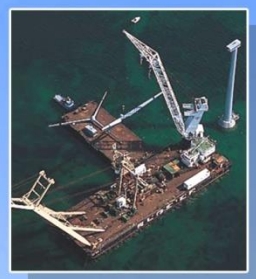


Renewable Resources

The Vital Issues of Offshore Wind Farm Development in Taiwan

PRESENTER：CHU-KUAN LIN

CECI 台灣世曦 工程顧問股份有限公司

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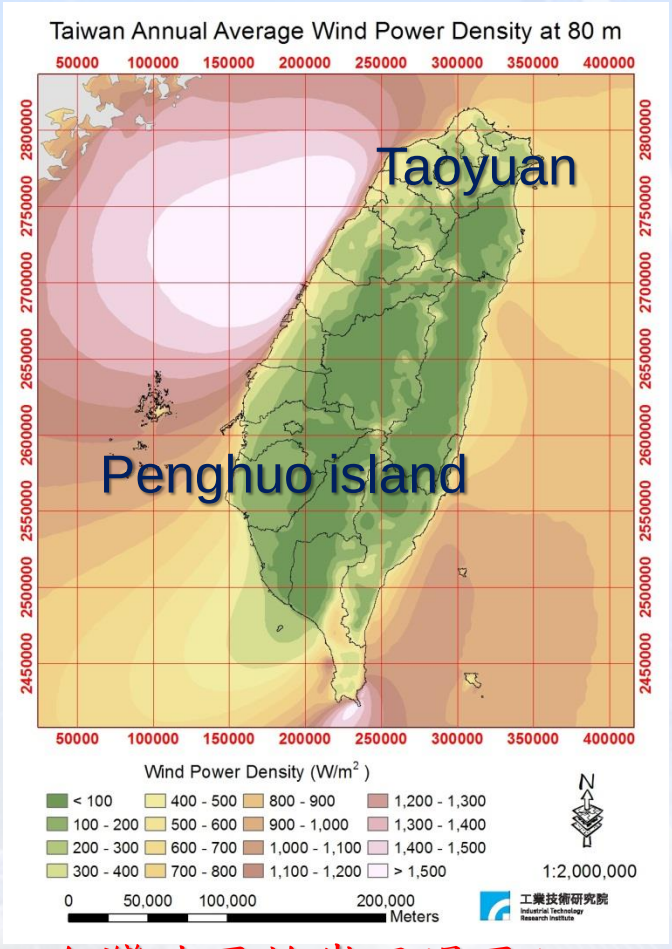
Content

1.Introduction

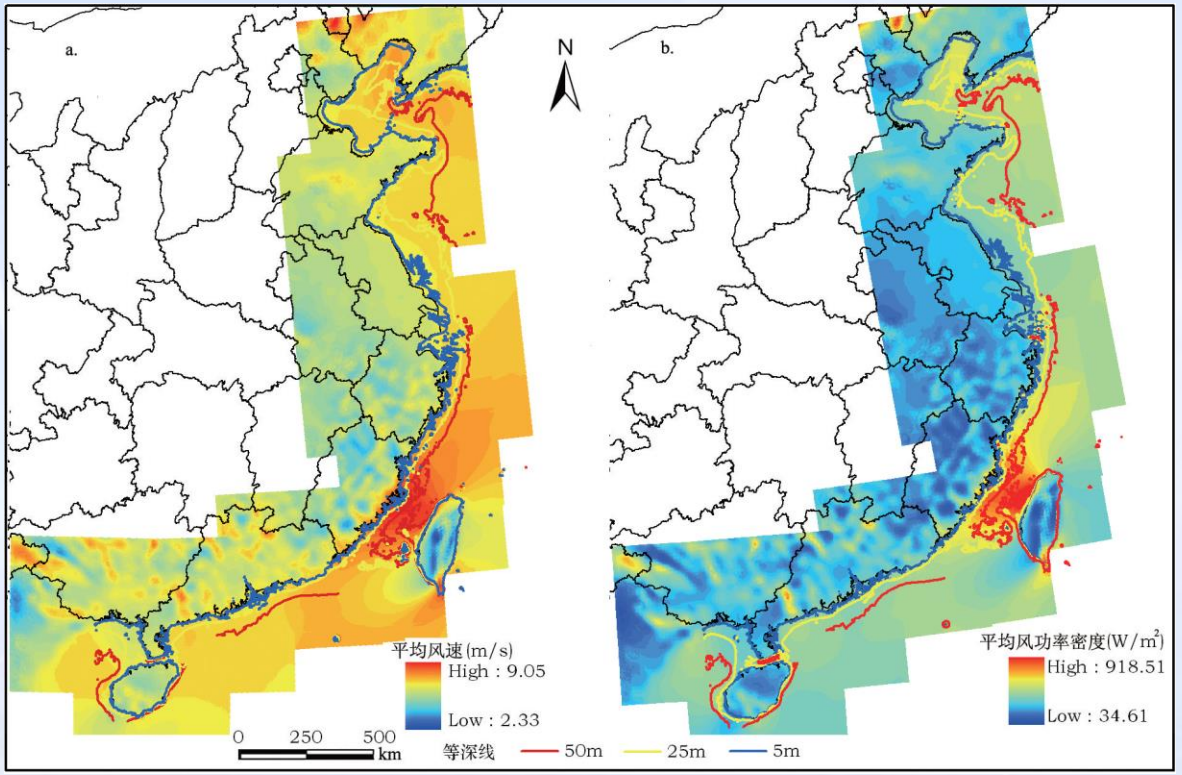
- It started from about 25years ago in North Sea, Denmark
- Normally in Array Layout of Wind Turbines on sea.
- Three main parts: wind turbine generation (WTG), substructure & foundation, Electrical power transport system.

1. Introduction

According to the evaluation standard by National Renewable Energy Laboratory (NREL) USA, if the average wind power density is larger than 400 w/m2 at 50m height. It could be said a plentiful and potential for developing wind energy.



台灣地區離岸風場區位

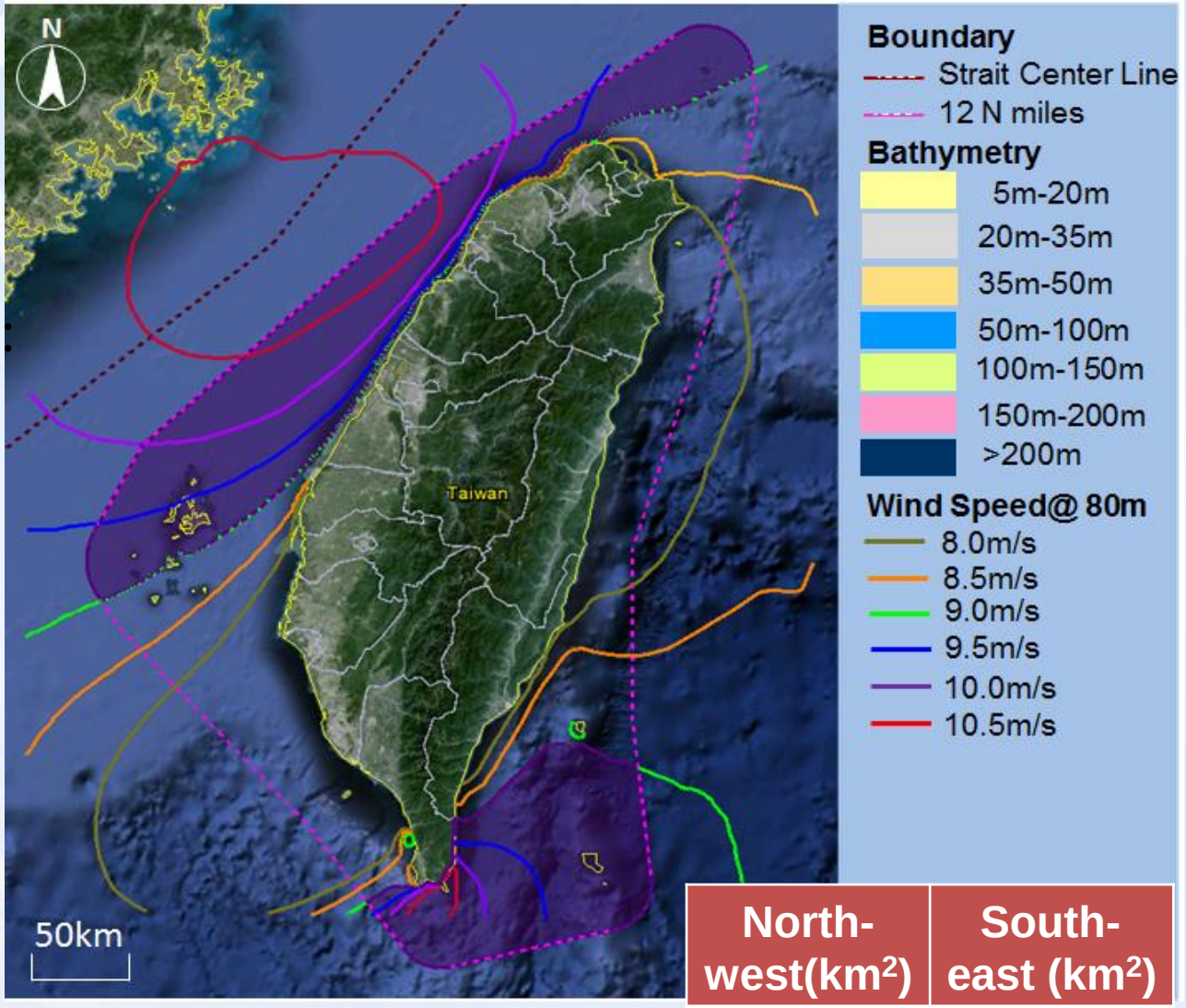


Based on Industrial Technical Research Institute (ITRI) research result , the wind power density at 80m height in Taiwan Strait , the potential wind energy distribution (x100w/m^2) area

1. Introduction

- **Criteria ：**
- In territory ：
  ＜12 Nautical mile
- Wind energy density ：
  ＞800W/m²
- Average speed：
  ＞9m/s

