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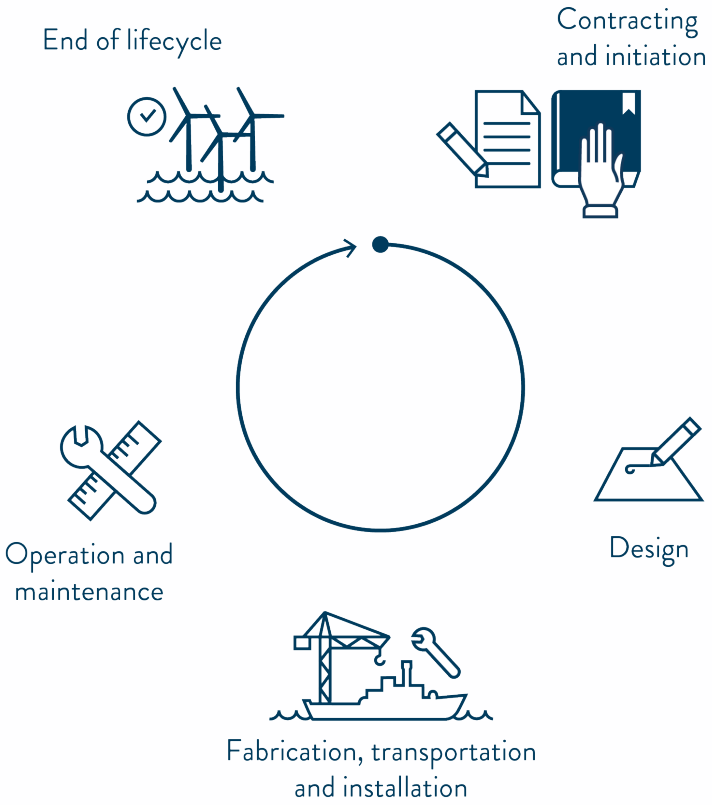
