SMARTENERGY

OCEANIC RENEWABLES AND THEIR ROLE IN THE GREEN HYDROGEN OF THE FUTURE

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APREN’s Oceanic Renewables Conference, 24 May 2023, Lisbon

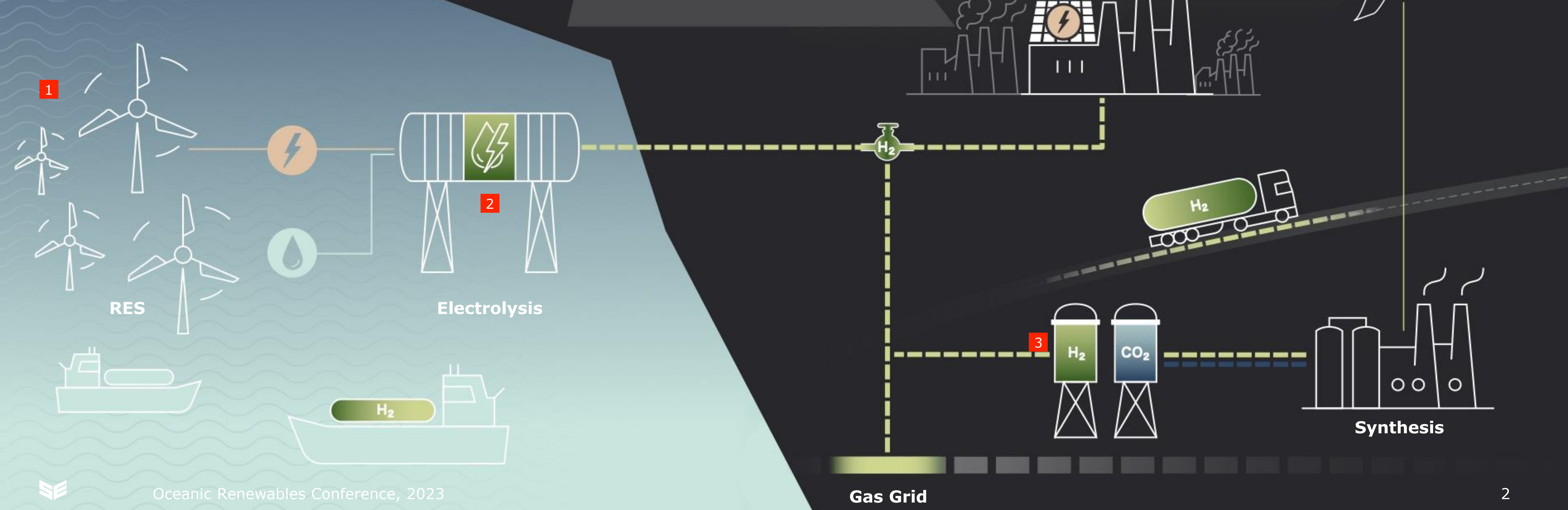
Offshore Power-to-X

Electrolyzer location options

1. Integrated in each wind turbine platform
2. Central platform
3. Onshore

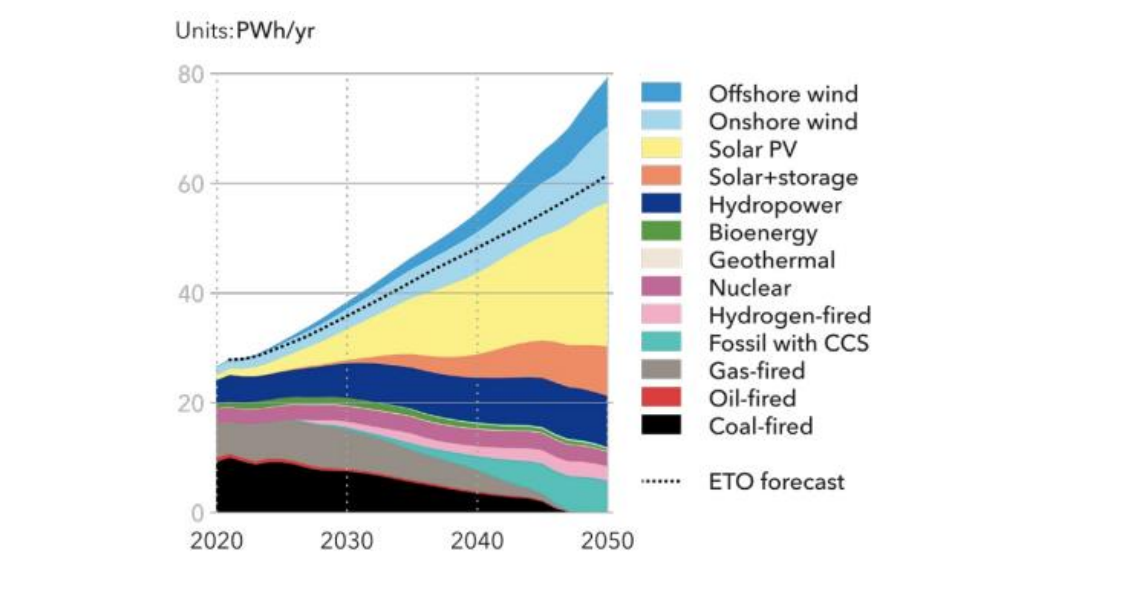
Producing hydrogen offshore can…

…eliminate the need for offshore electrical grid connections
…reduce transport costs and transmission losses
…enable economic viability for more wind sites
