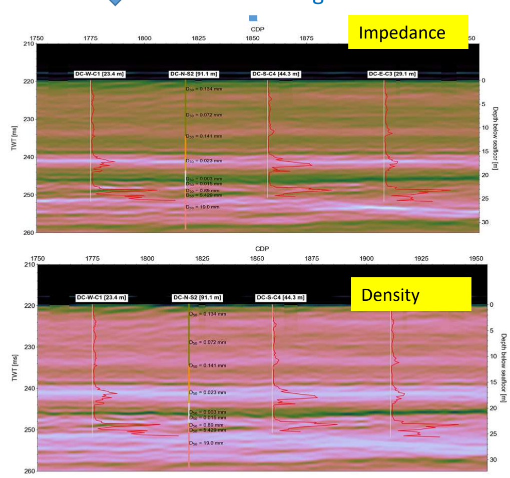
Field layout

Geotech parameters from geophysics?

Input: Seismic reflection data (chirp SBP or multichannel)

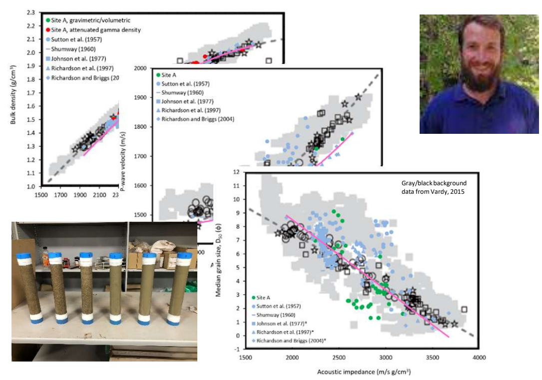
PyLops Post-stack acoustic impedance inversion + background model



Statistical correlation

Ground truth with Geotech data

Alex Osuchowski



Direct measurement + field validation

Quantification of uncertainty

+ correlations with q_{net}
+ correlations with near-seabed properties

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Addressing uncertainty

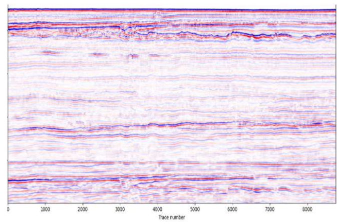
Large footprint = balance risk (related to installation, performance) vs. cost (of data acquisition)

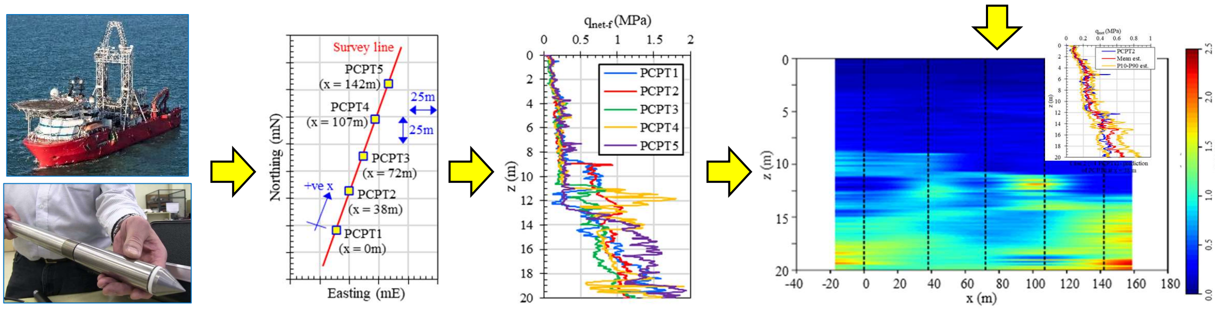
The challenge

- Interpolation & extrapolation of offshore PCPT data across survey area.

The solution

- Application of data-centric methods to analyse & use measured data.
- Incorporate other forms of geo-data (e.g. geophysical).
- Include uncertainty in estimating parameters at unsampled locations
- Inform & optimise strategies & planning for future investigations.





Installation

Vibro-installation & loading (monopiles)

Fast installation, less fatigue, reduced noise, economic

Creation of an innovative mini vibro-driver for centrifuge

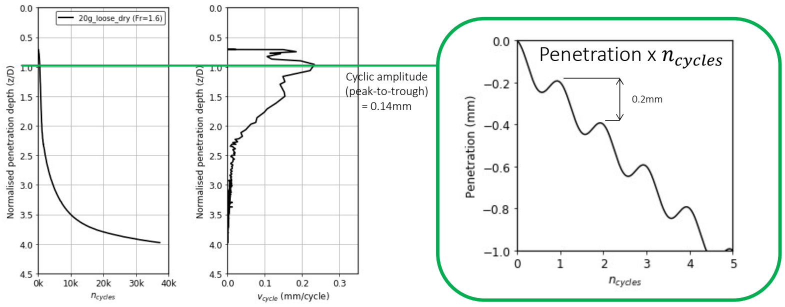
Challenge: scaling dynamic events!

Field f ≈ 23 Hz → N = 100 → Centrifuge f = 2300 Hz

Main goals: study mechanisms of vibro-driving and impact on lateral capacity

Vibro-installation

Cycle-by-cycle analysis of penetration



Júlia Hein Mazutti

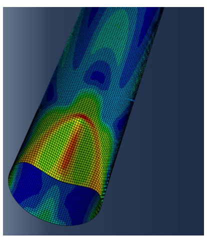
Pile damage during driving

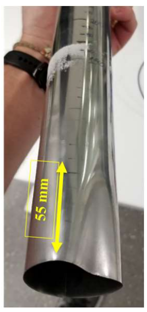
Driving though scour protection or with boulders

Centrifuge and numerical studies

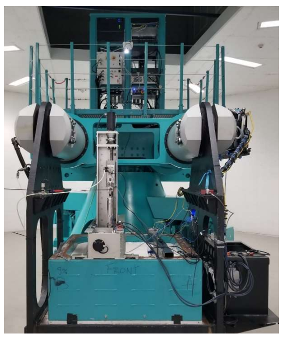
Low t/D can lead to failures

FE Analysis





Pile driving in centrifuge



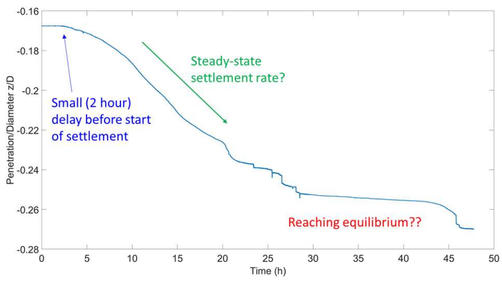
Juliano Nietiedt (now Fugro)

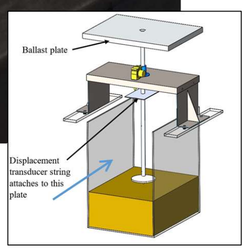
14

Scour

Spudcan penetration due to scour

Sandy seabeds may leave spudcans exposed





In closing

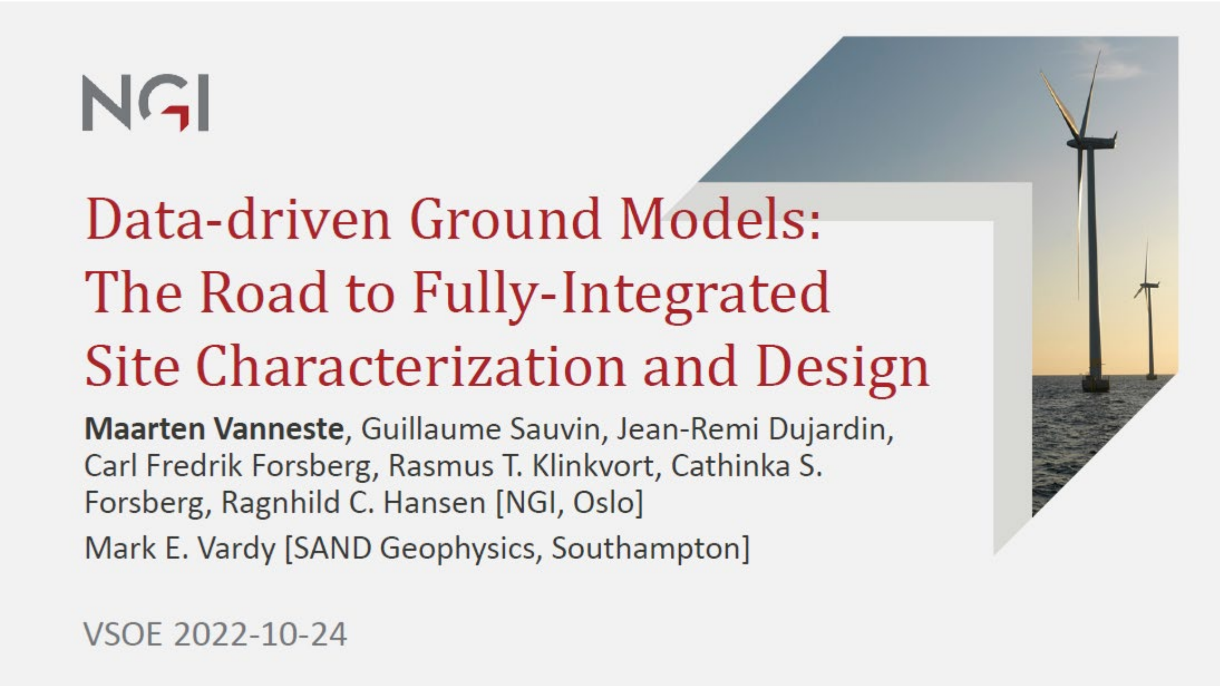
Offshore wind
- is well established in the North Sea, and rapidly expanding
- presents challenges that differ from conventional oil & gas projects
- has low margins to work with
- is putting pressure on supply chains

Geotechnical solutions need to be efficient, robust and economic – while considering fabrication and environment constraints

It is an exciting time for both researchers and practitioners!

Data-driven ground models: the road to fully-integrated site characterization and design

Maarten Vanneste
Norwegian Geotechnical Institute, Norway



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Data-driven Ground Models: The Road to Fully-Integrated Site Characterization and Design

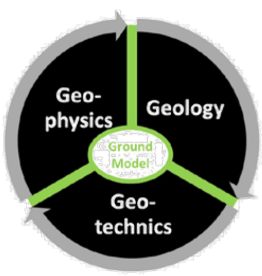
Maarten Vanneste, Guillaume Sauvin, Jean-Remi Dujardin, Carl Fredrik Forsberg, Rasmus T. Klinkvort, Cathinka S. Forsberg, Ragnhild C. Hansen [NGI, Oslo]

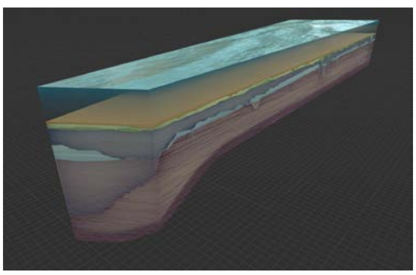
Mark E. Vardy [SAND Geophysics, Southampton]

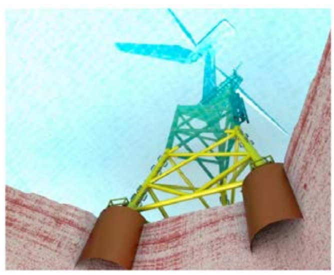
VSOE 2022-10-24

Outline

- Offshore Wind – Market Outlook
- Current Developments – Requirements on Geophysical and Geotechnical Site Investigations, and the need for Integration
- Data-driven Ground Models: site-wide predictions of geotechnical parameters and their uncertainties (examples)
- Looking ahead: Complementary data and methods







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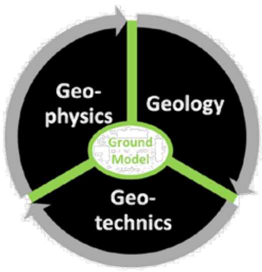
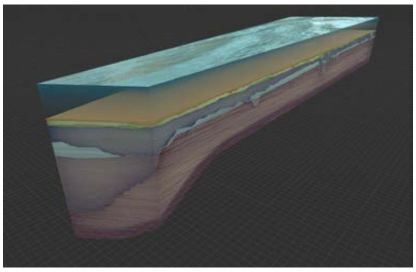
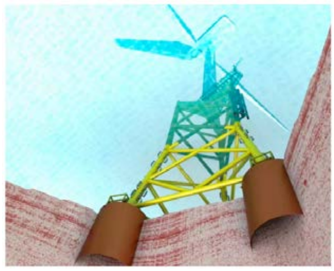
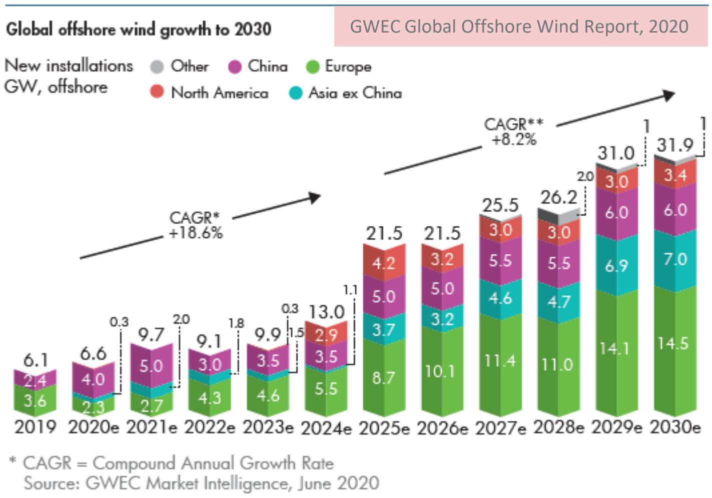






Market Outlook – Offshore Wind

- Green transition: transfer "reservoir" technology/methodology (and jobs) to near-surface characterization, adapted to different challenges
- Significant growth in offshore renewables (particularly OW)
  - shallow waters areas with fixed constructions
  - Floating systems, suitable for deep-water environments
- Key points
  - Fast-track solutions and early-phase decision gates
  - Extensive areas → efficient characterization



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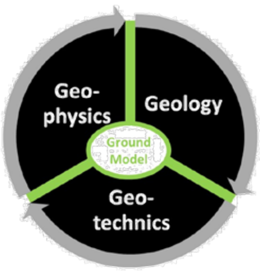
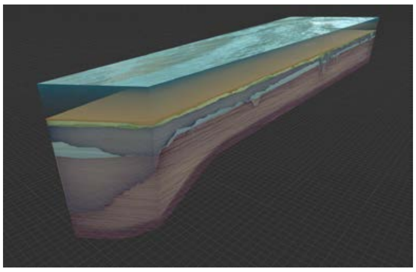
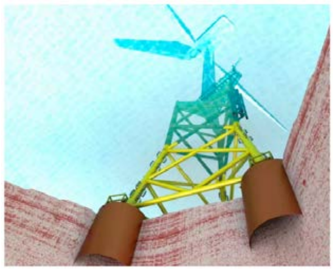
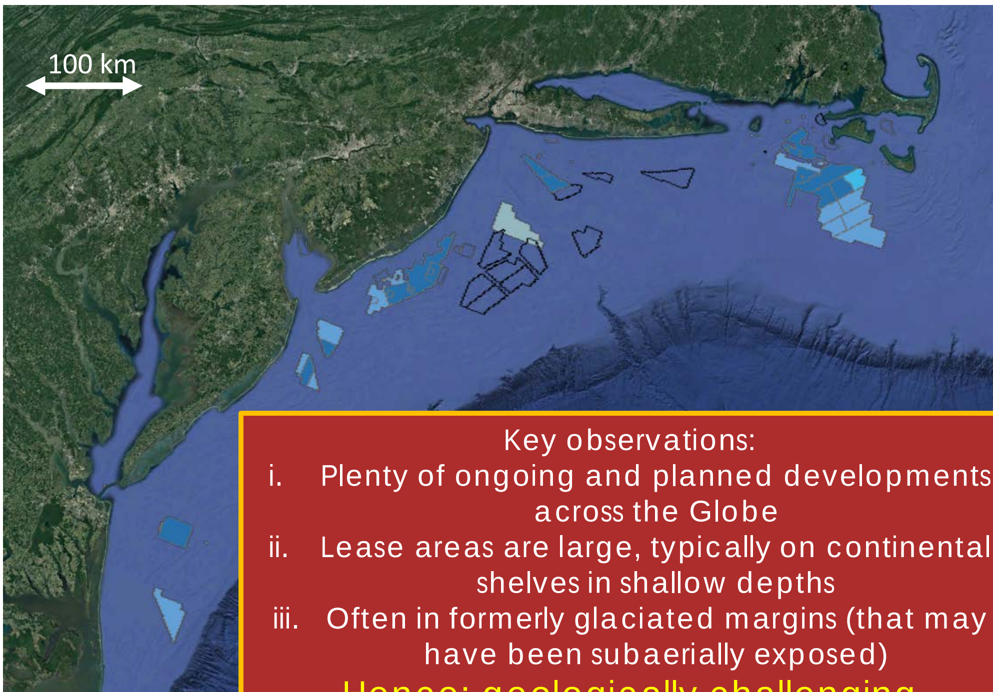
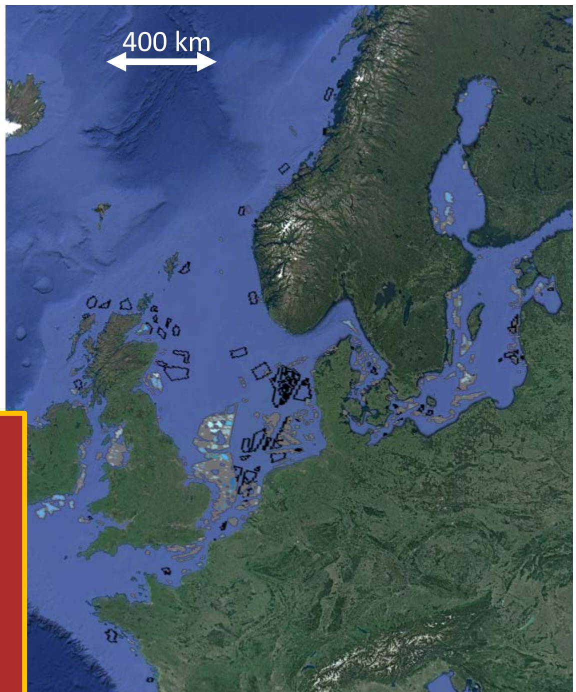






Offshore Wind – Current Developments



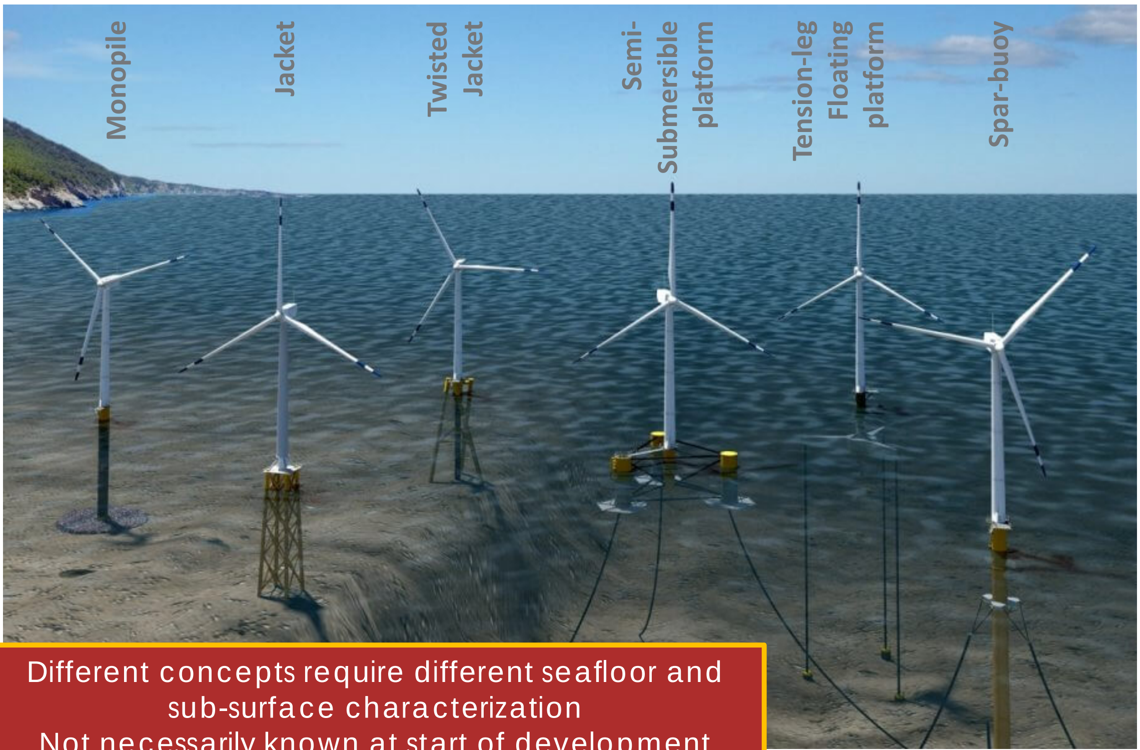


Key observations:

i. Plenty of ongoing and planned developments across the Globe
ii. Lease areas are large, typically on continental shelves in shallow depths
iii. Often in formerly glaciated margins (that may have been subaerially exposed)

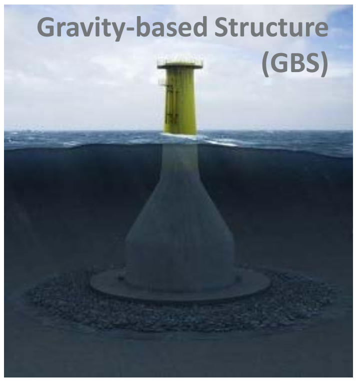
Hence: geologically challenging environments!!

Offshore Wind Foundation Concepts



Different concepts require different seafloor and sub-surface characterization
Not necessarily known at start of development

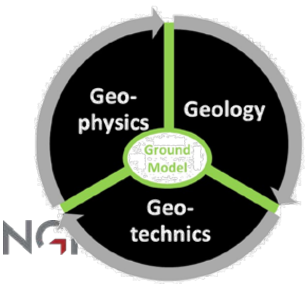
© WindPower Engineering & Development

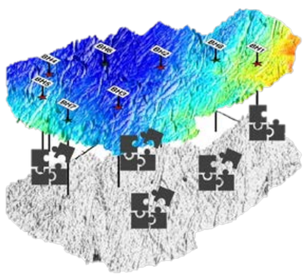


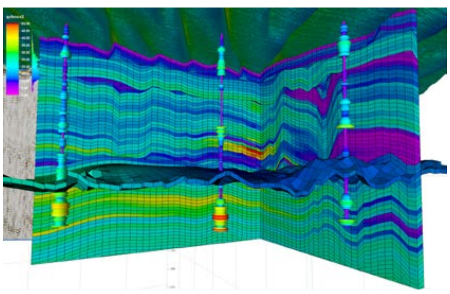
© Seatower AS

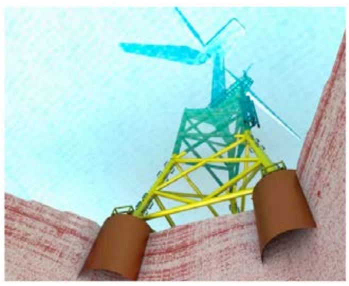
Geophysical SI: Characterization, Hazard & Risk

- **Prime hazards**:
  Weak layers; Shallow gas/fluid flow; Faulting/seismicity; Liquefaction; Bedforms/seabed mobility/scouring; Boulders; Loads; presence of Glauconite; UXO; ++
- **Spatial variability/stratigraphy** implies uncertainty in soil properties (like strength; stiffness, etc.)
- Establish **3D predictive model for engineering applications**









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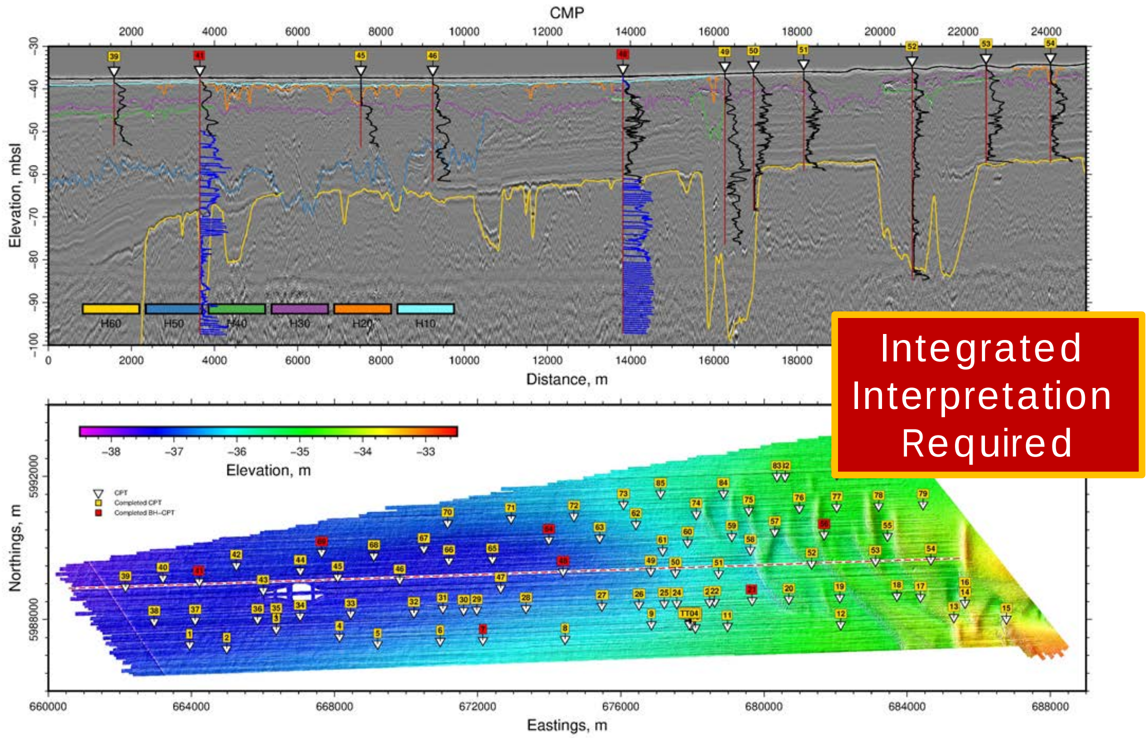
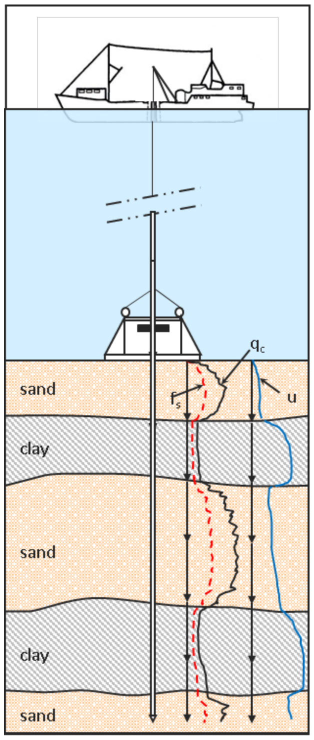
Integration is an absolute requirement





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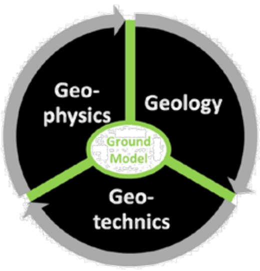
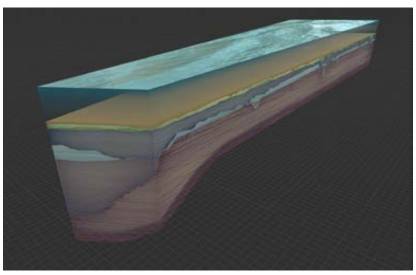
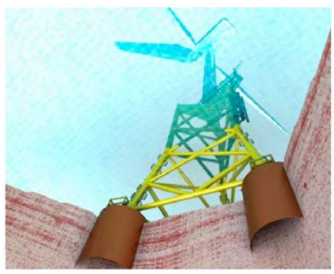
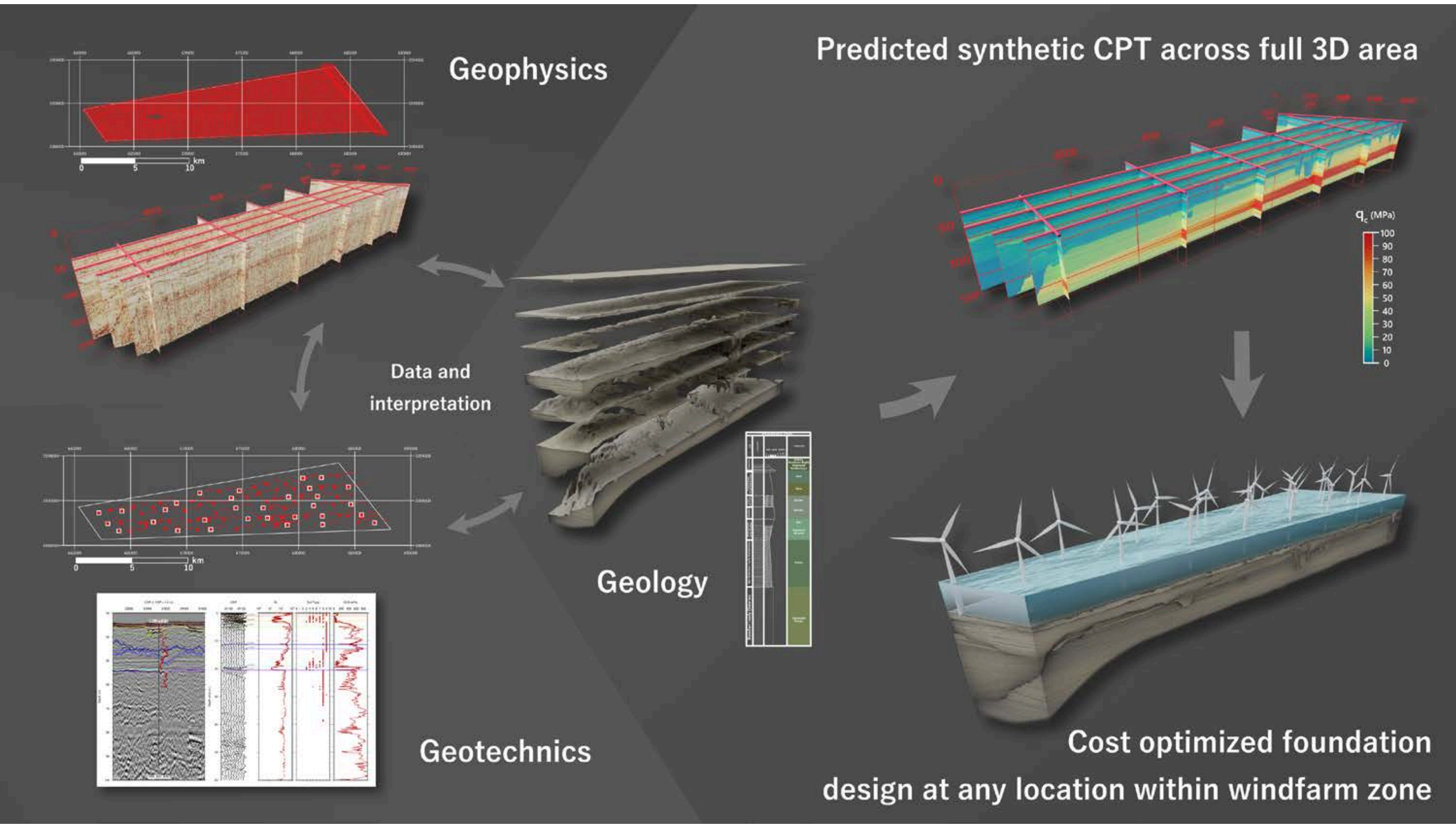






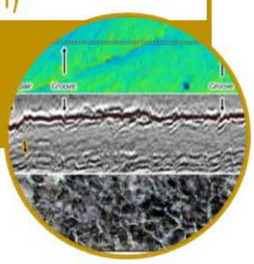


G^3 Trilogy: Fundamental building blocks

Powerful complementary techniques, with pros and cons, and specific language

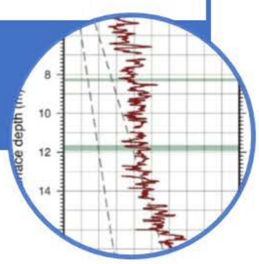
- Non-invasive
- 2D to 3D (# millions)
- Seismo-acoustics
- Ghost, multiples, time-depth conversions
- Resolution, z(~m), decreasing with depth
- R, Z, V, Q, ρ, σ (small-strain)

Geo-physics



- Invasive
- 1D (# tens)
- Samples + CPT
- Resolution, z (cm)
- Empirical relations
- Sample quality?
- $s_u, \gamma, \varphi, G_0, e, \rho, \sigma$ (large-strain)

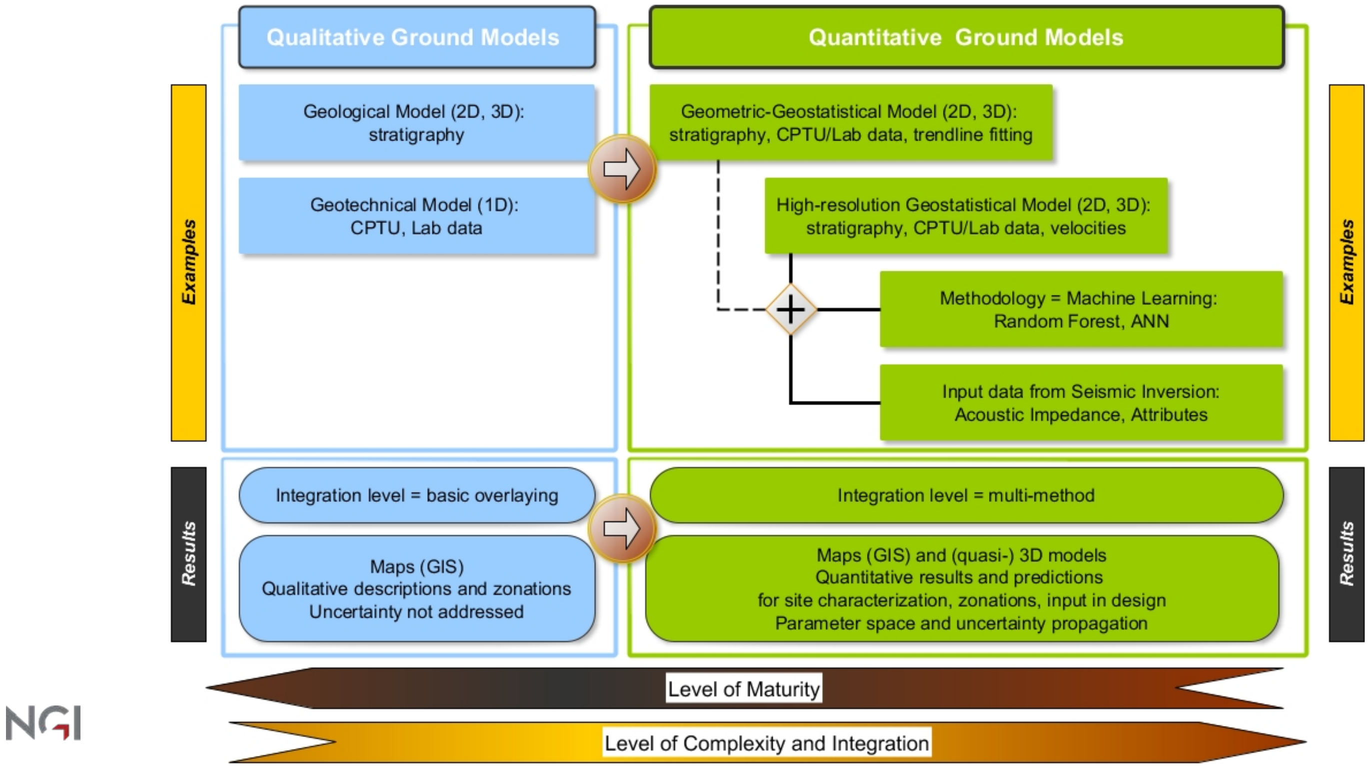
Geo-technics



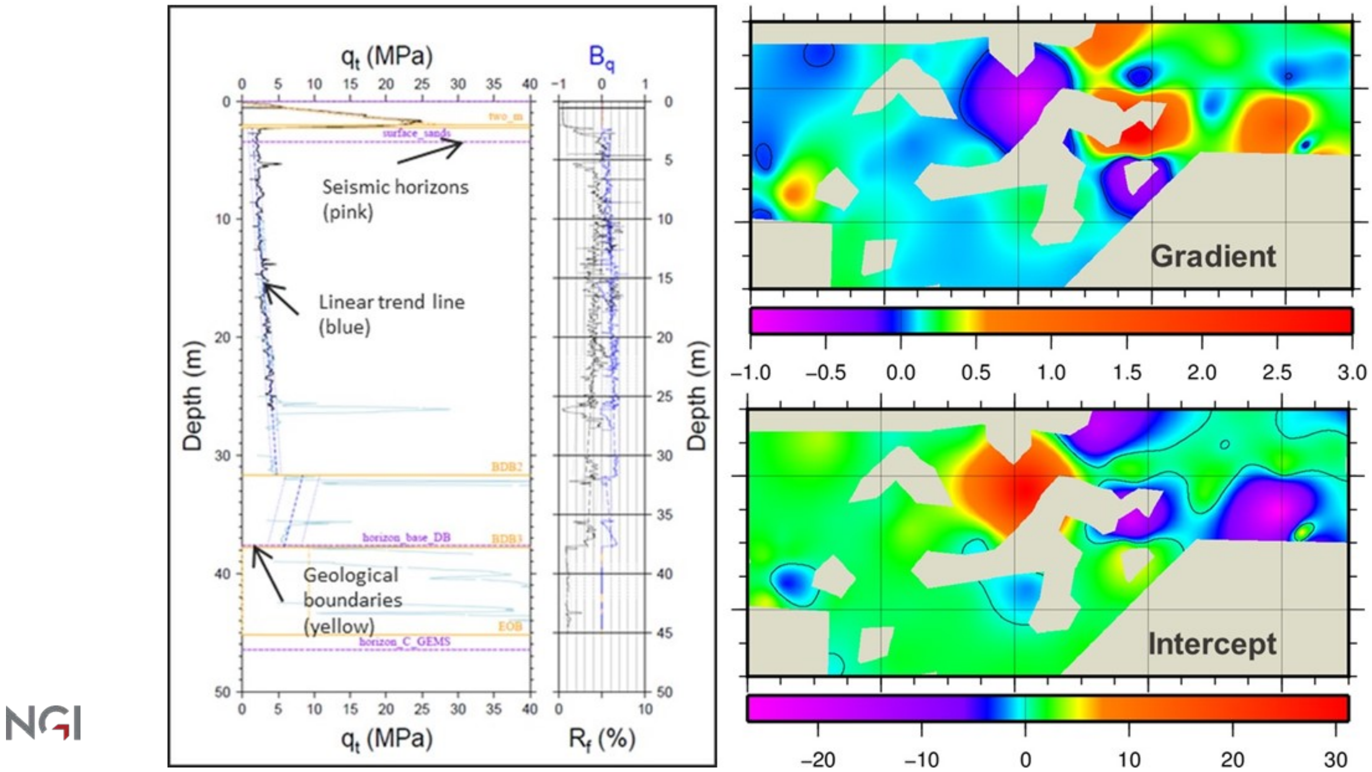
- Processes by which soils form and change over time
- Qualitative
- Time and spatial scales
- Geofantasies?
- Essential for consistency and data extrapolation

Geology

Solution – Data-driven Ground Model



QGM #1: Unit-based parameter model



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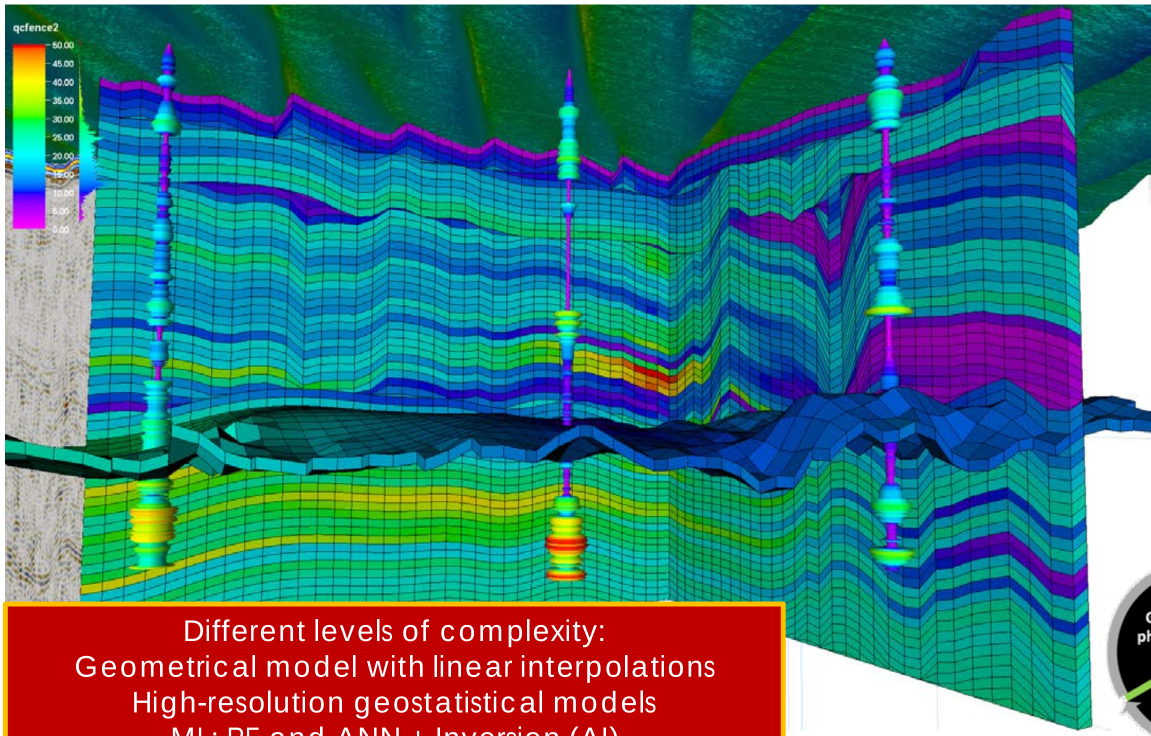
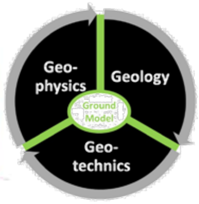
QGM #2: co-Kriging model

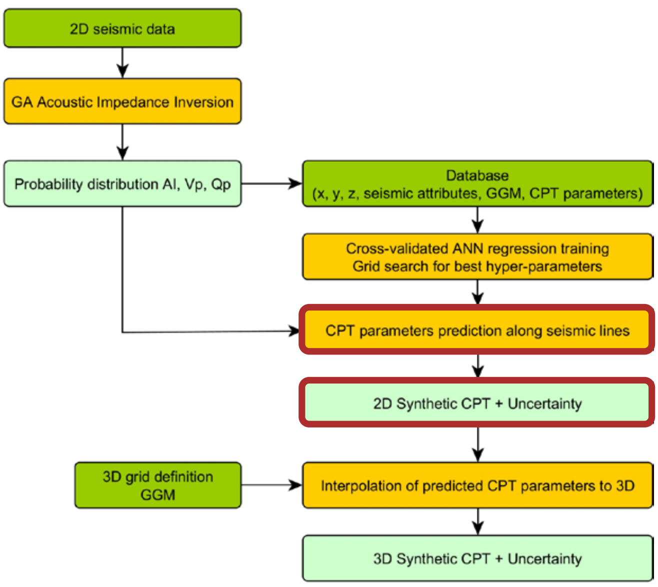


Different levels of complexity:
Geometrical model with linear interpolations
High-resolution geostatistical models
ML: RF and ANN + Inversion (AI)

- ❑ Multi-purpose data integration
- ❑ 3D parameter prediction (here q_c) + Uncertainty assessment (geostatistics)
- ❑ Input into survey planning and/or geotechnical design

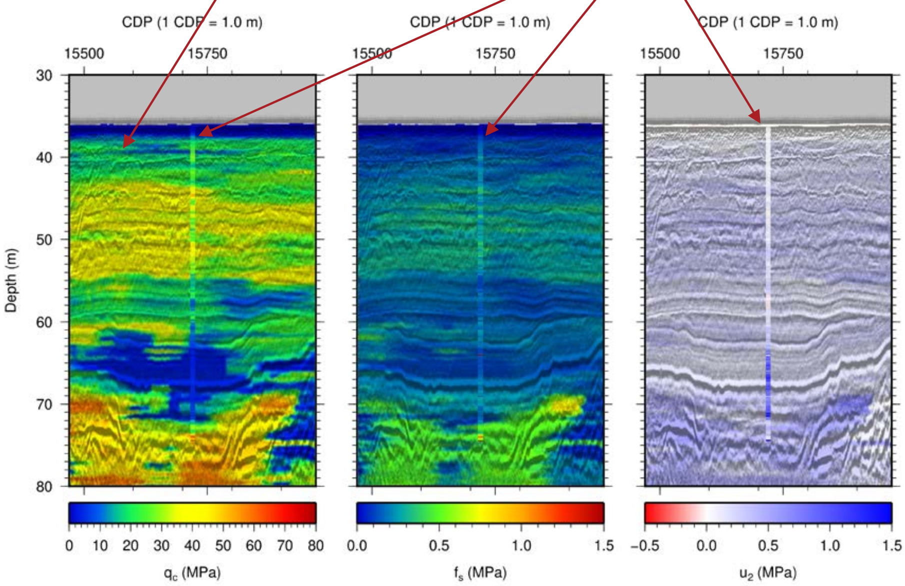


QGM #3: Inversion + ML

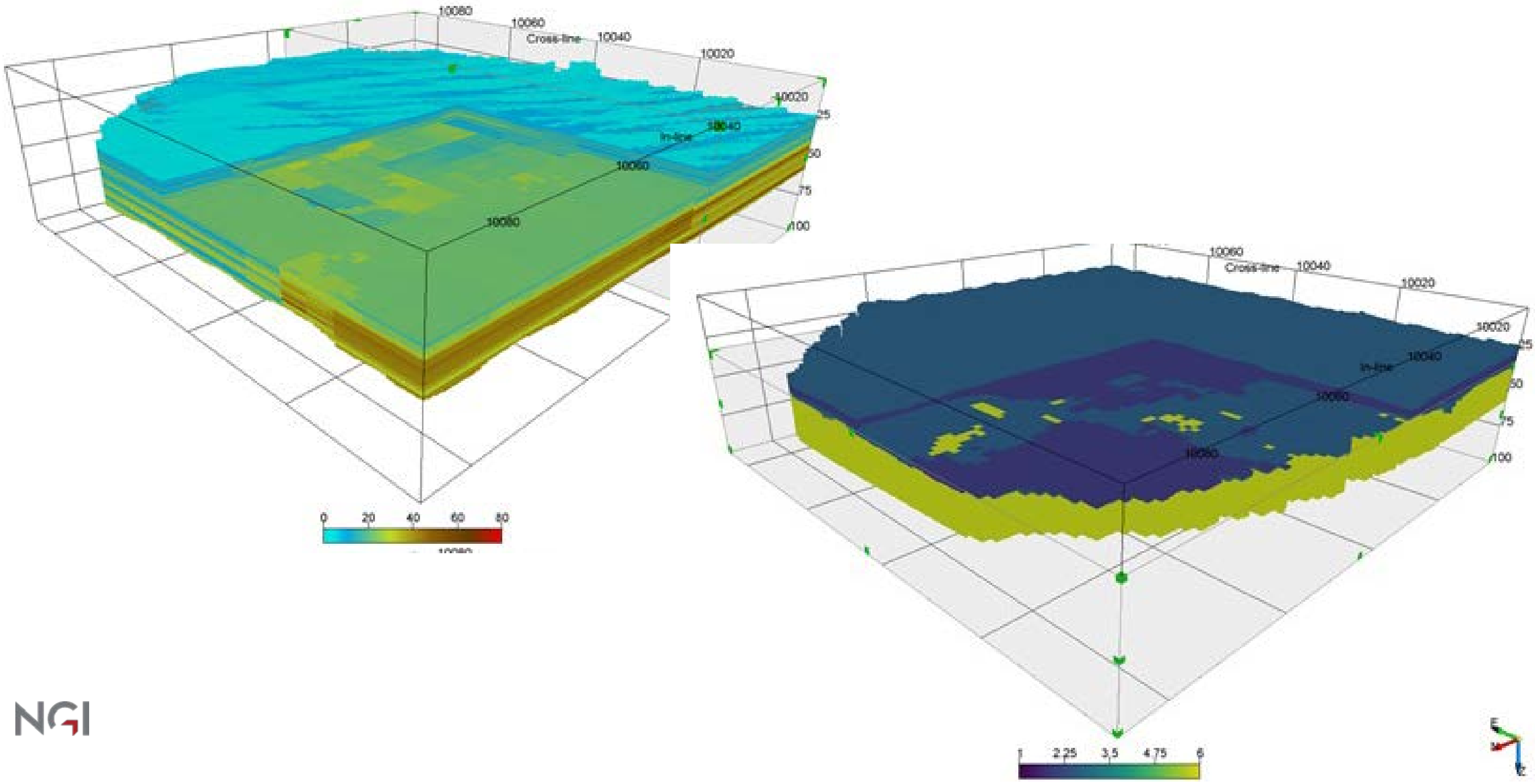


Best synthetic CPT prediction profile

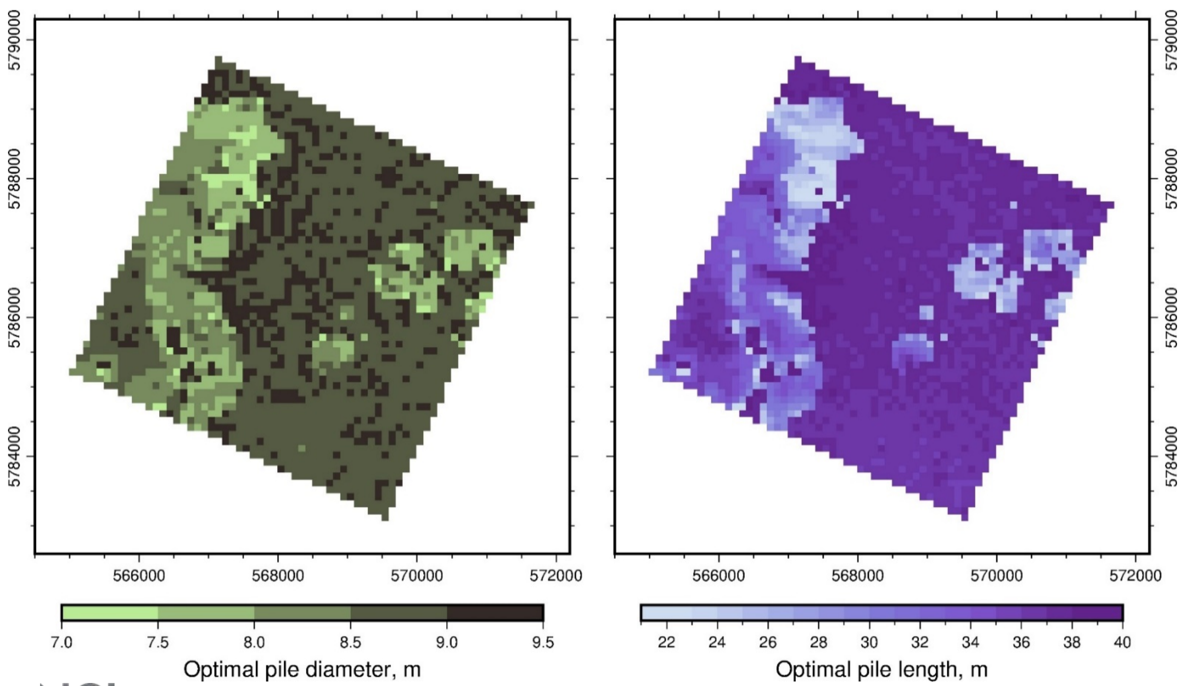
Measured CPT parameter plotted with same colour palette



Aim: 3D prediction of CPT properties



Ground Model – Input in foundation design



QGM → 3D geotechnical properties

\+ Models to obtain capacity (monopile)

Optimal pile geometry = least steal

→ cost reduction

Sauvin et al., 2019

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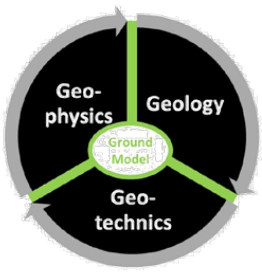

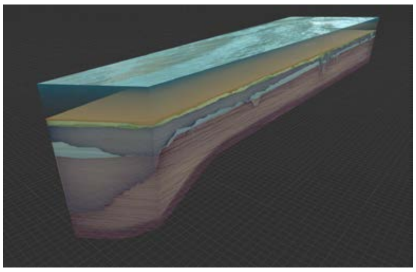

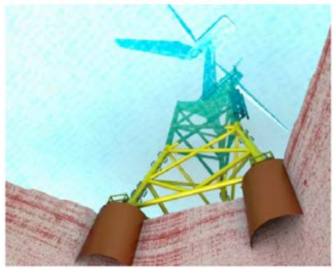

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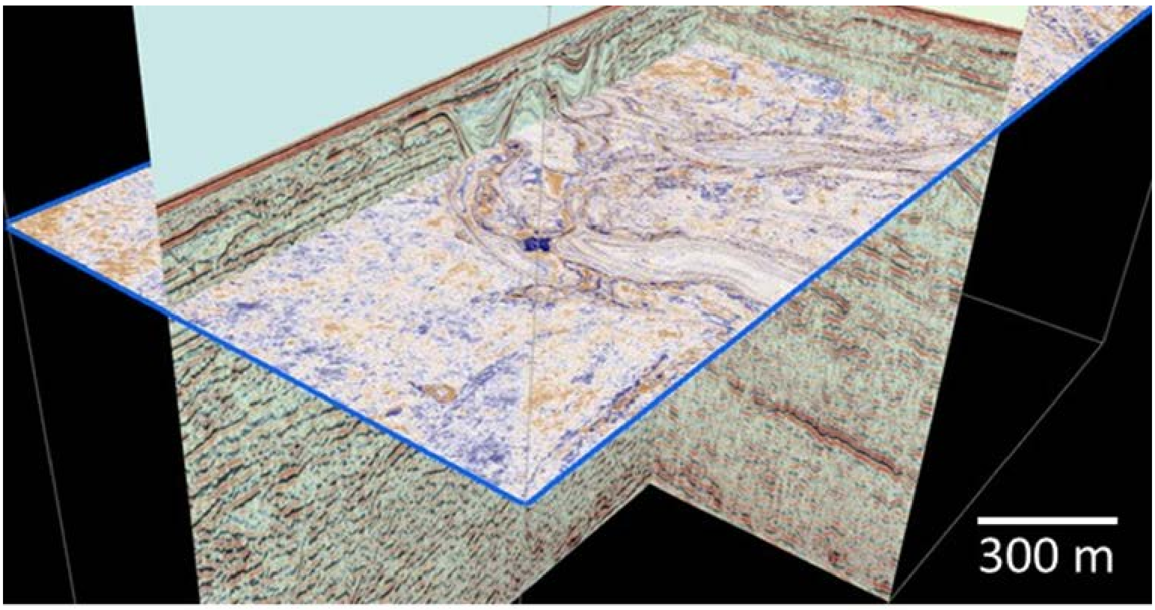
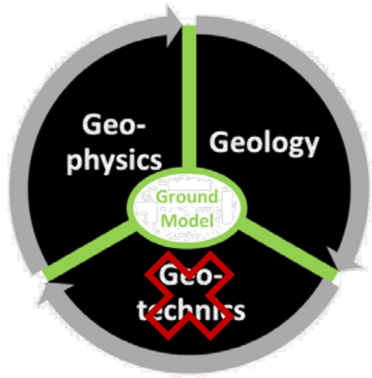
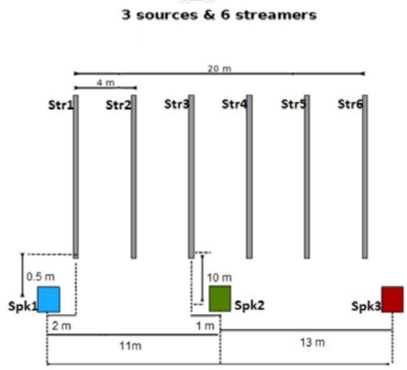
3D imaging can be accomplished!







