

# Offshore Bulk Hydrogen Production

Alice Lawrenson  
Senior Process Engineer

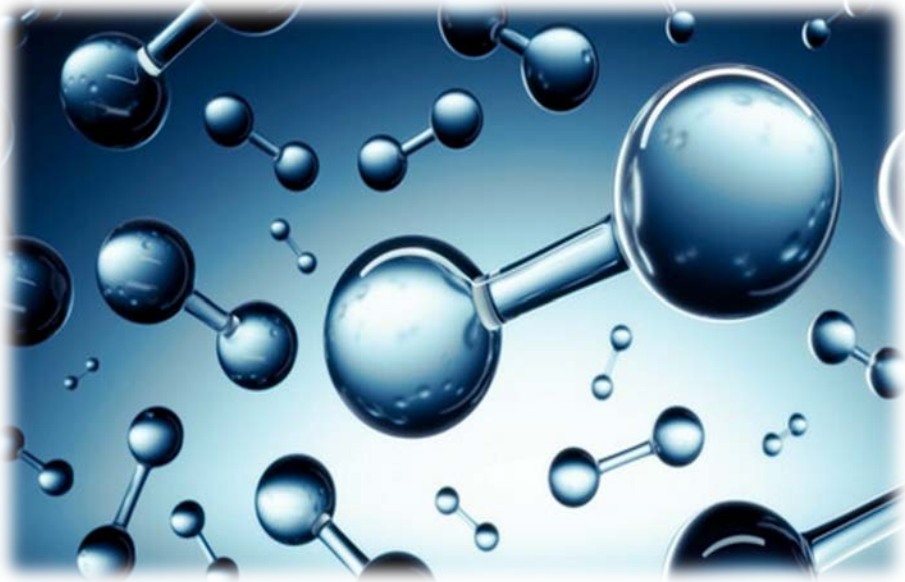


Organized by  



# What is Hydrogen?

- Clean fuel
- Lightest element
- A simple two molecule structure:  $H_2$
- Prevalent in quantity throughout the globe...

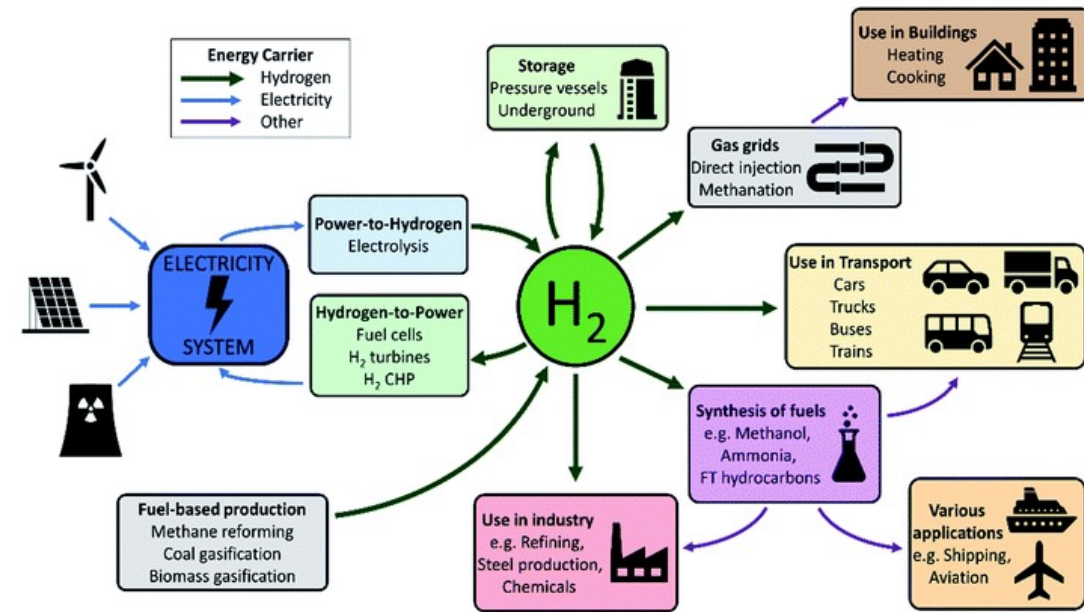


- Does not naturally exist in its elemental form
- Production of hydrogen requires energy
- Highly explosive

# Producing Hydrogen?

Hydrogen can be defined as:

- 'Grey' hydrogen
- 'Green' hydrogen
- 'Blue' hydrogen



Majority of hydrogen currently produced  $\sim 90\%+$  is derived from fossil fuels (natural gas or coal). The most common process is Steam Methane Reforming (SMR). For every kilogram of hydrogen, there is at least 5.5 kg of carbon dioxide produced.