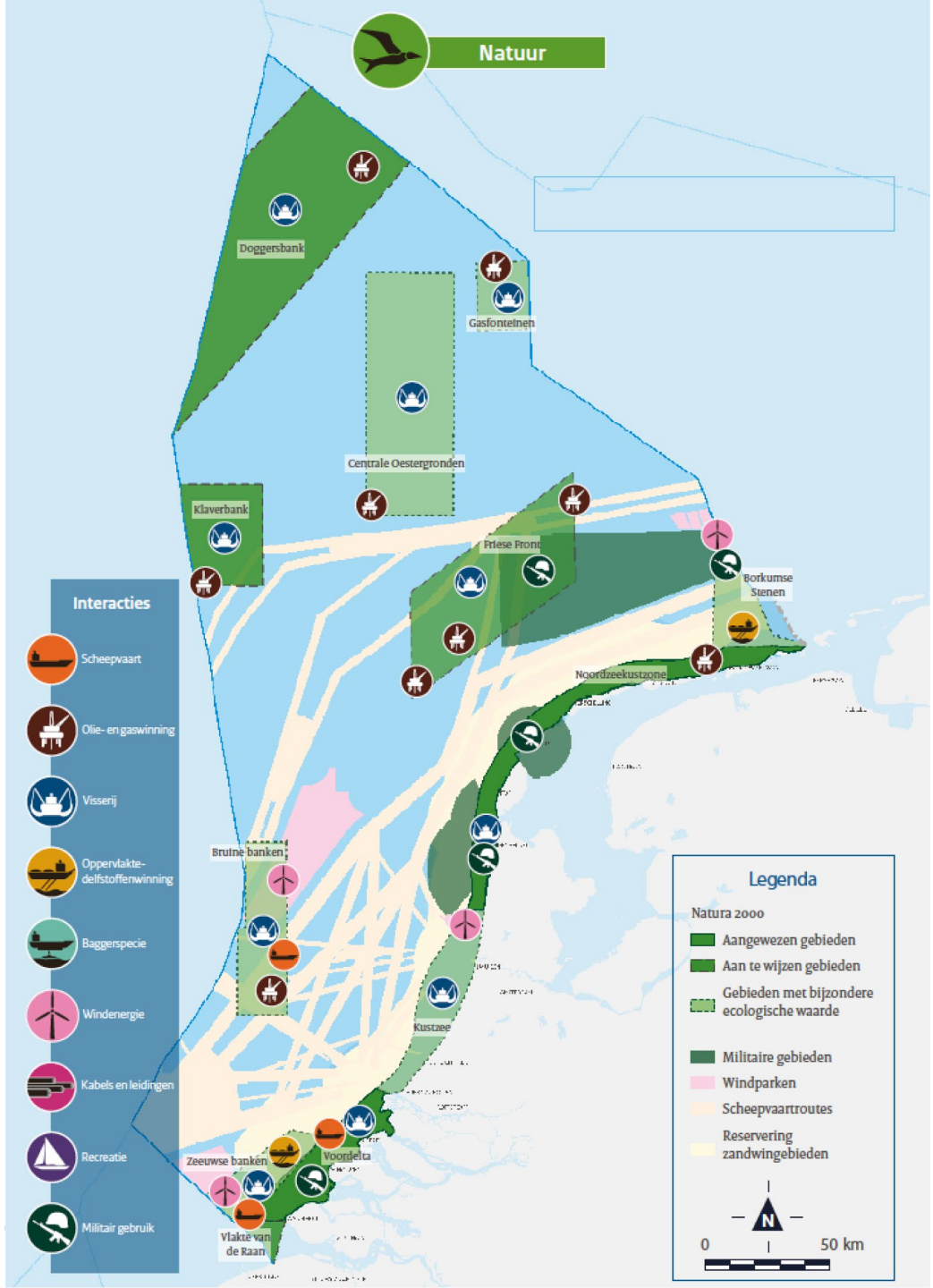
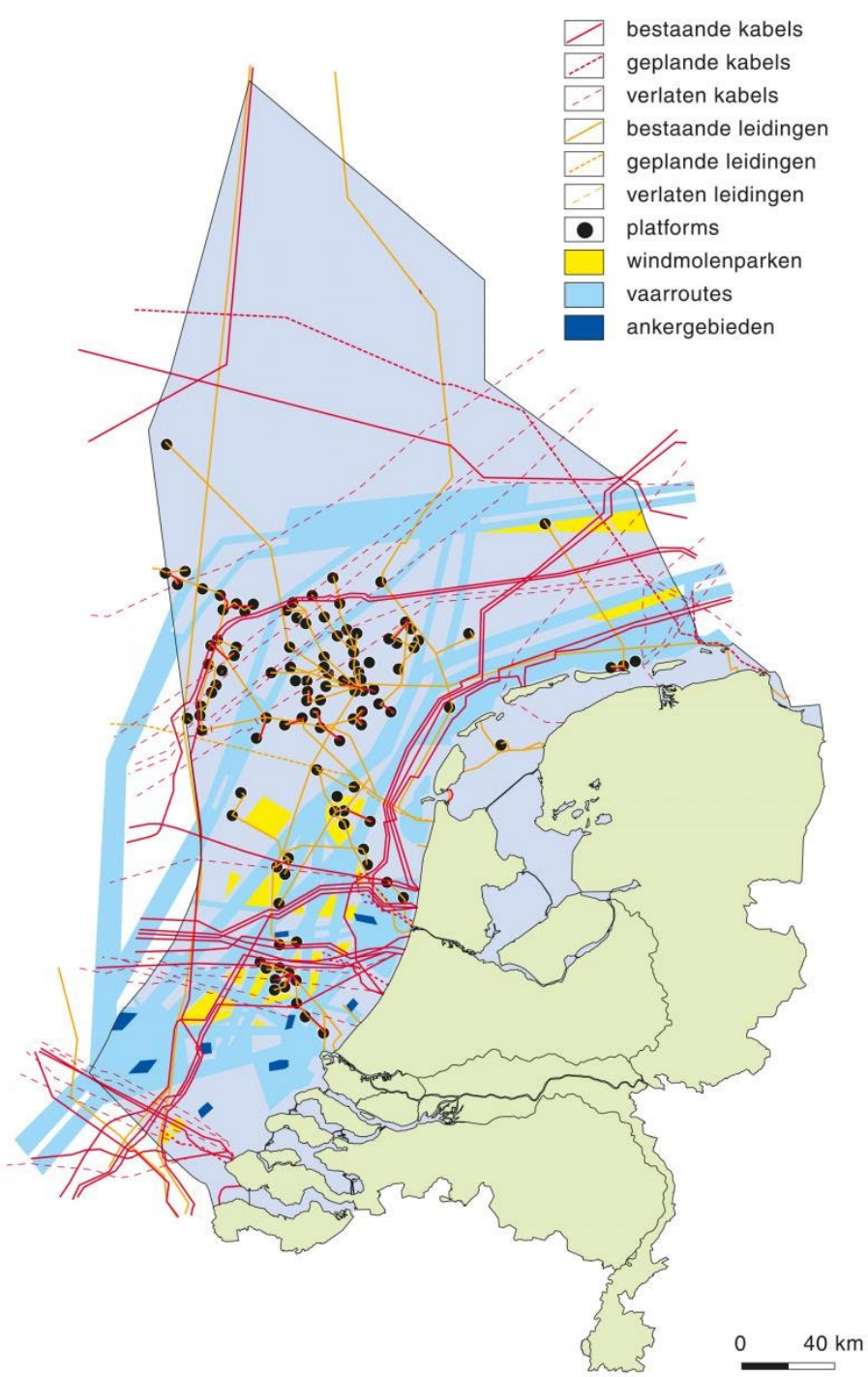
Offshore wind farm lifecycle



