REYNOLDS, J. 2022. *Hydrogen storage research at the National Subsea Centre*. Presented at the 2022 Subsea expo, 22-24 February 2022, Aberdeen, UK.

Hydrogen storage research at the National Subsea Centre.

REYNOLDS, J.

2022

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Hydrogen Storage Research

at the National Subsea Centre

Jemma Reynolds
Research Assistant

National Subsea Centre
Ocean Innovation through Partnership

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Let me introduce myself…

- I am a Research Assistant at the National Subsea Centre
- Currently starting my PhD (PT) at the School of Engineering at Robert Gordon University, focusing on subsea hydrogen storage
- MSc in Energy Management at Robert Gordon University
- BSc in Human Geography, from Manchester Metropolitan University
- I have experience in feasibility study, techno-economic analysis and life cycle assessment in renewable energy developments
- One of my most recent projects involved techno-economic and environmental impact assessment of renewable energy generation through an industrial symbiosis development in Orkney Islands.
- In my spare time I like to surf and climb hills

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The National Subsea Centre

Transparent Ocean

- Aiming to develop cutting-edge capability to detect, monitor and understand subsea and marine, including conditions and activities of the infrastructures and the environments, using the full range of state-of-the-art platforms and sources for data acquisition, visualisation, analysis, interpretation and prediction.

Integrated Marine Energy

- Aiming to develop leading-edge capability to design, model, evaluate and construct an integrated marine energy grid to support the transition to decarbonized energy, using smart materials, digital twins, robotics and mixed energy vector power systems.

Net Zero Marine Operations

- Aiming to develop leading-edge capability to reduce carbon emissions, resource consumption and environmental footprint of marine industry operations using digital twins, machine learning and optimization for operations planning and management, workforce transition planning and supply chain re-design.

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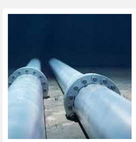
Insight into the research we are doing

Hydrogen

Storage

Subsea

Integration



Repurposing

Transition

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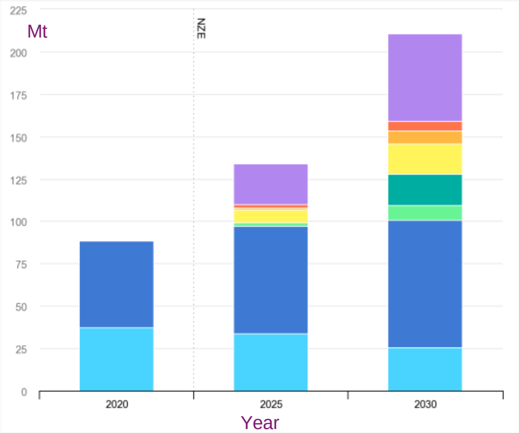
Why hydrogen?

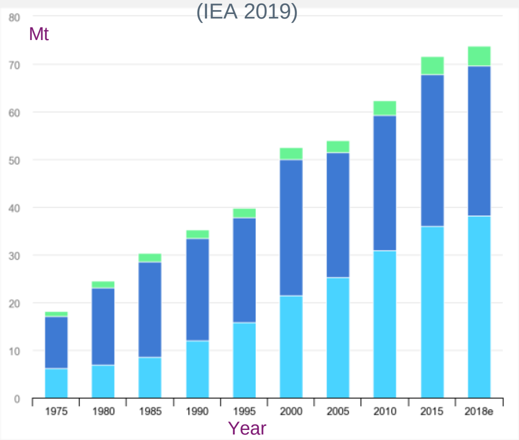
What is the challenge for hydrogen?

- Demand for hydrogen has grown more than threefold since 1975
- Investment plans and governments worldwide have committed in excess of 70billion USD in public funding to date
- Hydrogen storage developments will combat the issues regarding the intermittency associated with renewable energy production.
- IEA suggests that global hydrogen production is reaching over 70 million tonnes per year.
- Interest has heighted by international bodies supporting the trend of the 'hydrogen economy'
- Significant discussion around generating hydrogen from different sources but not much talk about new storage solution
- Re-purposing of old hydrocarbon storage is an option however we need more than just that

Global hydrogen demand by sector in the Net Zero Scenario, 2020-2030 (IEA 2021)