# How can it be used?

- Currently most prominent US usage is: refining petroleum, ammonia production, treating metals, producing fertiliser and processing foods.
- Hydrogen has the potential to majorly decarbonise industry, transport and domestic.
- Hydrogen can be stored.

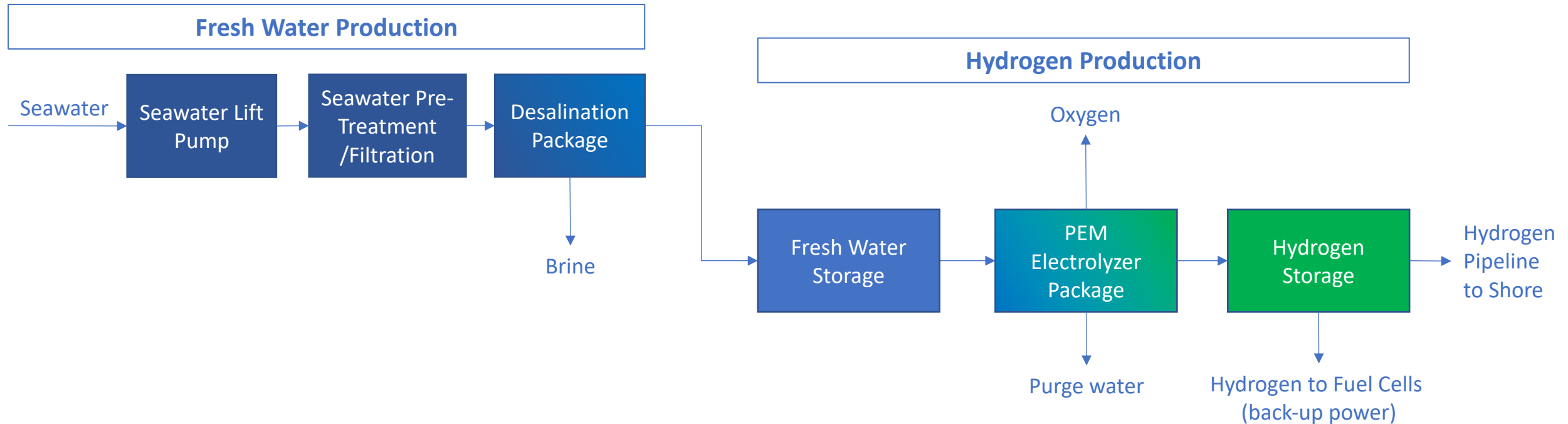


Reference: London government hydrogen bus [Cleaner buses](#) | London City Hall



Reference: Worcester Bosch

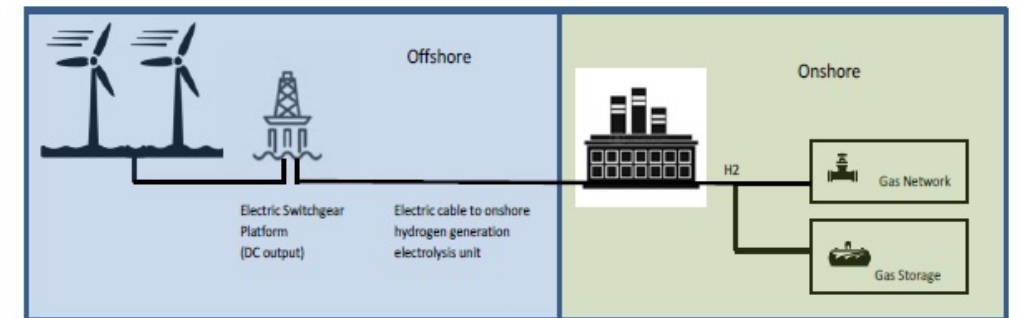
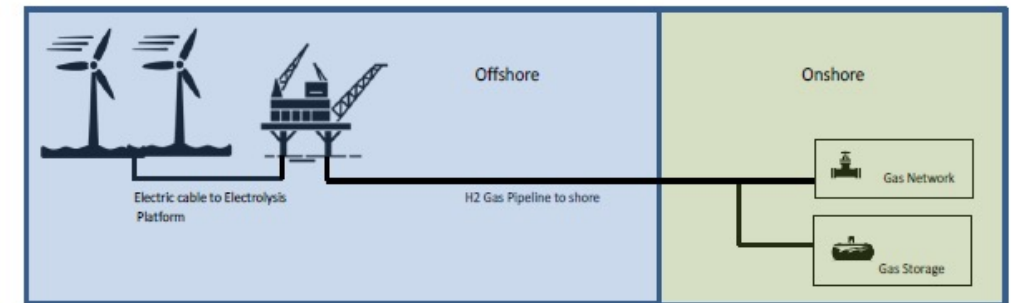
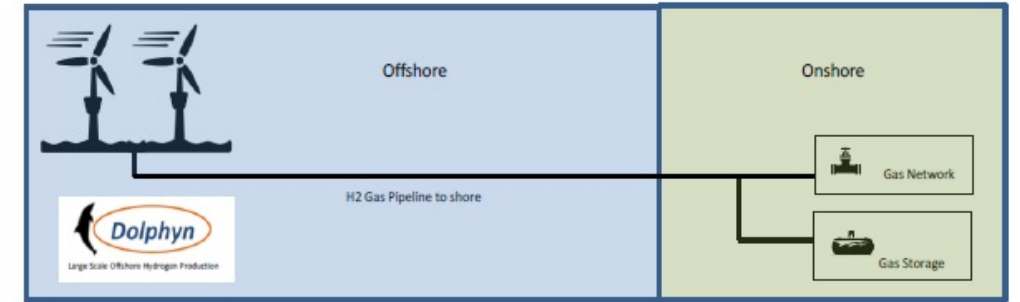
# Green Hydrogen Production



- Advances for PEM water electrolysis unlocking new opportunities for the technology to be deployed at scale.
- 1 MWh to PEM electrolyser – approximately energy value of 0.7 MWh from hydrogen produced.

# Production Options

- Case 1: **Modular Offshore** – desalination and electrolysis on each WTG structure with pipeline arrays to shore; Dolphyn Concept
- Case 2: **Centralised Offshore** - all desalination and electrolysis performed on a single offshore platform with pipeline export
- Case 3: **Centralised Onshore** - using electrical cables to bring power back to shore with all electrolysis performed on land



# Dolphyn Project

- As part of the UK Government "Hydrogen Supply Programme", the new design concept DOLPHYN is being developed: **D**eepwater **O**ffshore **L**ocal **P**roduction of **HY**droge**N**