3D facilitates interpretation and interpolation/ geostatistics!

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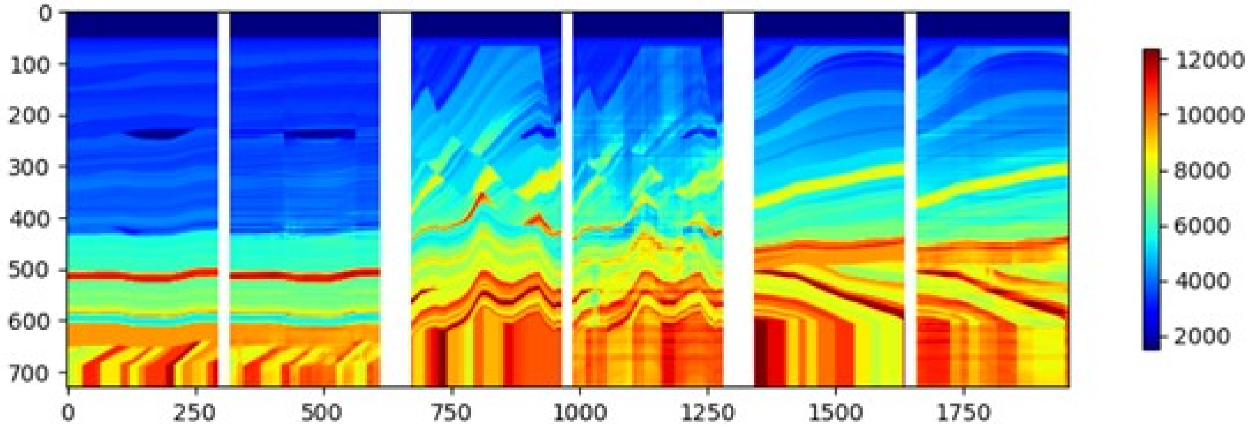
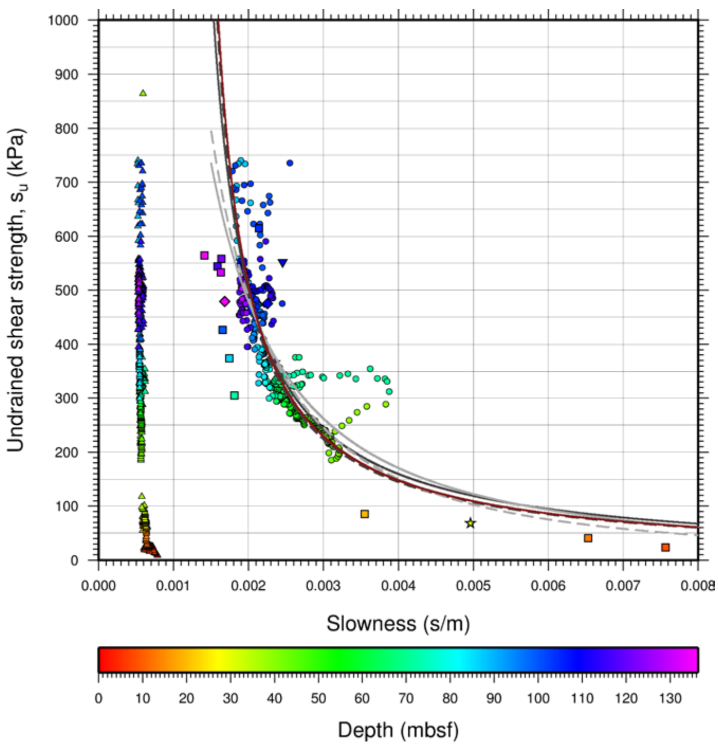
Physics-based ML



- Acoustic Impedance inversion combined with ML (Temporal Convolutional Network)
- Successfully applied to complex models, and can be scaled to higher frequencies
- Currently being be applied to OW settings

Dynamics – S-waves



- Correlation of Sonic Scanner data (giving slowness) and Cone Penetration Testing data (giving undrained strength)
- Application from shallow gas field in the North Sea
- Good relationship between S-wave slowness and undrained shear strength!
- Collect more data (e.g., MASW, SCPT)

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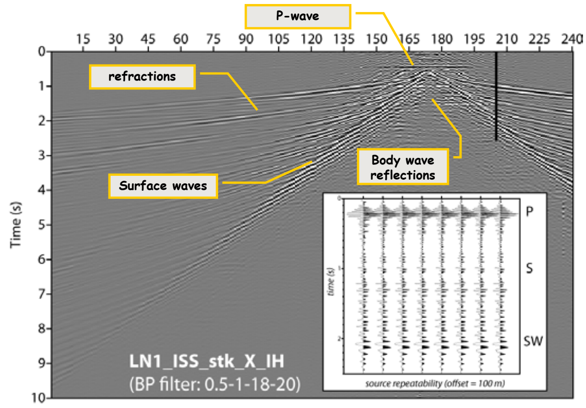
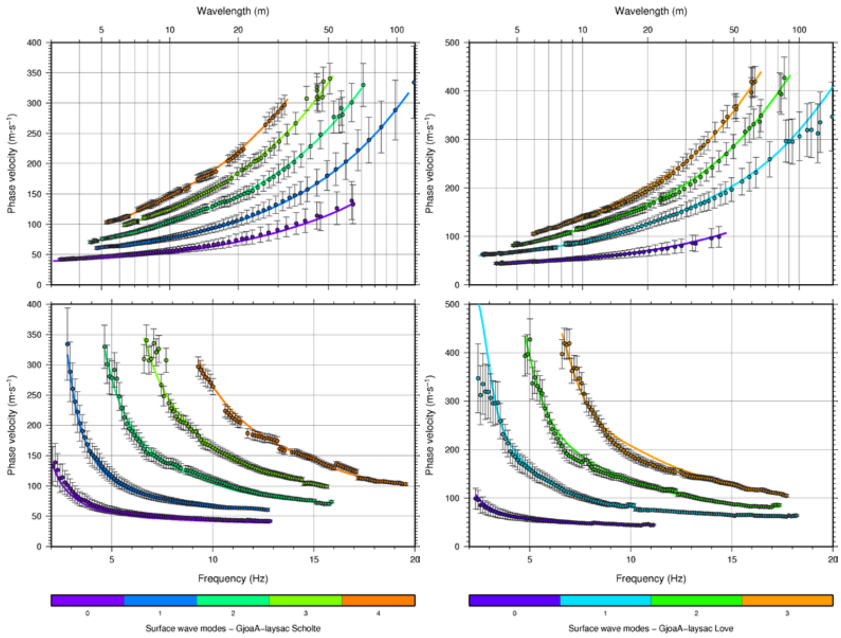
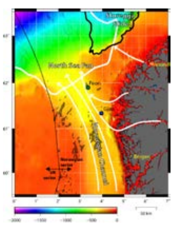
Dynamics – S-waves



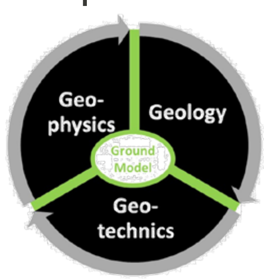


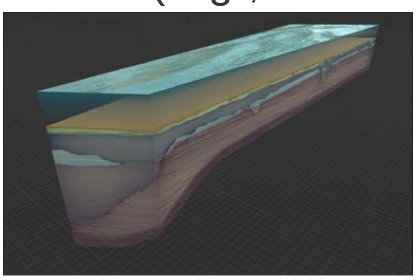


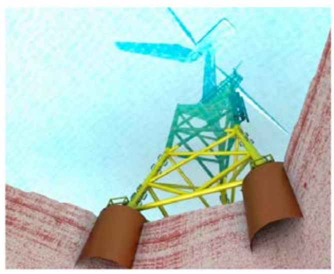
Summary

- Offshore Wind is key for the energy transition
- Development areas are complex, and multi-disciplinary data integration and innovation is essential: QGM with focus on uncertainty assessment can be used for engineering design (TNW qualified by DNV)
- Complementary geophysical (e.g., 3D, long-offsets, AVO, Shear waves) and geotechnical data (novel SCPT) should be acquired
- Open data bases (e.g., RVO model) allow significant R&D!

NGI







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https://vsoe2021.sciencesconf.org/

Vietnam OSW project development: key policy and framework issues

Denzel Eades
Pioneer International Consulting, Singapore

Pioneer International Consulting

Vietnam OSW Project Development
Key Policy and Framework Issues

Pioneer International Consulting

24 October 2022

Pioneer International Consulting

Denzel
Eades

CO-FOUNDER AND MANAGING DIRECTOR

Denzel is the Co-founder and Managing Director of PIC and manages the firm's offices in Vietnam and Singapore.

PIC is a strategic consultancy firm focused on energy transition and renewable energy project development in Vietnam. The firm brings over 25 years of experience in Vietnam's power sector and has been actively advising on Vietnam's onshore and offshore wind market since 2019.

Denzel brings over 17 years experience in project finance and development having worked with both global financial institutions and leading law firms in both Europe and Asia. Prior to founding PIC in 2018 he worked with Clifford Chance LLP, HSBC and MUFG Bank delivering financing solutions and transactions for leading corporates, private equity and project sponsors.

After qualifying with Clifford Chance in LLP in 2004 he had a global career with the firm based in London, Tokyo, Moscow, Hanoi and Bangkok. Following Clifford Chance he worked for HSBC in Hong Kong with a focus on distressed debt and global restructurings. He was based in Hanoi, Vietnam from 2010-2012 and was seconded to MUFG Bank's project finance team in Tokyo in 2013.

Having worked on some of the largest and country first project and leveraged financing in the UK and Asia he has broad and deep expertise in project, leveraged finance and complex global restructurings.

Denzel is a graduate of the London School of Economics (BSc Hons) and Kellogg School of Management MBA.

Contact

denzel.eades@pioneer-pic.com

Vietnam: +84 (0) 77841 5257

Hong Kong: +852 9842 2281

Pioneer International Consulting

1. NPDP 8
2. Incentive mechanism
3. Project development
4. Investment framework
4. Bankability
6. Marine policy and planning

Vietnam OSW
Key Policy and Framework Issues

NPDP 8

- Timing for approval
- Allocation of national OSW capacity
- Project delivery by 2030

Pricing after the FIT policy

- Transitional pricing mechanism
- Circular 15/2022/TT-BCT
- Circular 57/2020/TT-BCT

Project development

- Site survey application process
- Investor selection process

Investment framework

- IPP v PPP
- Grid development & cost recovery

Project finance

- Funding sources
- Bankability
- PPA and Government Guarantees

Marine policy and planning

- Decision 11
- National marine policy and planning

MONRE Report 126/BC-BTNMT dated 4 October 2022

MONRE Report 126/BC-BTNMT dated 4 October 2022

Pioneer International Consulting

- Report 126/BC-BTNMT
  - Proposals for offshore wind power survey
    - 55 applications (as of 31 August 2022)
      - 06 applications from foreign investors (10.9%).
      - 13 applications from foreign invested companies (23.6%).
      - 36 applications from domestic companies (23.6%).
      - 01 wind measurement proposal approved by the MONRE.
      - Total proposed capacity is over 100 GW. Minimum project capacity is 0.5 GW, and the maximum is 6 GW.
      - Total proposed sea survey area is approximately 30,000 km2. Some proposals are for a survey area of over 3,000 km2.
      - 40 OSW survey applications are under the approval authority of Provincial People's Committees. All of these are domestic investor sponsored projects located within 06-nautical-miles of the shoreline.
  - Difficulties and obstacles
    - Legal problems
      - Different interpretations of the approval process for conducting wind measurement, topographic and geological surveys.
      - Lack of regulations on the approval process for survey applications
    - Technical problems
      - Lack of regulations for technical assessment

5

MONRE Report 126/BC-BTNMT dated 4 October 2022

Pioneer International Consulting

- Report 126/BC-BTNMT (cont.)
  - Proposals and recommendations
    - Solutions to legal problems
      - Draft Decree to revise Decree 11/2021/ND-CP
        - Clearly state that foreign organizations and individuals are allowed to conduct sea investigation and survey activities.
        - Specific regulations on
          - Application dossiers, overlap, process, survey period, survey reports
    - Solutions to technical problems
      - MOIT in collaboration with MONRE and other relevant agencies will research and develop regulations on sea area standards for wind development, maximum capacity of a project and expected capacity for each planning period.
      - MPI in collaboration with MOIT and other relevant agencies take responsibility for researching and developing criteria for selecting suitable offshore wind project developers.
      - MONRE in collaboration with MOIT and other relevant agencies to be responsible of the announcement of potential sea areas for wind power development.
    - Specific proposals
      - Suspend wind survey appraisal and approval until a Government Resolution or a Decree to revise Decree 11/2021/ND-CP is issued to addresses relevant matters.
      - Assign MOIT to take primary responsibility for researching, developing, and promulgating mechanisms and policies with respect to offshore wind development.
      - The Prime Minister will chair a meeting with a number of relevant ministries and sectors to discuss policies and solutions to develop offshore wind power.

6

Experience in providing O&M service for wind power plant

Vu Viet Dung
Power Engineering Consulting Joint Stock Company 2 (PECC2), Vietnam

TABLE OF CONTENTS


01
About our company
PECC2POM
POWER PLANT OPERATION MANAGEMENT CENTER
PECC2POM
3

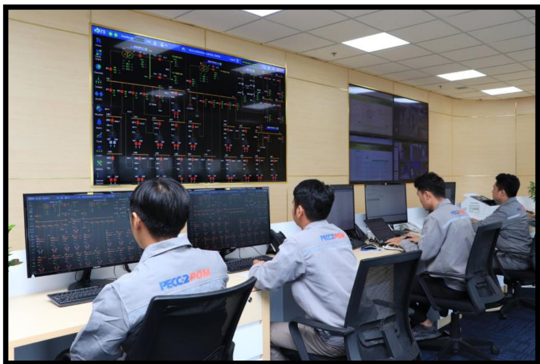

ABOUT PECC2POM
Over 37 years operating in the field of surveying, designing, monitoring and managing construction of power projects, PECC2 has continuously developed and become one of the leading brands in the energy industry in Vietnam. Foreseeing the development potential of the renewable energy industry in Vietnam, PECC2 has quickly launched the Power Plant Operation and Management service (PECC2POM) to meet the market's needs as well as contribute to boosting the development of the energy industry in Vietnam.
HIGHLIGHTS
31
Operating Power Plant Projects (Wind, Solar, Thermal)
#1
The first licensed OCC in Vietnam
>2,600 MW
Total O&M capacity of renewable energy
Zero Accident
Accident occurred or HSE violate happened in our power plant
250,000,000 kWh
Are being generated every month
98%-99% AF
The average Availability Factor of our power plants
PECC2POM
4

OUR PROJECTS

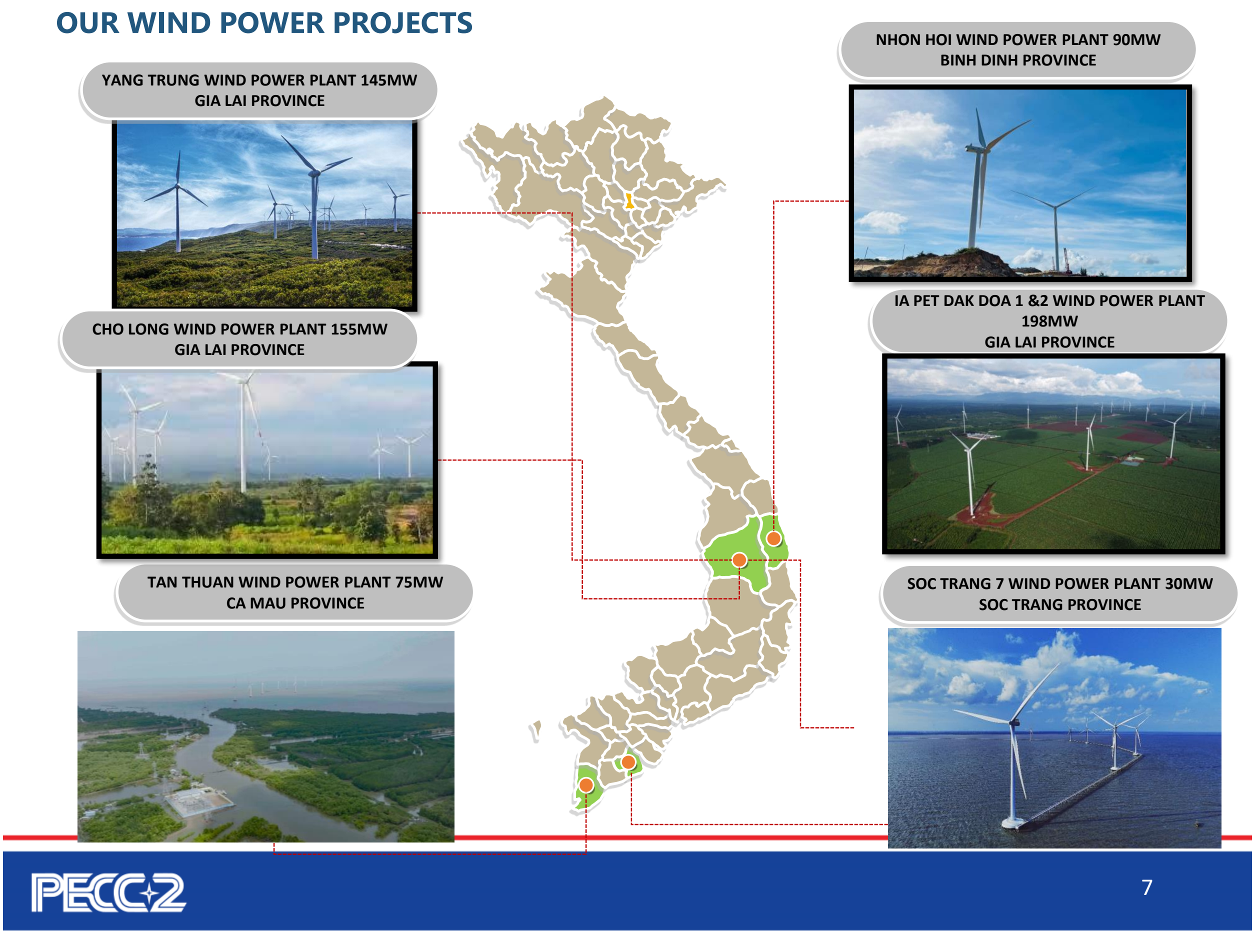
No.	PROJECTS	GRID VOLTAGE	CAPACITY	No.	PROJECTS	GRID VOLTAGE	CAPACITY
1	Loc Ninh 1 solar power project	220kV	200 MWp	16	Gio Thanh 2 solar power project	110kV	50 MWp
2	Loc Ninh 2 solar power project	220kV	200 MWp	17	Vinh Tan solar power project phase 1	22kV	6.2 MWp
3	Loc Ninh 3 solar power project	220kV	150 MWp	18	Mui Ne solar power project	110kV	40 MWp
4	Hoa Hoi solar power project	220kV	257 MWp	19	LIG Quang Tri solar power project	110kV	50 MWp
5	Son My 3.1 solar power project	110kV	50 MWp	20	Tan Thuan offshore wind power project	110kV	75 MW
6	Dau Tieng 1 solar power project	220kV	180 MWp	21	Kosy wind power project	220kV	40 MW
7	Dau Tieng 3 solar power project	220kV	180 MWp	22	Soc Trang 7 wind power project	110kV	30 MW
8	Ninh Phuoc 1&2 solar power project	110kV	58 MWp	23	Nhon Hoi wind power project	110kV	60 MW
9	Song Luy 1 solar power project	110kV	47 MWp	24	Yang Trung wind power project	220kV	145 MW
10	Phuoc Ninh solar power project	110kV	45 MWp	25	Cho Long wind power project	220kV	155 MW
11	Phong Dien 2 solar power project	110Kv	50 MWp	26	Ia Pet Dak Doa 1 &2 wind power project	220kV & 500kV	198 MW
12	Thien Tan 1.2 solar power project	220kV	100 MWp	27	Cam Hoa solar power project	110kV	50MWp
13	Thien Tan 1.3 solar power project	110kV	50 MWp	28	Chu Ngoc solar power project	22kV	15MWp
14	Nhon Hai solar power project	110kV	35 MWp	29	38 solar rooftops projects	22kV	30 MWp
15	Gio Thanh 1 solar power project	110kV	50 MWp	30	Duyen Hai 2 Coal Fired Thermal Power Plant (O&M of BOP)	500kV	1320 MW

PECC2POM 5

THE FIRST OPERATION CONTROL CENTER (OCC) LICENSED IN VIETNAM, OPERATED AND MANAGED BY PECC2POM



PECC2 6


OUR WIND POWER PROJECTS
YANG TRUNG WIND POWER PLANT 145MW
GIA LAI PROVINCE
CHO LONG WIND POWER PLANT 155MW
GIA LAI PROVINCE
TAN THUAN WIND POWER PLANT 75MW
CA MAU PROVINCE
NHON HOI WIND POWER PLANT 90MW
BINH DINH PROVINCE
IA PET DAK DOA 1 &2 WIND POWER PLANT
198MW
GIA LAI PROVINCE
SOC TRANG 7 WIND POWER PLANT 30MW
SOC TRANG PROVINCE
PECC2
7


OUR SERVICES
PECC2POM
Power plant management and operation
+ On-site power plant management and operation;
+ Remote Power plant management and operation through OCC;
+ Thermal power plants;
+ Hydroelectric power plants;
+ Renewable power plants: Solar, wind, biomass.
Project management consultancy
+ Project investment consultancy;
+ Commissioning service;
+ Issuance of electricity license and Commercial Operation Date (COD).
Experiment
+ PR experiment for solar power plants;
+ Efficiency test for thermal power plants;
+ Power plant performance accessment.
Provision of tools, equipments & spareparts
+ Tailored robot developed by PECC2POM for particular solar power plants.
+ Provision of tools, equipments & spareparts such as: MC, TU, TI, Inverter, ...
Power plant maintenance and repair
+ Routine maintenance:
• Tools, equipment, spare parts;
• PV cleaning, gardening.
+ Annual maintenance:
• Electrical experiment;
• Minor repairs to overhaul for transformers, substation, tools and equipment;
PECC2POM
8

ISO SYSTEM

ISO 9001:2015

QUALITY MANAGEMENT SYSTEM


DIRECTORATE FOR STANDARDS, METROLOGY AND QUALITY (STAMEQ)
VIETNAM CERTIFICATION CENTRE (QUACERT)

CERTIFICATE

ENSURE YOUR SUCCESS

This is to certify that the Quality Management System of

BRANCH OF POWER ENGINEERING CONSULTING JOINT STOCK COMPANY - POWER PLANT OPERATION MANAGEMENT CENTER (PECC2POM)

Address: No. 45, Street 2, Truong Tho Ward, Thu Duc City, Ho Chi Minh City, Vietnam

has been assessed and found to conform with the requirements of the following standard

TCVN ISO 9001:2015/ ISO 9001:2015

Certification Scope:	Management, operation, and maintenance services for power plants, substations, power transmission lines and technical management services for buildings
Certificate Number:	HT 4687.22.25
The validity of this Certificate:	From 04 October 2022 to 03 October 2025
Original Certification:	04 October 2022

DIRECTOR

Tran Quoc Dung

QUACERT - 8 Hoang Quoc Viet, Nghia Do Ward, Cau Giay Dist, Ha Noi, Viet Nam
The validity of this certificate can be checked at website: www.quacert.gov.vn and www.jas-anz.org/register

ISO14001:2015

ENVIRONMENT MANAGEMENT SYSTEM


DIRECTORATE FOR STANDARDS, METROLOGY AND QUALITY (STAMEQ)
VIETNAM CERTIFICATION CENTRE (QUACERT)

CERTIFICATE

ENSURE YOUR SUCCESS

This is to certify that the Quality Management System of

BRANCH OF POWER ENGINEERING CONSULTING JOINT STOCK COMPANY - POWER PLANT OPERATION MANAGEMENT CENTER (PECC2POM)

Address: No. 45, Street 2, Truong Tho Ward, Thu Duc City, Ho Chi Minh City, Vietnam

has been assessed and found to conform with the requirements of the following standard

TCVN ISO 14001:2015 / ISO 14001:2015

Certification Scope:	Management, operation, and maintenance services for power plants, substations, power transmission lines and technical management services for buildings
Certificate Number:	MT 470.22.26
The validity of this Certificate:	From 04 October 2022 to 03 October 2025
Original Certification:	04 October 2022

DIRECTOR

Tran Quoc Dung

ISO45001:2018

OCCUPATIONAL HEALTH & SAFETY MANAGEMENT SYSTEM


DIRECTORATE FOR STANDARDS, METROLOGY AND QUALITY (STAMEQ)
VIETNAM CERTIFICATION CENTRE (QUACERT)

CERTIFICATE

ENSURE YOUR SUCCESS

This is to certify that the Quality Management System of

BRANCH OF POWER ENGINEERING CONSULTING JOINT STOCK COMPANY - POWER PLANT OPERATION MANAGEMENT CENTER (PECC2POM)

Address: No. 45, Street 2, Truong Tho Ward, Thu Duc City, Ho Chi Minh City, Vietnam

has been assessed and found to conform with the requirements of the following standard

ISO 45001:2018

Certification Scope:	Management, operation, and maintenance services for power plants, substations, power transmission lines and technical management services for buildings
Certificate Number:	OH 133.22.26
The validity of this Certificate:	From 04 October 2022 to 03 October 2025
Original Certification:	04 October 2022

DIRECTOR

Tran Quoc Dung

PECC2 9

02

Health, Safe & Environment

PECC2POM 10

ZERO ACCIDENT AND ZERO FIRE

OBJECTIVES:

1) To ensure zero human accident
2) To ensure zero equipment damage

All of our personnel have to take Safety and Health training and have all required certificates:

✦ **Operational personnel:**

1) Electrical safety certificates
2) Occupational safety and health certificate
3) Fire prevention and fighting certificates

✦ **Wind Turbine Generator Maintenance Expert**

1) Above certificates as operational personnel
2) Elevator operation certificate
3) Certificate of Global Wind Organization (GWO)*

✦ **Crew transfer vessel operator:**

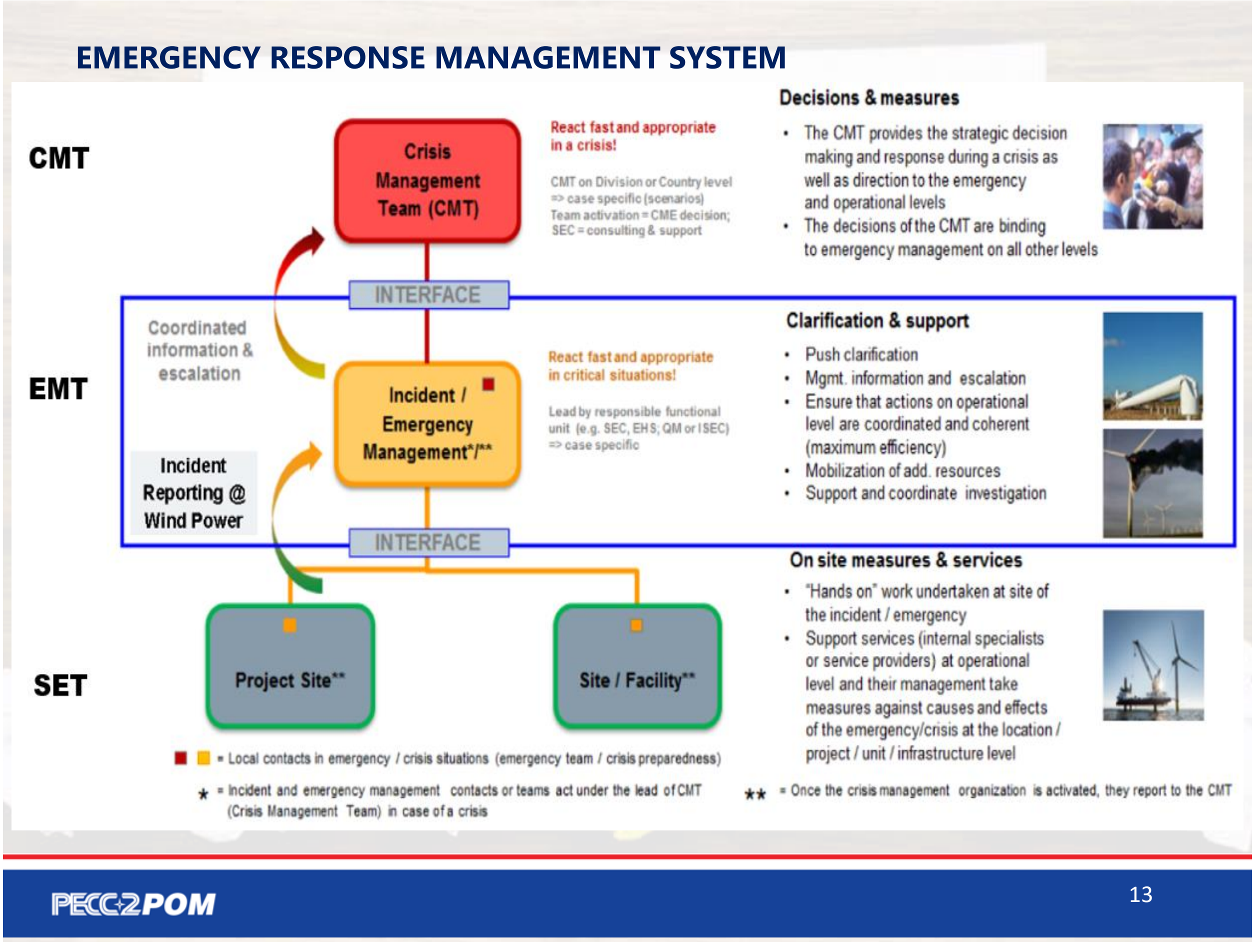
1) Above certificates as operational personnel
2) Safety Certificates of Authorized Organization by Ministry of Transport Viet Nam (Such as: Sea Survival Certificates, etc.)

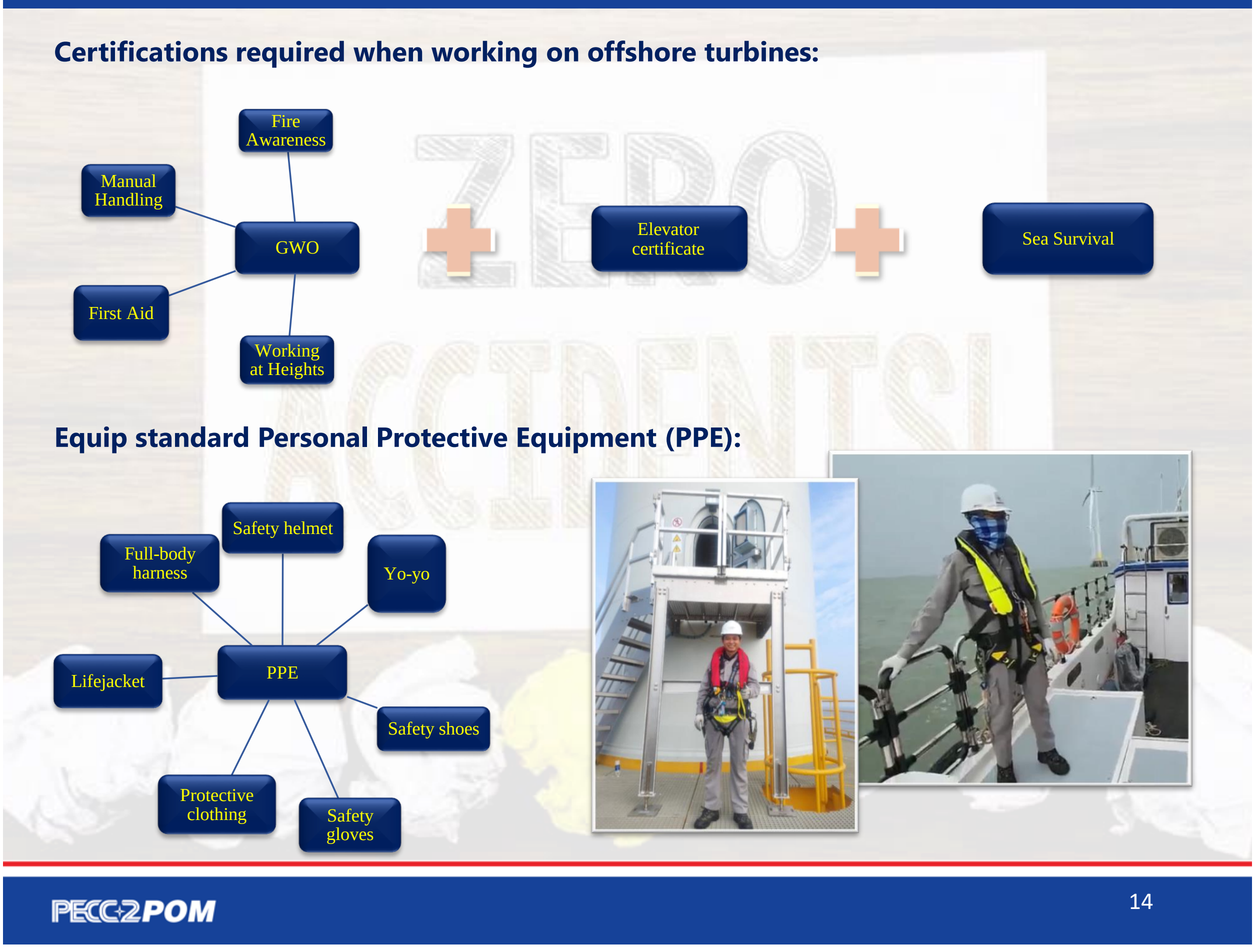
Build emergency response procedures and incident rehearsal:

1) Fire prevention procedures
2) Typhoon prevention procedures and rescue at sea

HSE PROCEDURES AND PLANS APPLIED AT OUR WIND PROJECTS

NO.	PROCEDURE
1	Safety Procedure in Operation and Incident handling
2	Typhoon and flood prevention Procedure
3	Rescue plan for operators who fell into the sea
4	Rescue and transfer plan for injured personnel on WTG's foundation to the CTV
5	Rescue plan for operators stuck in the elevator
6	Rescue plan for operators on WTG's foundation when the CTV can't access the foundation in bad weather





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Training necessary skills to ensure safety:

- **Method of traveling between CTV and wind turbine**
- **Method of climbing stair when there is no elevator**

PECC2POM

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CREW TRANSFER VESSEL AT OUR WIND POWER PLANT

CONTENT	SPECIFICATION
The CTV is capable of transiting and providing an Access Performance (m) of up to the following significant wave height.	[1.25m Hs] meter significant wave height
The CTV is capable of providing safe transport from the Service Base Facilities to each WTG at the following minimum speed in up to the following significant wave height.	knots at [1] Hs meter significant wave height
PAX	[12] PAX
A crew finder/man over board system, according to Vietnam standard regulations	
CTV bow deck area (m^2)	> $8m^2$
CTV bow deck load (t)	8t at 100% bunker capacity
CTV bow deck load/m^2 (t/m^2)	1.0 t/m^2
CTV internal storage (m^3)	6.0 m^3

PECC2POM

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ENVIRONMENT

OBJECTIVES:

To ensure compliance of all environmental statutory requirements

To achieve the above, the following operations are required:

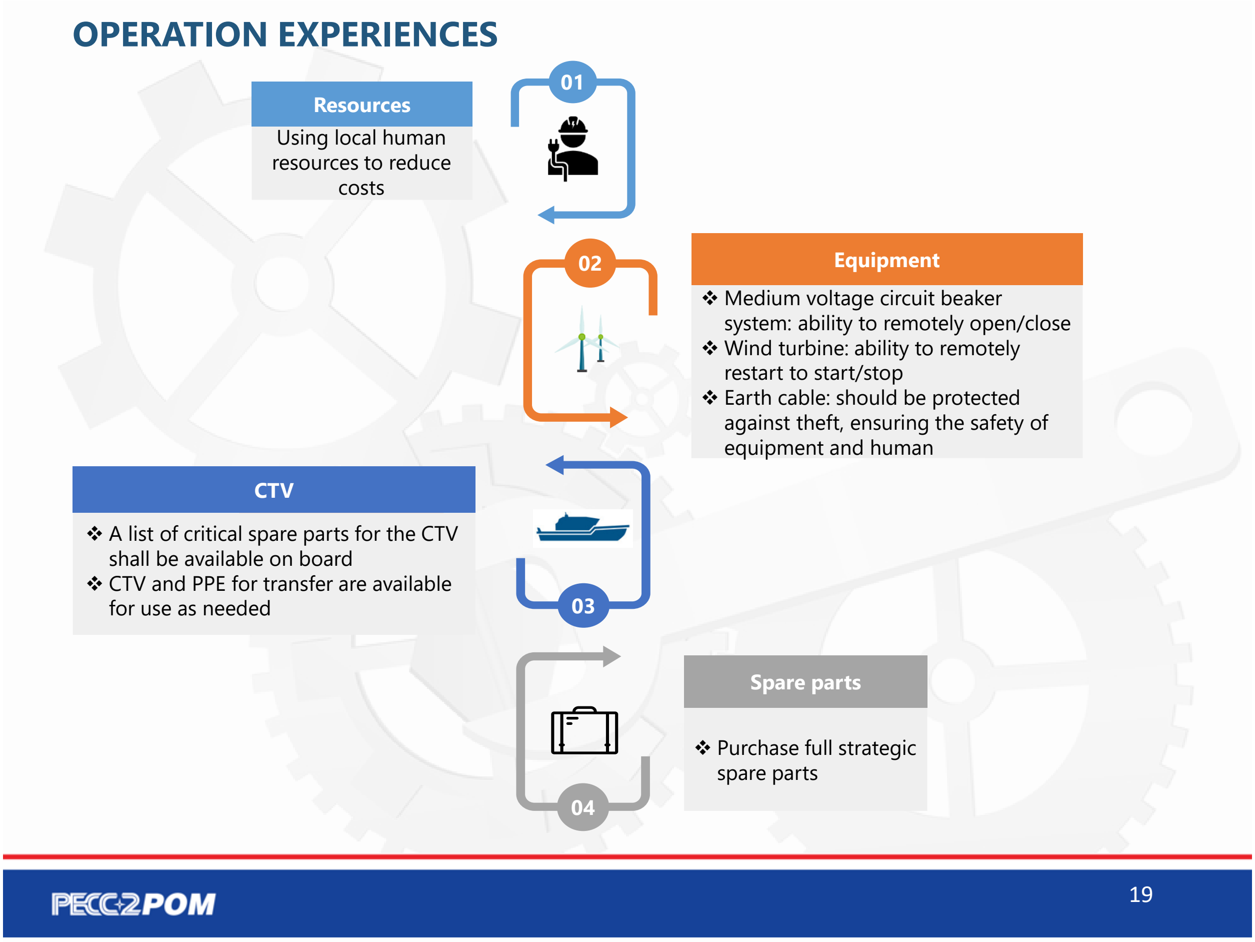
1) To make action plans to resolve all environmental issues and implement them
2) Monitor all key parameters and report on a regular basis highlighting exceptions
3) Maintenance waste management

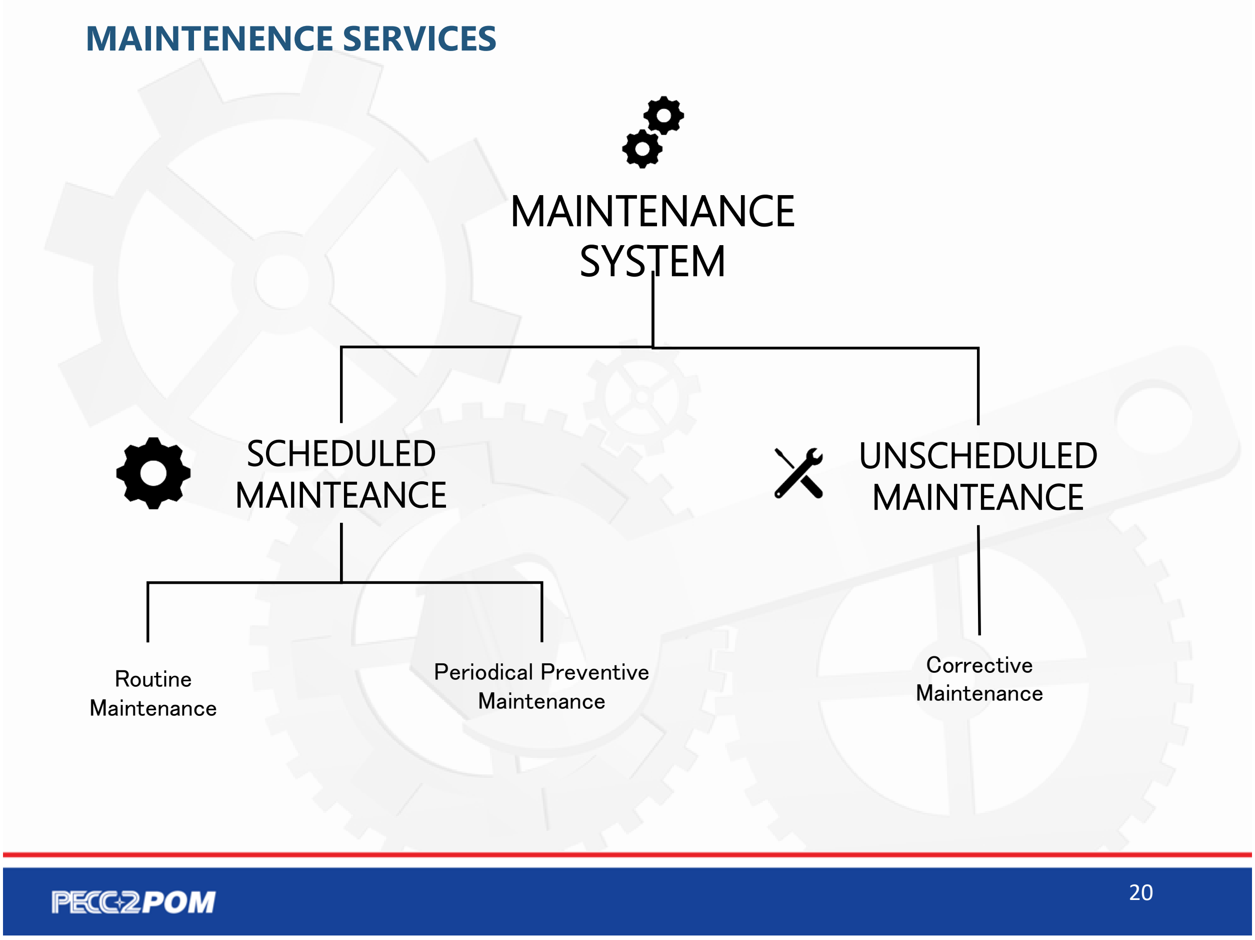
PECC2POM 17

03

O&M Services

PECC2POM 18


OPERATION EXPERIENCES
Resources
Using local human resources to reduce costs
01
02
Equipment
❖ Medium voltage circuit beaker system: ability to remotely open/close
❖ Wind turbine: ability to remotely restart to start/stop
❖ Earth cable: should be protected against theft, ensuring the safety of equipment and human
CTV
❖ A list of critical spare parts for the CTV shall be available on board
❖ CTV and PPE for transfer are available for use as needed
03
Spare parts
❖ Purchase full strategic spare parts
04
PECC2POM
19


MAINTENENCE SERVICES
MAINTENANCE SYSTEM
SCHEDULED MAINTEANCE
UNSCHEDULED MAINTEANCE
Routine Maintenance
Periodical Preventive Maintenance
Corrective Maintenance
PECC2POM
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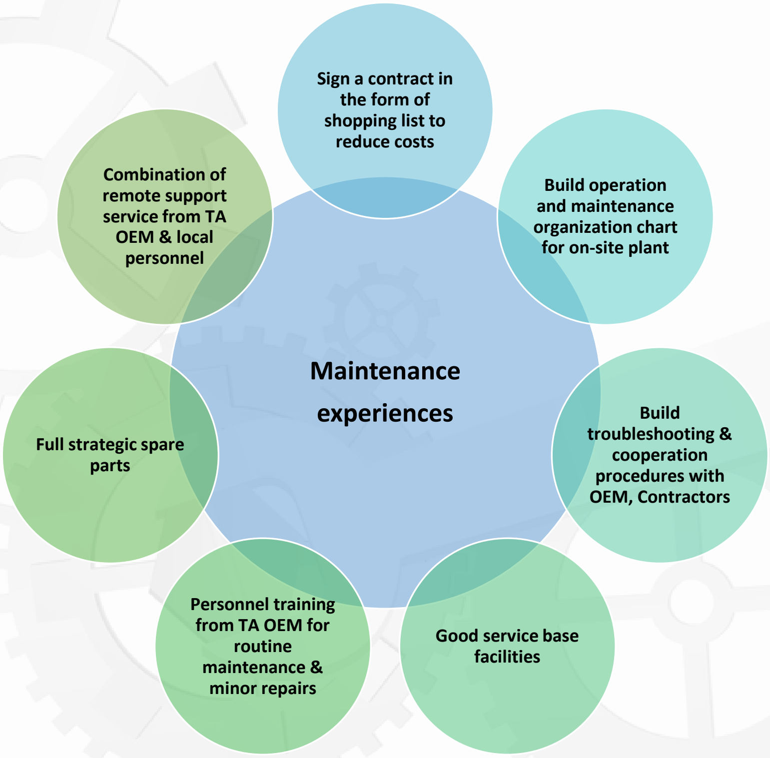
MAINTENENCE EXPERIENCES



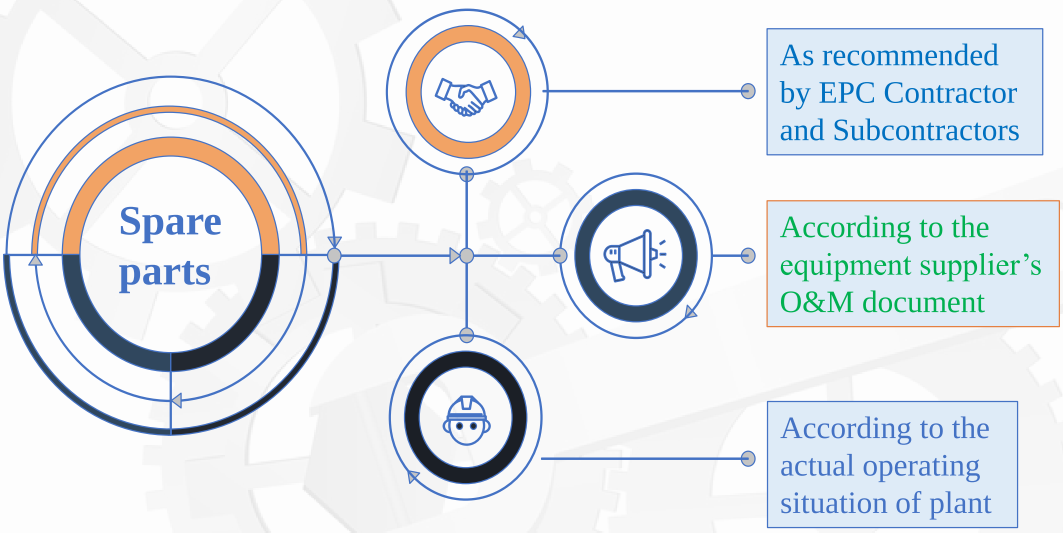
MAINTENENCE EXPERIENCES

➢ **TROUBLESHOOTING**

The Properties of offshore wind power plants are different from onshore, therefore, maintenance work must be promptly met for safe and reliable plant operation

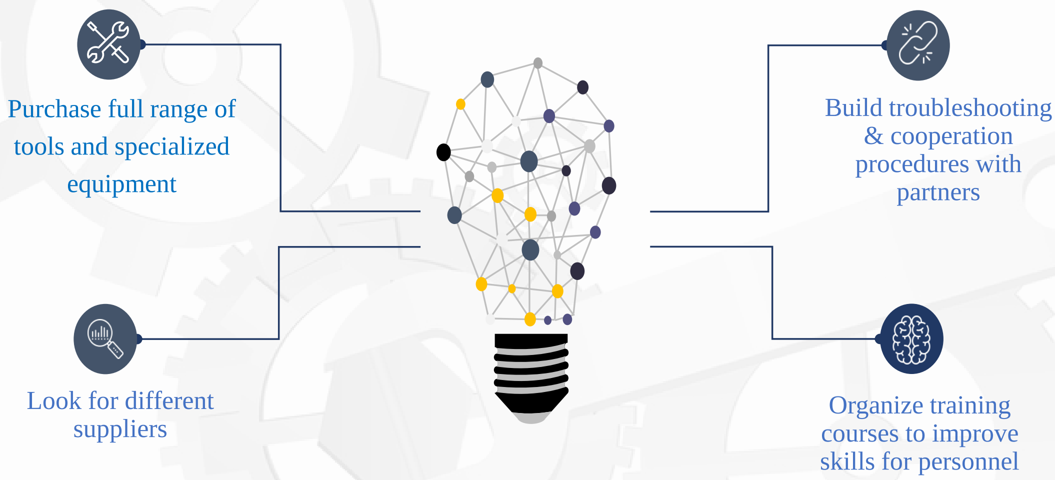
MAINTENENCE EXPERIENCES

➢ SPARE PARTS



MAINTENENCE EXPERIENCES

➢ SOLUTIONS FOR GOOD PERFORMANCE OF PREVENTIVE MAINTENANCE



MAINTENANCE ACTIVITIES

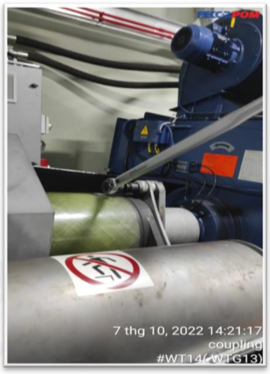
Access wind turbines for maintenance

MAINTENANCE ACTIVITIES

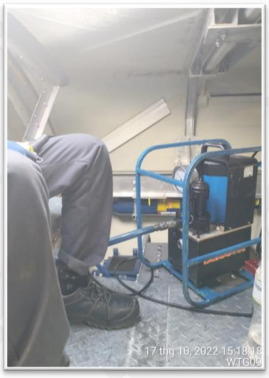
Local personnel carries out routine maintenance & minor troubleshooting

MAINTENANCE ACTIVITIES

Local personnel in coordination with TA OEM to carry out major troubleshooting

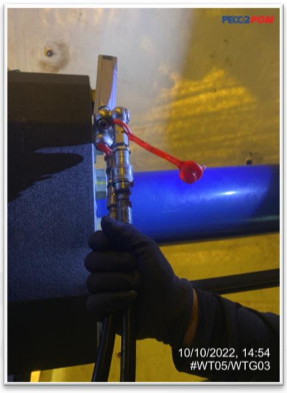



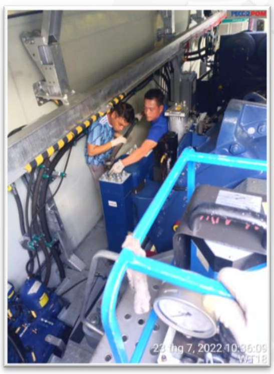
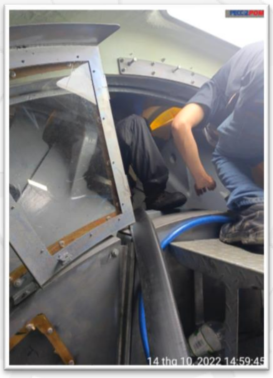
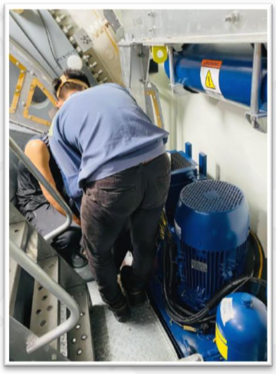





