Offshore Windturbines, Present and future

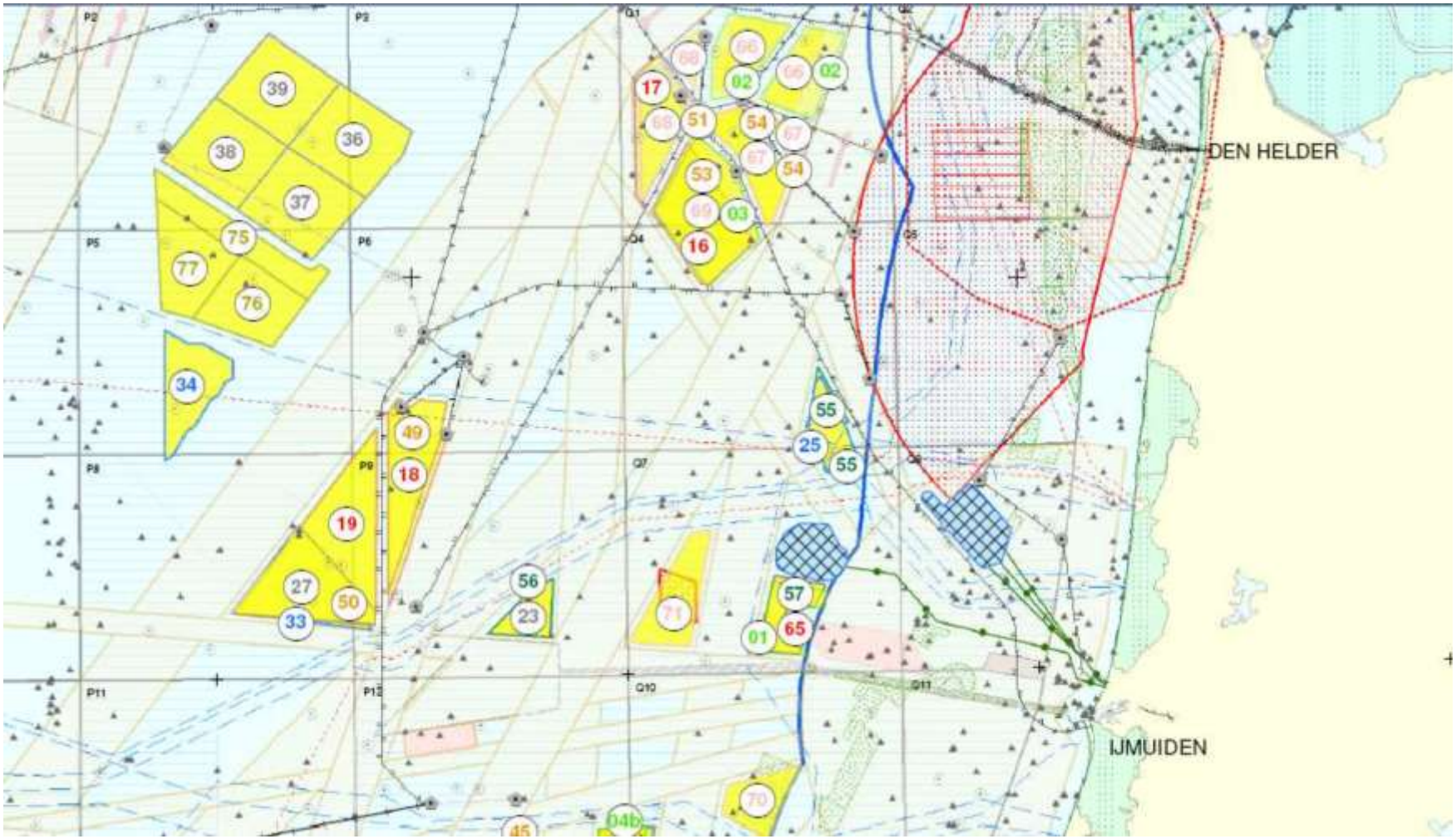
Chris Westra – January 11th 2022

1972	Start: building small wind “turbine”
1978 - 1997	Head Energy research IVAM (Universty of Amsterdam (UvA)
1980	published Windwerkboek (30.000 copies sold)
1997 - 2002	Leading "ECN Renewable Energy International"(REI)
2002 - 2011	ECN Windenergie: Offshore windenergie We@Sea
2011 - ??	self employed consultant and entrepreneur

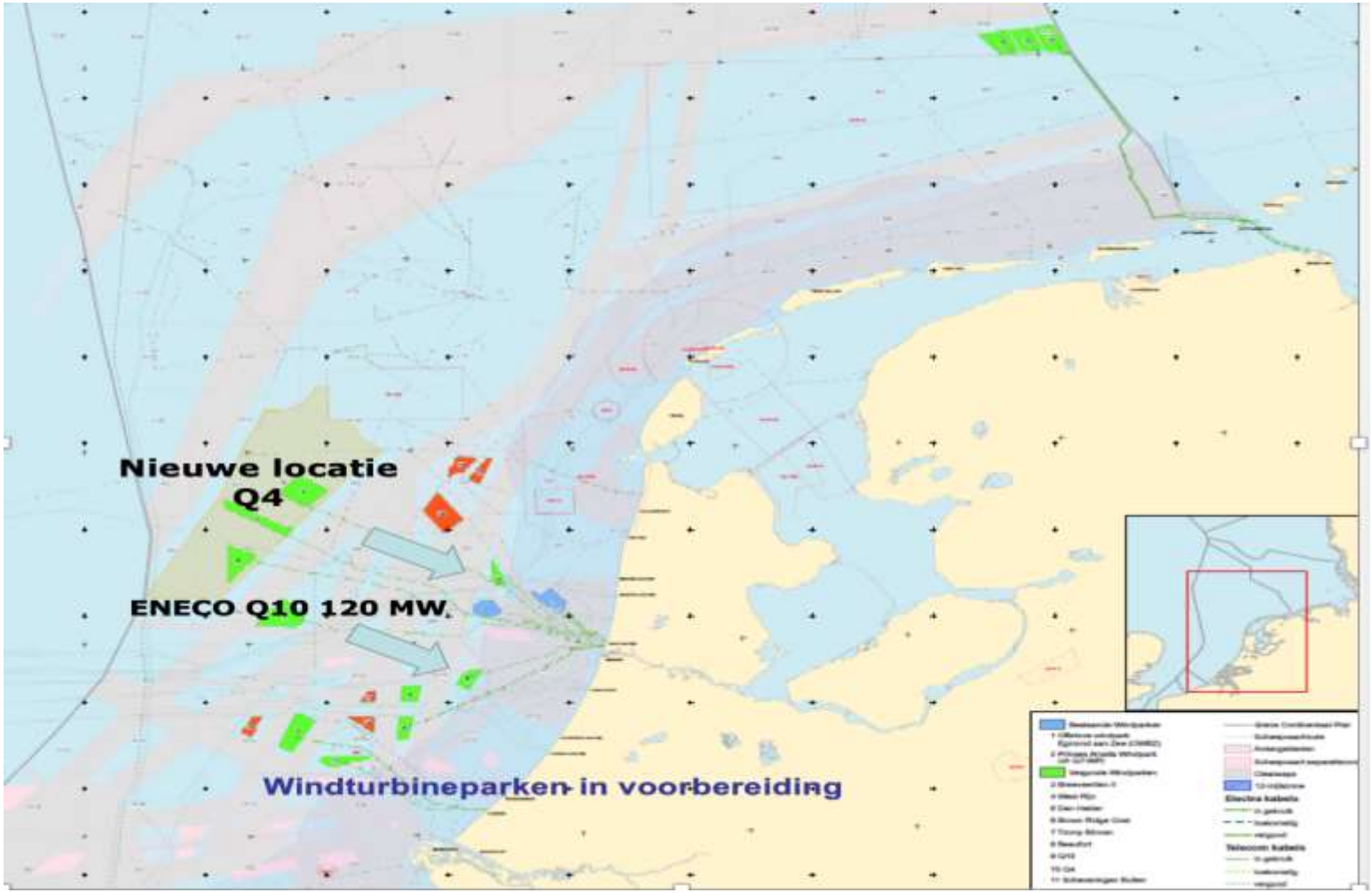
Next steps and challenges in Offshore wind

- Space (policy, strategic planning and legal aspects)
- (Floating) foundations
- Giant turbines
- Maintenance strategies & engineering
- System integration & energy network (grid)
- Yield optimisation (park design & controls)
- Greening the sector green fuels & Recyling (rotor blades)
- HR: ”Training & Education and Health, safety and environment”

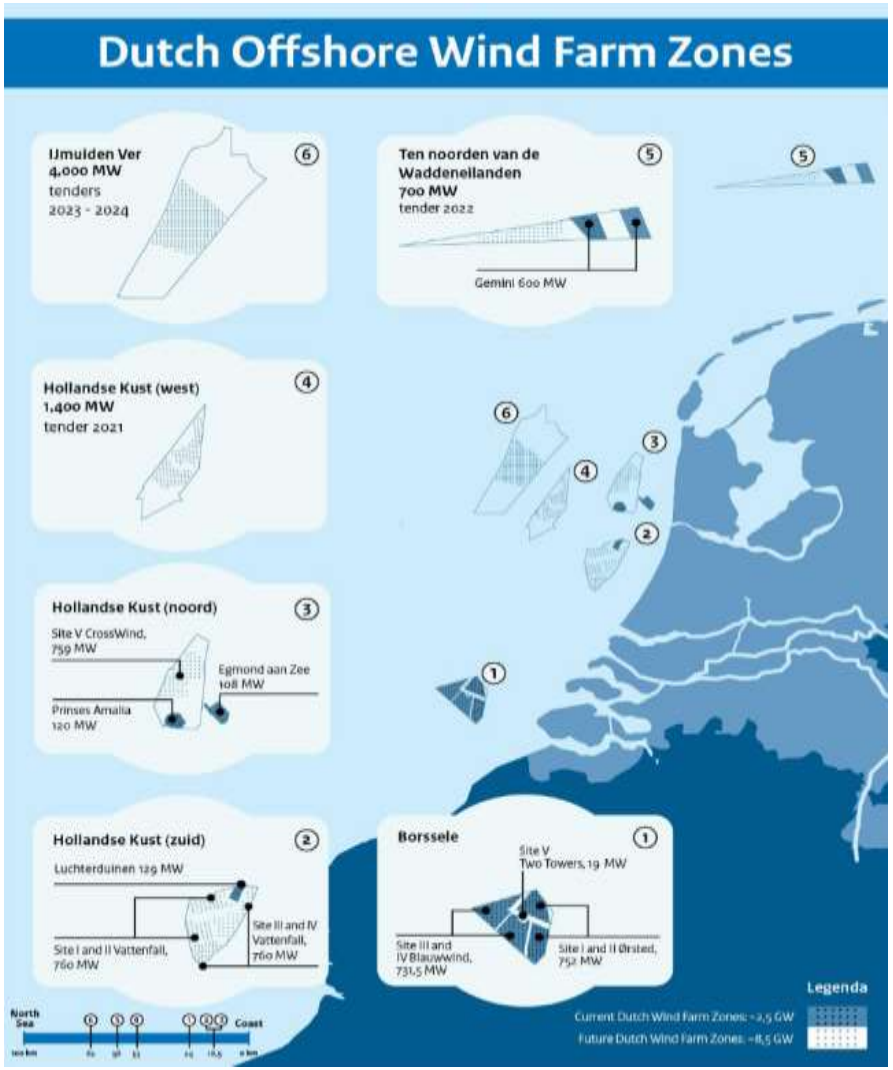
Policy and Space
2009 in search for 440 MW (> 70 applications)