Dutch North Sea





Consortium developing phase

- Developer wants to bid on a concession
- Developer needs partners to develop, finance and construct an offshore wind farm
- Form consortium for:
  - Financial means
  - Experience
  - Equipment
  - Skills
  - Spead risk

Starting the project: site investigation

- Metocean conditions
  - Wind
  - Waves
  - Sealevels
  - Currents
- Seabed obstructions (rocks, UXO's, etc.)
- Soil conditions

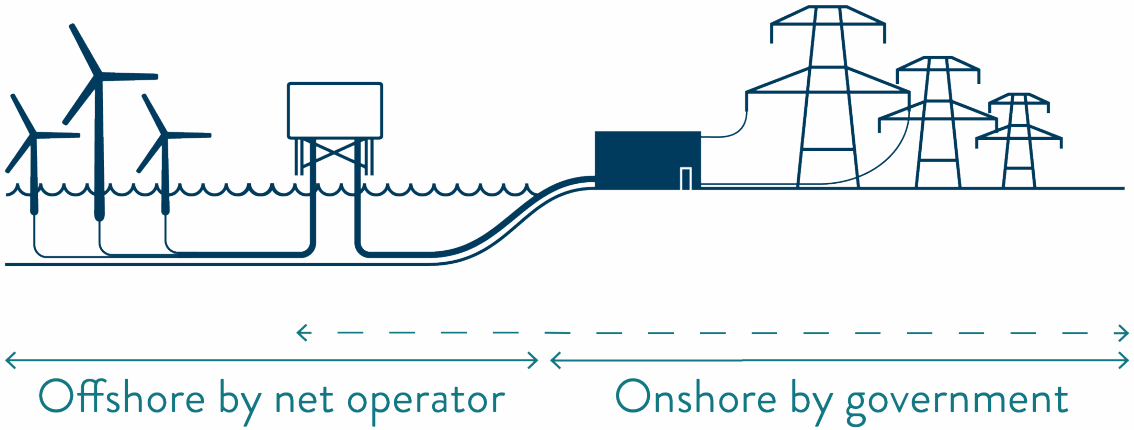
Wind farm layout

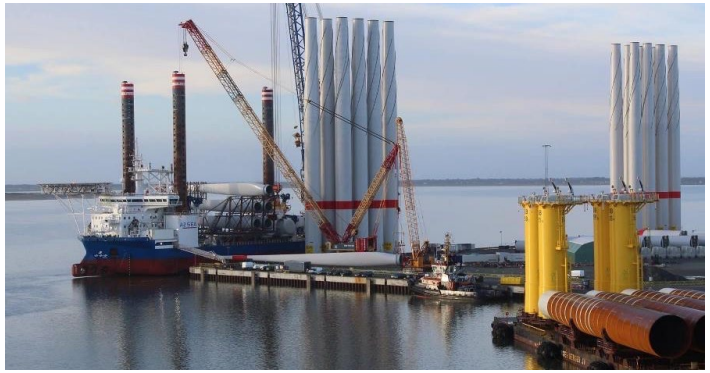
Wake Effects

Seabed occupation

Cable length