…make use of existing gas pipelines to transport hydrogen
…maximise the use of wind power (load factor >40%)



Renewable energies will be the dominant energy source – the role of off-shore wind can increase combined with hydrogen

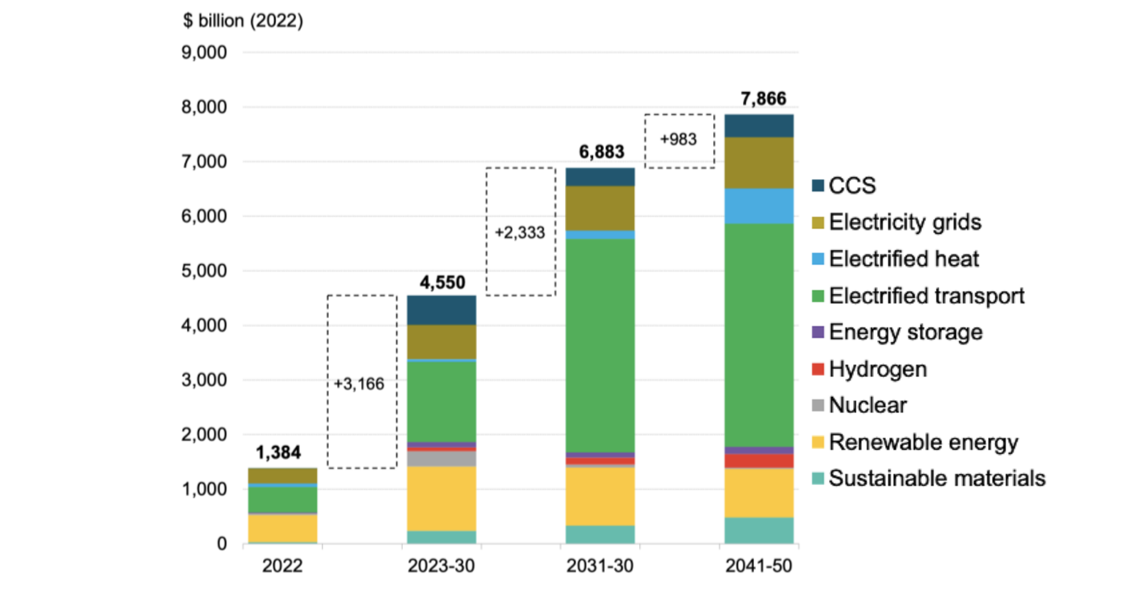
World grid connected electricity generation by power type



- Solar and Wind will be the major pillars of our future grid connected electricity
- Phase out of fossil needs to be replaced with stable supply from renewables
- Hydrogen can balance supply – demand and could increase the potential of off-shore wind