Policy and Space
2013 new situation after cleaning up action

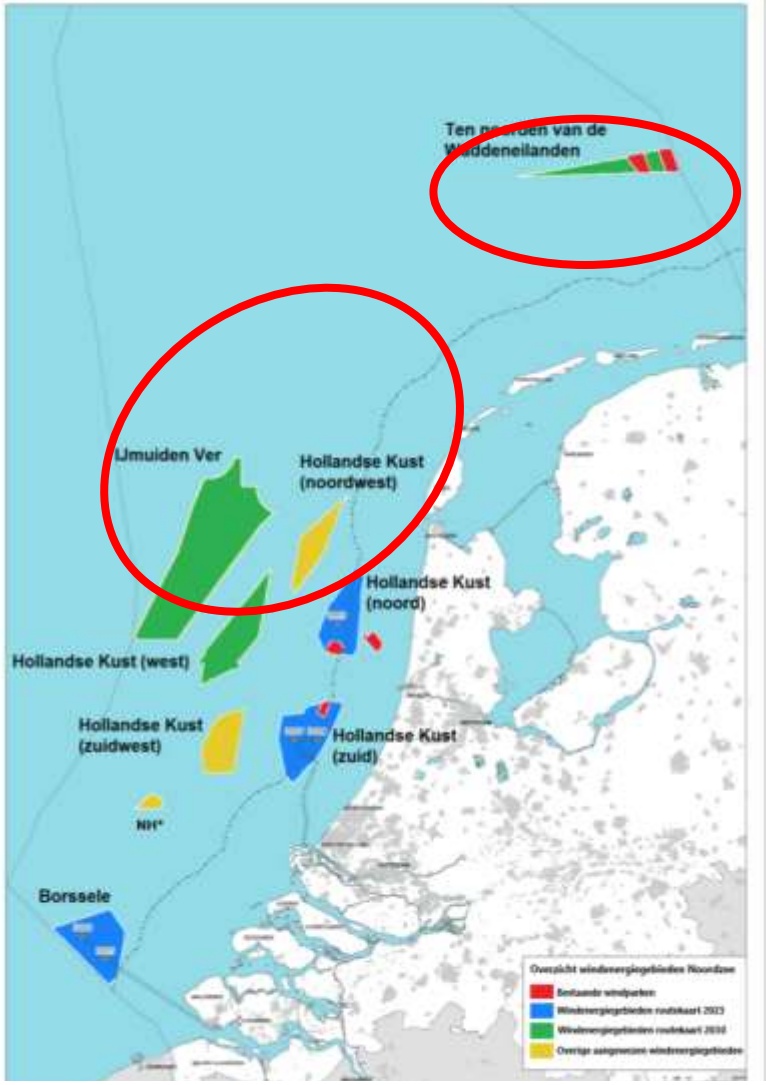


Policy and Space : 2022 situation



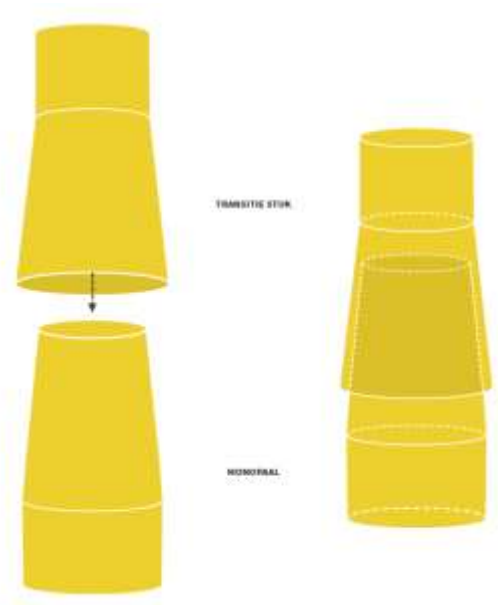
Roadmap 2030

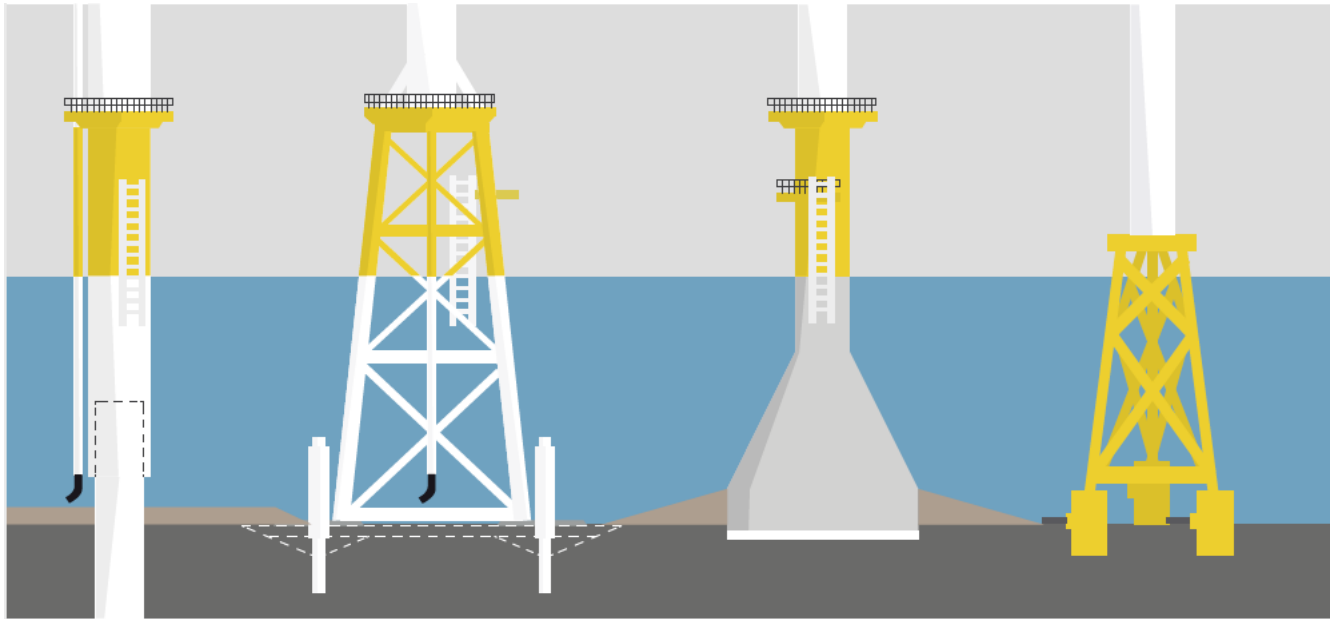
Policy and Space
2030 (11GW) → 2050 (38-72 GW)



Extention target: 21-27 GW (2030)

Foundations:
Assortment of bottom fixed foundations





Slip joint	Monopile	jacket	gravity based	suction bucket
2	5000	568	289	80

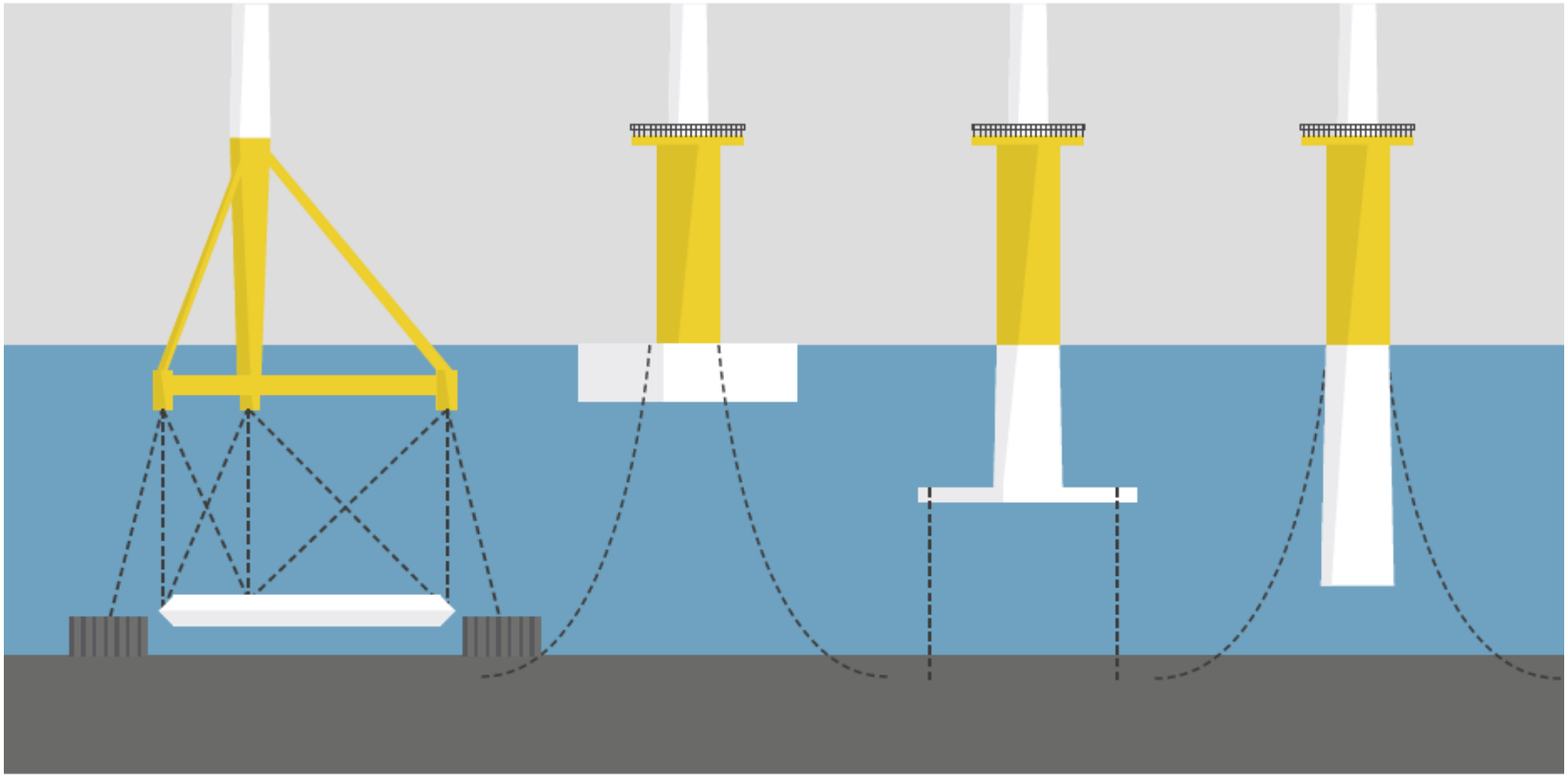
The champion: monopile

The jacket foundation

Gravity based foundation (demonstration BAM)

