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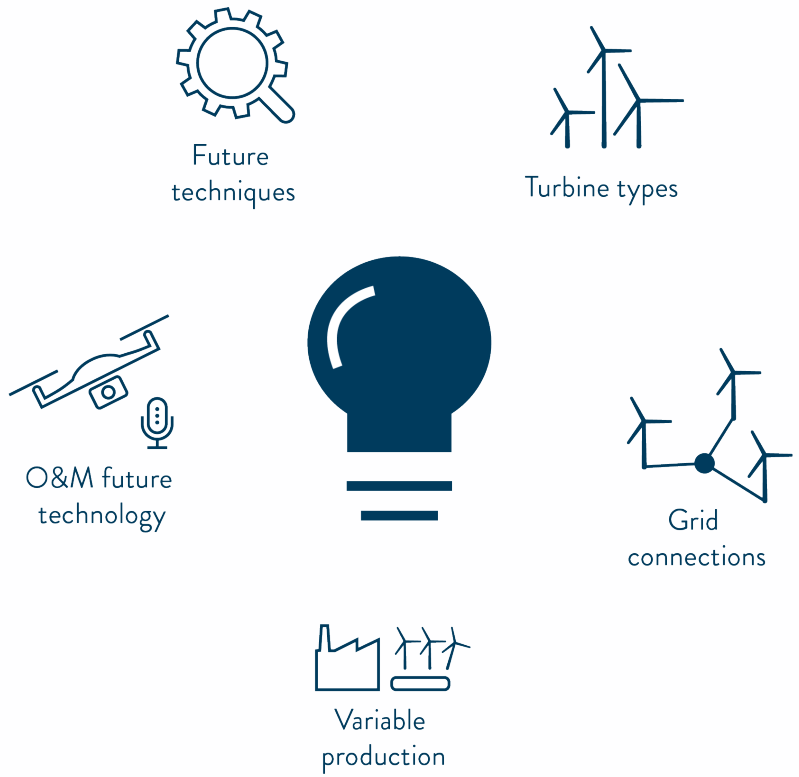
BIBLIOTHEEK
ACADEMY

Future technologies

- Installation
- Operation and maintenance
- Wind turbines
- Foundations
- Grid connection



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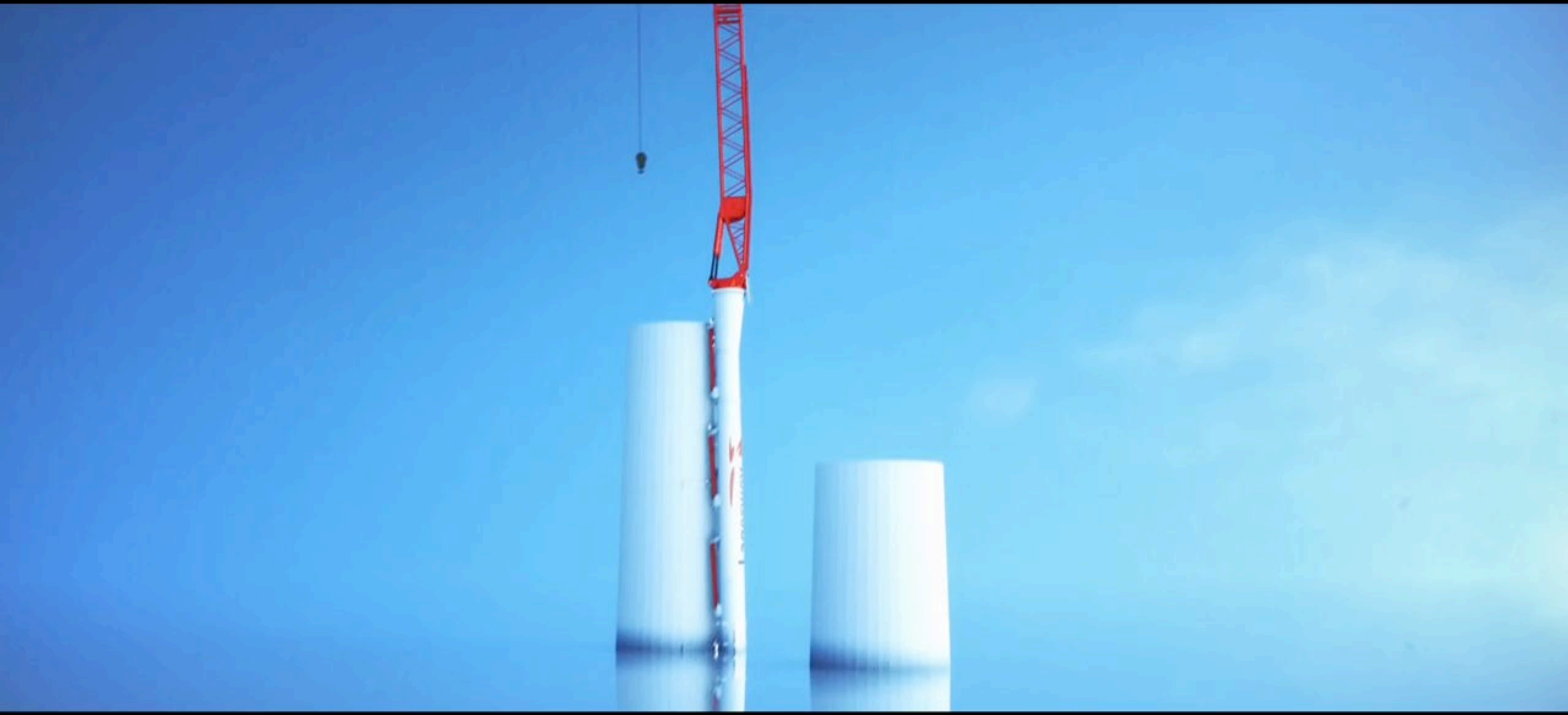
Installation

- Climbing crane
- Noise mitigation developments
- Vessel development
- Access
- Installation time

Climbing crane

Source:

Lagerwey



Noise mitigation

Produce less piling noise:

- Vibro Lifting Tool
- Blue Hammer

Mitigate piling impact:

- Big Bubble Curtain

Blue Hammer

Bubble Curtain

Sources:

L: BLUE Piling Technology

R: Hydrotechnik-Luebeck

Vibro lifting tool

Source:

CAPE Holland

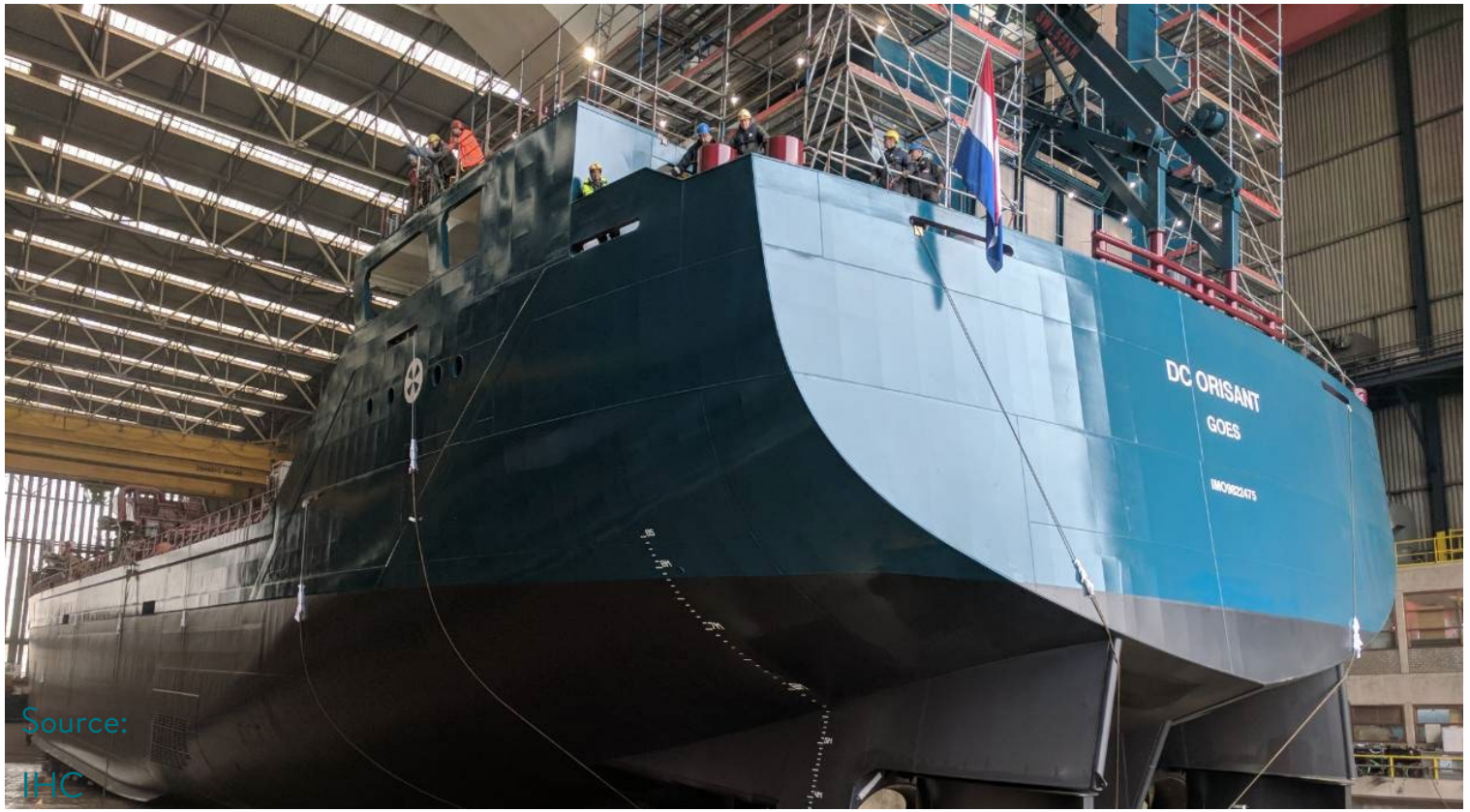
Vessel development

Orion Vessel, expected to be ready in 2019

Source:

DEME group

Construction vessel



Source:
IHC

Access

- Weather window and distance is important
- Future: floatels, O&M islands?
- Accessibility methods

Helicopter

- Fast
- Expensive
- Large operating window
- Helipad required

Boat + landing

- Fairly slow
- Cheap
- Small operating window
- Boat landing required

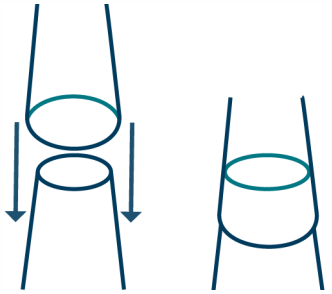
Boat + Ampelmann

- Medium fast
- Cheap
- Medium operating window

Installation time

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			

Slip-joint



Operation and maintenance

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- Improved cranes
- Cyber security
- Offshore access
- Drone inspection
- Artificial intelligence
- Failure prediction techniques
- Big data
- Improved power forecasting
- Crew transfer vessels
- Decommissioning

Climbing crane

The Lagerwey climbing crane can be used for both installation and maintenance

Source:

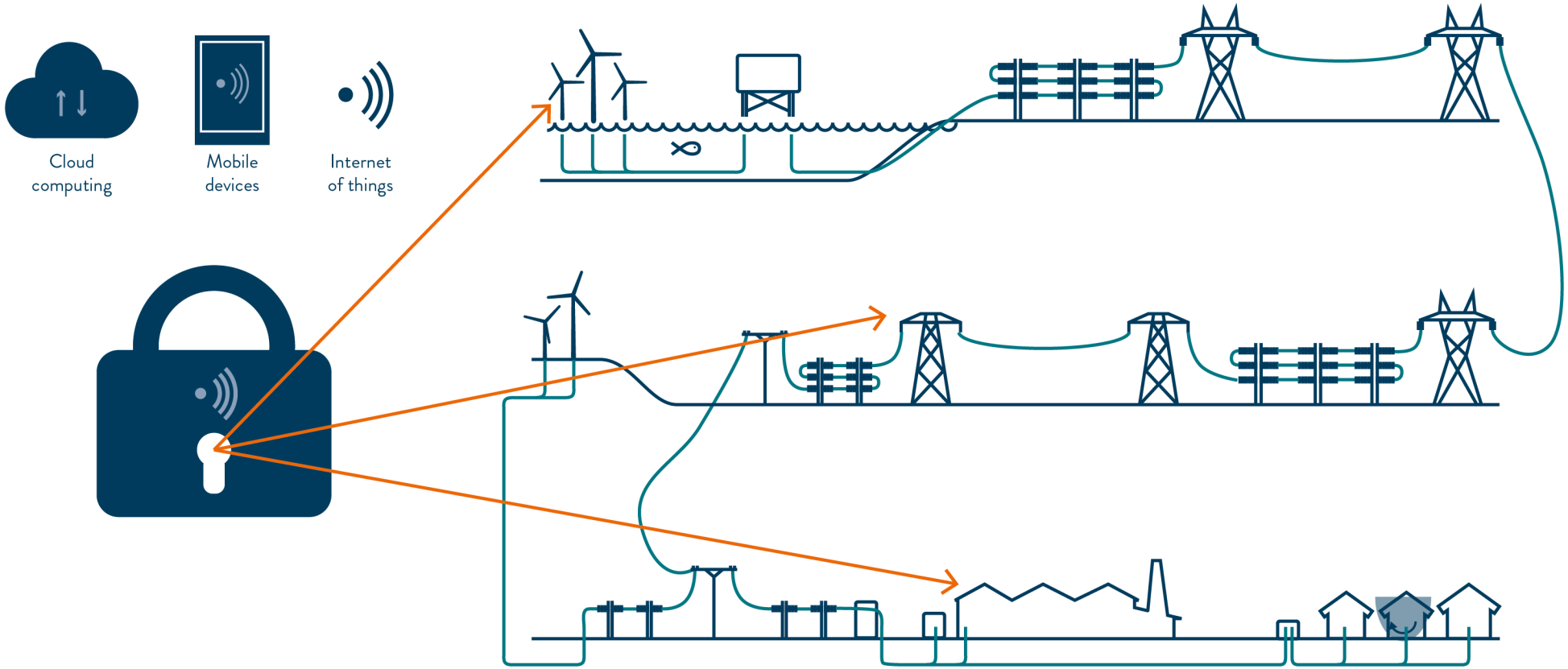
Lagerwey

Foldable crane

Source:

Huisman

Cyber security



Offshore access

PowerHub: joint project of TenneT Netherlands, TenneT Germany, Energinet, Gasunie and Port of Rotterdam

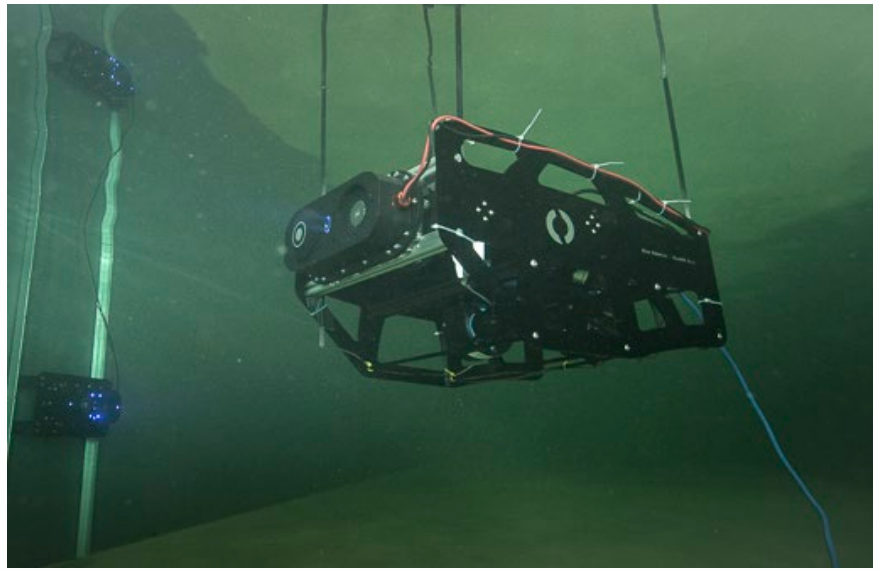
Source:

Port of Rotterdam

Drone inspection

- Fast inspection, reduced downtime
- Lower costs and risks

Unmanned Aerial Vehicle (UAV)



Unmanned Underwater Vehicle (UUV)

Sources:

R: Technical University of Denmark

Artificial intelligence

- Benefits: planning, monitoring, robotics, inspection, supply chain optimization, employment

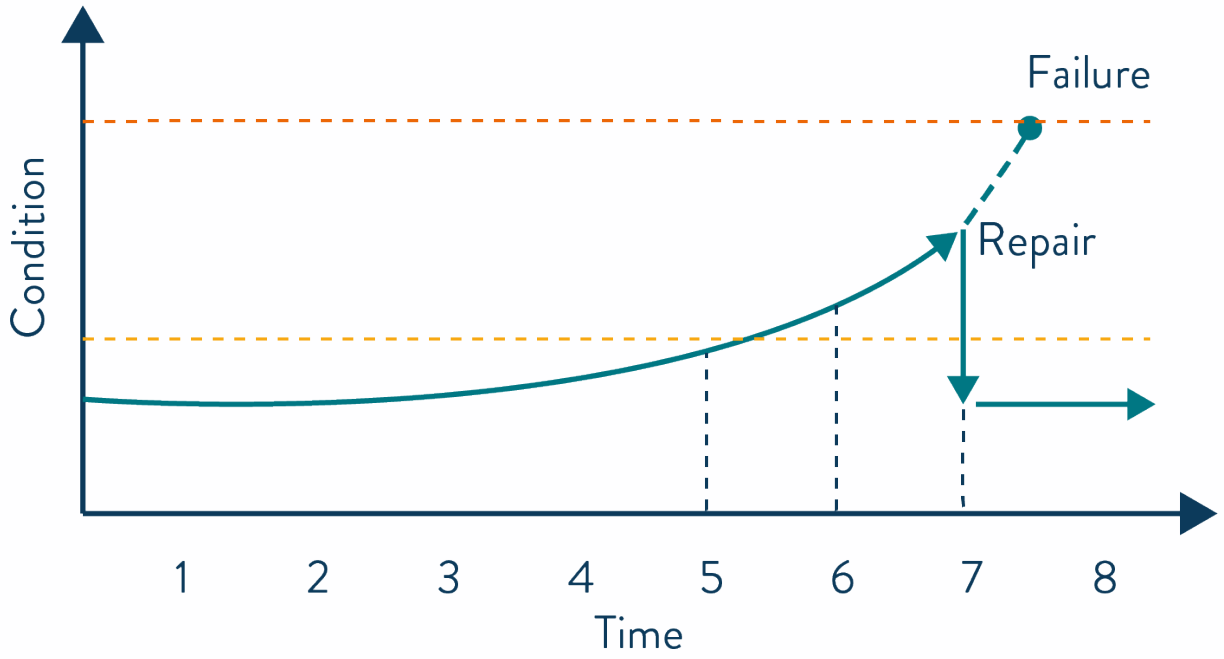
- Risks: system safety (cyber security), unemployment, deskilling

Source:

DNVGL

Failure prediction techniques

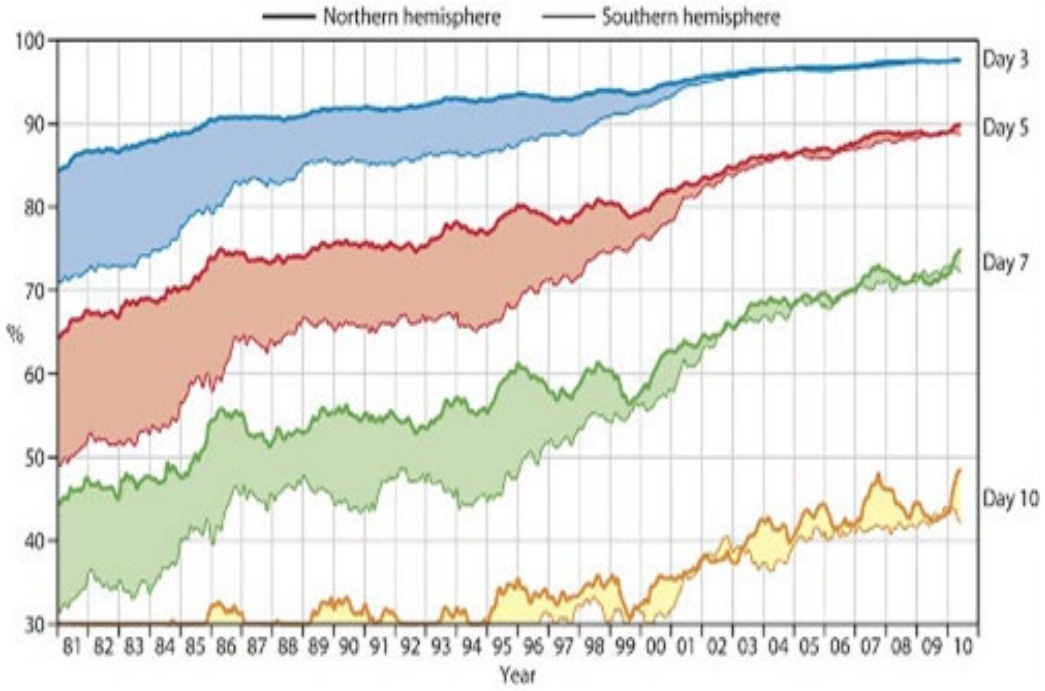
- Vibration sensors
- Pressure sensors
- Temperature sensors
- Voltage and Ampere meters
- Flow meters



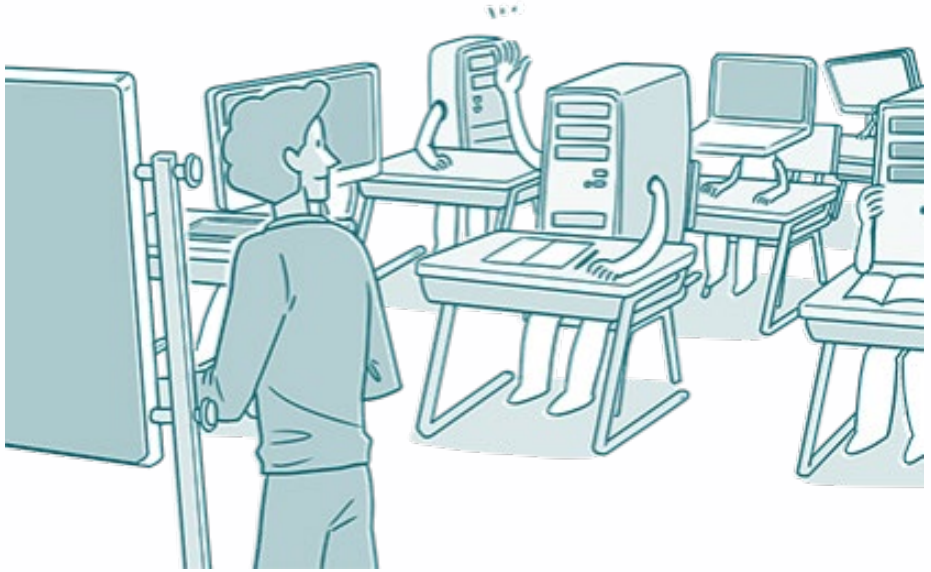
Big data

- Performance monitoring (SCADA)
- Maintenance planning
- Supply chain management
- Marine operations