Source: DNV, 2022

Comparison energy transition and grid investment vs required annual investment in Net Zero scenario

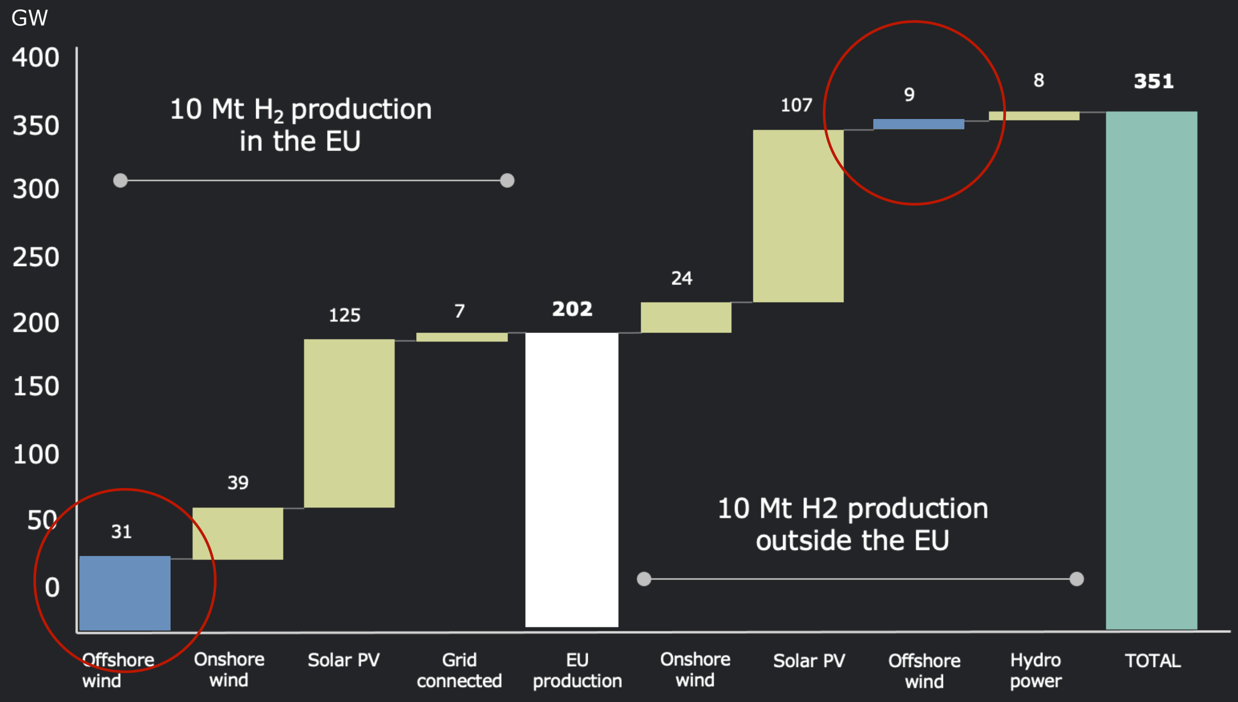


- Strong growth of investment already in this decade required
- Continued growth of investments until 2050 with opportunities in all renewable segments, in particular transport, grid and renewable energy
- Off-shore wind to H2 may reduce required grid investments

Source: Bloomberg-NEF, 2023
* Values from the New Energy Outlook 2022 Net-Zero Scenario by 2050 in line with 1.77 degrees Celsius of warming. Investment includes electricity grids

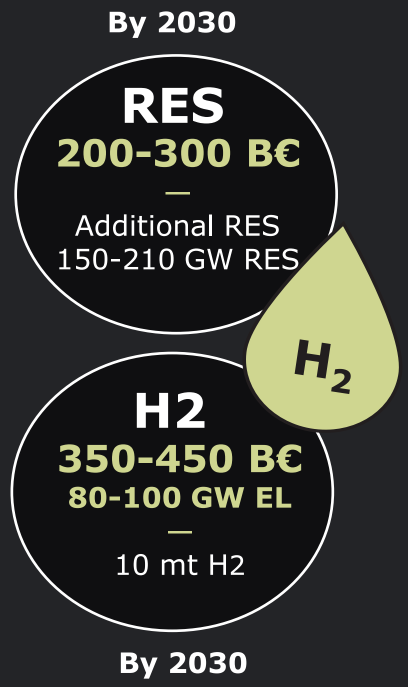
Europe set a target of 10+10 mt p.a. by 2030 to be generated with Renewables. Off-shore wind H2 is an important pillar of the strategy.