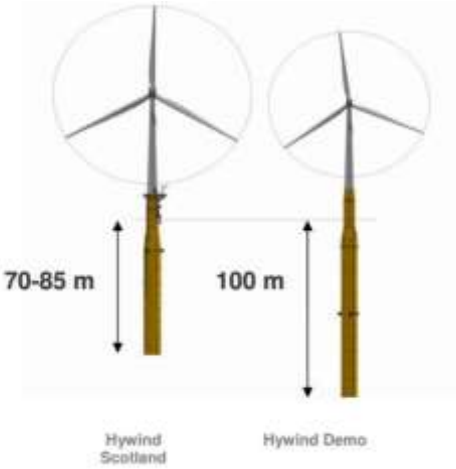
Suction buckets

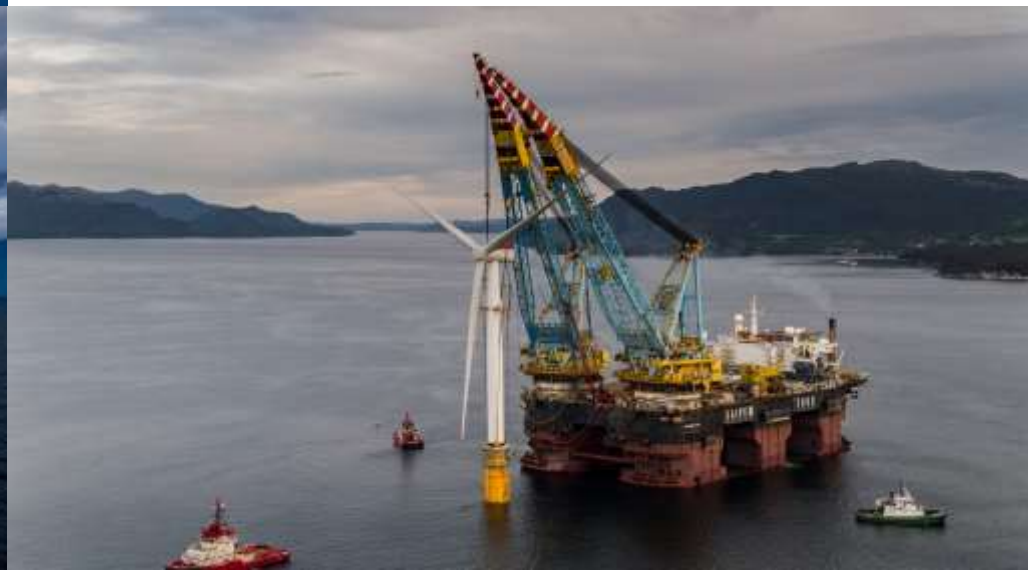
The need for floating foundations



TetraSpar Barge tension-leg spar

Spar: first floating wind farm Hywind (2017)





Hywind: Scotland 5 x 6 MW

Ideol (Barge; damping pool)

2 MW （Vestas V80) : 2 km uit de kust van Le Croisic (Loire-Atlantique) Frankrijk

Floating wind farm Portugal (2020)

Floating wi3 x Vestas 164-8.4 MW (25 MW) Portugal)

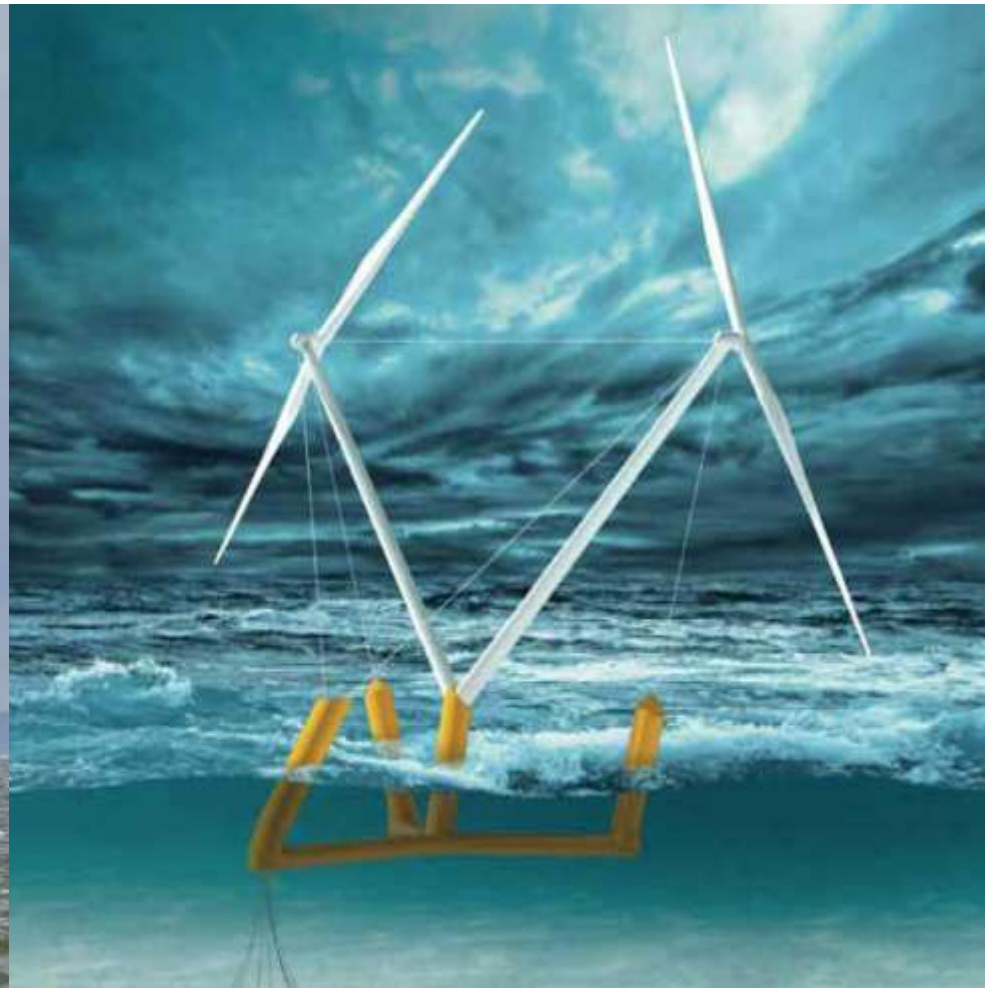
Floating project Kincardine (50 MW) 5 X V164-9,5 MW

Dutch Designs

SBN

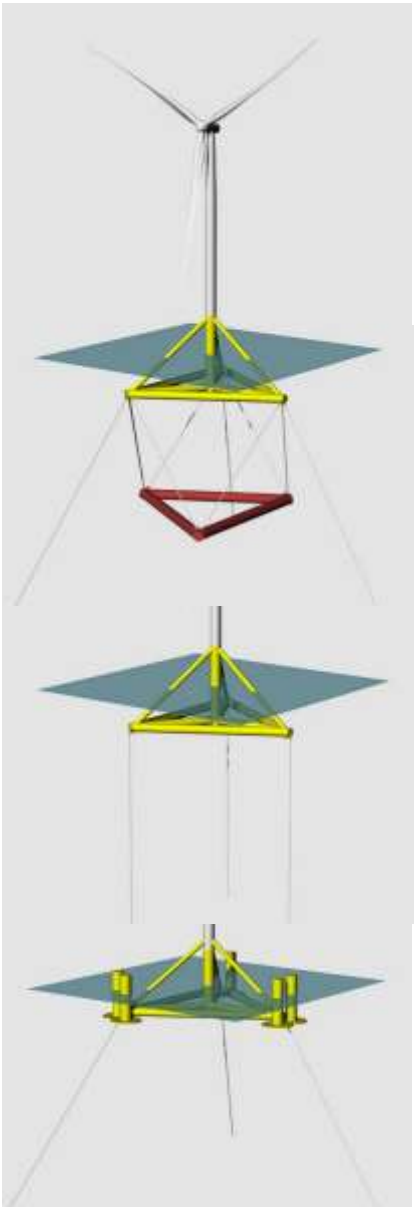
Tri floater Gusto MSC

SCD nezzy-concept (2x 8 MW) water depth 35 meter

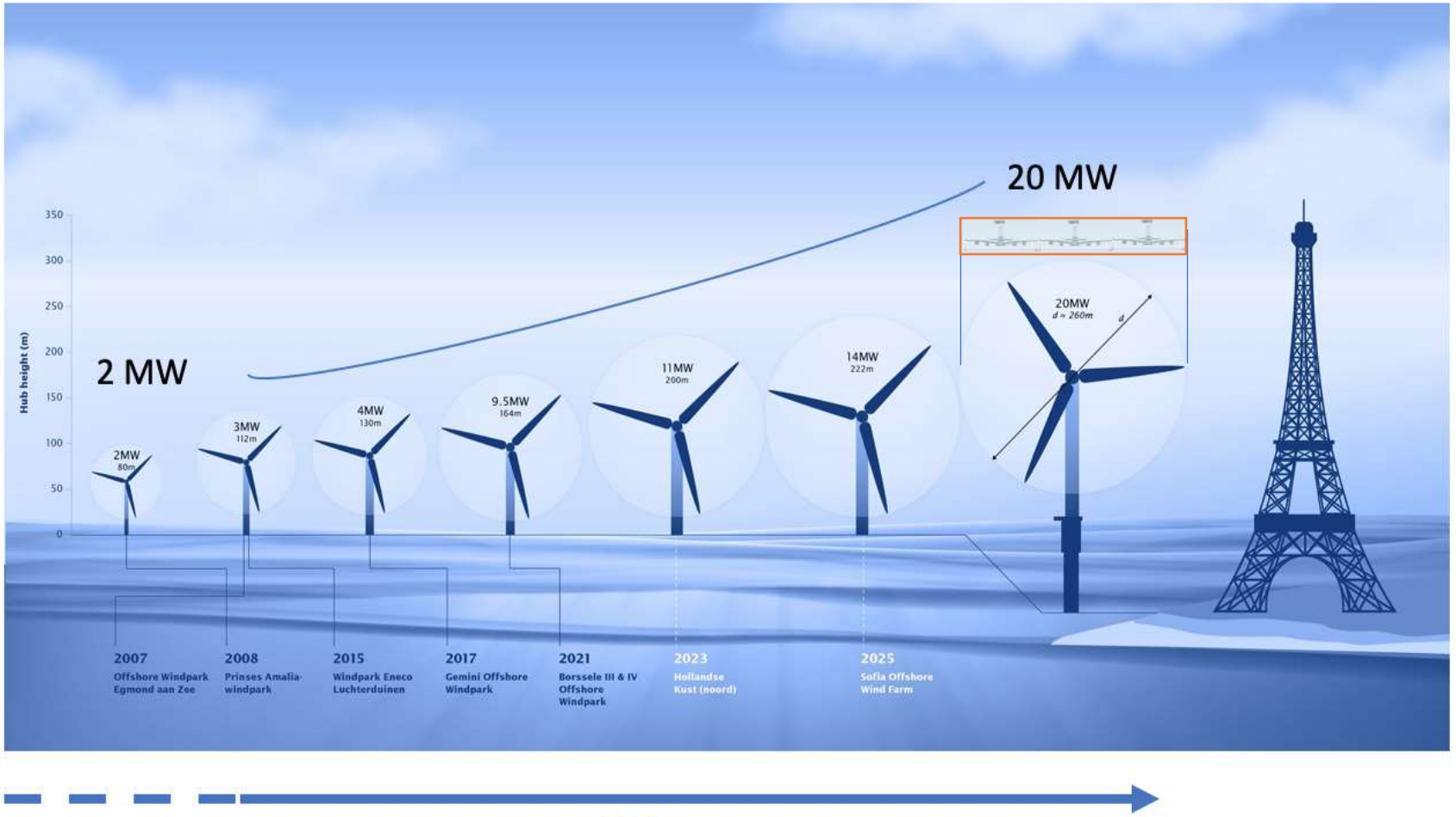


Nezzy 2 floating offshore platform (1:10) in the Bay of Greifswald in the Baltic Sea