The potential power will be 40GW

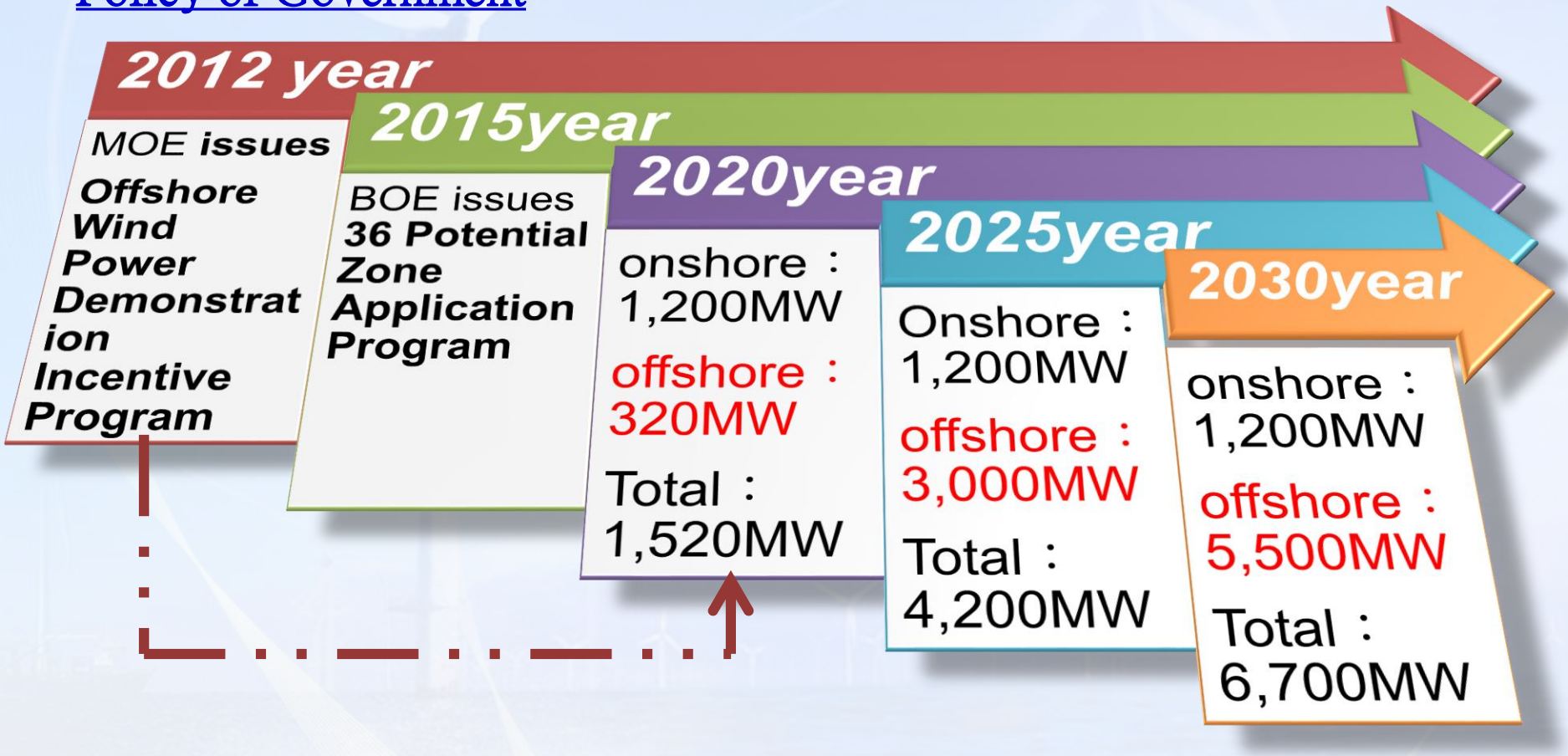


North-west(km²)	South-east (km²)
16,466	9,560

2.Milestone of offshore wind Farm Development in Taiwan

2. Milestone of offshore wind Farm

- Policy of Government



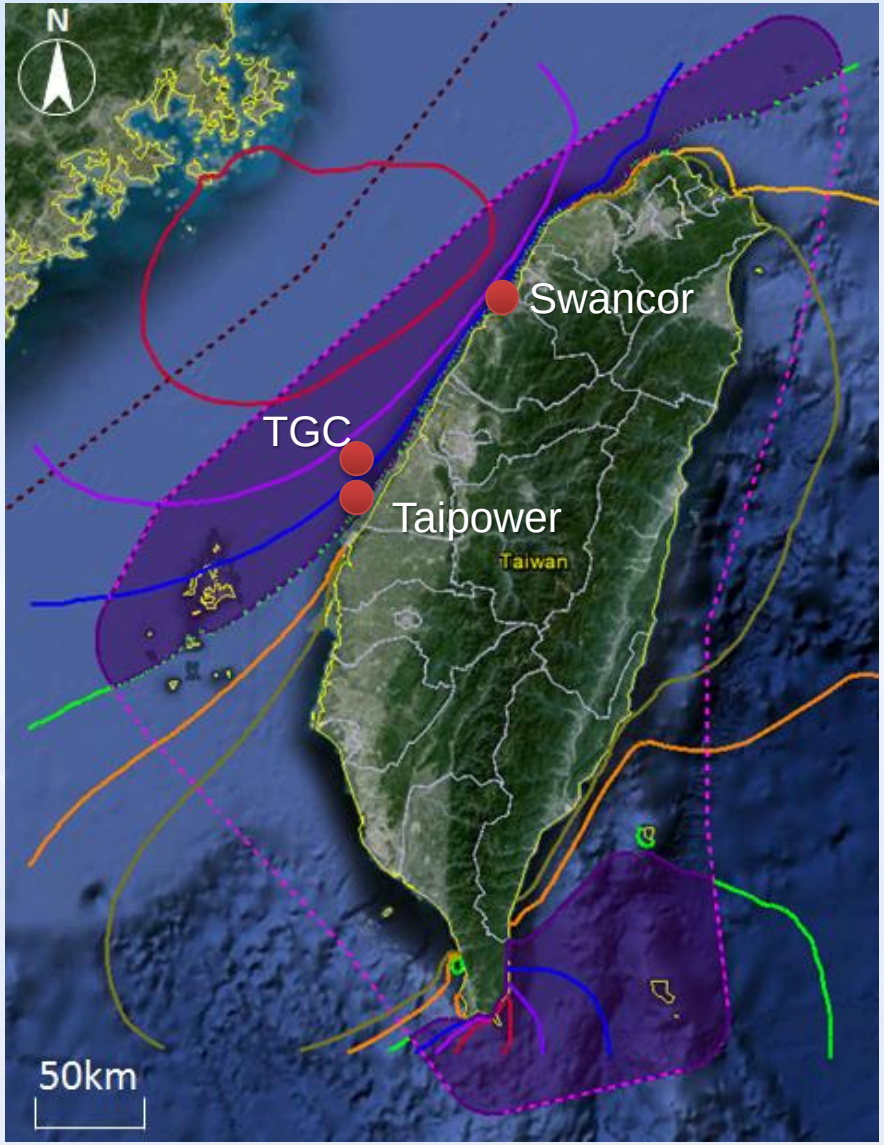
Onshore Contract rate for 20 years:NT$2.6900/kWh(2015年）
Offshore Contract rate for 20years:NT$5.7405/kWh(2015年）

2. Milestone of offshore wind Farm

Demonstration Incentive Program

2016：complete 2 pilot turbines
2020：complete demonstration wind farm

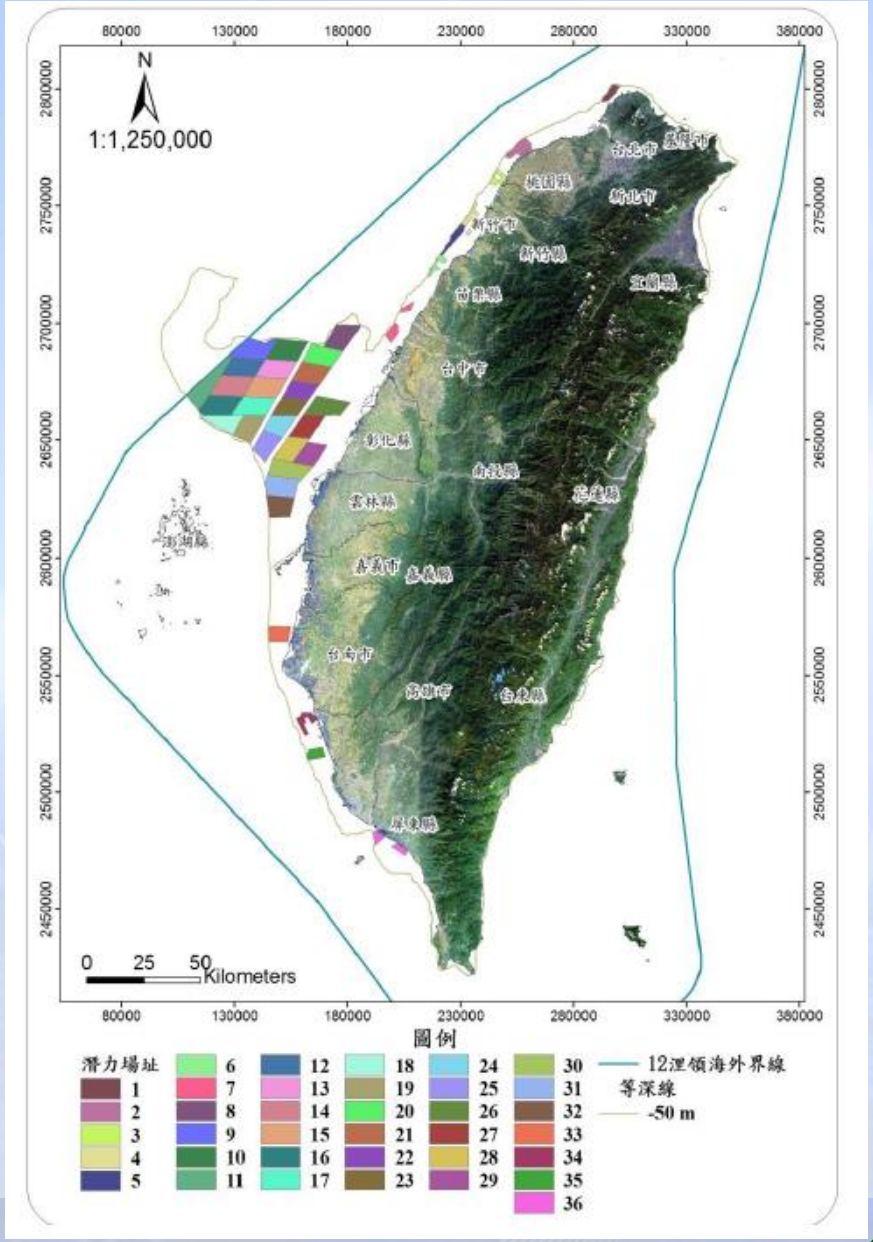
- Swancor：
  - Sep. 2015, completed Met mast (CECI design and supervision)
  - Dec. 2020, 32 Demonstration 4MW turbines=128MW
- TGC：
  - Sep. 2015 completed Met mast (CECI design and supervision)
  - Dec. 2016 2 pilot 4MW turbines=8MW
- Taipower：
  - Nov. 2015 completed Met mast



