RENEWABLE ENERGY HAMBURG
ENERGIESYSTEME DER ZUKUNFT

STIFTUNG OFFSHORE WINDENERGIE

Offshore-Trends 2020
EEHH-Webseminare

Episode 3

Hydrogen & Offshore Wind

Thursday, 5 November 2020 | 14:00 – 15:00h

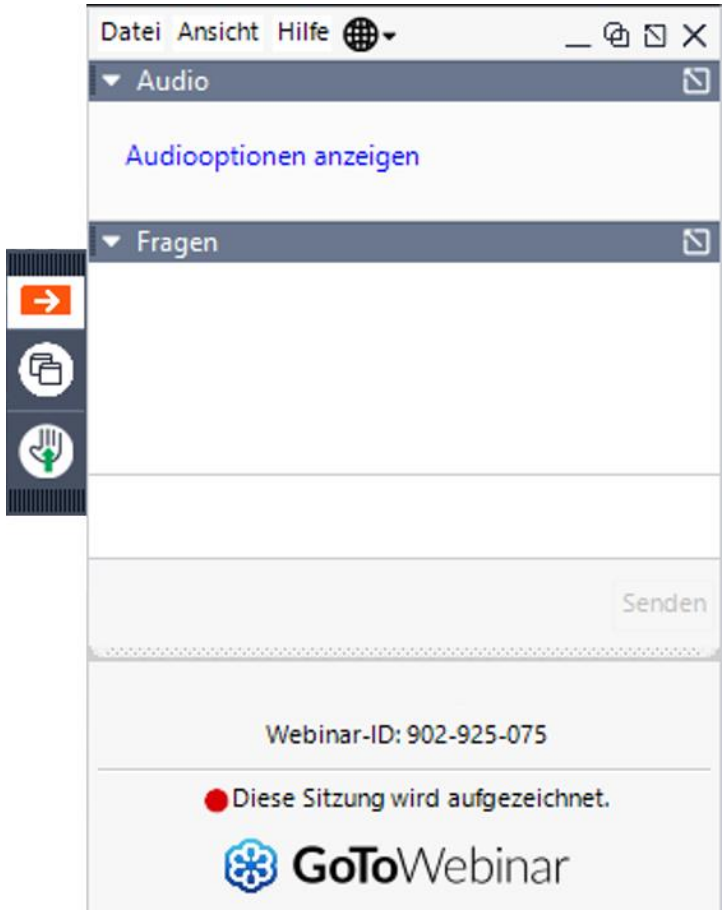
Image: © Areva Multibrid | Jan Oelker | Stiftung Offshore Windenergie

Agenda

14:00 – 14:05h	**Welcome & Introduction** **Astrid Dose** | Renewable Energy Hamburg
14:05 - 14:20h	**Hydrogen and Offshore Wind: Enabling the Next Step of the Energy Transition** **Claas Hülsen** | Business Development Director Advisory - Region CEMED | DNV GL
14:20 - 14:35h	**The Role of Offshore Wind and the Potential for Hydrogen to Support the British Transition to a Low Carbon Energy System** **Dr David Hodgson** | Sector Specialist | UK Department for International Trade
14:35 - 14:50h	**AquaVentus Project** **Andreas Wagner** | Managing Director | Stiftung OFFSHORE-WINDENERGIE **Malcolm J. Langham** | External Consultant Development Offshore Wind
14:50 – 15:00h	**Q&A Session**

Q&A

Maximize
Minimize



Enter question

Send question

About Renewable Energy Hamburg

- Cluster and network organization with about 190 members from the Metropolitan Region of Hamburg
- Founded in 2010 on initiative of the renewable energy industry in Hamburg and the Free and Hanseatic City of Hamburg
- Connection between actors from industry, research, politics and society
- **Current services:**
  - Web-Seminars on latest topics
  - Working groups on Finance & Regulation, PV and Heat
  - Matchmaking
  - Marketing of topics from our cluster members
- **Focus topics:**
  - Offshore and onshore wind energy
  - Photovoltaics
  - Renewable Heat
  - Sector Coupling & Hydrogen
  - Energy Storage

Further information on our network and how to become a cluster member you may find here: www.eehh.de/en

10 JAHRE RENEWABLE ENERGY HAMBURG
ENERGIESYSTEME DER ZUKUNFT

Upcoming Events

Episode 4 | Web Seminar

18 November 2020 | 14:00h | Registration

The TetraSpar Concept – Floating Wind Turbines

Speakers:

- Henrik Stiesdal, Stiesdal Offshore Technologies
- Poul Skjaerbaek, Siemens Gamesa RE
- Chris Willow, RWE Renewables
- Melissa Read, New Energies Shell
- Henrik Bredmose, DTU Wind Energy

Episode 5 | Web Seminar

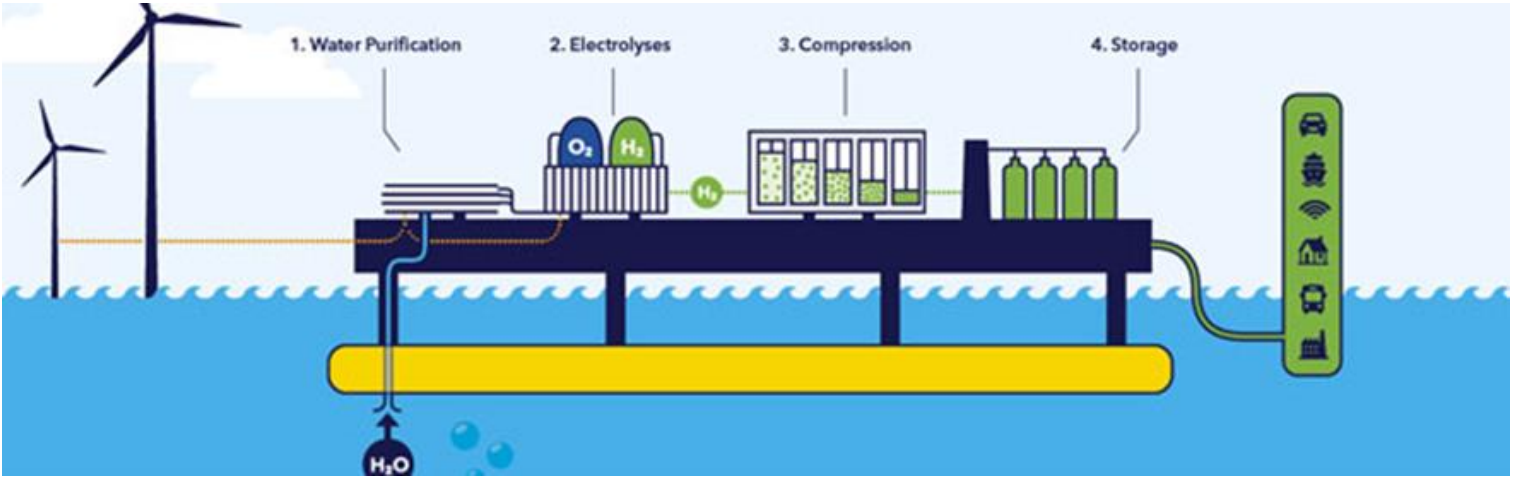
10 December 2020 | 14:00h | Registration

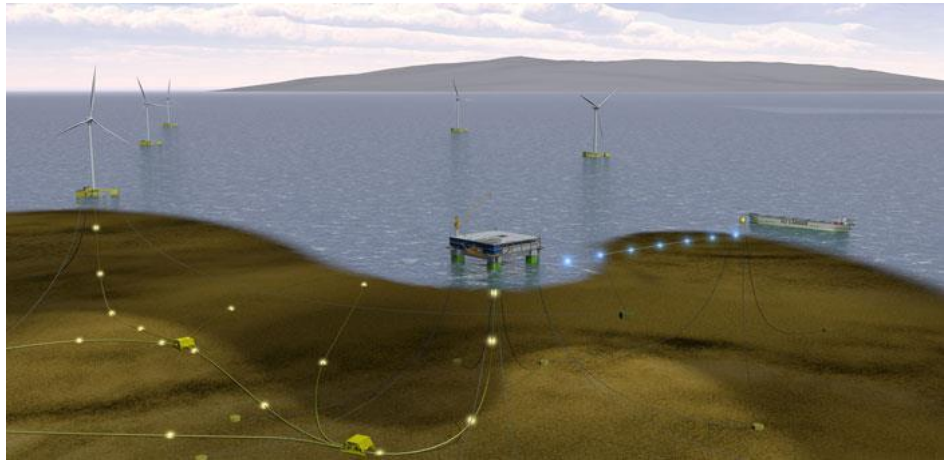
Nationales Testfeld Offshore-Windenergie

Speakers:

- Thilo Krupp (German Foundation Offshore Wind Energy)

Please check in the chat of GoToWebinar the links to the upcoming events and to other information around the cluster Renewable Energy Hamburg: www.eehh.de





ENERGY

Hydrogen and Offshore Wind: Enabling the next step of the energy transition

Claas Hülsen

05 November 2020

Hydrogen and Offshore Wind: enabling the next step of the energy transition

Overview

- Why is hydrogen so indispensable for the energy transition overall?
- Why is hydrogen in combination with offshore wind an important option?
- What are the dynamics that will drive hydrogen in the combination with offshore wind?
- Where should we expect this to happen?
- What is needed from the regulatory side? – a few ideas

Why is hydrogen so indispensable for the energy transition overall?