Available facilities





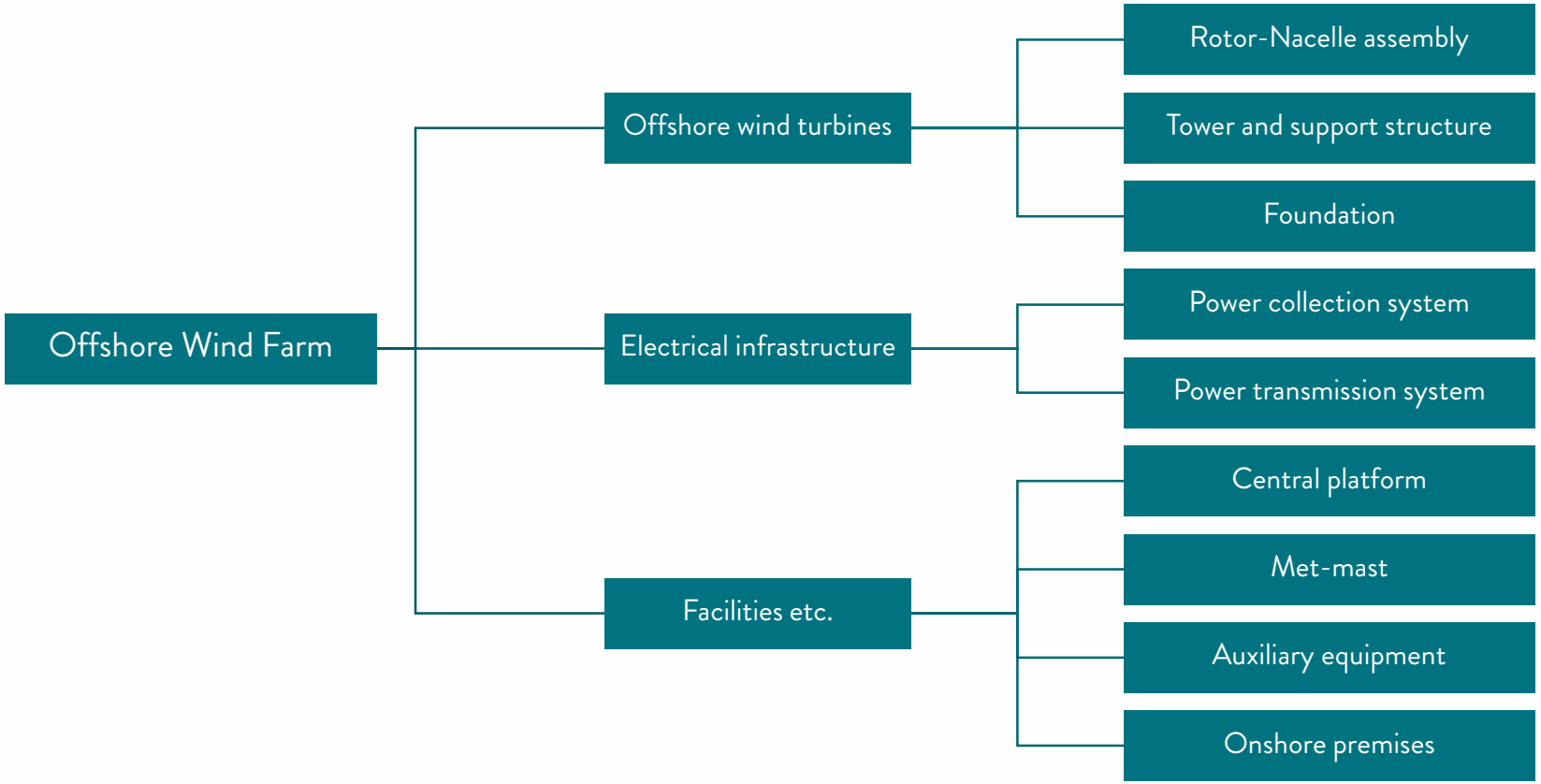
Grid connection

Provided by grid operator

Port facilities

Provided by port

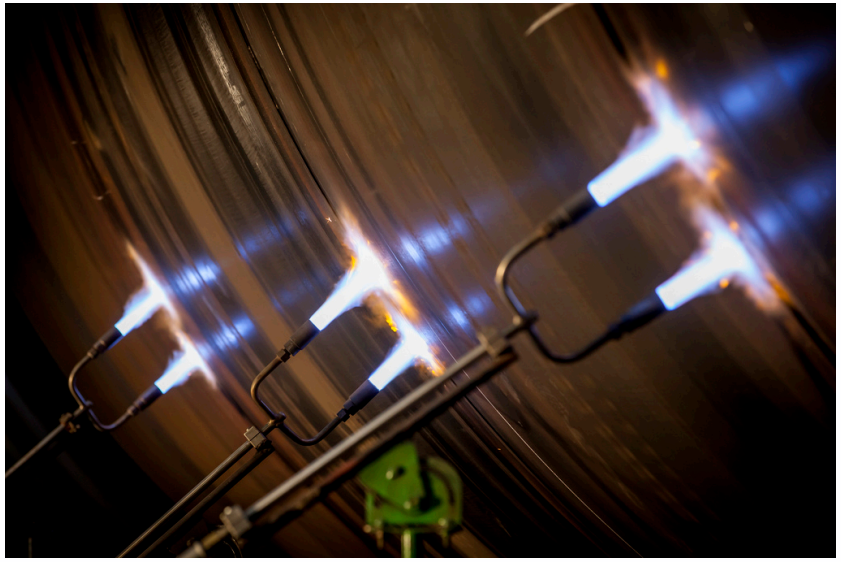
System hardware overview



Fabrication

Governing aspects:

- Series-work
- Supply chain management

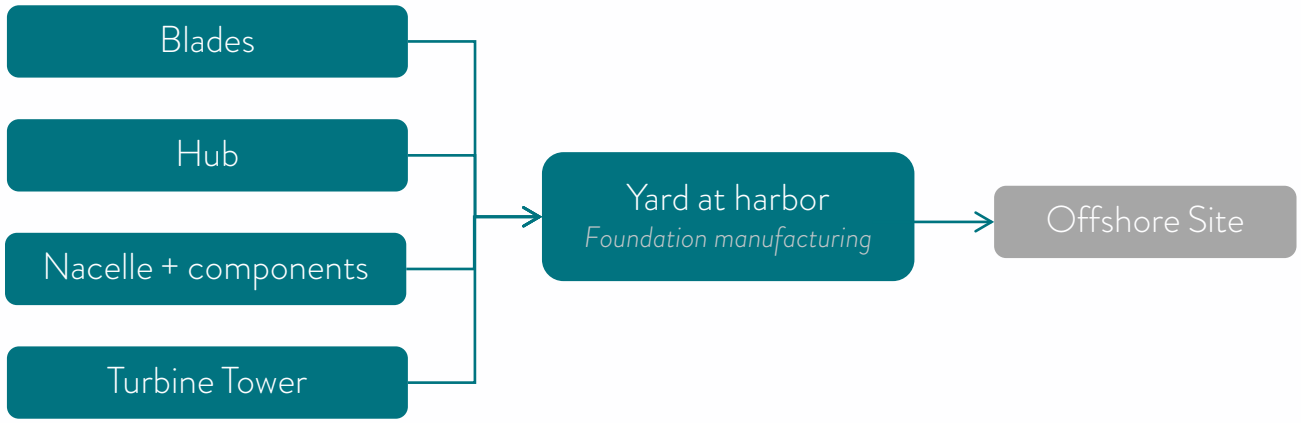



LM WIND POWER
Pilot Plant

Transportation

From land, to yard, to offshore

- Large and many components!
- Operability: calm sea states decisive



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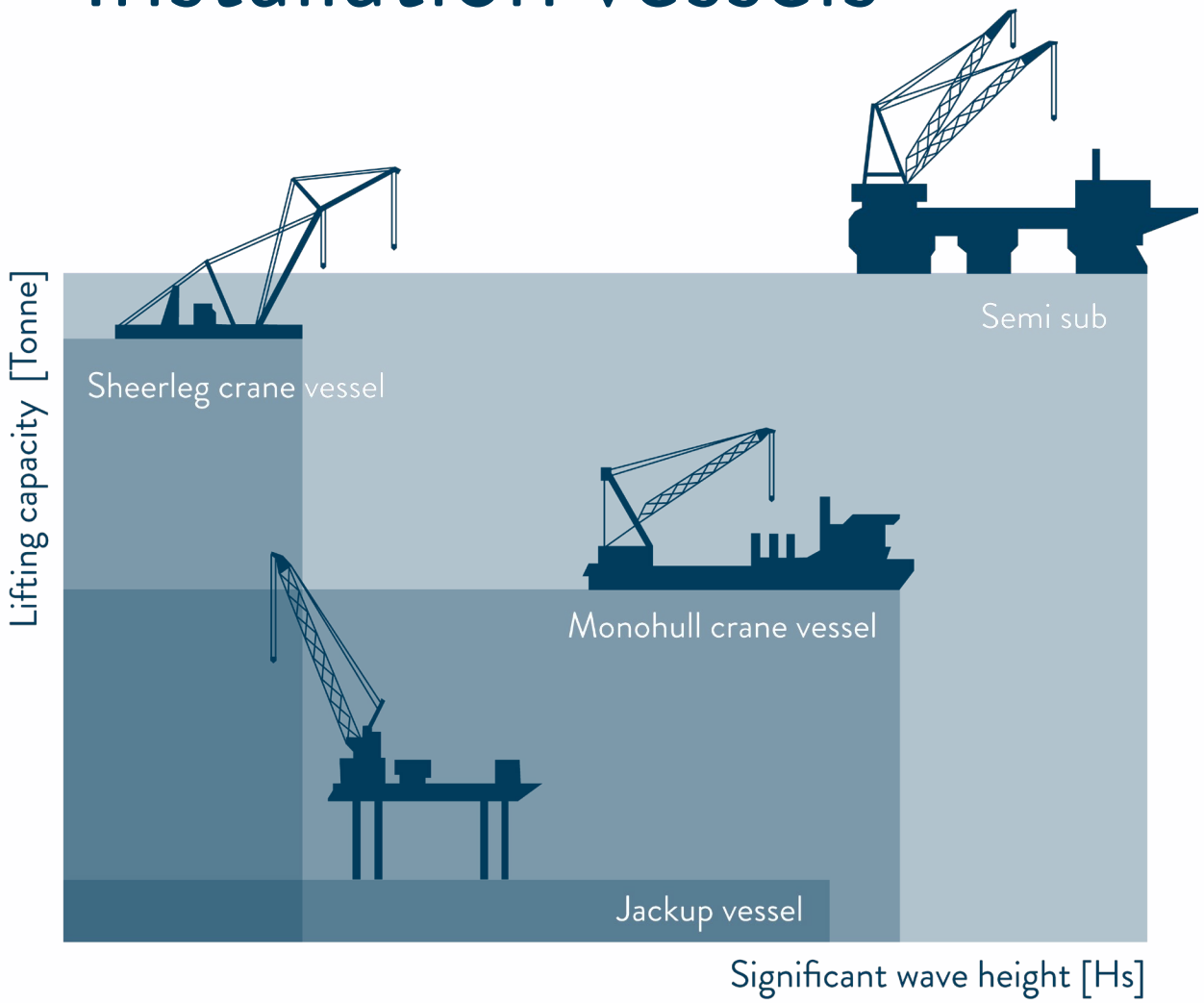
Collection