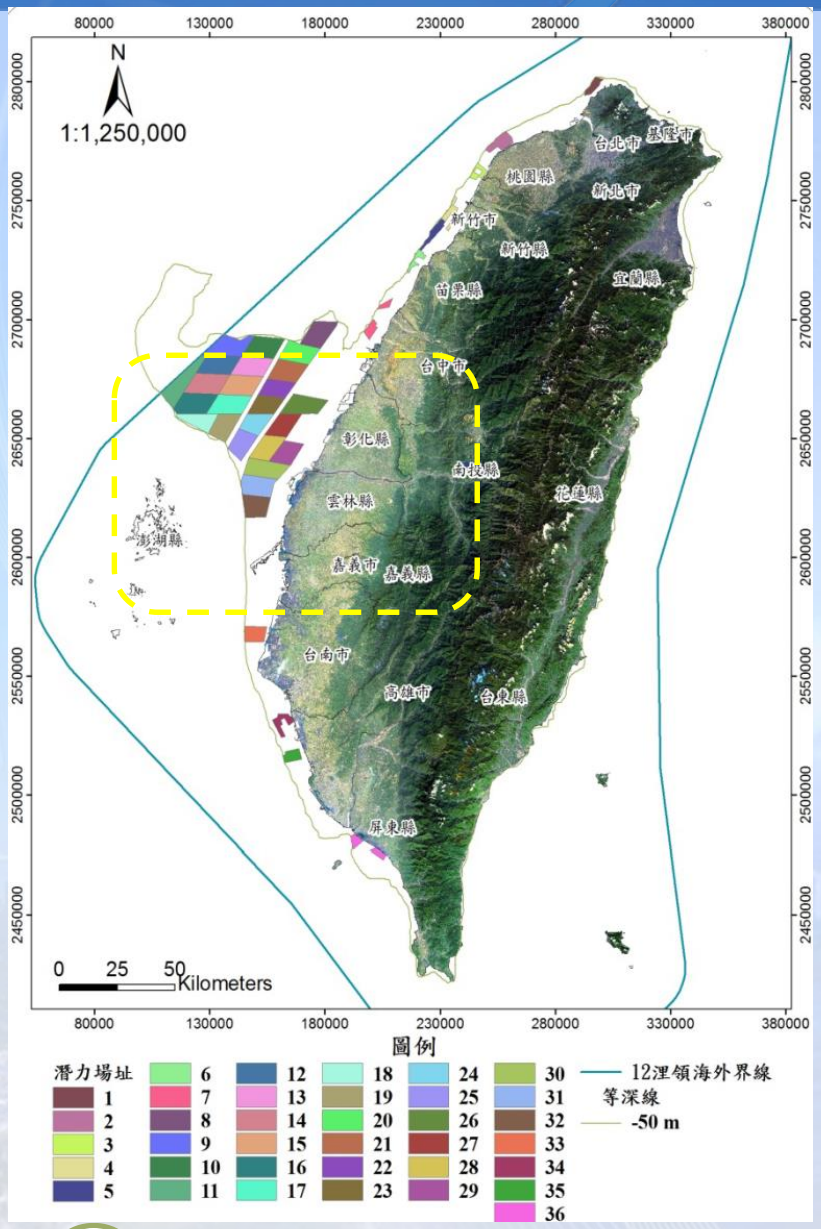
2. Milestone of offshore wind Farm

Bureau of Energy (BOE) announced the second phase program in July 2nd, 2015. and issues 36 Potential Zones

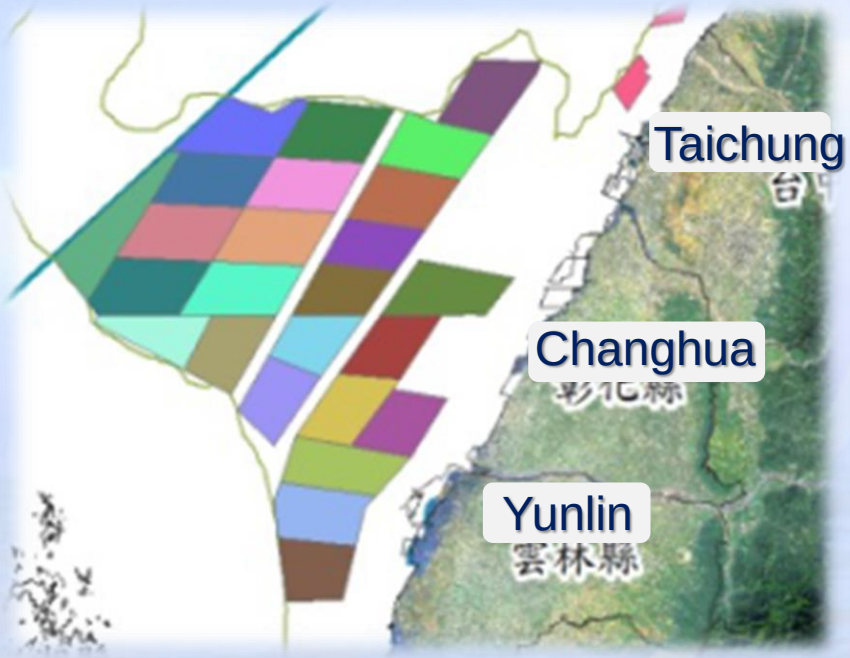
Purpose:
To encourage the private company to joint the development of green energy.



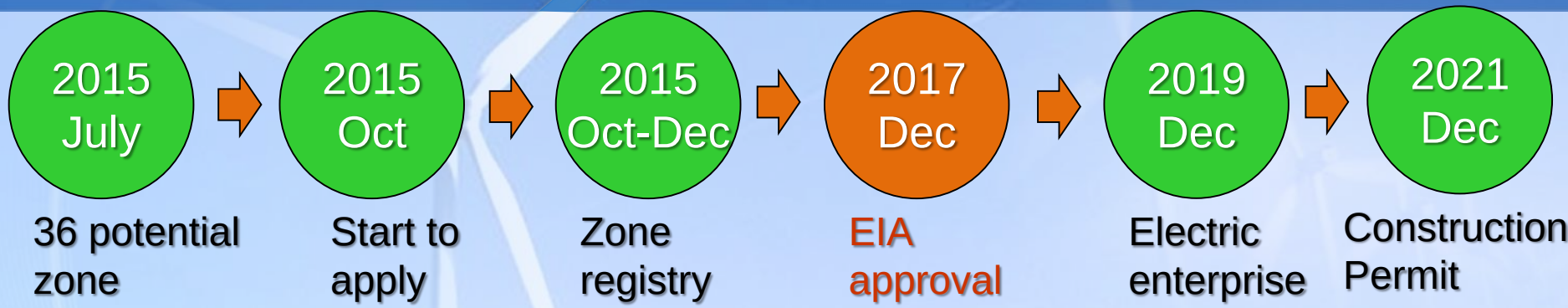
Taiwan Potential Offshore Wind Farm



- Water depth is less than 50m for all zones
- 25 zones located at Chunghua open sea



2. Milestone of offshore wind Farm



1. Accoring to Electric Enterprise regulation, the private capital of developer shall be higher than 5% of CAPEX.
2. Power generation shall be larger than 100MW and the density shall be larger than 5MW/km2 for each wind farm application.
3. Other necessary documents
   - ✓Financial certification
   - ✓Preliminary layout of wind farm
   - ✓Constrains statement from related authorities

Timeline of Development of offshore wind farm

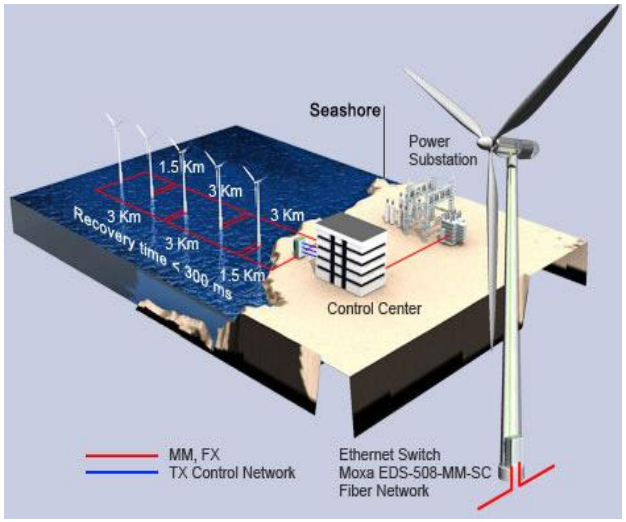
Years	2016	2019-2020	2021-2025	2026-2030	2031-2040	2040-(new +renew)
Accumulation (MW)	15	520	3000	5500	10500	11020=10500+520
Turbines(quantity)	4	104	600	1100	2100	2204=2100+104
Turbine Installation		50	100	100	100	150=100+50

註：1.Based on 5MW turbine module
2.Life cycle 20-25years, thus the decommission and renew turbine will be from 2040.
3.Strategy review every 5 years.