Required installed electrolysis capacity
(in GW)

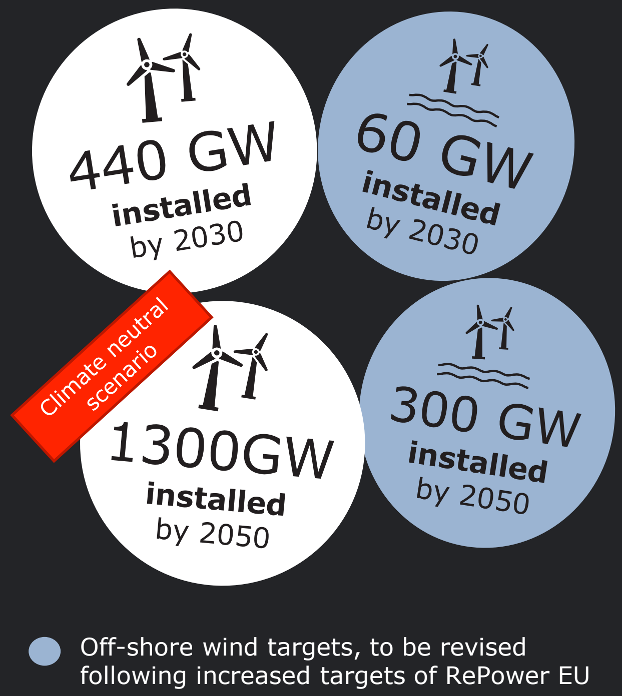


Source: Hydrogen Europe

Required investment and additional RES
10mt EU production



Total installed wind and off-shore wind targets
European Union



Source: Wind Europe, European Commission 2022

Off-shore (in particular floating) and hydrogen are both challenging technologies – the combination may be beneficial in relevant criteria

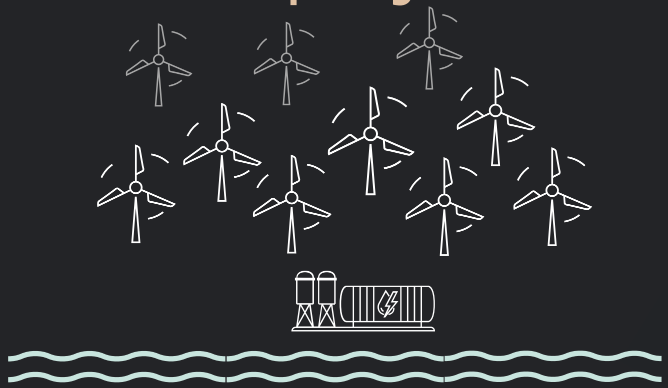
	Off-shore wind/ Floating	Hydrogen (on shore)	Combined (Both offshore)	
LCOE / LCOH	High / very high	High	More competitive	+
Electrical grid connection	Dificult; HVDC solutions needed due to scale	Lack of grid capacity	Off-Grid	+
Additionality	Not applicable	Hard to secure PPA	Full compliance	+
Technology	Established / New	New at scale	New, to be proven	-
RES Variability	Must be grid code compliant	Technical challenge	Lower impact due to higher loading factors	+
H2 pipeline to shore	Not applicable	Not applicable	Increased CAPEX	-
H2 export by vessel	Not applicable	Requires harbor and infrastructure	Independent from harbor limitiations	+

Location options for off-shore H2 projects

1 Integrated Wind Turbine with H2

A
- Stepwise scalable from small to larger array
- Standardized design

C
- CAPEX (smaller scale, H_2)
- OPEX (Maintenance challenging, H_2)
- Subsea H_2 Pipeline to shore