	Coal ("brown")	Natural gas ("grey")	Natural gas + CCUS ("blue")	Electrolysis ("green")
Energy to produce a kg of H2 (kWh)	59	46		55
Production energy efficiency (%, LHV) - theoretical	56%	72%		61%
Production cost of a kg of H2 ($)	1,1	1,7	2,3	6,0
CO2 intensity (kgCO2/kgH2)	20	9	1-4	0

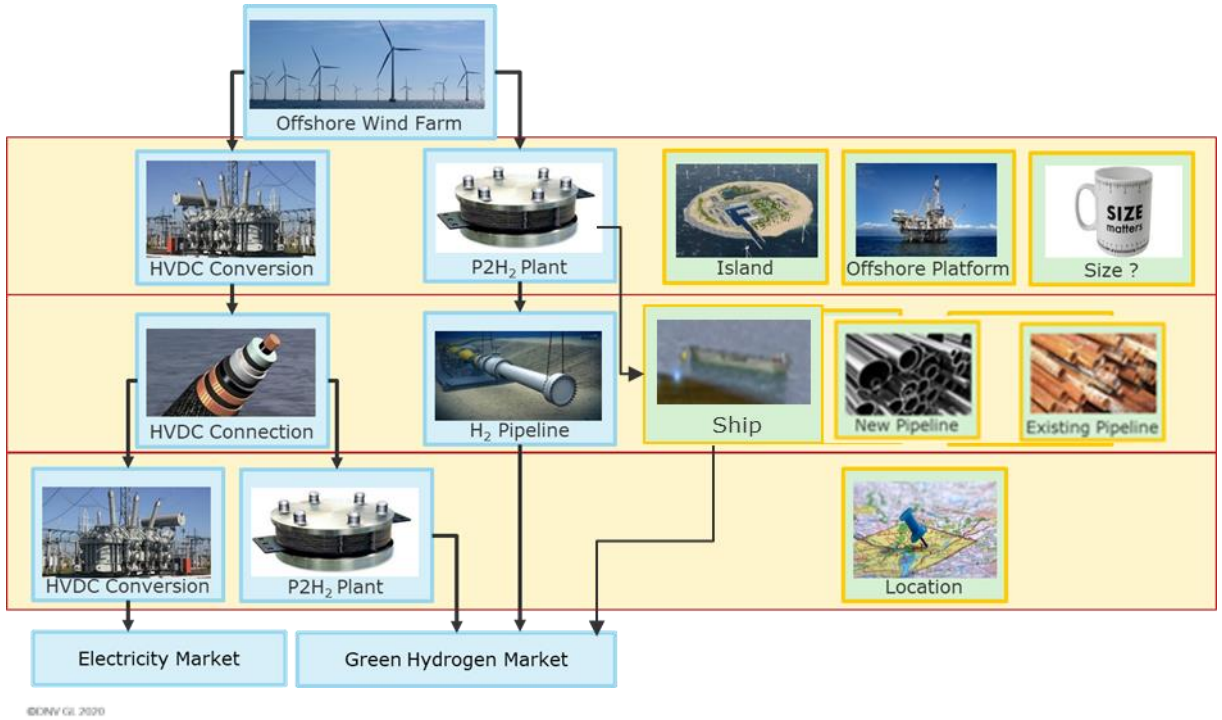
Hydrogen is the fuel of the future:

- Green hydrogen is the only gaseous energy carrier that can be made available with zero emissions.
- Green hydrogen **can be stored in various ways** and transported via pipelines
- Green hydrogen can be used in many use cases.
  - Transport
  - Industrial processes
  - Heat
  - Power generation

→ As significant energy is lost when producing green hydrogen, the **usage should be ideally be realized in areas where there is hardly any better alternative looking at CO2 avoidance**.

→ **German hydrogen strategy** is providing a clear roadmap for establishing a hydrogen market. **Measure 4** is dedicated to offshore wind and hydrogen

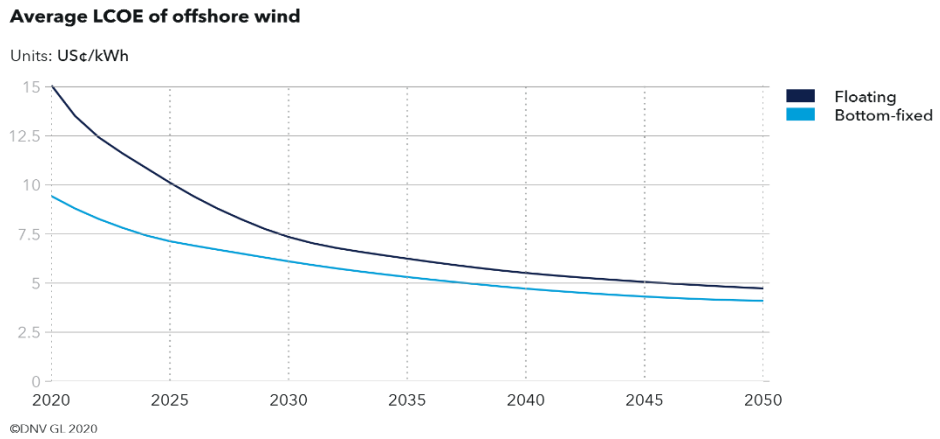
Why is hydrogen in combination with offshore wind an important option?

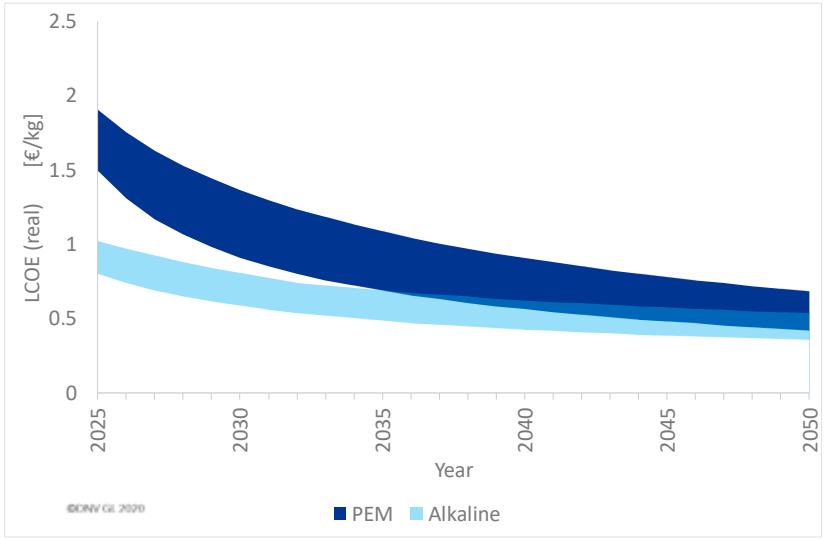


Hydrogen - enabler to speed up offshore wind:

- **Various options** how to **combine offshore wind and hydrogen** do exist.
- **High full load hour of electrolysers** offshore are given compared to any green hydrogen production on shore so producing green hydrogen offshore comes in theory most efficient.
- Whilst there is a very high potential for offshore wind energy in general, **grid congestion is a major issue for being more ambitious regarding offshore wind plants – hydrogen can be a way of releasing this potential.**
- **Water** needed for an electrolyses is offshore **limitless available on site.** Still desalination is needed offshore and reduces efficiency.

What are the dynamics that will drive hydrogen in the combination with offshore wind?





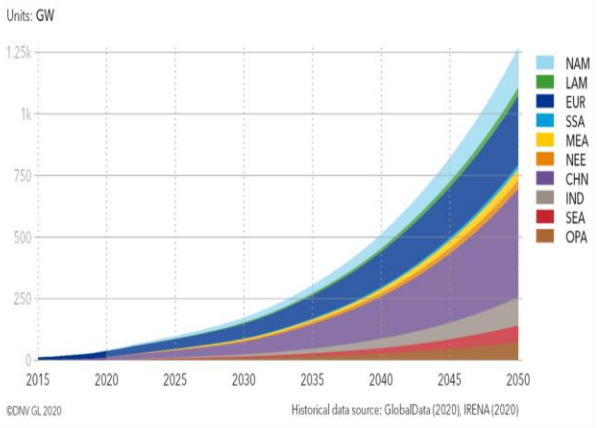
- DNV GL assumes with its Energy Transition Outlook still significantly sinking LCOE for offshore wind. This cost reduction will also favour hydrogen production by offshore wind as LC of green hydrogen will decline and LC of grey hydrogen will rise due to rising CO2 prices.

- On the electrolyser side also massive cost reductions will take place – especially for PEM systems. – another driver for hydrogen…
- As Alkaline systems (which are more mature today) require much more maintenance at the moment –they are rather immature for offshore purposes.
- Most likely PEM technology will be the prevailing technology for offshore hydrogen production.

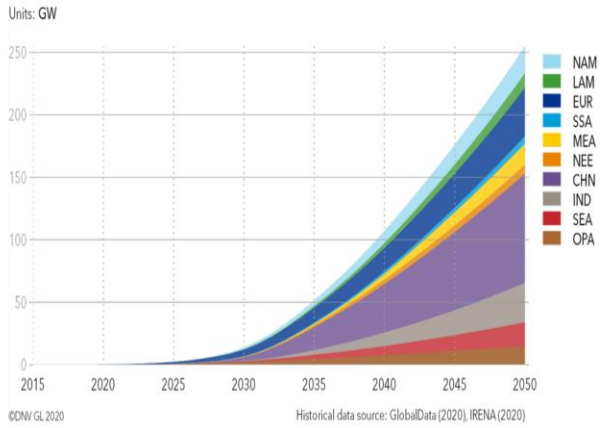
What are the dynamics that will drive hydrogen in the combination with offshore wind?