TetraSpar (industrial production)



The development of offshore wind turbines



40 years

source: van Oord; diameter of 20 MW turbine = *3 Airbus 380 (*wingspan *80m)*

Big turbines: the latest announced

- 12 (14) MW General Electric
- 14 MW Siemens Gamesa
- 15 MW Vestas
- 16 MW MingYang Smart Energy
- Siemens (internal) talking about (27 MW)

Turbines installed by 2020 average capacity of 8.2 MW
Upcoming projects 10+ MW turbines
→ per project 1200 up to 1500 MW

Big turbines need big installation vessels

O&M strategy

O&M strategy

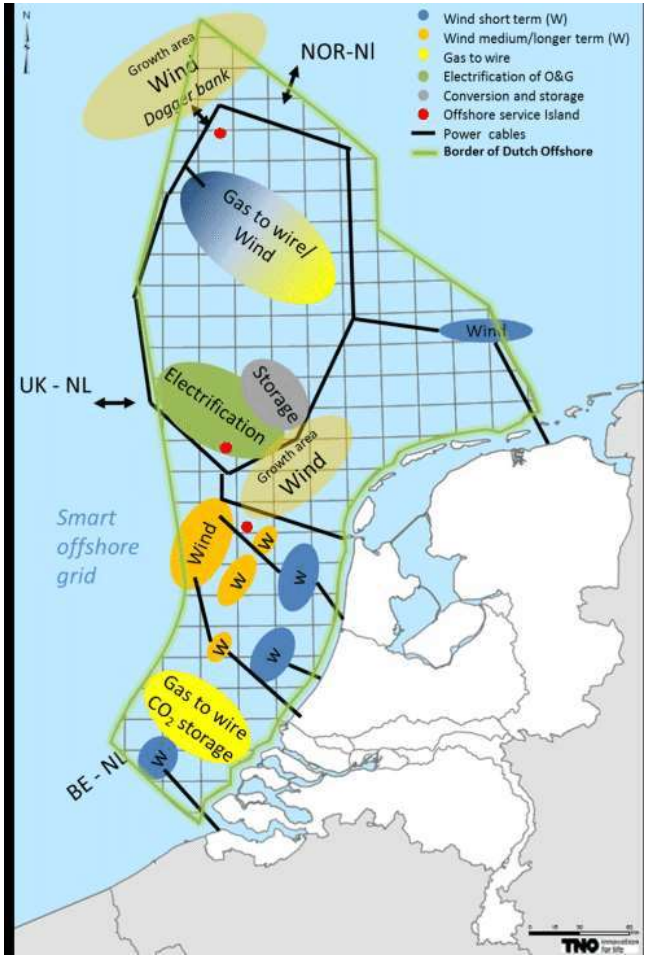
New low-cost W2W and B2W systems (NL !!!)

What’s new ? (1949)

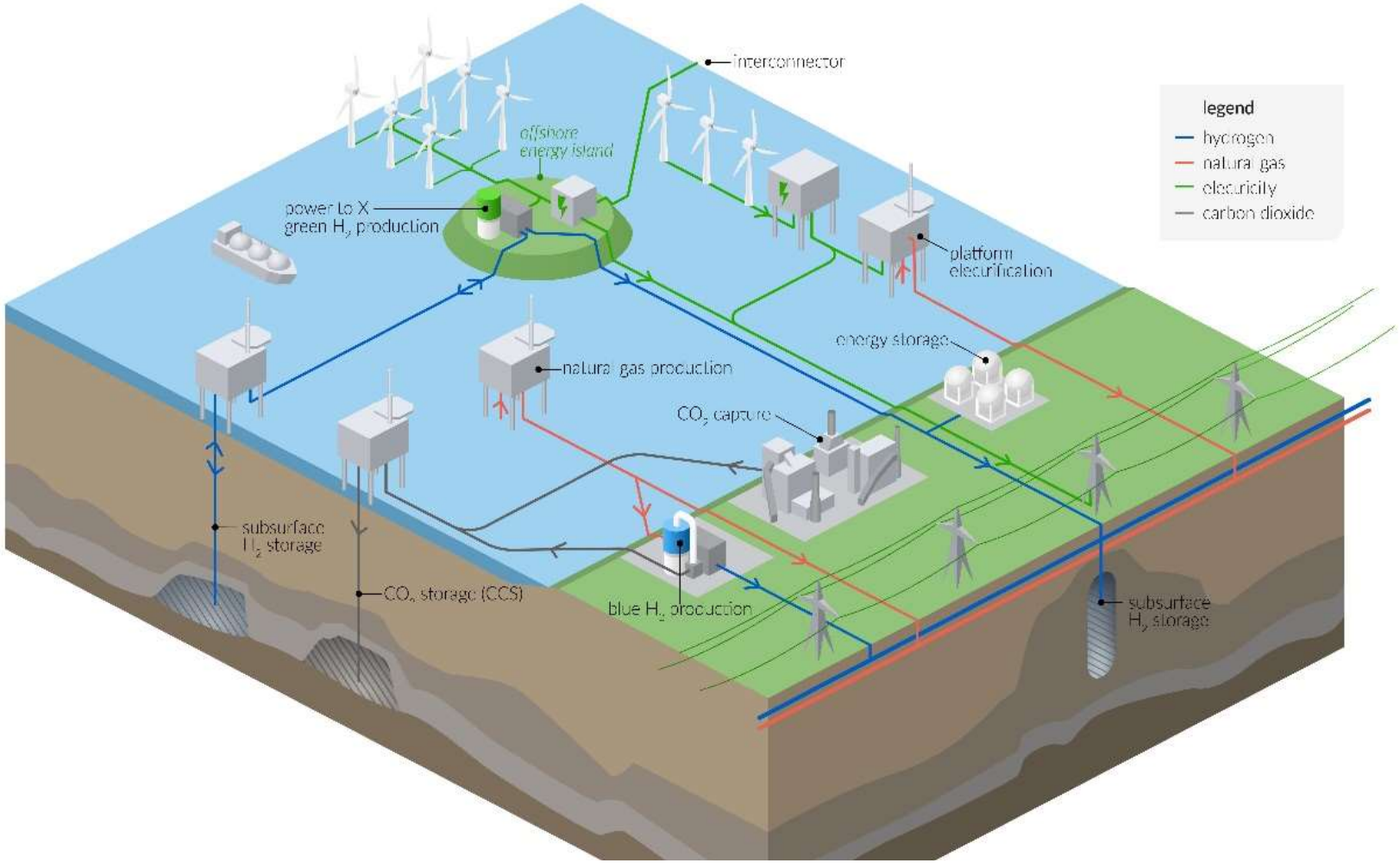
System integration: electrons and hydrogen gasHubs in the North Sea are necessary!

- AC → HVDC
- Large amount of electrical energy

  → H2 production on land
- H_2 production on sea
- H_2 storage on sea
- National and international H2 network development



System perspective on the transition in the North Sea



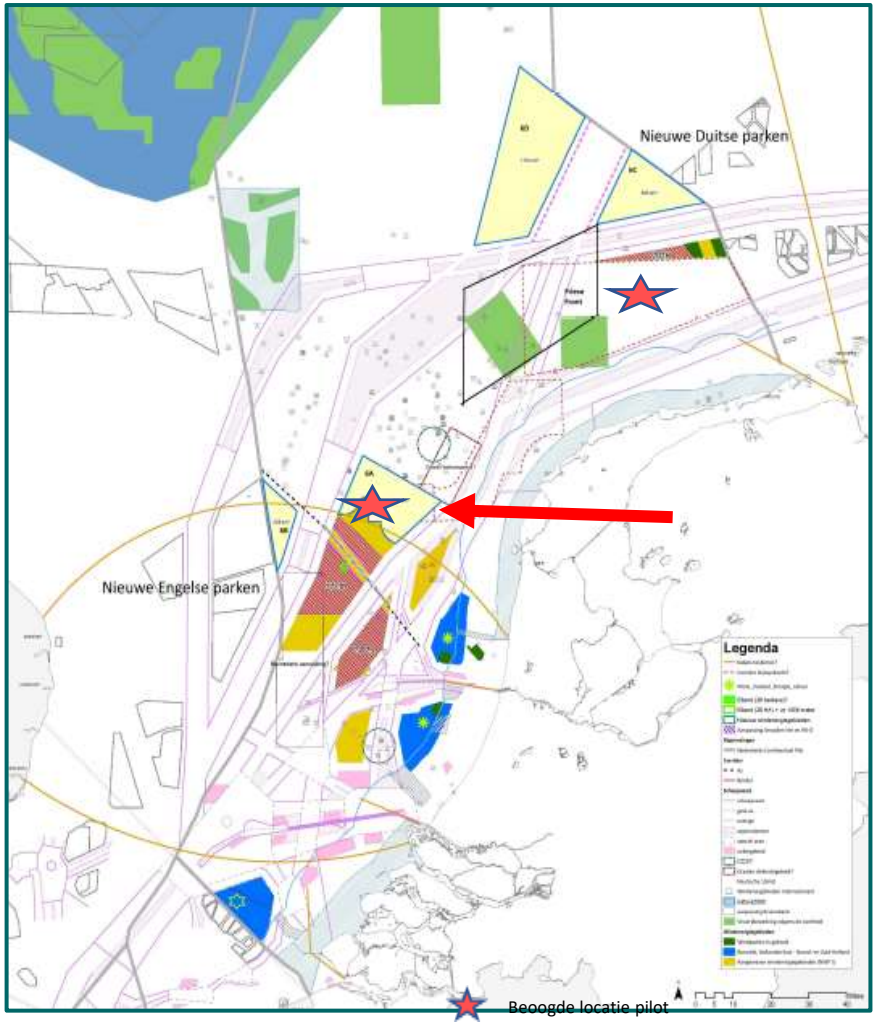
From oil and gas extraction to sustainable energy generation, hydrogen production, storage and transport and CO2 storage in empty gas fields.