Siemens

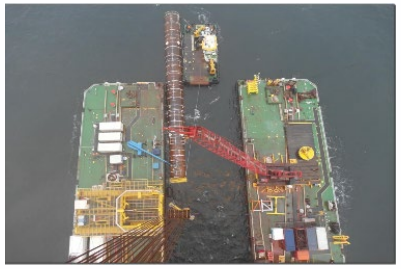
Installation vessels



Installation steps

Monopile

1. Pile driving
2. Scour protection
3. Transition piece installation
4. Cable connection
5. Turbine installation



Svanen, Van Oord

Cable installation

Cable connection to wind turbine

- Pull-in via “J-tube”

Turbine installation

Tower + nacelle + rotor

- Various installation methods

Traditional	Turbine tower (2 or 3 parts)	Nacelle + Hub	Blades
One piece rotor	Turbine tower (2 or 3 parts)	Nacelle	Rotor (hub + blades)
“Bunny Ear”	Turbine tower (2 or 3 parts)	Nacelle + Hub + 2 blades	Blade nr. 3
One-go	Tower + Turbine		

Traditional

One piece Rotor

“Bunny Ear”

One-go

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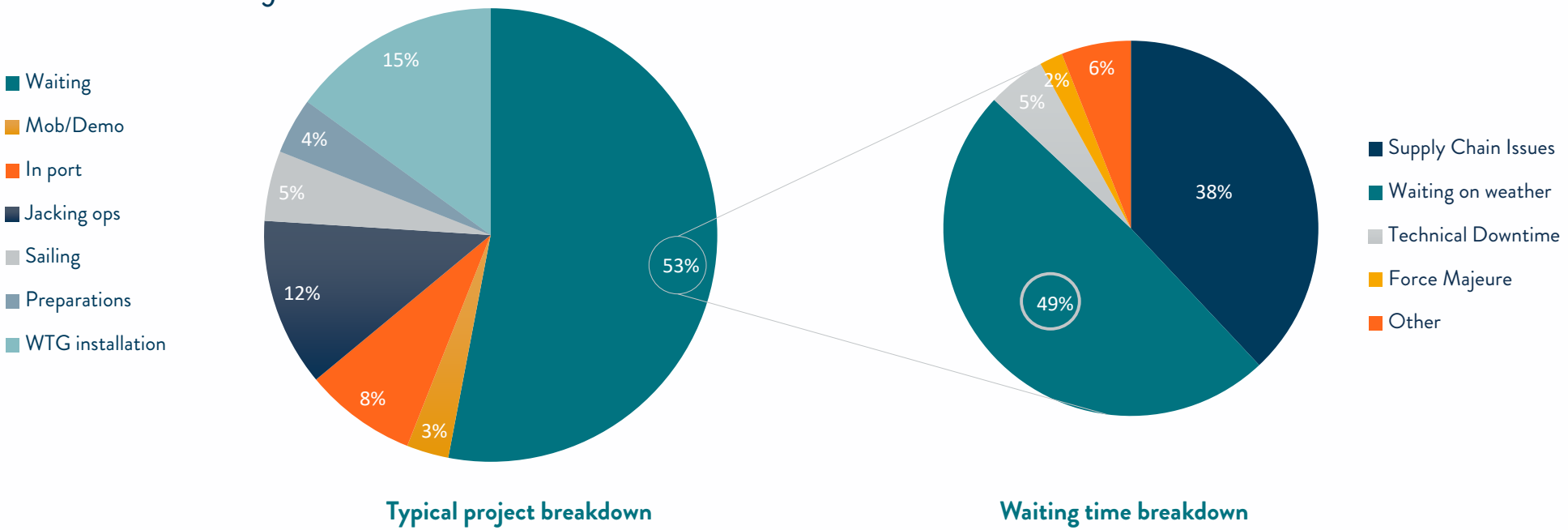
Installation

Weather window extremely important

"There is no bad weather, only bad clothing!"