MAINTENANCE ACTIVITIES

Local personnel in coordination with TA OEM to carry out major troubleshooting

Work in confined space


THANK YOU

From nearshore to offshore – opportunities and challenges

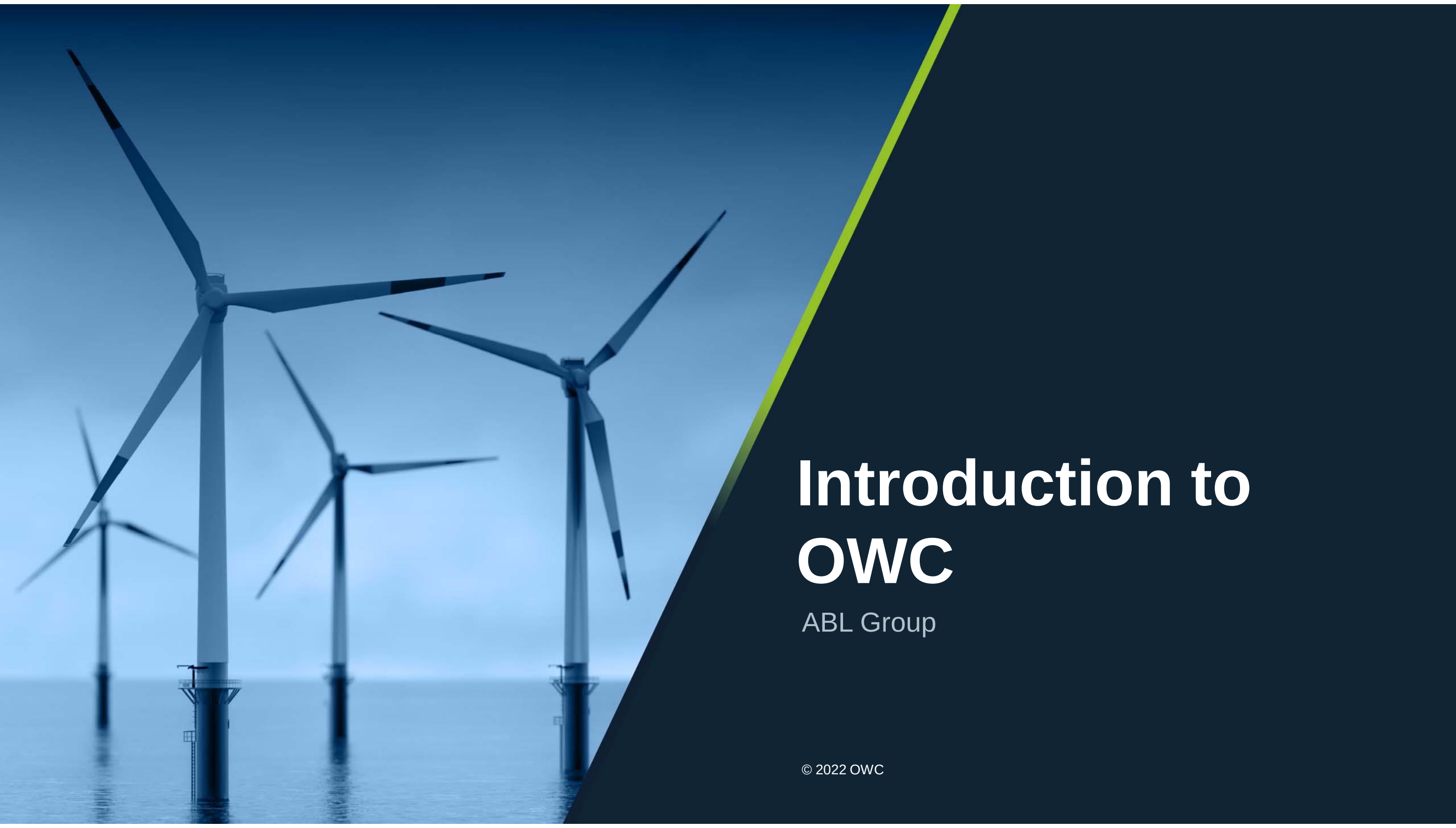
Riccardo Felici
OWC Vietnam, ABL Group

An ABL Group Company

VSOE

From Nearshore to Offshore – Opportunities and Challenges

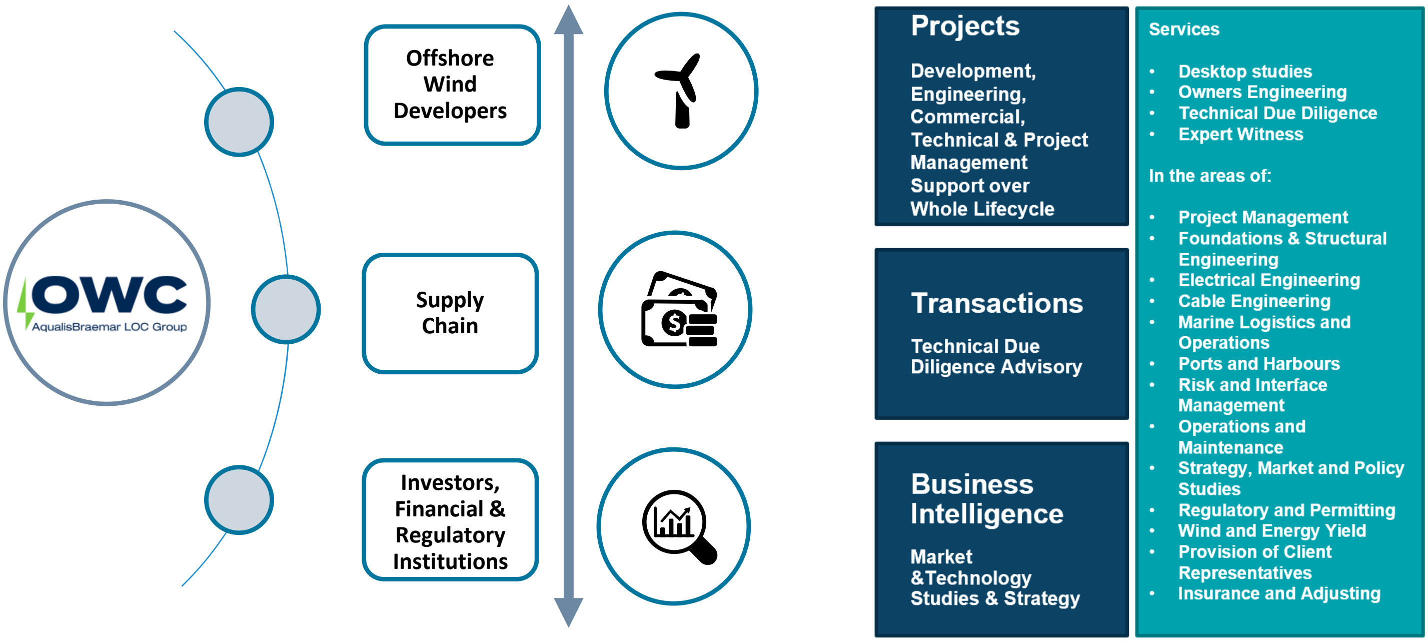
owcltd.com



OWC – the Offshore Wind Consultants

- **Long standing experience of developing and realising projects**
  - **Established in 2011** by a team of experts who had been involved in offshore wind farm construction **since 1990s**
  - Consulted on **68 GW** or **82 offshore wind projects** since 2011*
- **Global specialist offshore wind consultancy with a local presence**
  - Experienced **technical advisor, engineering consultant and project management consultant**, the only global consultancy dedicated to offshore wind
  - **>100 offshore wind experts** in 8 countries, Supported by c **380 master mariners, naval architects, project managers & engineers** in **33 countries**
  - Dedicated OWC teams in **London, Edinburgh, Hamburg, Warsaw, Taipei, Ho Chi Minh City, Tokyo, Busan, Boston, New York & Australia**

Providing advisory services across the market



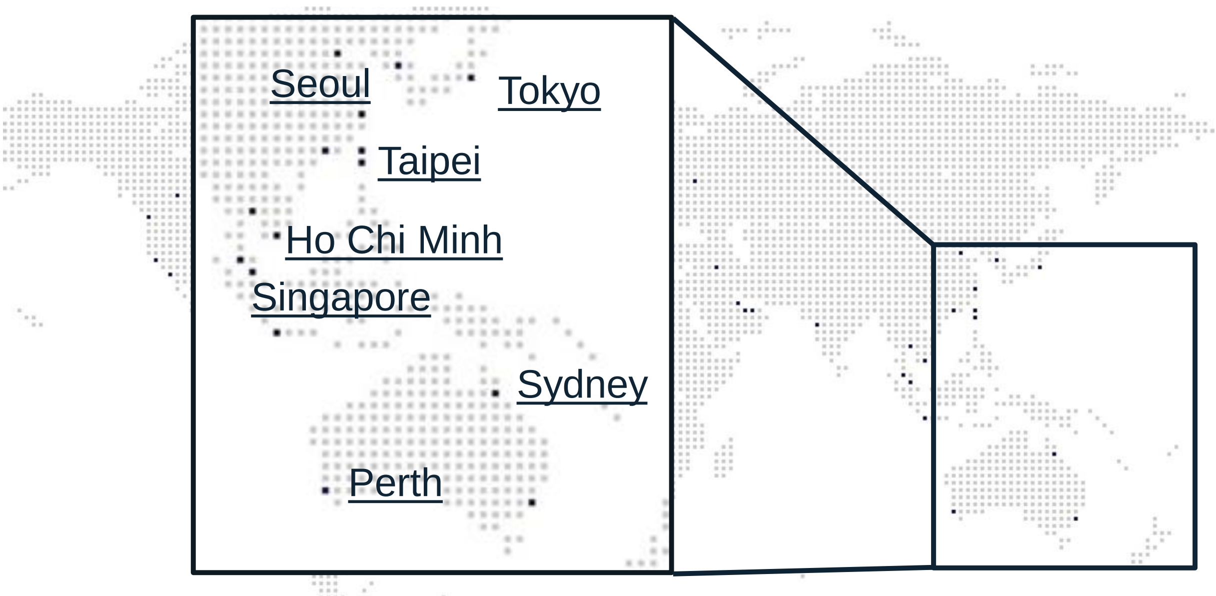
ABL Group - Global Partner, local expert

60 Offices

38 Countries

303** Locations

884* People



Main APAC Offices

5

* 884 full-time equivalent employees as of 31 December 2020
** ABL locate many staff strategically at maritime and offshore hubs to be able to serve clients locally
Additional note: the 38 countries number is driven by our offices, in terms of locations where we have surveyors etc we cover 71 countries, a truly global footprint

OWC An ABL Group Company

From Nearshore to Offshore

Opportunities and Challenges

Vietnam wind development

To date majority of wind developments are onshore and nearshore.

Primarily nearshore developments have been driven by

- Unique seabed profile and resource opportunities
- Lower costs (both construction and O&M)
- Quicker development and installation

With increasing energy demand, larger scale projects are needed.

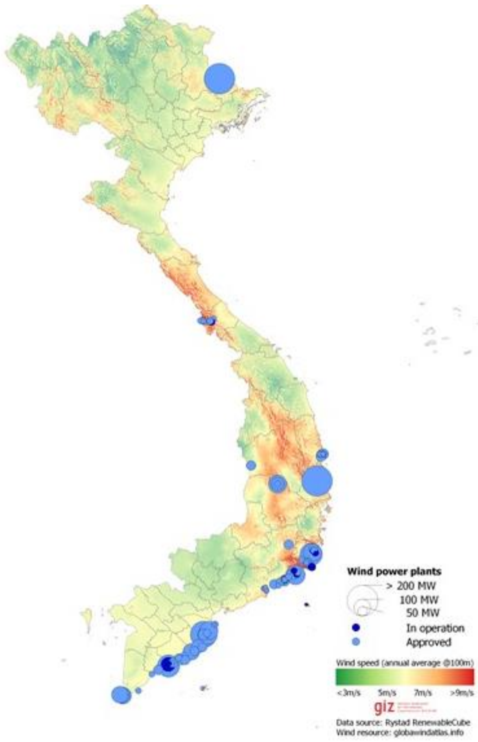
Thanks to its world class resources in Vietnam

→ Offshore wind will become a key asset in its renewable energy mix

What are the Opportunities?

What are the Challenges?

What can we leverage from the country's experience?

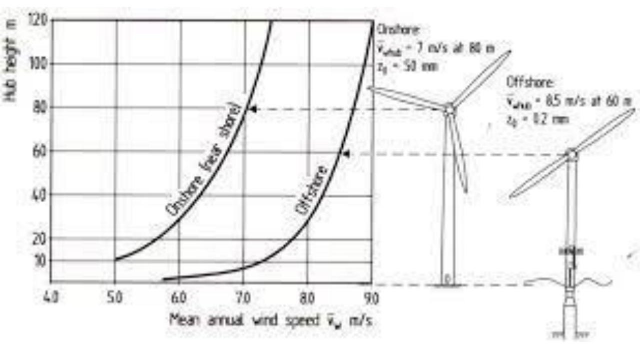


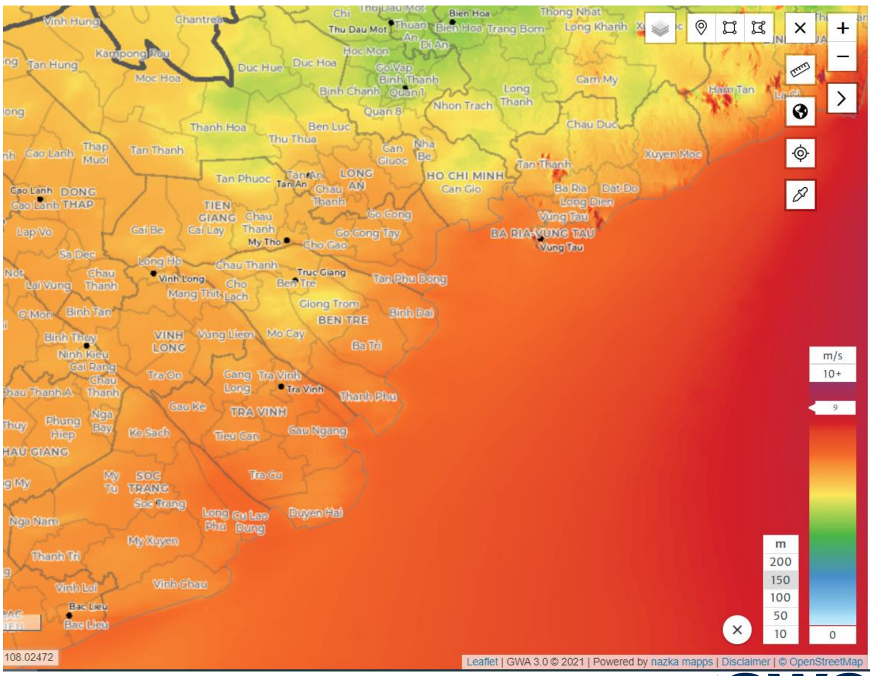
7

Opportunities - Wind Resource

Offshore offers typically:

- Higher Wind Speed
- More Consistent wind speed
  - Stable Direction
  - Reduced Turbulence





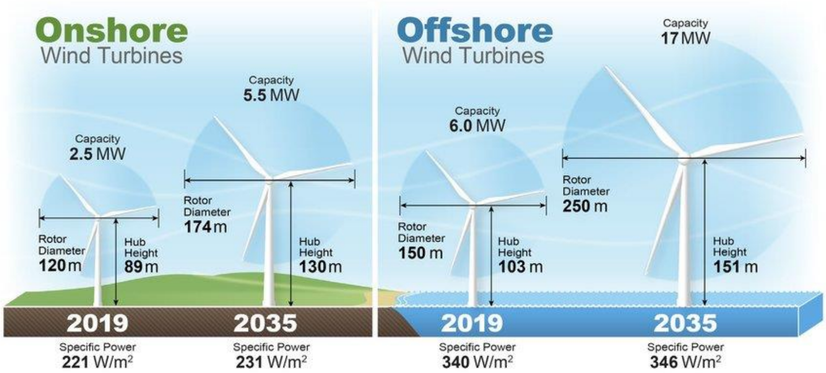
8

OWC
An ABL Group Company

Opportunities – Scale & Location

Offshore Wind typically offers:

- Much larger turbines
  - Higher wind speed
  - More consistent wind
  - Lower visual impact
  - Lower noise impact
- Larger projects
  - Availability of sea-area



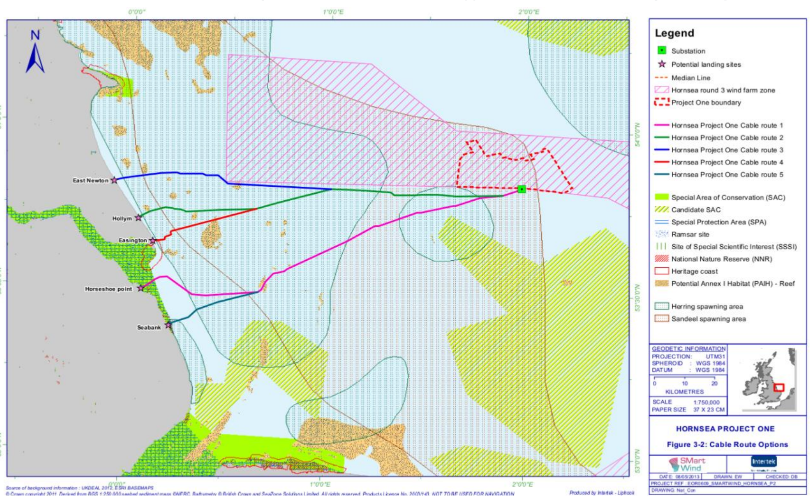
Ultimately these factors lead to an overall higher energy yield

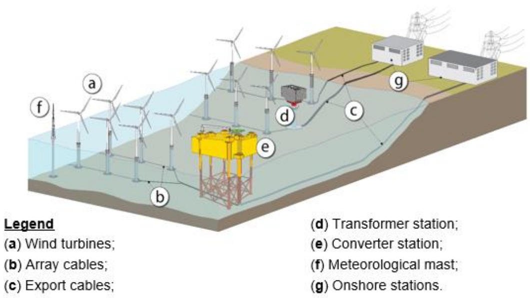
OWC An ABL Group Company

Challenges – Development

Offshore development presents several differences during the development phase.

- Assessment of resources (FLIDAR vs LIDAR)
- Electrical architecture (offshore transformer or converter station)
- Foundations design (jacket or monopiles)
- Increased number of potential landfall (grid connection points)





OWC An ABL Group Company

Challenges – Installation

Moving offshore increases overall operations complexity due to:

- Distance to operations port
- Increased wind farm size
- Water depth
- Met-ocean

Result of these factors would lead to a reduced installation window when using methodologies and vessels used for nearshore.

Typically, the use of specialized vessels is needed to achieve higher operability.

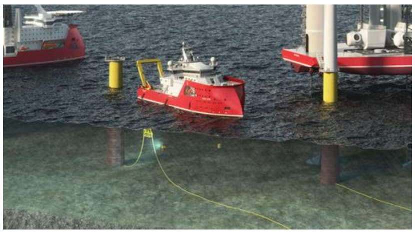
All operations need specialized vessels:

Foundation Installation

WTG installation

Cable installation

OSS Installation



11

Challenges – O&M

Operations and Maintenance (O&M) also require more specialized vessels to be able to access the wind farm year-round.

Typical specialized vessels will be:

- Offshore Supply Vessels with walk to work systems to access WTG / OSS
- Cable repair vessels with jointing equipment
- Jack-up vessels for blade replacement

These are not currently present in the Vietnamese market

12

Opportunities

Vietnam has developed several onshore, nearshore windfarms and O&G to date.

Key opportunities can be found in:

- Foundations and OSS construction
- Barges and tugs for transportation
- Offshore supply vessels
- Understanding and development of offshore sites
- Understanding WTG installation
- Specialized personnel
- Ship construction

Innovation within offshore site investigation

David Donaghy
Ocean Infinity, UK

The Second **Vietnam Symposium** on Advances in **Offshore Engineering**

HO CHI MINH CITY 2021

Innovation within offshore site investigation.

David Donaghy – Technical Manager Geotechnics
Ocean Infinity
24th October 2022

Innovation within offshore site investigation.

Innovation within offshore site investigation.

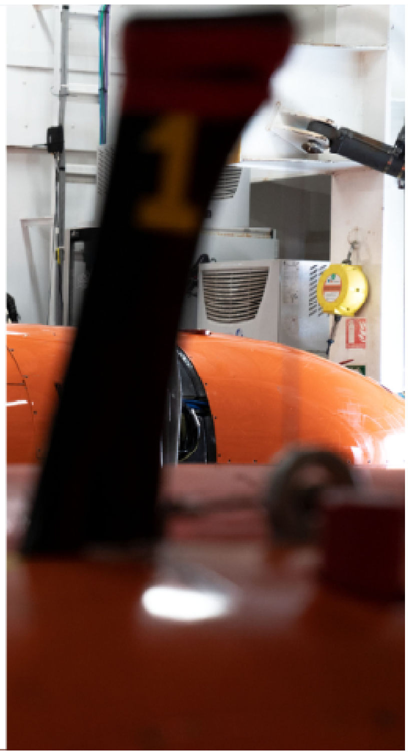
Who are Ocean Infinity?

Our team

More than 500 technology and data specialists, including uncrewed vessel operators, ROV pilots, AUV operators, robotics engineers, payload specialists, geotechnical specialists, data processors, surveyors, oceanographers, hydrographers.

We have teams in the UK, Portugal, Norway, Sweden, New Zealand, Australia, Singapore and the USA.

We use **innovative technology**, to **transform operations at sea**, to enable people and the planet to thrive.



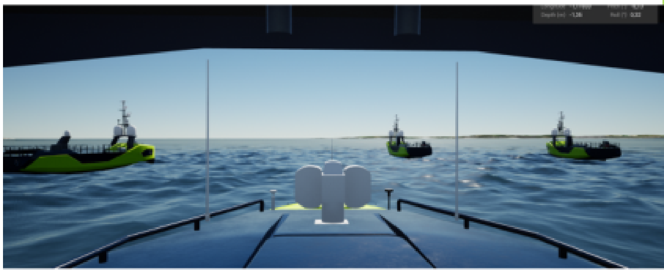
Innovation within offshore site investigation.

Our technology.

Next generation operations at sea

We envisage a time, in the not too distant future, where remote and lean-crewed operations at sea will overtake conventional crewed operations.

Technological infrastructure



Integrated digital environment

Remote Control Centres

Our custom developed Remote Control Centres bridge human operators with robotic platforms.

Safe navigation

A new way of working

Marine Robotics

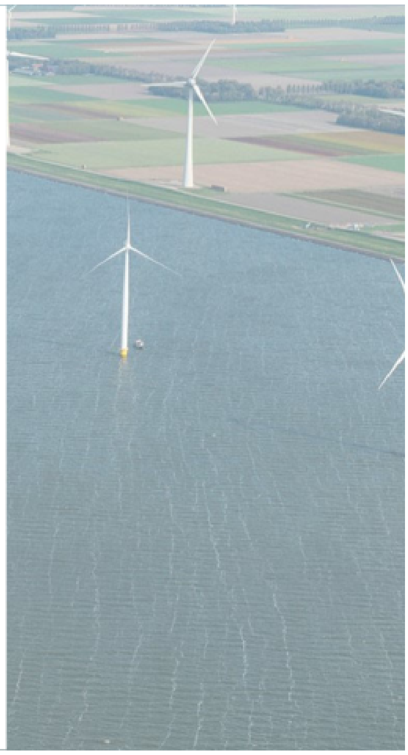
Remotely operated vessels and equipment offer safer and more environmentally responsible operations.

Clean fuelled

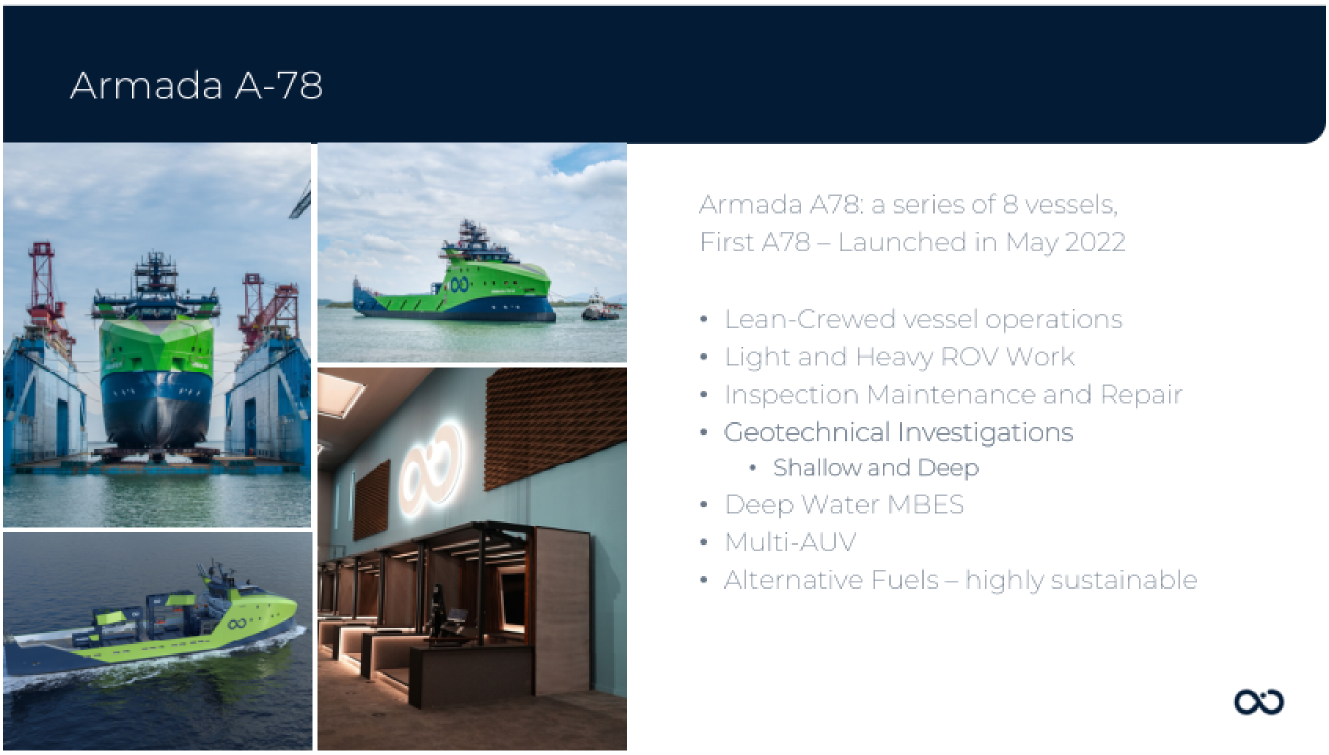
Driving change

Energy

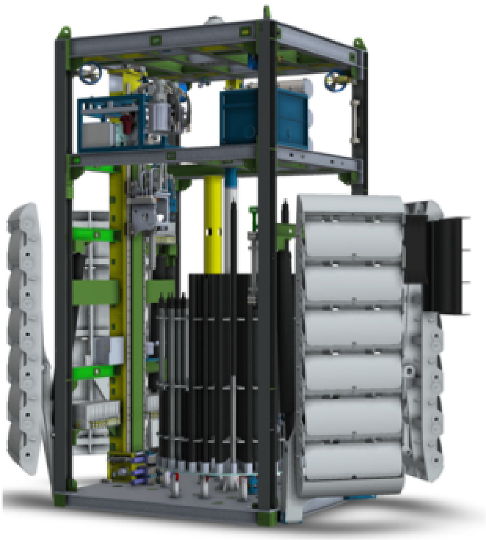
Offshore data acquisition with minimal environmental impact.




Innovation within offshore site investigation.
Marine & Geotechnical Robotics.


Armada A-78
Armada A78: a series of 8 vessels,
First A78 – Launched in May 2022
• Lean-Crewed vessel operations
• Light and Heavy ROV Work
• Inspection Maintenance and Repair
• Geotechnical Investigations
• Shallow and Deep
• Deep Water MBES
• Multi-AUV
• Alternative Fuels – highly sustainable

Geotechnical Robotics



Innovation within offshore site investigation.

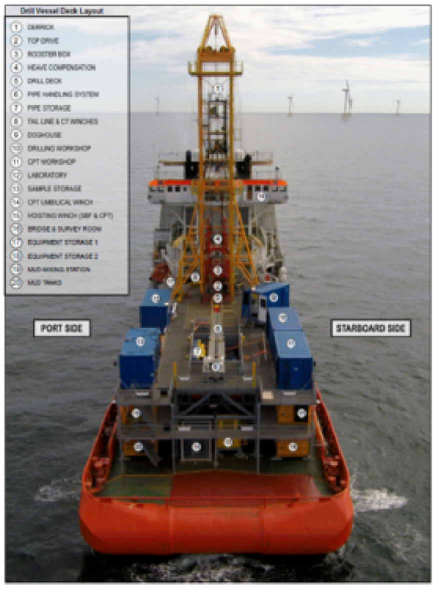
Some specific challenges we are solving.

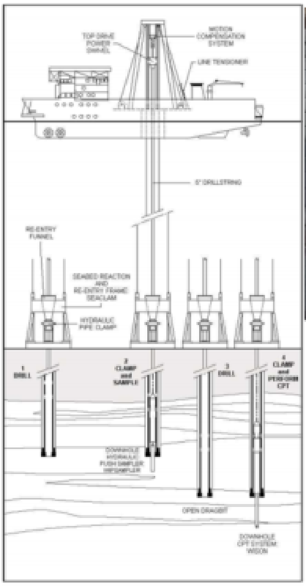
Innovation within offshore site investigation.

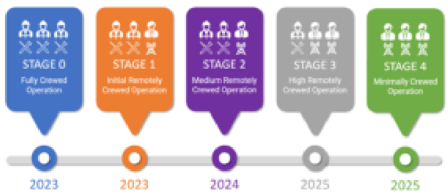
In the domain of Offshore Site Investigation, renewal of services and introduction of new techniques should result in;

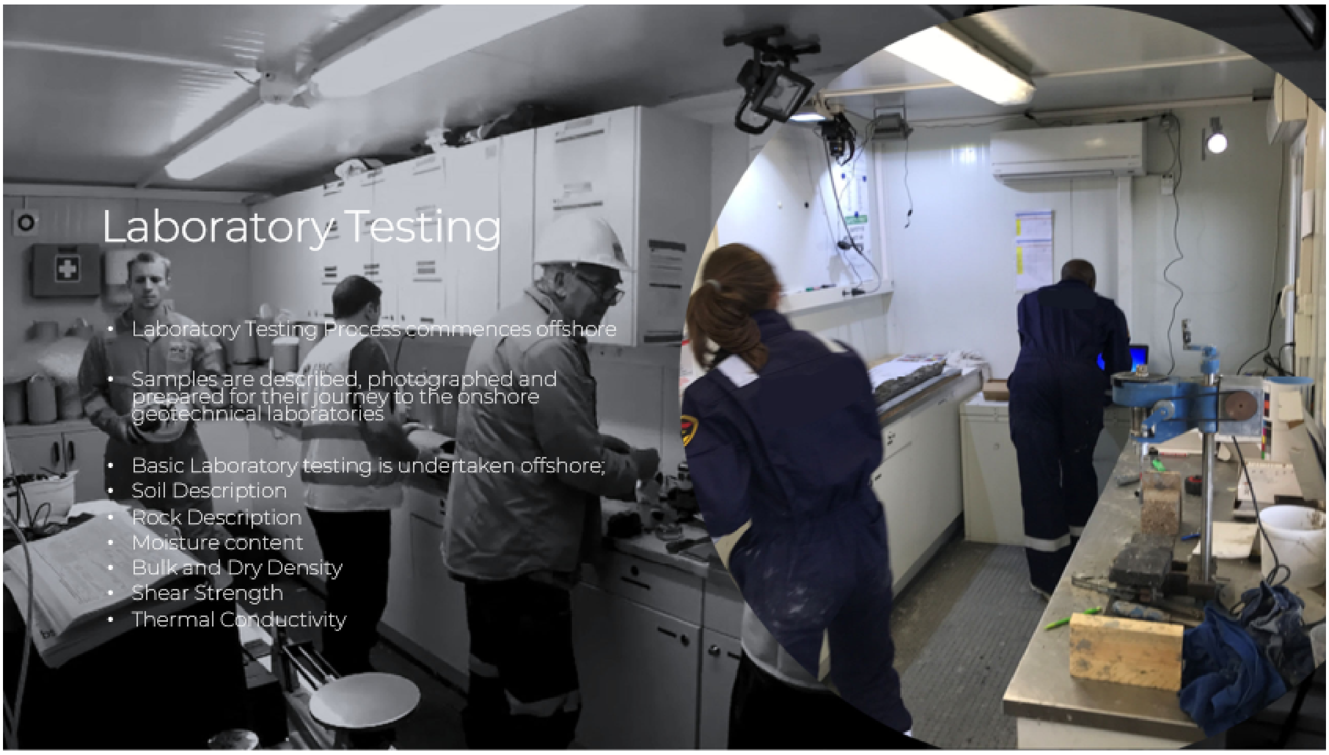
- ✓ Increase in Quality
- ✓ Increase in Accuracy
- ✓ Increase in Reliability
- ✓ Increase in Repeatability
- ✓ Increase in Efficiency/Productivity

Manning & Space Requirements

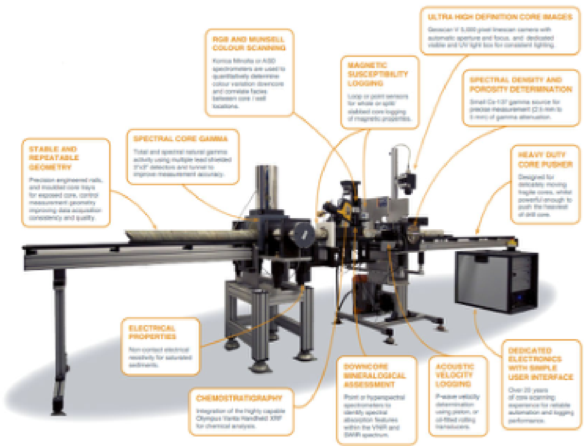


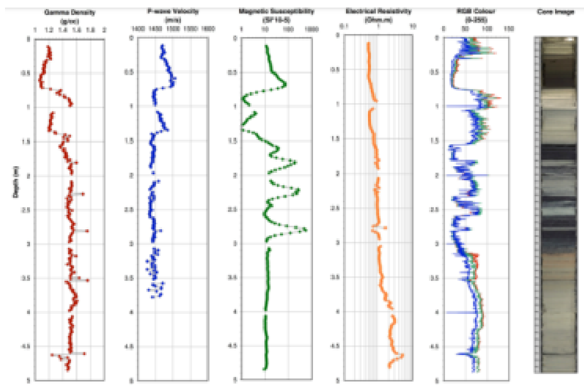




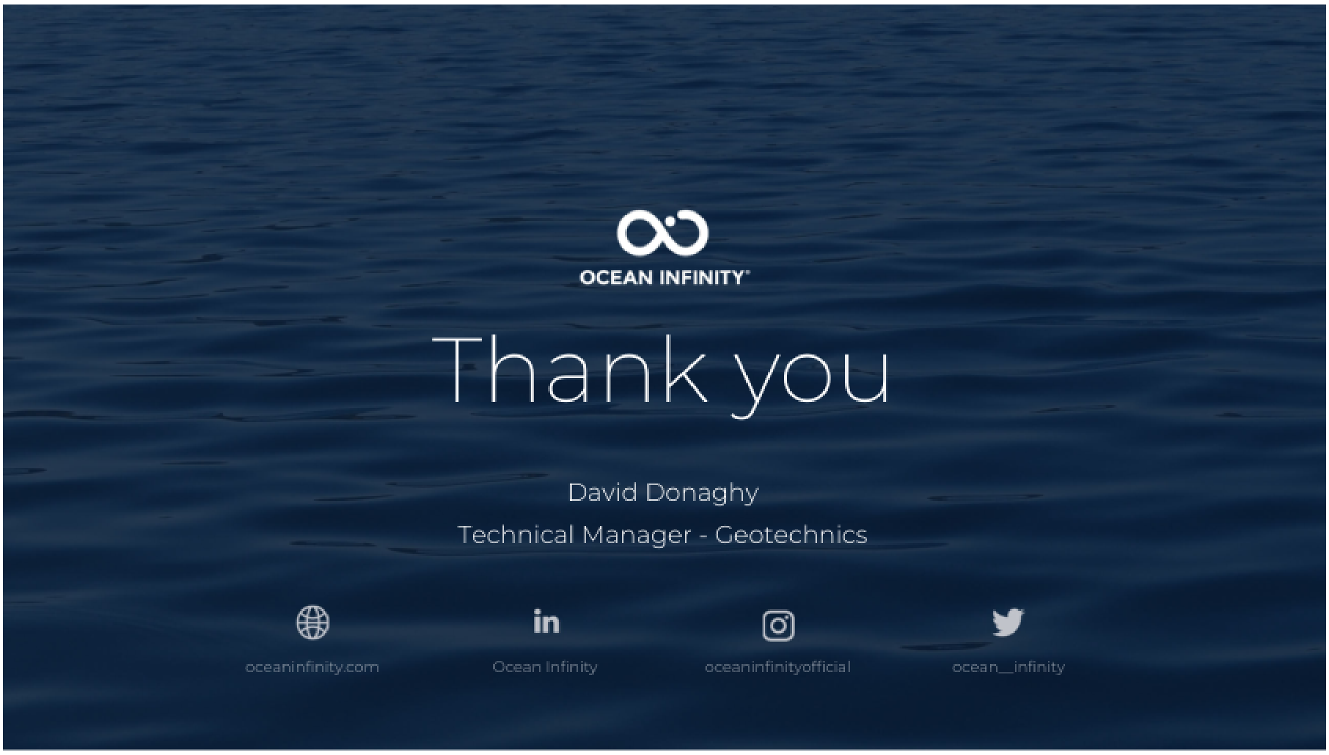


Offshore Sample & Core processing





- Automated core processing and laboratory test scheduling
- X-ray
- Samples stay in tubes


OCEAN INFINITY
Thank you
David Donaghy
Technical Manager - Geotechnics
oceaninfinity.com
Ocean Infinity
oceaninfinityofficial
ocean__infinity

Offshore wind power: the potential renewable energy & remarkable aspects

Tran Quoc Dien
Power Engineering Consulting Joint Stock Company 3 (PECC3), Vietnam

The Second Vietnam Symposium on Advances in Offshore Engineering

VSOE2021

Sustainable Energy and Marine Planning

EVNPECC3

Offshore Wind Power
The Potential Renewable Energy &
Remarkable Aspects

Speaker: Tran Quoc Dien – PECC3
Deputy General Director

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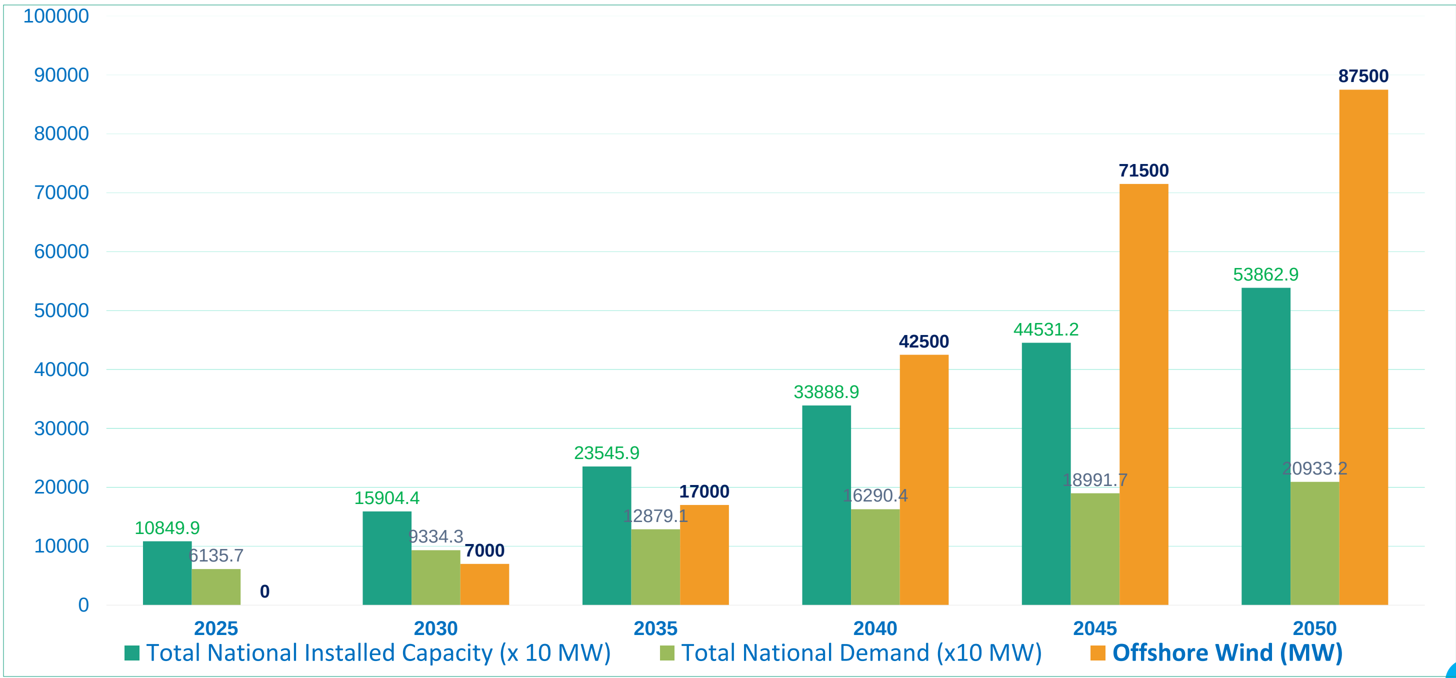
Offshore Wind Power - Development Trend

EVNPECC3

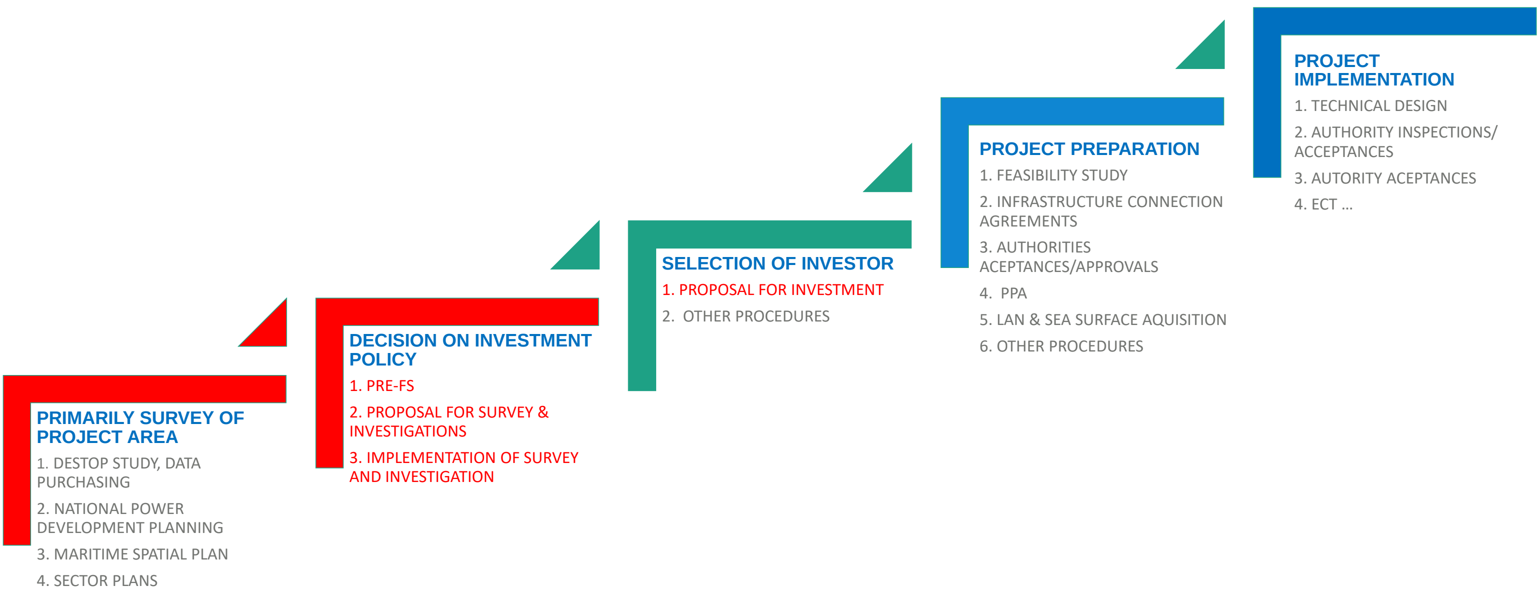


Resource: The last draft NPDP8

3

Offshore Wind Power – Possible Initial Steps

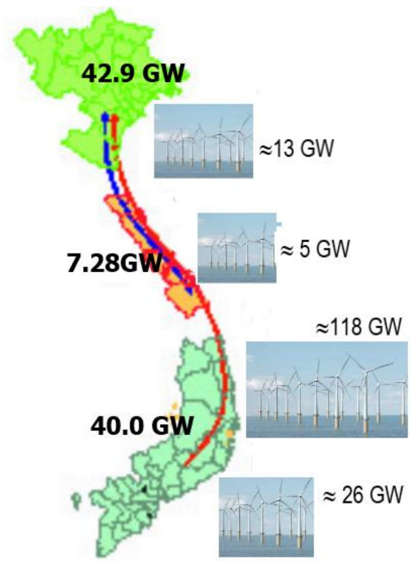
EVNPECC3



4

Remarkable Aspects

LEGAL FRAME WORKS	• Power Development Plan 8 • Maritime Spatial Plan • Sector Plans • Relevant Resolutions, Laws, Decrees, Circulars
REGULATION MECHANISMS	• Technical Instructions (Electrical Price, Power Purchasing, Standards) • Procedure Instructions (Approvals, Appraisals, Bidding,..) • Supplement Mechanisms
SOCIO-ECONOMIC SUSTAINABILITY	• Electric Price compromising with Economic Development • Energy Security
COP 26 & ENVIRONMENTAL IMPACT	• Approaching Zero CO2 in 2050
TECHNICAL	• Load Evacuation Schemes Compromising with Sources and Load Regionals • Power System Stability



Offshore Wind Technical Potential Capacity & Base Load Demand Scenario, forecasted in 2030
Source: The last draft NPDP8

5

Recommendation for Developers

It is essential to process the procedure and appraisal with prudence.

- Offshore Wind Development should be approached with long-term strategy, requiring thorough preparations from parties;
- Particularly, the government, as well as state management agencies, hold the major responsibility in making decisions, forming the policies that will affect the country's energy security as well as economic and social impacts.

At this moment, all parties should be patient and well-prepare for the next steps.

- Based on the international lesson learnt and knowledge from previous seminars, it is shown that, in the US & Western countries, the energy transition and the initial stage of the Offshore Wind Power Development took a long time.

Especially, the investor should prepare for project technical aspects, start looking for potential suppliers at this stage.

- To compose competitive bidding document and ensure the feasibility of the project by the time the national legal framework and procedures are ready.

6

PECC3 and Wind Power Development

EVNPECC3

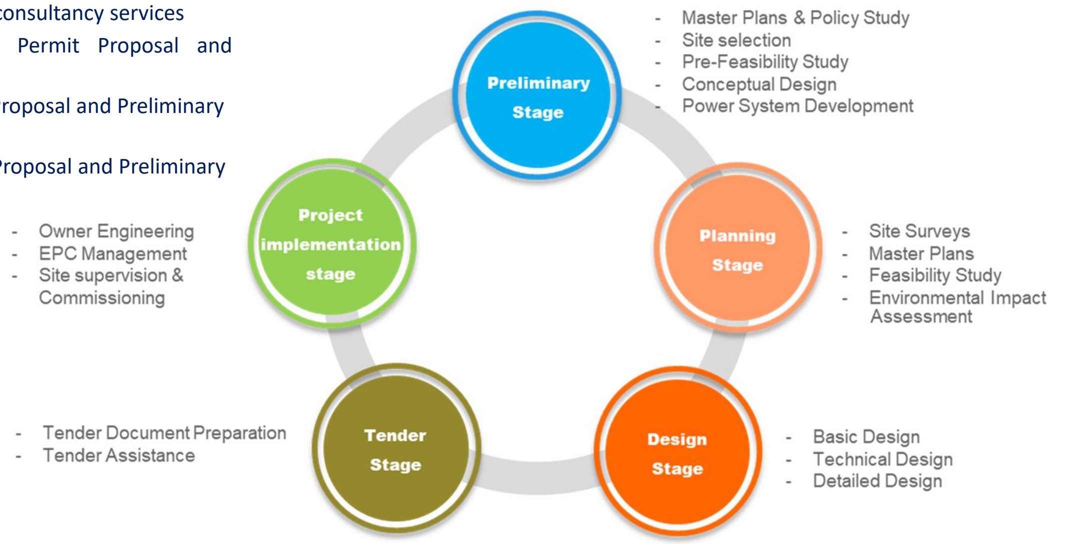
PECC3 have provided consultancy services for 27 Onshore & Offshore Wind Power Projects with total installed capacity of onshore is 1505 MW;

Remarkable Offshore Wind Projects:

- Thang Long Offshore Wind Project: full range of consultancy services
- Binh Thuan Offshore Wind Project: Survey Permit Proposal and Preliminary Load Evacuation Study;
- Vung Tau Offshore Wind Project: Survey Permit Proposal and Preliminary Load Evacuation Study;
- Thai Binh Offshore Wind Project: Survey Permit Proposal and Preliminary Load Evacuation Study.

Partnerships:

THANG LONG WIND, ENTERPRIZE ENERGY, wpd, Lamek, Sumitomo, PTSC, PONDERA



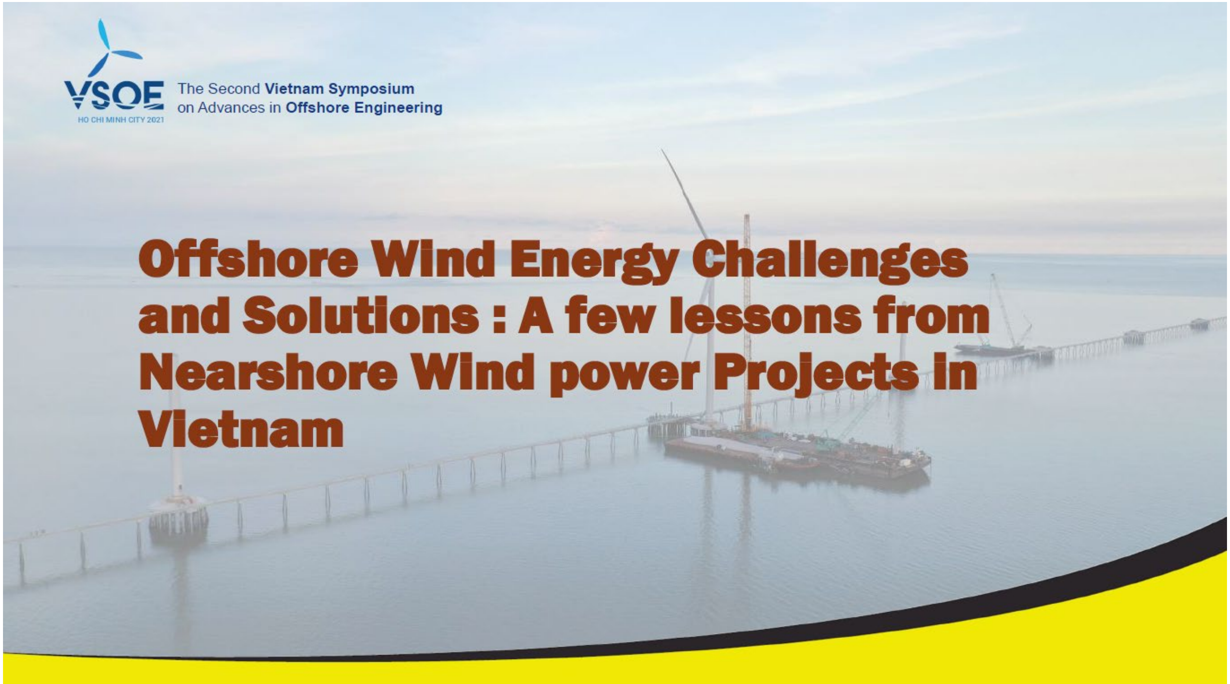
Please refer our website:
www.pecc3.com.vn
Mr. Tran Quoc Dien – Deputy General Director
Email: Dientq@pecc3.com.vn

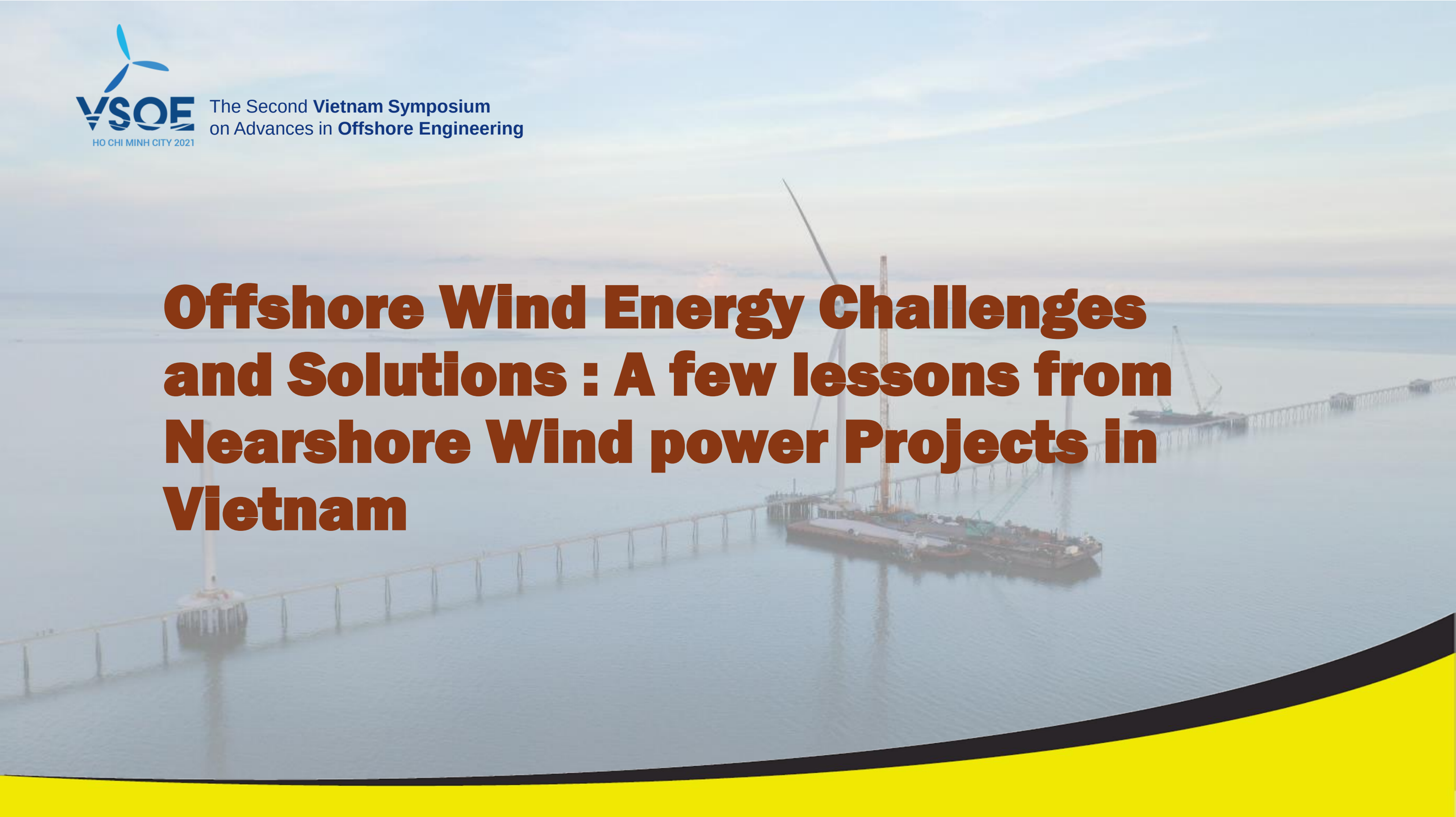
EVNPECC3

THANK YOU!