2 Wind park cluster H2 centralized offshore

A
- Large scale -> Lower CAPEX
- Lower OPEX (Maintenance)
- System balancing and stability

C
- Investment scale
- Electrical connection to electrolyzer
- Subsea H_2 Pipeline to shore

3 Wind park cluster H2 centralized onshore

A
- Lowest technology risk
- Easier integration into valleys
- Easier hybridisation with PV

C
- Electrical connection to shore
- Additionality

A Advantages
C Challenges

Key decisions for H2 off-shore project setup

The choices strongly influence achievable LCOH and IRR

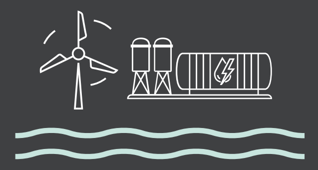
LOCATION

Selection parameters

- Wind speed
- Distance to shore
- Bathimetry
- Etc.

FLOATING OFF-SHORE WIND	LOGISTICS, TRANSPORT, STORAGE	ELECTROLYSER
Spar	Pipeline	Alkaline
Semi submersible	LOHC	PEM
Barge	Ammonia	SOEC
Tension Leg Platform	Liquefaction	Other

Offshore H_2 project



Key decisions for H2 off-shore project setup

The choices strongly influence cost and IRR

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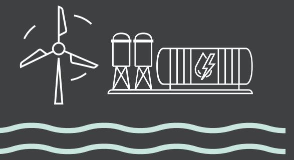
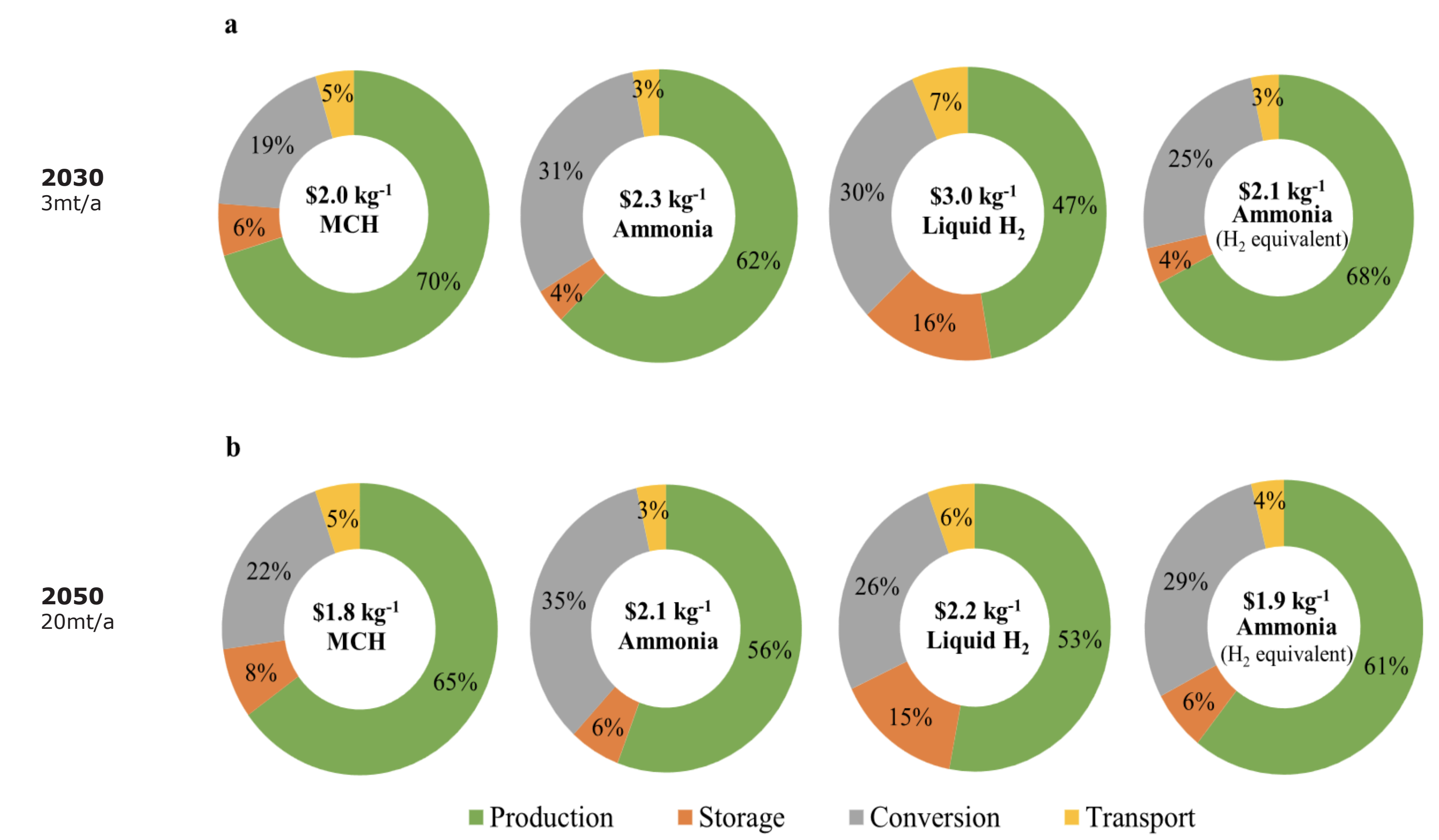
Wind float in Viana do Castelo