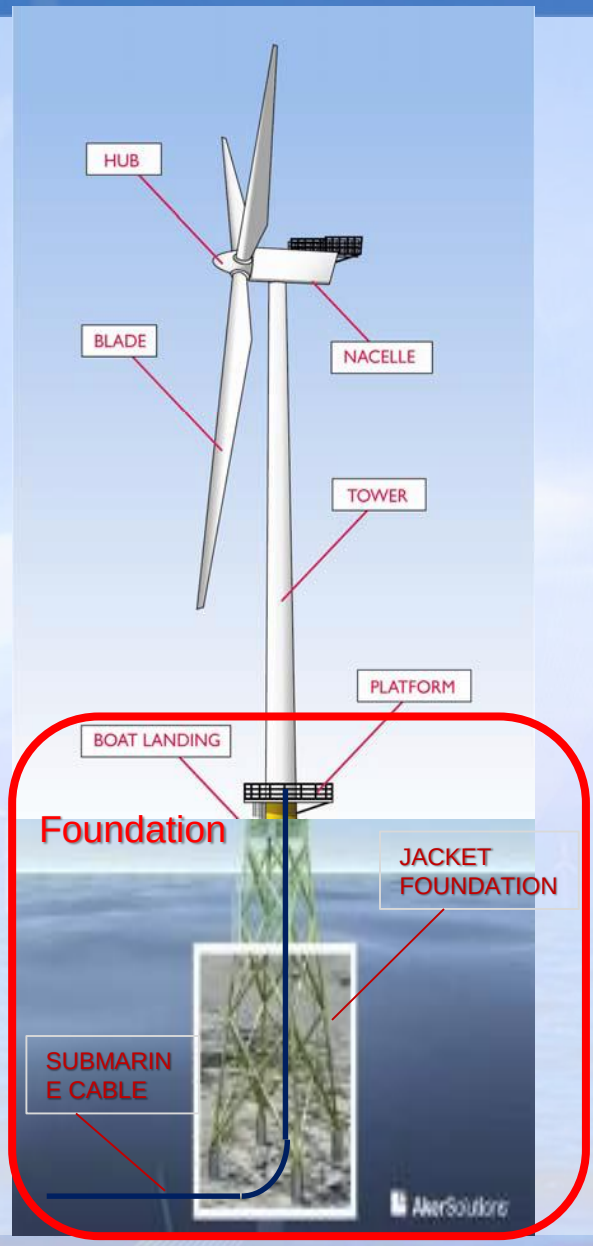
3. The Vital Issues of Planning and Design of offshore Wind Farm

Site survey
Met mast
Marine traffic
Typhoon
Soft soil of seabed
Earthquake & liquefaction
Supply chain problem
Installation vessel

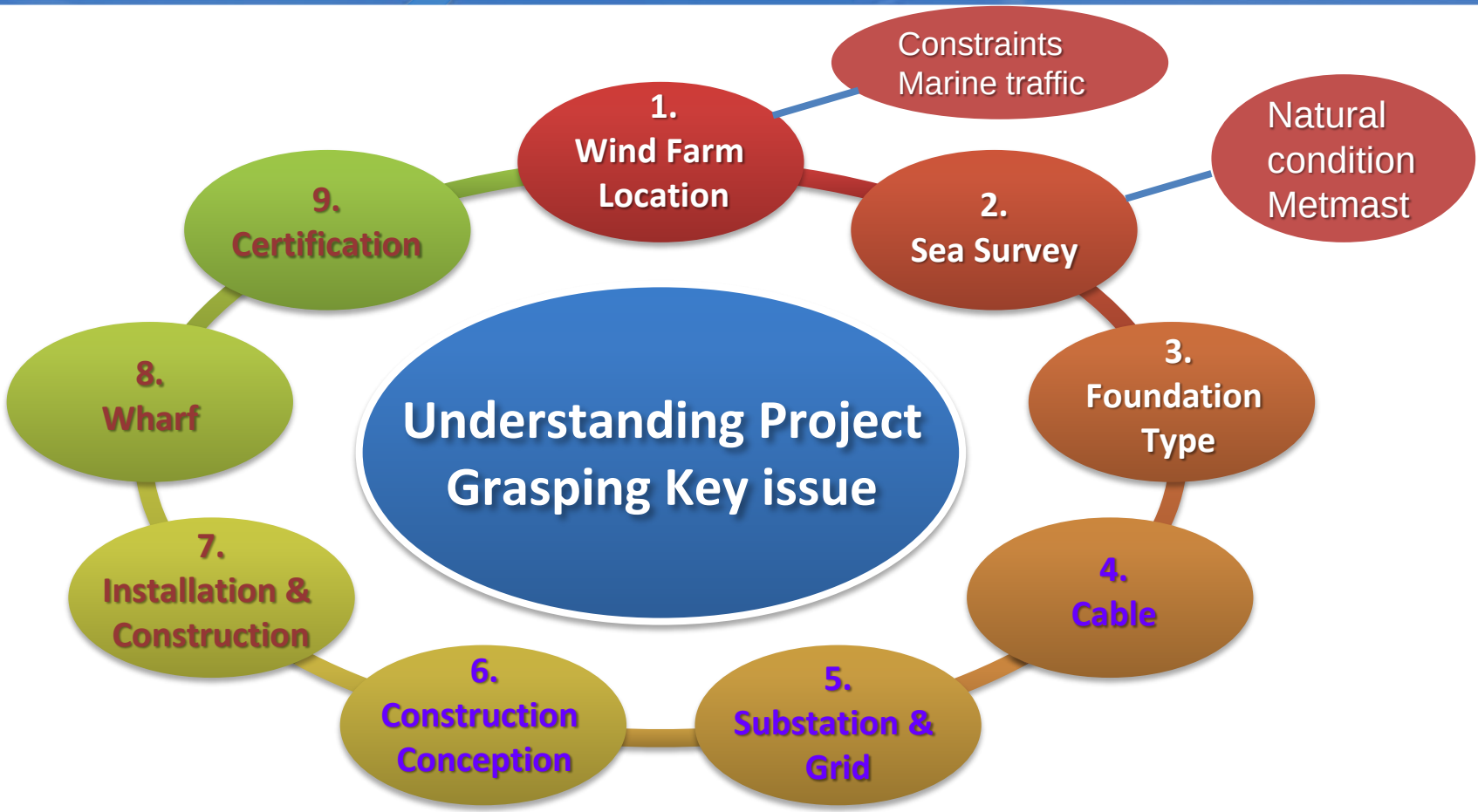
3. Vital Issues of Planning and Design



Item	Key Technique
MetMast	Tower、Foundation
Wind Turbine	Generators
	Tower
Support Structure & Foundation Design	Monopile
	Jacket
	Tripod, Twist
Electrical System Design	Coherence system of offshore wind turbine
	Submarine and Land Cables
	Offshore Substation
	Onshore Substation
Installation of wind turbine	Installation supervision
	Wharf of Logistics management
Construction Management	Ship deploy and management
	Wharf, Logistics
Operation & Maintenance	Wharf of Maintenance Base
	Development of Industry Park