Offshore wind energy challenges and solutions: a few lessons from nearshore wind power projects in Vietnam

Nguyen Viet-Hung
CTE Wind Vietnam



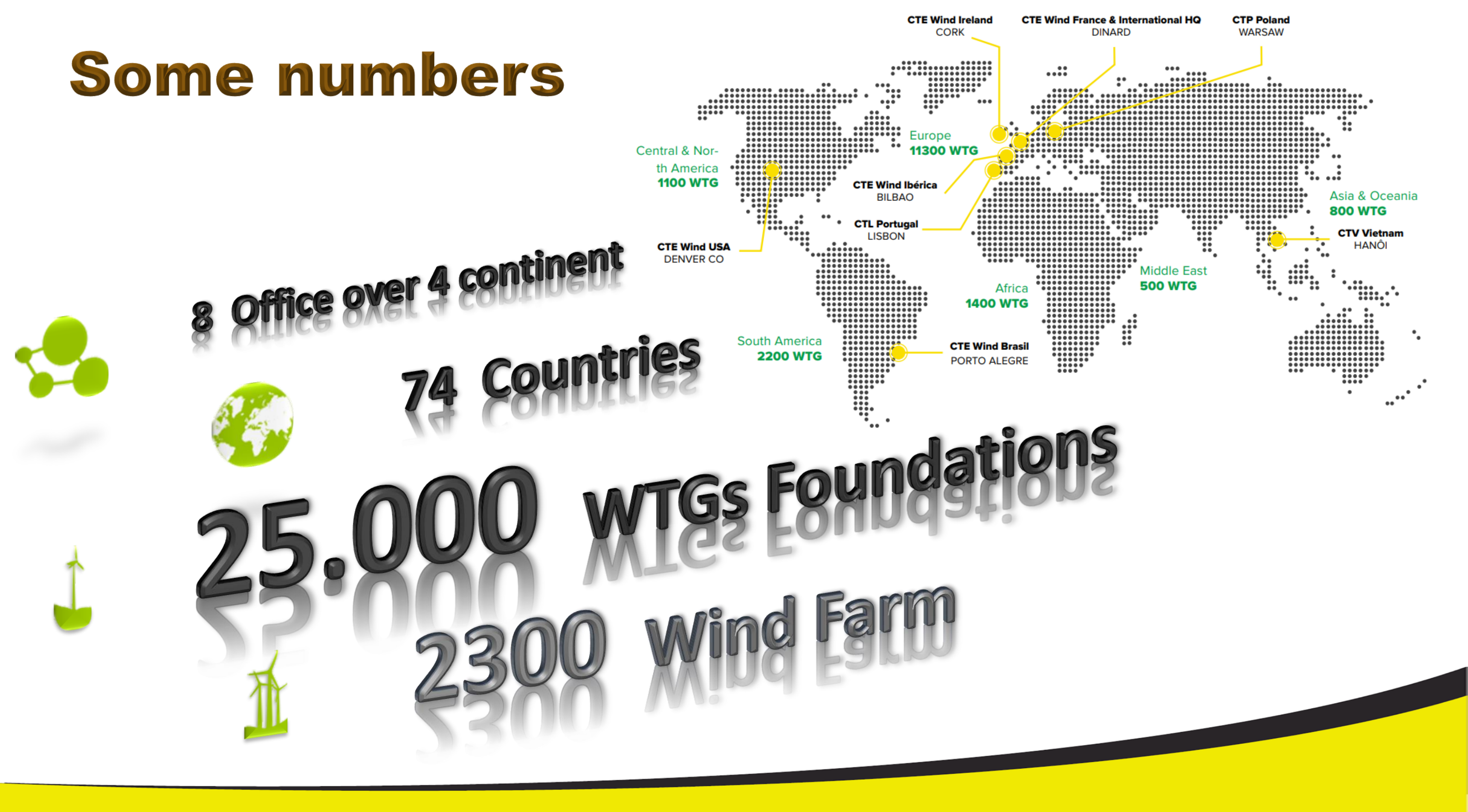


Offshore Wind Energy Challenges and Solutions : A few lessons from Nearshore Wind power Projects in Vietnam

Viet-Hung NGUYEN,
CEO of CTE Wind Vietnam
vh.nguyen@cte-sa.com
cell: +84979858540

Web: cte-wind.com

- **Hung Nguyen, Ceo of CTV Wind, CTE Wind group who specialize in cBoP design for Wind power Plant with a wide international experience on large scale active in Vietnam.**
- **Hung NGUYEN received his Ph.D. in Structural Engineering and Materials from the "Ecole des Ponts ParisTech", have nearly 20 years of experience in the design of cBoP of Wind Power project in Europe, Asia especially in Vietnam**
- **He have worked on a wide range of technical design and management including infrastructures, geotechnics, Wind power master plan and specializing for onshore and nearshore Wind Turbine foundations**
- **CTE Wind group has designed more than 2000 wind Farm with the total 20 GW over 74 countries.**
- **CTV has design more than 60 Wind projects in Operation, 11 near offshore wind Farm**



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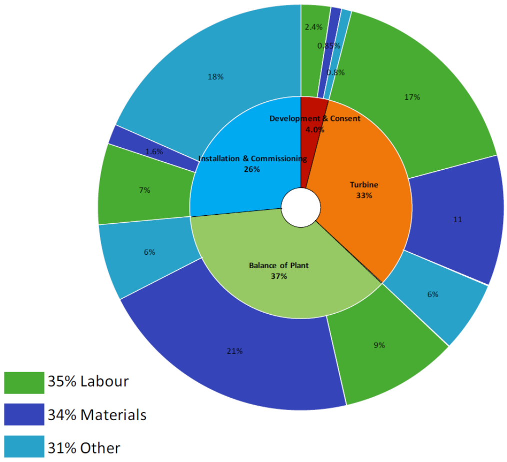
All CAPEX COST BREAKDOWN

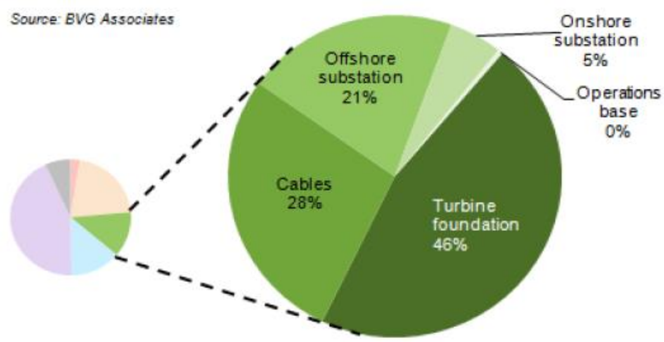


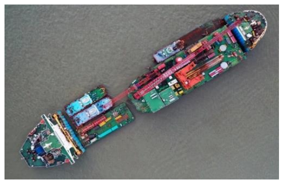
Category	Category cost	Category component	Category component cost	Overall component	Overall component cost
Development & Consent	4%	Labour	2.4%	Labour	35%
		Materials	0.9%		
		Other	0.8%		
Turbine	33%	Labour	17%		
		Materials	10%	Material	34%
		Other	6%		
Balance of Plant	37%	Labour	9%		
		Materials	21%		
		Other	6%	Other	31%
Installation & Commissioning	26%	Labour	6%		
		Materials	2%		
		Other	18%		
TOTAL (%)	100%		100%		100%

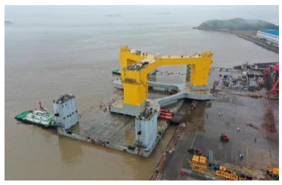
Source: BVG Associates

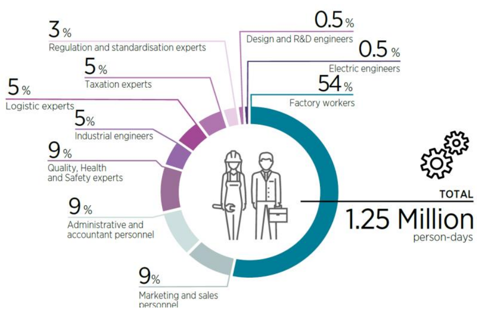
BoP Supply chain

Breakdown of balance of plant sub-element







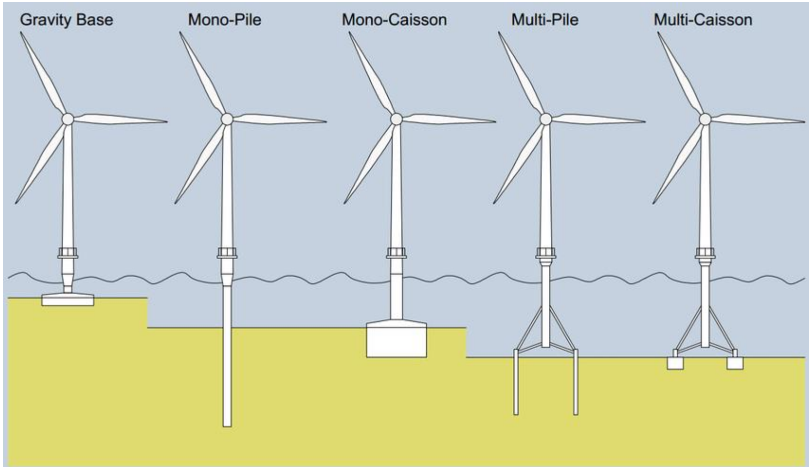


Distribution of human resources required to manufacture the main components of a 500 MW offshore wind farm, by occupation

Preliminary Study for foundation types

One preliminary report for choose the foundation type has performed the criteria below:

- ***Constructability, including the local availability of construction materials and skilled labour;***
- ***Logistics of installation, including local installation contractor experience, availability of installation equipment, etc.;***
- ***Cost of manufacturing/construction;***
- ***Cost of installation;***
- ***Driveability of driven piles***
- ***Dynamic response (typically only significant in relatively deep water).***



The two types best suited to the Project were selected

Pile cap foundation and mono pile foundation

- *The cost of solution mono-pile foundation has higher than classical pile cap foundation*

NEARSHORE& OFFSHORE FOUNDATION CASE STUDY

- Context
- Site is flooded
- The depth of water is shallow from 3 to 10 m
- The position of foundation is about 500 – 10km from the shore.
- Seabed is very plane slope < 1- 2%
- The classical foundation has a lot inconvenience
  - The construction cost is very high
  - The quality of construction is not assured
  - Duration of construction is very long
  - ….
- It is difficult to user the offshore technical because shallow water
  - Big vessels

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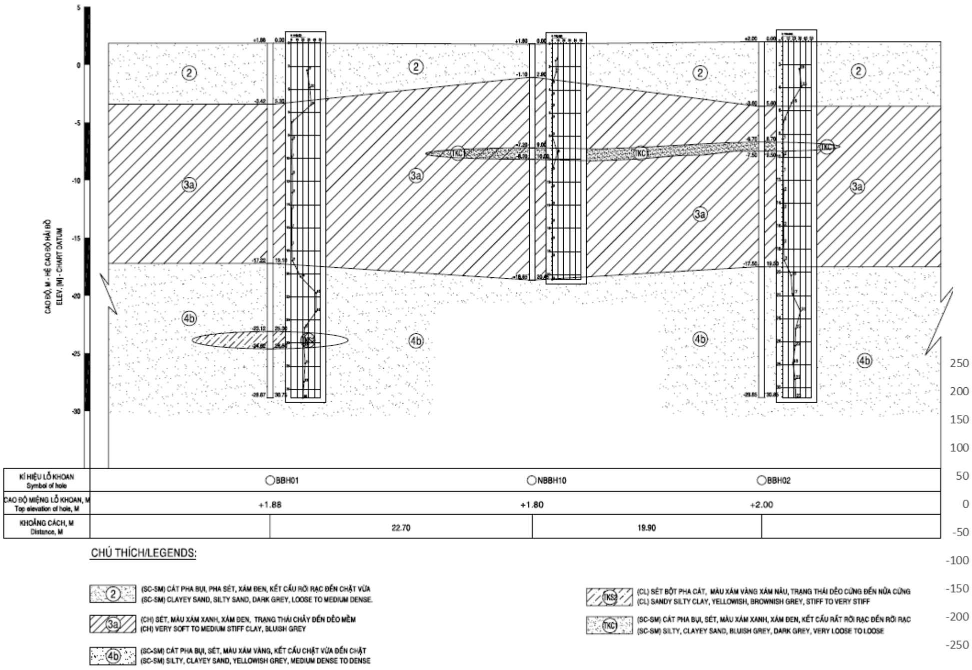
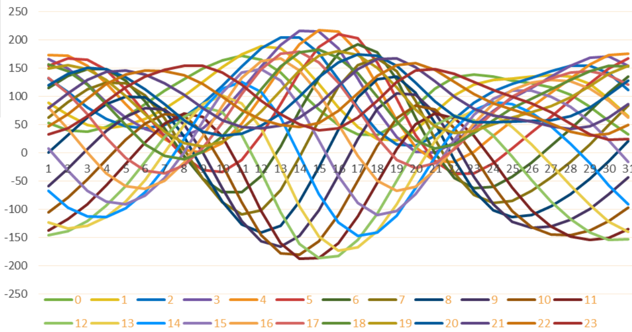
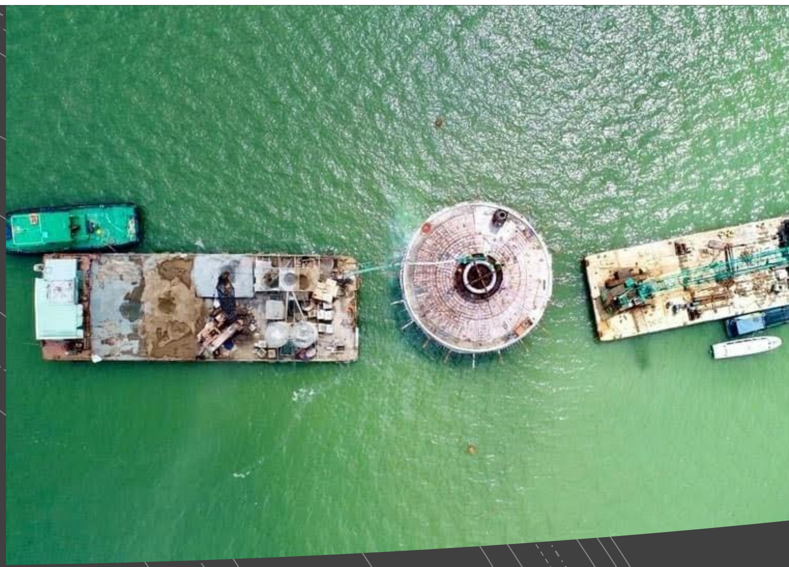


- Site condition
  - Geotechnical
  - Met-ocean
  - Bathymetry

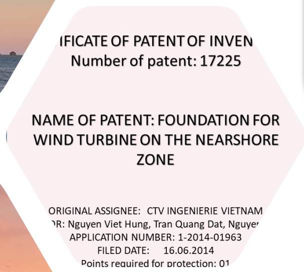




Adapt to Local condition

- Materials information
- Local suppliers chains
- Local equipment and local cultures
- Local natural and geographic condition
- Create synergy team between the international know how and the local Partner

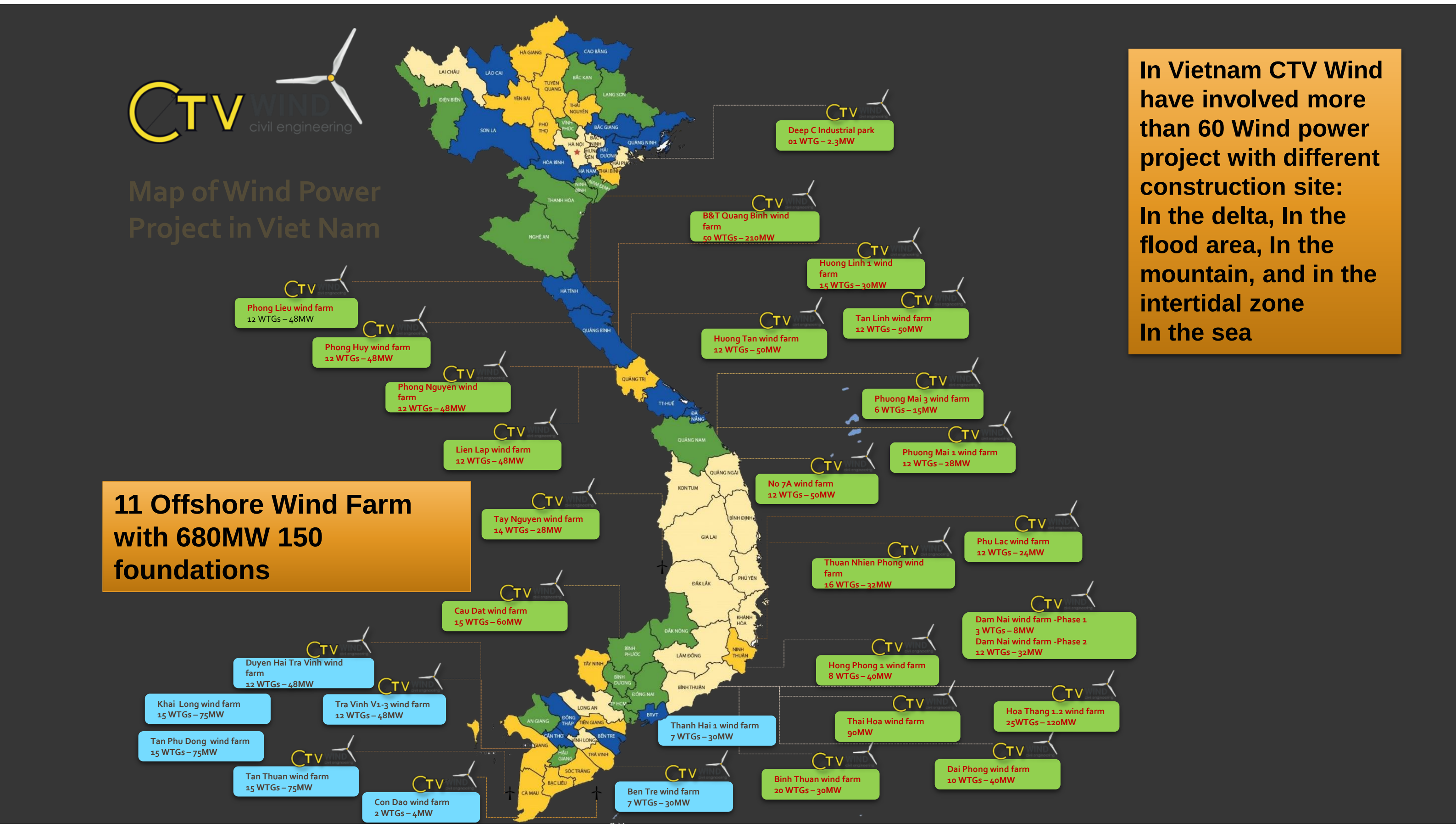
New Design adapt to the local conditions


IFICATE OF PATENT OF INVEN
Number of patent: 17225

NAME OF PATENT: FOUNDATION FOR WIND TURBINE ON THE NEARSHORE ZONE

ORIGINAL ASSIGNEE: CTV INGENIERIE VIETNAM
)R: Nguyen Viet Hung, Tran Quang Dat, Nguyer
APPLICATION NUMBER: 1-2014-01963
FILED DATE: 16.06.2014
Points required for protection: 01

- User the local materials
- User the local equipment
  Small barge and equipment
- Adapt to real condition
- Allow to finished the wind project eventhought the Covid
- Profit well the local human ressources



11 Offshore Wind Farm with 680MW 150 foundations

In Vietnam CTV Wind have involved more than 60 Wind power project with different construction site: In the delta, In the flood area, In the mountain, and in the intertidal zone In the sea

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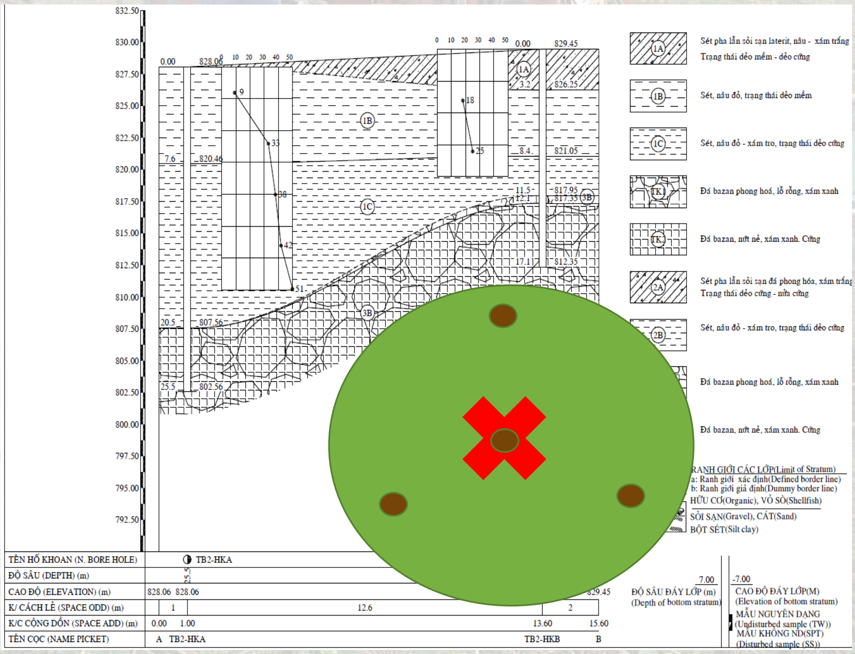
Geotechnical Conditions

- Type of soil indicates type of foundation
- Dry or flood-risk region
- Complex or homogenous soil
- Number of boreholes needed

Geotech survey program and resulting foundation design are cost relevant



International - local conditions

- **Local Regulations and Standards**
  - **Blended and adapted the international and local regula**
    - **Standard for design**
    - **Standard for cconstruction**
    - **For environment impact**
    - **........**

Bảng 12 - Các cường độ tiêu chuẩn của bê tông R_{bn}, R_{btn} và cường độ tính toán của bê tông khi tính toán theo các trạng thái giới hạn thứ hai $R_{b,ser}$, $R_{bt,ser}$, MPa

Trạng thái	Loại bê tông		Cấp độ bền chịu nén của bê tông																		
			B1	B1,5	B2	B2,5	B3,5	B5	B7,5	B10	B12,5	B15	B20	B25	B30	B35	B40	B45	B50	B55	B60
							M50	M75	M100	M150	M150	M200	M250	M350	M400	M450	M500	M600	M700	M700	M800
Nén dọc trục (cường độ lăng trụ) R_{bn}, $R_{b,ser}$	Bê tông nặng, bê tông hạt nhỏ		-	-	-	-	2,7	3,6	5,5	7,5	9,5	11,0	15,0	18,5	22,0	25,5	29,0	32,0	36,0	39,5	43,0
	Bê tông nhẹ		-	-	-	1,9	2,7	3,5	5,5	7,5	9,5	11,0	15,0	18,5	22,0	25,5	29,0	-	-	-	-
	Bê tông tổ ong		0,95	1,4	1,9	2,4	3,3	4,6	6,9	9,0	10,5	11,5	-	-	-	-	-	-	-	-	-
Kéo dọc trục R_{btn}, $R_{bt,ser}$	Bê tông nặng		-	-	-	-	0,39	0,55	0,70	0,85	1,00	1,15	1,40	1,60	1,80	1,95	2,10	2,20	2,30	2,40	2,50
	Bê tông hạt nhỏ	nhóm A	-	-	-	-	0,39	0,55	0,70	0,85	1,00	1,15	1,40	1,60	1,80	1,95	2,10	-	-	-	-
		nhóm B	-	-	-	-	0,26	0,40	0,60	0,70	0,85	0,95	1,15	1,35	1,50	-	-	-	-	-	-
		nhóm C	-	-	-	-	-	-	-	-	-	1,15	1,40	1,60	1,80	1,95	2,10	2,20	2,30	2,40	2,50
	Bê tông nhẹ	cốt liệu đặc	-	-	-	0,29	0,39	0,55	0,70	0,85	1,00	1,15	1,40	1,60	1,80	1,95	2,10	-	-	-	-
		cốt liệu rỗng	-	-	-	0,29	0,39	0,55	0,70	0,85	1,00	1,10	1,20	1,35	1,50	1,65	1,80	-	-	-	-
	Bê tông tổ ong		0,14	0,21	0,26	0,31	0,41	0,55	0,63	0,89	1,00	1,05	-	-	-	-	-	-	-	-	-

CHÚ THÍCH 1: Nhóm bê tông hạt nhỏ xem 5.1.1.3.

Local condition: materials

- **Concrete**
  - **WTG foundation needs high concrete grades, which is not very popular in Vietnam, C50/60**
- **Reinforcement (steel)**
  - **In general the strength of reinforcement used in Vietnam is less than 400 MPa**
  - **It better to use high strength grades, for example B500B, but this kind of reinforce is not common in the province**
- **Grout high strength**
  - **In Vietnam, we must import the grout. It should be planed to buy it before the construction starts because the importation process takes time**

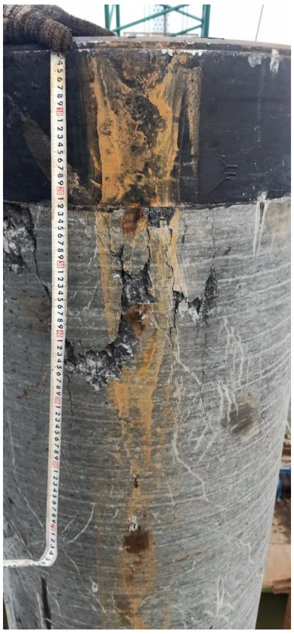
Pile driving

- **Equipment**
  - **Hammers**
    - **Diesel hammers**
    - **Hydraulic hammers**

The number of big diameter (more than 1.4m)is very limited

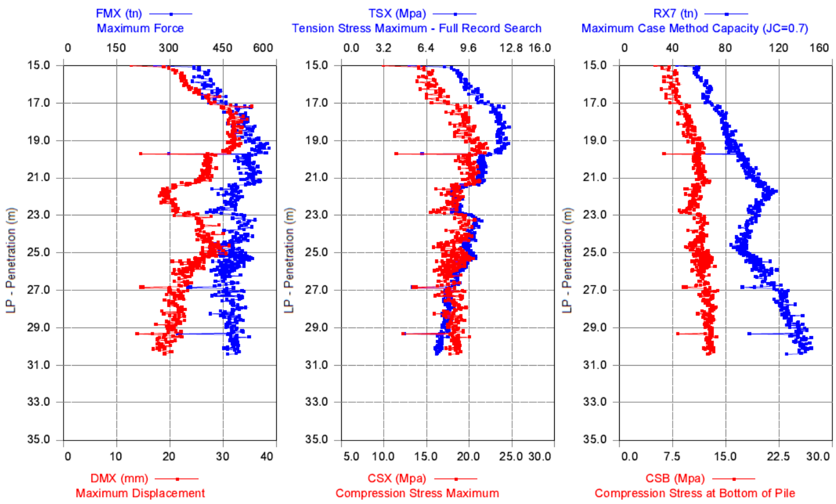
PHC pile diameter more than 1200mm is very limited

Pile broken accident – Case stiff soil



- Control the stabilization of barge for driving.
- The wave height in the driving process is important
- Contact with the head pile is not good
- It should choose the suitable hammer
- Plan to use the cushion

Piles broken in soft soil



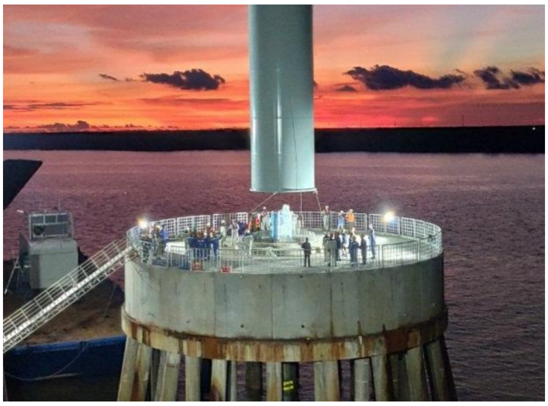
Control the temperature for mass concrete

- Use the concrete Low Heat Cement
- Use the cooling system
- Control the slump of concrete
- Use isotherm system

Never allow to moring the badges to the foundation

Conclusion

- It should pay attention about the local condition.
- It should develop the local supply chain about
  - The construction materials for example the high performance of concrete, steel structure, piles
  - Heavy equipment for transportation and installation: heavy transportation vehicles, big crane, driving barge, Vessel, etc..
  - Education and training the human resource for the construction, installation, operation and maintenance
  - Create synergy betwen Vietnameses Companies and Internationals companies



Tân Thuận Wind Farm 75 MW

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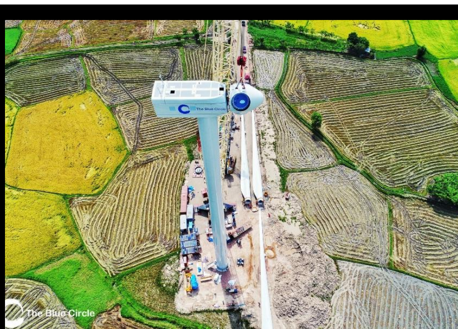
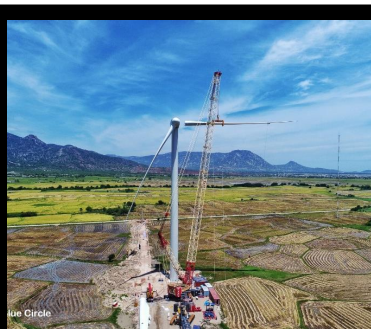
PHU LAC PROJETS





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WIND FARM IN THAILAND

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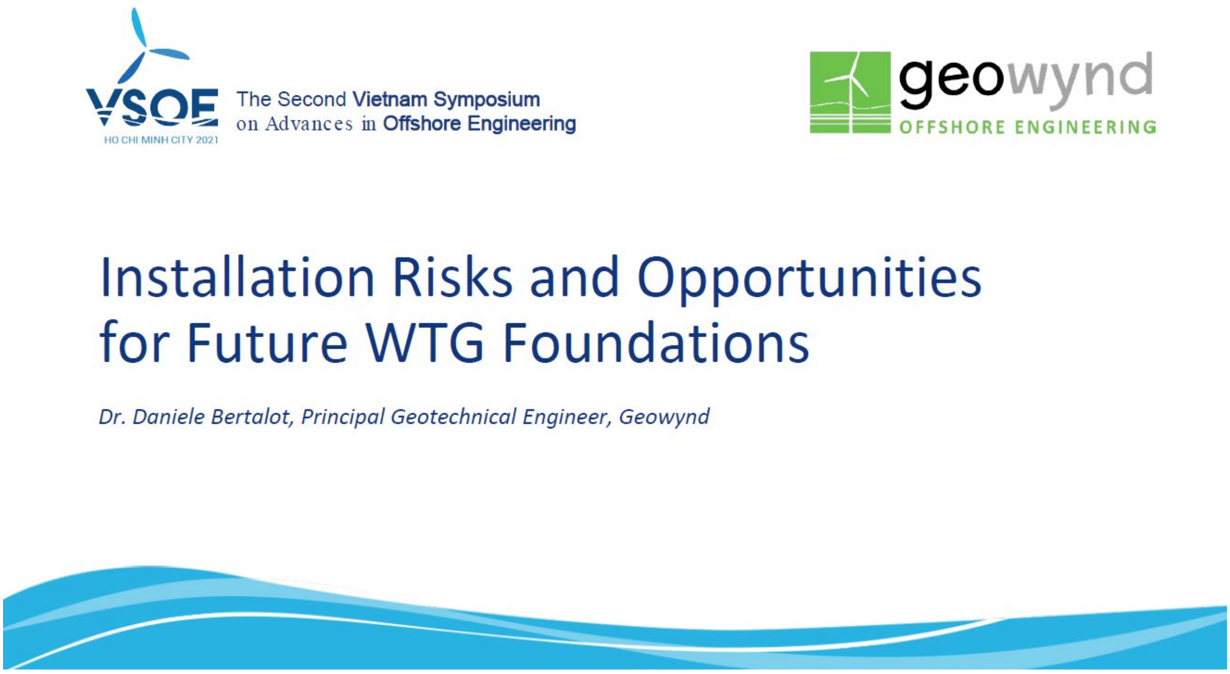
Installation risks and opportunities for future WTG foundations

Daniele Bertalot
Geowynd, Italy



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Installation Risks and Opportunities for Future WTG Foundations

Dr. Daniele Bertalot, Principal Geotechnical Engineer, Geowynd

Content of the Presentation

- Overview of WTG Installation Operations
- Jack-up related (geotechnical) installation hazards
  - ➢ Example 1: Assessment of jack-up vessel response upon soil liquefaction
  - ➢ Example 2: Assessment of pile driving induced soil softening
- Pile related (geotechnical) installation hazards
  - ➢ Example: Performance of SRD methodologies applied to Monopile foundations
- Conclusions

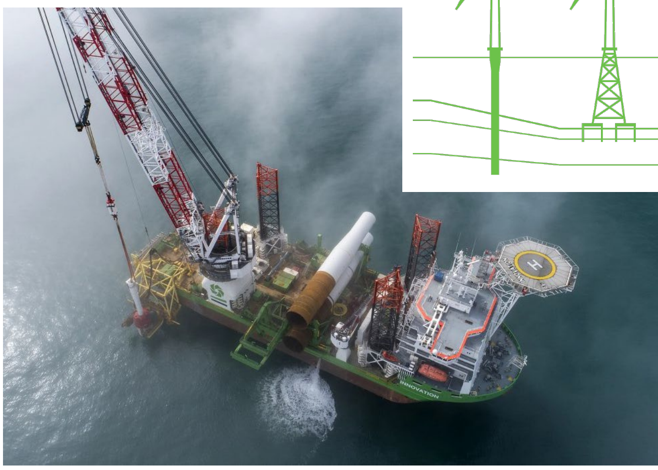
Overview of WTG Installation Operations

Most of WTG foundations in the South-East Asia region are/will be:

- Monopiles
- Pin-pile Jackets
- Jackets on suction buckets

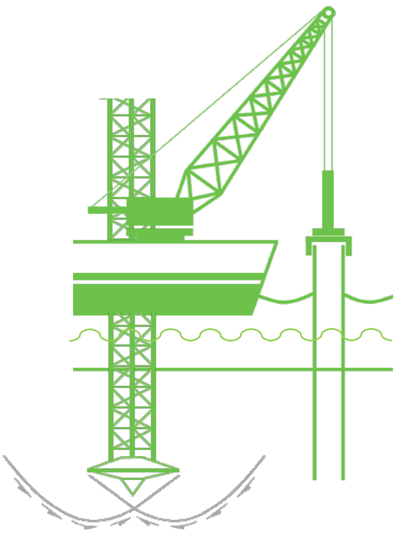
In most cases installation operations are carried out from jack-up vessels (few DP installation vessels also available)

Pile foundations (both Monopiles and Pin-piles) are typically installed by impact driving (limited cases of vibro-driving)



Credit: Ground Engineering, Hornsea II OWF

Jack-up Related (Geotechnical) Installation Hazards



Jack-up related hazards, concern with the stability of the installation vessel during operations. Jack-up stability is routinely addressed by means of:

- Leg Penetration Analyses
- Site Specific Assessment (Yield Interaction, Footing Eq. Stiffness,…)

ISO 19905-1 also stresses the need to check jack-up stability against cyclic loads, in cases where foundations soils are potentially subject to 'cyclic mobility':

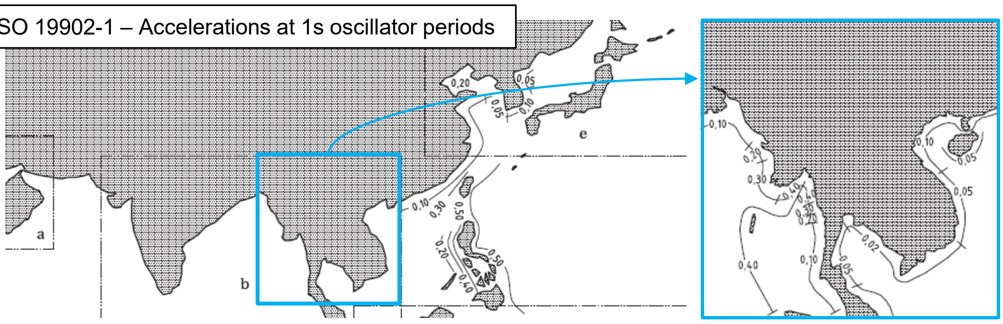
9.4.6 Cyclic mobility

Cyclic loads can cause a progressive build-up of pore pressures within the foundation soils and consequent soil strength degradation (liquefaction). The effects can be either local to the soils under the spudcan or over a larger area. Local foundation cyclic loading can be caused by the jack-up response to earthquakes, severe storms, rotating machinery, etc. Earthquakes can cause large-scale cyclic loading and result in failure of the soil mass over a large area. Depending on the magnitude of pore pressures developed, cyclic loading can result in large vertical displacements of the spudcans, which can be differential in some cases.

The assessment shall consider the effects of cyclic loading on the stability and displacements of foundations.

Cyclic Mobility: Seismic Loading

ISO 19902-1 – Accelerations at 1s oscillator periods



$S_{a,map}(1,0)$	<0,03 g	0,03 g to 0,10 g
Seismic zone	0	1

It is not necessary to perform an earthquake assessment for seismic zone 0. For seismic zone 1, an earthquake assessment should be considered when any of the following conditions apply:

- sites with the potential for cyclic mobility (e.g. liquefaction)
- sites with the potential for unacceptable leg penetrations if preload exceeded
- ratio between leg preload reaction and the maximum still water reaction is less than 1,25

Open issue: Lack of guidance in the definition of a reference risk level for WTG installation operations (i.e. Return period of the seismic action):

→ ISO 19901-2 treating jack-up as a manned, fixed, offshore structure (very conservative)

→ ISO 19905-1 recommends ELE=1000 yrs for O&G jack-up drill rigs, still applicable to wind industry?

→ DNV RP 0585 substitutes 'service life' with 'construction window' in ISO 19901-2 (ELE>95 yrs)

Cyclic Mobility: Seismic Loading

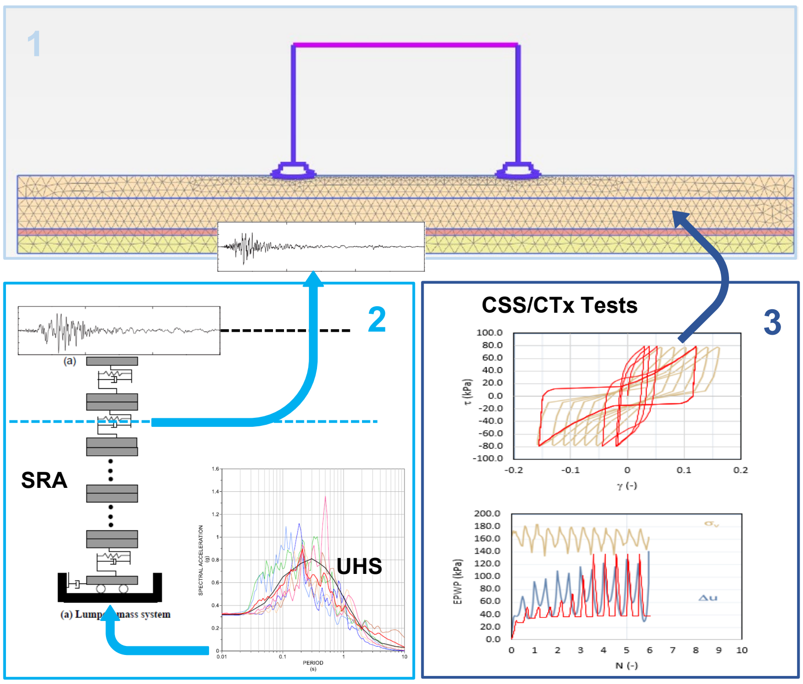
Modelling approach:

1. Definition of the 2D (or 3D) FE model geometry including at least 30 m soil column
2. Definition of seismic input in the form of in-profile acceleration time histories at model base level
3. Material model calibration based on cyclic laboratory element tests (Fully coupled u-p formulation required)

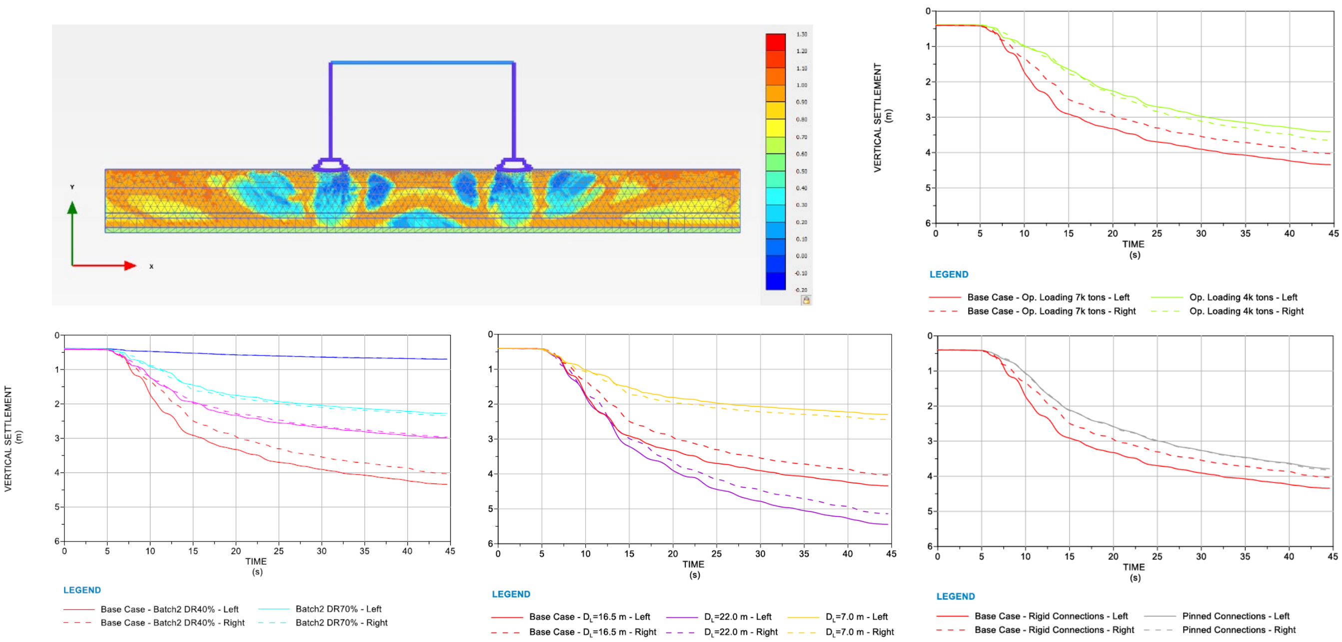
⇩

→ Undrained dynamic analysis (conservative)

→ Dynamic analysis + consolidation

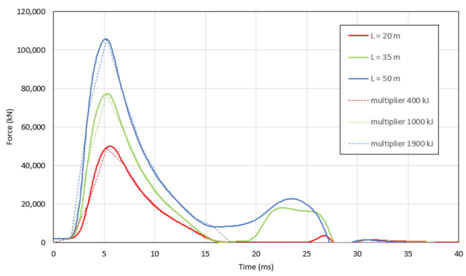


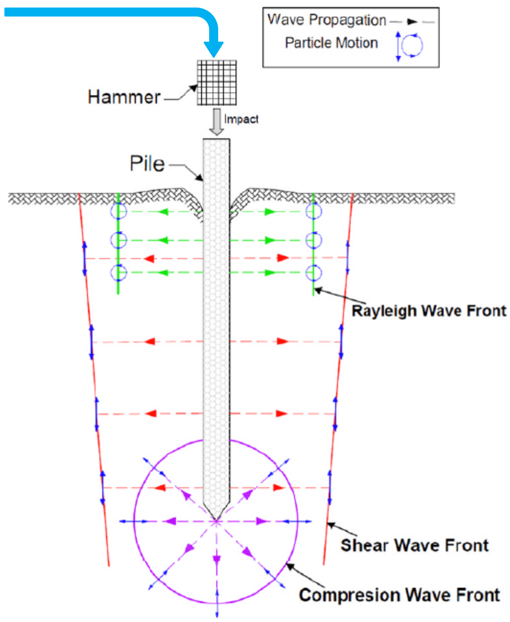
Cyclic Mobility: Seismic Loading



Cyclic Mobility: Pile Driving Induced Vibrations

During driving of pile foundations part of the energy of the hammer stress wave is radiated away from the pile in the form of shear and volume waves:





- **Cylindrical shear waves**: generated at the pile-soil interface, Vs, decay with a rate proportional to 1/R
- **Spherical volume waves**: generated at the pile-soil interaface, Vp of about 1500 m/s, decay with a rate proportional to 1/√R
- **Rayleigh waves**, surface waves with both transverse and longitudinal motion components, ~ Vs

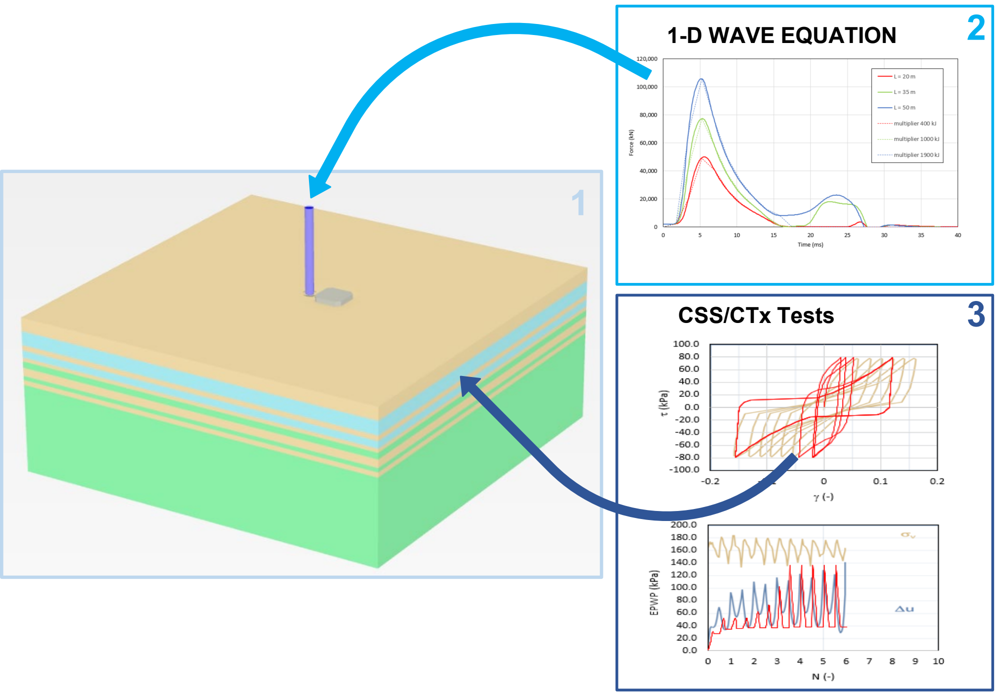
Cyclic Mobility: Pile Driving Induced Vibrations

Modelling approach:

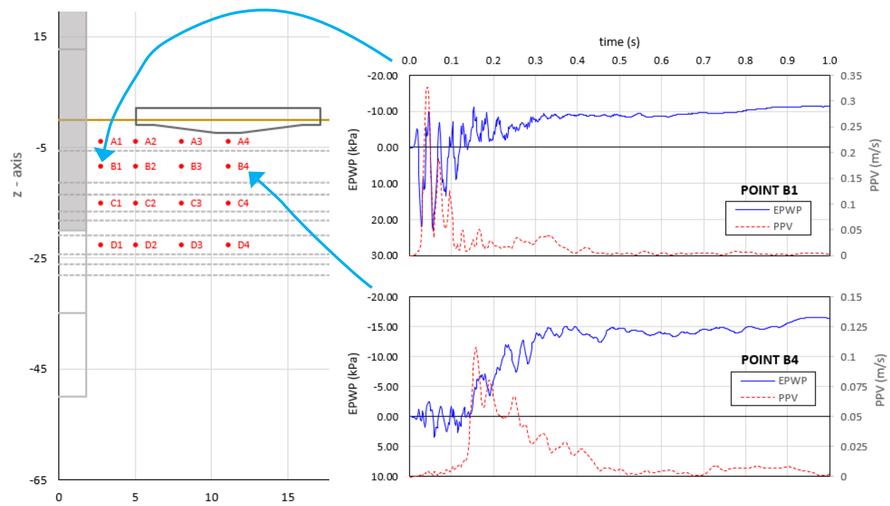
1. Definition of the 3D FE model geometry, single spudcan + adequate boundary cond.
2. Definition of hammer stress wave by means of 1-D wave equation model
3. Material model calibration based on cyclic laboratory element tests
(Fully coupled u-p formulation required)

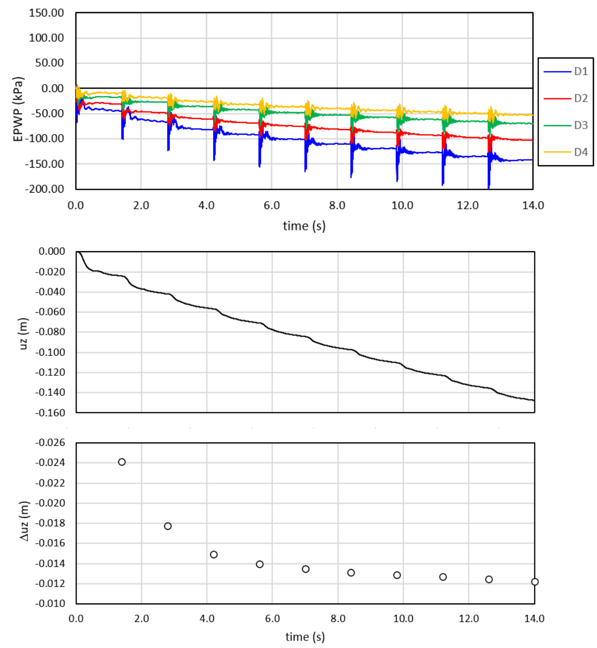
⇩

→ Dynamic analysis + 3D consolidation



Cyclic Mobility: Pile Driving Induced Vibrations





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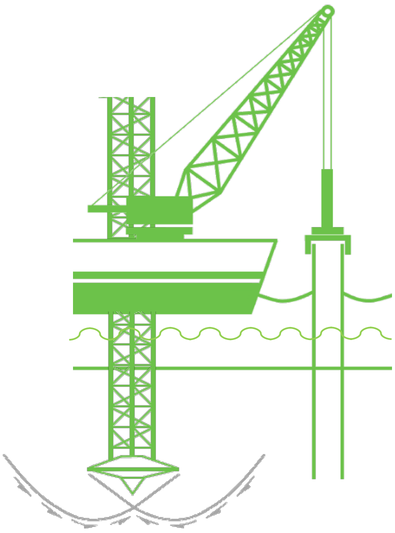
Pile Related (Geotechnical) Installation Hazards



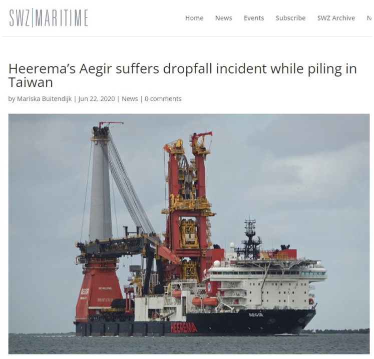
Pile related hazards, concern with the safe installation of the pile to target penetration.