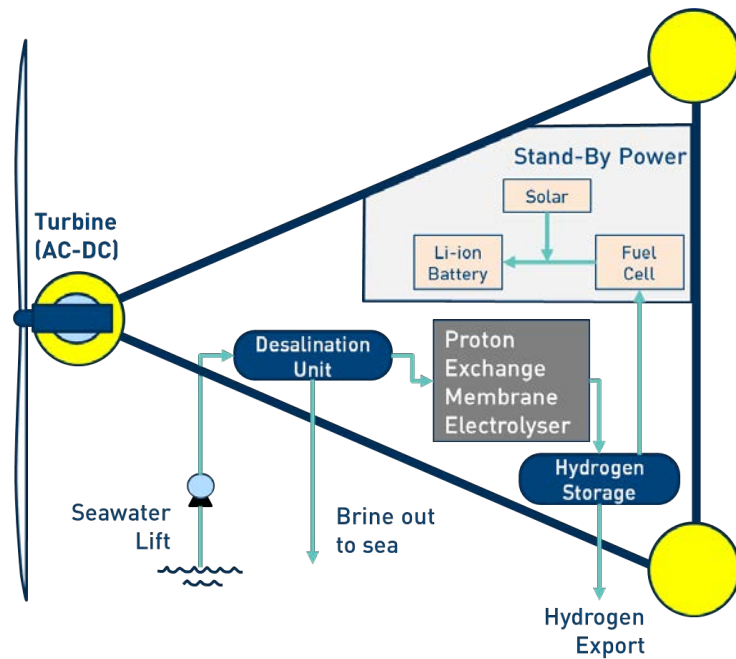
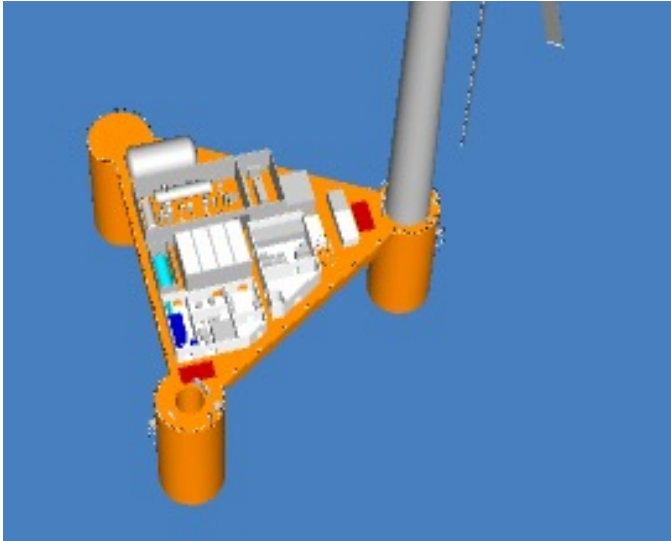
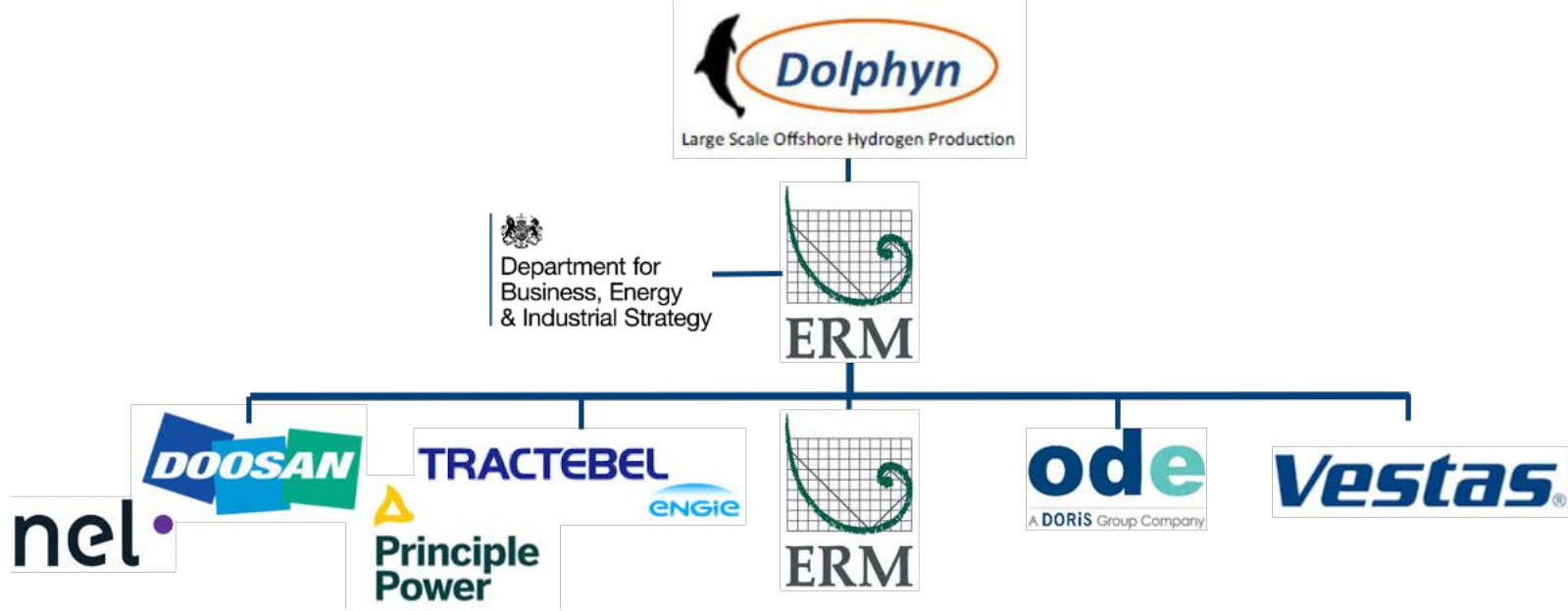