Offshore wind installations per region:

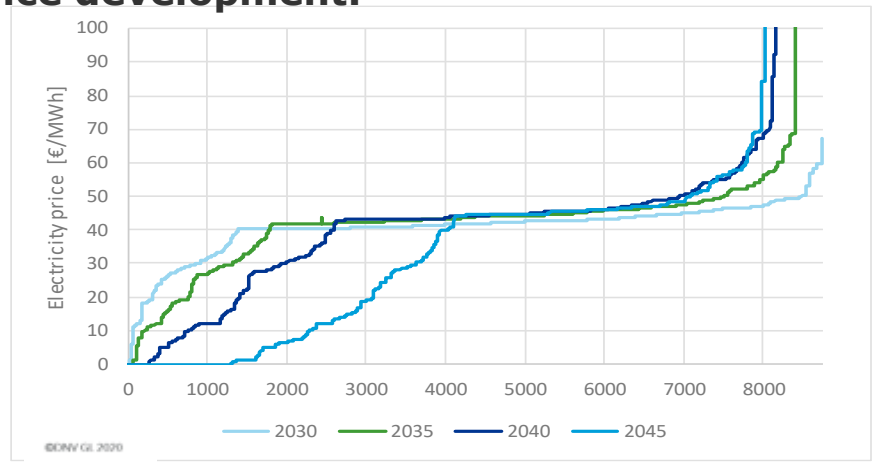
Bottom fixed



Floating



Power price development:



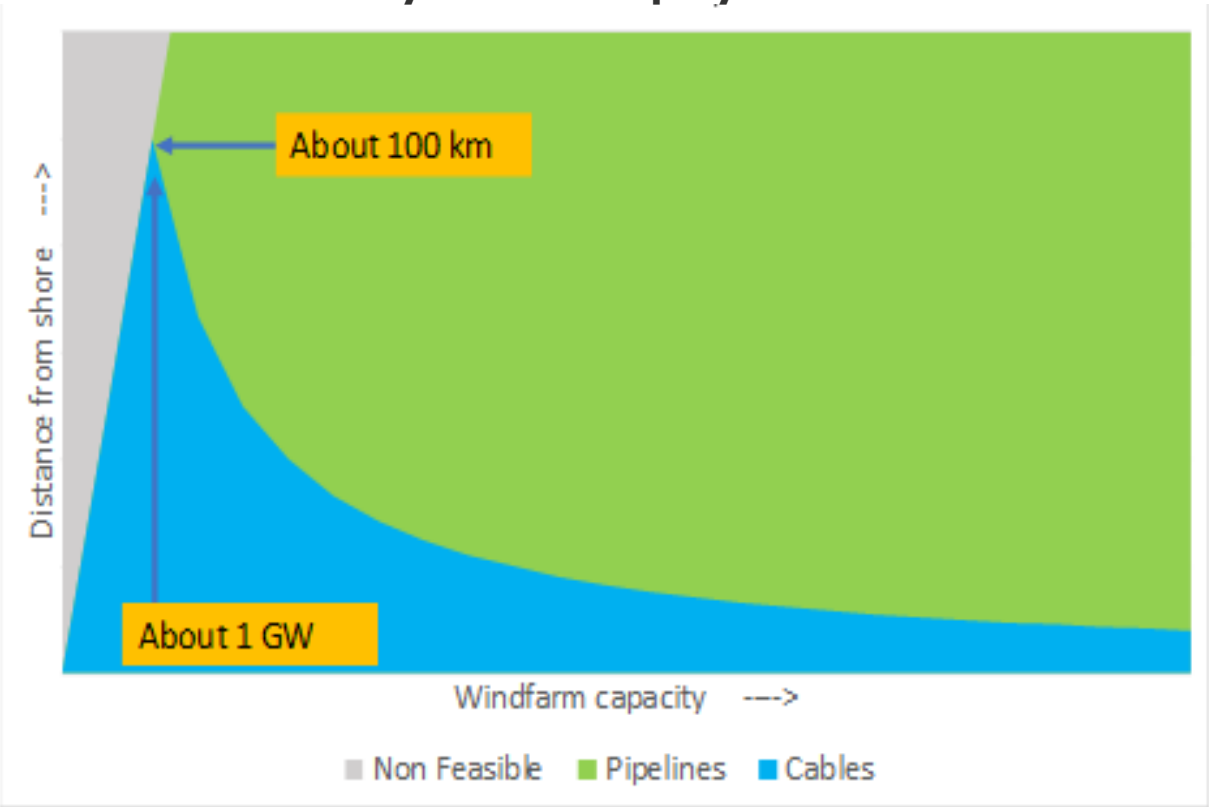
Economics will drive search for additional revenue streams from offshore wind

- With more and more renewable energy installed the power price curves will change. For more and more hours in the future power will be rather cheap as renewables feed in at marginal cost of zero.
- In order to escape this low prices the production of hydrogen will become a viable option as the energy can be stored.
- On the other hand side the energy stored can be sold in an international hydrogen market – or hydrogen may even in the long run become relevant as fuel in the power market.

→ Operation modes (peak operation/base operation) for electrolyser systems must be optimized against power prices and the system costs in order to achieve the optimal earnings.

What are the dynamics that will drive hydrogen in the combination with offshore wind?

Offshore electrolysis field of play

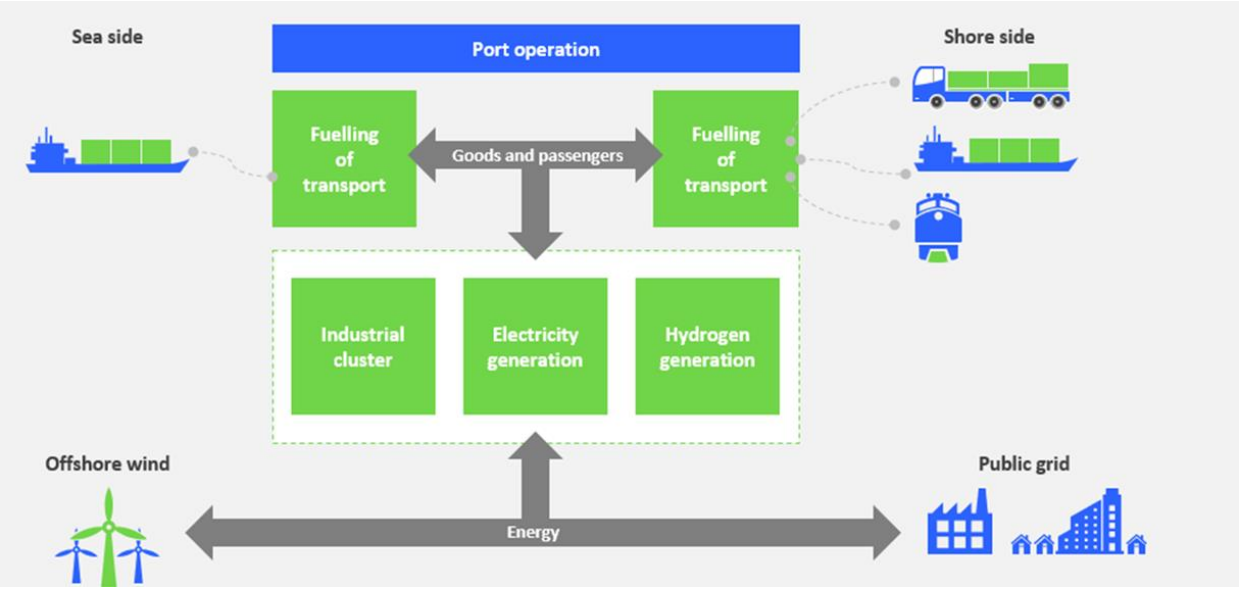


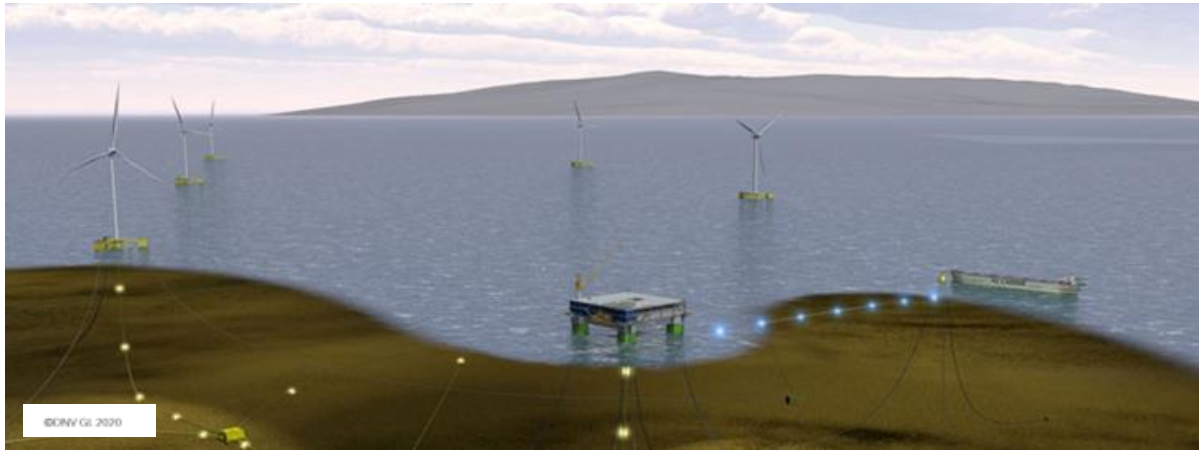
Distance and capacities are in favour of offshore electrolysis

- With higher distances offshore grid connections become very expensive – a hydrogen production offshore then gets attractive – possibly also in connection with floating offshore wind. If available pipeline systems that exist from O+G can be reused for hydrogen transport.
- The higher the desired capacity of an wind farm is, the more attractive it will become (also due to high costs of offshore connections) to produce hydrogen offshore (e.g. also as part of a concept with cable + hydrogen production)

→ This graph also shows, that hydrogen only installations may also become a case in the future

Where should we expect this to happen?