Main pile driving hazards are:

- Pile refusal
- Tip extrusion buckling (e.g. boulder impact)
- Driving induced steel fatigue
- 'Pile running'

Risk for specific installation is typically assessed by means of 1-D wave equation analysis of the hammer-pile-soil system:

Reliable Soil Resistance to Driving (SRD) profile is key



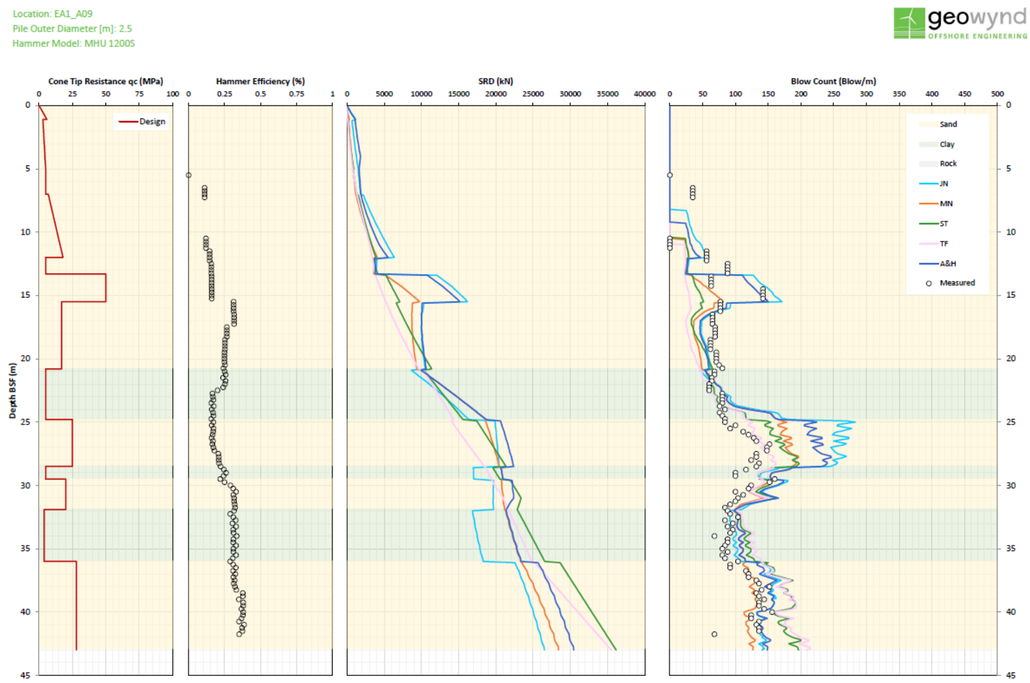
Soil Resistance to Driving

- 20 installation case histories
- 3 Offshore Wind Farms
- 10 Monopiles
- 10 Pin-piles
- Soil conditions considered:
  - ✓ Very dense to medium dense sands
  - ✓ Slightly to heavily over consolidated clays

SRD Method	γ'	q_c	q_t	f_s	u_2	ϕ'	δ	s_u	S_t	YSR	I_p	UCS
Alm and Hamre [2]	✓		✓	✓			✓					
Stevens et al. [33]	✓						✓	✓		✓^	✓^	✓
Fugro-modified Toolan and Fox	✓	✓		✓			✓	✓				
Maynard et al. [25]	✓		✓	✓			✓			✓	✓	
Jones et al. [21]	✓	✓		✓		✓^	✓		✓	✓		

Method	No. of Piles	Range of Pile Geometries						Range of Ground Conditions
		Bound	D [m]	L [m BSF]	t [mm]	L/D [-]	D/t [-]	
Alm and Hamre [2]	164	Min.	0.76	35.0	-	14.4	-	Typical North Sea conditions: dense to very dense sands, low to extremely high strength clays, lightly to heavily overconsolidated.
		Max.	2.74	115.0	-	150.9	-	
Stevens et al. [33]	27	Min.	0.91	17.4	38.1	53.4	20.6	Arabian Gulf carbonate soils: medium dense to very dense sands, very high to extremely high strength clays, gypsum and sandstone rock.
		Max.	1.07	50.6	44.5	181.5	28.0	
Toolan and Fox (1977)*	32	Min.	1.37	59.7	50.8	43.5	27.0	Forties Bravo Platform, North Sea: dense to very dense sand, very low to extremely high strength clay.
		Max.		67.1		48.9		
Maynard et al. [25]	202	Min.	4.80	23.6	50	3.8	57.5	Predominantly very high to extremely high strength clays and dense to very dense sands across three sites.
		Max.	7.50	46.5	100	7.3	130.0	
Jones et al. [21]	277	Min.	0.66	20.8	35.0	3.3	17.4	Ranges from normally consolidated clays and silts offshore China to very dense sands and overconsolidated clays in the North Sea and mudstone in the Irish sea.
		Max.	6.50	126.0	82.7	131.8	130.0	

Soil Resistance to Driving



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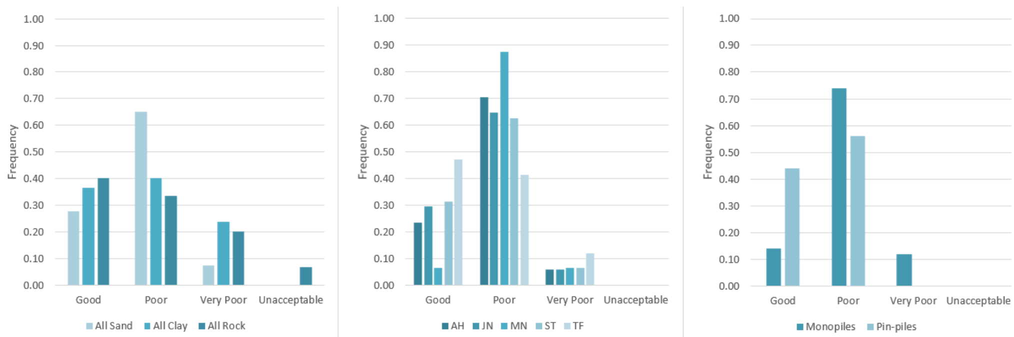
Soil Resistance to Driving

$$NRMSD = \frac{RMSD}{BC_{meas,av}}$$

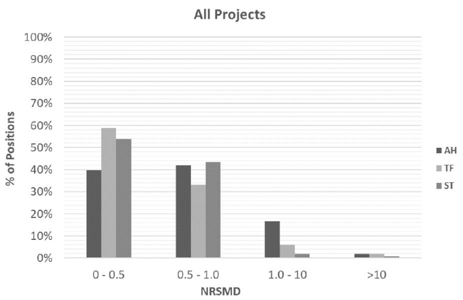
$$RMSD = \sqrt{\frac{\sum_{i=1}^{n}(BC_{meas} - BC_{sim})^2}{n}}$$

where:

BC_{meas} = measured blow counts at depth i;
BC_{sim} = simulated blow counts at depth i;
n = sample size of the measured driving log.



- Good match: $0 < NRMSD \leq 0.5$
- Poor match (but acceptable): $0.5 < NRMSD \leq 1.0$
- Very poor match: $1.0 < NRMSD \leq 10.0$
- Unacceptable match: $NRMSD > 10.0$



AN ASSESSMENT OF THE ACCURACY OF SRD METHODOLOGIES FOR OWF MONOPILE INSTALLATION AGAINST A NORTH EUROPE DRIVING RECORDS DATABASE

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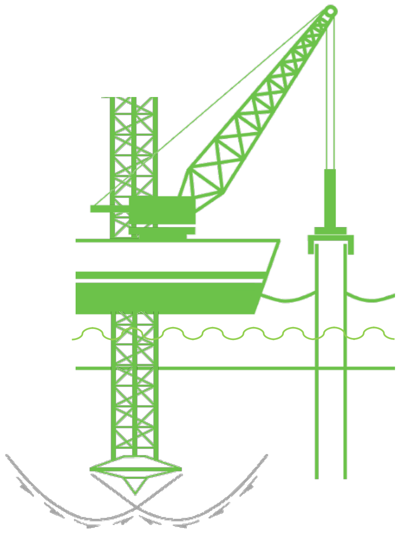
Conclusions

Few key points to be considered for future installation of WTG foundations in Vietnam:

- Site characterization for future OWF shall focus on identifying soils potentially affected by cyclic mobilty/liquefaction, and carefully determine their response to cyclic loading (i.e. adequate cyclic laboratory program)
- For OWF projects located along Vietnam's Eastern an Northern coasts, the impact of earthquake loading on jack-up stability shall be carefully assessed, including cyclic mobility effects
- The risk level to be considered for jack-up vessels in the wind industry is an open issue, ultimately up to the operator/certifier to define acceptable risk
- Uncertainty related to SRD predictions from industry standard empirical methods shall be considered when assessing pile installation of large diameter monopiles



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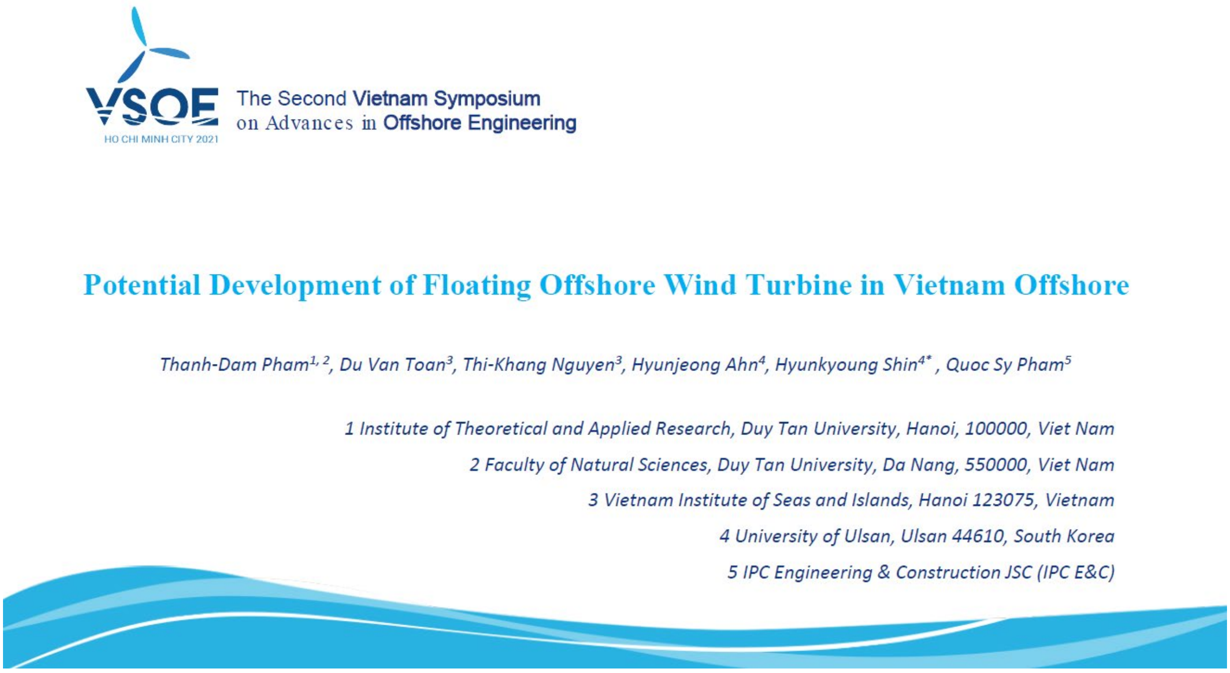
Thank You for the Kind Attention

Please feel free to reach out for additional details

dbe@geowynd.com

Potential development of floating offshore wind turbine in Vietnam offshore

Thanh-Dam Pham
Duy Tan University, Vietnam



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Potential Development of Floating Offshore Wind Turbine in Vietnam Offshore

Thanh-Dam Pham[1, 2], Du Van Toan[3], Thi-Khang Nguyen[3], Hyunjeong Ahn[4], Hyunkyoung Shin[4] , Quoc Sy Pham[5]*

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3 Vietnam Institute of Seas and Islands, Hanoi 123075, Vietnam

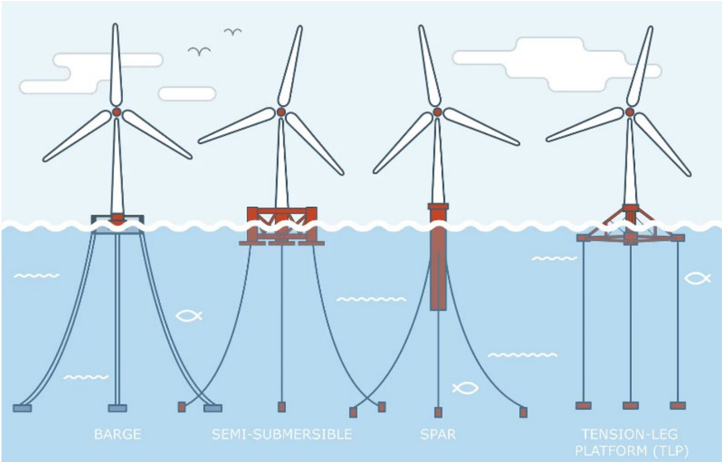
4 University of Ulsan, Ulsan 44610, South Korea

5 IPC Engineering & Construction JSC (IPC E&C)

Outline

- Introduction
- Reference Location and Environmental Conditions
- 10 MW Floating Offshore Wind turbine Models
- Numerical Simulation Modelling
- Results
- Conclusion

Introduction



Floating offshore wind platform concepts

Source: COWI

- Shared supply chains
  – Turbines
  – Array and export cables
  – Regulations
  – Ports and Infrastructure
– Operations and Maintenance
- Floating cost reductions lag fixed-bottom offshore wind cost by 5 -7 years
- Floating cost are likely to converge with fixed-bottom wind

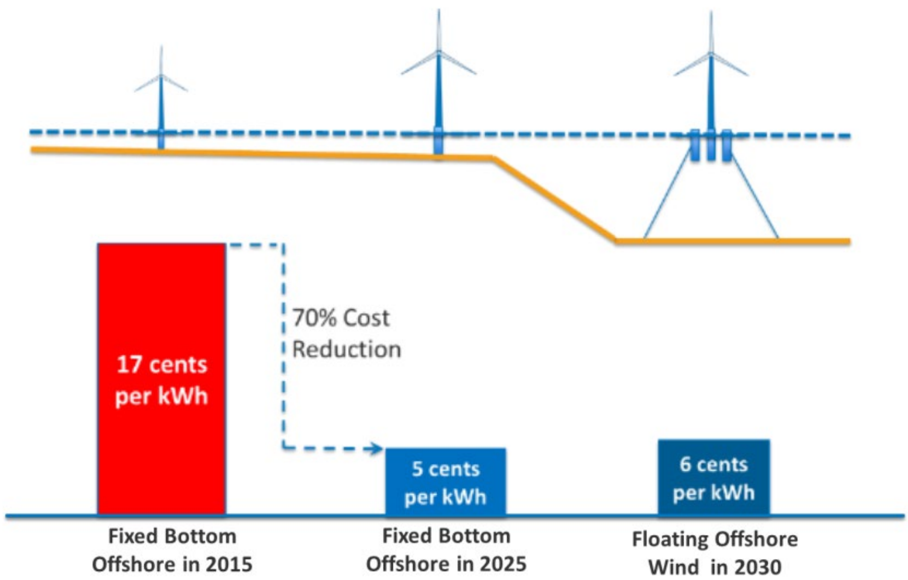


Figure credit: NREL

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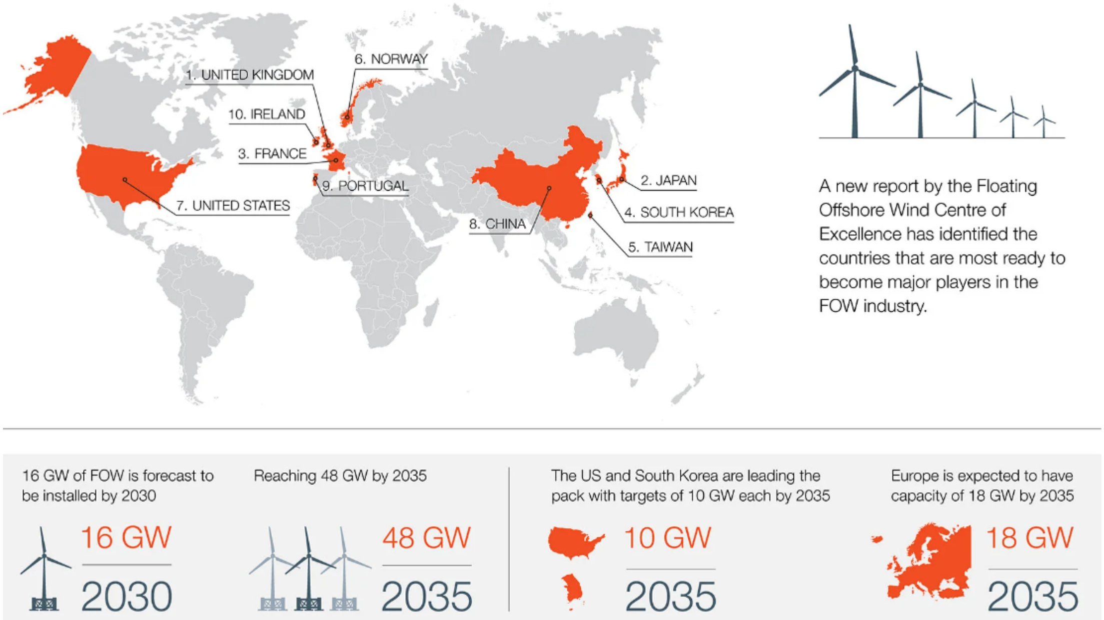
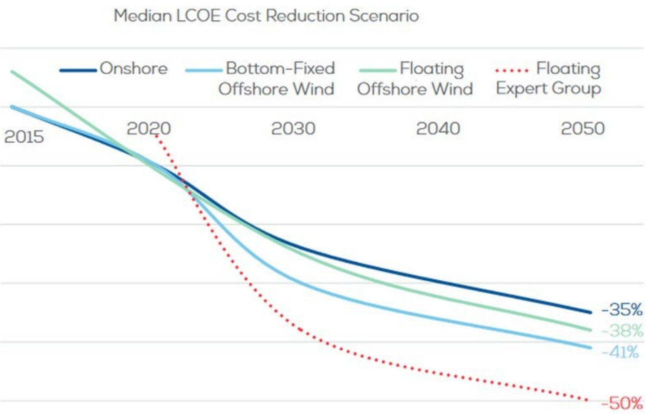
Introduction

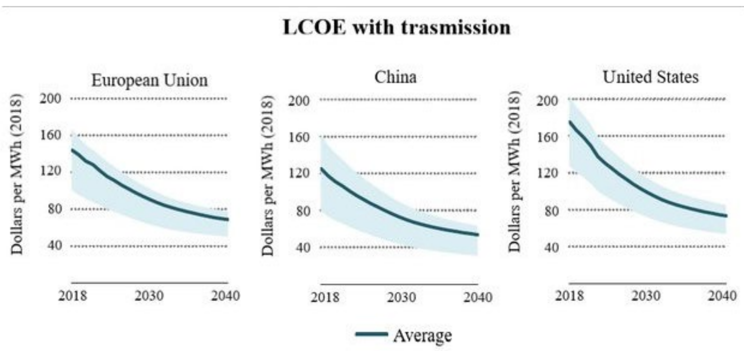


Source: COWI

Introduction

LCOE of floating offshore wind



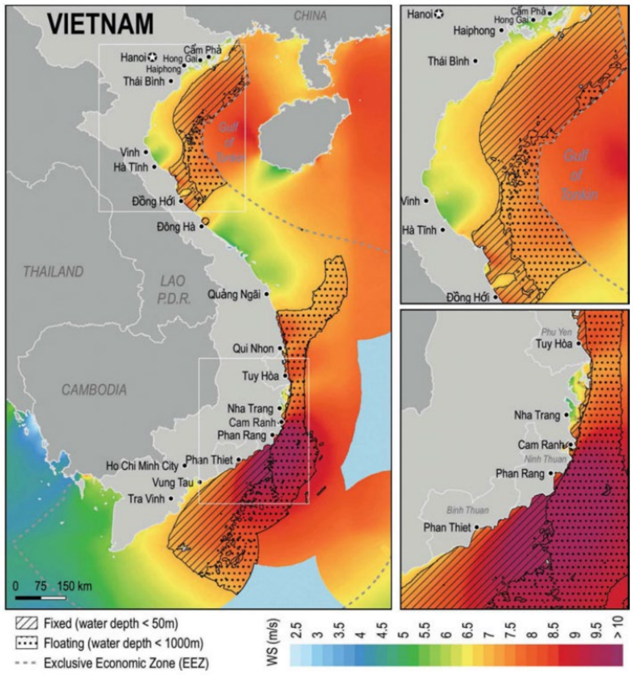


Reference Location and Environmental Conditions

Technical potential capacity of offshore wind: **599 GW**

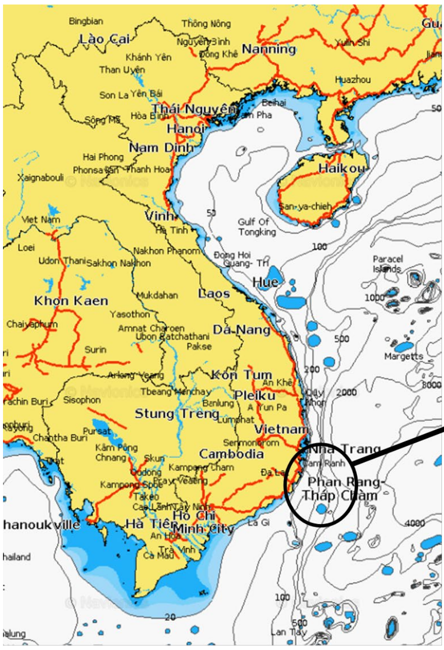
Fixed bottom offshore wind is **261 GW**

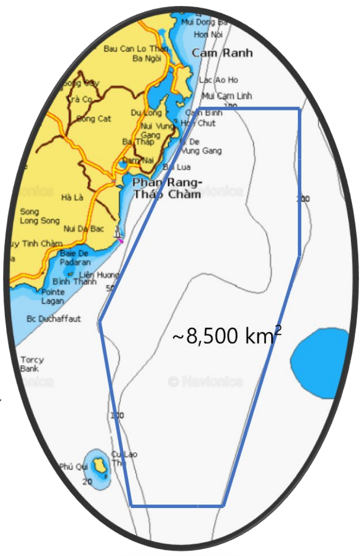
Floating offshore wind is **338 GW**



Source:Worldbank, "Technical Potentia for Offshore Wind-in Vietnam Map"

Reference Location and Environmental Conditions





Ninh Thuan, Binh Thuan Offshore:
Water depth from 50-250 m, area~8500 km2
Wind speed 10.6 m/s at 100m height

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Reference Location and Environmental Conditions

Typical environmental conditions at Ninh Thuan offshore area based on data from Vietnam Institute of Seas and Islands

Sea State	Wind	Wave		Current	DLC
		Hs	Tp		
	m/s	m	s	m/s	
SS1	4	0.12	2.9	0.4	DLC1.1
SS2	6	0.47	2.9	0.4	DLC1.1
SS3	8	0.63	2.9	0.4	DLC1.1
SS4	10	1.05	3.68	0.4	DLC1.1
SS5	12	1.33	3.88	0.4	DLC1.1
SS6	14	1.81	4.51	0.4	DLC1.1
SS7	16	2.36	5.08	0.4	DLC1.1
SS8	18	3.01	5.74	0.4	DLC1.1
SS9	20	3.79	6.38	0.4	DLC1.1
SS10	22	4.71	7.18	0.4	DLC1.1
SS11	24	5.6	7.72	0.4	DLC1.1
SS12	4 - 24	8.8	10	0.4	DLC1.6a
SS13	42.1	8.8	10	1.47	DLC6.1a

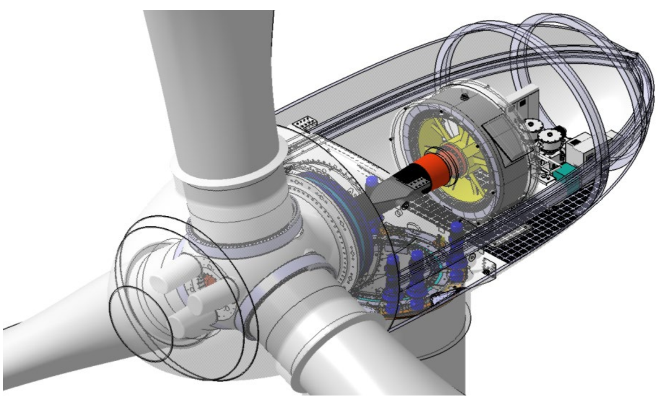
Reference DLC

Item	DLC 1.1	DLC 1.6a	DLC 6.1a
Wind model	NTM	NTM	EWM
Sea state	SS1-SS11	SS12	SS13
Wind and wave directionality	0°, COD	0°, COD	MIS ± 30° Yaw ±8°, 0°
Current model	NCM	NCM	ECM
Wind turbine status	Operation	Operation	Parked, blades:90°

Note: COD is co-directional, ECM is extreme current model, ESS is extreme sea state, EWM is extreme wind speed model, MIS is misalignment of wind and wave, NTM is normal turbulence model

10 MW FOWT Models

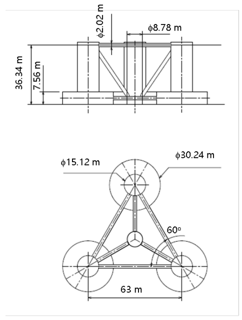
10 MW Offshore Wind Turbine



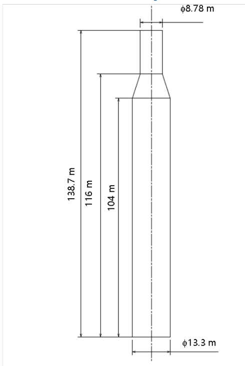
Description	Value
Rated power of wind turbine	10-MW
Rotor orientation	Upwind, 3 blades
Control	Variable Speed, Collective Pitch
Rotor diameter [m]	178
Hub height [m]	120
Rated wind speed [m/s]	11.2
Rated rotor speed [rpm]	9.6 (gearless)
Hub mass [kg]	169,440
Hub inertia about shaft [kg·m^2]	829,590
Nacelle mass (target) [kg]	335,000

10 MW FOWT Models

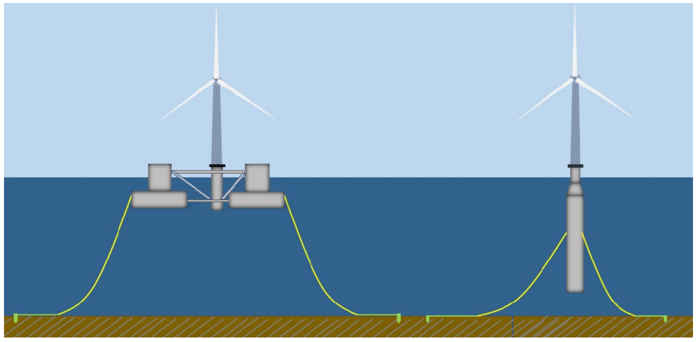
Platforms: semi-submersible and spar



Semi-submersible



Spar

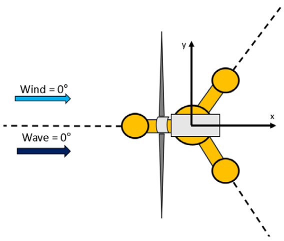


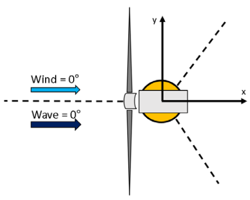
Principle of platform design:
Rated pitch angle < 5 degree,
Heave and pitch natural periods are out of ocean wave period range
Semi-submersible: upscaled from 5 MW semi-sub DeepCwind model
Spar: upscaled from 5 MW OC3 Hywind model, but keep the same draft 120m

Description	Unit	Semi-sub	Spar
Volume Displacement	m3	25888.63	16056
Center of Buoyancy below SWL	m	-16.18	-62.133
Platform Mass	ton	25,297	14512
Center of Mass (CM) of Platform below SWL	m	-16.56	-92.31
Platform Roll Inertia about CM	kgm^2	1.922E+10	9.87E+09
Platform Pitch Inertia about CM	kgm^2	1.922E+10	9.87E+09
Platform Yaw Inertia about CM	kgm^2	3.452E+10	3.42E+08

10 MW FOWT Models

Mooring systems



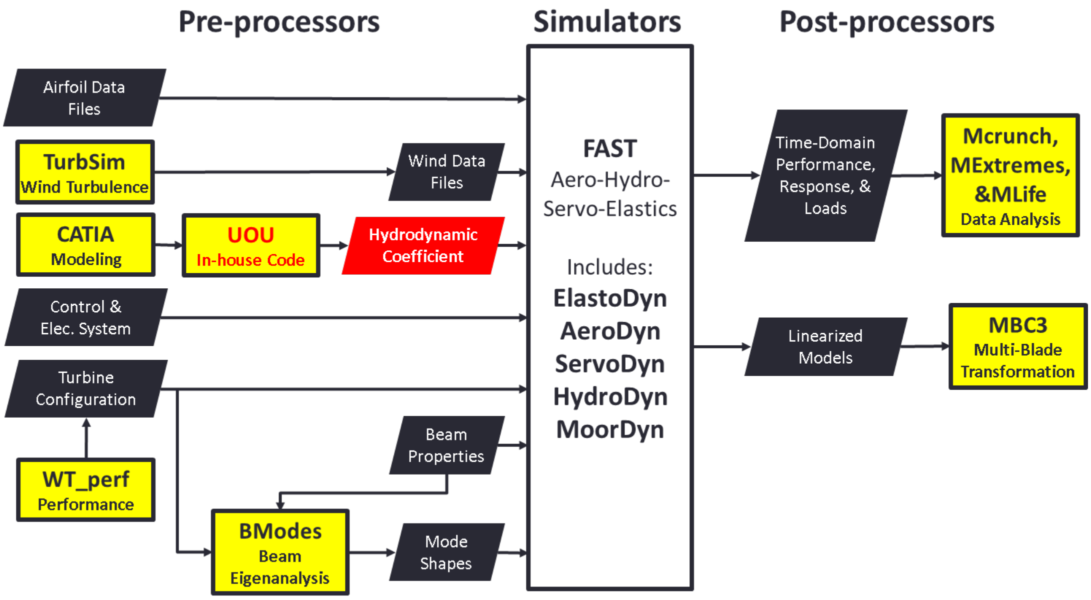


Description	Unit	Semi-Submersible			Spar	
Water depth	m	**50**	**150**	**250**	**150**	**250**
Mooring diameter	mm	162	142	130	130	111
Mooring line mass density (air)	kg/m	576.8	443.2	371.5	371.5	270.8
Axiall stiffness (EA)	MN	2362.0	1814.8	1521.0	1521.0	1108.9
Unstretched mooring line length	m	500.0	800.0	1050.0	800.0	1100.0
Depth to fairleads below SWL	m	-17.2	-17.2	-17.2	-48.0	-48.0
Radius to fairlead	m	51.0	51.0	51.0	7.0	7.0
Radius to anchor	m	543.0	810.6	979.5	785.0	1057.2
Minimum Breaking Load (MBL)	MN	18.2	14.7	12.7	12.7	9.6

Principle of mooring design:

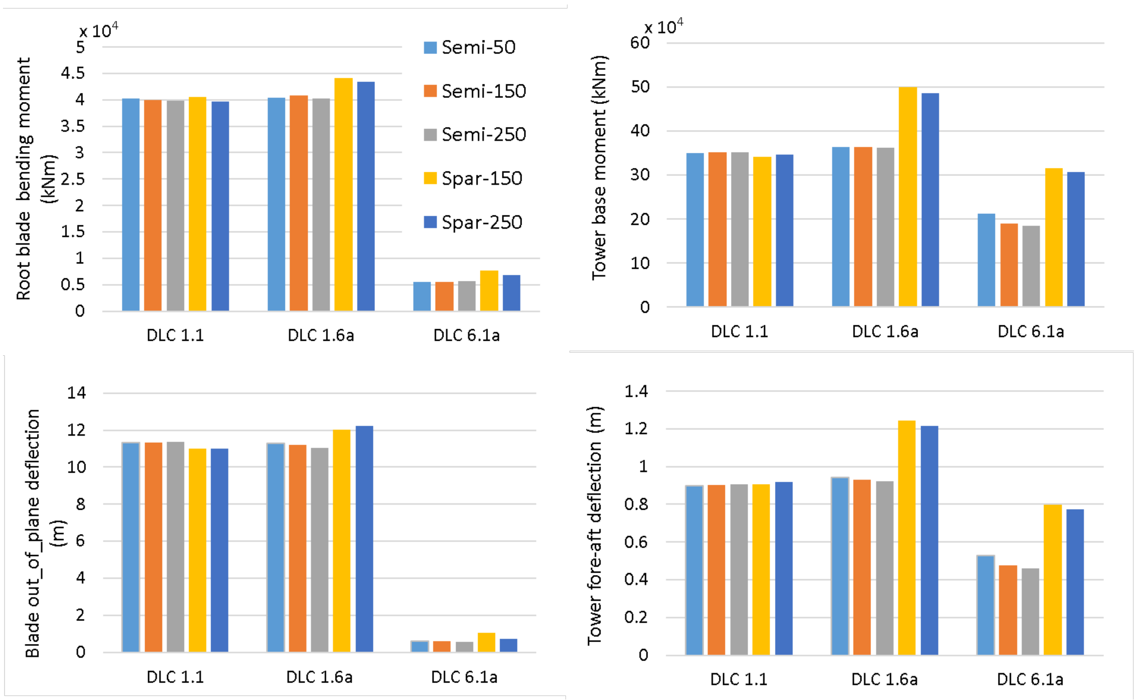
- The same pretension, the same mooring line angle at fair lead
- Touchdown length is equal or bigger to ensure there will be no lift up force at anchors
- Mooring lines are studless chain class R3

Numerical Simulation Modeling



Source : J. Jonkman, FASTWorkshop, NREL

Results



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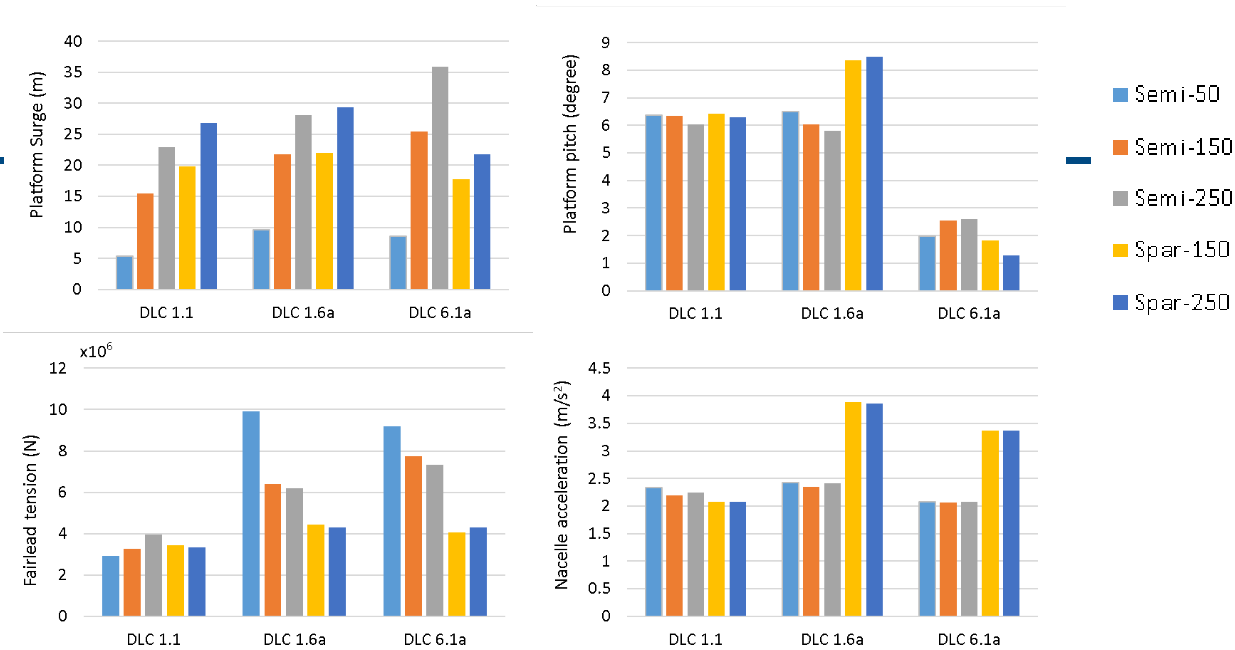
Results



Model	Max tension (N)	MBL (N)	Ratio max/MBL
Semi-50	9.90E+06	1.82E+07	0.54
Semi-150	7.80E+06	1.47E+07	0.53
Semi-250	7.30E+06	1.27E+07	0.57
Spar-150	4.40E+06	1.27E+07	0.35
Spar-250	4.30E+06	9.60E+06	0.45

Conclusion

- **Vietnam offshore area is suitable for deploying floating wind farms.**
- **Semi-sub and spar models work well and stable in operation conditions and extreme environmental conditions at different water depths.**
- **Considering to installation, semi-submersible model is preferable for the deployment of floating wind farms.**

Thank you!

AI-based framework to predict wave-induced settlement of offshore wind turbines

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School of Engineering, RMIT University, Australia

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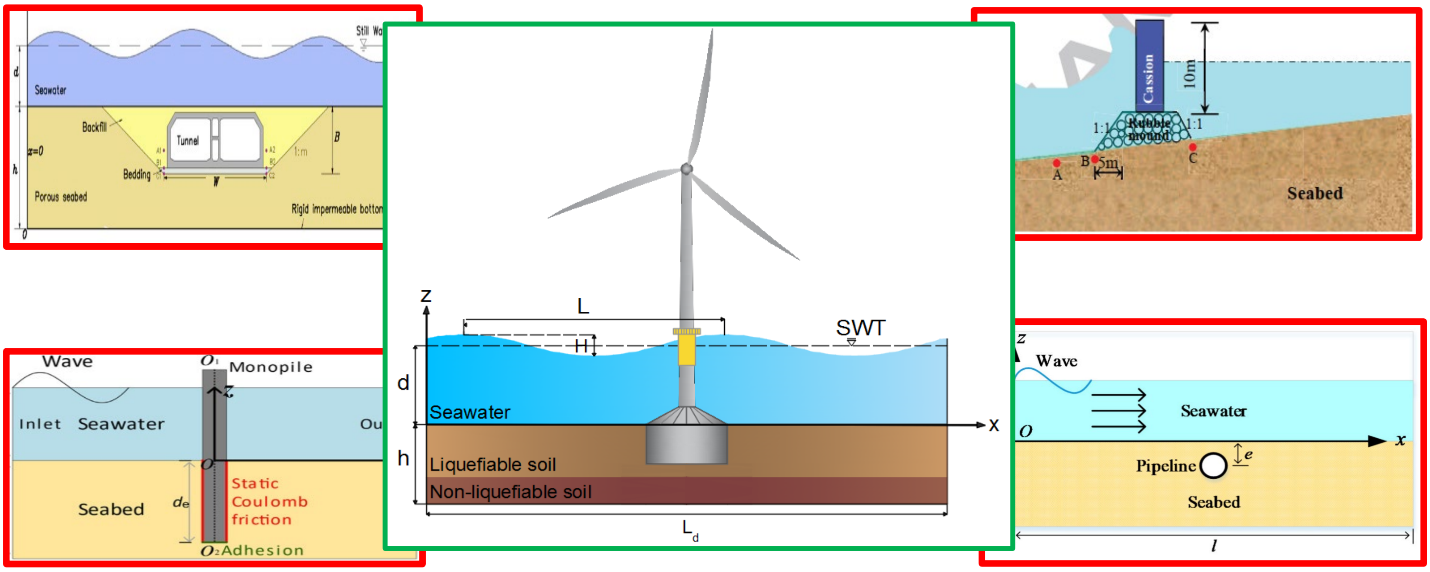
AI-based framework to predict wave-induced settlement of Offshore Wind Turbines

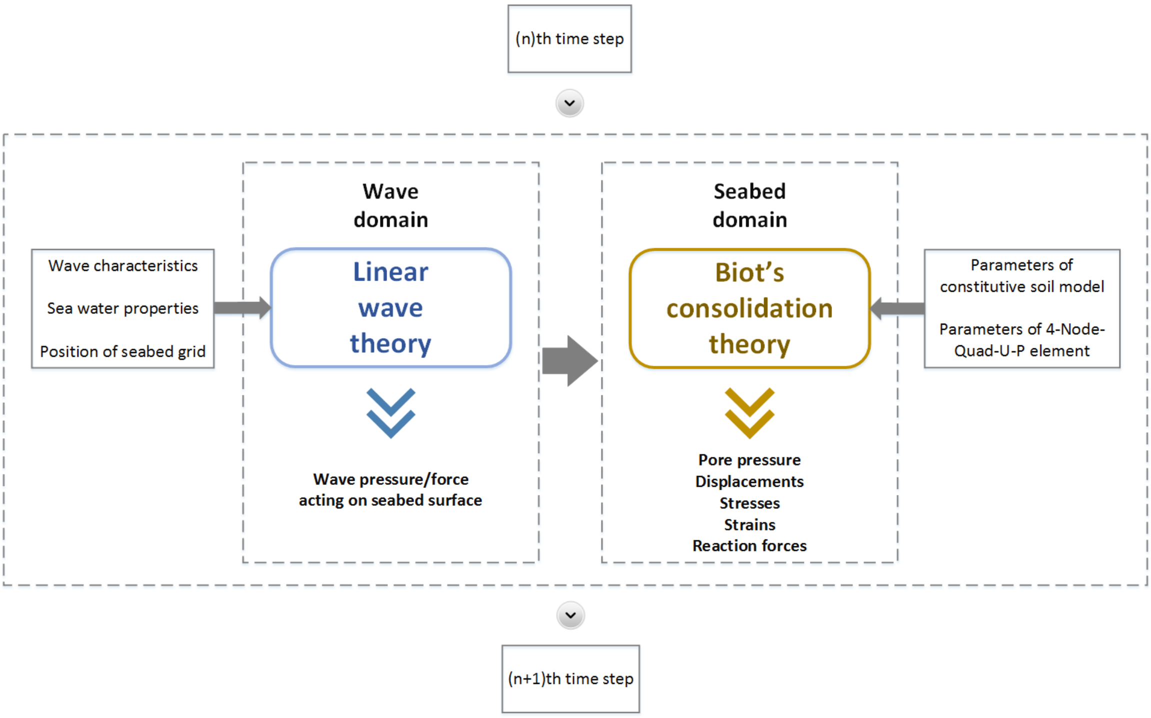
Amir Moghaddam, Amin Barari

School of Engineering, RMIT University, Melbourne, VIC 3000, Australia

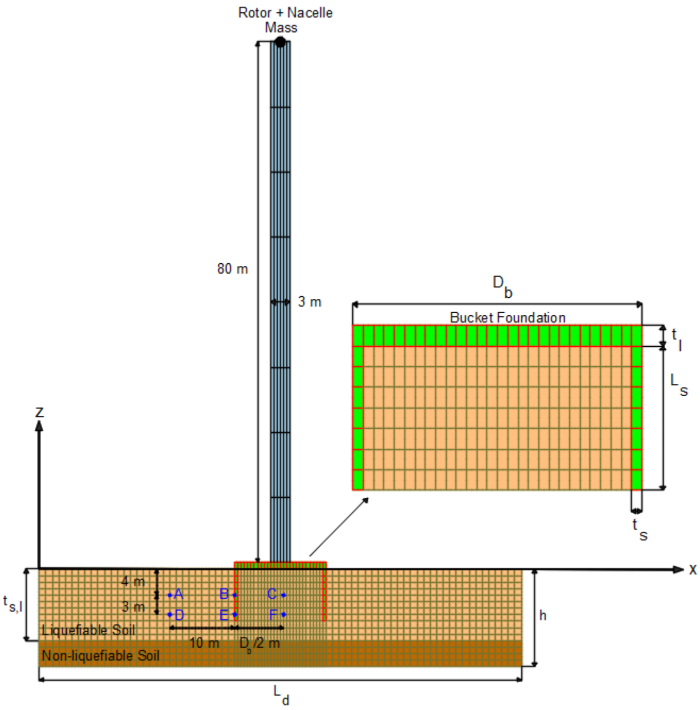
Introduction



Solving algorithm of WSFI



FE model setup



1400 elements

+

1500 nodes

- **Suction caisson**
- **Offshore wind turbine**
- **Liquefiable layer**
- **Non-liquefiable layer**

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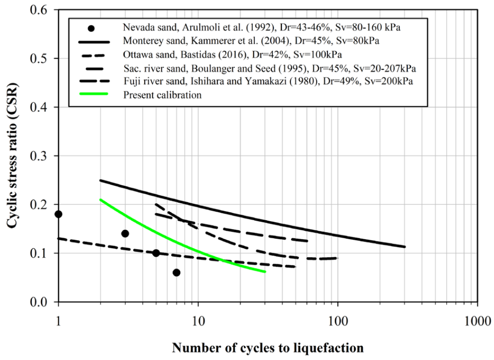
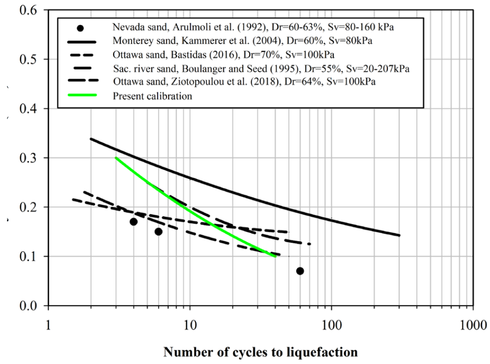
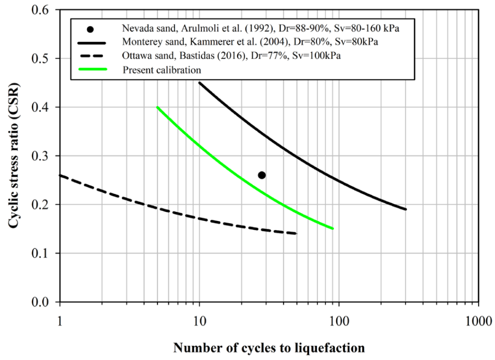
Calibration of CycLiqCPSP parameters





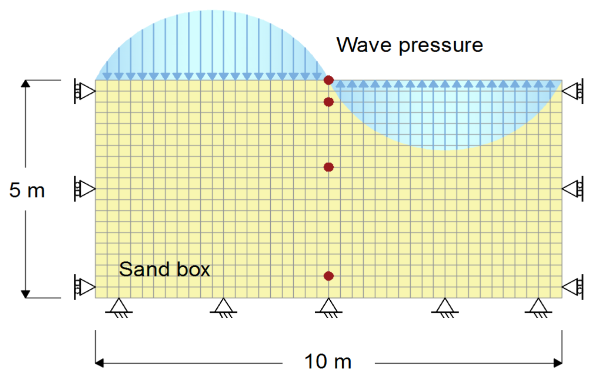


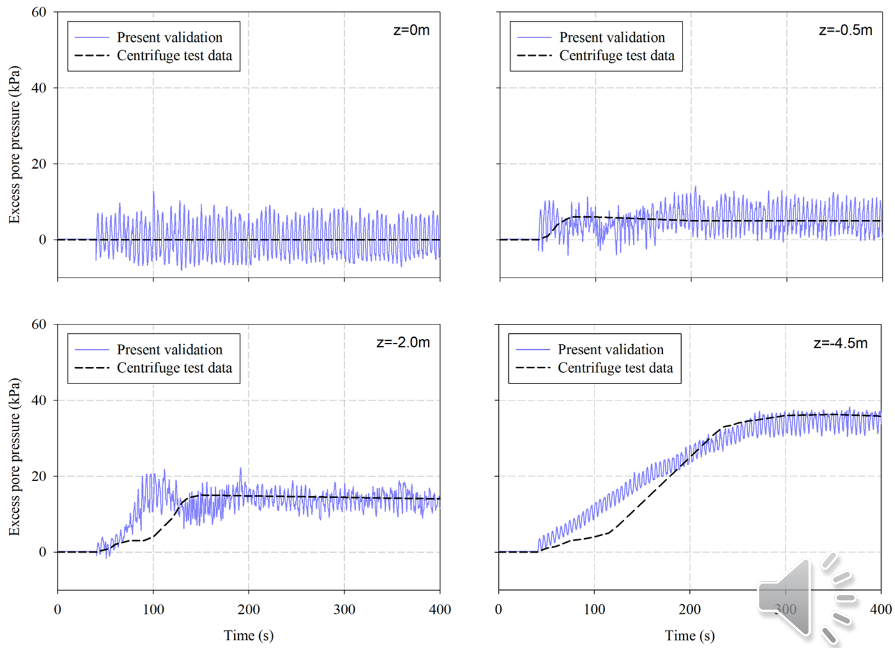
40 % **60%** **80 %**

3 different relative densities

Simulation of cyclic direct simple shear (CDSS) test in OpenSees

Validation of numerical model





Simulation of centrifuge wave tank test in OpenSees

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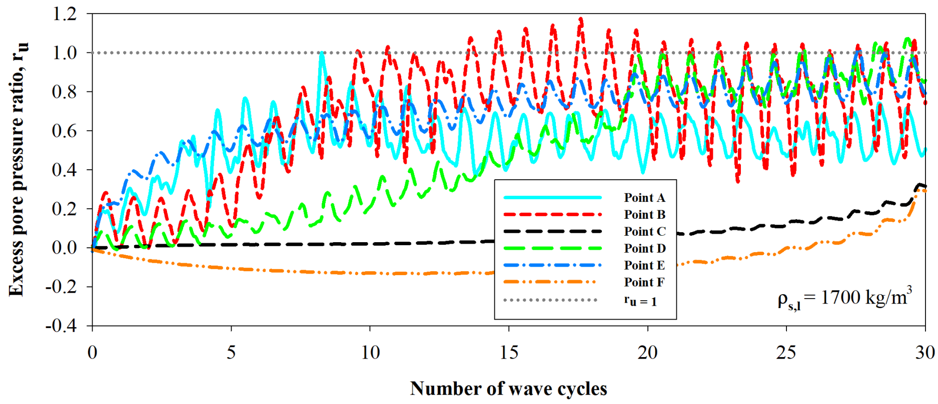
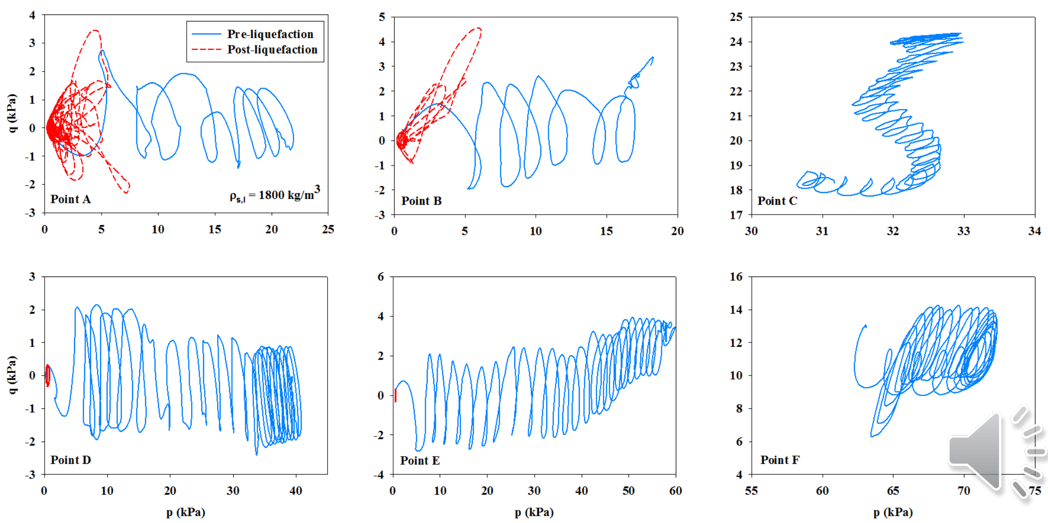
Results from numerical analyses

- **Development of EPWP around the caisson**



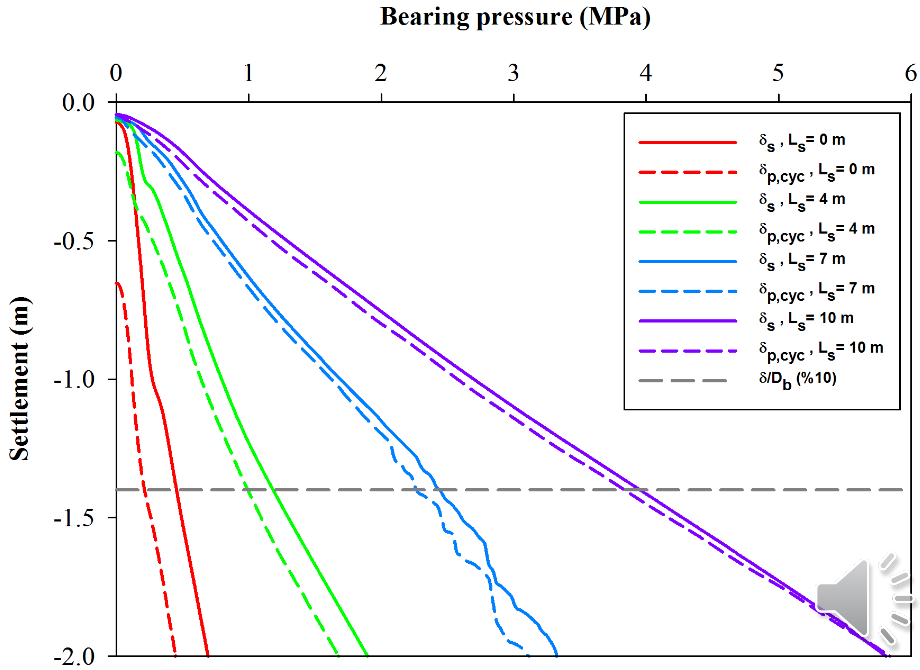
Results from numerical analyses

- **Development of EPWP around the OWT foundation**
- **Influence of initial stress and plots of stress path**



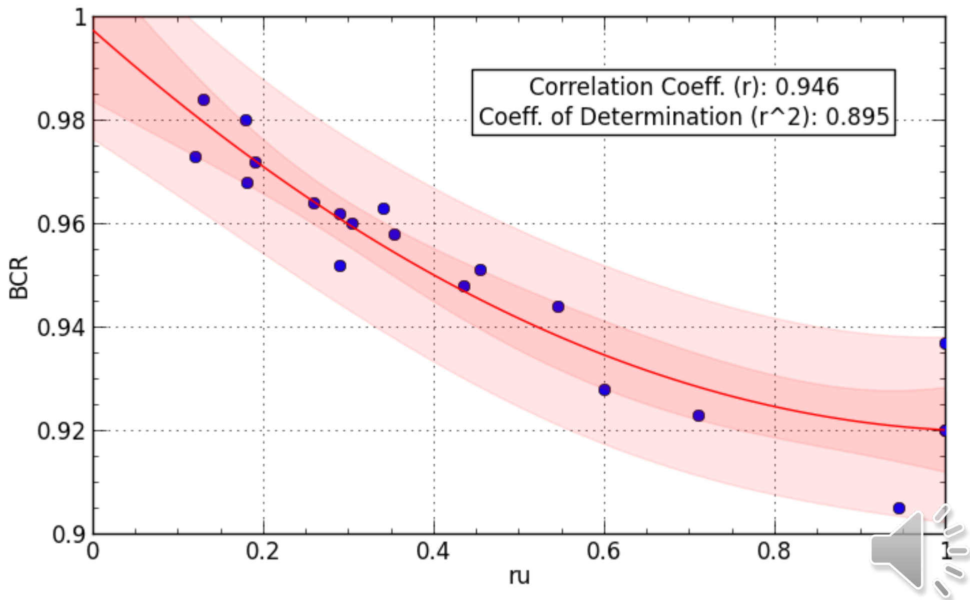
Results from numerical analyses

- Development of EPWP around the caisson
- Influence of initial stress and plots of stress path
- Bearing capacity and degraded bearing capacity



Results from numerical analyses

- Development of EPWP around the caisson
- Influence of initial stress and plots of stress path
- Bearing capacity and degraded bearing capacity
- Influence of wave characteristics on bearing capacity ratio



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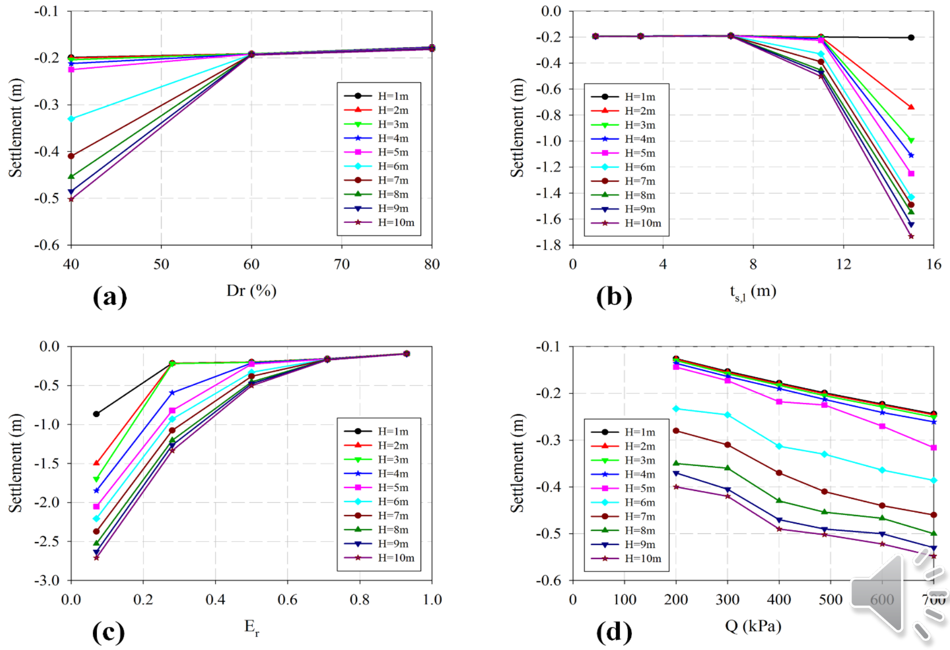
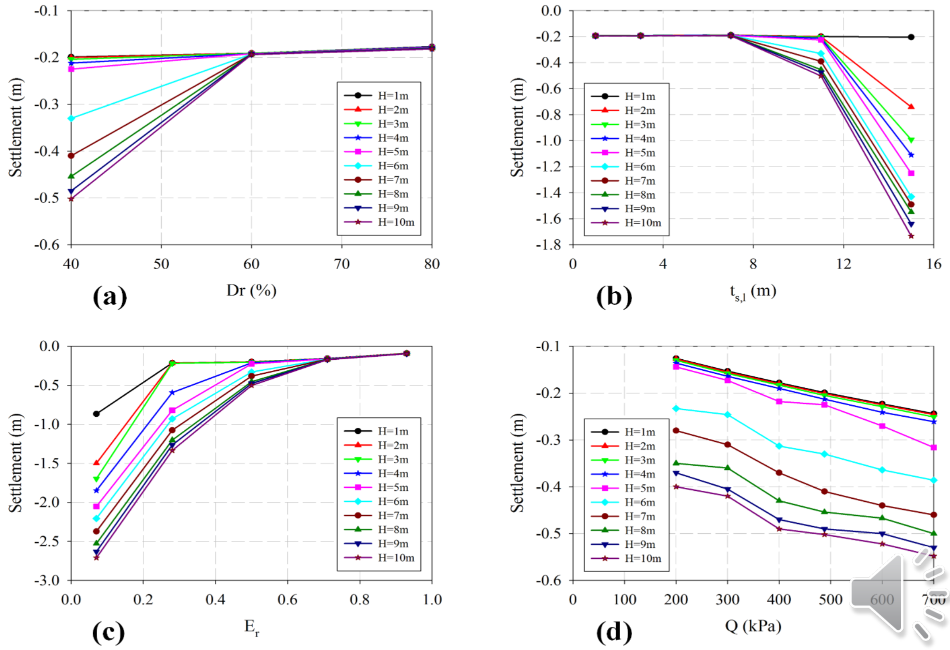
Results from numerical analyses

- **Development of EPWP around the caisson**
- **Influence of initial stress and plots of stress path**
- **Bearing capacity and degraded bearing capacity**
- **Influence of wave characteristics on bearing capacity ratio**
- **Influence of various model configuration on caisson settlement**



Results from numerical analyses

Over <u>250</u> FE dynamic analyses with the aid of high performance computing (HPC) facilities



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Non-linear multi-variable regression

$$Sw = a/(1 + be^{-cD_r})$$

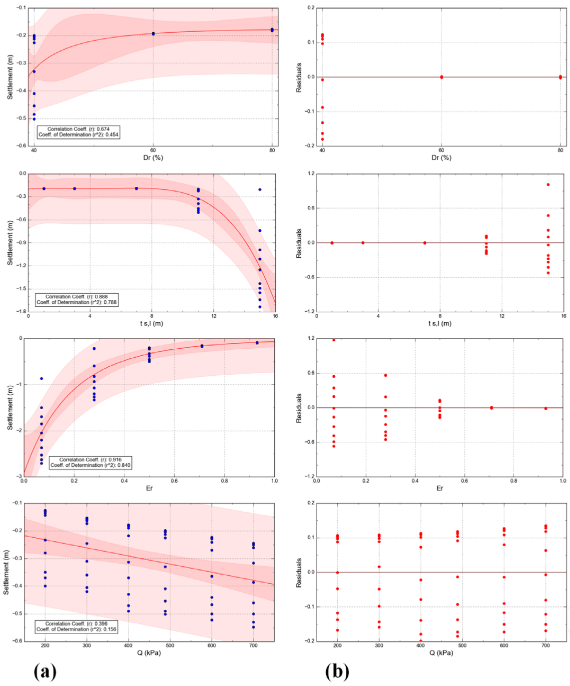
$$Sw = a + bt_{s,l} + ct_{s,l}^2 + dt_{s,l}^3 + et_{s,l}^4$$

$$Sw = q\,(1 + bE_r/a)^{(-1/b)}$$

$$Sw = a + bQ$$

$$Sw = a + bD_r + ct_{s,l} + dE_r + eQ + fH$$

R^2 = 0.716 !!!!