Photo: Windfloat Atlantic (PPI) Technology

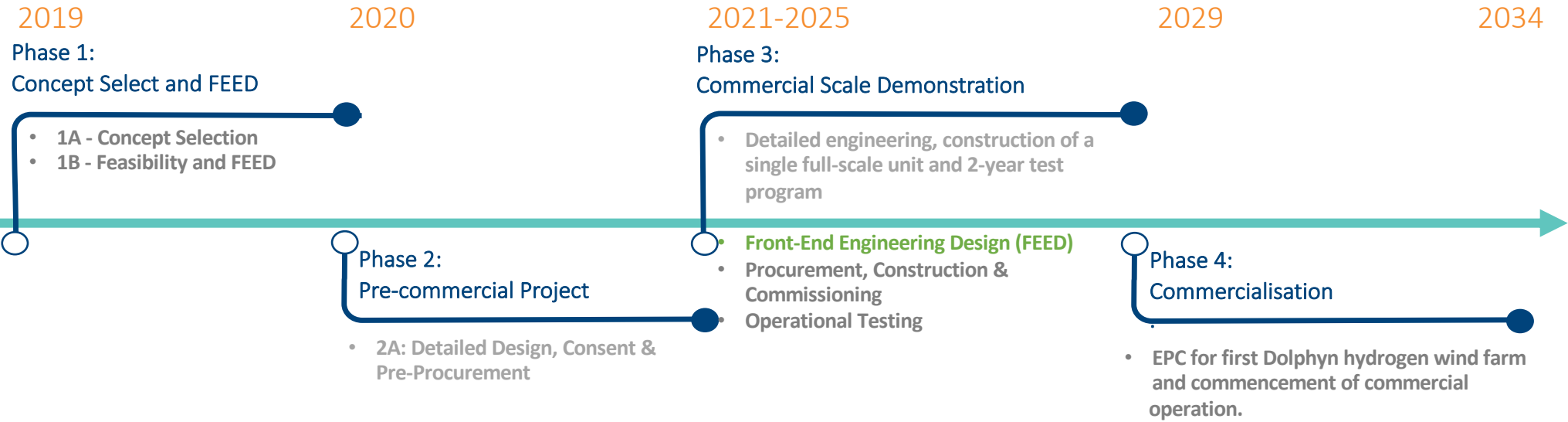
**Floating Wind Solutions**

# Dolphyn Project Team





# Dolphyn Project Timeline



# Dolphyn Demonstrator Unit

- Pilot demonstrator unit, single offshore floating 10MW wind turbine, approximately 4 tonnes/day hydrogen produced. The Dolphyn unit(s) will be located approximately 15km offshore Aberdeen (Greater Kincardine Area) with proposed location as shown below:



# Dolphyn Scale Up

- Expansion of Dolphyn into GW scale offshore hydrogen wind farms further out into the North Sea are planned with potential to tie-in to SGN's Gas Network and Industrial project (offshore hydrogen super-grid pipeline).
- In this concept, each wind farm will consist of a 20 x 20 array of 10MW units giving a 4GW capacity. Potential locations for the first 10 wind farms (illustrative only) are shown here:



# Dolphyn End Users



- SGN / National Grid / Pale Blue Dot Initiative
- Focus initially North-East of Aberdeen (Dolphyn focus is South-Central Aberdeen)
- Blue Hydrogen production at St Fergus
- Link to the Acorn CCS project
- Commencing with 2% volumetric blend into grid. Ramping to 20% blend
- Conversion to 100% hydrogen grid conversion on a regional basis
- Dolphyn would give earlier reason to install southern 100% H2 pipelines, expanding customer base of “converted” end-users
- Dolphyn land-fall would connect to the proposed future SGN 100% H2 pipeline south of Aberdeen