Improved power forecasting



Improved weather prediction models



Power forecasting algorithms based on machine learning

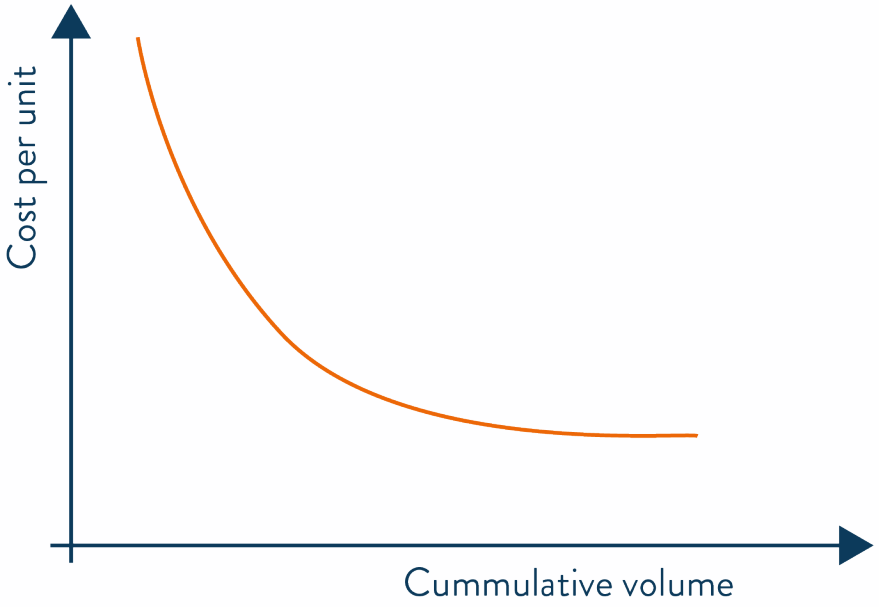
Crew transfer vessels

- Shorter transit times
- Allows working in more extreme conditions

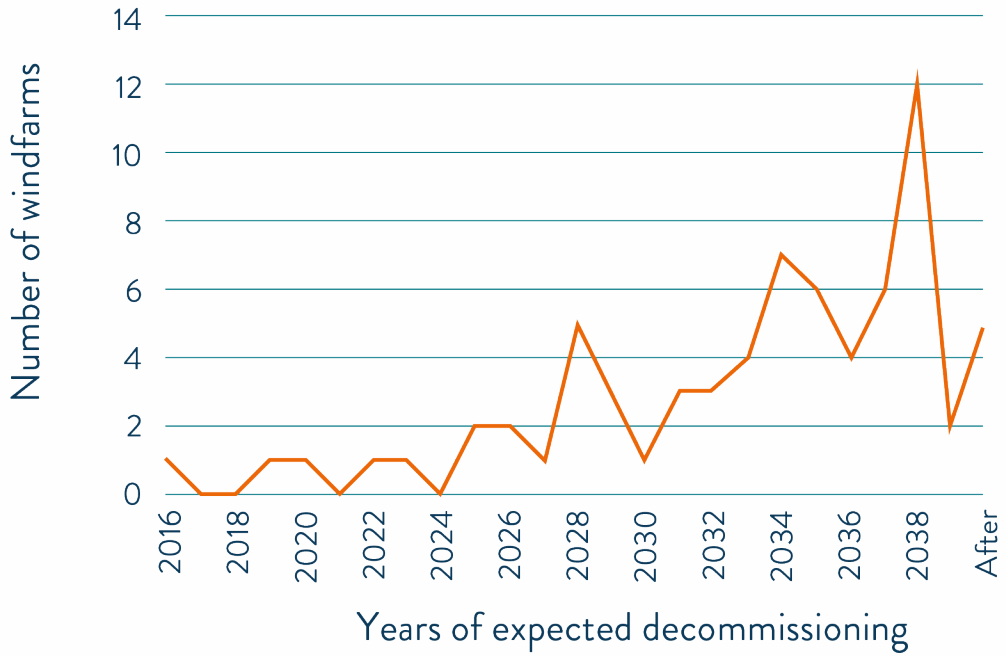
Source:

Wavecraft

Decommissioning



The learning curve in terms of marginal costs and volume



European wind farms to be decommissioned

Wind turbines

- Growing size
- Innovative drivetrains
- Improving blade tip speed
- Types of turbines
- DOT

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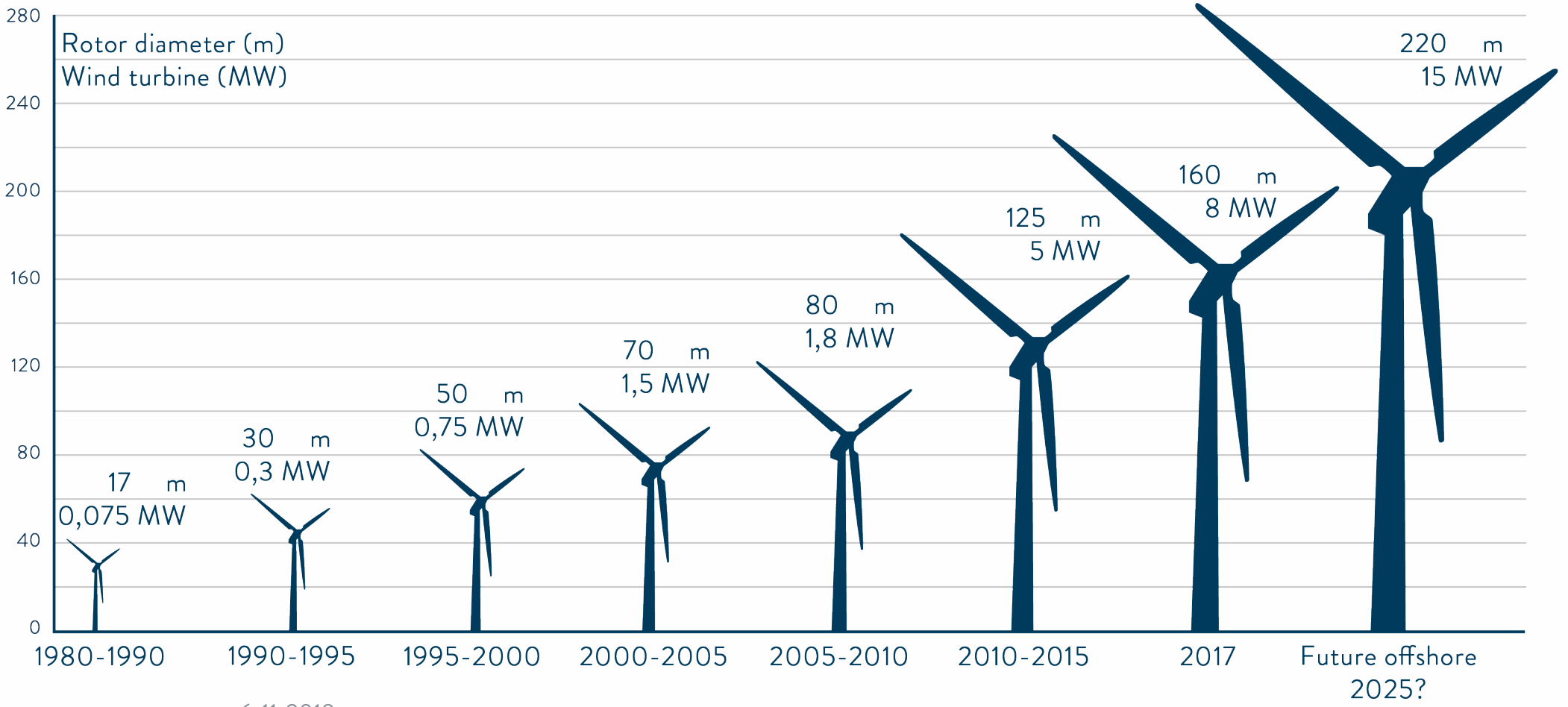
Growing size