Electrification and hydrogen production is necessary for the system integration of offshore energy:

- Large amounts of electricity from the sea need consumers
- Industry close to the coast have to switch from gas to electricity: Rotterdam, North Sea Canal and Eemshaven.
- HVDC stations (4-6 ha) & Hydrogen production needs a lot of room (1GW=10 ha) → H2 production at sea (existing network)

A multi-functional energy island: North Sea

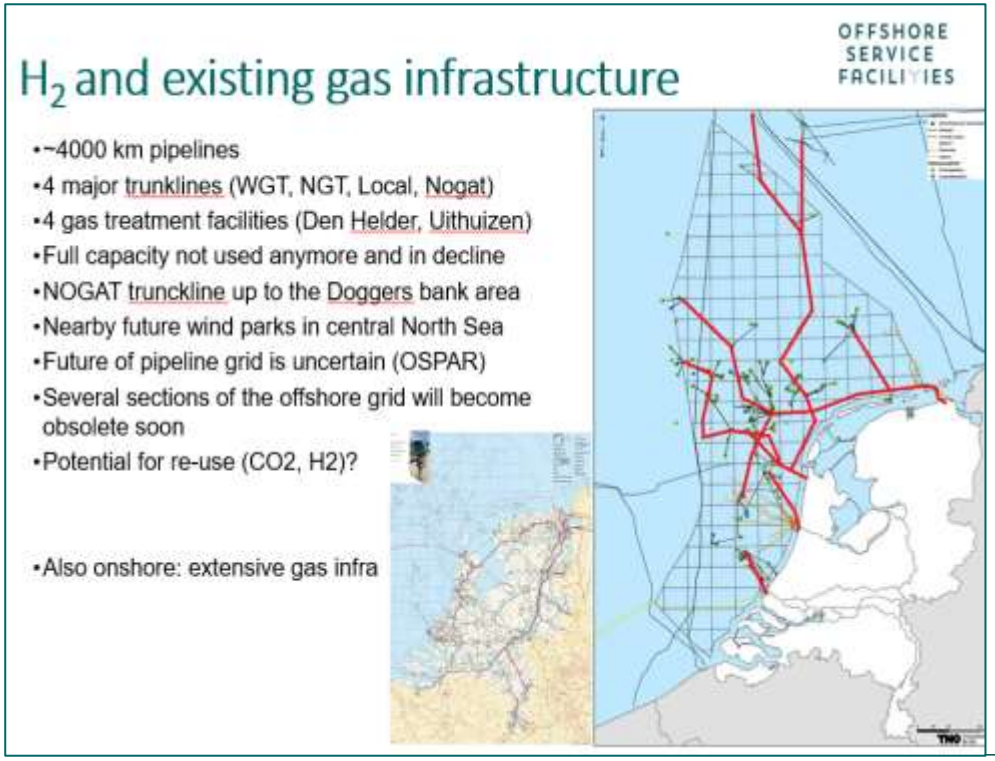
- A multifunctional island
- Hydrogen production: feeding into existing gas pipelines
- Electrical infrastructure (HVDC substation and interconnection)
- O&M accommodation, security, coastguard, data hotel, seaweed farming, etc.
- Knowledge development: e.g. ecology (nature-inclusive design)



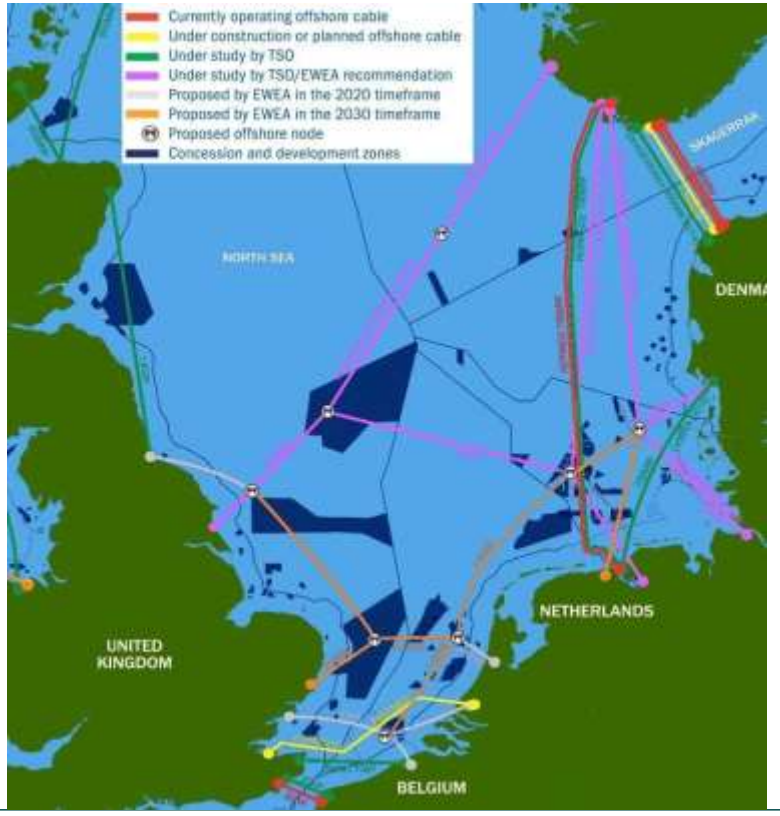
Studies artificial islands

IJVERGAS: 2019 & 2020

- Business case of H2 production and transport using exisiting offshore gas infrastructuur



Many studies on possible offshore electrical infrastructure using hubs



Danish Energy-island (green light government)

Dutch energy-islands

TenneT (Doggersbank)

Offshore Service Facilities (OSF)
with: Boskalis, van Oord, Royal HaskoningDHV, Deltares and Marin
(IJmuidenVer or above Wadden Islands

Dutch Islands studies (OSF)

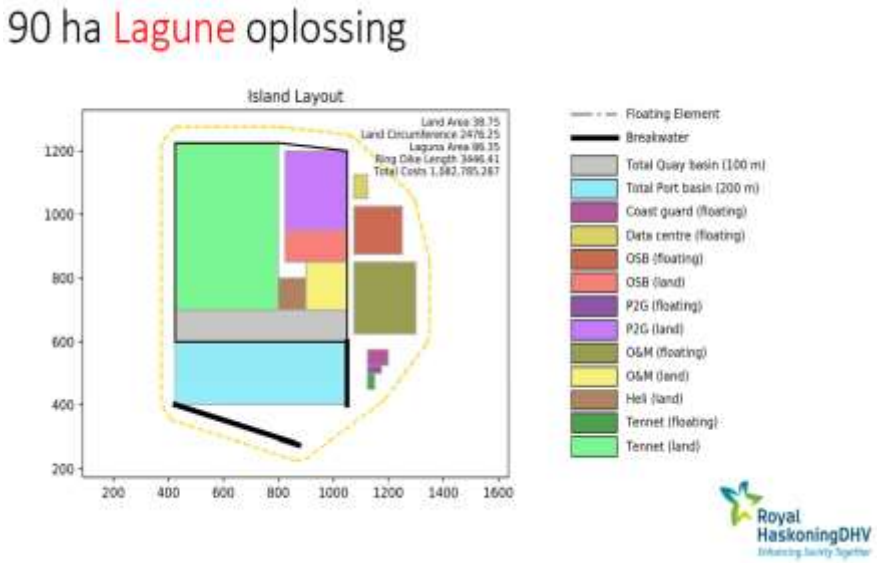
Synergy between R&D and project development

IJVERTECH: 2019

- What is a good and reliable design

Hybrid Energy Island Joint Industry Project:

- Muliti functionalities and space claims
- applications of floating islands and elements in combination with artificial islands



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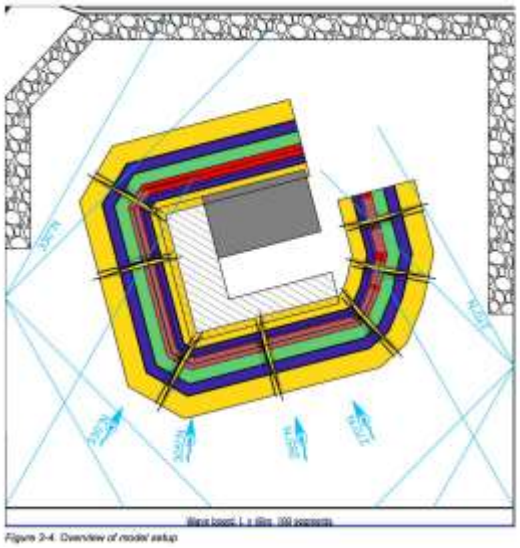
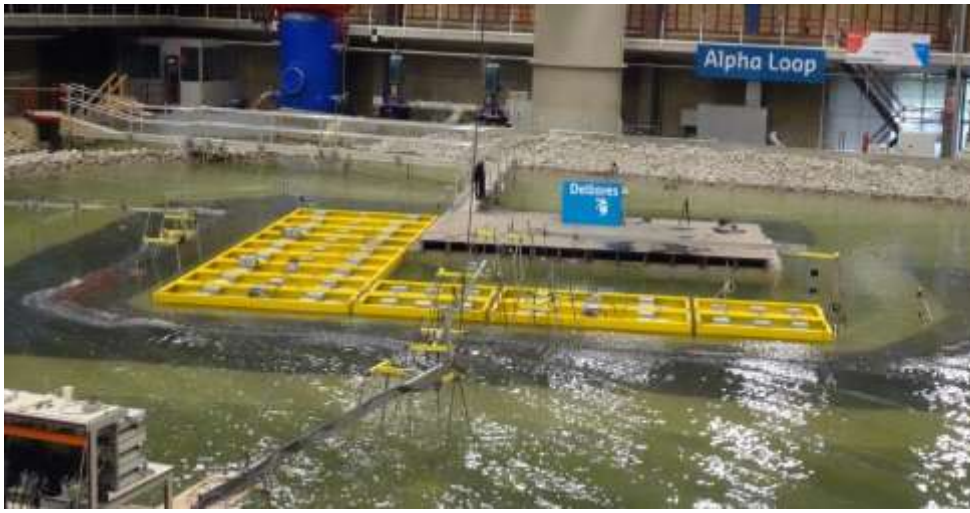
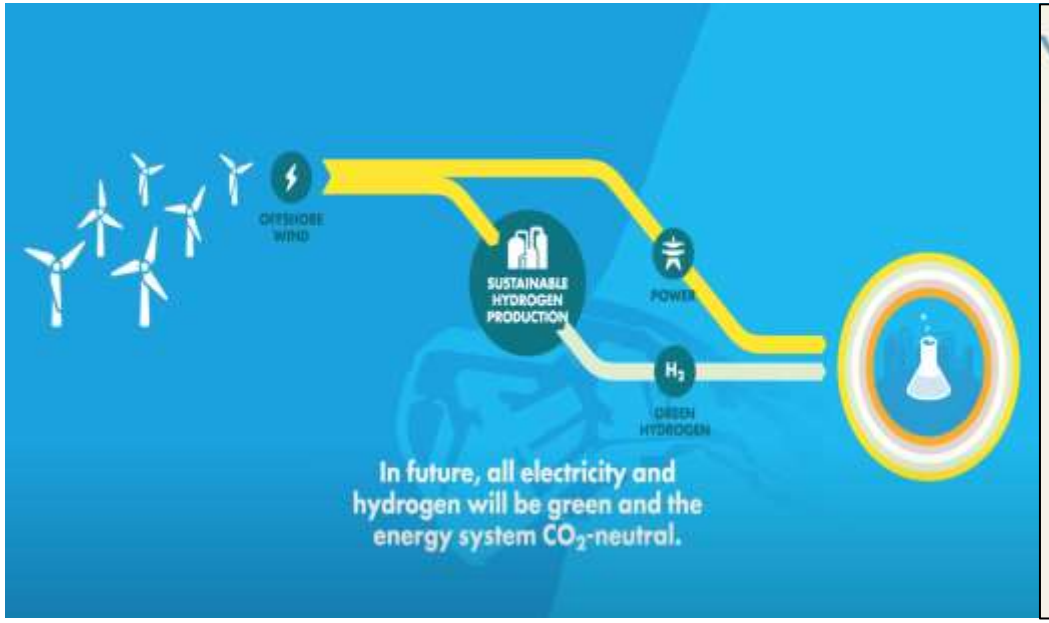