Group Method of Data Handling (GMDH)

$$q_1 = -0.1522 - 0.0483D_r - 0.0717E_r - 1.9004 \times 10^{-4} {D_r}^2 - 3.8269{E_r}^2 + 0.1512D_rE_r$$

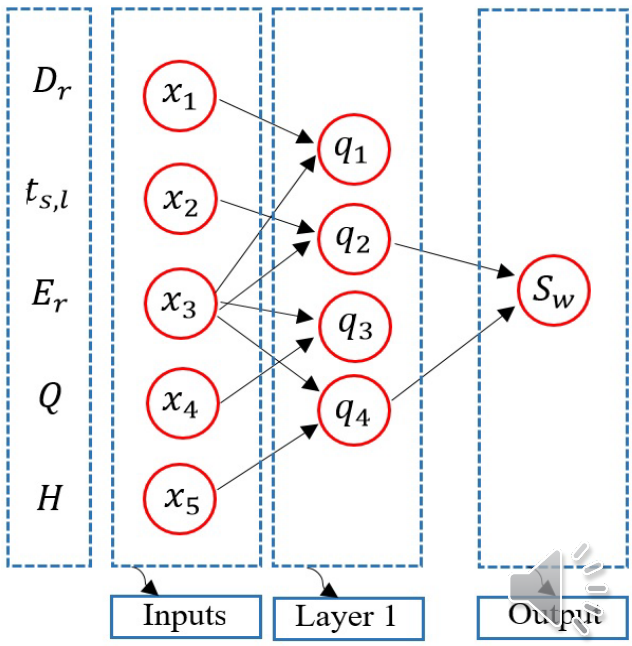
$$q_2 = 0.4003 - 0.0915t_{s,l} + 0.2540E_r - 0.0150{t_{s,l}}^2 - 4.1192{E_r}^2 + 0.5468t_{s,l}E_r$$

$$q_3 = 0.7832 + 0.3916E_r - 0.0070Q - 3.8721{E_r}^2 + 1.0916 \times 10^{-6}Q^2 + 0.0115E_rQ$$

$$q_4 = -1.4123 + 4.5882E_r - 0.1637H - 3.8962{E_r}^2 - 0.0010H^2 + 0.2531E_rH$$

$$S_w = 0.0055 + 0.7044q_2 + 0.2051q_4 - 0.2023{q_2}^2 - 0.5432{q_4}^2 + 0.6998q_2q_4$$

R^2 = 0.931 ☺



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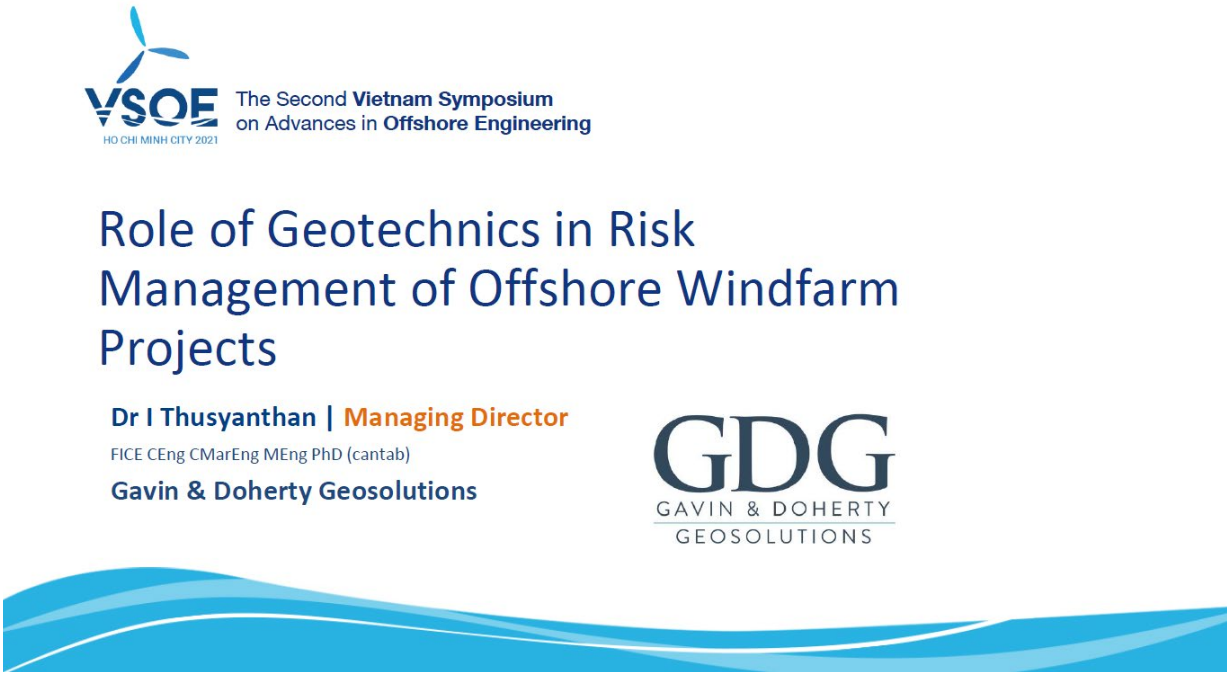
Conclusion

1) **Wave-seabed-foundation interaction is modelled to investigate wave-induced liquefaction and wave-induced settlement of OWT caisson foundation.**
2) **Non-linear multi-variable regression cannot predict the wave-induced caisson settlement rationally, due to complexity of problem and high scatteredness of data**
3) **A neural network-based method is put into practice known as Group Method of Data Handling (GMDH) using the repetition of a series of multilayered perceptron type network structures to estimate wave-induced caisson settlement with high accuracy**

THANK YOU FOR YOUR ATTENTION!

Role of geotechnics in risk management of offshore windfarm projects

Indrasenan Thusyanthan
Gavin & Doherty Geosolutions, Ireland



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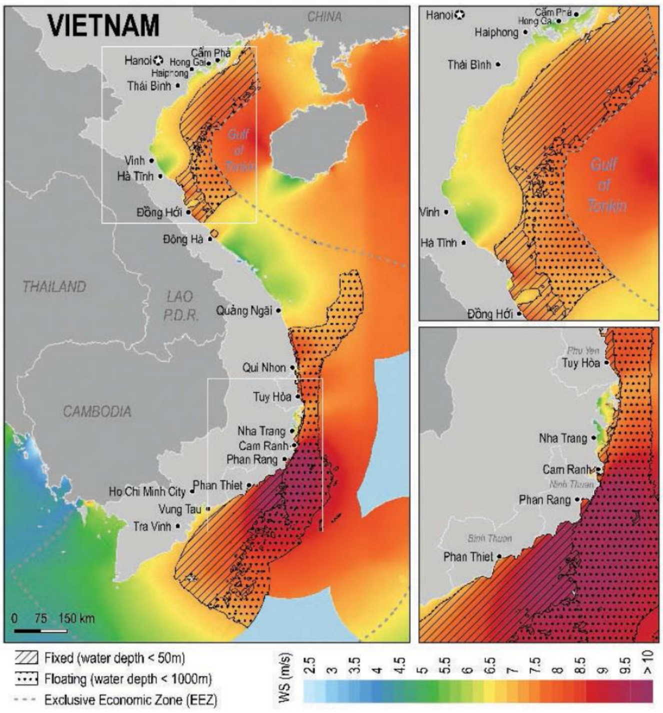
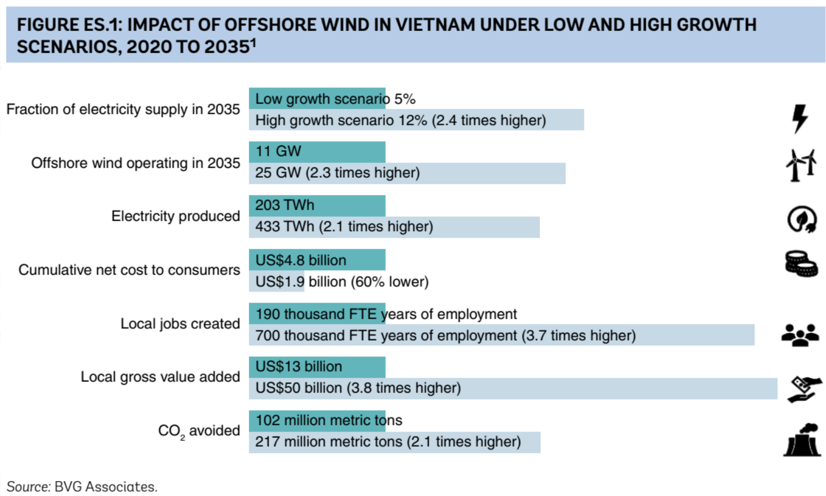
Role of Geotechnics in Risk Management of Offshore Windfarm Projects

Dr I Thusyanthan | Managing Director
FICE CEng CMarEng MEng PhD (cantab)
Gavin & Doherty Geosolutions

GDG GAVIN & DOHERTY GEOSOLUTIONS

Offshore Wind Roadmap for Vietnam (WBG)





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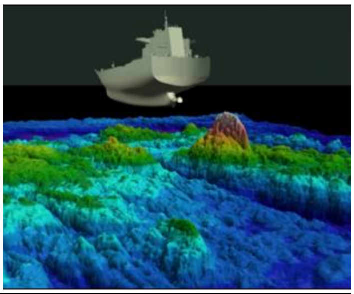
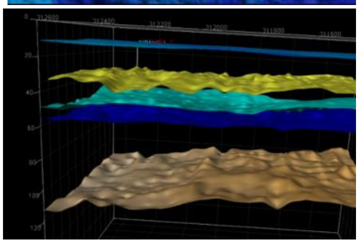
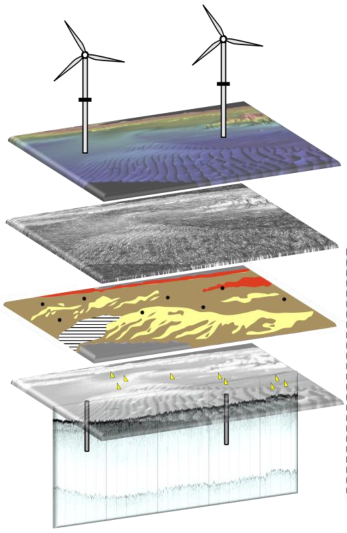
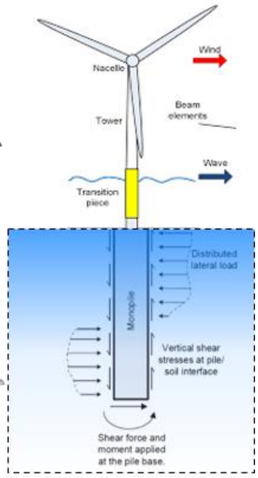
Role of Geotechnics in an Offshore Windfarm Project

1. **DESK TOP STUDIES & SURVEY SCOPING** – Conceptual studies & survey specifications
2. **SURVEYS** – Geophysical & Geotechnical Surveys undertaken at Site
3. **GEOTECHNICAL TESTING** – Soil properties from in-situ & lab testing
4. **SITE CHARATERISATION** – Soil classification & design parameters
5. **GROUND RISKs & DESIGN** – Design & Risk Identification
6. **INSTALLTION** – WTGs & Cables installation technical support

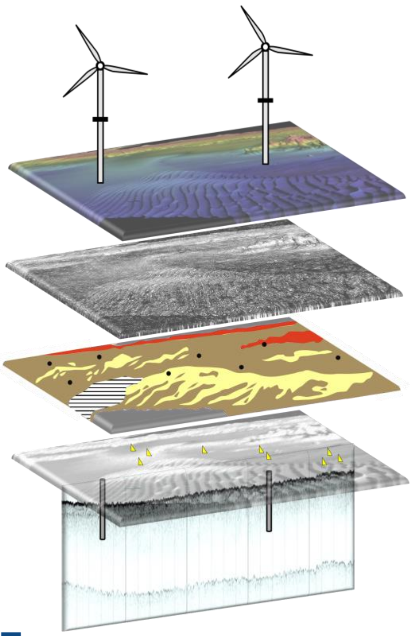


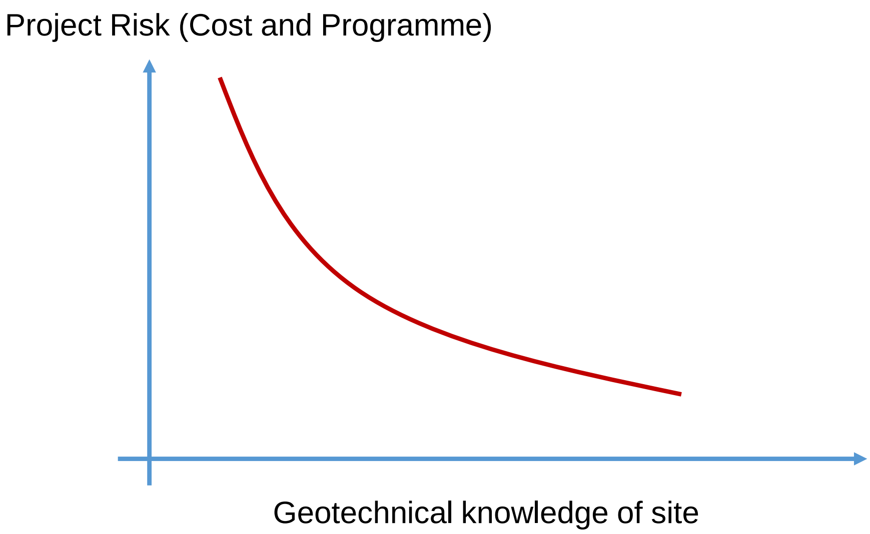






Role of Geotechnics in Risk Management of Offshore Windfarm Projects





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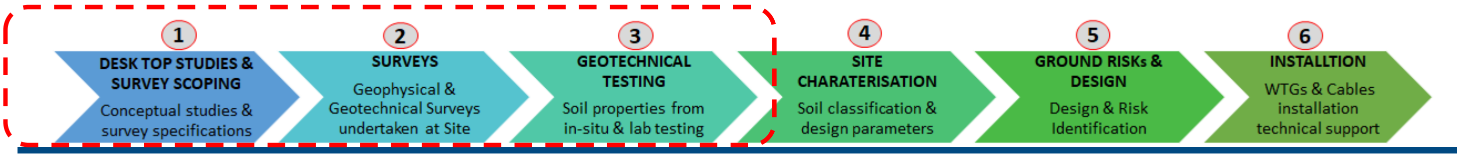

- Stages 1, 2 and 3 are associated with desk top studies, geotechnical and geophysical survey implementation, and geotechnical testing.
- Desk top studies provide an early indication as to the likely seabed conditions to be expected at the project site.
- During site surveys, seabed soils would be subjected to in in-situ testing and seabed soil samples would be further characterised by laboratory testing.
- The number of intrusive geotechnical tests required to characterise the offshore windfarm site would depend on several factors such as geology, accuracy and resolution of the available geophysical survey data, geohazards etc., and hence it cannot be generalised.
- In general, soil conditions cannot be assumed to be uniform across a site unless proven with geotechnical and geophysical data. Therefore, knowing the seabed soil stratigraphy at two locations does not necessarily enable one to interpret the soil stratigraphy between those two locations.
- Since intrusive geotechnical testing has a high impact on project schedule and cost, it is often the case that the number of test locations is optimised to save cost and time. A geotechnical consultant is best place to advise on this optimisation as - if not undertaken properly - this can lead to increased project risk.

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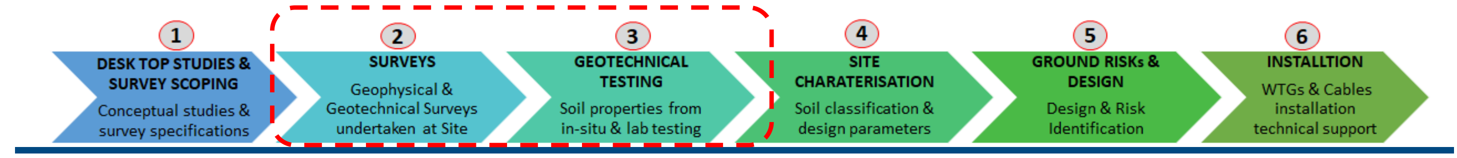

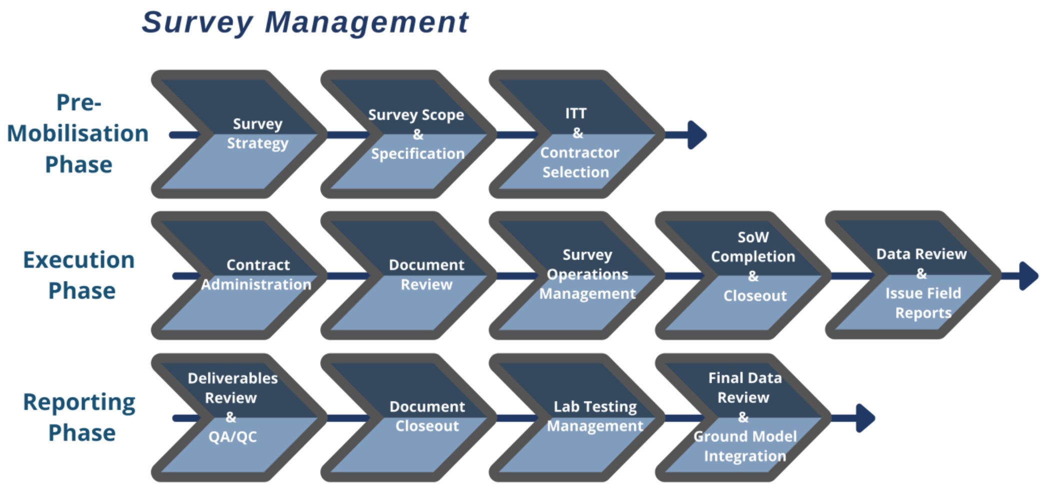

Geotechical data from Survey & Lab testing together with Geophysical survey data are key to ensure that we understand the wind farm site and enables us to design foundations cost effectively

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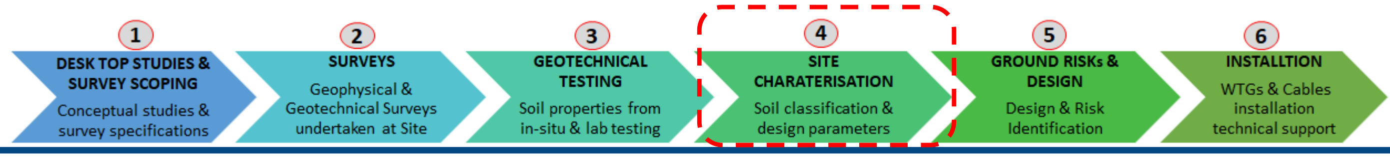

- **BS5930** and **ASTM D2487** are the most commonly used standards in the industry for soil classification. But BS 5930 and ASTM D2487 follow different methodologies in the way they classify soils.
- BS 5930 (2020) states that, where a soil (omitting any boulders or cobbles) “sticks together when wet and remoulds” it is described as a fine soil (“CLAY” or “SILT” dependent on its plasticity) and when soil does not stick together and remould, it is described as a coarse soil (“SAND” or “GRAVEL” dependent on its particle size grading).
- As per ASTM D2487, if more than 50% of the soil is retained on No. 200 sieve (0.075mm), the soil is classed as a coarse-grained soil, and if 50% or more passes the No. 200 sieve, the soil is classed as a fine-grained soil. Note that the particle size boundary between fine soils and coarse soils is different in these standards, in BS 5930 it is 0.063mm whereas in ASTM D2487 it is 0.075mm.

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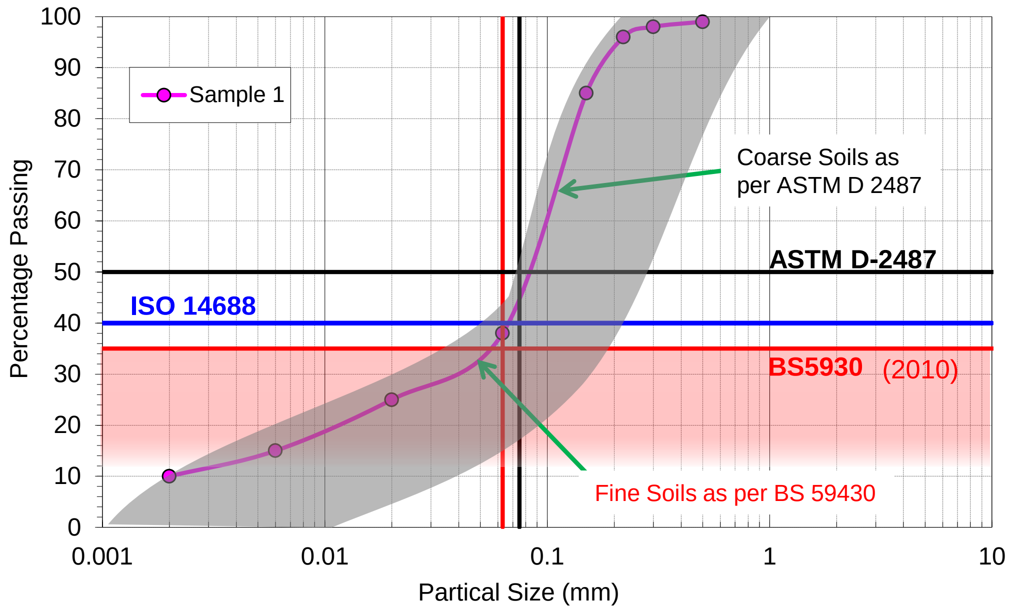
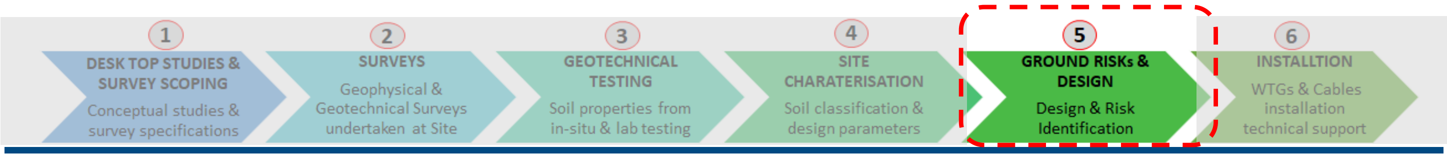
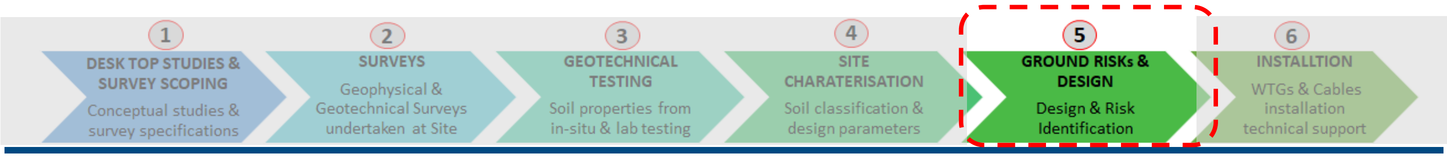
Soil Classification - BS5930 vs ASTM D2487



References
1. Thusyanthan, N. I. (2018), “Insight into On-bottom stability, DNV RP F109 and DNVGL RP F114”,Offshore Technology Conference 2018
2. Thusyanthan, N.I, (2012), "Seabed Soil Classification, Soil behaviour and Pipeline design", Offshore Technology Conference 2012



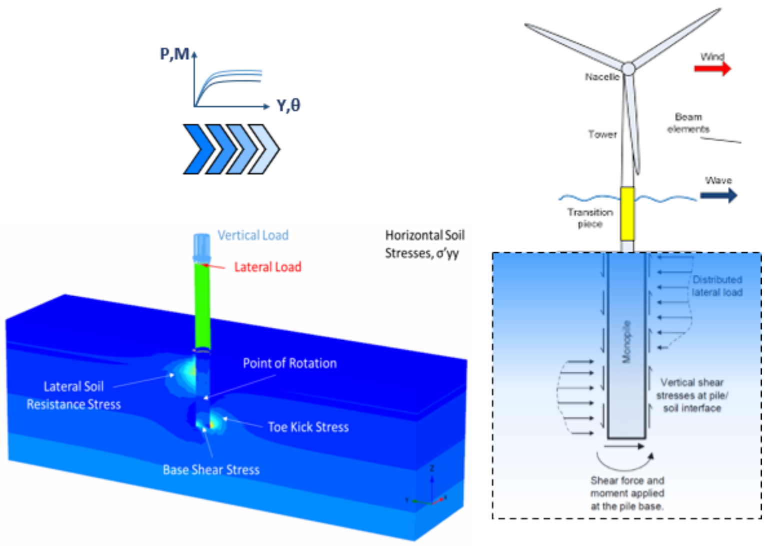
- Windfarms can cover hundreds of square kilometers of seabed, hence ensuring that WTGs and cables are not exposed to geohazards both during their installation and operational lifetime is vital. Below are the most common geohazards that need to be considered during design and installation;
  - ❑ Seafloor Slope
  - ❑ Landslides and earthquakes
  - ❑ Faults
  - ❑ Presence of boulders
  - ❑ Shallow gas
  - ❑ Channel System (palaeochannels)
  - ❑ Environmentally Sensitive Areas
  - ❑ Manmade Hazards (e.g.. **Unexploded Ordnance (UXO))**
- These geohazards need to be identified early in the project timeline and all identified risks need to be managed using appropriate risk mitigation mechanisms. This may include a modified design, micrositing WTGs locations or re-routing the cable routes, change of installation procedure etc. It is acknowledged that some risks can never be fully eliminated, and residual risks may need to be managed through design or during construction.



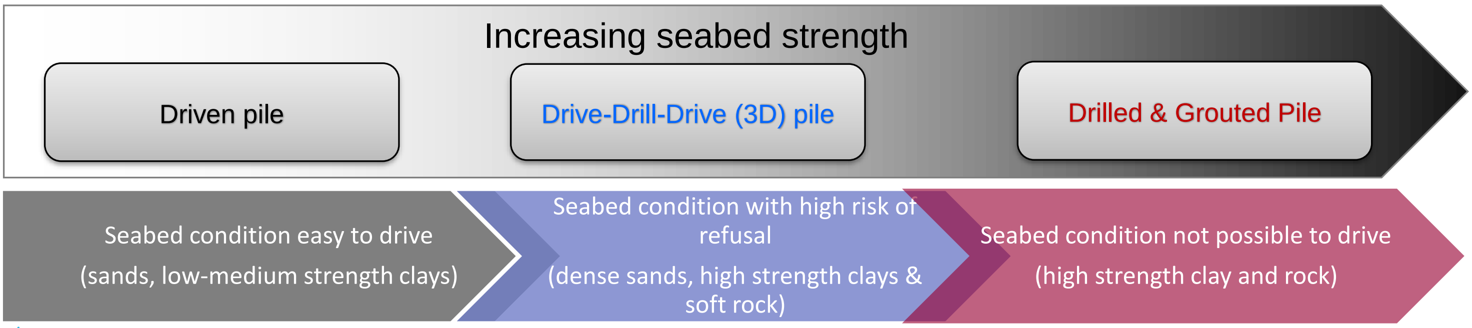
- **Foundation Design – Geotechnical Knowledge**

Geotechnical insight in critical to be able to design cost effective foundations for the offshore windfarms

As we now reply heavily on Numerical Analyses for designs, we need to ensure that we fully understand the numerical models and the software we use. All numerical models have limitations and we need to ensure we are fully aware of them.



- There are three common pile installation methods
  - ❑ Driven pile
  - ❑ Drive-Drill-Drive (3D) or
  - ❑ Drilled & Grouted.
- Seabed soil conditions determine which method is the most cost effective and have the lowest risk in a particular project as summarized below



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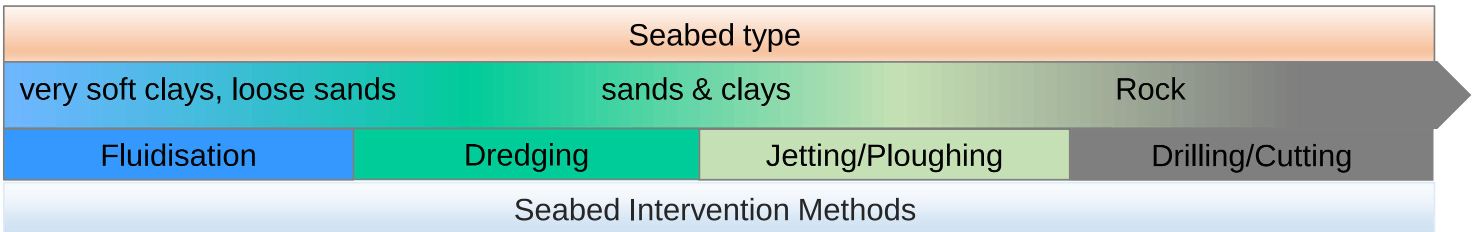
- All Wind Turbine Generators (WTGs) are connected via inter-array cables and linked to an offshore substation via terminal cables. The offshore substation is then connected to an onshore substation via export cables.
- All cables need to be installed at the correct burial depth to ensure they are protected from natural and man-made damage risks. Cable Burial Risk Assessment (CBRA) guidance offers a standardized and qualitative method to ensure that cable burial depths are determined consistently using a risk-based approach.
- Trenchability or ploughability assessment for cables needs to be undertaken during design stage to identify risks associated with installation.



Conclusion

- If ground risks are allowed to pass on in project stages, its impact and consequences on project cost and programme can be very high at later stages. Thus, ground risks should be identified as soon as possible and mitigated early on through site investigation, ground modelling and design.
- Ground risks in the project needs to be identified and mitigated by the early engagement of a specialist geotechnical consultant. In-depth knowledge of site surveys, geotechnical testing, seabed classification, foundation designs and seabed interventions are paramount for successfully derisking offshore wind projects.

"Unmanaged geotechnical risks can have escalated impact on project cost and programme. Geotechnical consultant's role in ground risk identification and mitigation is paramount for successful offshore wind project"

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Investigation of the long-term cyclic behaviour of monopile foundation by impact and vibratory installation

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Investigation of the long-term cyclic behaviour of monopile foundation by impact and vibratory installation

Viet Hung Le, Frank Rackwitz
Technische Universität Berlin - Germany

Investigation of the long-term cyclic behaviour of monopile foundation by impact and vibratory installation

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Technische Universität Berlin - Germany

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- Introduction
- Calculation concept
- Numerical model and validation
- Results

Aims

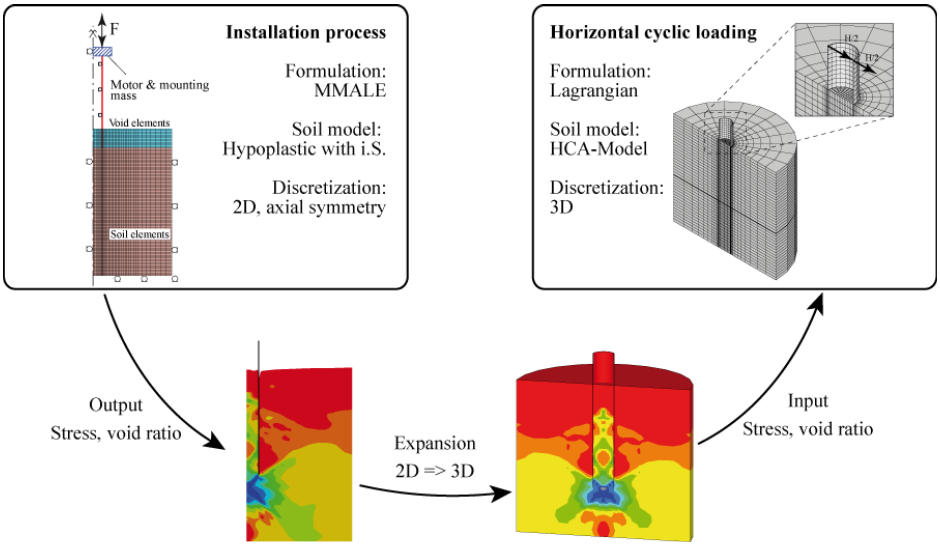
- Cost reduction of offshore pile foundations
- Serious alternative to impact driving
- Prediction of long-term loading behaviour

vs.

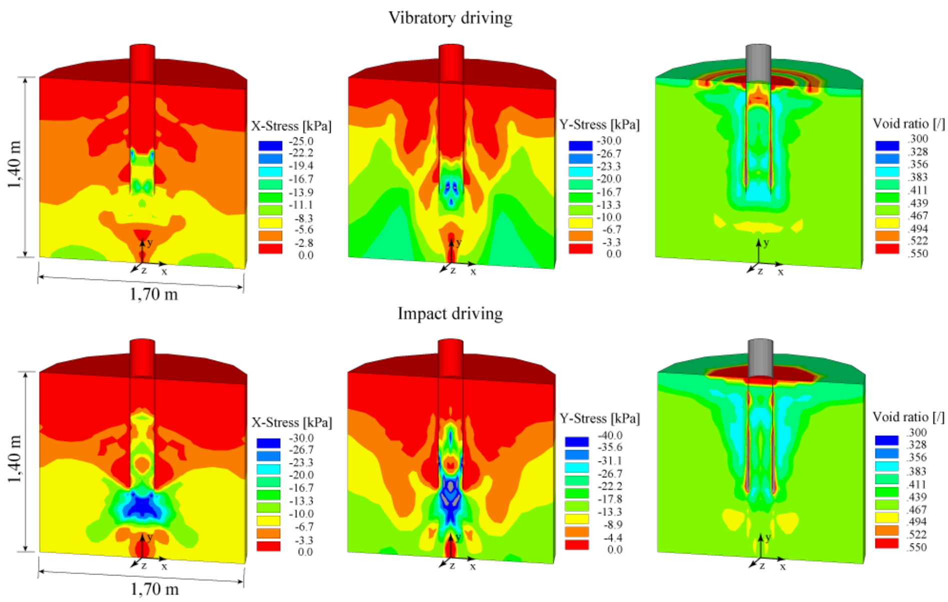
Challenges and simplification in FE numerical model

- Complicate soil behavior during pile driving
- After installation: Change of stress condition and density
- Large deformation by penetration process
- Calculation time and error by large number of cycles

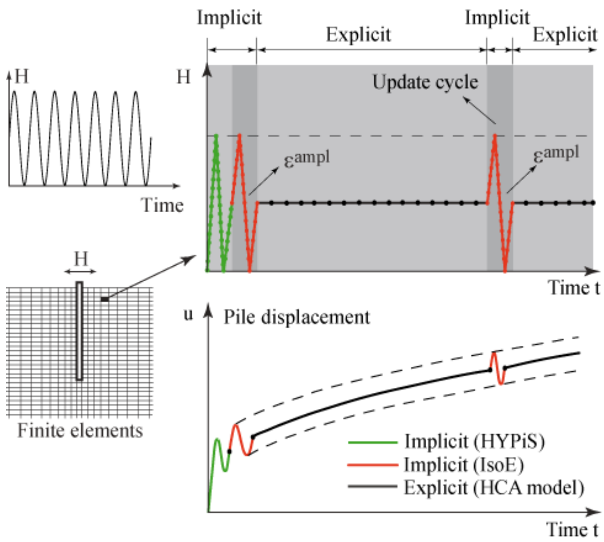
Calculation concept



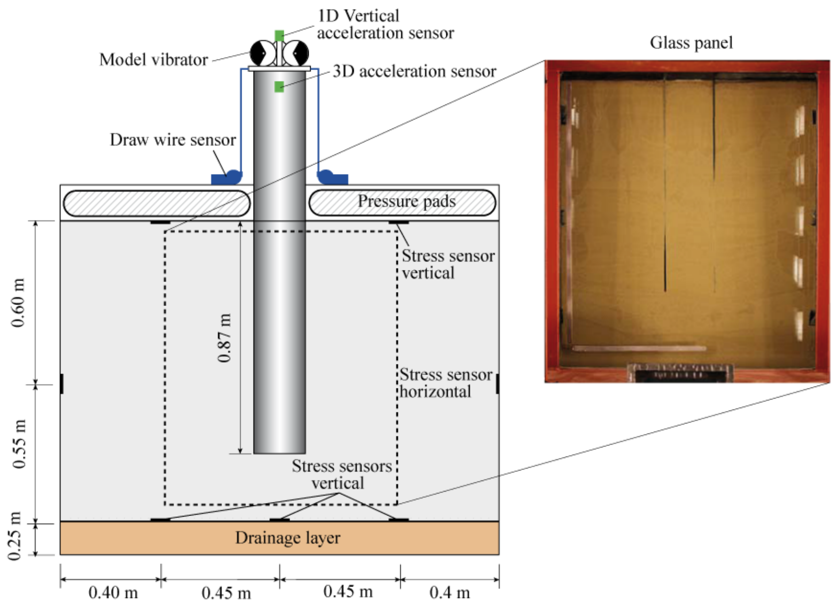
Soil condition after vibratory and impact diving



Explicit calculation for high cyclic loading



Model set up



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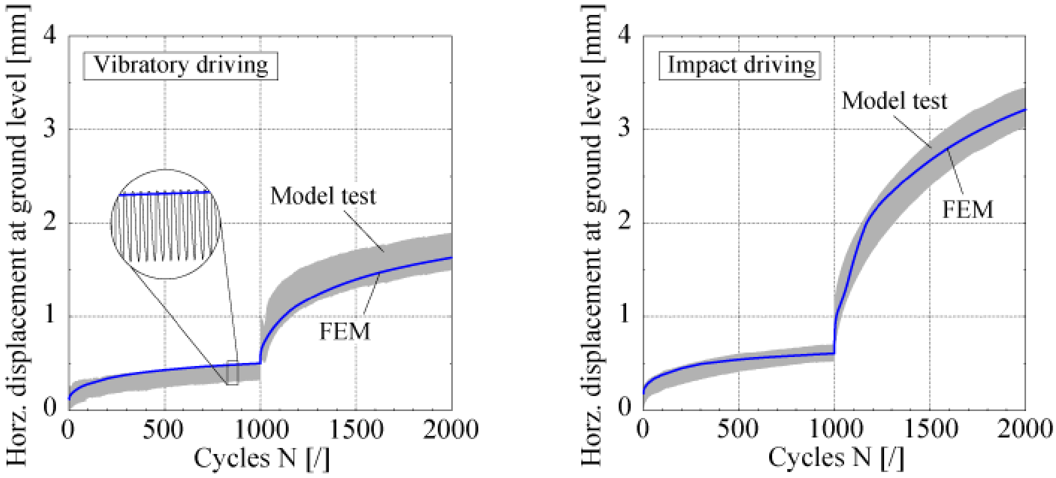
Validation of the numerical model



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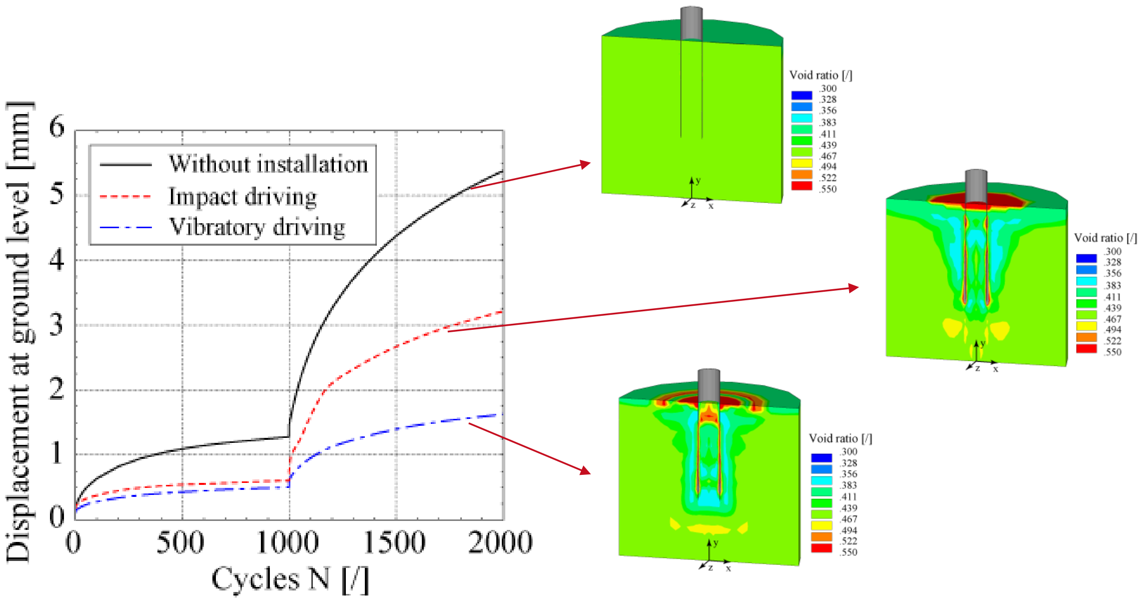
Comparison of the numerical results influence of the installation



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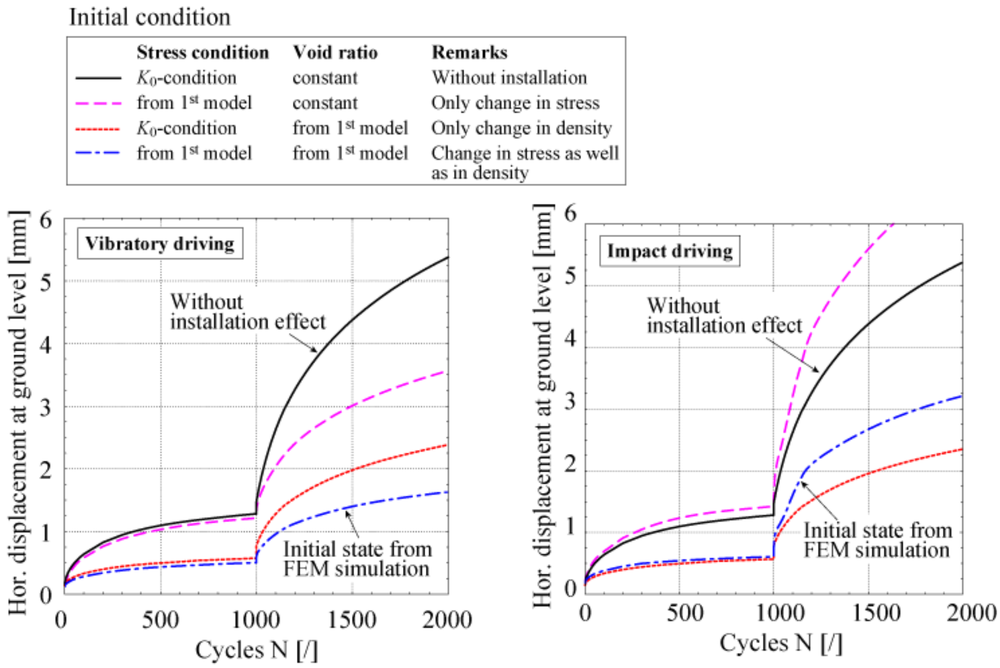
Changes in vertical displacement



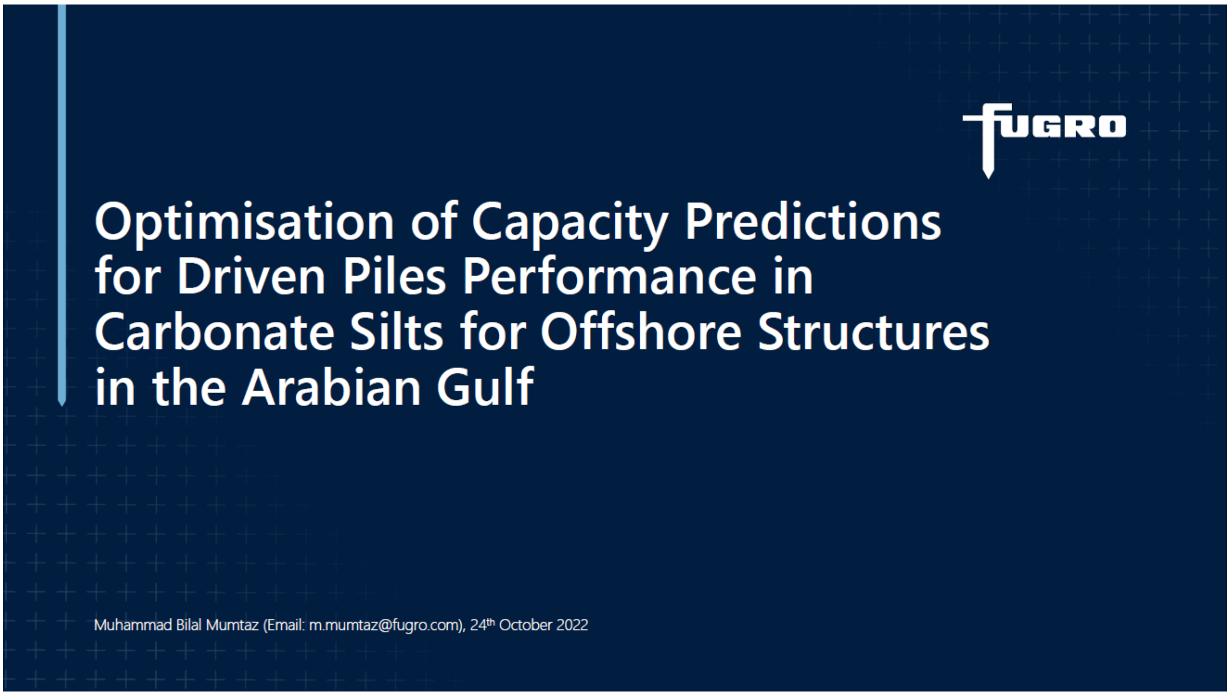
Conclusion

- Successful validation of the numerical model
- “Wished in place” => larger deformation
- Vibratory driving pile has less deformation as impact pile

Thank you

Optimisation of capacity predictions for driven Piles performance in carbonate silts for offshore structures in the Arabian Gulf

Muhammad Bilal Mumta
Fugro Survey Middle East, UAE



Optimisation of Capacity Predictions for Driven Piles Performance in Carbonate Silts for Offshore Structures in the Arabian Gulf

Muhammad Bilal Mumtaz (Email: m.mumtaz@fugro.com), 24th October 2022

Introduction

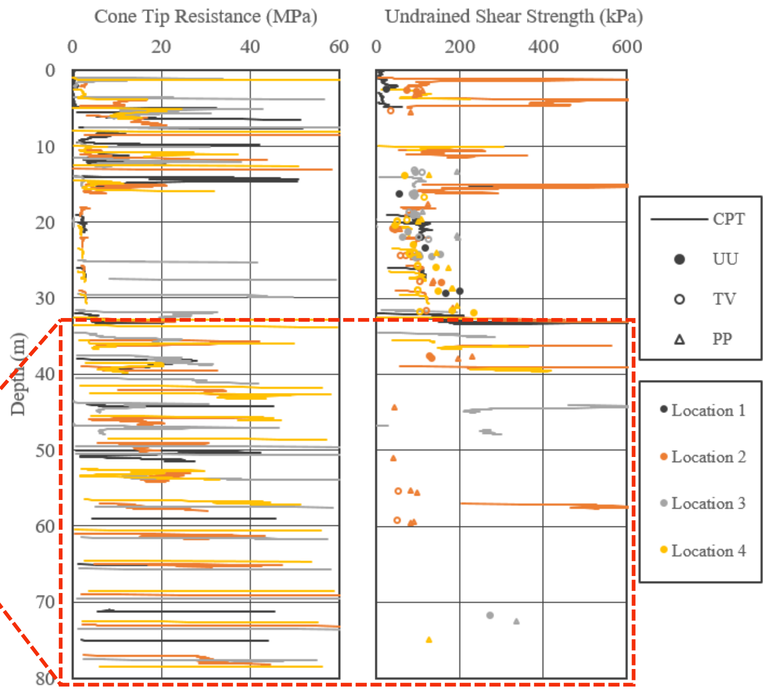
- Industry standards provide guidance on dealing with sands (drained) and clays (undrained) soils.
- Lacking guidance on dealing with intermediate soils such as silts.
- Typical practice is to either model silt as drained (frictional) or undrained (cohesive) – dependent on the engineer.
- Carbonate Silts are commonly found in the Arabian Gulf.
- 4 platform locations in the Arabian Gulf further examined.