Innovative drivetrains

Developments in technology lead to:

- Decrease of critical components
- Reduced maintenance
- Reduced costs
- Lower material use

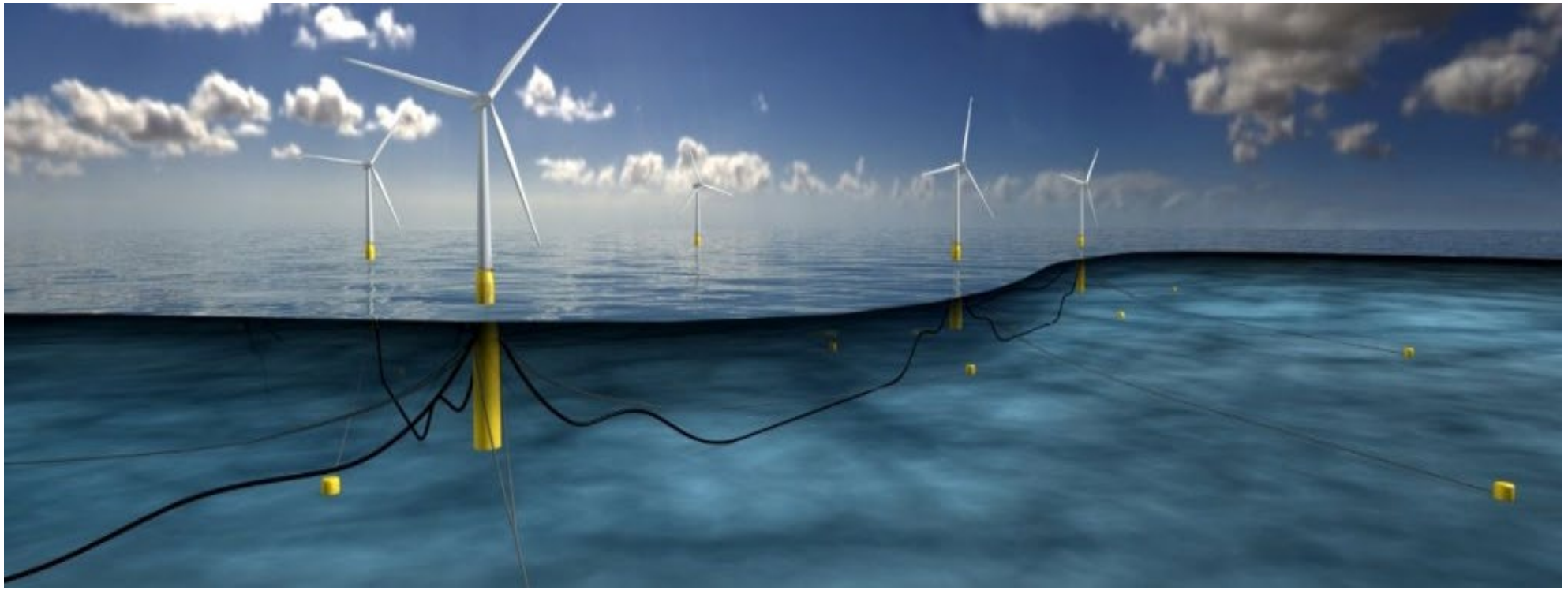
Source:
Siemens Gamesa

Improving blade tip speed

Source:

Sciencedirect.com

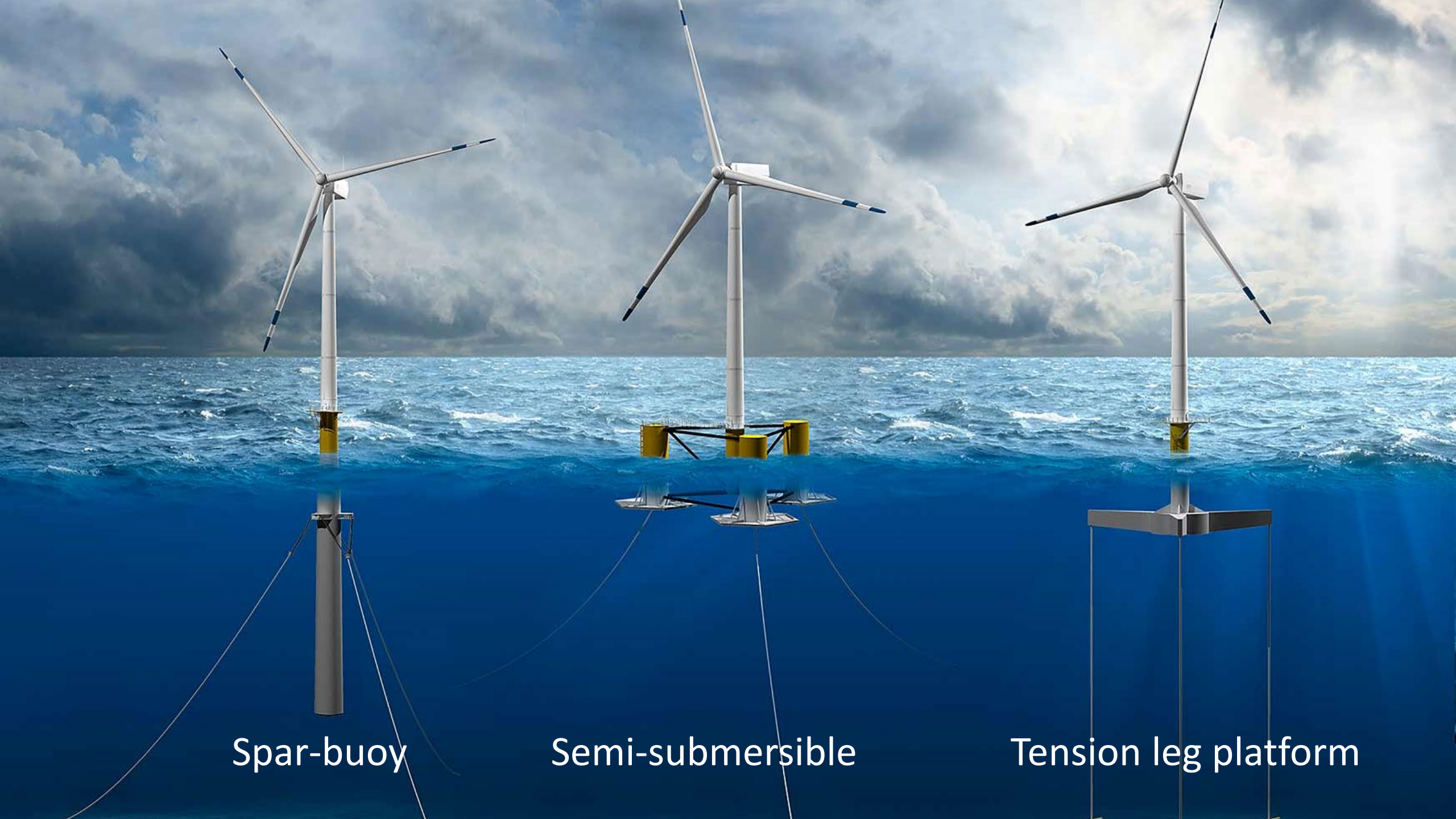
Floating wind turbines



Hywind is worlds first floating wind farm

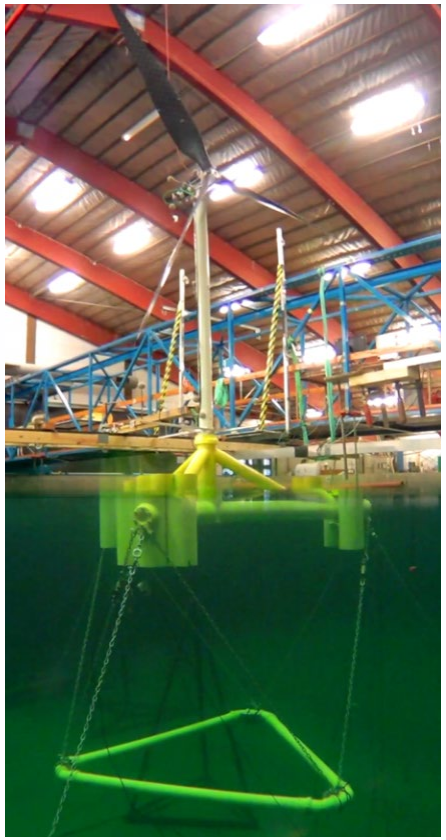
Source:

Statoil


Spar-buoy
Semi-submersible
Tension leg platform

Tetraspar

- New floating concept combines benefits of existing floater concepts
- Shallow installation depth
- Low weight



Sources:

L: DTU

R: Stiesdal A/C

VAWT

Vertical axis wind turbine:

- Vertical shaft
- Operates in all wind directions
- First onshore VAWTS installed in 1990

Offshore potential:

- Closer to water (O&M)
- Lower bending moment at water level

Source:

Quiet revolution

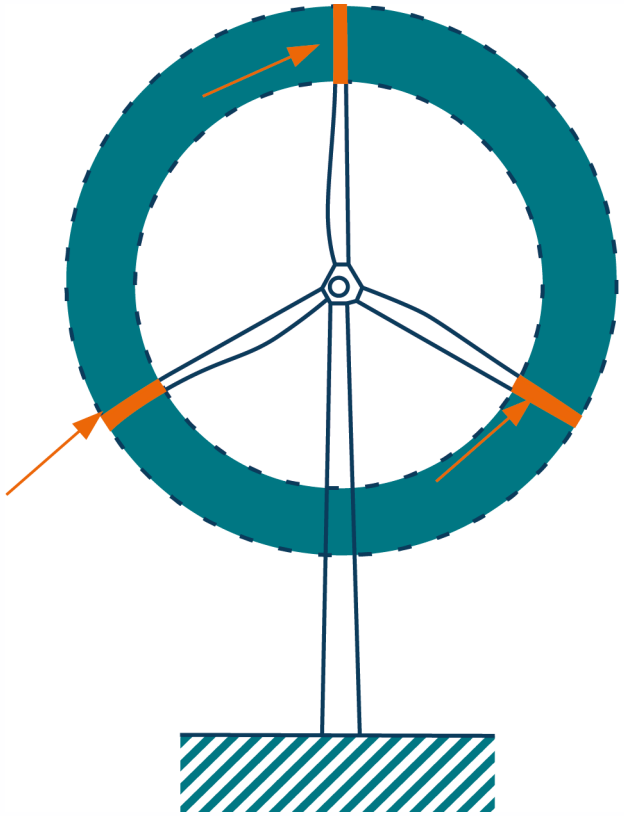
SeaTwirl floating VAWT

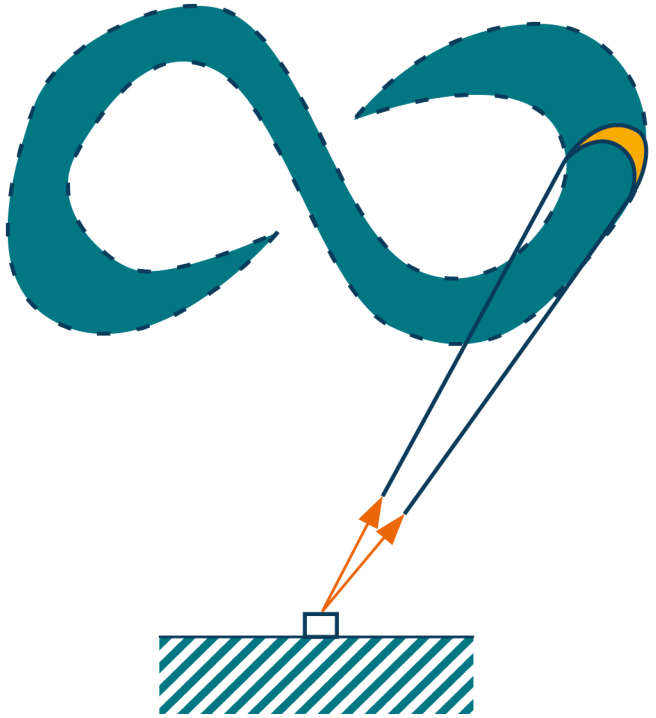
Animation of multiple 1MW S2 SeaTwirls

Source:

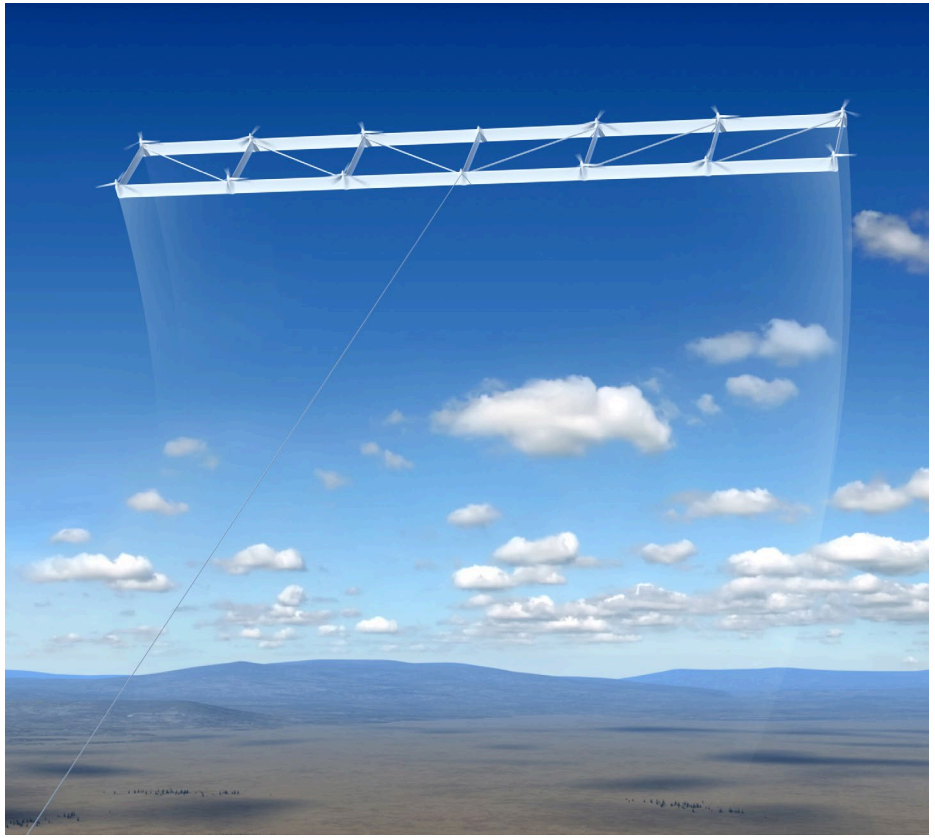
SeaTwirl

Airborne turbines





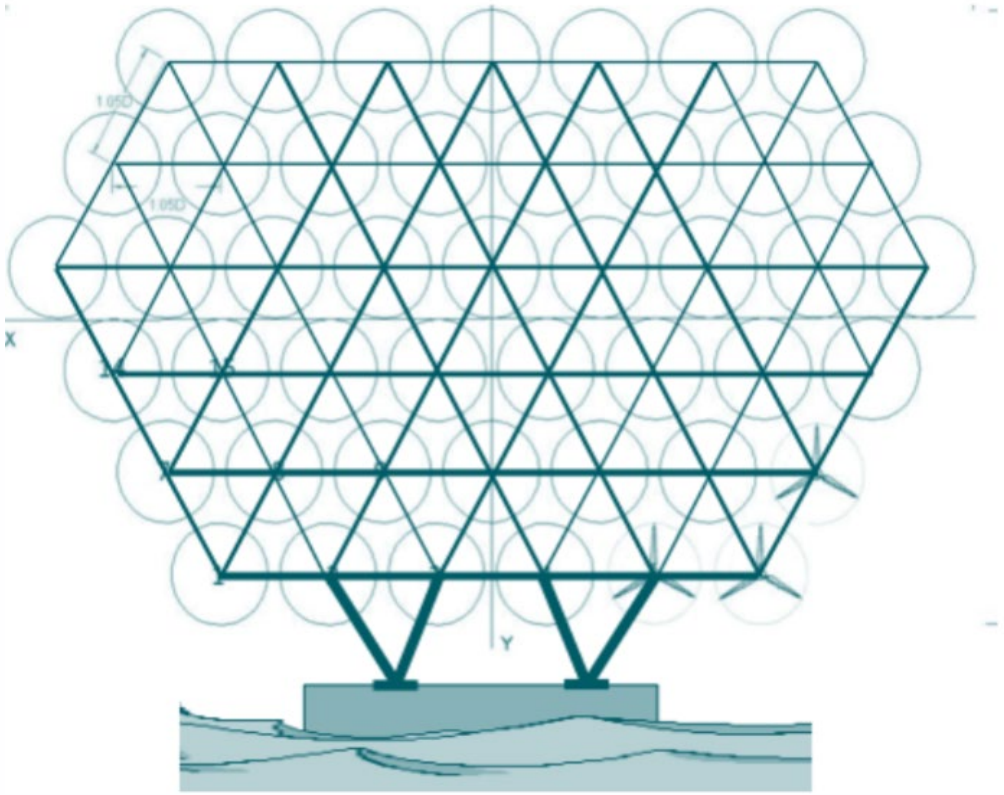
Airborne turbines



Source:

JOBY energy

Multi rotor system



Source:

L: *University of Strathclyde*

R: Vestas

Delft offshore turbine (DOT)

Source:
nvidia

Foundations

- Suction bucket foundation

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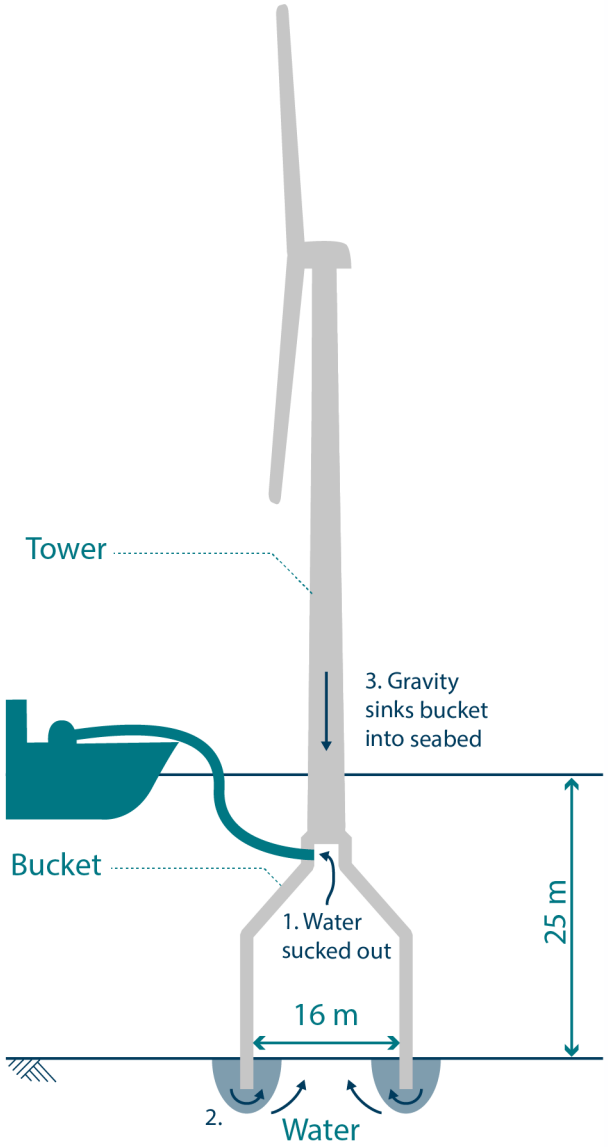
Suction bucket



Universal
Foundation

Grid connection

- Cable development
- Offshore hubs
- Smaller platforms
- Combined interconnectors and windfarms
- Storage