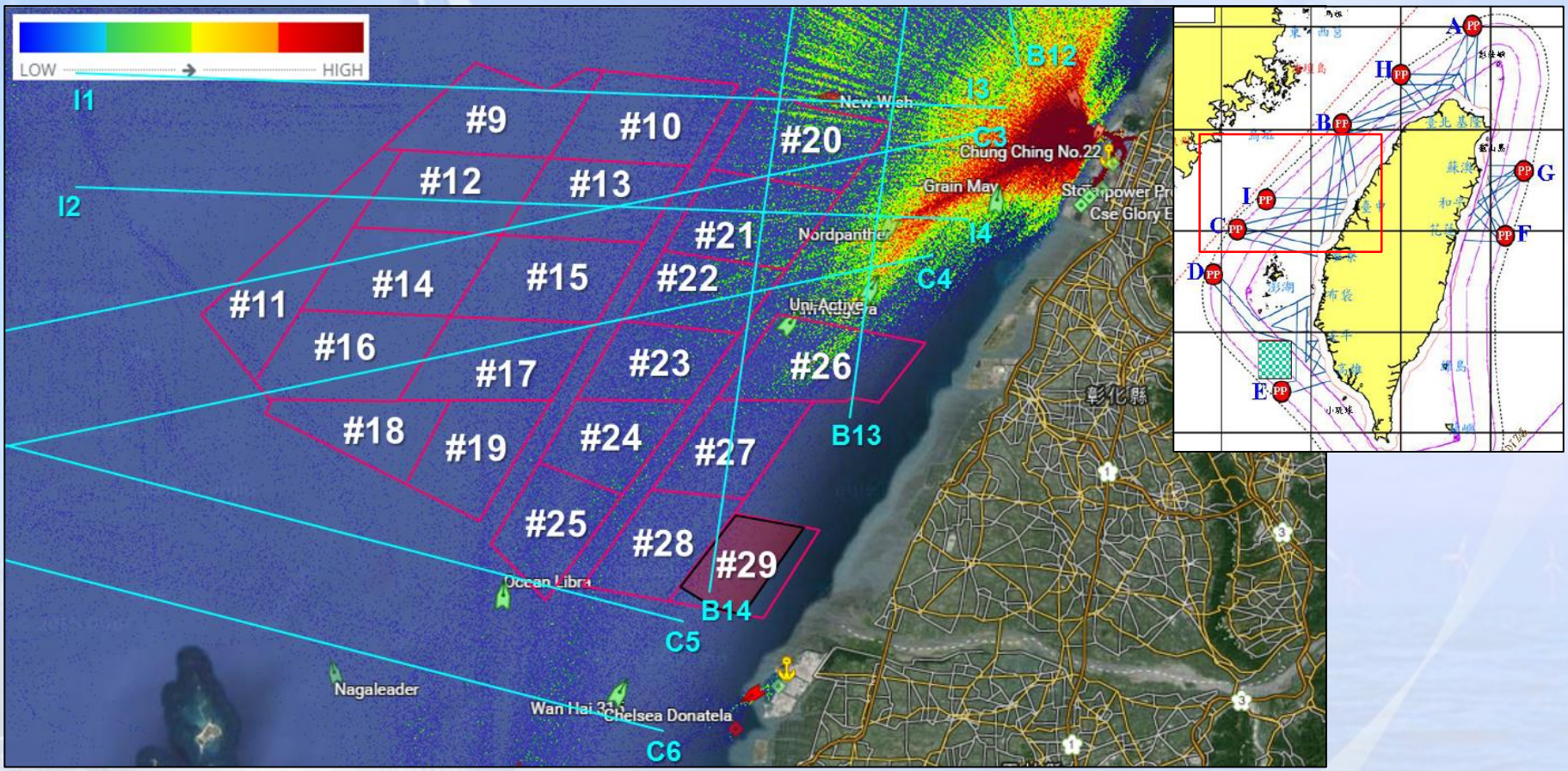
3. Vital Issues of Planning and Design



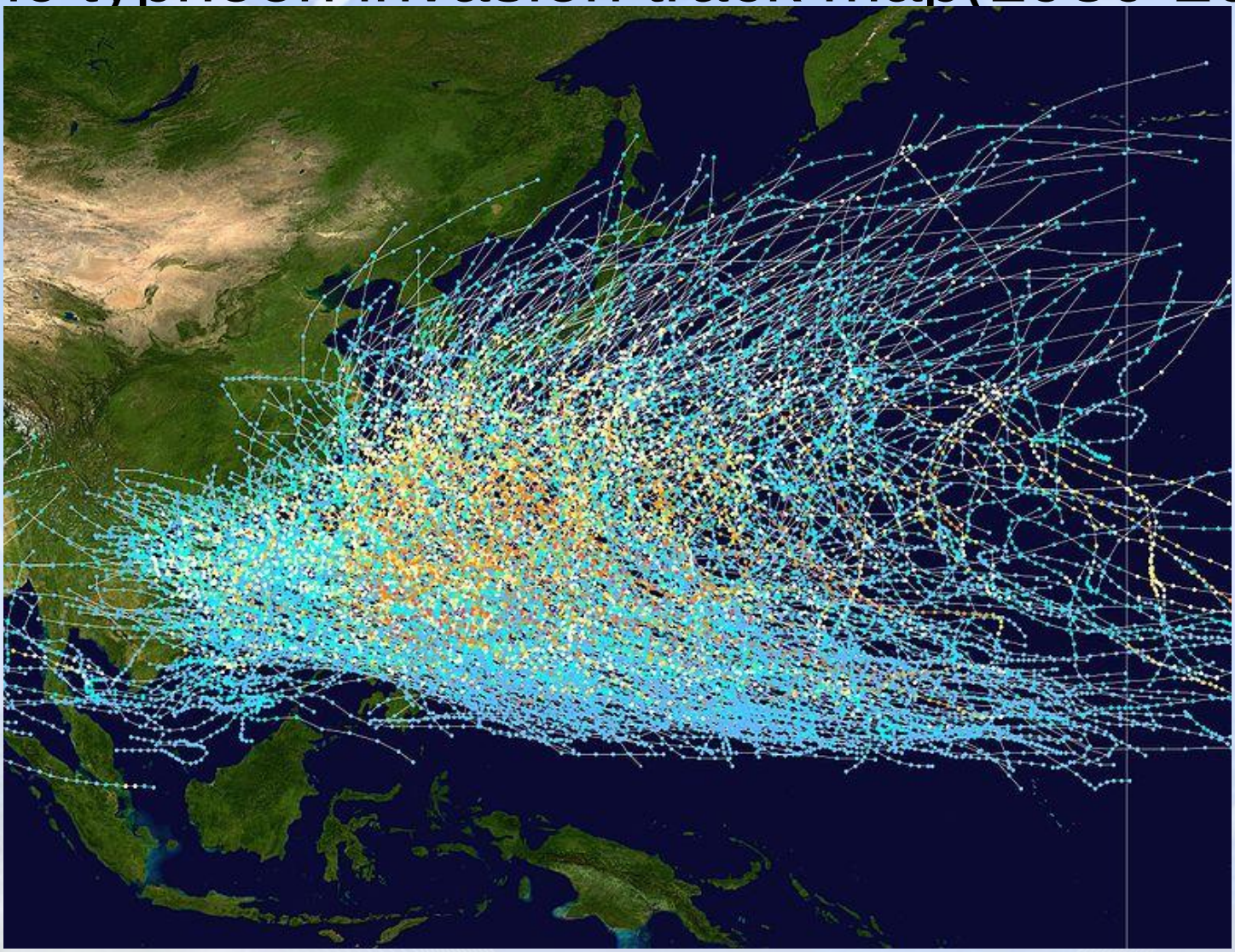
The Technical requirement

Coordinate the professional engineers (Hydrology, Harbor, Structure, Geotechnical, Electrical, Construction Supervision and Project Management) are necessary.

Navigation density analysis（Marine Traffic map）



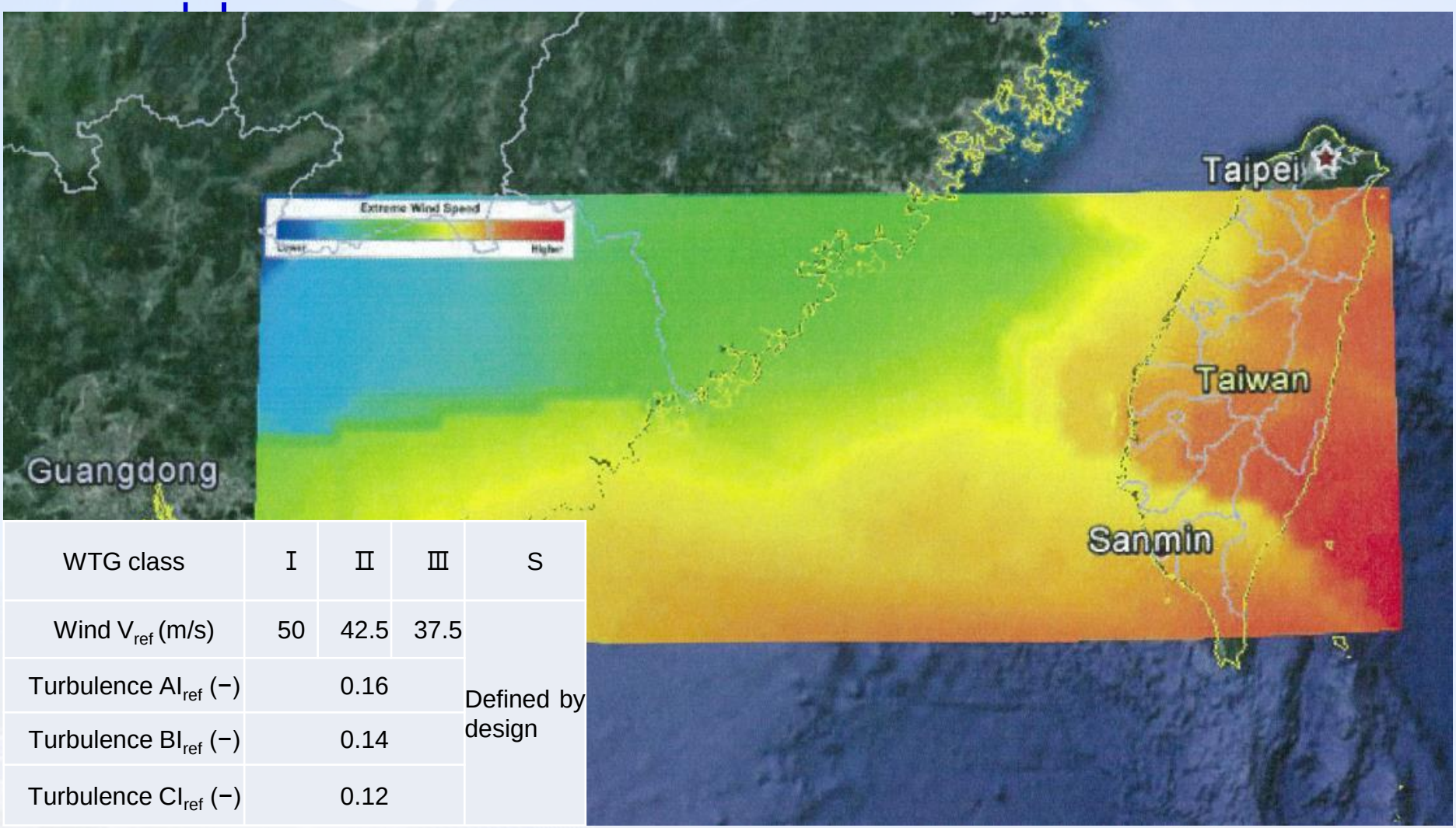
Tropic typhoon invasion track map(1980-2005)