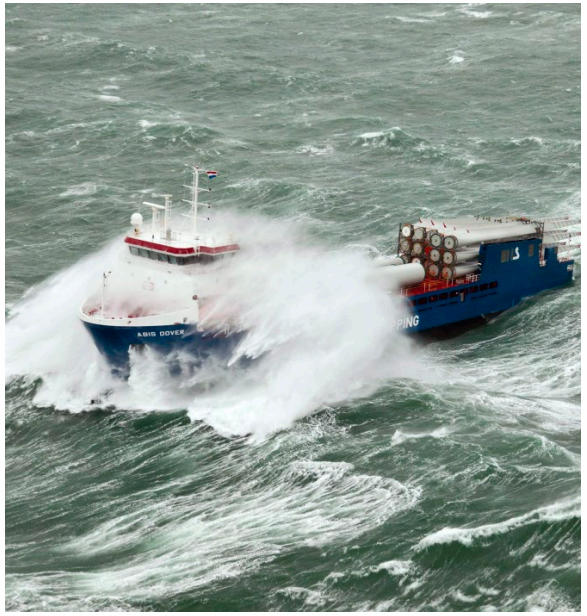


Typical project breakdown

Waiting time breakdown

Van Oord

Operational limitations

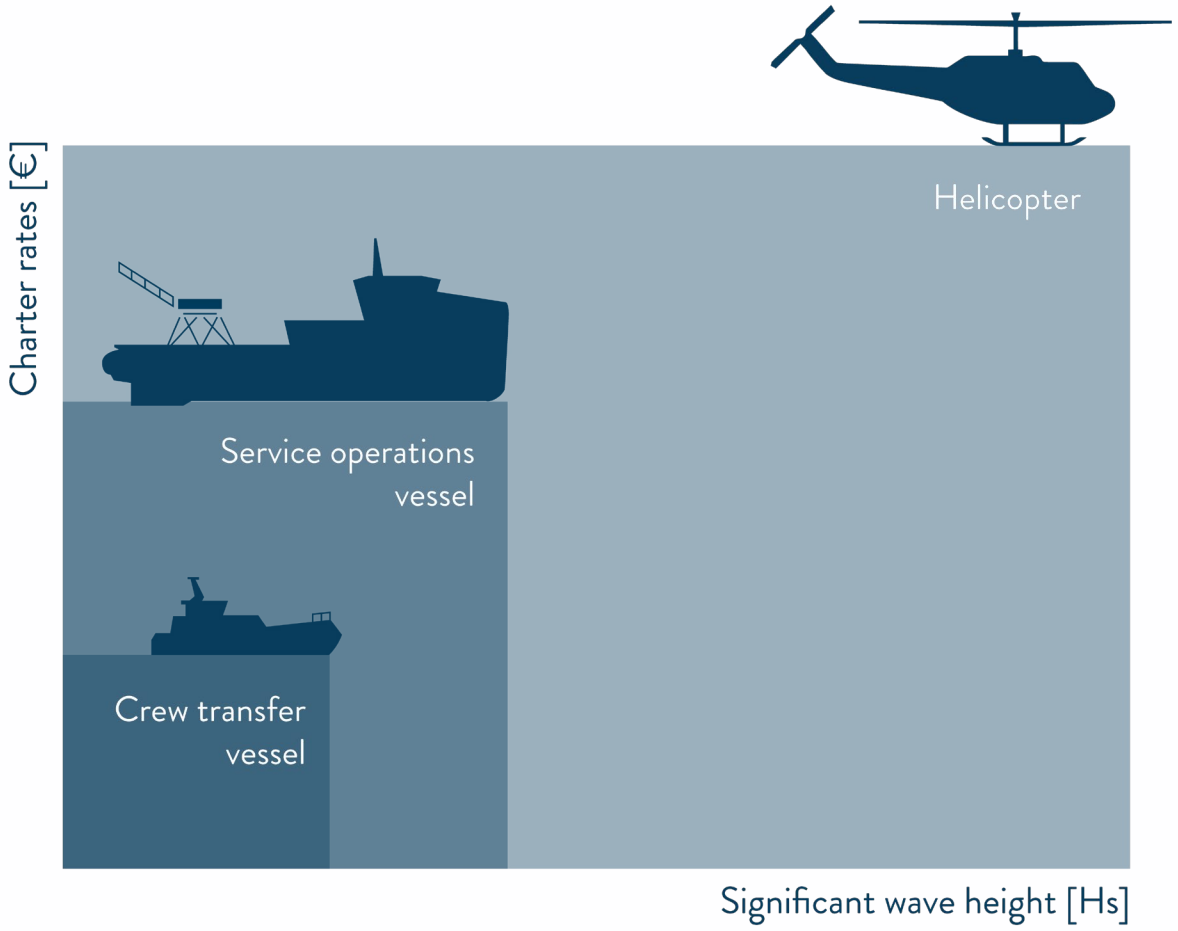


Waves