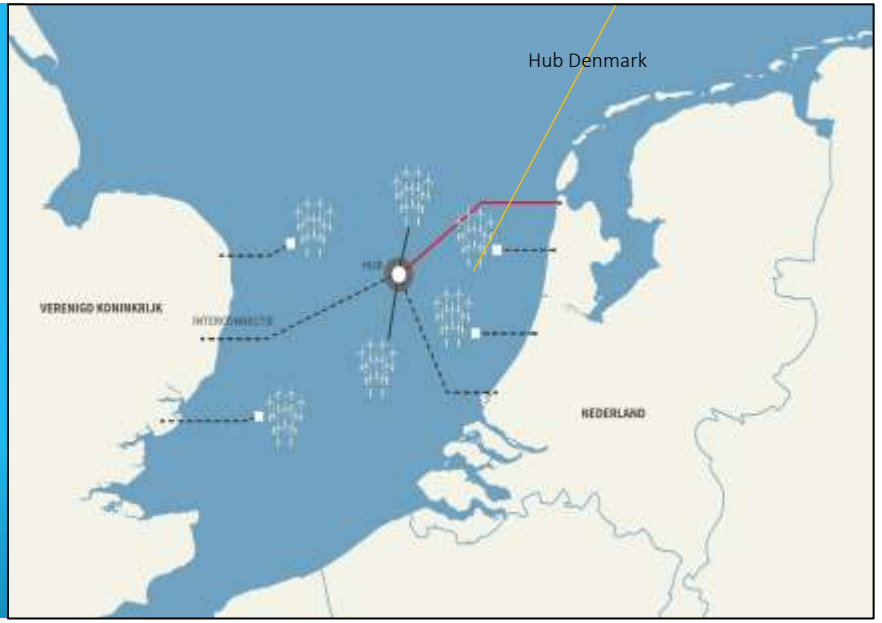


Study by OSF in cooperation with TNO

A new infrastructure and green hydrogen from the North Sea (energy hub)

Opportunities for the Rotterdam the industry (companies) in the Rotterdam region





Maximize energy production by lay-out

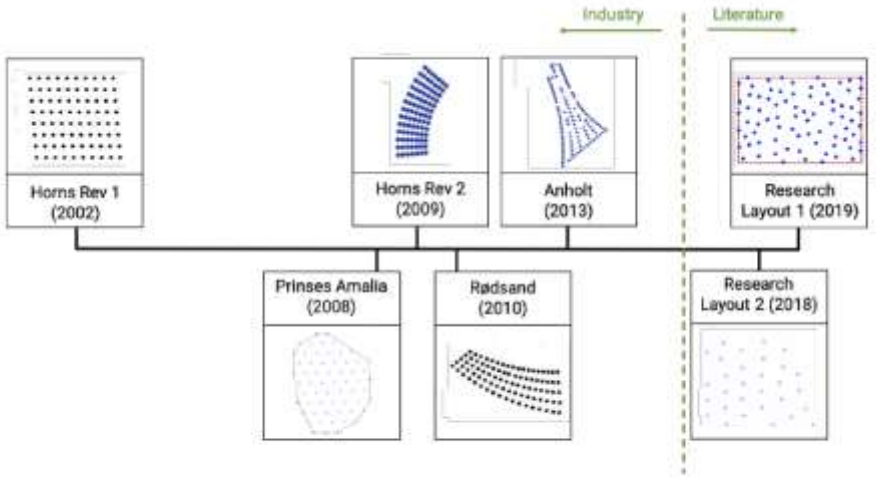
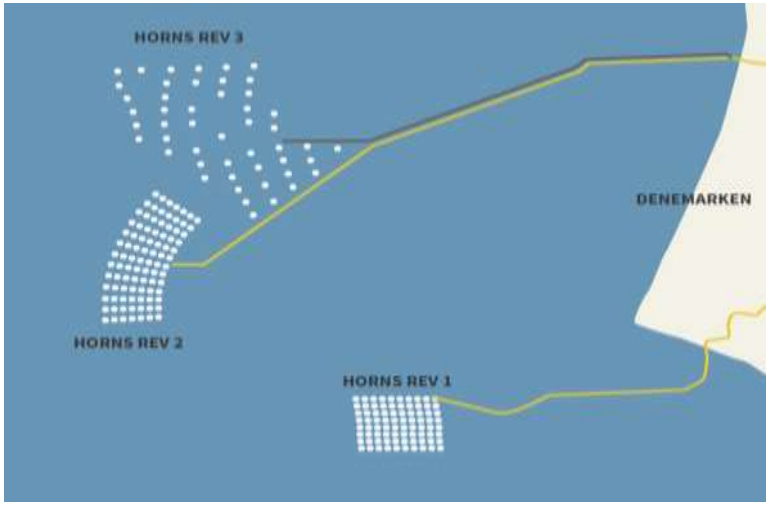
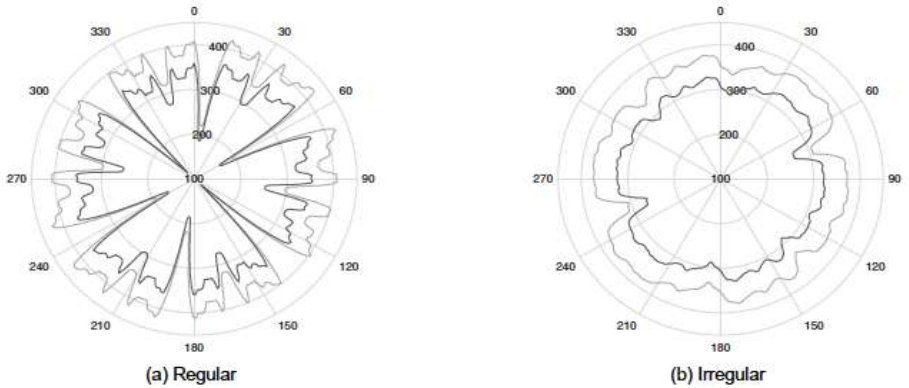


Figure 1.2: Timeline of wind farm patterns in history. Left of the green dashed line wind farm layouts operational in industry are depicted [14–17], and right of the green dashed line optimised layouts from literature studies are depicted [18, 19].

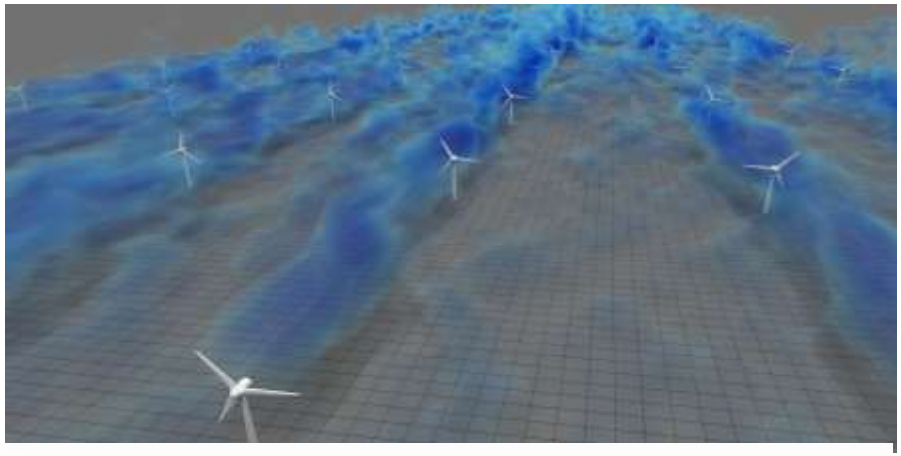


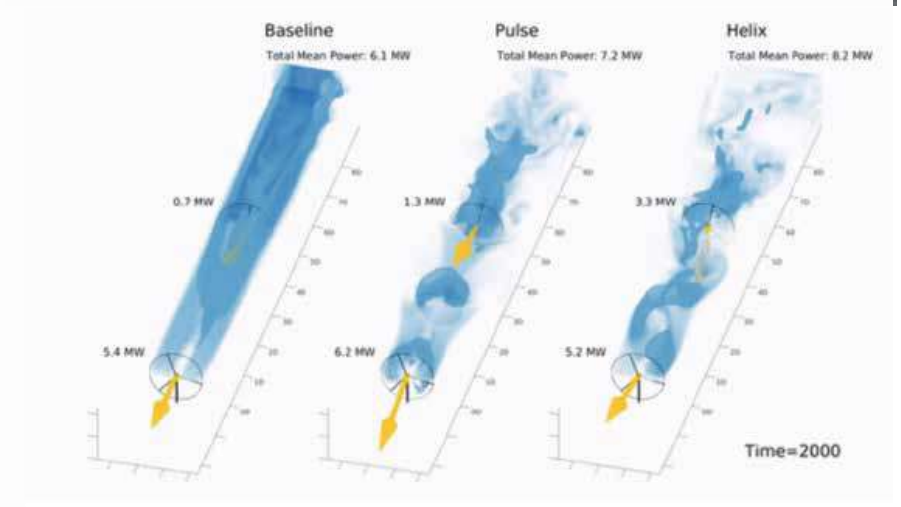


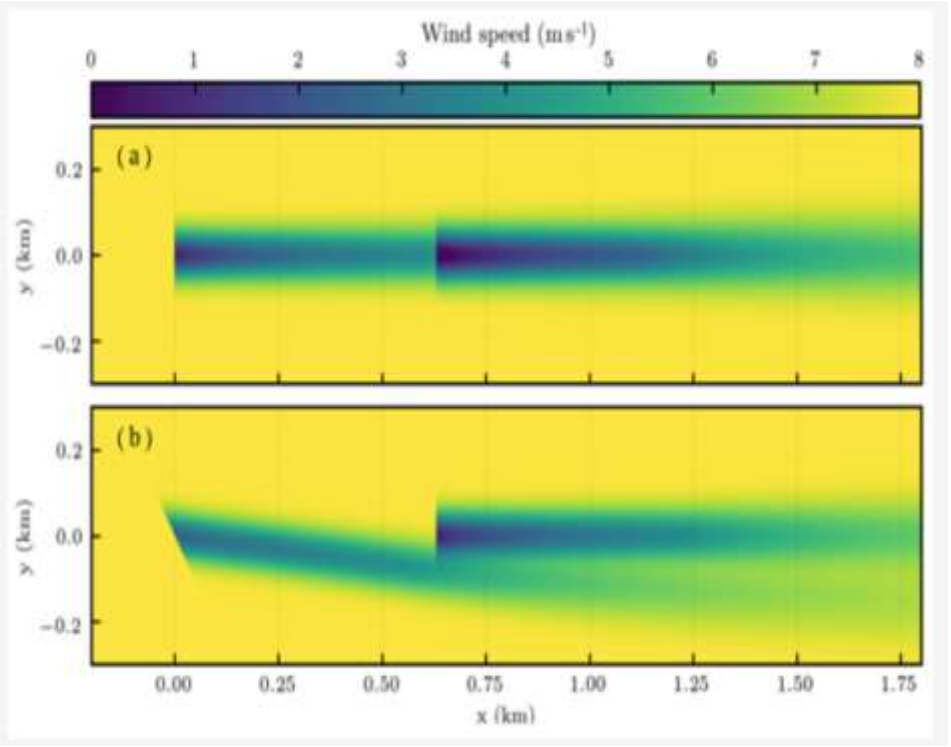
(a) Regular (b) Irregular

Figure 6.2: Power output in MW as a function of wind direction for the (a) Regular and (b) Irregular wind farm layout with the IEA Base (light-grey) and IEA Small (dark-grey) turbines, with a mean wind speed of 9.5 m/s.