Global demand for pure hydrogen, 1975-2018 (IEA 2019)



Issues

- Poor efficiency
- Large scale capacity on land unsuitable and unsafe
- Very high-cost manufacturing processes
- High costs to store large amounts
- High operating pressures
- Circular economy prospects in structural design
- Unsafe compared to other gases due to its flammability potential and lightness
- Ability to penetrate porous media
- Hydrogen Embrittlement

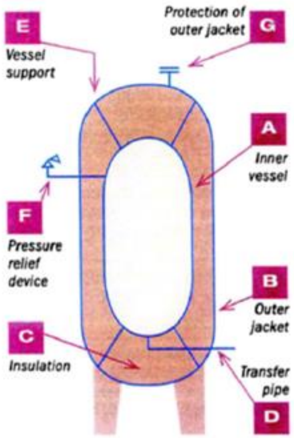
Current hydrogen storage types

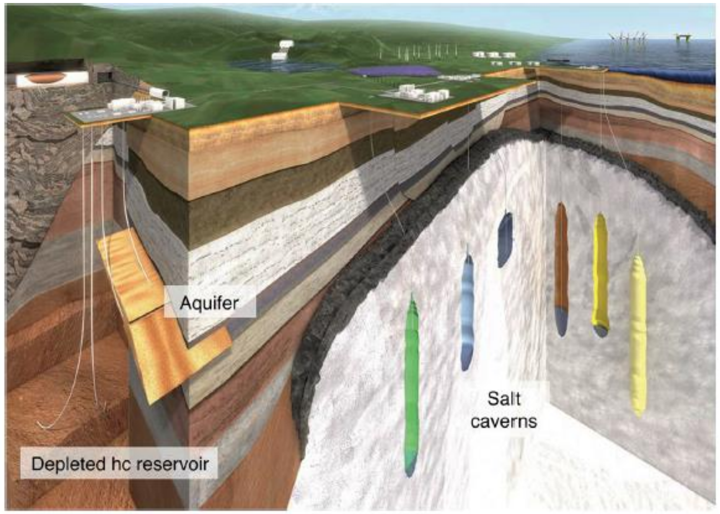
On land

- Compressed hydrogen storage
- Liquified hydrogen storage
- Solid material based storage
- Fuel cells

Underground

- Salt Caverns
- Deep Aquifers
- Depleted hydrocarbon reservoirs





On land

- Most commonly stored as a gas or liquid in tanks for small scale mobile and stationary applications.
- Compressed gas in lightweight composite cylinders
- Relatively low hydrogen density
- Blending in pipelines max 40%

Underground

- Up to 10 cycles of injection and withdrawal a year
- Limitations with the construction and operation of all underground storage options
- Lots of adaptations needed to make underground caverns hydrogen suitable
- Higher capacity
- Lower cost

NSC Research Area

Above ground

- Compressed hydrogen storage
- Liquified hydrogen storage
- Solid material-based storage
- Fuel cells