Reference: NASA, USA

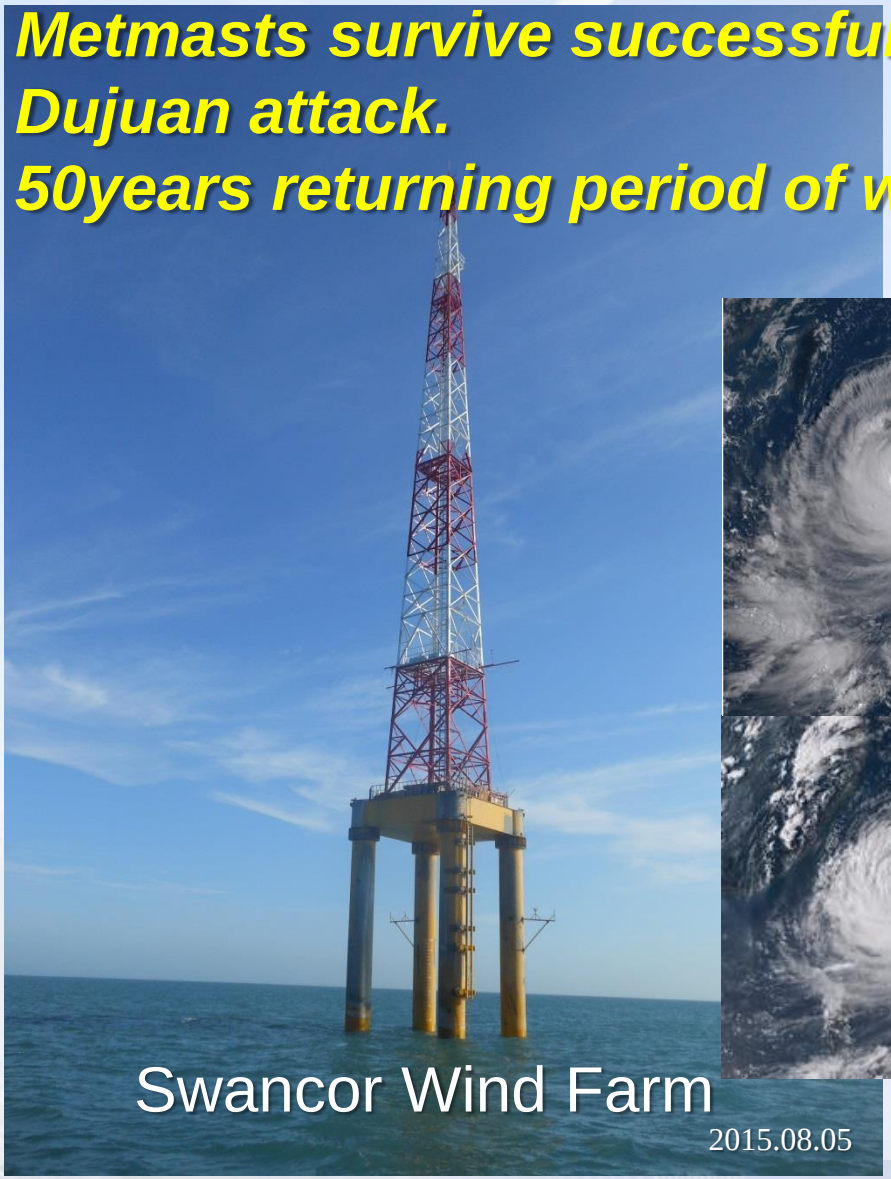
3. Vital Issues of Planning and Design

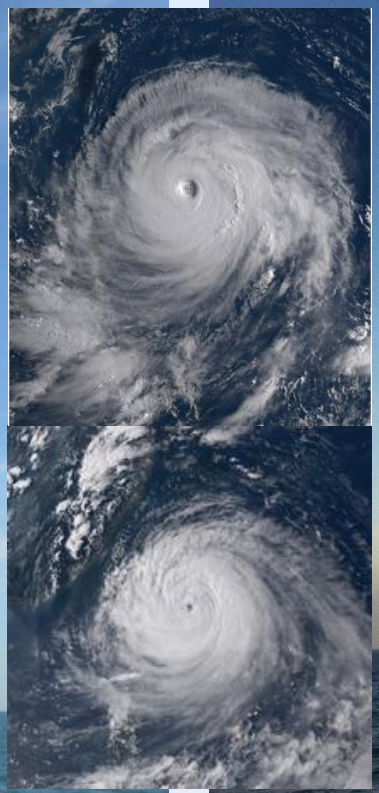
- **Typhoon**： IEC 61400-1 Class 1A > extreme wind load



WTG class	Ⅰ	Ⅱ	Ⅲ	S
Wind V_{ref} (m/s)	50	42.5	37.5	Defined by design
Turbulence AI_{ref} (−)	0.16			
Turbulence BI_{ref} (−)	0.14			
Turbulence CI_{ref} (−)	0.12			

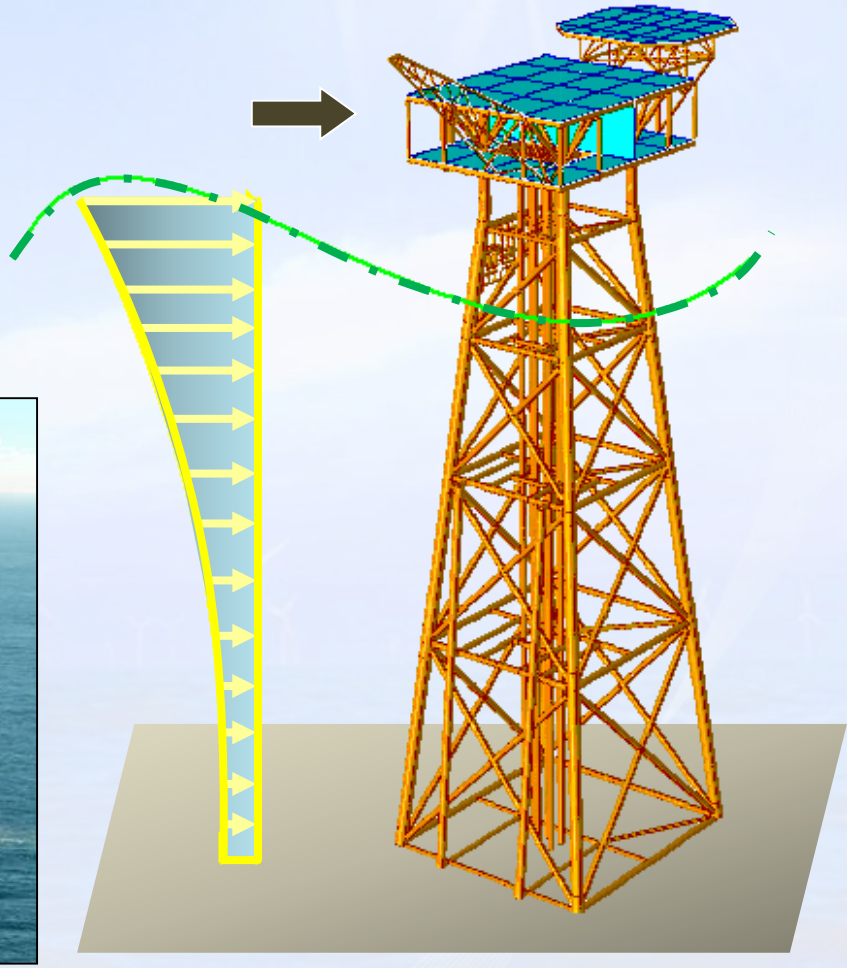
Metmasts survive successfully after Typhoon Soudelor, Dujuan attack.
50years returning period of wave Hs, Tp





Key Item of Design for Support Structure

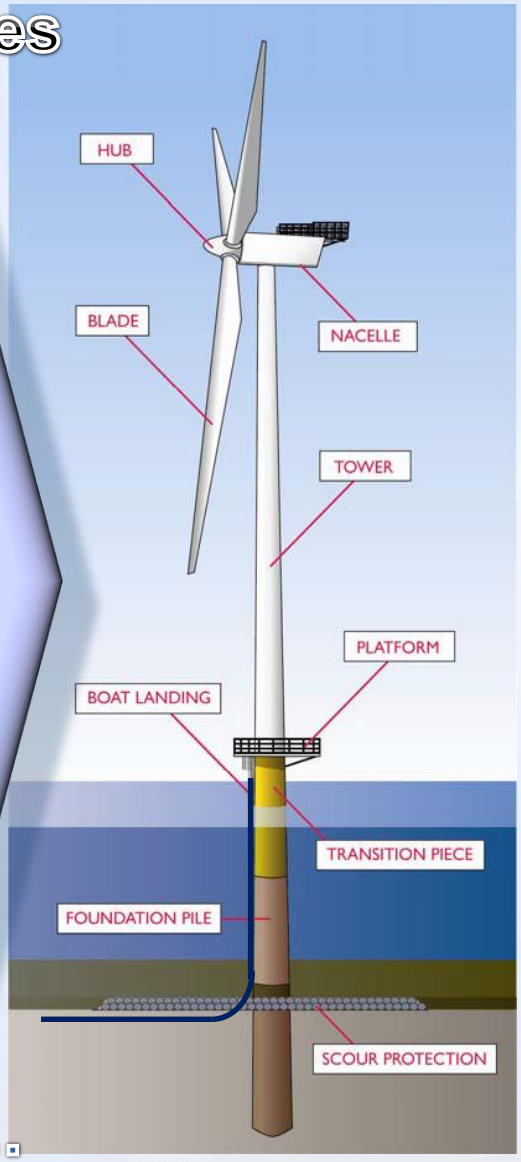
- Offshore Structure Analysis
- Pile Foundation Analysis
- Collapse Analysis
- Fatigue Analysis