Maximize energy production by controls

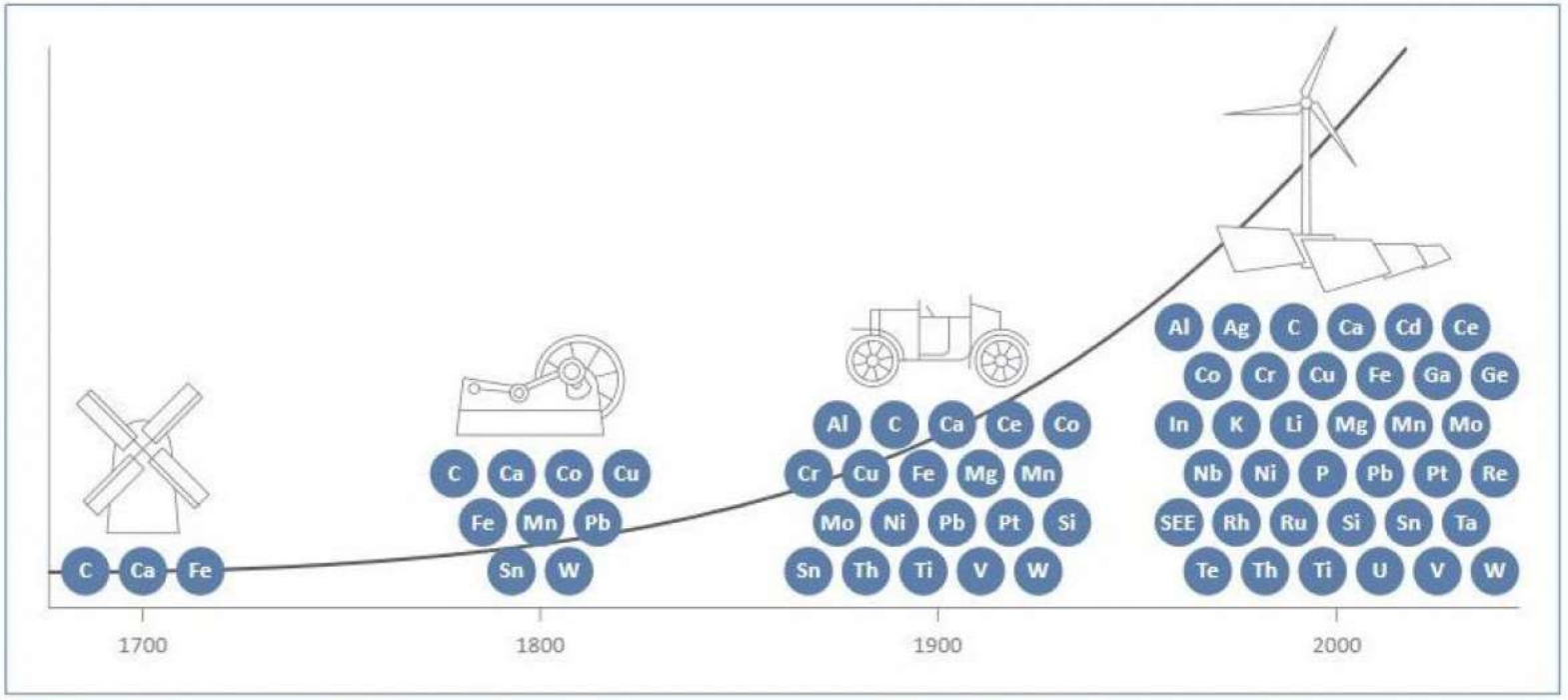






Greening the sector (Recyling)

Used elements in energy technology grow

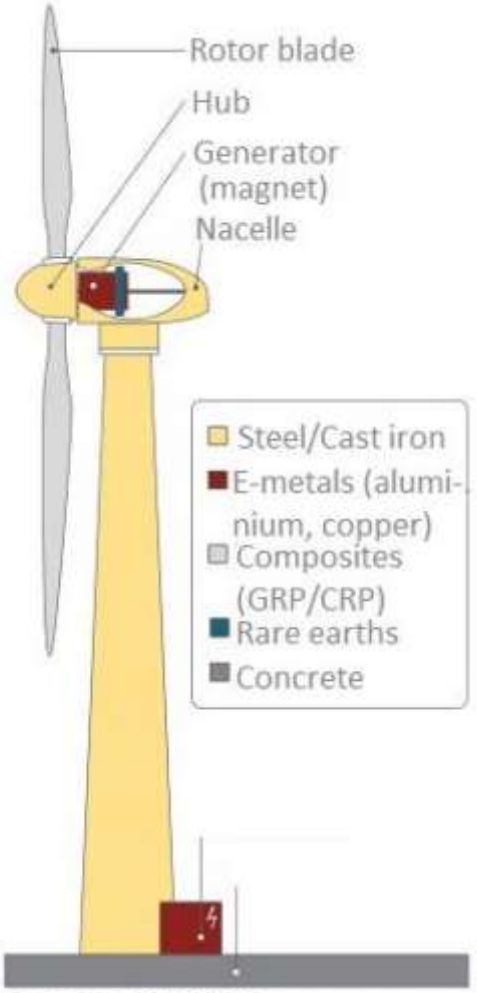


Development of element use in energy generation technology over time

Number of elements used in wind mills, steam engines, combustion engine, renewable power installations growing constantly, with almost exponential growth since beginning of industrial revolution.

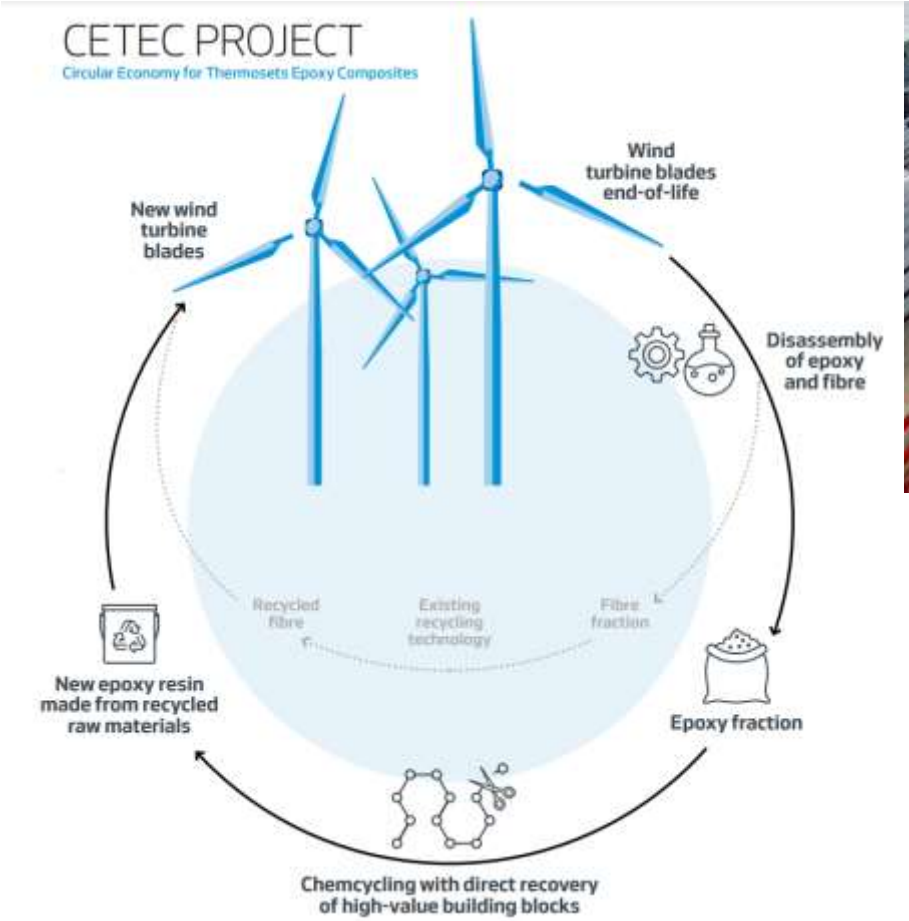
Source: ESYS 2016

Greening the sector (Recyling → rotor blades)

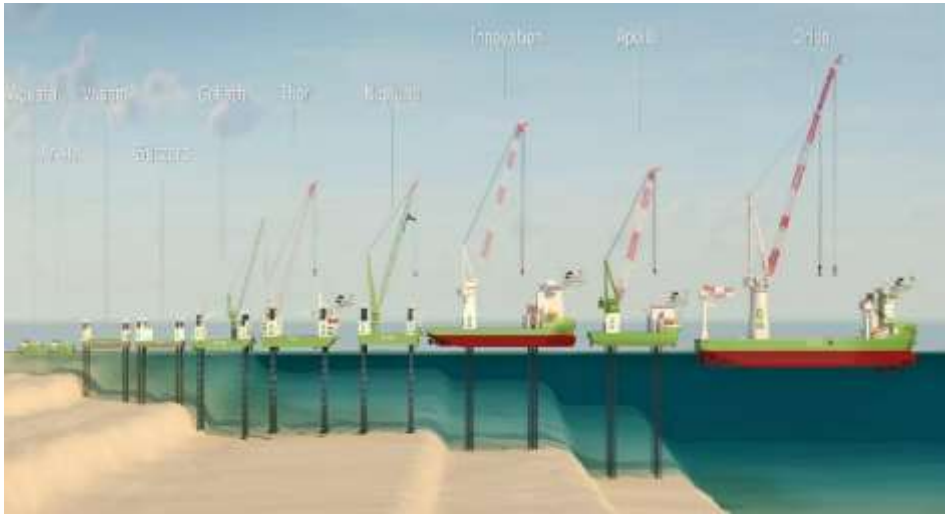


Source: BGR 2016

Recyling → rotor blades (vestas)