Below ground

- Salt Caverns
- Deep Aquifers
- Depleted hydrocarbon reservoirs

Subsea

- Large tanks
- Repurposed pipelines
- Repurposed hydrocarbon well reservoirs

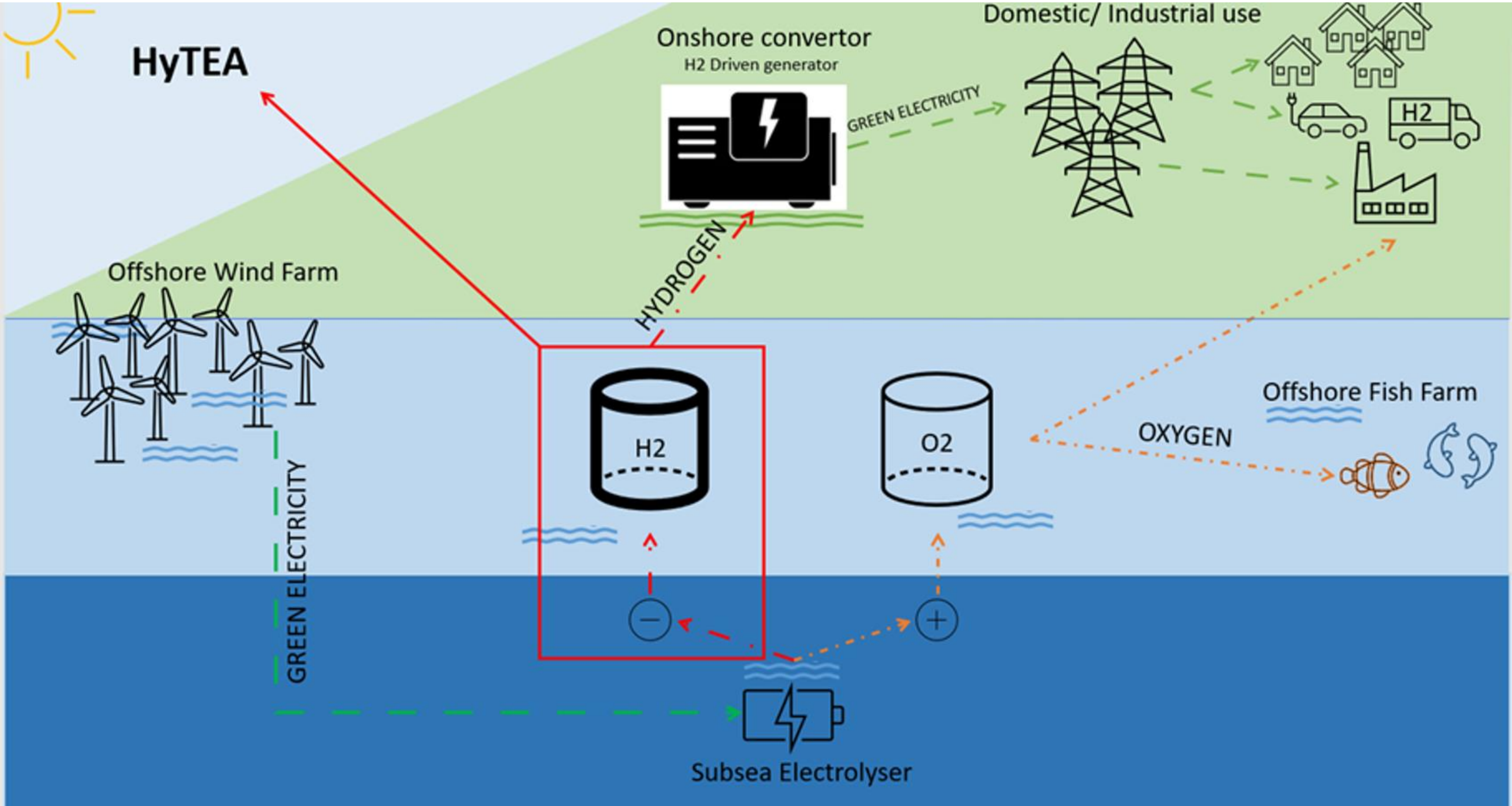
Developments being considered by NSC

- Optimised safe structures and versatile shapes (above 700 bars pressure) at a large scale
- Improvements in weight, volume storage efficiency, conformable shapes, system integrations and cost reduction are needed to realises grid level storage
- Low-cost manufacturing processes, maintenance routines and standards to govern the safe use of improved compressed cylinder storage technology

Proposed Solution

- Subsea Storage (Underwater tanks)
- Provide a green energy source to offshore platforms
- On a large-scale, space saved on land
- High pressure depths
- Ongoing developments for strength-to-weight ratio materials
- Integrated energy systems with the use of green hydrogen for easy transport and utilization
- This will provide a storage solution for PURE hydrogen

HyTEA


HyTEA
Onshore convertor
H2 Driven generator
Domestic/ Industrial use
GREEN ELECTRICITY
H2
Offshore Wind Farm
HYDROGEN
H2
O2
Offshore Fish Farm
OXYGEN
GREEN ELECTRICITY
Subsea Electrolyser

HyTEA

Title: Techno-economic assessment of large-scale subsea hydrogen storage technologies for green hydrogen.

Aim: Assess the feasibility of large-scale subsea hydrogen storage methods in terms of techno-economic assessment and life cycle analysis.