3. Vital Issues of Planning and Design

DNV-OS-J101, GL Guidelines

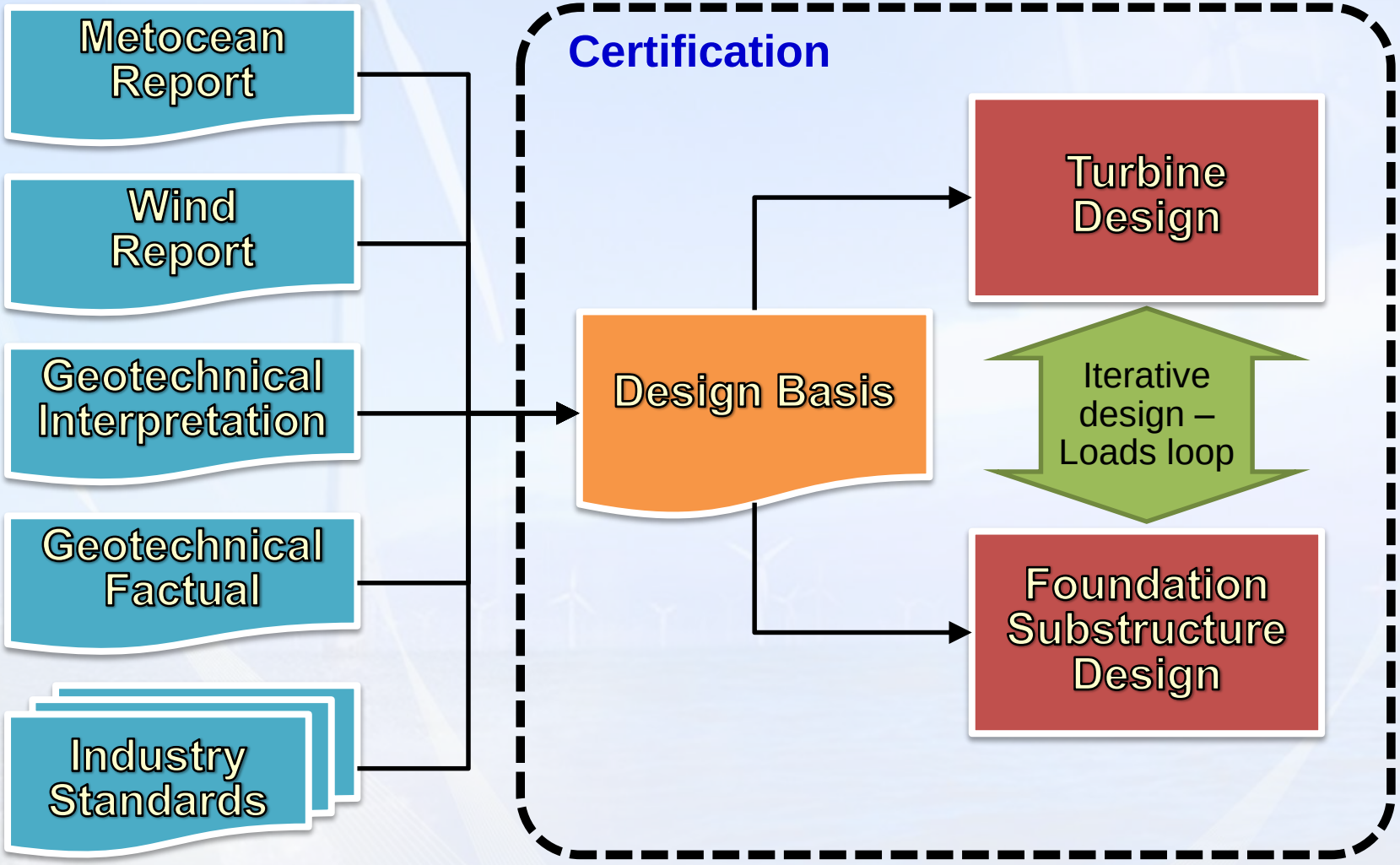
- Average Wind and gust load
- High Horizontal force & Moment
- Structure flexible
- Nonlinear wave load
- Dynamic response of structure
- Fatigue control
- Time domain analysis



IEC 61400-3, ISO 19902……

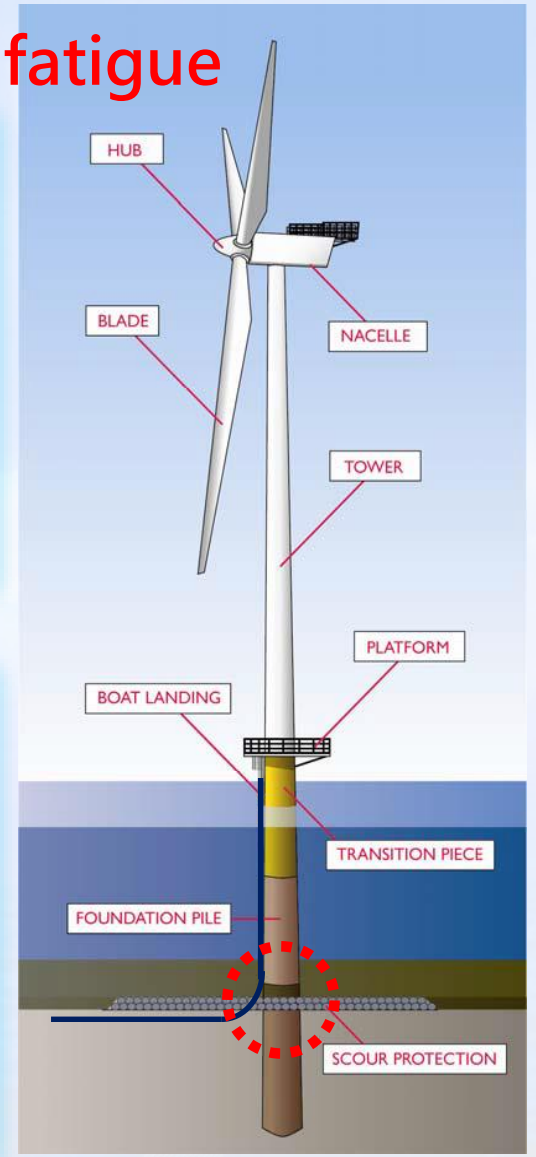
3. Vital Issues of Planning and Design

- **Front End Engineering Design(FEED)**：Setting Basis of Design (BOD) based on site survey result



3. Vital Issues of Planning and Design

- **FEED**：check **deformation**、**frequency**、**fatigue**



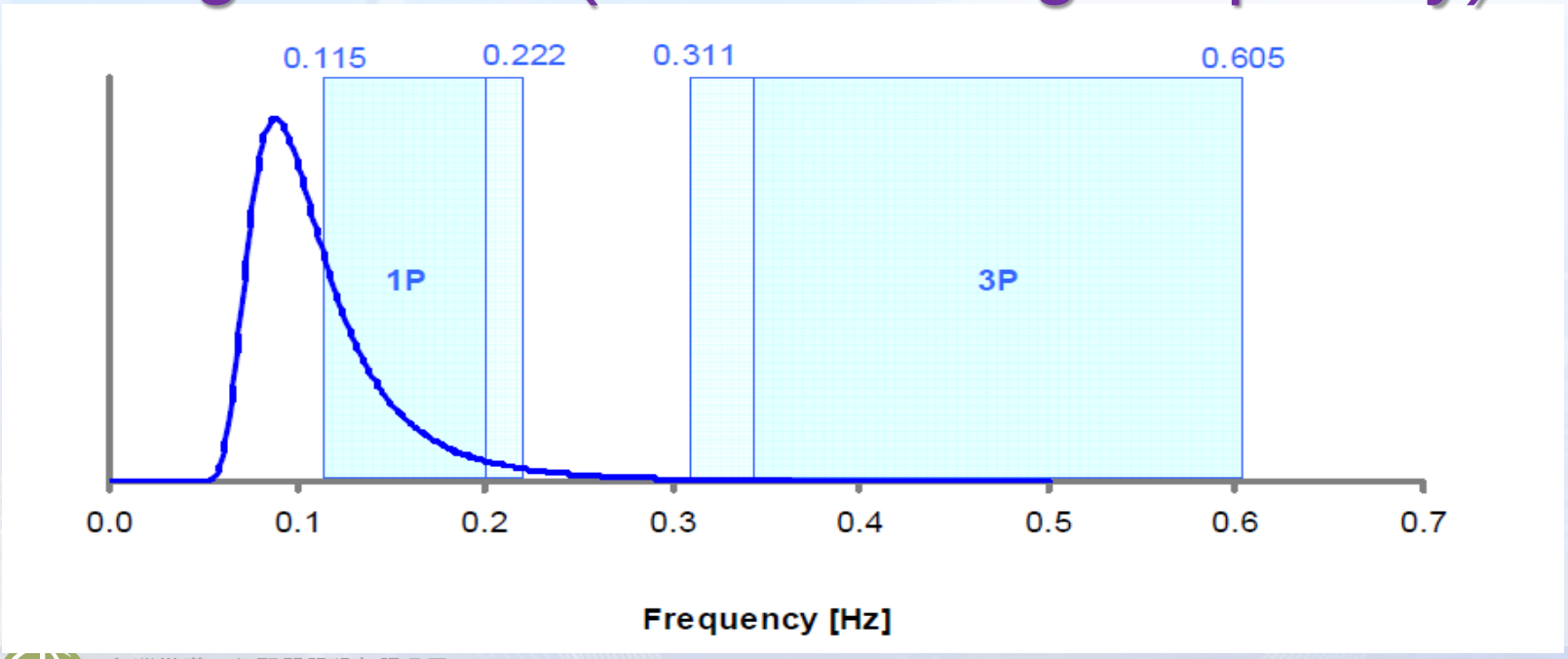
- DNV-OS-J101

Loading combination- 4 scenarios

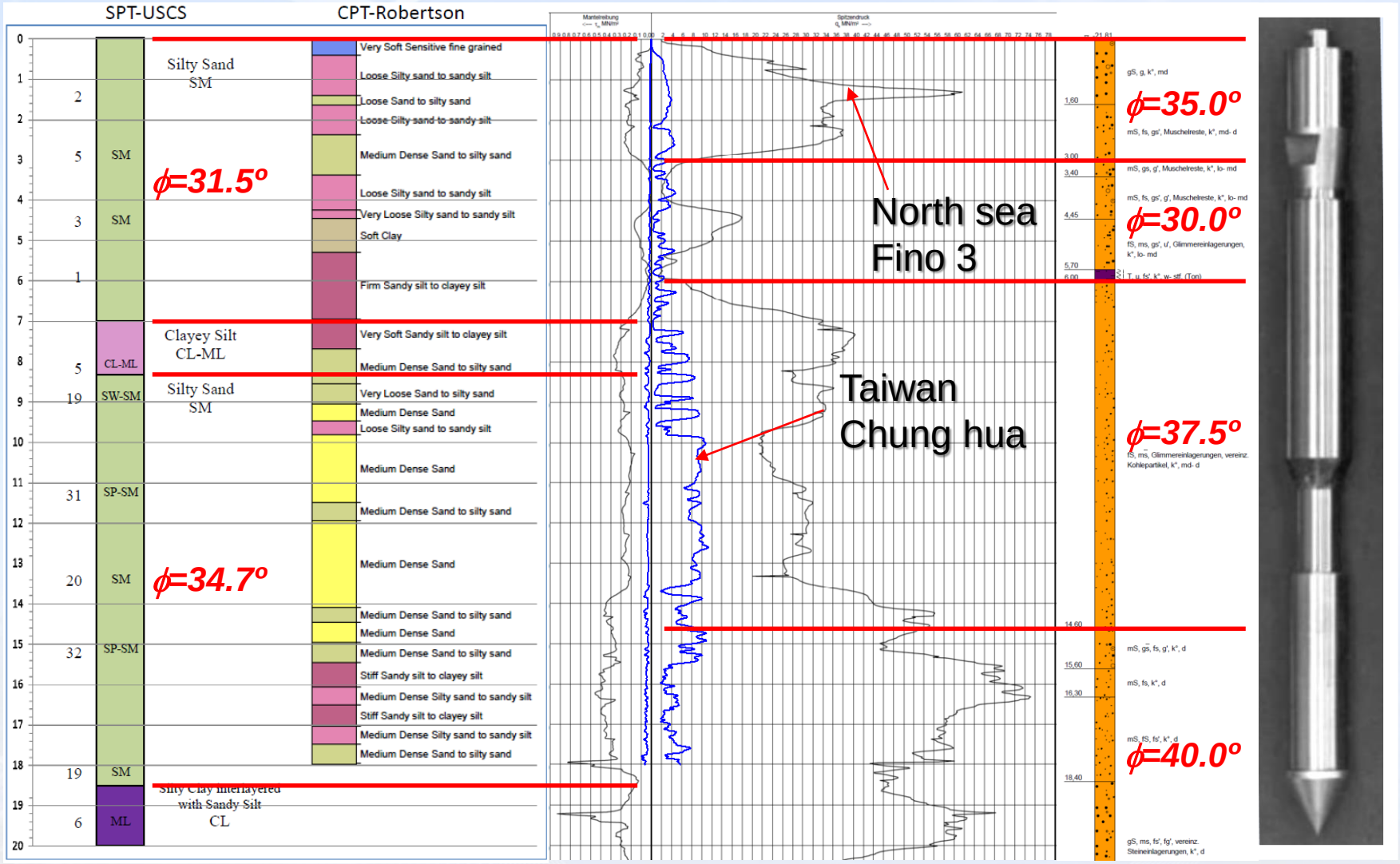
(1)Ultimate Limit States (2)Fatigue Limit States