Source: <https://sgn.co.uk/about-us/future-of-gas/hydrogen/aberdeen-vision>

# Cost Targets

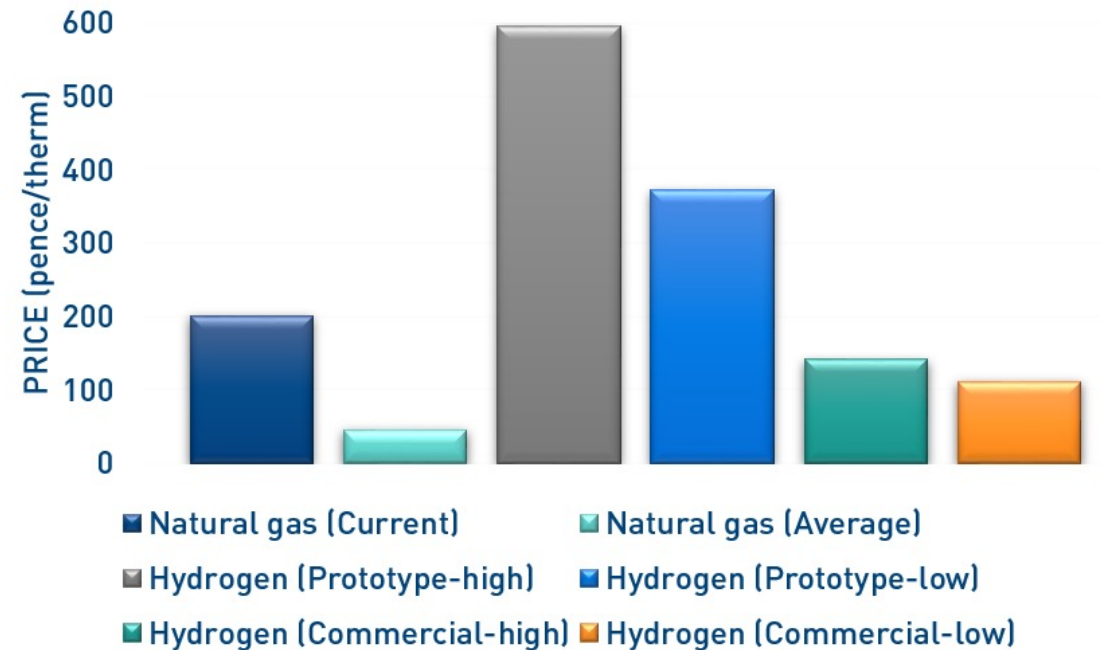
## UK Green Hydrogen Price

- Commercial Development target: £1.90/kg H<sub>2</sub> and lower towards £1.50/kg.
- For prototype, target around £6-5 /kg H<sub>2</sub>. 2019 market price was approximately £8/kg.