- Assessment of a safe structural design for large scale subsea hydrogen storage
- Perform a technical screening of the subsea structure
- Assess the economic performance of subsea structure and systems including a cost benefit analysis of storage solutions
- To provide a preliminary life cycle assessment of tanks and materials
- To assess the scalability of large-scale subsea hydrogen tanks systems

Expected Outcome

- Safe structure design for large scale hydrogen storage
- Improved system integrations into grid level storage
- Techno-economic analysis of subsea structure and technology including cost benefit analysis of storage solutions
- Sensitivity analysis of the influential factors within the manufacturing process

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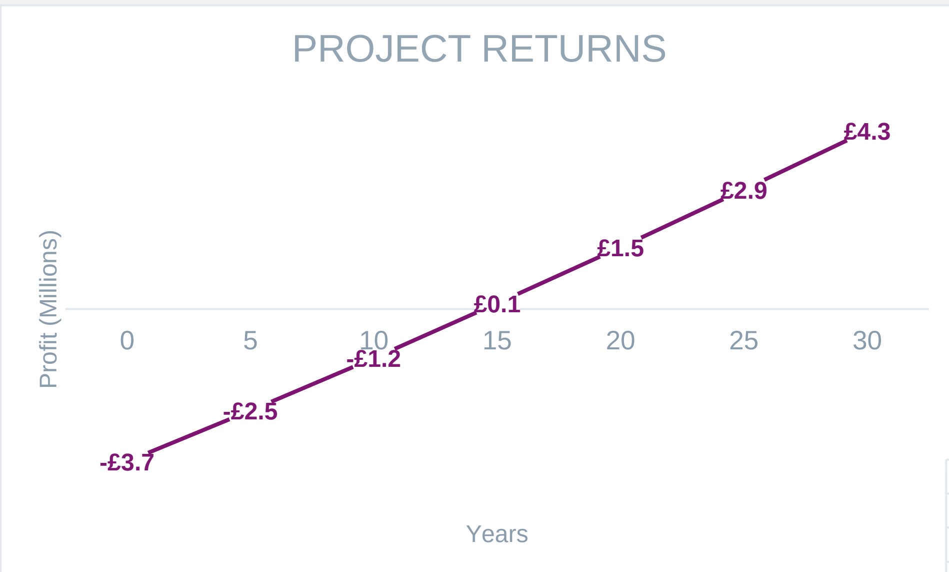
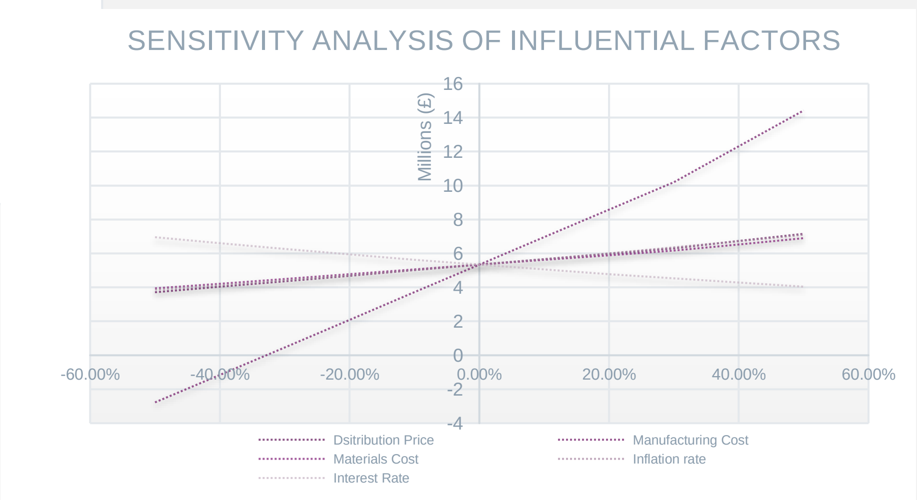
Proposed economic modelling



- Cost benefit analysis
- Project NPV and IRR
- Sensitivity analysis
- Economic Recommendation



- Preliminary life cycle assessment
- Based on a combination of natural gas storage and subsea pipelines

Project Impact

- Increased efforts for meeting demand
- Less reliance on fossil fuels for hydrogen production process
- Significant reduction in carbon emissions on the journey to net zero
- Cost reduction in storage solutions providing high access rates

Any questions?

Jemma Reynolds

Hydrogen Storage Research at the National
Subsea Centre