Offshore H_2 project



Cost considerations – LCOH as function of scaling and carrier

Cost breakdown of levelized cost of hydrogen (LCOH) for delivery of the potential products from China to Japan



Study: Off-shore in China, export to Japan

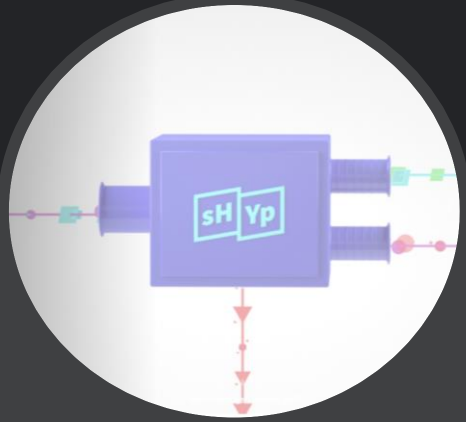
Source: Nature Communications

- MCH as the most cost effective solution before ammonia (both direct use and de-hydration) and LH2
- Both in 2030 but even more in 2050 attractive LCOH can be achieved below 3$/kg
- Conversion is the most relevant factor after production
- Liquid hydrogen with highest storage costs

Trends and technology innovations relevant to future off-shore hydrogen projects

Large scale integration
Tractebel by Engie

- Industrial H2 production platform
- EL units and transformers for the transformation of electricity from offshore wind
- Range of 100MW to 800MW



Direct sea water use
sHYp

- EL located to an offshore turbine
- Membrande less EL
- Seawater into H_2 – no desalination needed

Wave energy
Corpower

- Additional energy for more production
- Time shift of energy profile compared to wind leading to optimized generation profile
- Lower total variability due to more constant wave power characteristics

Many Off-shore H2 projects have been announced, mostly large scale. Fast learning can be expected.