Soil Conditions

Table 1. Generalized overview of soil stratigraphy at the four locations

Unit	Soil type	Thick-ness (m)	Cone Tip Resistance, qc (MPa)	Car-bonate Content	Plasticity Index	Fines Content
1	Silt/Sand	1 – 8	0.5 – 30	> 80%	2 – 12	15 – 99%
2	Calcarenite/ Calcisiltite *	5 – 11	20 – >60 (Refusal)	> 80%	N/A	N/A
3	Silt/Sand	0 – 15	4 – >60 (Refusal)	>80%	4 – 21	55 – 90%
4	Clay	14 – 22	2 – 5	10 – 60%	16 – 32	95 – 100%
5	Silt	>55 **	15 – >60 (Refusal)	> 85%	2 - 18	55 – 98%

* Rock in Unit 2 was usually recovered as sandy/silty material due to very low strength of the rock.
** The silt layer (Unit 5) was observed till the maximum investigation depth of 100 m at all four locations.

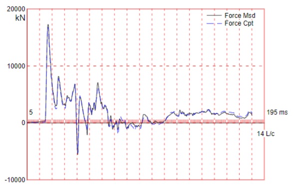


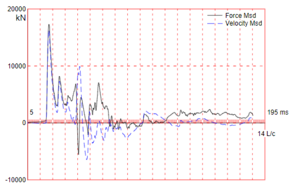
Axial Capacity Prediction

- **Method A**: API RP2 GEO main text guidelines.
  - Cohesive soils: α method based on undrained shear strength ratio
  - Frictional silica soils (CaCO3<20%): β method
  - Frictional carbonate soils (>80% CaCO3): Kolk (2000) approach with f_{lim} =15 kPa.
  - Carbonate silt (CaCO3 >80%): either **frictional** or **cohesive** (depending on geotechnical contractor's experience)
  - Intermediate carbonate soils (20%< CaCO3 <80%): Logarithmic interpolation
- **Method B**: Adjusted Karlsrud et al. 2005 and Clausen et al. 2005:
  - Cohesive soils : α method based on undrained shear strength ratio and plasticity
  - Frictional silica soils (CaCO3<20%): CPT based approach
  - Frictional carbonate soils (>80% CaCO3): based on effective stress and strength degradation with depth
  - Carbonate silt (>80% CaCO3): same as frictional carbonate soils
  - Intermediate carbonate soils (20%< CaCO3 <80%): Logarithmic interpolation
- **Method A** and **B** provide capacity for **100 days** after installation.

Pile Monitoring

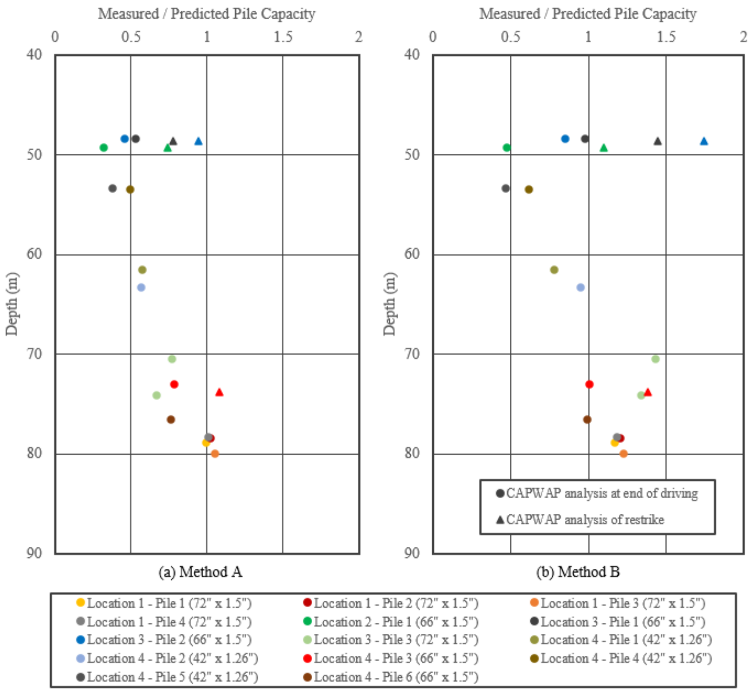
- Axial pile capacities can be estimated using signal matching analyses (most commonly CAPWAP) during driving
- Somewhat user dependent
- Restrike tests can result in estimates of set-up
- CAPWAP analysis results were available at the four selected locations
  - Restrike tests ranging between 1 – 24 hours





Results

- Comparison of measured pile capacities at end of driving and restrike (at 1 to 24 hours after end of driving) with pile capacities predicted by two different methods.
- Predicted capacities consider the silt as frictional.
- Set up measurements likely under-estimated compared to 100 days capacity.
- Capacities are underestimated in the deeper silt layer, this is attributed to high shaft resistance.



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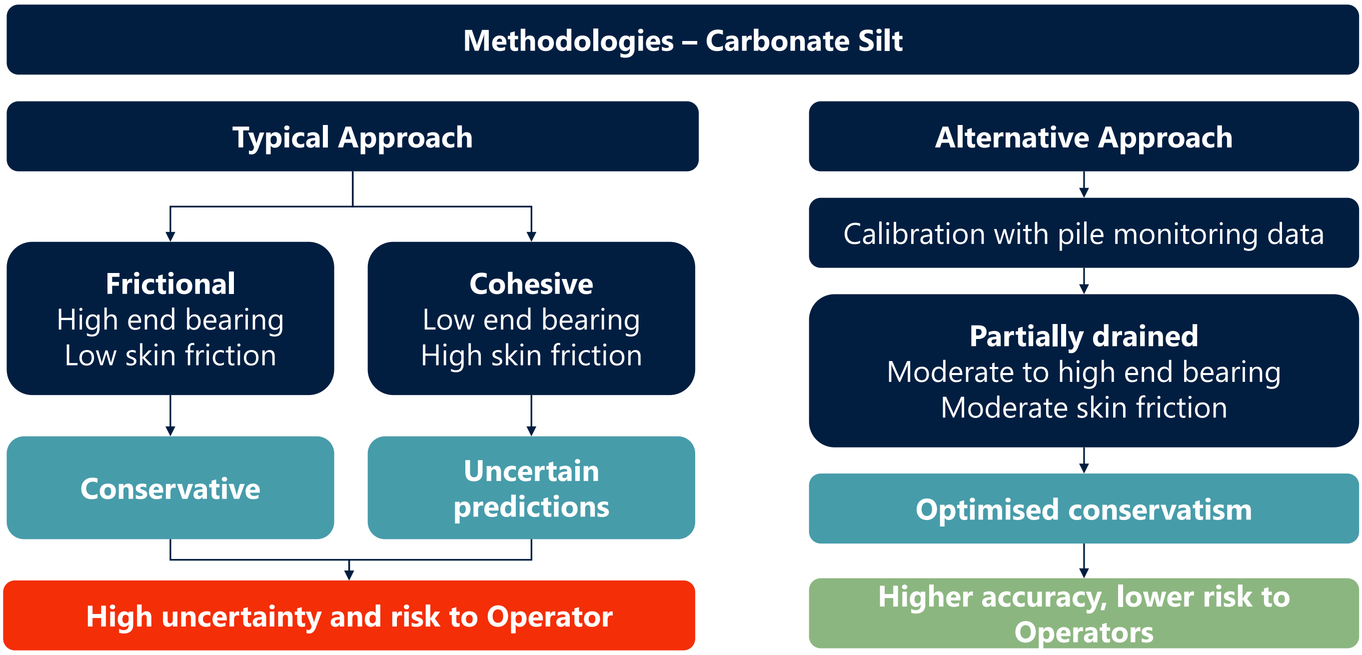
Discussion



7

Conclusions

To help address unconventional soil types the following is recommended:

- Carry out pile monitoring with minimum restrike after 24h
- Compare results from different methodologies with pile monitoring measurements
- Consider pile monitoring data in similar soil conditions to adjust engineering predictions
- Develop site specific methods when adequate pile monitoring records are available
- Additional scope:
  - Investigate the potential for cyclic degradation
  - Explore alternative pile testing techniques to improve measurements accuracy
  - Combine measurements from structure, metocean and pile foundations to improve accuracy

8

Questions?

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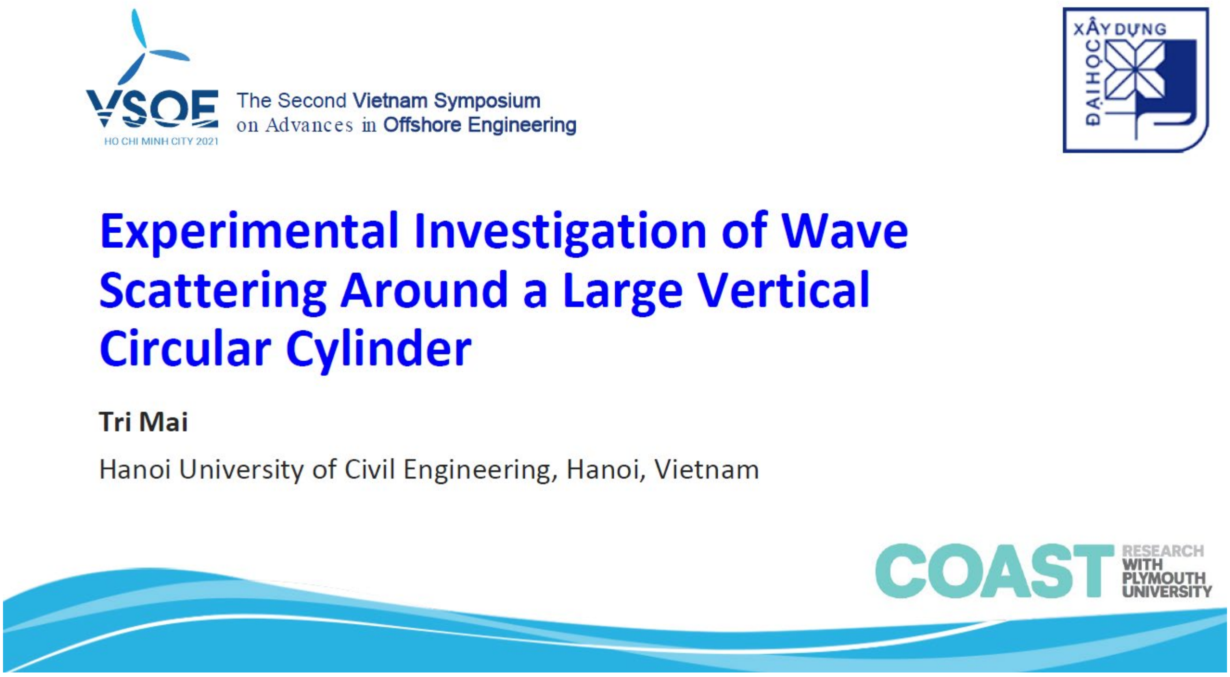
Experimental investigation of wave scattering around a large vertical circular cylinder

Tri Mai
Hanoi University of Civil Engineering, Hanoi, Vietnam



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Experimental Investigation of Wave Scattering Around a Large Vertical Circular Cylinder

Tri Mai

Hanoi University of Civil Engineering, Hanoi, Vietnam

COAST RESEARCH WITH PLYMOUTH UNIVERSITY

Content

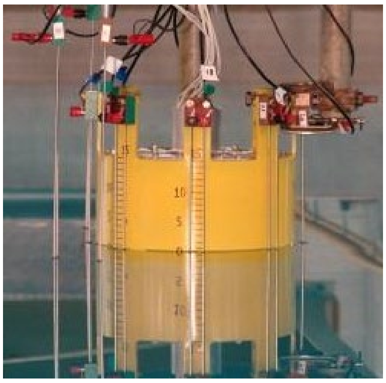
- Objectives
- Physical model test
- Phase-based harmonic separation method
- Scattered wave field
- Conclusions

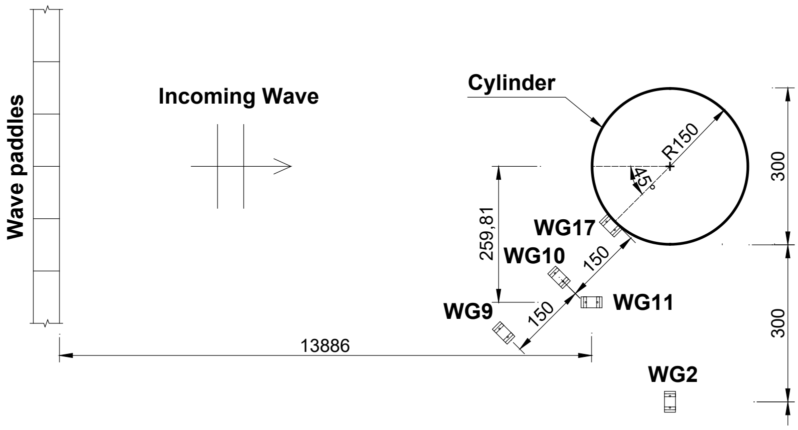
Objectives

- To investigate experimentally wave scattering around a truncated cylinder model to get a better understanding of how wave steepness effects on the local scattered wave field, may affect local and global loads, which may cause damage to or failure of offshore structures.

Physical model test

- The test was carried out in the Ocean Basin at Plymouth University.





Focused wave groups: kA = 0.13 & 0.18
(The NewWave methodology with an underlying JONSWAP spectrum (γ = 3.3))
Water depth: 2.93 m
Sampling rate of wave gauges: 128 Hz
Cylinder: Diameter of 0.3 m and height of 0.3 m; Draft = 0.15 m; D/L = 0.09

Phase-based harmonic separation method

An incident wave group that has amplitude A and relative phase θ can be expressed as the classic Stokes perturbation expansion (Fenton, 1985):

$$\eta(A,\theta) = B_{11} A \cos\theta + A^2 (B_{20} + B_{22}\cos 2\theta) + A^3 (B_{31}\cos\theta + B_{33}\cos 3\theta) + A^4 (B_{40} + B_{42}\cos 2\theta + B_{44}\cos 4\theta) + O(A^5) \quad \textbf{(1)}$$

where B_{ij} are the coefficients in Fourier series for $\eta(A,\theta)$; i is the amplitude content order; and j is the frequency content order.

$$\eta(A,\theta) = \eta_{11} + (\eta_{20} + \eta_{22}) + (\eta_{31} + \eta_{33}) + (\eta_{40} + \eta_{42} + \eta_{44}) + O(A^5) \quad \textbf{(2)}$$

where, η_{ij} are the j^{th}-order harmonic components, $\eta_{ij} = A^i B_{ij} \cos(j\theta)$.

If i and j are identical, then η_{ij} are the j^{th}-order harmonic sum, e.g. the first-order sum η_{11}.
If i and j are different, then η_{ij} are the j^{th}-order harmonic difference, e.g. the term η_{31} is at the first-harmonic in frequency but 3rd order (cubic) in input wave amplitude.
-> the subscript i is referred to as the (amplitude) order and j as the harmonic.

Phase-based harmonic separation method

The separation method (Fitzgerald et al., 2014):

$$\frac{\eta^0 + H(\eta^{90}) - \eta^{180} - H(\eta^{270})}{4} = \eta_{11} + \eta_{31} \quad (3)$$

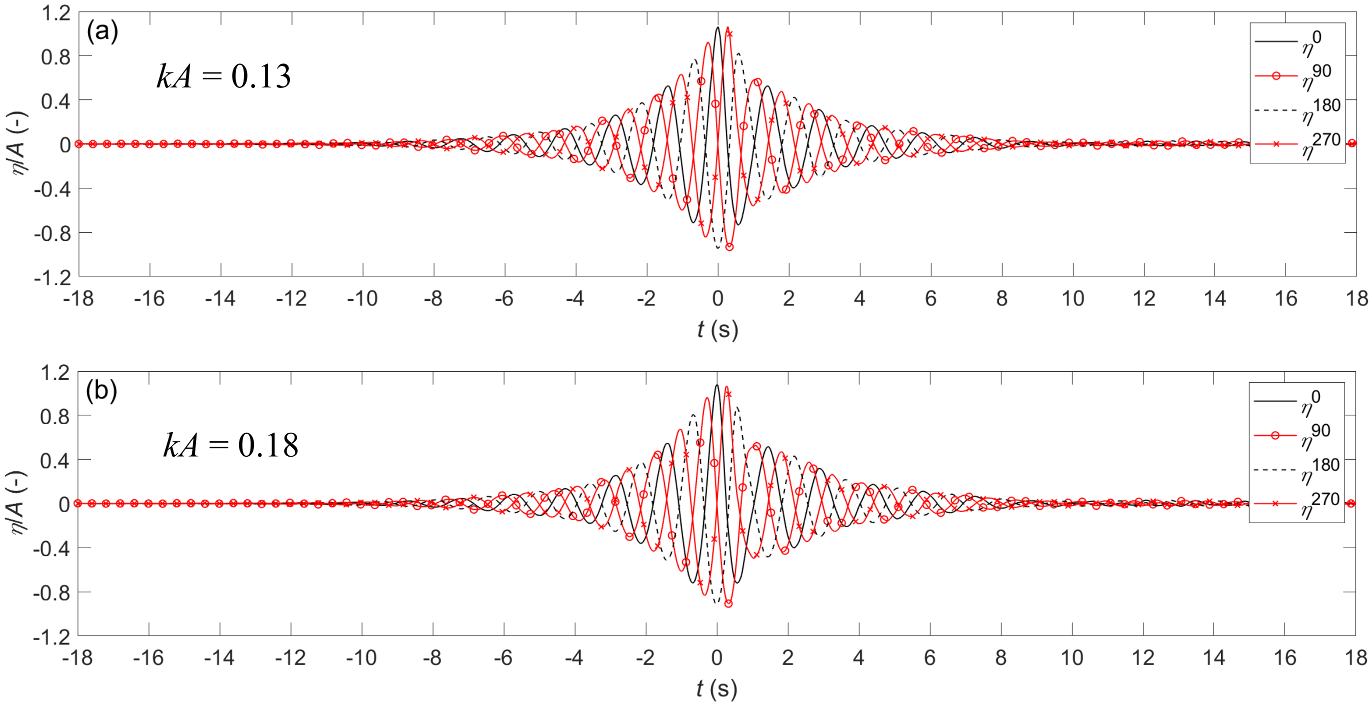
$$\frac{\eta^0 - \eta^{90} + \eta^{180} - \eta^{270}}{4} = \eta_{22} + \eta_{42} \quad (4)$$

$$\frac{\eta^0 - H(\eta^{90}) - \eta^{180} + H(\eta^{270})}{4} = \eta_{33} \quad (5)$$

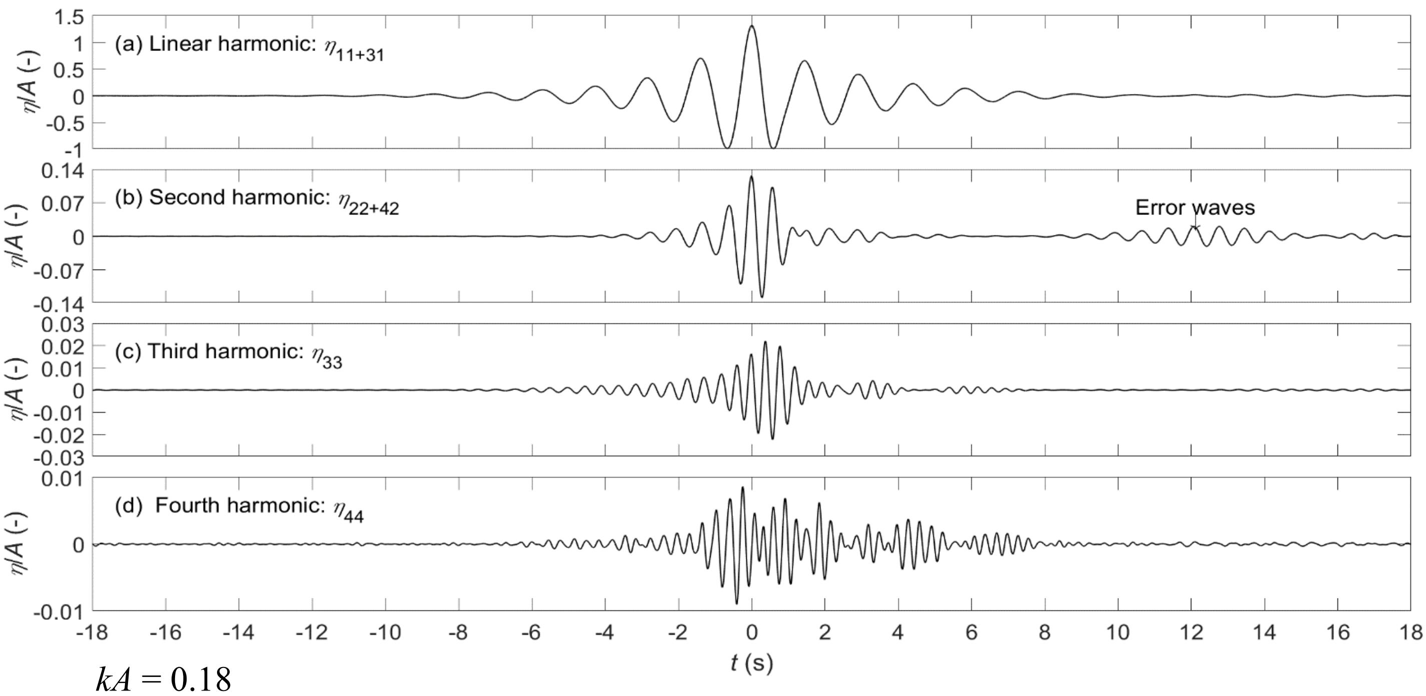
$$\frac{\eta^0 + \eta^{90} + \eta^{180} + \eta^{270}}{4} = \eta_{20} + \eta_{40} + \eta_{44} \quad (6)$$

The linear combinations of time histories and the Hilbert transforms of the 90° and 270° free-surface elevation time histories are applied!

Phase-based harmonic separation method



Phase-based harmonic separation method



$kA = 0.18$

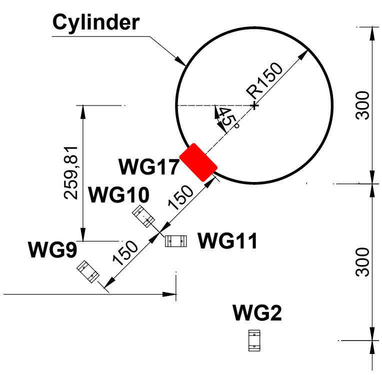
Scattered wave field

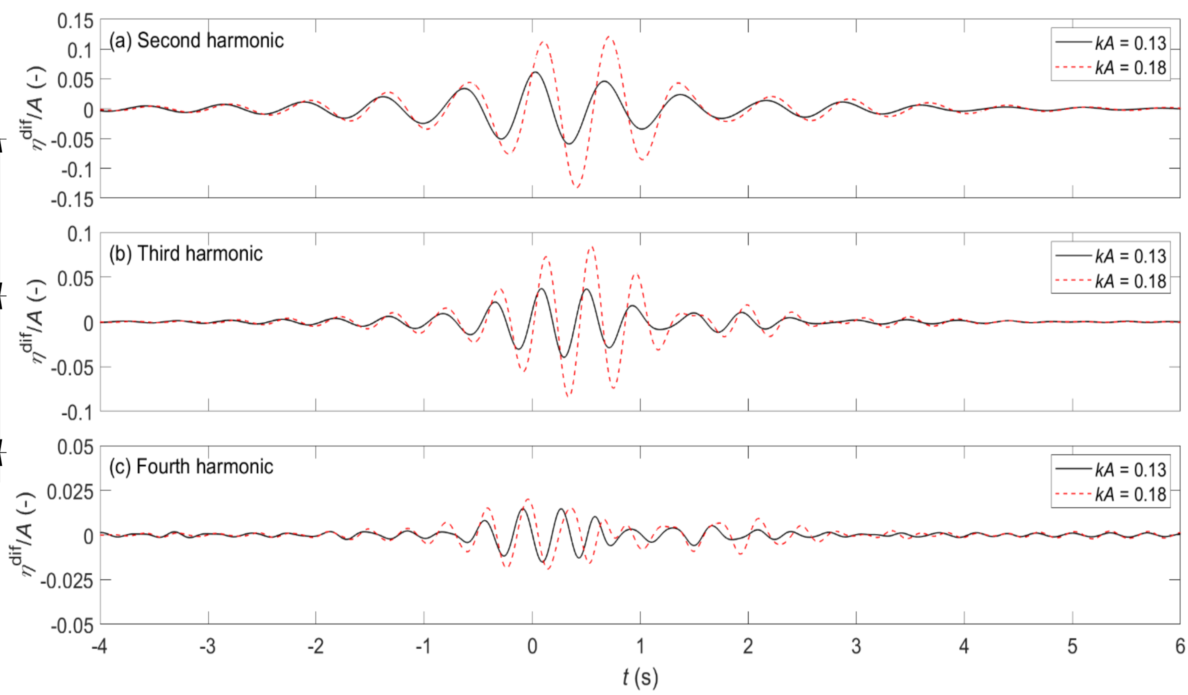
The scattered or diffracted wave field:

$$\eta_{ij}^{dif} = \eta_{ij}^{Model} - \eta_{ij}$$

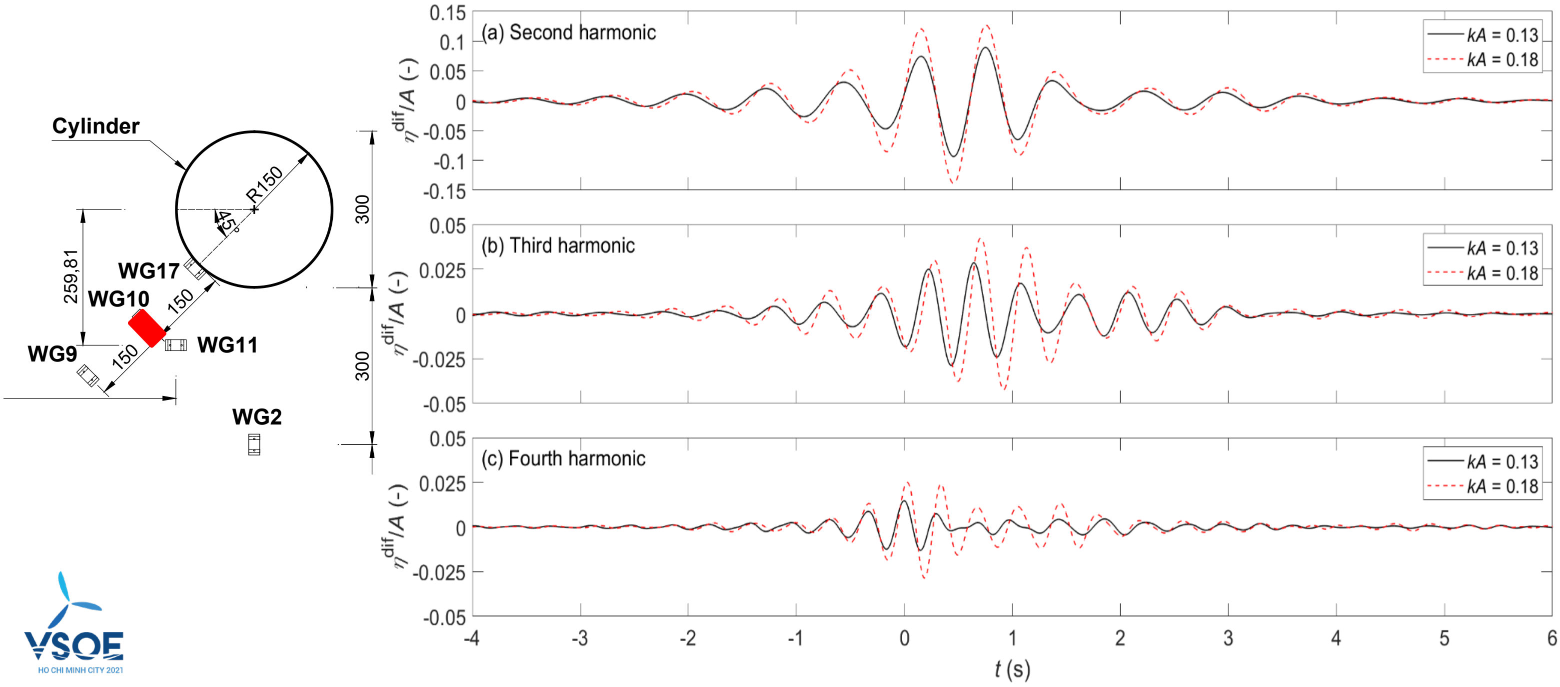
Where: η_{ij}^{dif} is the $(i,j)^{th}$ component of the scattered/diffracted wave
η_{ij}^{Model} is the equivalent component with the model present
η_{ij} is the undisturbed incident wave component measured at the same gauge location in the absence of the model

Scattered wave field

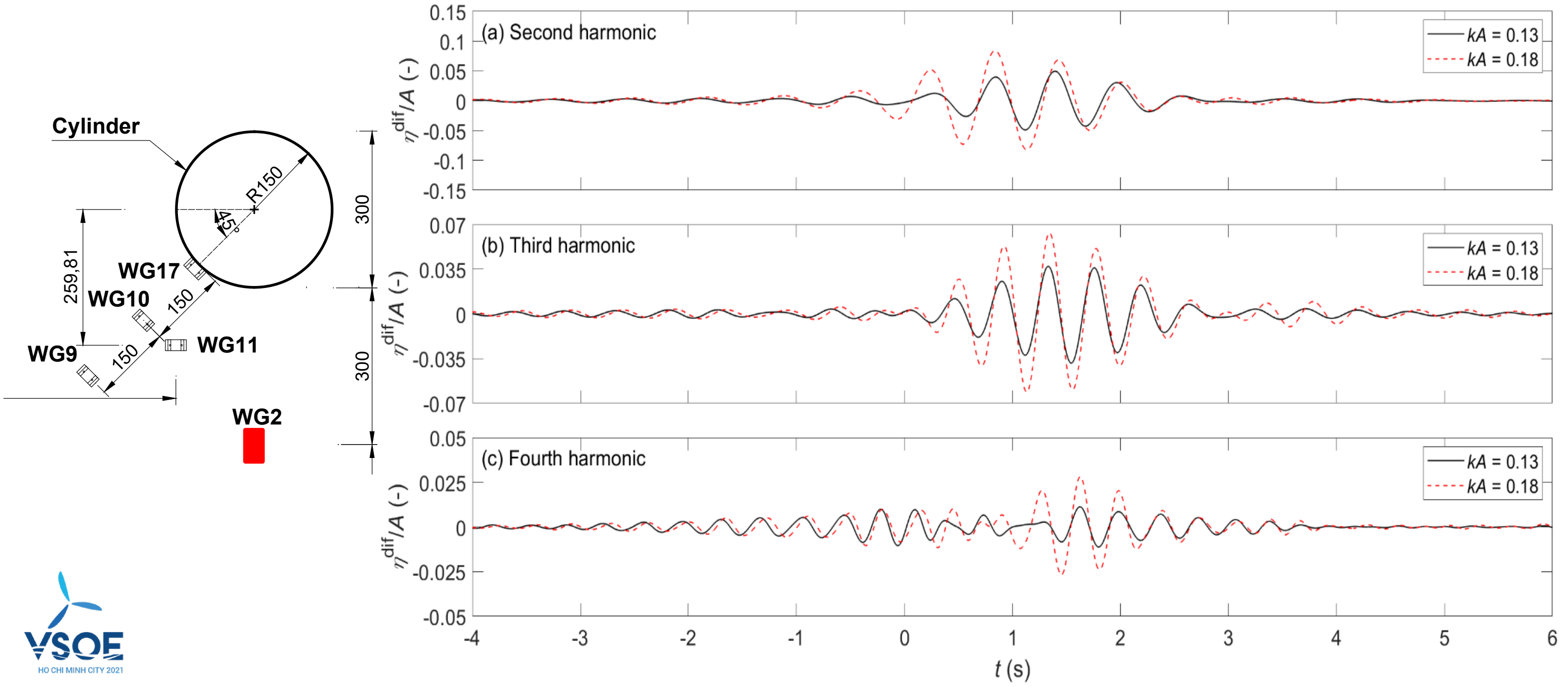




Scattered wave field



Scattered wave field



Conclusion

- This experimental study have investigated the effects of wave steepness on the scattered wave field around a truncated cylinder;
- A general phase-based harmonic separation method has been applied;
- There is a significant effect of wave steepness on the second and third harmonic components where the amplitude of those higher harmonic components increases with increasing the wave steepness;
- The fourth harmonic component at the bow of the cylinder is smaller than that at the locations around the cylinder;
- The second, third and fourth harmonics should be considered in practical design of offshore structure for assessment of springing- and ringing-type responses and the air gap.

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CÁM ƠN!

THANK YOU!

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Case studies on mitigating pile foundation refusals

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Case Studies on Mitigating Pile Foundation Refusals

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A. GEOTECHNICAL INVESTIGATION

B. PRE INSTALLATION DRIVEABILITY STUDY

C. PILE MONITORING DURING DRIVING

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PRE INSTALLATION DRIVEABILITY STUDY

- INPUT
  - Hammer properties
  - Hammer and pile cushion properties
  - Pile properties
  - Soil Properties

- OUTPUT
  - Resistance Vs Blow Count
  - Stress vs pile length
  - Transferred Hammer Energy

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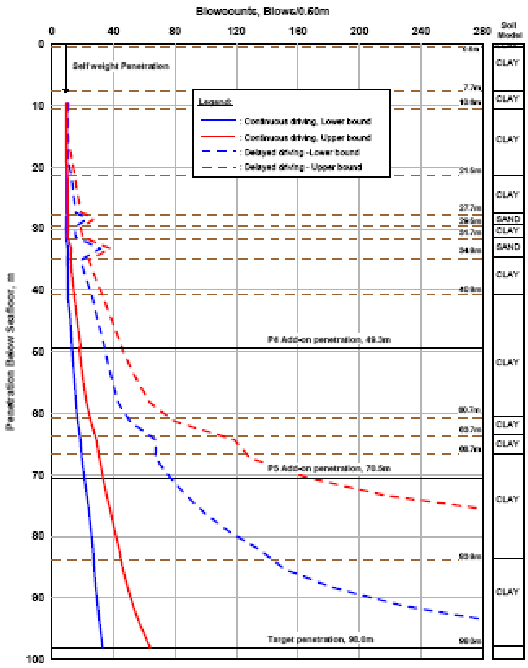
SGES

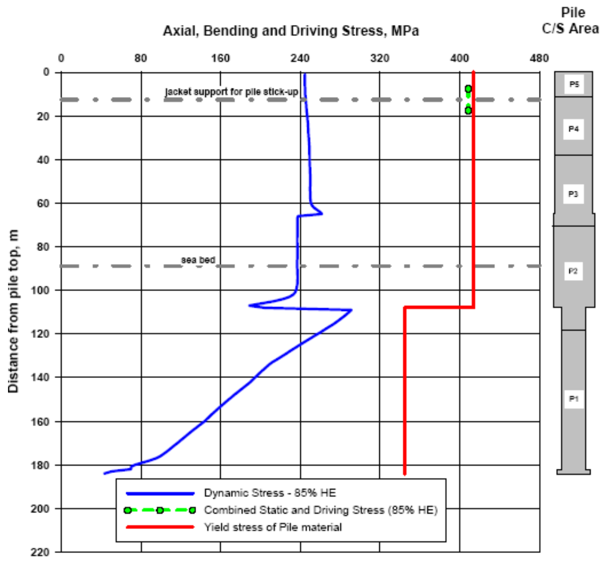
PRE INSTALLATION DRIVEABILITY STUDY



PREDICTED BLOWCOUNTS VS PENETRATION

IHC S-280 Hammer, 76% Efficiency

0.914m (36-in) Diameter Steel Pipe Pile

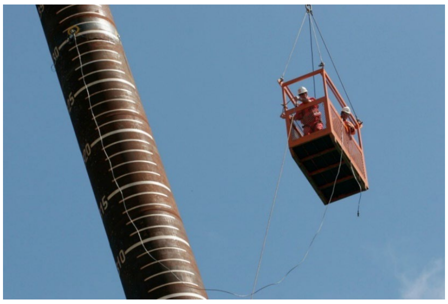


AXIAL, BENDING AND DRIVING STRESSES IN PILE - P5 ADD-ON ~ 11.5m

MHU 1700 Hammer, 85% Hammer Efficiency

1.524m (60-in) OD Open Ended Steel Pipe Piles

OFFSHORE PILE MONITORING



Driving of Pile with Hydraulic Hammer

Pile Monitoring Using PDA

INTRODUCTION

- Assessment of as installed pile capacity is required for acceptance of offshore piles refused prematurely at a penetration shallower than design penetration
- Piles refused prematurely generally satisfy the requirement of compression capacity but not the tension capacity and the minimum penetration requirements for lateral stability
- In such cases, the refused pile is advanced to deeper penetrations by drill and drive technique up to the design penetration
- The following case studies highlight the importance of assessing the as installed capacity during the drill and drive process for control over drill-out length and the use of pile driving records for back analysis of pile capacity.

CASE STUDY-1
Persian gulf

CASE STUDY-1

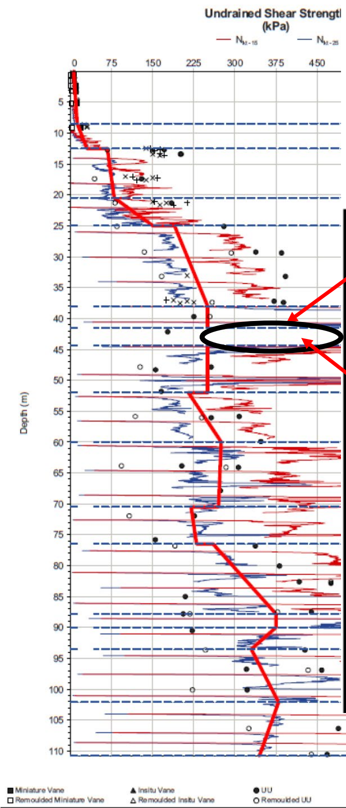
- Steel pipe piles of outer diameter 1.524m and varying wall thickness of 31.75-88.90mm formed the foundation piles for a four-legged offshore jacket platform installed in the Persian Gulf.
- The IHC500 hydraulic hammer was proposed to drive the piles through the jacket legs to the final penetrations ranging 88-95m below the seabed.

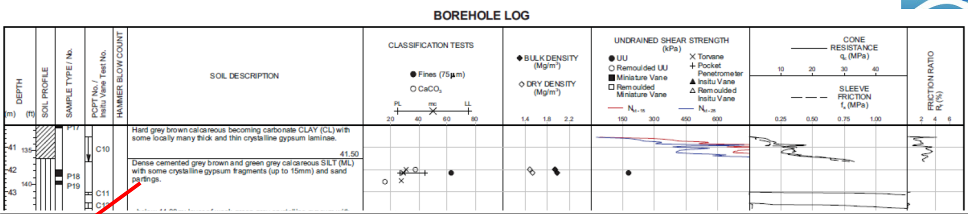
0 -12m	**Very Soft CLAY**
12.0 – 76.5	**Stiff to Very Stiff CLAY**
76.5 – 110.8	**Hard CLAY**

- An intermittent 2.8m thick, dense cemented carbonate SILT is present at 41.5m, followed by **0.3m thick weak crystalline GYPSUM** at 44m.
- Pile drivability analysis, performed for the estimated soil resistance to driving using the soil parameters, indicated no premature refusal.

- The first driven pile, Pile A2, encountered refusal at 44.50m. No decision could be taken on pile acceptance at refused depth, as the pile was not instrumented and monitored and so with all the remaining piles.
- Pile toe buckling suspected due to hard driving and driving was stopped
- About a year later, in the second pile driving campaign, pile A2 was instrumented and found the pile toe was intact, and the compression and tension capacity was not sufficient for acceptance
- CAPWAP (Case Pile Wave Analysis for Piles), a signal matching software, estimated compression and tension capacities were **26MN** and **5.6MN**, respectively, while the design capacities were 68 MN and 58 MN at design penetration of 95m.

OFFSHORE PERSIAN GULF





Layer	SOIL	Depth [m] From	Depth [m] To	γ' [kN/m³]	Shear Strength [kPa] From	Shear Strength [kPa] To	CaC03 [%]	Shaft Factor
1	CLAY	0.00	8.50	5.5	5.5	12		
2	CLAY	8.50	12.50	6.5	12	30		
3a	CLAY	12.50	20.50	9.6	67	80		
3b	CLAY	20.50	25.00	10.0	80	150		
4	CLAY	25.00	38.00	9.0	190	250		
5	CLAY	38.00	41.50	10.7	250	250		
6	SILT	41.50	44.30	9.2			27	0.
7a	CLAY	44.30	52.00	9.2	250	250		
7b	CLAY	52.00	60.00	8.7	215	275		
8a	CLAY	60.00	70.50	10.0	275	270		
8b	CLAY	70.50	76.50	9.0	220	230		
9	CLAY	76.50	87.80	10.5	260	375		
10a	CLAY	87.80	90.00	11.0	375	375		
10b	CLAY	90.00	93.50	10.6	375	330		

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- CPT data of Gypsum layer indicated a refusal tip resistance of more than 50MPa.

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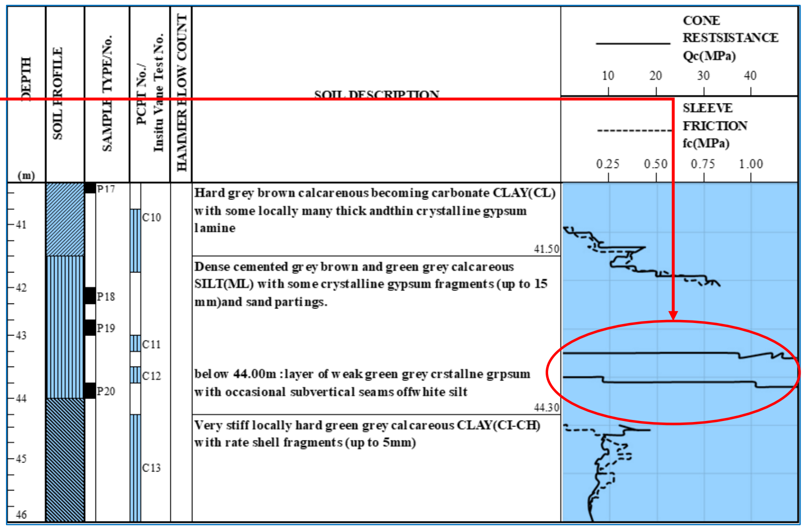

Fig 1: Borelog Excerpt

- A pilot hole of 1.2m diameter was drilled up to 1.0m below the pile toe. The core cuttings stuck in the drill brit confirmed that the material encountered was grey Gypsum.

Fig 2: Drill Bit

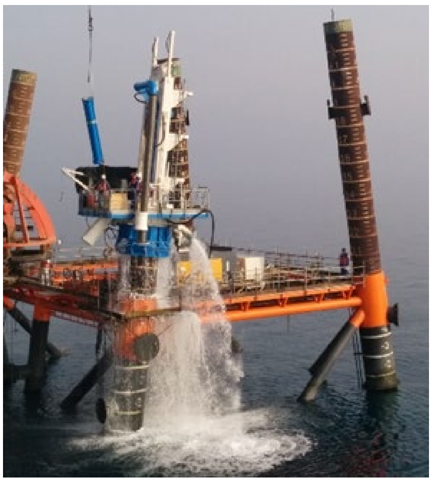

Fig 3: Drilling in Progress

Pile driving resumed after the drill-out. It was hard driving again with a restart blowcount of 300blows/0.25m because of the Gypsum below the pile wall area.

The CAPWAP computed compression capacity after the drill-out of Gypsum was **20MN** vis-à-vis **26MN** before drill-out.

The reduction in capacity was due to reduction in skin friction as evident in the Force-Velocity vs Time graphs as shown in below.

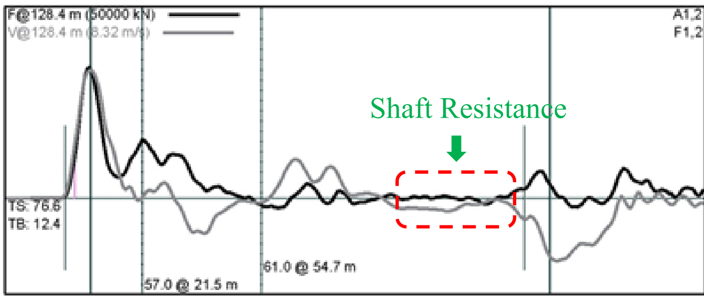

Fig 4: Force-Velocity vs Time graph Before Drill-out

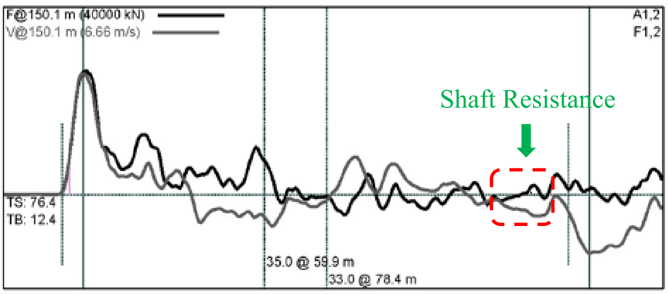

Fig 5: Force-Velocity vs Time graph After Drill-out

- Although the end bearing was still high, since the pile toe was intact and computed capacity was within the mobilized capacity during refusal, pile driving was continued without resorting to another round of plug drill-out below pile toe which otherwise would have caused more reduction in pile capacity.

- The blowcounts gradually reduced to 50blows/0.25m after about 1m drive, and the pile could be driven to design penetration successfully.

- It was concluded that the Gypsum layer thickness was 1.3 to 2.6m vis-à-vis 0.3m reported in the borelog. The strength of Gypsum was underestimated with an end bearing of 1.13MN vis-à-vis mobilized end bearing of 18MN from CAPWAP.

- Predicted vs Computed capacity, Blowcount vs penetration are shown in figures 6-7

Case STUDY-1

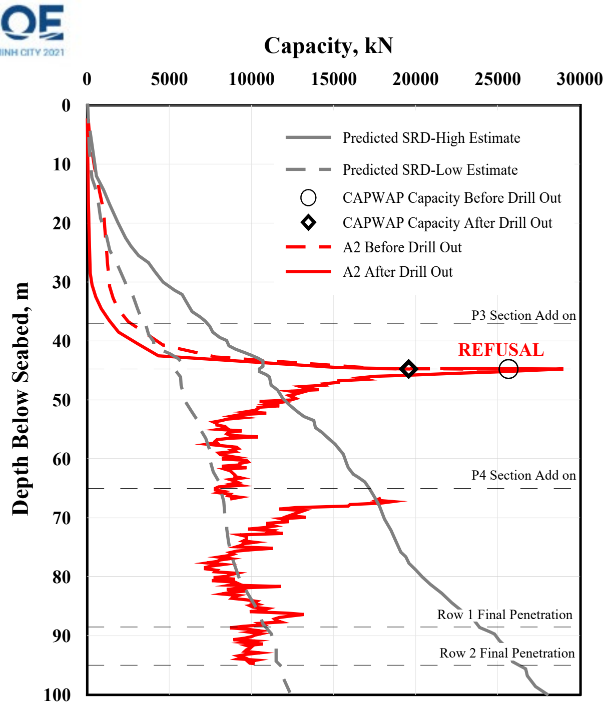

Fig 6: Predicted Capacity vs. Computed Capacity

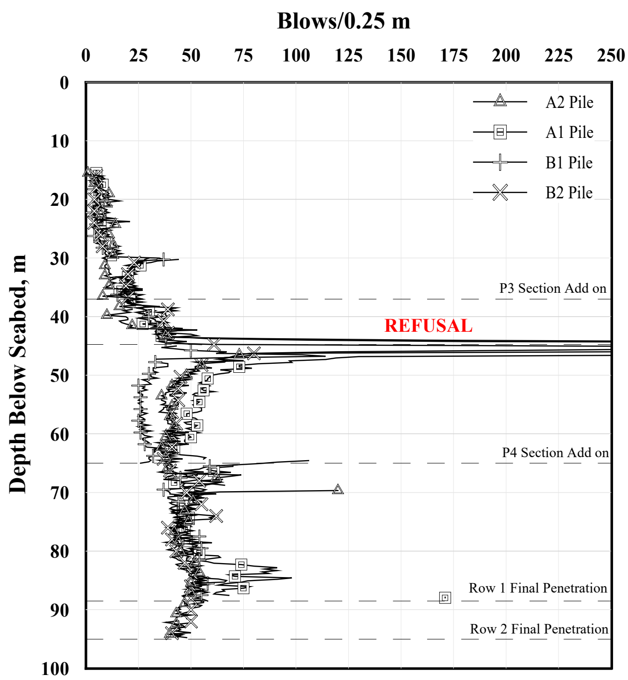

Fig 7: Blowcounts vs. Penetration

Case STUDY-2
Offshore West Coast India

- Four Legged jacket platform, located in Mumbai High Field. Foundation piles of 2.134m OD with varying wall thickness 38-74mm.
- Hydraulic hammers IHC S-600, IHC S-900, and IHC S-1200 were proposed for pile driving. Three piles were driven to their design penetration of 116.6m below the seabed, while the fourth pile, pile B1, had met with premature refusal at 113.5m depth.
- It was required to assess the as-installed pile capacity for acceptance. However, piles were not instrumented, hence, Pile driving records viz., blowcounts, and energy readings from the hammer console were used for pile capacity assessment
- GRLWEAP (Wave Equation Analysis for Piles) was used in simulating the hammer-pile-soil system and pile capacity was back analyzed using a technique called Blow Count-Depth Matching (BCDM) [Rausche F et al, 2009, Gangisetti R et al, 2020],

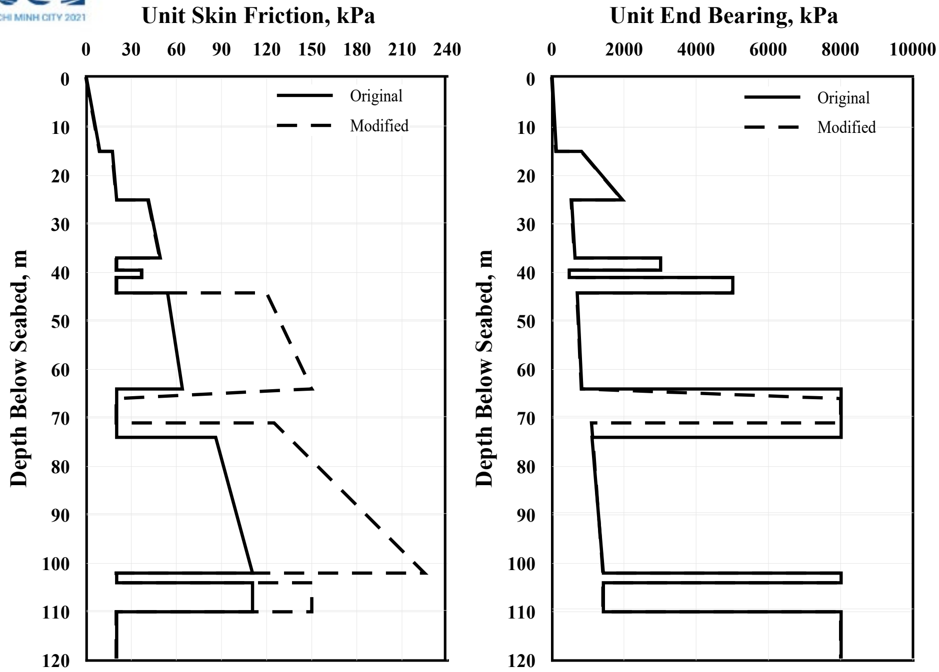

Fig 8: Modified/Static Unit Skin and End Bearing values vs Penetration

- The back analyzed as-installed capacity was 45.4MN with skin friction and end bearing components of 22.6MN and 22.8MN.
- The modified unit skin and end bearing values vs Penetration is shown Figure 8.

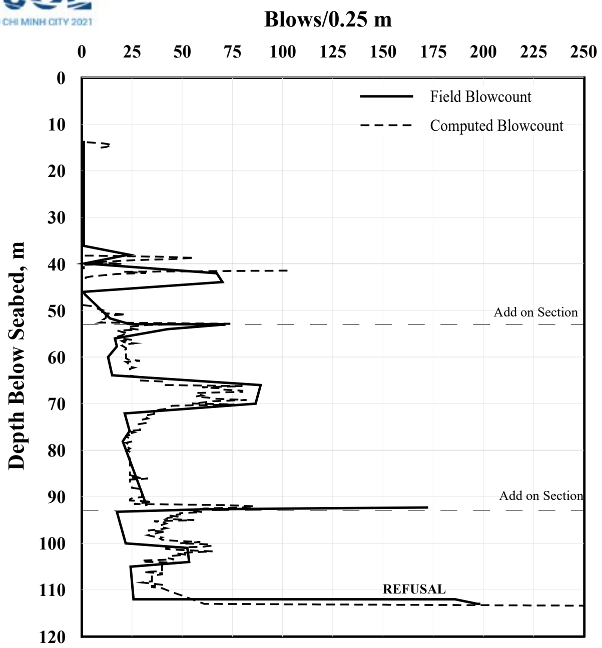

Fig 9: Blow count-Depth Matching (GRL WEAP)

- Blowcount-Depth matching is shown in Figure 9
- The back analyzed capacity of **45.4MN** for **the** end-of-driving (EOD) condition was less than the design capacity of **66.16MN**.
- Pile monitoring equipment was mobilized for instrumentation, and a re-strike test was conducted using IHC-S900 hammer on pile B1, 3.8 days after the pile had experienced the refusal driving conditions.

- The CAPWAP computed pile capacity was **56.6MN** with skin friction and end bearing components of **47.18MN** and **9.3MN**.

- As the hammer energy during re-strike test was sufficient only to mobilize skin friction, full end bearing could not be mobilized. Therefore, the back analyzed end bearing for the end-of-driving condition was added to the skin friction mobilized during the re-strike.