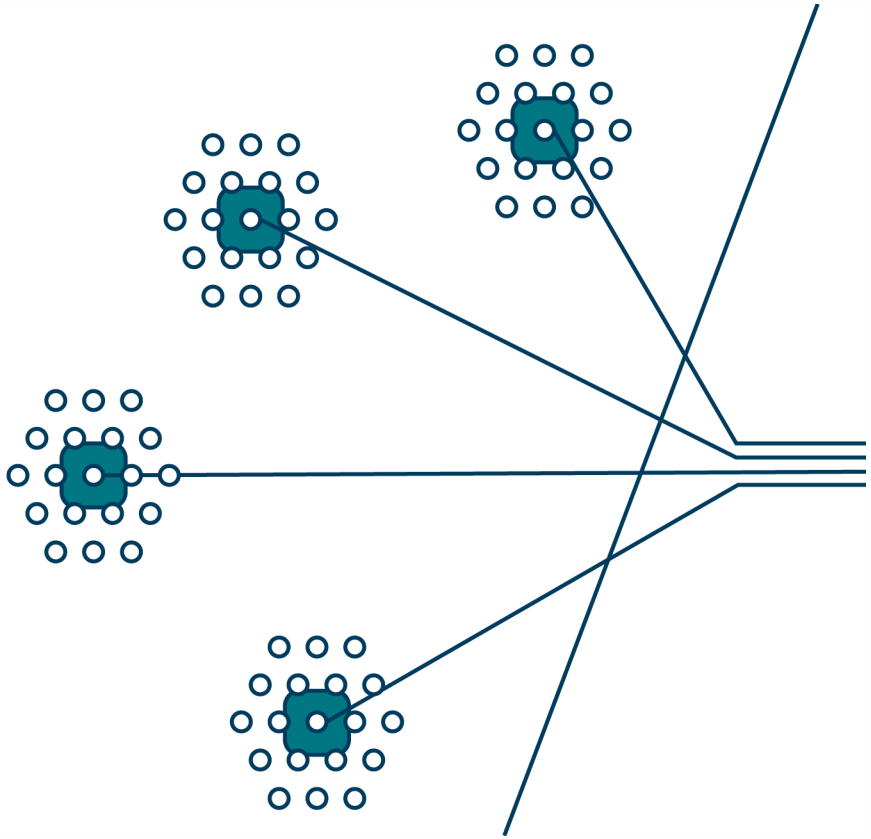
Cable development

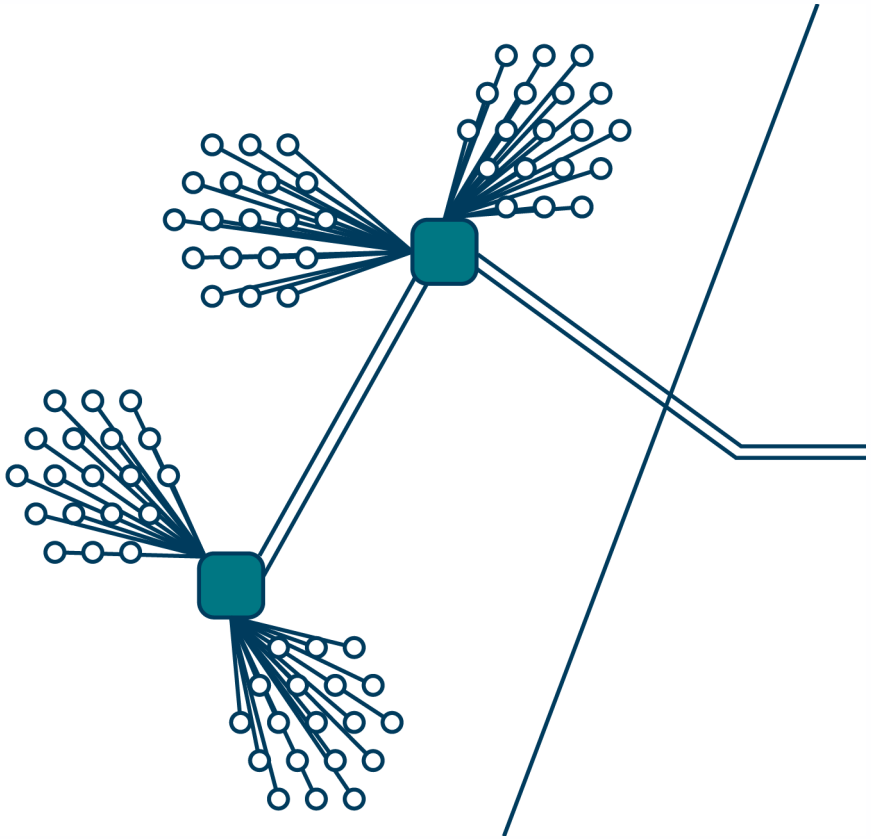
- Cables with higher operating voltages
- AC transmission over longer distance

Source:

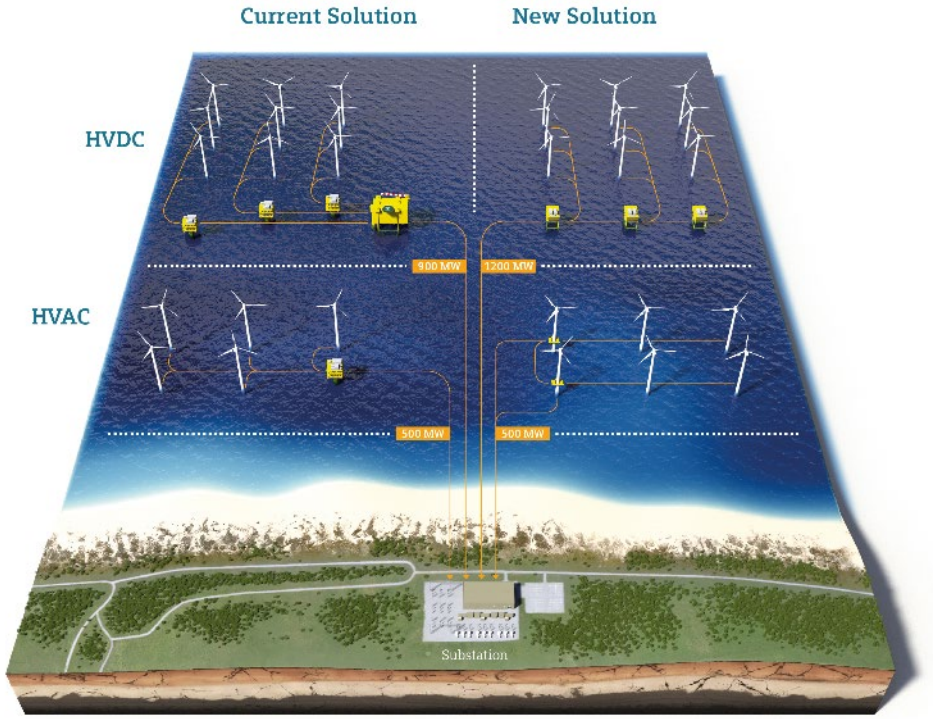
Nexus

Offshore hubs





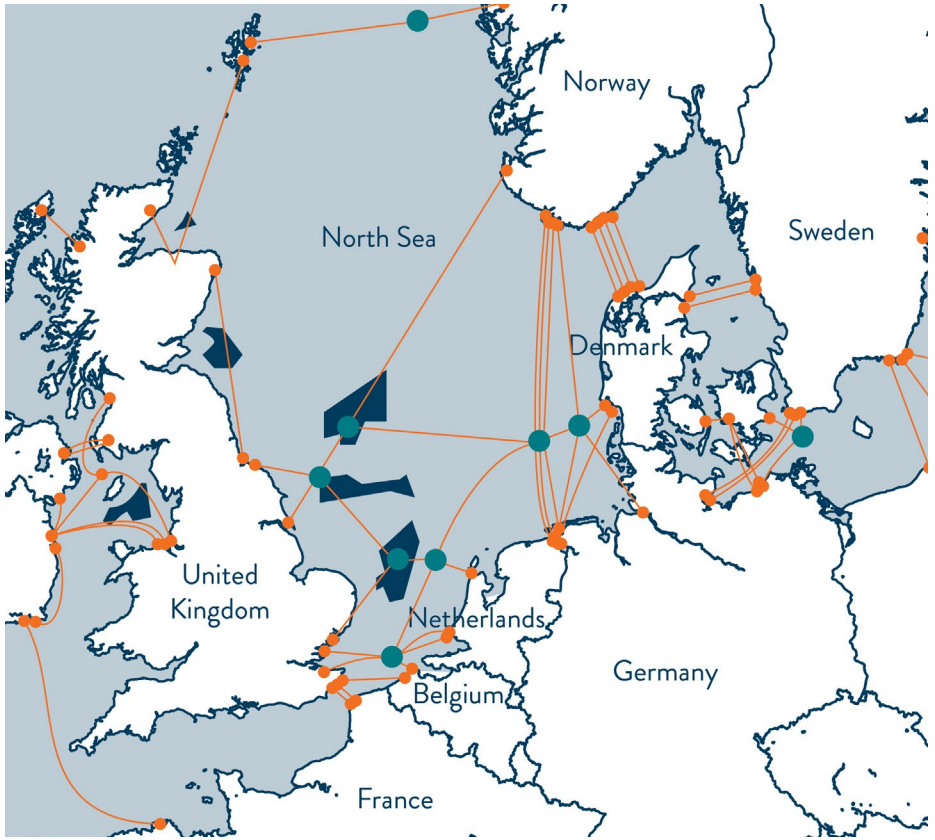
Smaller platforms



Source:

Siemens (2015)

Combined interconnectors and windfarms

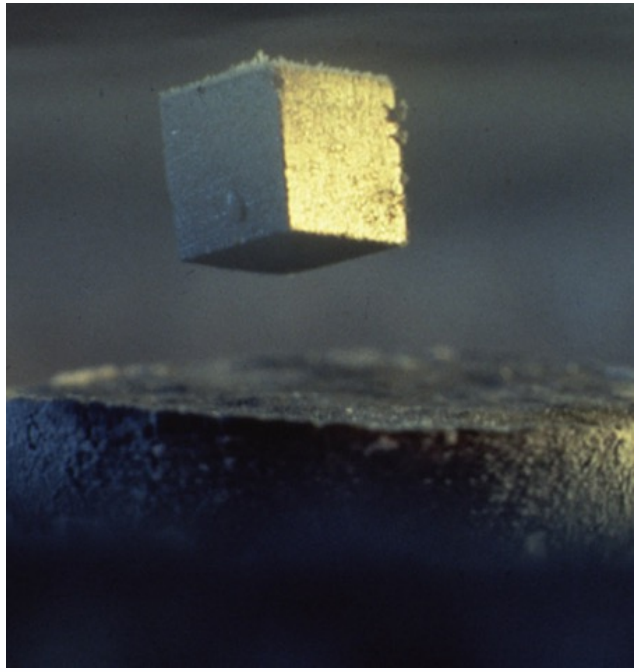


R: Energinet

Storage

TESLA Powerwall

Hydrogen



Super conductivity

Large scale energy storage

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