DolPHyn 2
UK

H_2 on a bulk-scale, integrated floating system

PosHYdon
Netherlands

H_2 production unit on Neptune Energy's Q13 platform, 4GW up to 10 GW

OCEANH$_2$
Spain

Solution for H_2 production and distribution using floating and PV systems

LHYFE FR Atlantic
France

DORIS' floating wind turbine solution, on-grid and off-grid applications

ScotWind H$_2$
Scotland

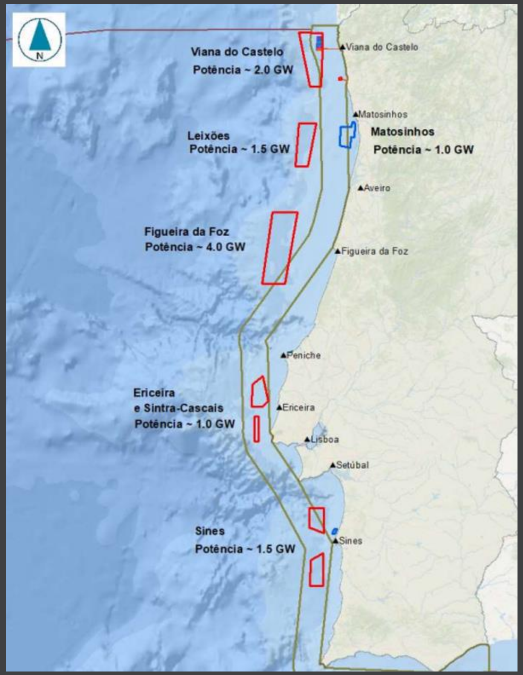
Site 6,717MW of offshore wind, over 1600 turbines

NorthH$_2$
Netherlands

GW scale green H_2 production with offshore wind in the North Sea.

Ideal combination of off-shore wind locations and large-scale storage to overcome the seasonal challenge

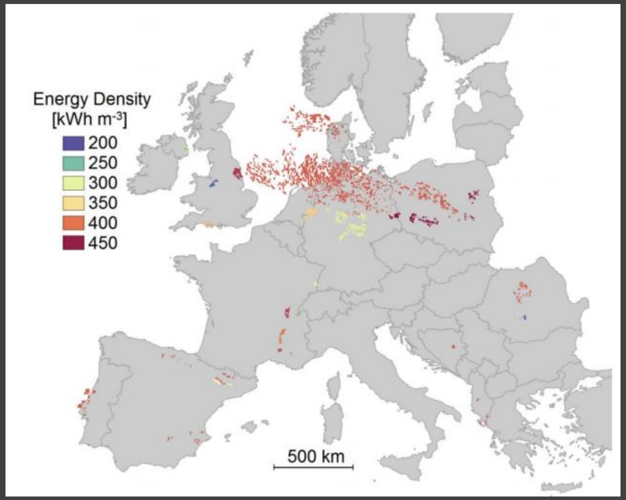
1 Off-shore wind locations in Portugal



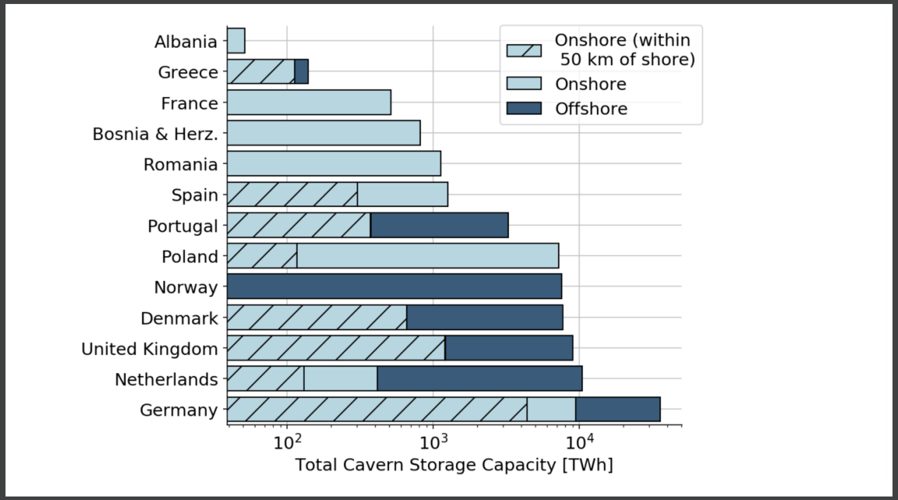
Portuguese Ministry of Economy and Maritime Affairs

2 H2 potential large scale storage in Europe including off-shore

Distribution of potential salt cavern sites with corresponding energy densities



Total cavern storage potential in European countries classified as onshore, offshore and within 5 km of shore