Ports are pivotal for sector coupling in the energy transition

- **Offshore sites are often close to port areas** where large industries like Chemistry, Steel and Cement have their production sites – producing hydrogen close to these sites is efficient from a logistics perspective as otherwise the transport costs add significantly up, so that the economics of the use case are not working.
- Also in areas where energy needs from the industry are high and an abundancy of good wind sites offshore exists, hydrogen is certain to play a role.
- Certainly also floating installations wind + hydrogen production will become viable solutions especially with increasing water depths e.g. in Japan

What is needed from the regulatory side? – a few ideas

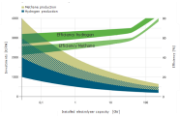
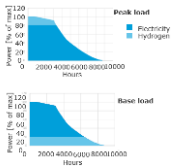
- Integrated regulatory strategy on sector coupling around offshore wind and hydrogen
  - Grid connection (power, gas)
  - Designated lease areas for hydrogen + offshore applications
  - Dedication of areas for hydrogen only?

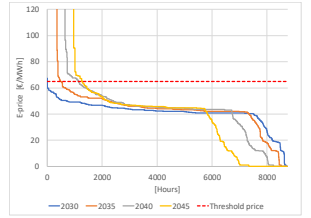
- Temporary promotion scheme for green hydrogen

- Joint tenders for wind + hydrogen (balancing power and hydrogen market needs)
- Fit for purpose tender designs for “electrolysis on shore” and electrolysis “off shore” applications

Making decisions on offshore wind and hydrogen – building blocks

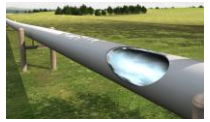
- **Technical properties of electrolysers**
- **Economics of electrolysers.**



- **Assessment for the possible landing locations for electricity and/or hydrogen**
- **Determine parameters for offshore installations**


- **Evaluation of hydrogen logistics: e.g. hydrogen pipeline or hydrogen tankers**

- **Market and regulatory analysis**
- **Use cases and applications for hydrogen**


DNV·GL

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www.dnvgl.com

SAFER, SMARTER, GREENER

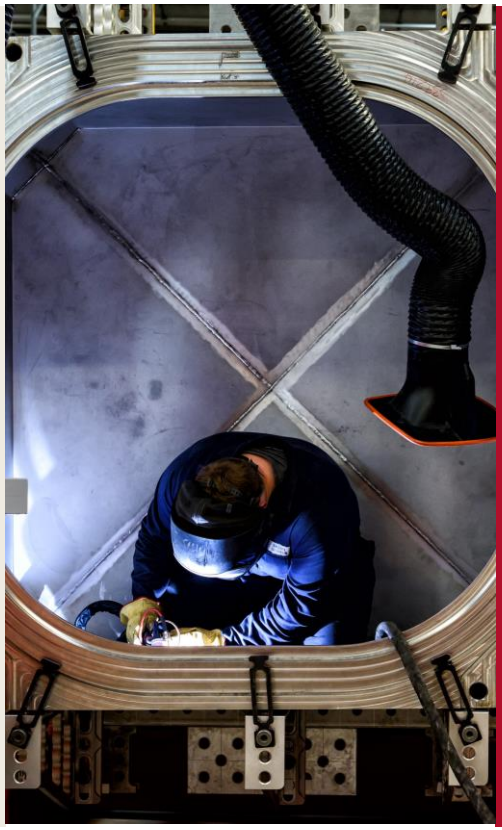
Department for International Trade

Hydrogen as an Energy Vector in the UK

Dr David Hodgson

Sector Specialist, Energy & the Northern Powerhouse

David.hodgson@trade.gov.uk



GREAT BRITAIN & NORTHERN IRELAND

The Department for International Trade

The UK's Department for International Trade (DIT) helps businesses export, drives inward and outward investment, negotiates market access and trade deals, and champions free trade.

We are an international economic department, responsible for:

- Supporting and encouraging UK businesses to drive sustainable international growth
- Ensuring the UK remains a leading destination for international investment and maintains its number one position for international investment stock in Europe
- Opening markets, building a trade framework with new and existing partners which is free and fair
- Using trade and investment to underpin the government's agenda for a Global Britain and its ambitions for prosperity, stability and security worldwide.

Quayside, Newcastle

Net Zero and the Northern Powerhouse

Overview

Delivering on the UK's net zero target

>30% of UK renewable electricity is generated in NPH

5 of 10 Energy Network Operators

The NPH is the home of UK civil nuclear

World leader in Offshore Wind (size, scale, low cost)

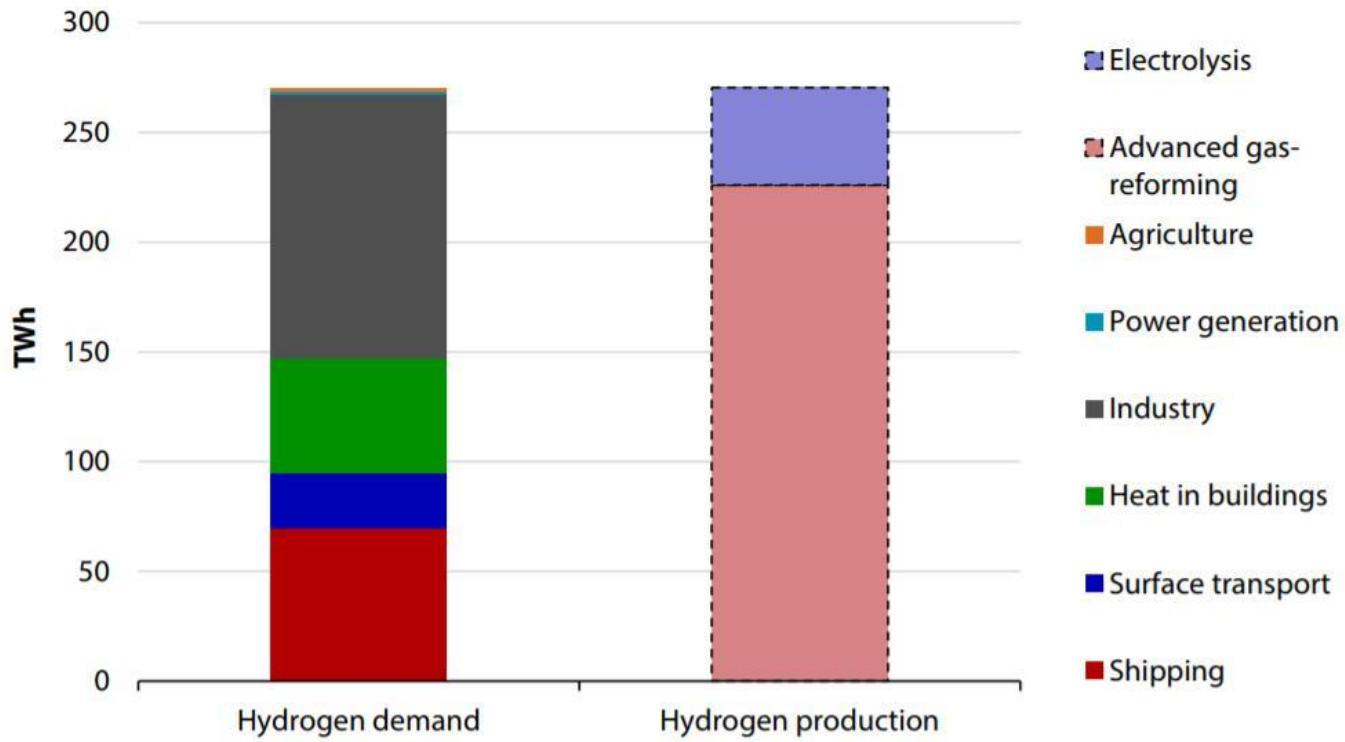
Leading Innovation

UK Leadership in hydrogen technologies/deployment

Why Hydrogen and why now?

Net Zero & Air Quality

Figure 2.8. Use and production of hydrogen in the Further Ambition scenario (2050)



Source: CCC analysis.
Notes: Our analysis assumes the majority of future hydrogen production in the UK is from advanced methane reformation with CCS (225 TWh), with a limited contribution from electrolysis (44 TWh).

UK Capability in Hydrogen

From materials to systems

- Materials
- Fuel cell and water electrolyser stacks
- Systems & Integration
- Engineering
- Automotive
- Consultancy (Policy, project development, engineering)

UK & Hydrogen - what's happening?