(3)Accidental Limit State (4)Serviceability Limit State

The frequency of structure vibration must be among 1P～3P (blade turning frequency).



- **Sea bed Soil comparison**：soft soil in Taiwan



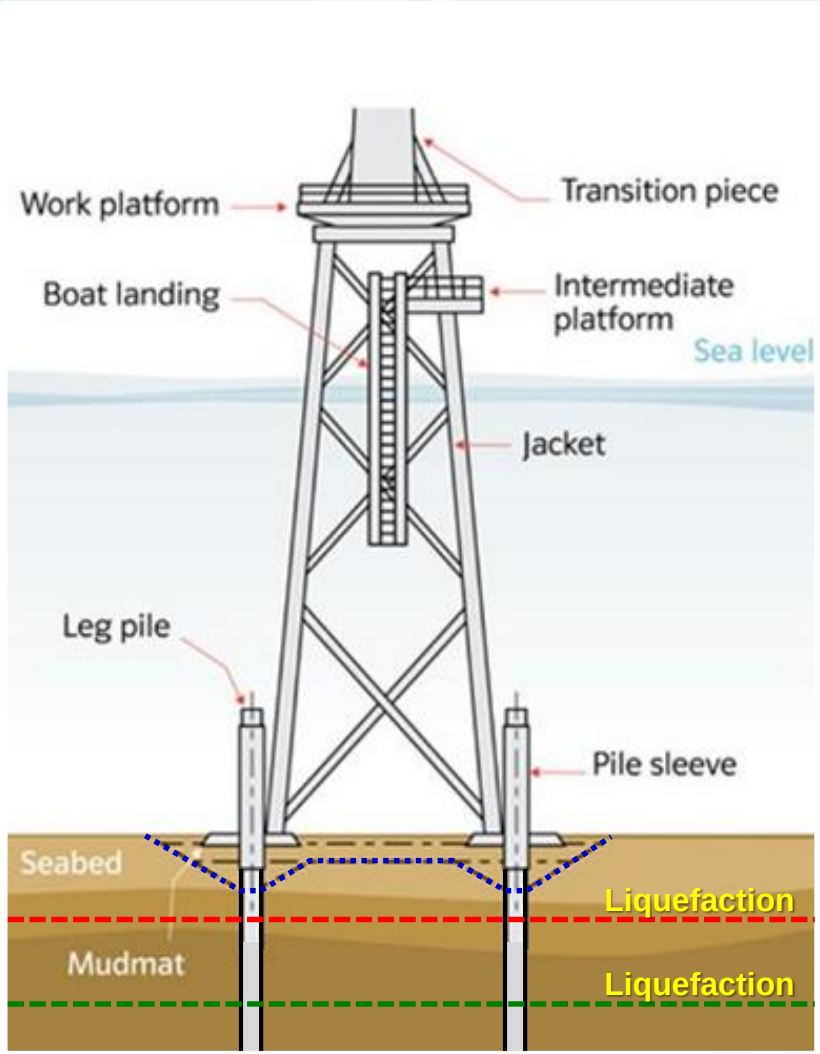
3. Vital Issues of Planning and Design

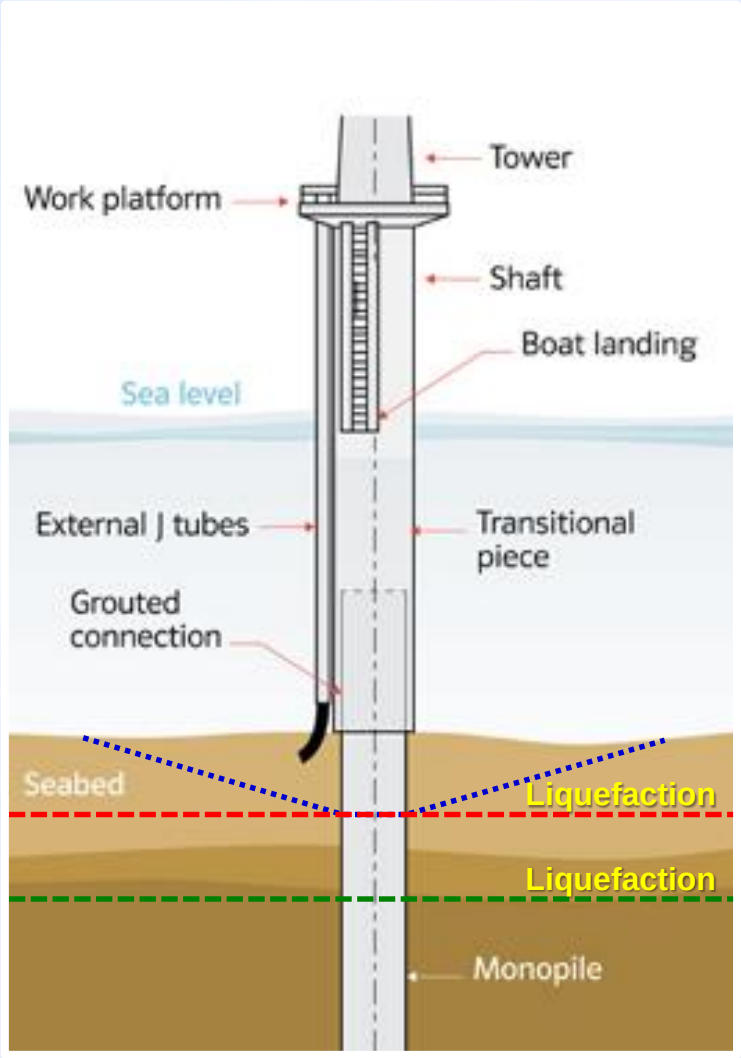
- **Soft soil problem induces Risk**

Soil condition	(Monopile)	(Jacket)
Soft soil on seabed surface	🟠	🟠
Friction around pile	🟠	🟢
Liquefaction index LI>1.0	🔴	🔴
Scouring	🟢	🔵
Over the design experience of European company	🟠	🟠
Earthquake(Potential Liquefaction)	🟢	🟢
Difficult to soil sampling	🟠	🟠
Side and axial bearing capacity	🟠	🟠

Note：🔴 most effect 🟠 Challenge 🟢 Acceptable 🔵 minor effect

- Earthquake：liquefaction, land slide、fatigue



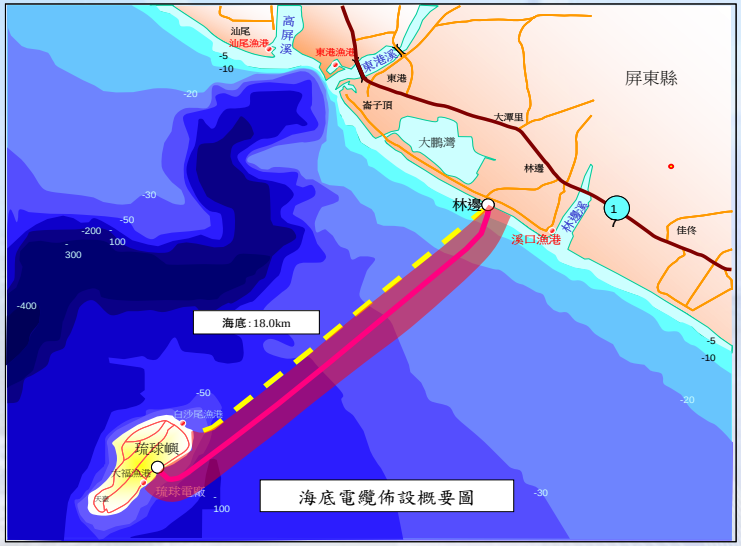


3. Vital Issues of Planning and Design

supply chain problem, for example submarine cable

Taiwan-Penghu 161kV Submarine Cable ---sand wave variation

Linbian-Xiao Liuqiu 25kV Submarine Cable– seawall or dyke



Supply chain problem: Manufacture, construction & installation







4. Conclusion

4. Conculsion

- The offshore wind farm development is brand new industry to Taiwan, even there are about 4 hundred turbines installed and operated on shore. To set up the supply chain from upstream work, such as site investigation, planning, and design to downstream construction & installation are the most important issues to Taiwan.
- There are many challenge, such as the typhoon and Earthquake problem, even the European accumulates over 25 years experience in offshore wind farm development. They still can not solve it well, and without defining a clear standard. Therefore, not just only follow European guideline, standards, we suggest the Taiwan government shall collaborate the scholar, research center, industrial, and marines to find out the suitable and real meet the requirement of local situation solution.


THANK YOU
FOR YOUR ATTENTION !