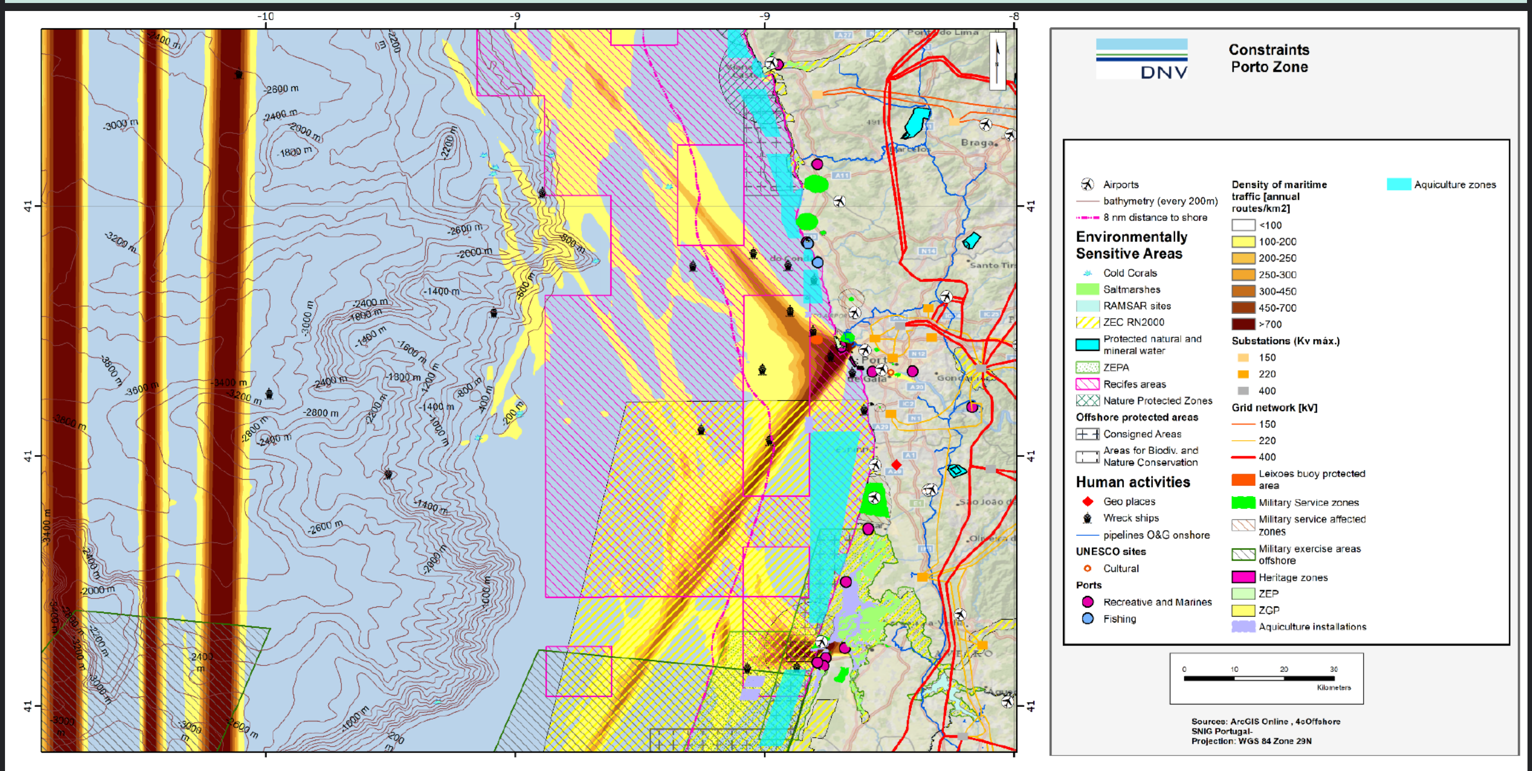


Caglayan, D.G., 2020

Portugal`s unique strategic positioning

Hydrogen Off-shore production opportunities close to major shipping routes at promising locations potentially solving the logistics issue

Summary constraints review of Porto area



Source: Smartenergy / DNV study

Thank you!

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