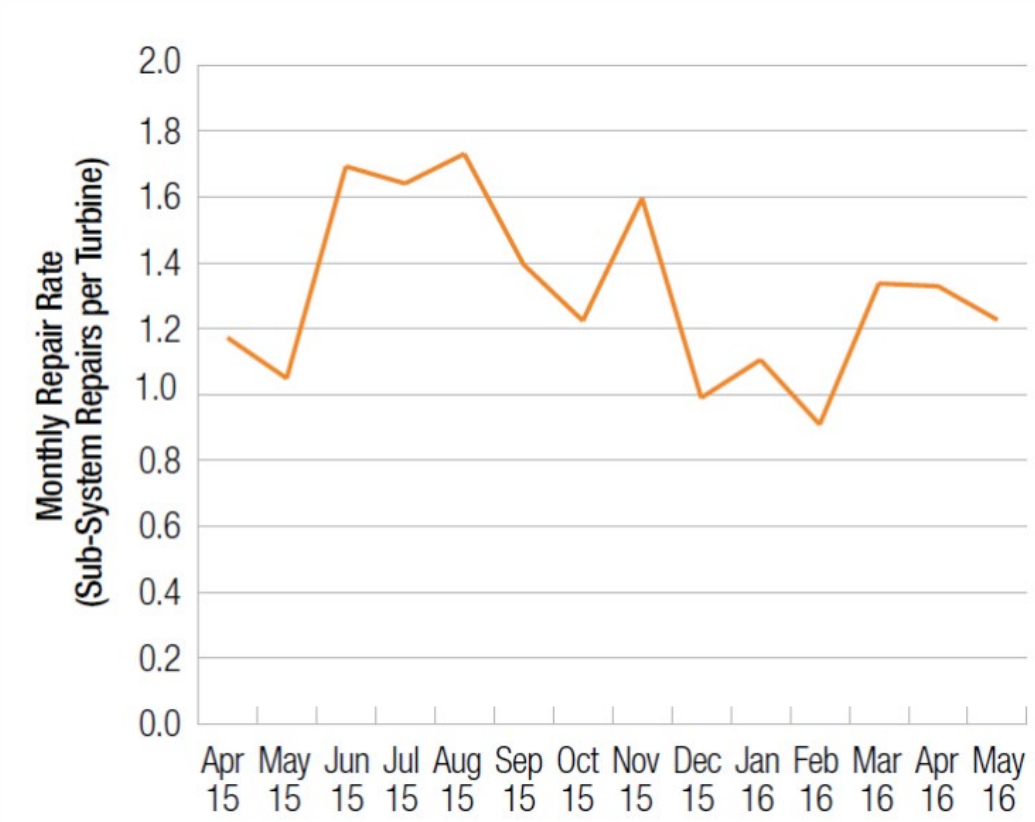
Wind

Water depth, current

Crew vessels



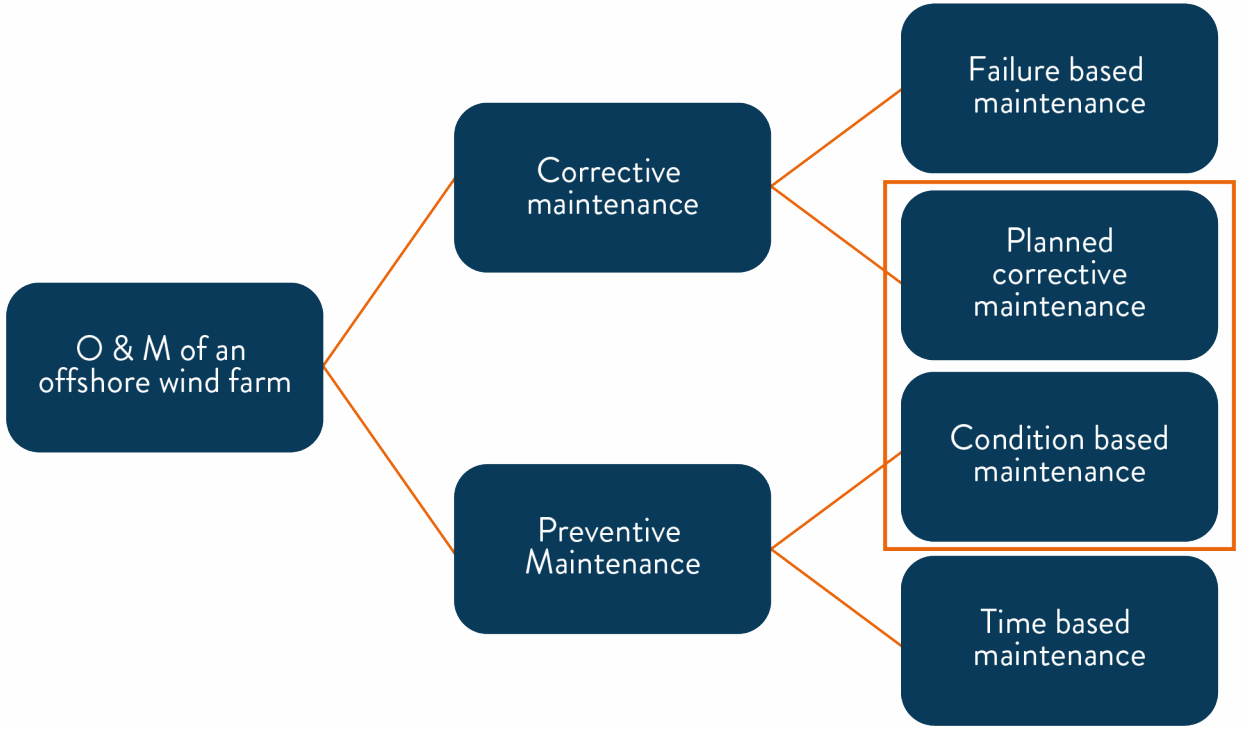
Monthly failure rates



1.32 times per month on average!