### UK Natural Gas Price ytd. 23/03/22



### UK H<sub>2</sub> heating price projections compared with Natural Gas September 2021 (HHV)

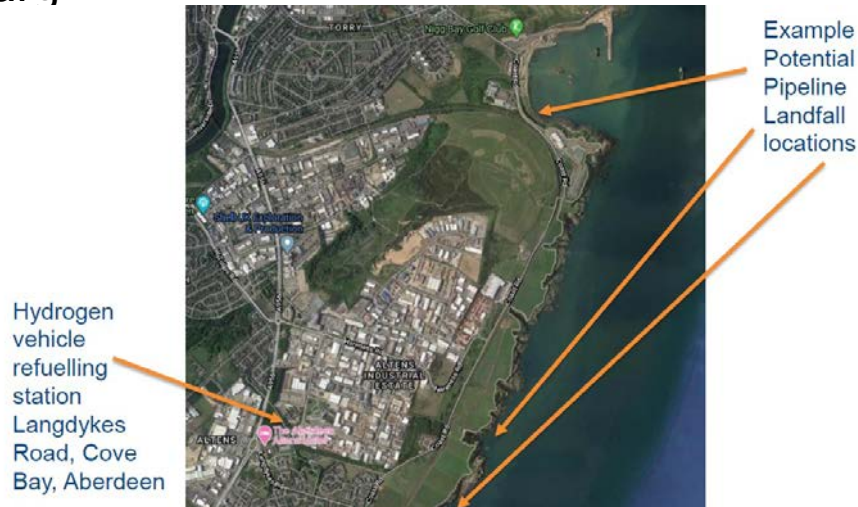
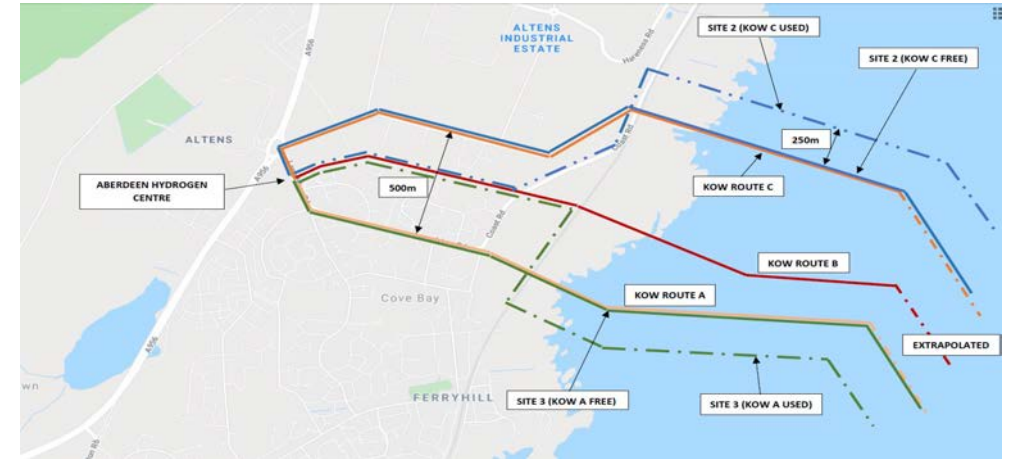


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# Dolphyn Pipeline

- Nominal Length: 15.8km
- Inside Diameter: 88.9/3" (or 50.8mm/2")
- Nominal Flow Rate: 154.9 - 171 kg/hr
- Volume H<sub>2</sub>: 79.5m<sup>3</sup>
- Mass H<sub>2</sub>: 207kg
- Requirement for re-pressurisation as car: 700 barg and buses: 350 barg



**Floating Wind Solutions**

# Dolphyn Project Notes;

## **Design approach – not typical for electrical WTGs**

- Design aligned with GS(M)R (UK), Offshore Safety Case Regulations (UK) and Pipeline Safety Regulations (UK) in addition to Construction Design Management Regulations (UK). Actual process risks appear low at each unit. Marine risks relevant
- Process and Structural Engineering-Led
- Risk Assessment – both technical (including safety) and commercial
- HAZID/ENVID and HAZOP
- Design Basis and Functional Specification Development
- Integration of Unit Operations and Control Systems
- Total Automation of Process Systems. SIL/LOPA

## **Key Risk Topics and Actions**

- Scale-up of whole system to 10MW
- Motion Sensitivity of Electrolyser Package and re-design, Electrolyser design and interface with standby power
- Pipeline & Flexible Riser assessment for 10MW single unit and expansion
- Layout – will equipment fit on the floating structure available?
- Weight assessment, Structural concept

# Dolphyn Project Notes;

## Pipeline Requirements;

- $\rho \cdot v^2$  is generally very low for H<sub>2</sub>.
- Pressure drop a better criteria – 3” recommended for 10MW, but could run with 2” and re-compress onshore (notionally using some of the extra H<sub>2</sub> generated during this case to power the re-compression).
- For small arrays (Island concepts) - there is an optimisation exercise to be performed for each location depending on the distance to the windfarm, the daily wind fluctuations and extremes to determine the pipeline size.
- Construction methods require further optimisation – a small reel-able coil tubing solution and lay technique may be optimal.



# CHANGING ENERGY

**Contact:**

[alice.lawrenson@ode-ltd.co.uk](mailto:alice.lawrenson@ode-ltd.co.uk),

[andrew.baker@ode-ltd.co.uk](mailto:andrew.baker@ode-ltd.co.uk)

[www.ode-ltd.co.uk](http://www.ode-ltd.co.uk)

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