- Gas System
- HyNet HyDeploy
- Leeds H21

•Transport

•Tees Valley as Hydrogen Transport Hub

•Bus Programmes in: London, Birmingham, Aberdeen, Liverpool, Belfast

•Offshore Wind

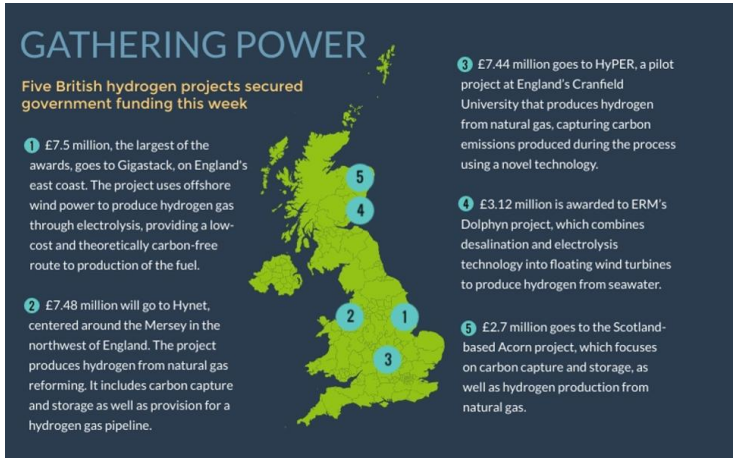
- Gigastack Project Centurion

•Heat & Appliances

- Hy4Heat (BEIS)

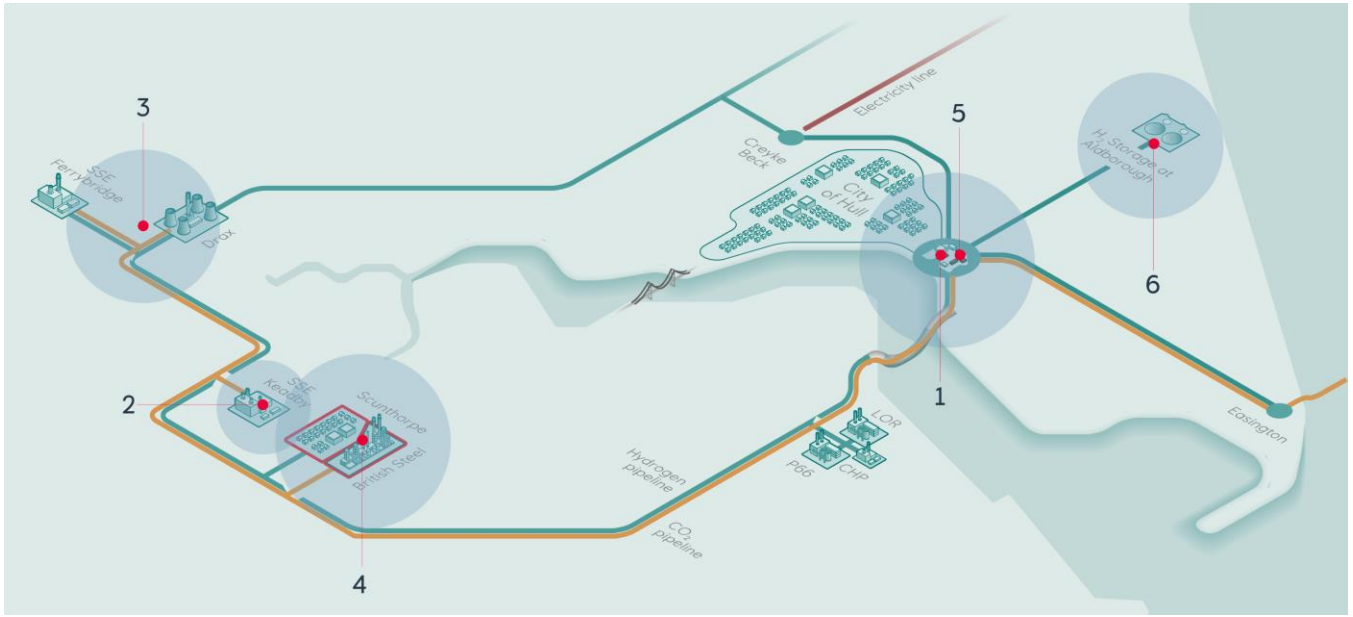
•Island Communities

•Business Model development



UK Hydrogen Projects – more to come

H2H Saltend

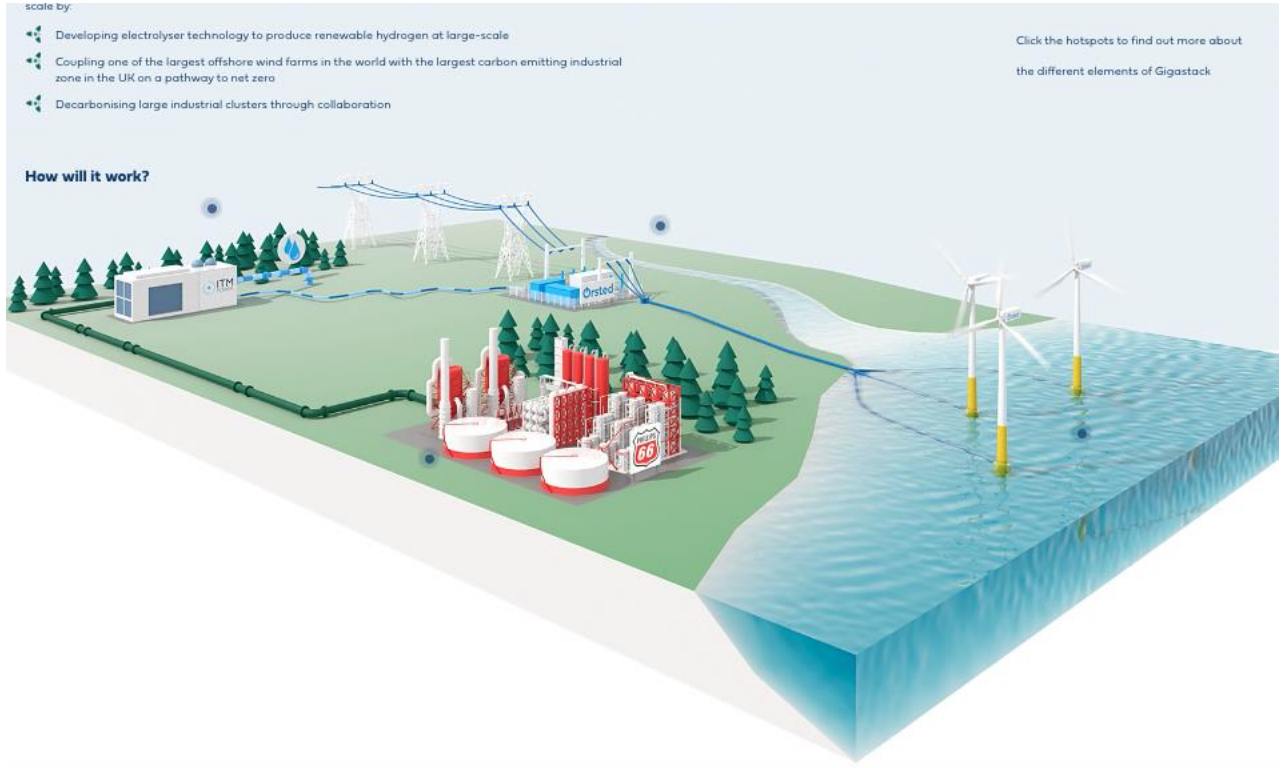


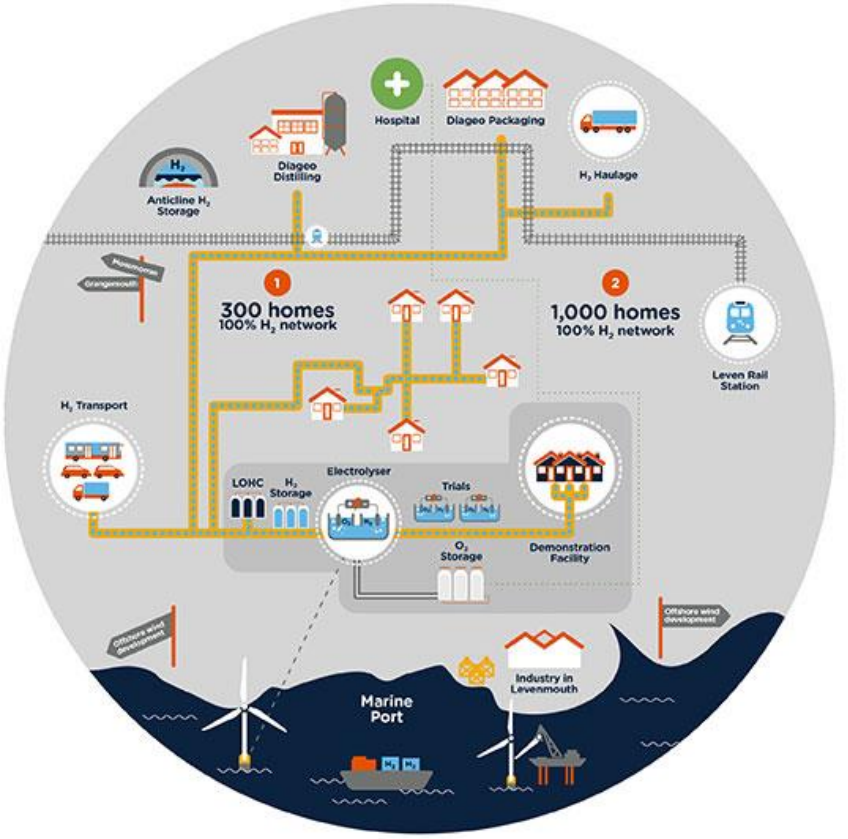
Offshore Wind-Hydrogen Projects

Right across the UK

[H100 Fife]

[Gigastack]





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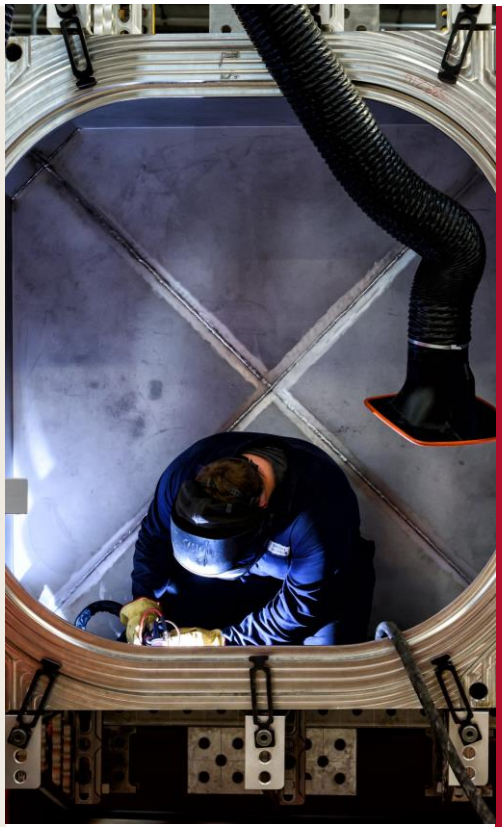