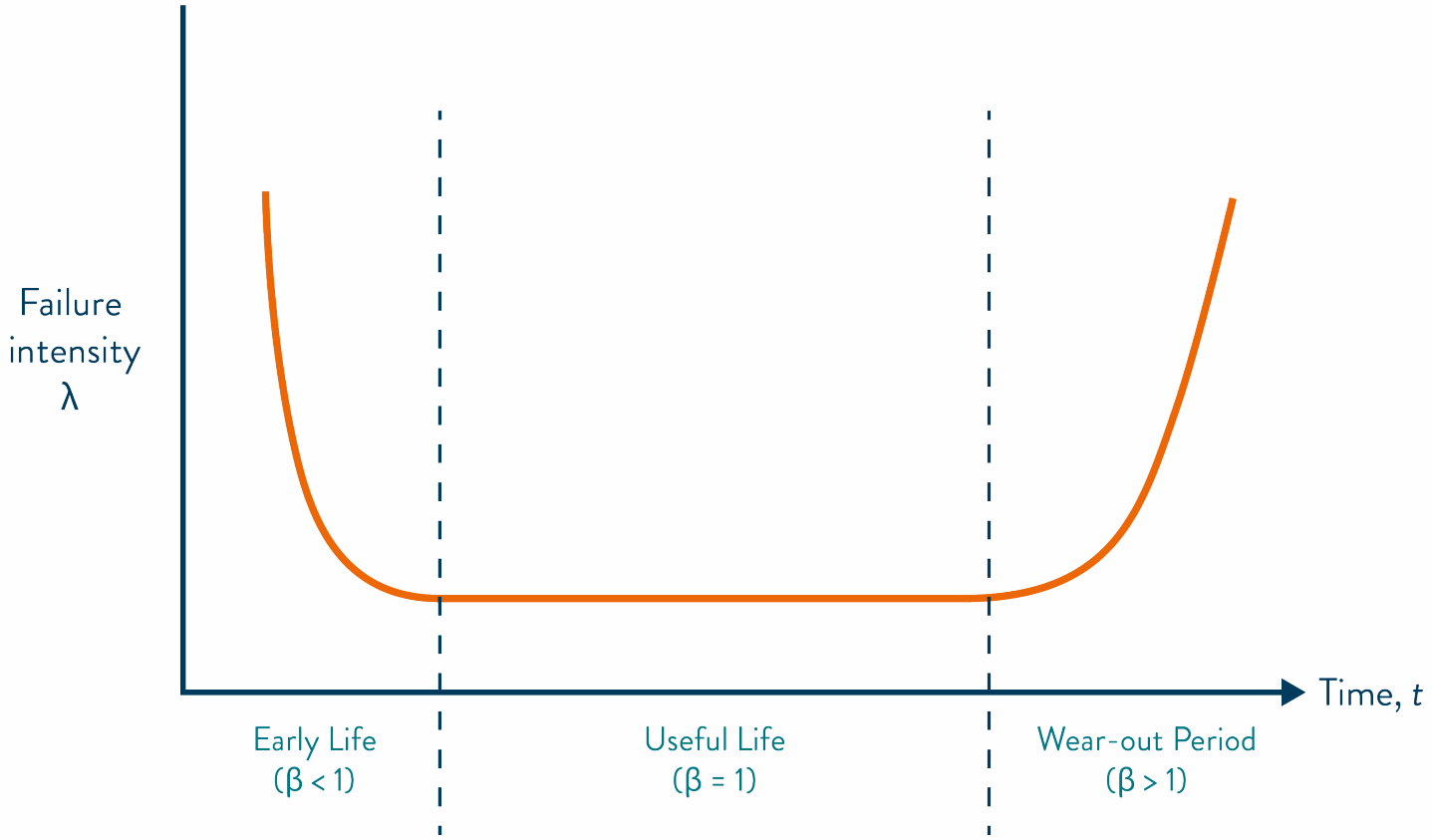
Sparta, 2017

Maintenance



Maintenance

Failures


Failure intensity λ
Time, t
Early Life (β < 1)
Useful Life (β = 1)
Wear-out Period (β > 1)

Actual availabilities

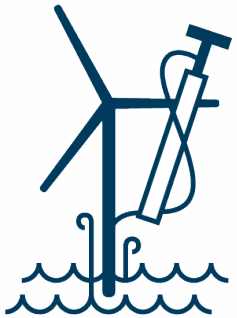
Onshore availability: 98.2%

Offshore availability: 70% - 95%

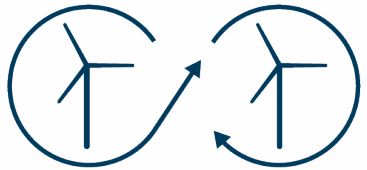
Faulstich, 2013
Tavner, 2013

End of lifecycle

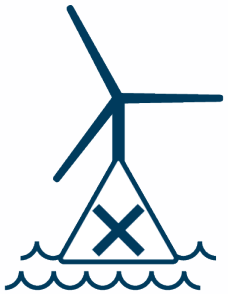
Three main options:



Lifetime extension



Re-powering



Decommission

Decommissioning

- Vindeby, Denmark
- First offshore wind farm
- First decommissioned

Decommissioning – North Sea

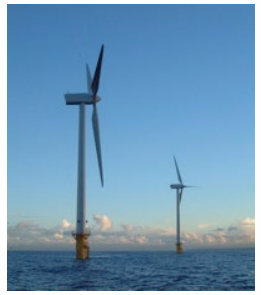
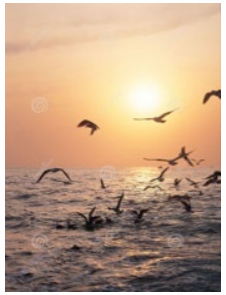
All until 2 meters under seabed – SINTRA 1998

→ Take into account in design phase!

- Drilling and grouting in rock?
- Ballasting GBS with iron ore?

The cycle of an offshore wind farm



Contracting → Design → Fabrication → Transport → Installation → O & M → Decommis-sioning

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