- The total as-installed capacity of **69.78MN (47.18MN+22.6MN)** during re-strike test was more than the design capacity of 66.16MN; hence the pile was accepted at 113.5 penetration depth of refusal.

- The Force-Velocity vs Time graph from PDA and CAPWAP results and The back analyzed EOD capacity, CAPWAP Re-strike capacity and Design capacities [API RP-2A, 2000] are shown Figures 10-11

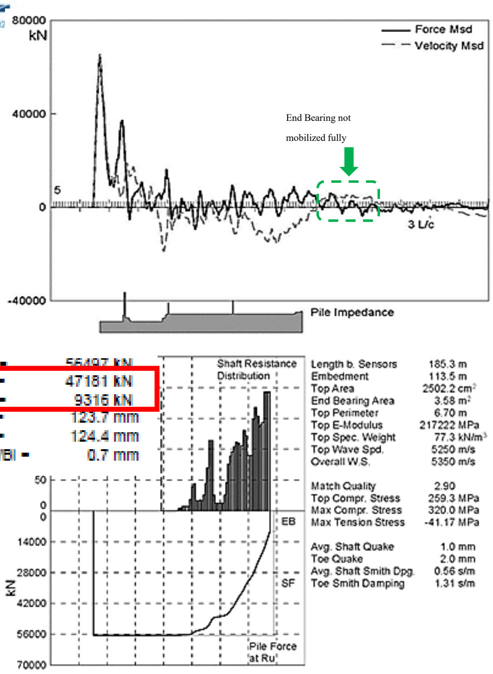

Fig 10: Force-Velocity vs Time graph from PDA and CAPWAP results

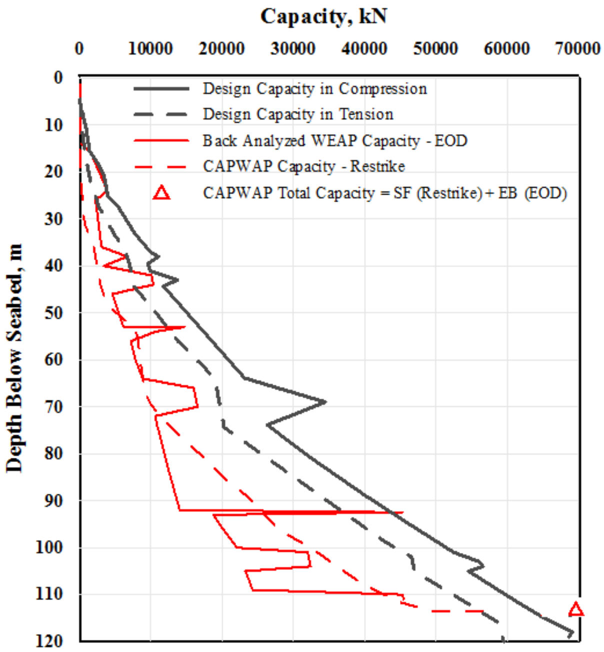

Fig 11: Pile Capacity Vs. Penetration

CONCLUSIONS

- Most of the premature pile refusals can be attributed to unexpected lateral variation in the strata and their thickness.
- Cemented hard silt with crystalline Gypsum stains or weak Gypsum rock can cause refusal conditions if its strength is underestimated during pile drivability studies.
- If the capacity requirements are not met, then plug drill-out can be done to advance the pile to design penetration.
- Plug drill-out done in stages with capacity assessment using CAPWAP will avoid over drill-out, which otherwise would cause a significant capacity reduction.
- If instrumented data is not available, the capacity can be back analyzed using pile driving records and GRLWEAP, although less accurate than CAPWAP using instrumented data.

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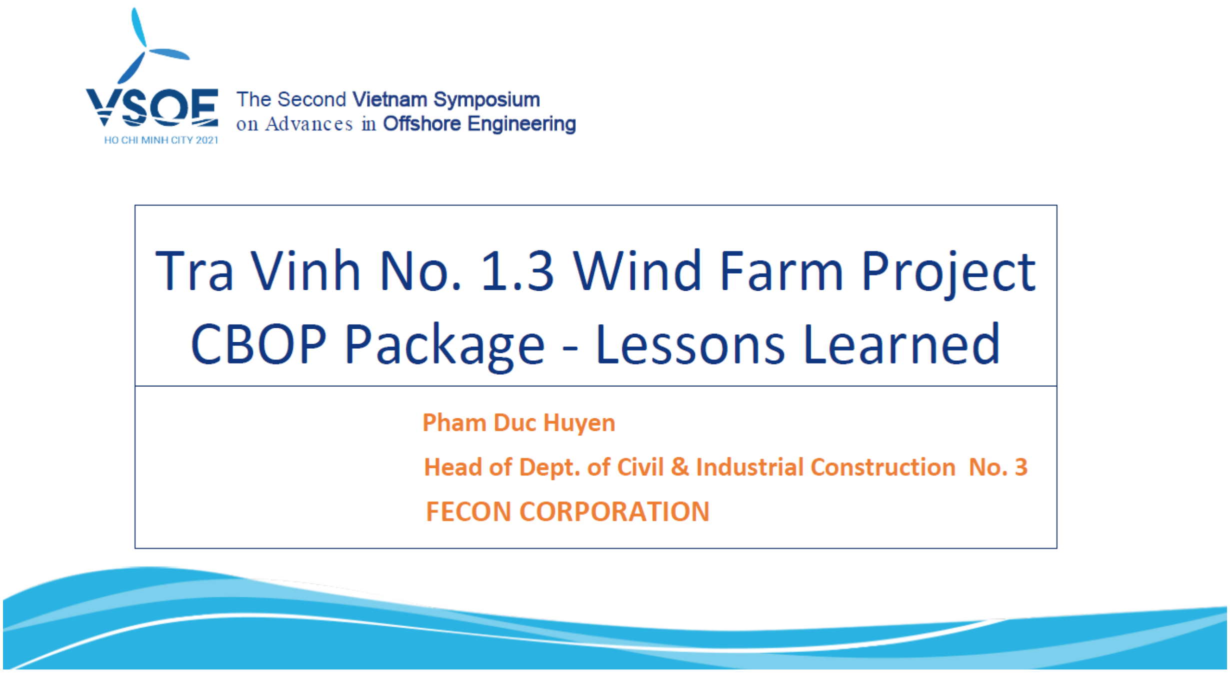
Tra Vinh No.3 windfarm: CBOP package - lessons learned

Pham Duc Huyen
FECON, Vietnam



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Tra Vinh No. 1.3 Wind Farm Project CBOP Package - Lessons Learned

Pham Duc Huyen
Head of Dept. of Civil & Industrial Construction No. 3
FECON CORPORATION

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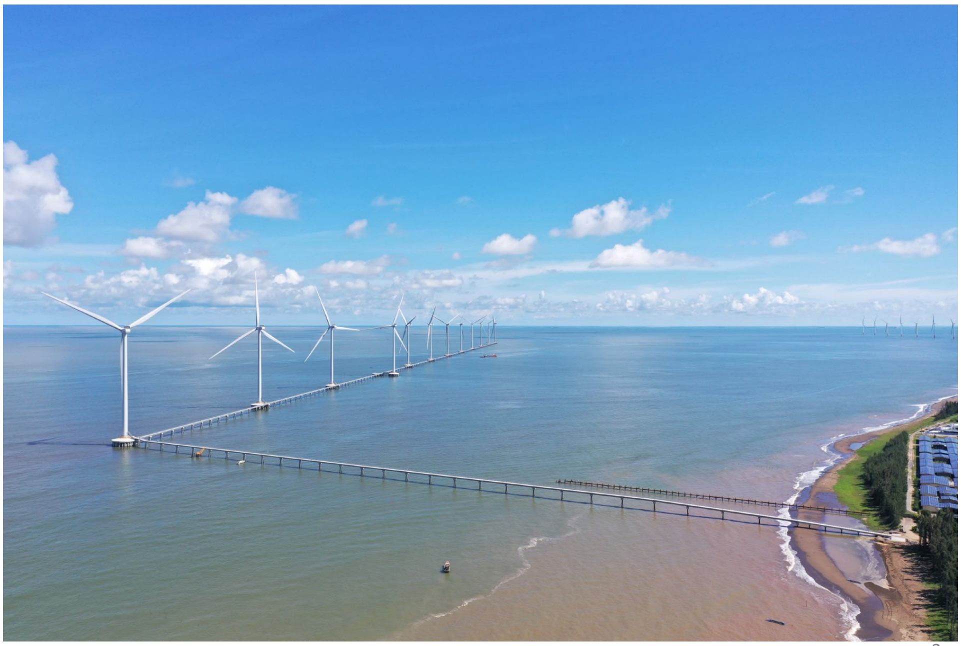
CONTENTS

1. BRIEF ON TRA VINH No.3 WINDFARM

- **Location: Duyen Hai town-Tra Vinh Province**
- **Investor: REE Corporation**
- **Capacity: 48 MW with 12 Turbines of Vestas**
- **EPC Contractor: Vestas**
- **CBOP Contractor: FECON**



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1.BRIEF ON TRA VINH No.3 WINDFARM

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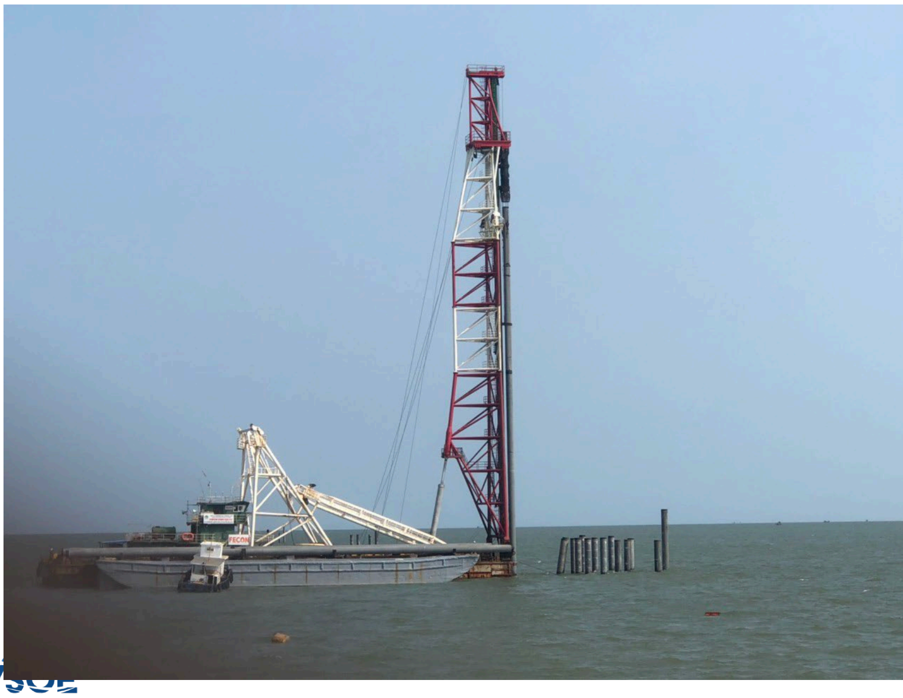
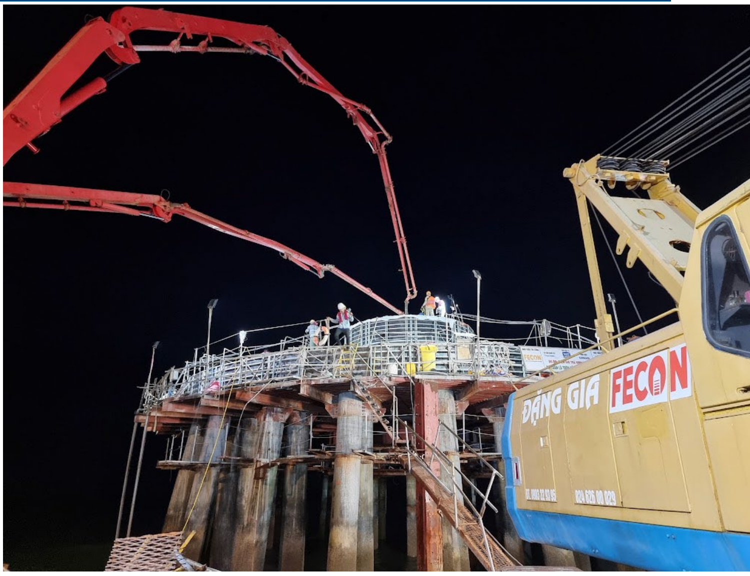


1. BRIEF ON TRA VINH No.3 WINDFARM

Formwork and rebar work

1. BRIEF ON TRA VINH No.3 WINDFARM



Floating batching plant-Concreting work

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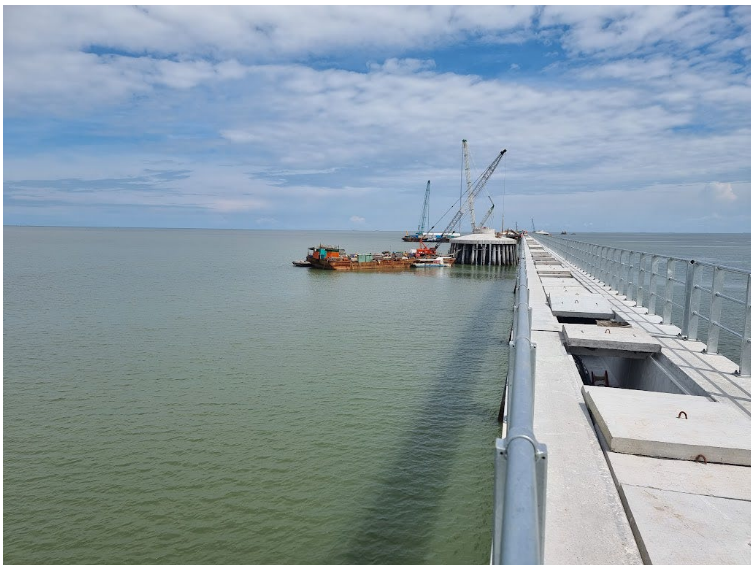
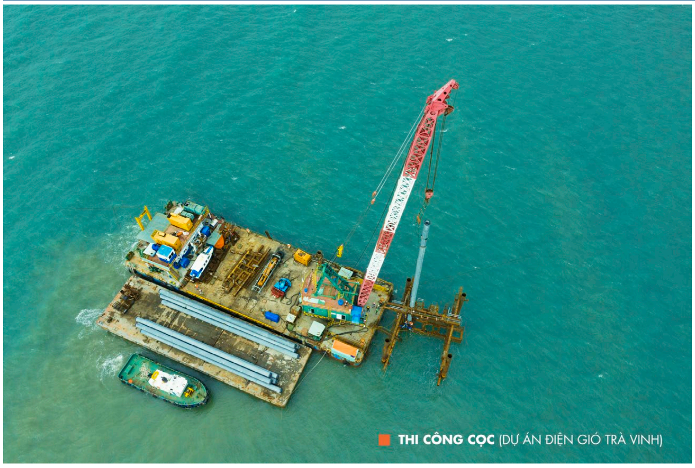


Link Bridge U-beam installation

1. BRIEF ON TRA VINH No.3 WINDFARM

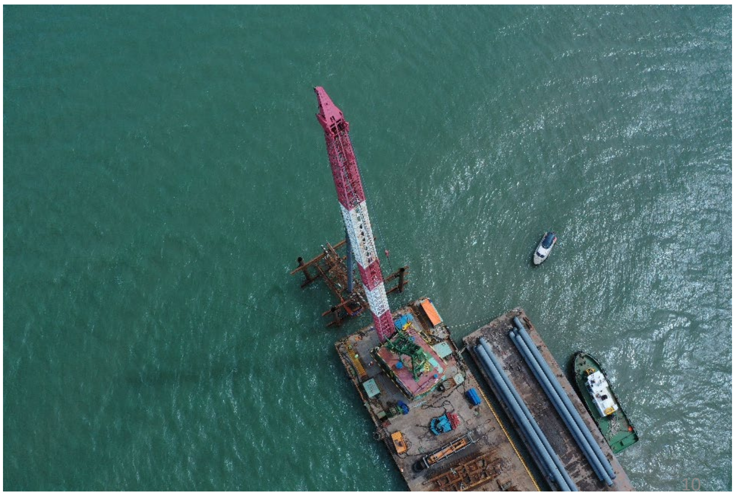
Turbines installation

2. MOBILIZATION OF RESOUCES



Test piling work

❖ Using inappropriate construction equipment will affect the progress and quality of the project



2.1 EQUIPMENT MOBILIZATION

The suitable equipment for the marine piling work is the most important to make sure the progress, safety and quality.

Fixed leader

2.2 EQUIPMENT MOBILIZATION

Hydraulic hammer selection for construction

- ✓ Selection of construction equipment based on technical calculations and construction experience.
- ✓ Closely monitor the construction process.
- ✓ Check the frequency by the necessary experiment.

❖ The project encountered many serious construction quality errors, due to the use of inappropriate construction equipment

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2.3 THE WEATHER CONDITION AFFECTED

Every year, the windy season begins in the southern at the end of October and will last until the end of March. During this season, the waves up to 5m high can occur at times, putting any equipment at sea in danger.

The project's progress should be adjusted accordingly to avoid falling into the windy season, or construction must be suspended to ensure the project's safety.

3. QUALITY MANAGEMENT

2.1 PILING WORK:

Experiences in driving PHC piles at sea:

✓ Choosing inappropriate equipment (hydraulic hammer) will cause:

- damage to piles (shown by low BTA)
- additional cost and slow progress.

Pile damaged at the connection joint due to hammer blows dropped in a short period time.

3. QUALITY MANAGEMENT

CHALLENGES IN PILING

Some challenges in piling at the site

- ✓ Severe weather conditions (storms, high waves) hamper the foundation work significantly
- ✓ Large barges cannot be deployed in shallow waters, so small barges is appropriate. Small barges, on the other hand, is vulnerable to high waves and strong wind
- ✓ Supplies can easily be interrupted by severe weather conditions. Pile material could not be transported to the site due to this.

EXPERIENCES IN PILING

Some recommendations to minimize pile damages

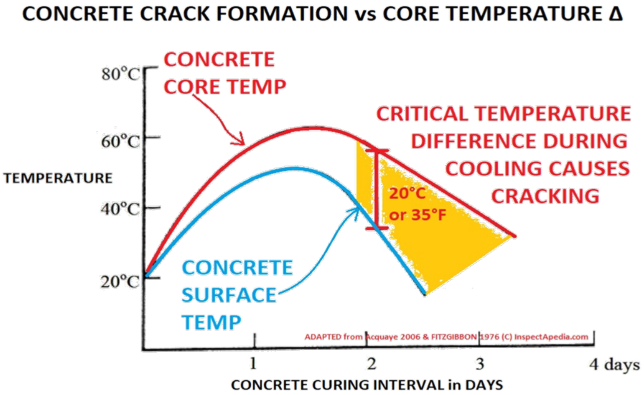
- ✓ The proper hammer type and capacity are critical factors to keep pile integrity. Using high-load hydraulic hammers can cause severe damage to PHC piles.
- ✓ Diesel hammers are found better than the hydraulic hammers and are generally recommended.

3. QUALITY MANAGEMENT

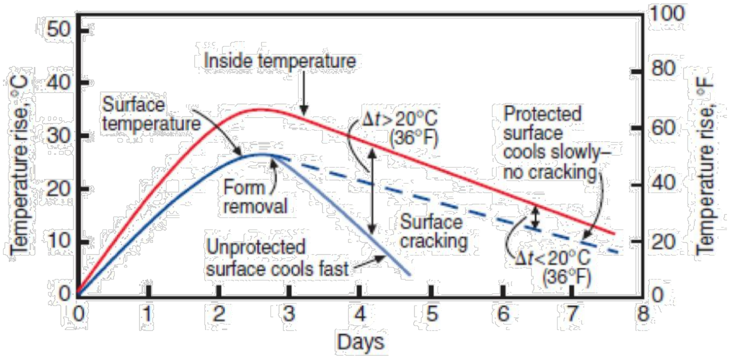
2.2 MASS CONCRETING OF FOUNDATION

3. QUALITY MANAGEMENT

TEMPERAURE CONTROL IN MASS CONCRETING



Cracking due to insufficient insulations



Cracking due to early formwork removal (although sufficient insulation)

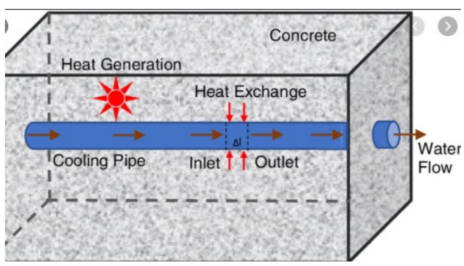
→ **Selecting correct insulation & correct removal time is crucial importance for mass concreting**

3. QUALITY MANAGEMENT

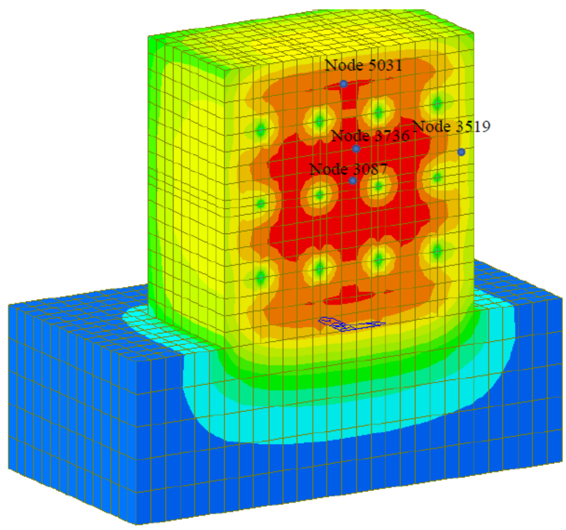
TEMPERAURE CONTROL IN MASS CONCRETING

Key methods to control temperature

- Control of mix design (cement content, W/C ratio)
- Use of different lifts
- Proper insulation methods and proper removal time
- Installation of cooling system (if any)



Principle of temperature reduction by cooling pipe



An example of FEM analysis with cooling pipes installed

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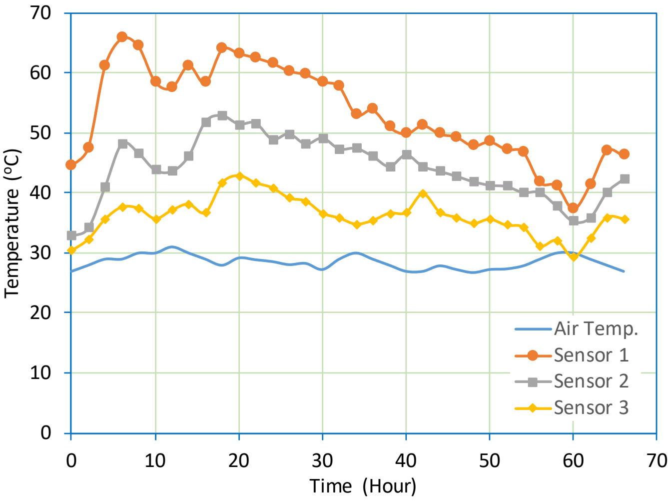
3. QUALITY MANAGEMENT

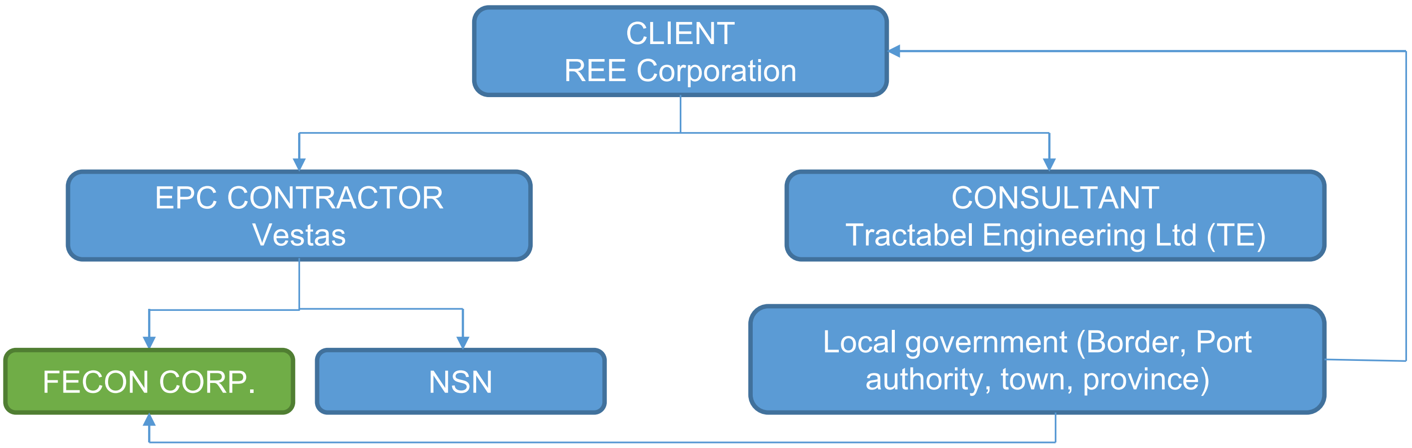
MASS CONCRETING AT WT No.9



Measured temperature profiles (WT No. 9)

Curing concrete surface (covered by wetted jute bags and watered daily)

4. STAKEHOLDER MANAGEMENT



- ❖ FECON's role of "Tra Vinh V1.3 Wind Farm Project" as CBOP contractor: design and construction of 12 WTG and Link bridge.
- ❖ FECON contracts directly with the EPC contractor Vestas, but in fact most of the implementation must be flexible and work directly with other stakeholders.

4. STAKEHOLDER MANAGEMENT

- Fishermen may be drawn into the construction site, potentially endangering both equipment and people. To ensure the project's security and safety, it is necessary to coordinate and support local border guards.
- The process of obtaining a maritime safety permit can be time-consuming, so getting access to Maritime authorities as soon as possible should also be a priority.

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Highlights from R&D on innovative monopile installation and decommissioning

Ahmed Elkadi
Research Program Manager: Energy Transition, Deltares, Netherlands

Deltares

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Highlights from R&D on innovative monopile installation & decommissioning

Ahmed Elkadi, PhD, CEng

Deltares, Delft, Netherlands

Rijksdienst voor Ondernemend Nederland

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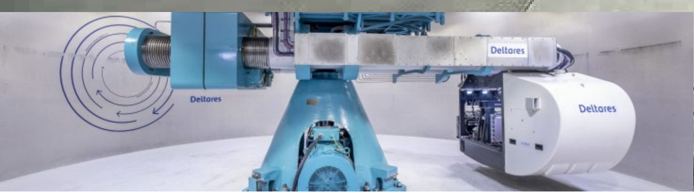
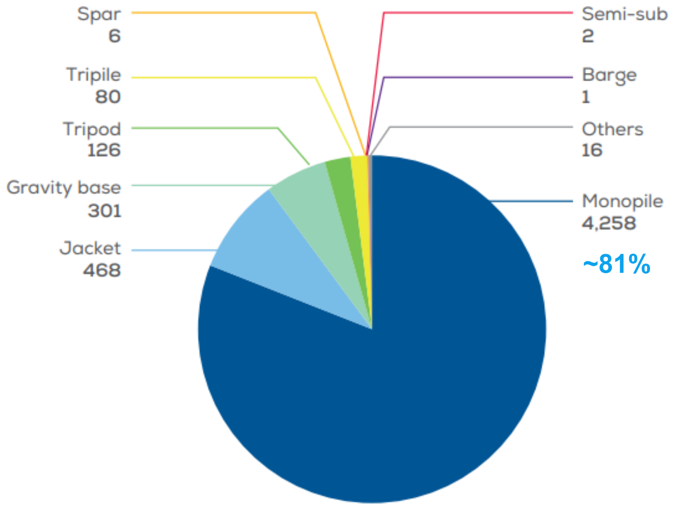


Monopiles



Source: WindEurope

2019, Europe

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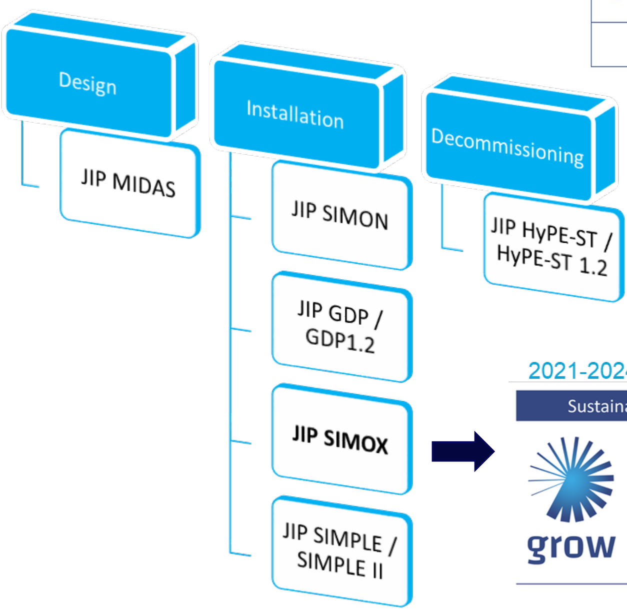
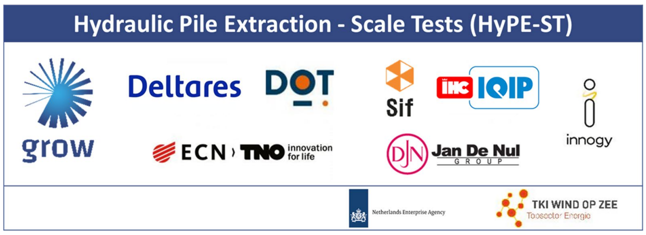
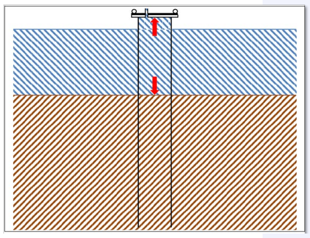
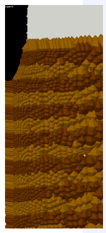
Monopile R&D

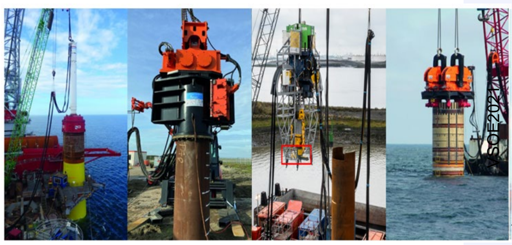








2021-2024



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SIMOX (Sustainable Installation of XXL Monopiles)

- Start date 1st June 2021
- 3 years project; 2021 – 2024
- 6.5 M€; of which ~4 M€ government subsidy

Sustainable Installation of XXL Monopiles (SIMOX)

Deltares

Project Objectives (WHAT)

SIMOX will investigate, collect, and develop the necessary technical and environmental knowledge with the aim of having one or more qualified and validated next-generation installation technologies available within 5 years.

This is by testing various installation techniques, of which the degree of technical development differs from each other, namely

- the technologies that utilize vibratory driving with a purely vertical excitation;
- the Gentle Driving of Piles concept, which is an emerging technology that combines a vertical vibratory excitation with a high-frequency torsional shaking;
- the VibroJet technique, combining controlled inner jetting with axial vibration

Additionally, the project will assess the implications for decommissioning at the end of service life.

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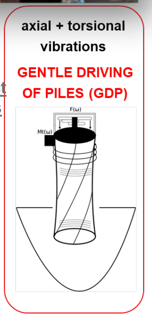
Installation Technologies

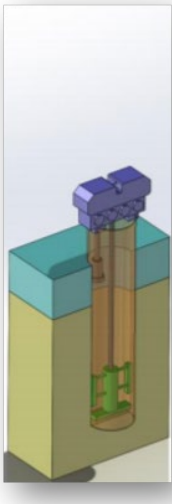
Axial Vibro Tool

https://www.cape-holland.com/

GDP Shaker

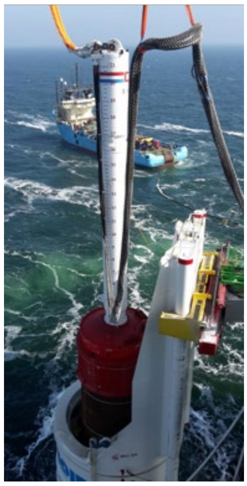
https://grow-offshorewind.nl/project/gentle-driving-of-piles





VibroJet

https://www.gbmworks.com/



Impact Hammer (As reference case)

https://www.ihciqip.com/en/products/piling-equipment/hydrohammer

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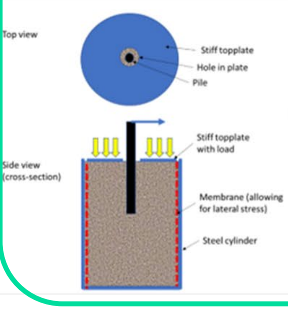
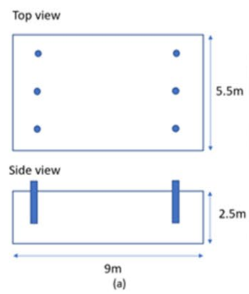
SIMOX test campaign





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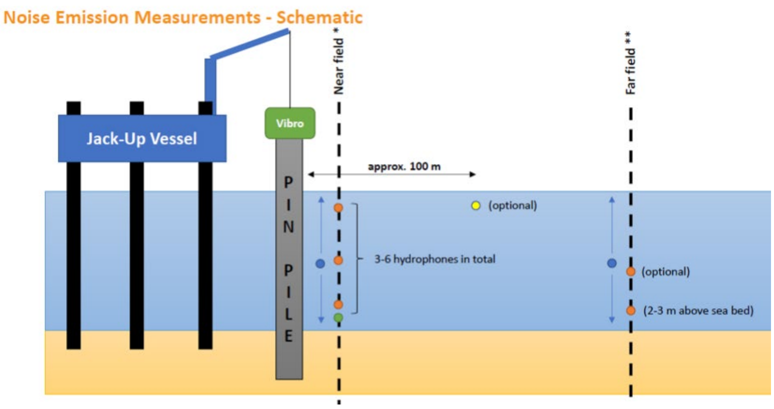

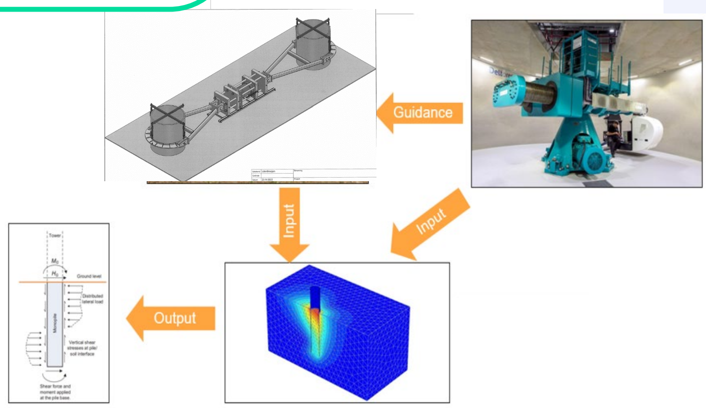

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SIMOX test campaign – scaled lab testing

Filling tank with excavator

Compaction with vibrating needles

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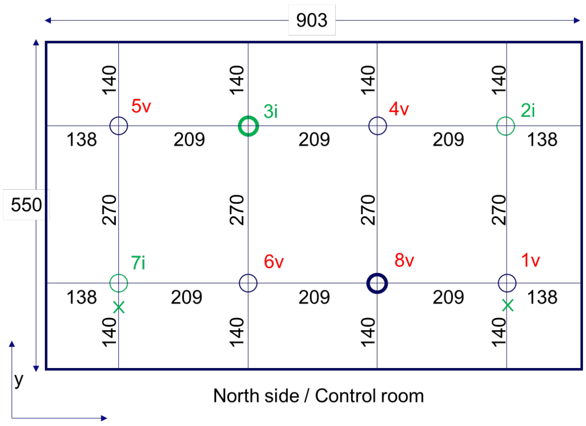
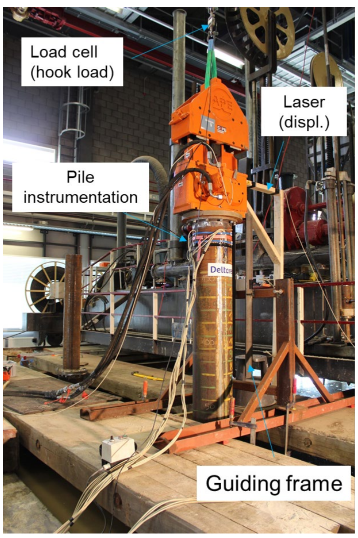
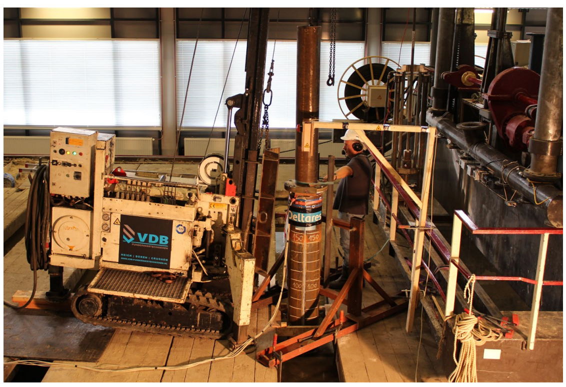
SIMOX test campaign – scaled lab testing

- Per tank: 2 impact, 6 vibro or 3 impact, 5 vibro
- Variables:
  - Impact: fall height, weight
  - Vibro: frequency, lowering speed of crane







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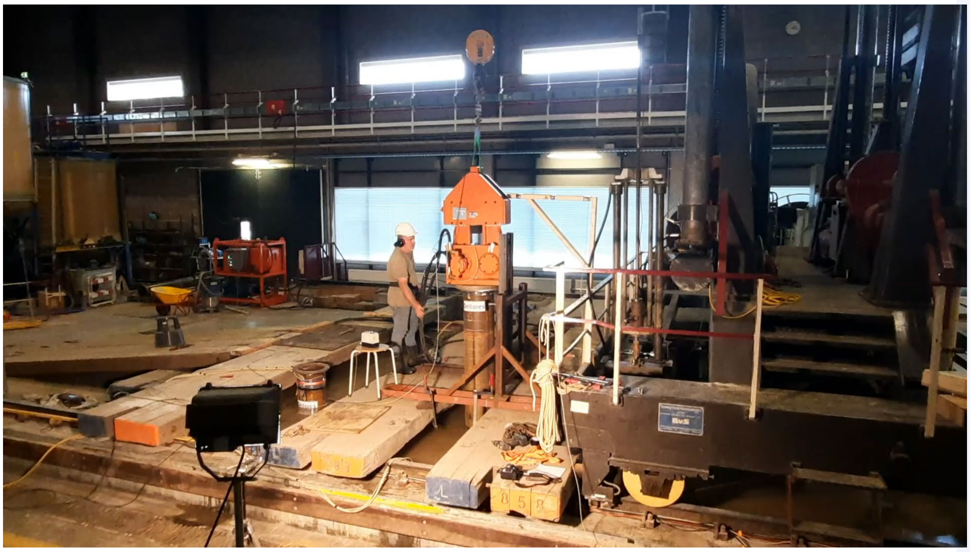
SIMOX test campaign – scaled lab testing



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Decommissioning offshore wind farms

- Almost 30% of the total installed wind turbine capacity in Europe is older than 15 years
- By the end of service life, wind farm operators need to decide between the **extension of the asset lifetime, repowering or decommissioning** the site
- Nevertheless, regardless the final service life of a wind turbine, **decommissioning will always happen**

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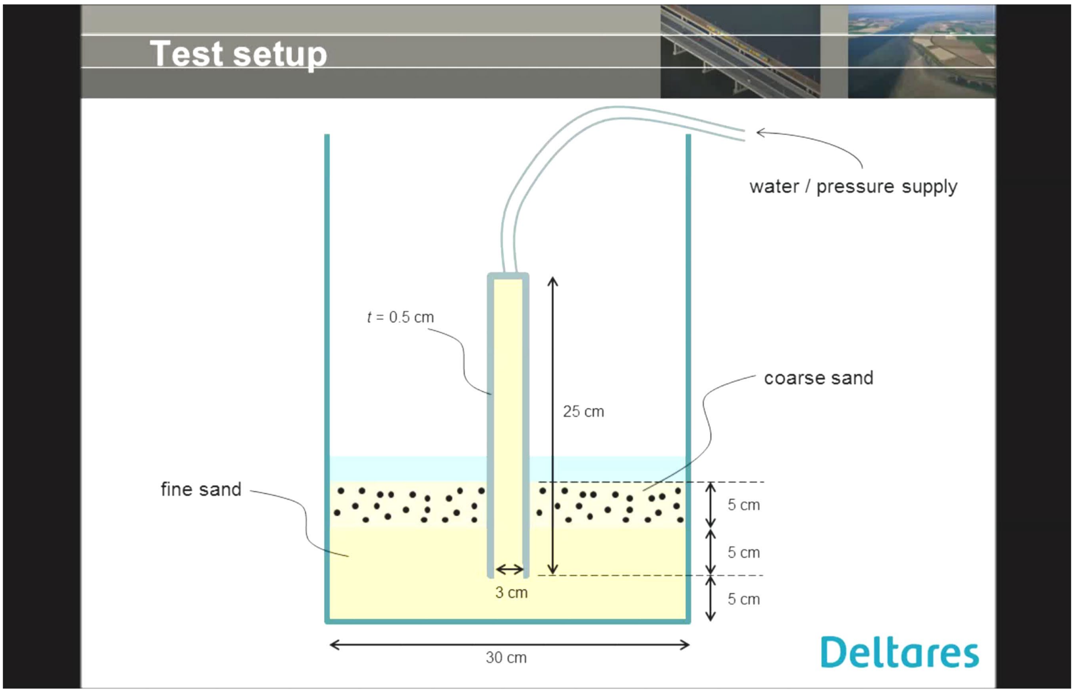
Hydraulic Pile Extraction – sustainable decommissioning



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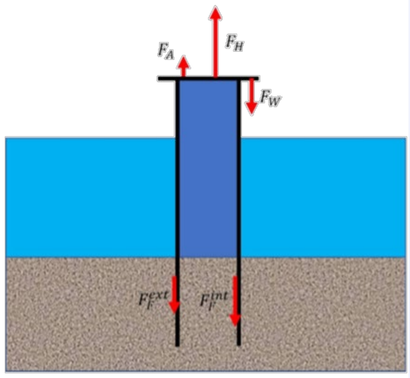
Jan De Nul



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JIP HyPE-ST (Hydraulic Pile Extraction-Scale Tests)

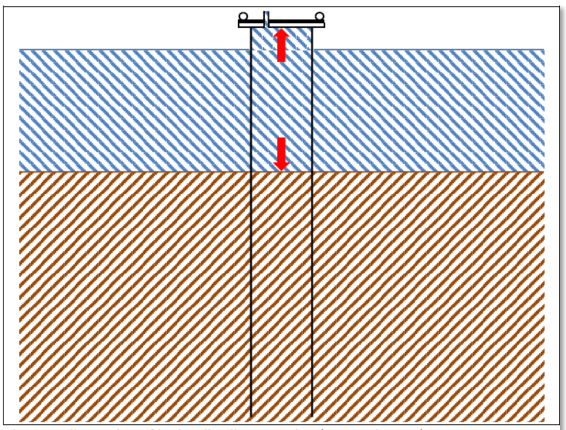


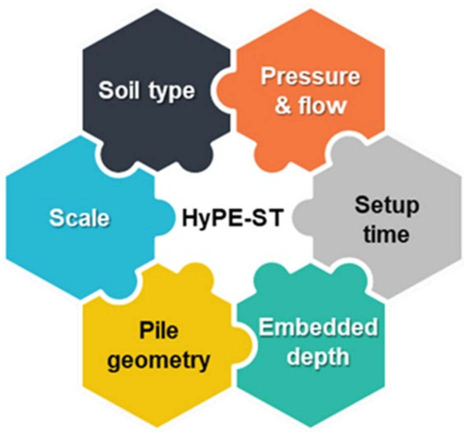
Figure 2. Illustration of hydraulic pile extraction (source: innogy)

HyPE benefits:

- **Circular & Sustainable**
- **Cheaper** vessels
- **Simple** equipment
- More **scrap value**

JIP goal:

- **Proof of concept**
- **TRL 4 to TRL 5**
- In-depth understanding of the process



Identify, understand and quantify **soil-pile-interaction mechanisms** during application of **hydraulic overpressure** to extract a (mono)pile under different boundary conditions in a controlled environment (small-scale)

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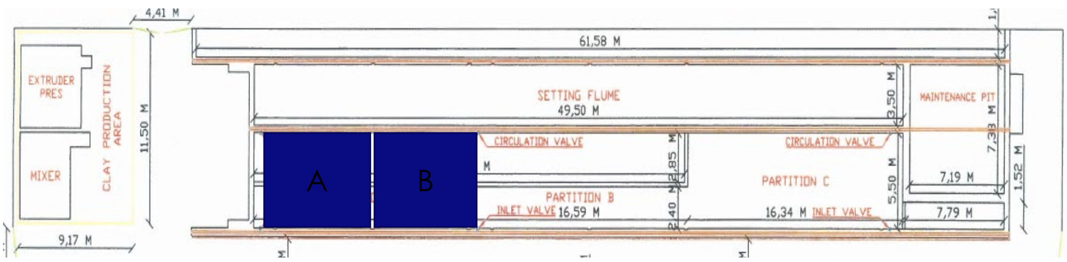
Larger scale: Water-Soil-Flume (Water-Grond-Goot)



Water Soil Flume

- **Water AND soil** handling and conditioning infrastructure
- Allows testing **larger dimensions**
- Still **laboratory environment**

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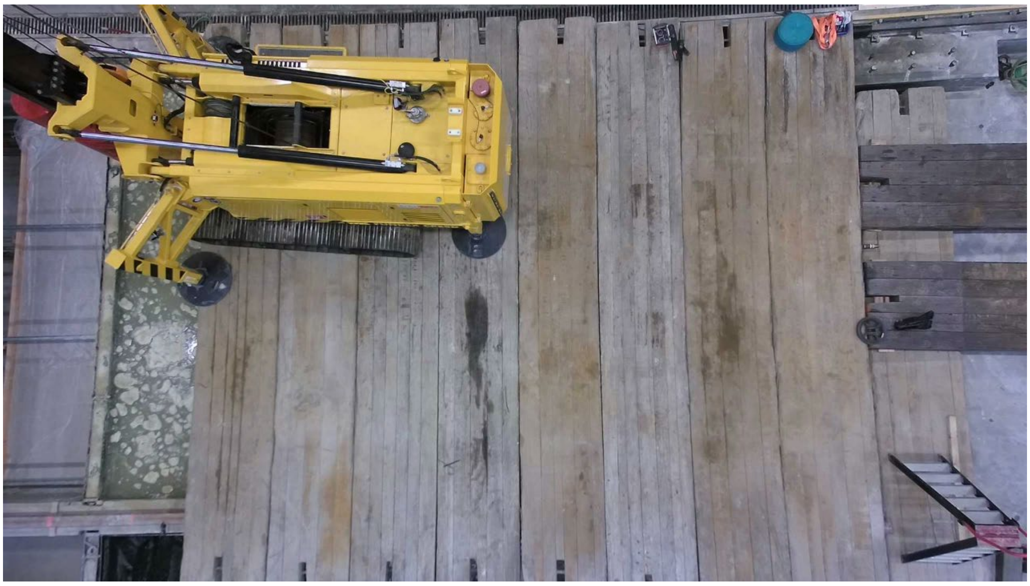
Preparing clay bed

Preparing sand bed

Test piles

Pile installation



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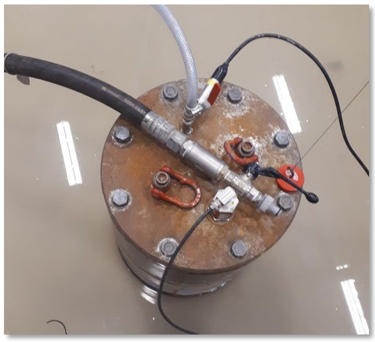
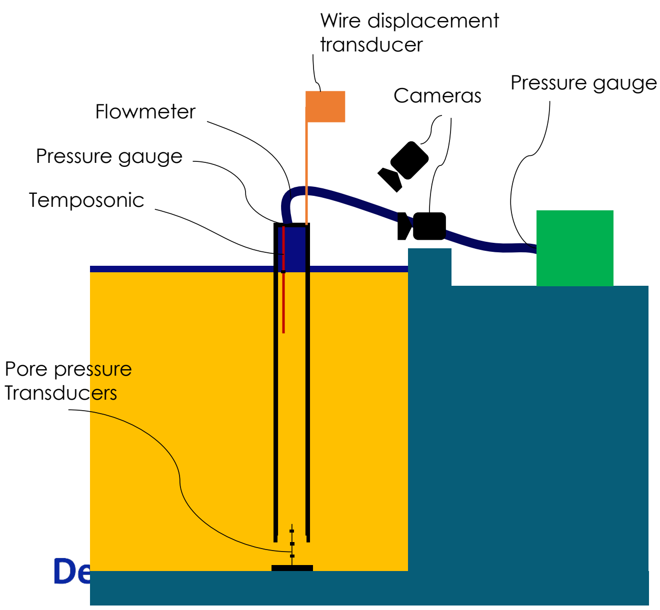
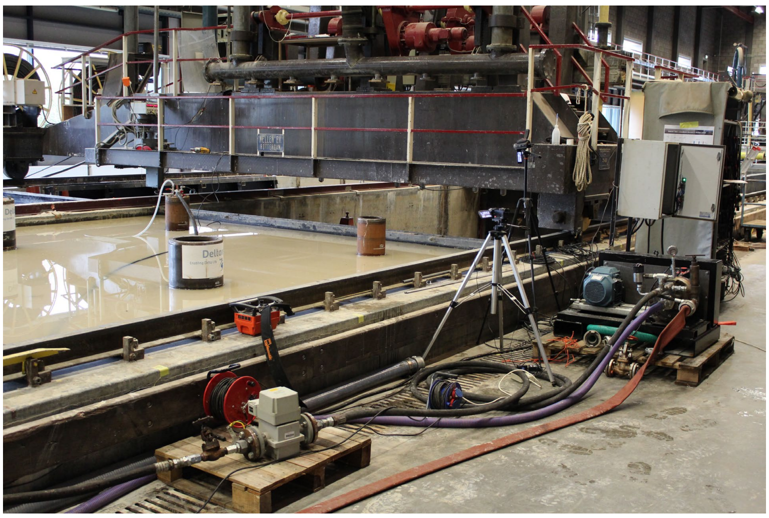
Hydraulic extraction - measurements







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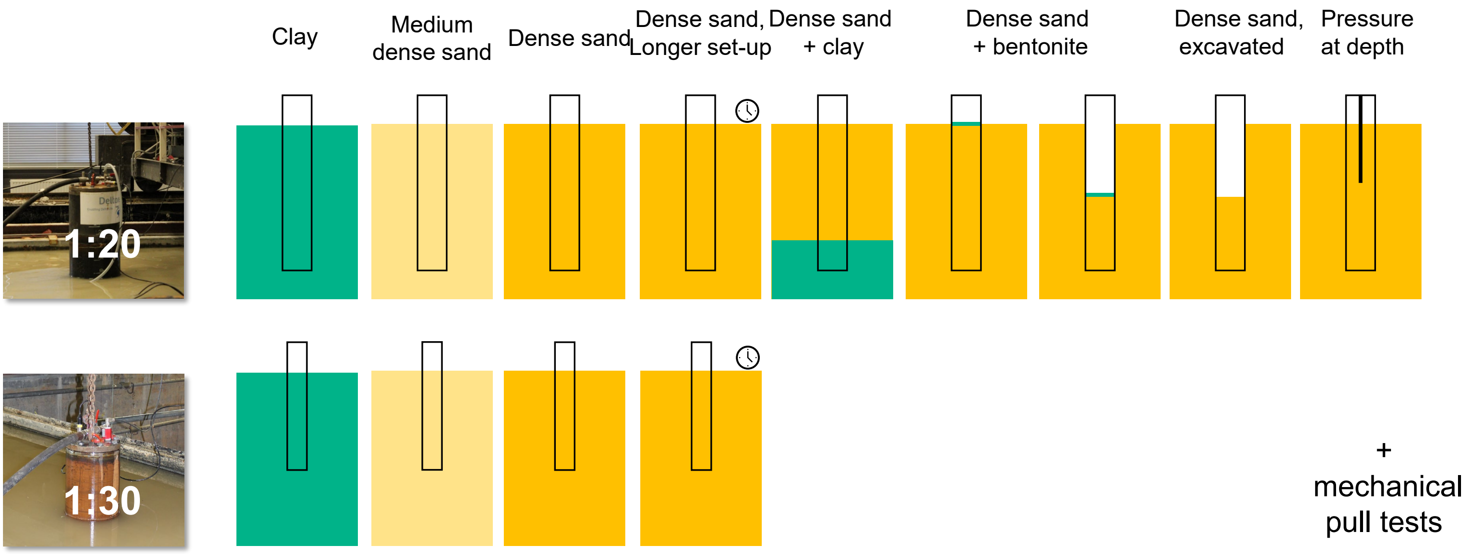
Overview



Scale	1:20	1:30
Outer diameter [mm]	406.4	273.0
Wall thickness [mm]	10	6
Length [mm]	2400	1750
Embedded depth [m]	2.0	1.33

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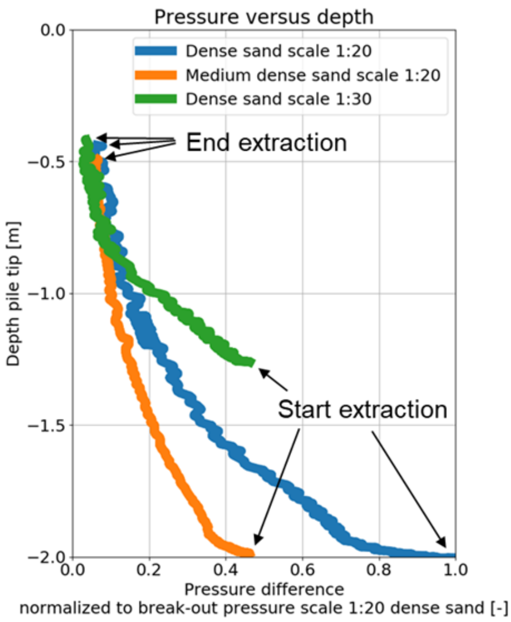
Hydraulic extraction - experiment



Deltares

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