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RWE

FOUNDATION OFFSHORE WIND ENERGY

AQUAVentus

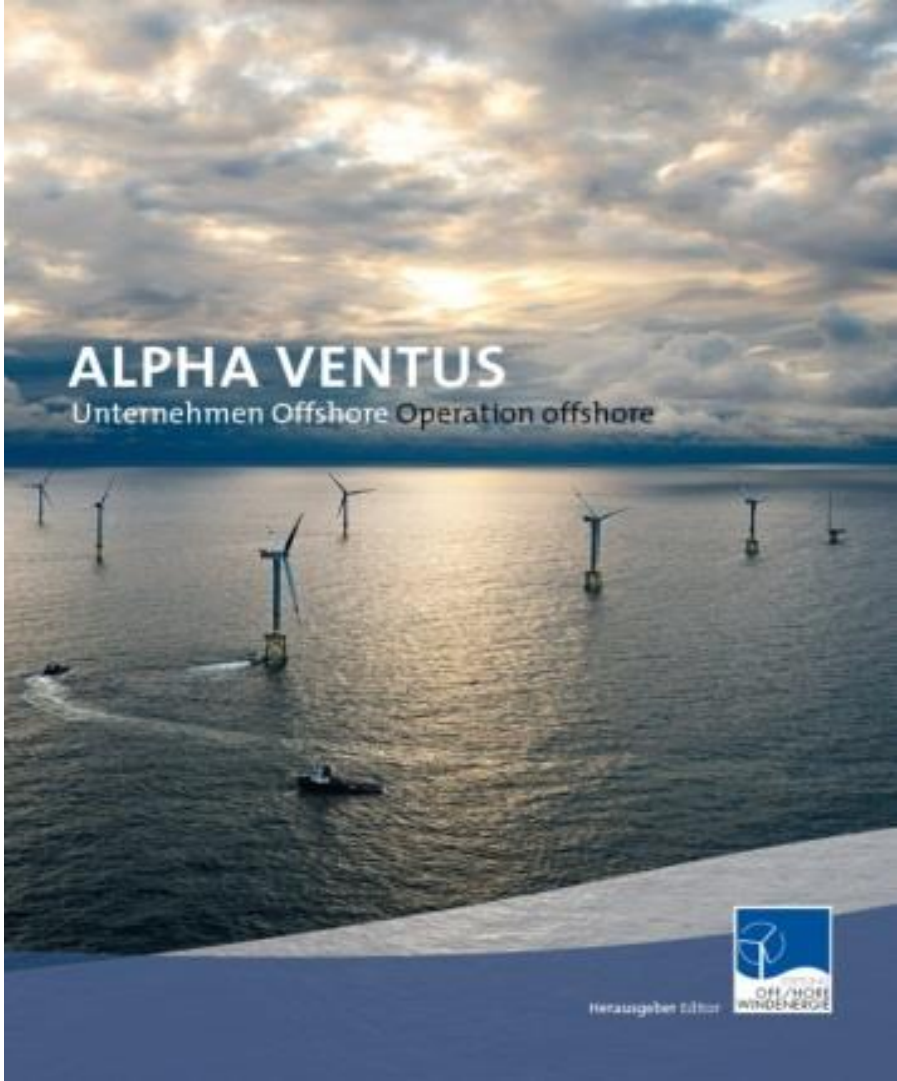
AquaVentus

10 GW of Green Hydrogen from the North Sea

M.J. Langham, Andreas Wagner | October 2020

German OFFSHORE WIND ENERGY Foundation (Stiftung OFFSHORE-WINDENERGIE)

- Founded in 2005 to promote environmental and climate protection by **supporting the development of offshore wind in Germany**
- Non-profit trust - multiregional, independent organization
- **Communication platform** for policy makers, maritime and offshore wind industry, as well as research organizations
- Offices in Varel (Lower Saxony) and in Berlin
- **Ownership rights for alpha ventus** (first offshore wind farm in Germany 2010); SOW initiated and moderated overall project with all relevant stakeholders/authorities
- **Member of the AquaVentus Consortium**



Andreas Wagner – Managing Director German Offshore Wind Energy Foundation

- From 1998 until 2000, he was CEO of FGW, the German Federation of Wind Energy.
- From 2000 until 2008, Andreas held various positions with GE Wind Energy in Salzbergen, Germany, e.g. head of European marketing and communications, public affairs, and business development.
- Andreas Wagner has been managing director of the German Offshore Wind Energy Foundation based in Varel, Stiftung OFFSHORE-WINDENERGIE (SOW) since 2008. In 2013, he moved to Berlin and is heading the Berlin office of SOW.

Importance of offshore wind energy for H2 production

- **The German government and the EU Commission consider offshore wind energy to be a central pillar for the production of green H2**

- Offshore wind energy has high availability with over 4000 full load hours and high reliability in electricity production

- Additional potential through cross-border offshore wind projects

Hydrogen is coming!

German Hydrogen Strategy
in June 2020 – the dices have fallen

- → **Five GW** of Electrolysis capacity by 2030
- → Germany as **leading** hydrogen **country**
- → Substantial **funding** and market integration program
- → Adapt framework for **Offshore Wind**

July 2020
European Hydrogen Strategy

6 GW by 2024
40 GW by 2040

Importance of offshore wind energy for H2 production

- A key issue is the creation of a financial incentive systems for the production of green H2 by offshore wind **- reform of the electricity levy system is necessary**
- Creating of a level playing field between fossil fuels and renewables (Appropriate CO pricing is needed)
- Stimulation on the demand side also important (e.g. Introduction of H2 quotas)
- Designation of large areas for offshore wind energy for H2 production necessary
- No premature definition of whether pipeline or direct production of H2 at sea

Preconditions for the market upturn of green hydrogen:

- **Strong expansion of renewable energies**
- **Development of a level playing field including a strong domestic market**
- **Development of a corresponding transport infrastructure**
- **Development of a demand structure**
- **Investment in R/DD, support for innovative demo and frontrunner projects, e.g. Aquaventus**

What does AquaVentus stand for?

- → The German and European government are taking it seriously - **we are not going to mess this up!**
- → We build at least **5 GW** by 2030 in Germany!
- → Europe will become **World Market Leader** in hydrogen technology!
- → **Offshore Wind** is going to play a significant role in this!

The Goals of AquaVentus

Personal

Malcolm J. Langham

Born 1969

Trained architect

Studied in London, Karlsruhe, Hamburg

Married, two children

Since 2008 independent consultant in the energy sector

Since 2012 in Project Development Offshore Wind

Currently active as advisor for RWE Renewables in **Hydrogen & Offshore Wind**

The new RWE:

One of the largest producers of electricity from renewable sources in the world.

No. 4

globally in renewables

No. 2

in renewables in Europe

No. 2

globally in offshore wind

A globally leading renewables player
with a well diversified portfolio

What we focus on

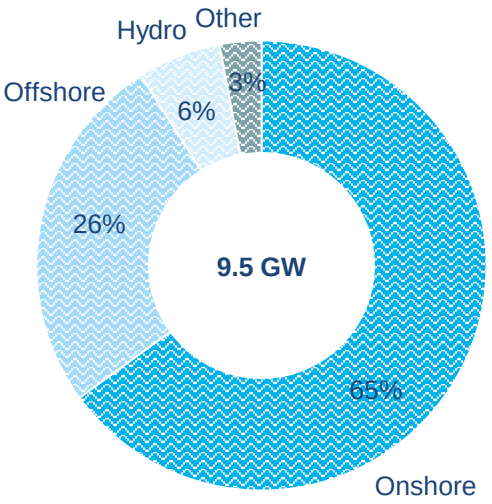
Onshore Wind | Offshore Wind | Utility Solar PV | Energy Storage

Our main geographies

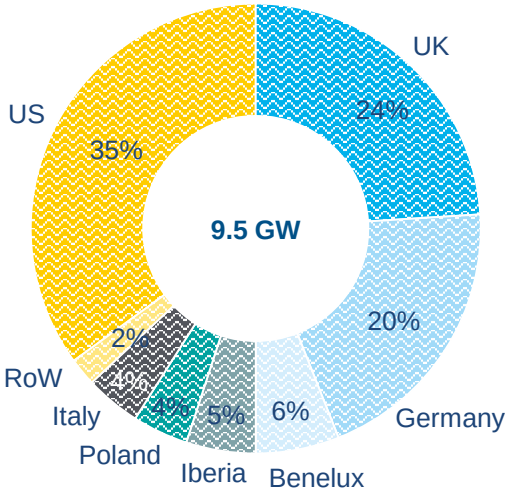
Americas | Europe | Asia/ Pacific

RWE Renewables footprint

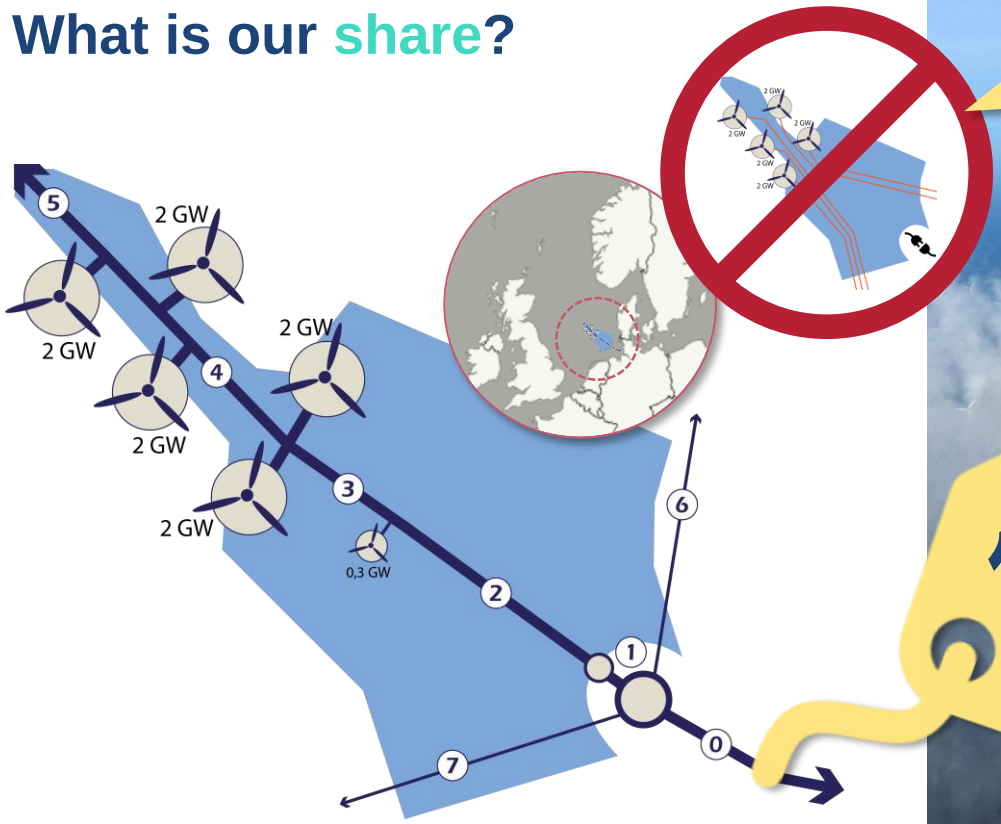
Renewables Capacity Split by Technology



Renewables Capacity Split by Country



What is our share?



Avoid 5x 2 GW HV/DC Grid connections

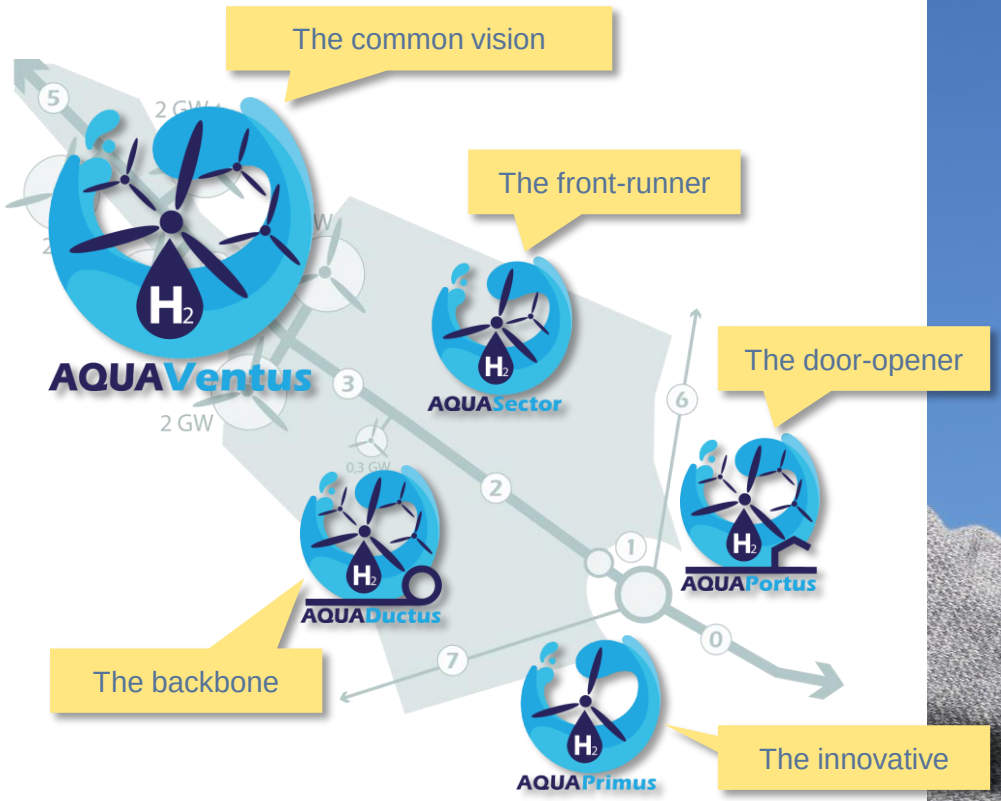
10 GW

1 Mio. t/y[1]

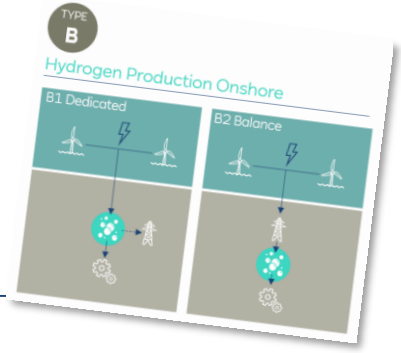
Saving up to 10. Mio. t **CO_2** per year[2]

[1] Under optimized conditions
[2] Compared to grey hydrogen

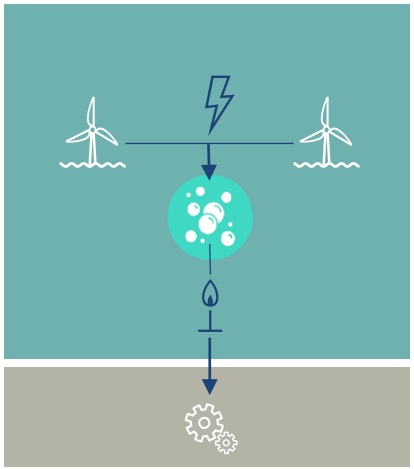
A family of projects



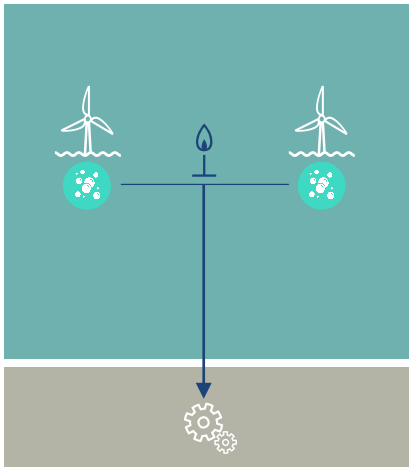
EXKURSION
Hydrogen-Production Offshore



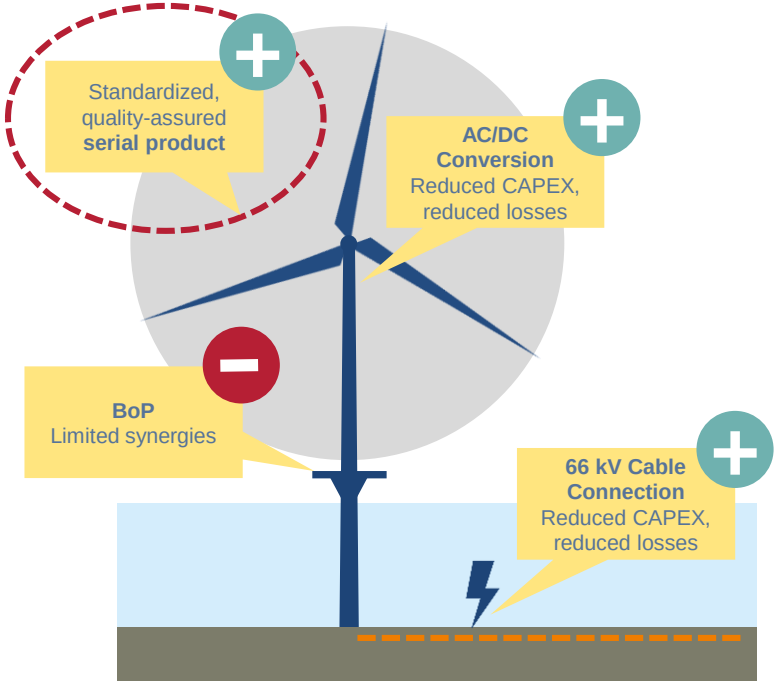
A1 Central

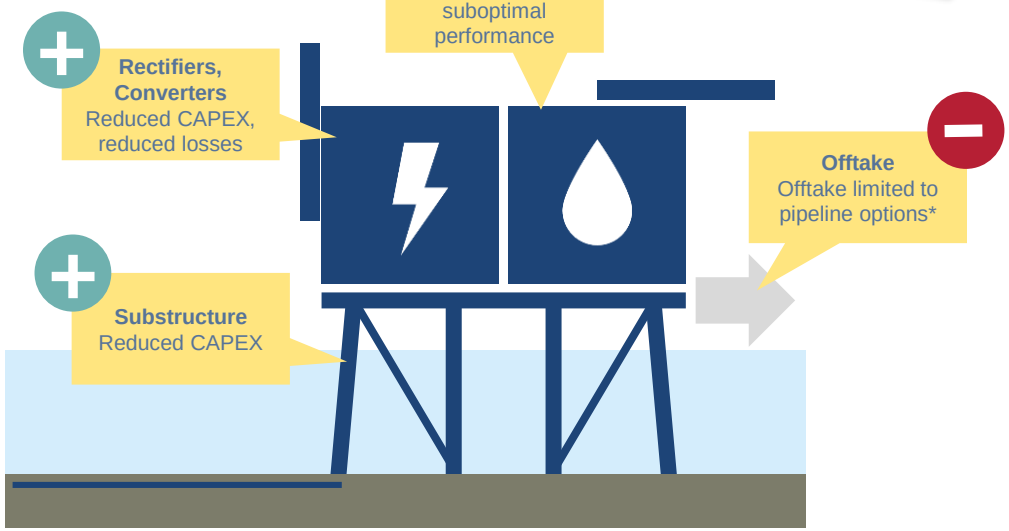


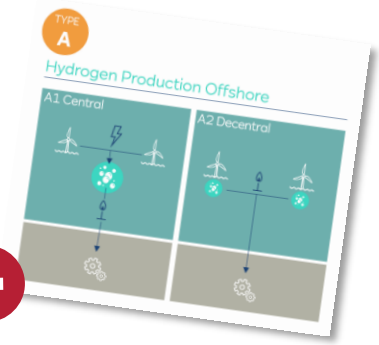
A2 Decentral



EXKURSION
Central vs. Decentral Solution







* Hybrid solutions need to be investigated

The Details

AquaPrimus
First Prototyp at Mukran

- Strong **consortium** led by RWE
- Construction of the first 14 MW **prototype**
- No own turbine, but green electricity provided by dedicated **solar** park on site
- Easy **access** at quayside to test and optimize configuration
- One year **test period** parallel to further development
- After this **commercial operation** as HyStarter project in TYPE B configuration

AquaPortus

Preparation of south harbor of Heligoland

- Preparation of harbor infrastructure in the **South Harbor** of Heligoland
- Implementation of an **LOHC infrastructure** to process the hydrogen production provided by AquaPrimus
- Re-configure island district heating from domestic oil to climate-neutral LOHC **waste heat** as by-product
- Prepare first H_2 **mobility-solutions**, e.g. dune-ferry, CTVs

AquaPrimus

Two Offshore Pilots

- Construction of two pilot turbines in the **coastal area** around Heligoland
- Linking of 2x 14 MW by **pipeline** via Heligoland-Fraunhofer test-site to the south harbor
- One year operation test to prepare for serial **implementation**
- Commercial **operation** to decarbonize Heligoland

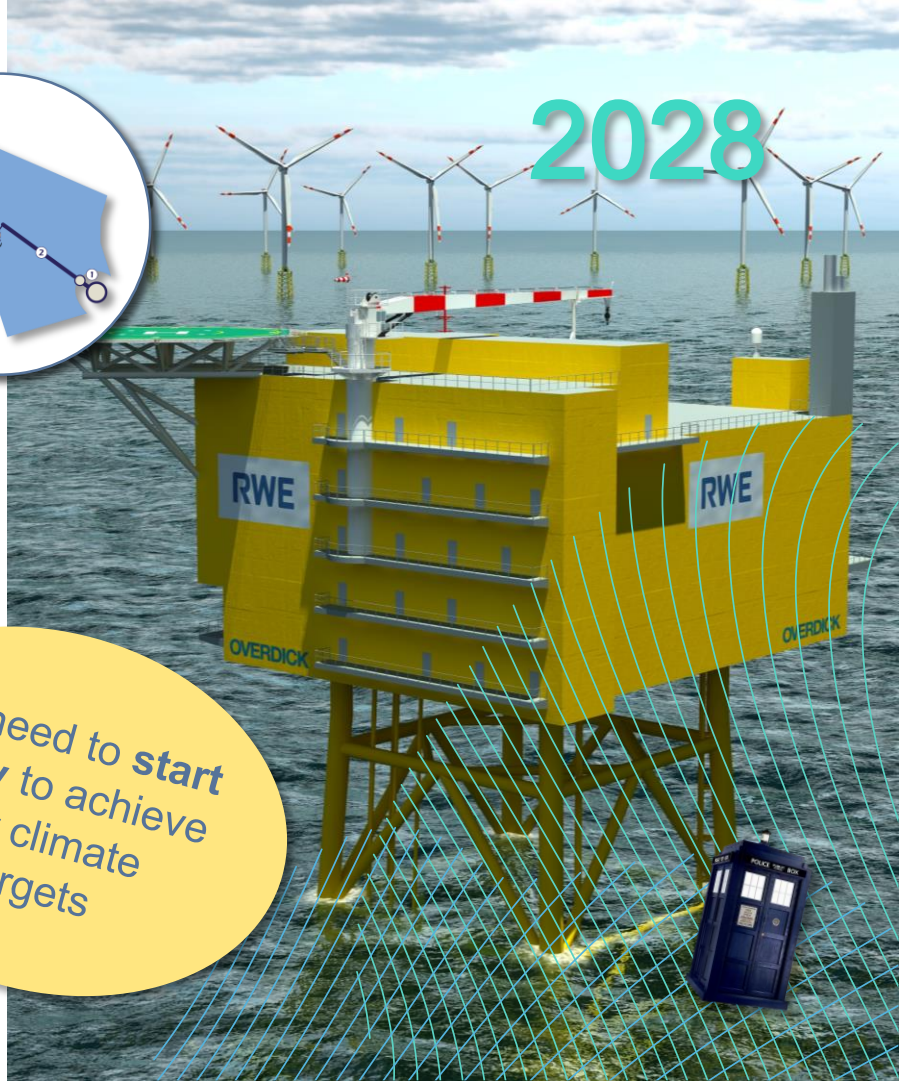
AquaPortus
Heligoland becomes green

- Further development of the **Hydrogen-Infrastructure** on Heligoland
- Conversion of N-1 **backup power system** on fuel cell technology incl. system services
- Buffer storage of required H_2 **volumes on sea**
- **Demounting** of existing fossil infrastructure (Diesel generators, lattice-chimney and tanks)

AquaSector

The new AlphaVentus

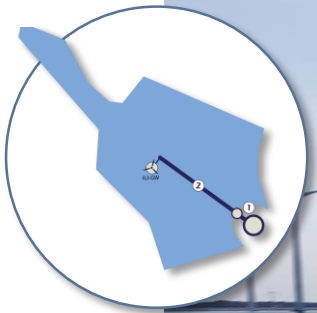
- Award of **project rights on SEN-1** by the BSH after transparent beauty contest latest mid **2022**
- Successful consortia constructs the world's first large-scale **Offshore-Hydrogen-Park** (290 MW)
- Up to 25.000 t of Green Hydrogen run via the second AquaDuctus **pipeline-segment** to Heligoland
- If AquaPrimus pilot turns out to be feasib large scale application of **decentral solution** also possible



We need to **start today** to achieve our climate targets

AquaPortus

The Nord-Sea Hydrogen Hub

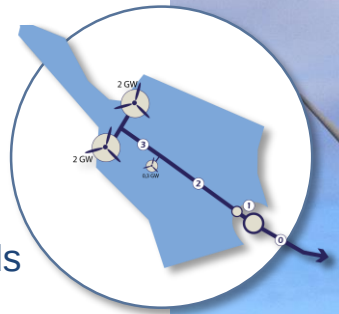


- Heligoland becomes central **Hydrogen-Hub** in the North Sea
- Future H_2 or LOHC powered vessels **bunker** on the island
- The *Halunderjet* and all incoming marine traffic run **CO2 neutral**
- Via Heligoland the **North Sea Coastal Region** is supplied with surplus volumes of AquaPrimus and AquaSector via **feeder***

*Especially for regions, where a future hydrogen pipeline grid can not be expected within a mid-term period

AquaDuctus
Step by step

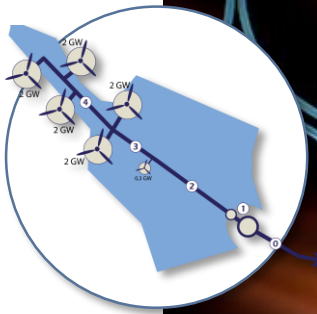
- The dedicated **hydrogen pipeline** extends further out to the *Entenschnabel*
- At the same time the landfall and a connection to the industrial chemical center **ChemCoast*** is completed
- The first **gigawatt** of production capacity has been awarded and is being constructed
- Up to **100.000 t** of competitive Green Hydrogen become available to industrial and mobility end users



2030

* The landfall should also provide sufficient local offtake to mitigate delays in implementation of an onshore grid

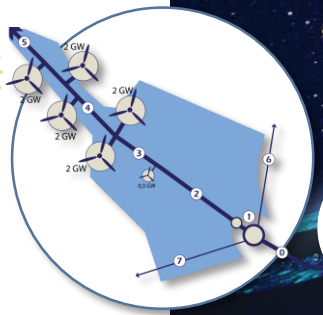
AquaDuctus
It becomes large!



2035

- In the following years 10 GW represent a significant **production capacity offshore**
- The **central pipeline** provides a reliable, non-discriminatory and cheap offtake option for future project owners
- **Replacement of five HV/DC grid connections** offers clear advantages on macro-economic level, preserves the valuable natural habitat *Wattenmeer* and relieves the TSOs in terms of conventional grid expansion

AquaVentus
Think European!



GET H2

2035+

- Long term integration into a **European Hydrogen Network**
- Onshore connection to the **GET-H2** initiative for a national hydrogen grid
- End-point Dogger-Bank ties into the **North Sea Wind Power Hub** initiative
- Cross-connections to **Denmark** and into the **Netherlands** turn hydrogen into a widely available commodity

Down to the point!

- Large scale offshore-production solves the key problem of availability of additional energy — **where else should it come from?**
- Well coordinated projects and a step-by-step approach coordinate **supply and demand**!
- The concept takes effect on **various levels** — Energy production, infrastructure, industrial development, climate protection and nature conservation

Thank you for our attention

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