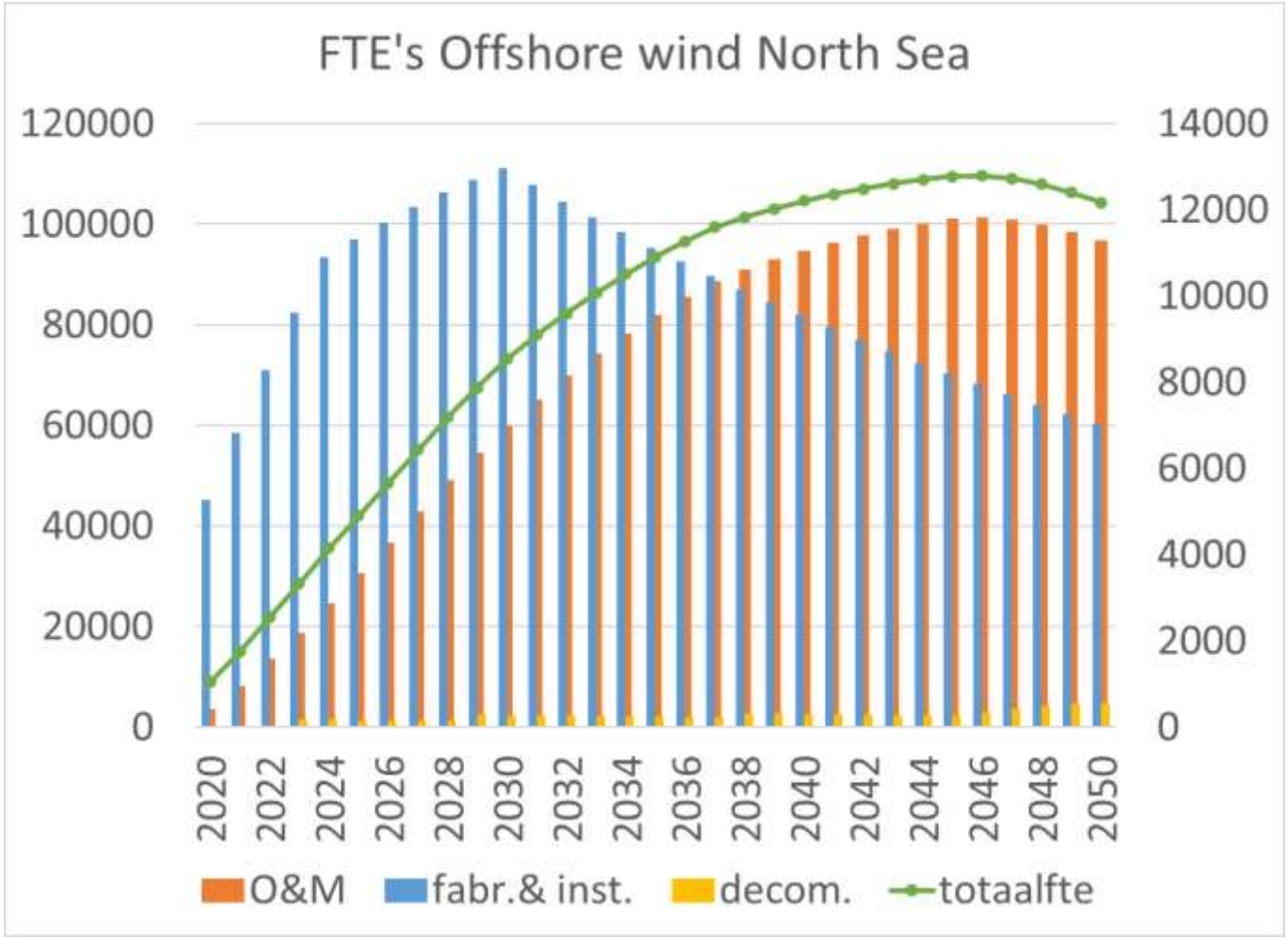


Greening = decarbonize the sector



More attention for “Health, Safety & Environment” → people !

Growing number of jobs in offshore wind energy



Where do we find the workforce and educate and traines them?

Potential offshore wind

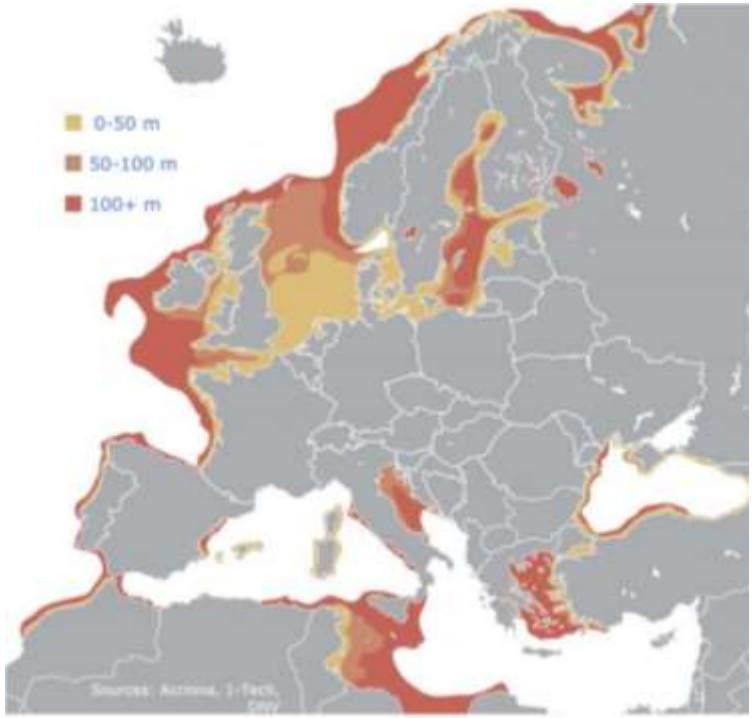
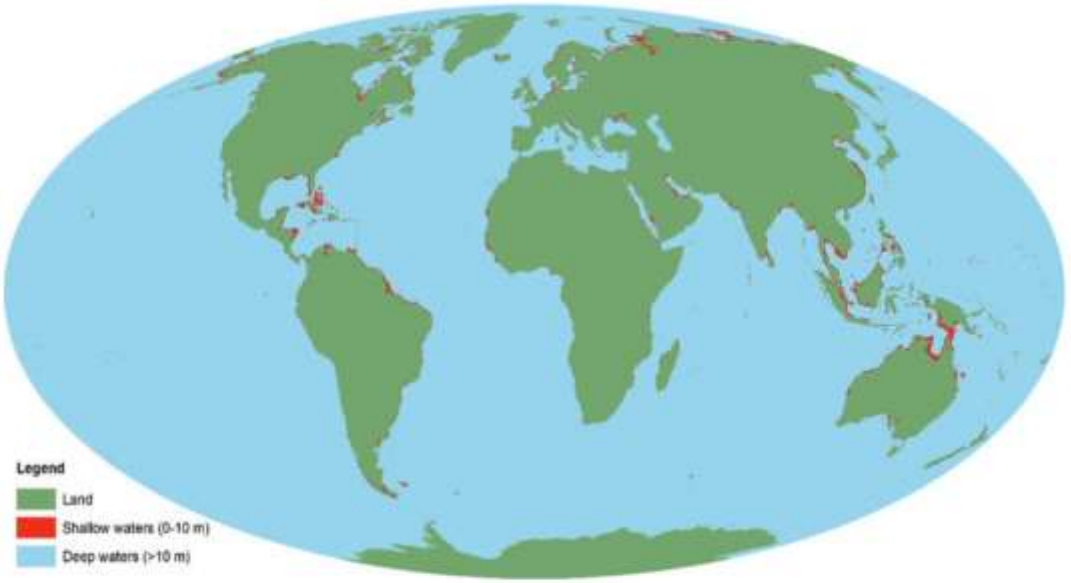
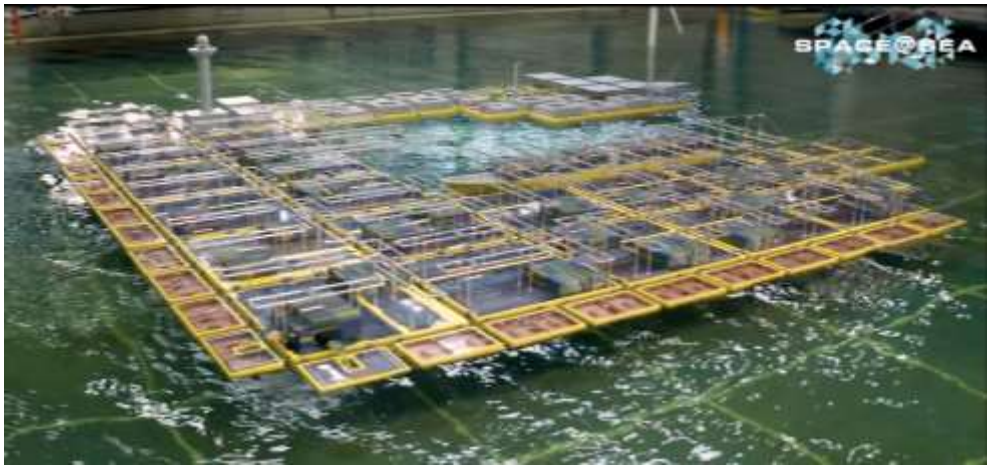


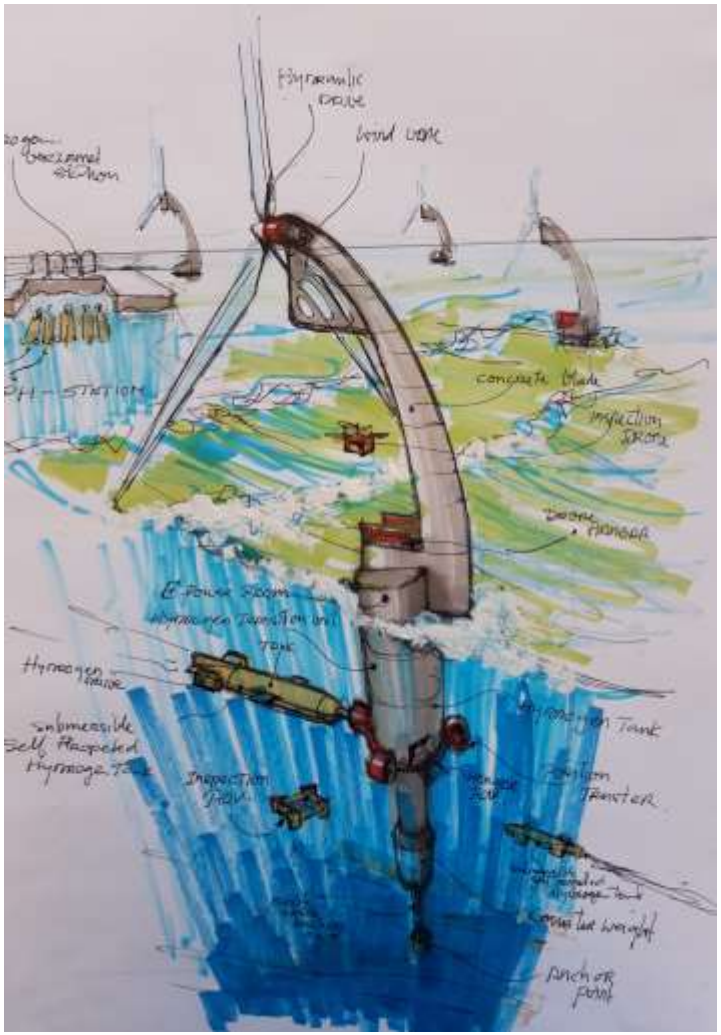
Figure 15. The water depth in European waters.



Worldwide distribution of shallow waters (≤10 m depth). The map was generated in ArcMap (v. 10.6; Esri Inc., Redlands, USA; http://desktop.arcgis.com/en/arcmap/), and is based on the ETOPO1 1 Arc-Minute Global Relief Model [20]. Projection: Mollweide, Datum: WGS 1984.

The oceans are the limit





Offshore windenergie is here to stay !

Alles na te lezen in het boek:
Everything can be read in the book: