IMPACTS OF ZERO CARBON ELECTROFUELS ON SHIPPING FOR SHETLAND ISLANDS

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Presenting at BlueForum

June 15th 2022

WHO WE ARE

Ricardo plc is a world-class environmental, engineering and strategic consulting company listed on the London Stock Exchange.

We bring deep technical insights, capabilities and services to the full range of global challenges including climate and energy, air and environmental quality, waste and resource efficiency, and sustainable transport. Our work spans development of government policy through to helping businesses navigate those policies

OUR ISLAND PROJECTS

Study showing zero carbon marine fuels can support the investment case for renewable energy, support job creation and the just transition from fossil fuels to a clean economy, enabling wider decarbonisation far beyond the shipping sector

Ricardo is developing a bespoke balance of plant for a hydrogen fuel cell auxiliary power generator for an Orkney ferry. We are also converting a gas engine to hydrogen for ferry propulsion

We have now worked on nearly 50 separate pieces of work, developing Bermuda's capability in renewables, technical and economic regulation, procurement activities and other various capacity building activities

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THE NEPTUNE PROJECT

- The Shetland Islands are a remote archipelago North of Scotland
  - There is outstanding local wind resource but local wind farms will exceed the proposed interconnect

- *Neptune* is a UK Department for Transport part-funded project

- *Consortium* of Ricardo, Babcock, Shetland Islands Council & Strathclyde University

- Project **goals** are:
  - Estimate the current & future energy demands of the Shetland marine sector
  - Assess renewable energy potential to provide zero carbon fuels for local maritime industry
  - Understand land-side production & distribution infrastructure

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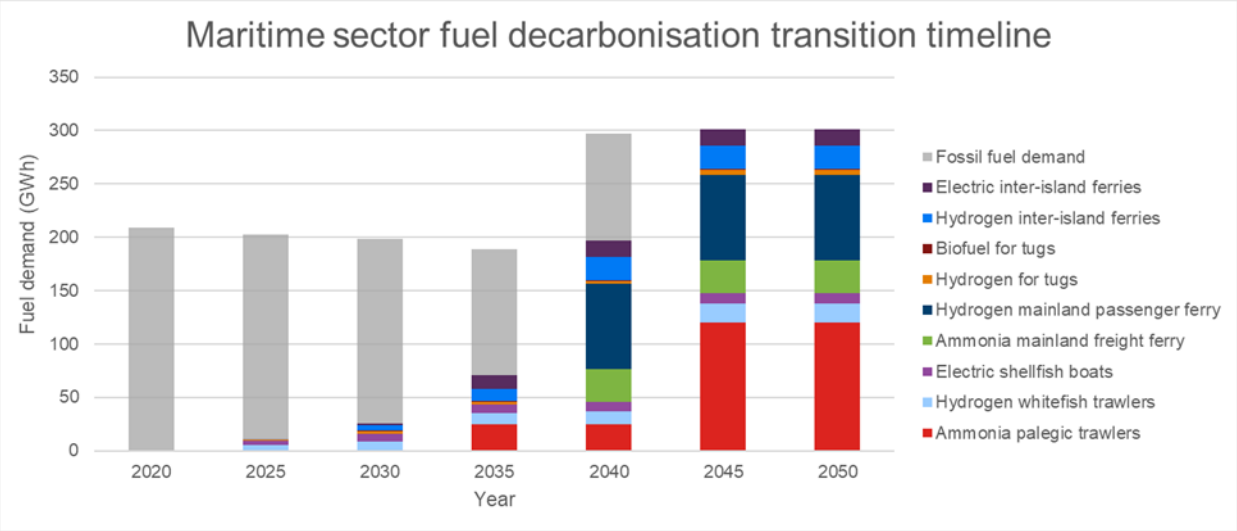
THE SHETLAND FLEET & DEMAND

Islands' boats and ships are *a lifeline and the backbone of the economy*, and have a large energy use

Multi-criteria analysis showed there is *no "one size fits all" fuel for all vessels* that is appropriate considering cost, safety, range, etc

The potential variety of fuels could prove challenging for production and landside infrastructure



ROPAX - LNG→CH_2/LH_2/ammonia

RORO - LNG→CH_2/LH_2/ammonia

Pelagic Trawler - Methanol/ammonia

Tugs:
Dual Fuel
H_2/ diesel/
MeOH

Interisland
Ferries
:Battery
/CH_2

Battery

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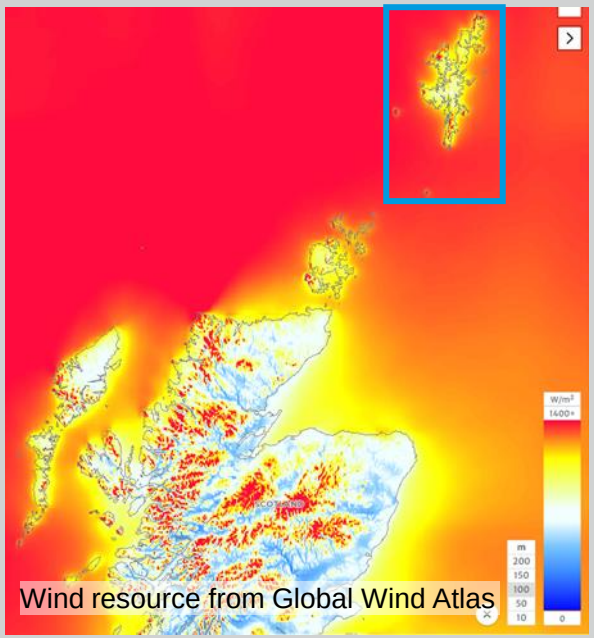
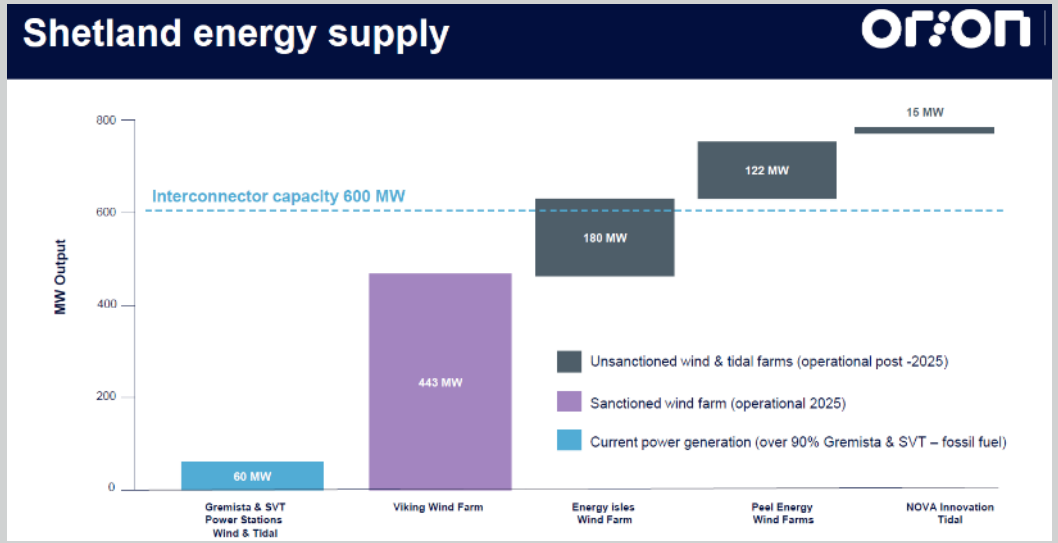
RENEWABLE POTENTIAL & BUILDOUT

- Shetland Islands have excellent on- and offshore wind potential, but are distant from electricity demand
- Island electricity demand is currently ~60MW, but forecast to increase to ~150MW
- Currently *11MW of onshore wind* (plus tidal and energy from waste), but four new onshore projects planned increase that to 690MW
  - **443MW Viking windfarm** online in 2024
  - Potential to overpower the 600MW grid interconnect
- Offshore projects could dwarf onshore
  - Cerulean Winds *3GW*
  - Aker Northern Horizon *10GW*
  - Both projects envision local hydrogen production for export



Viking turbine base under construction



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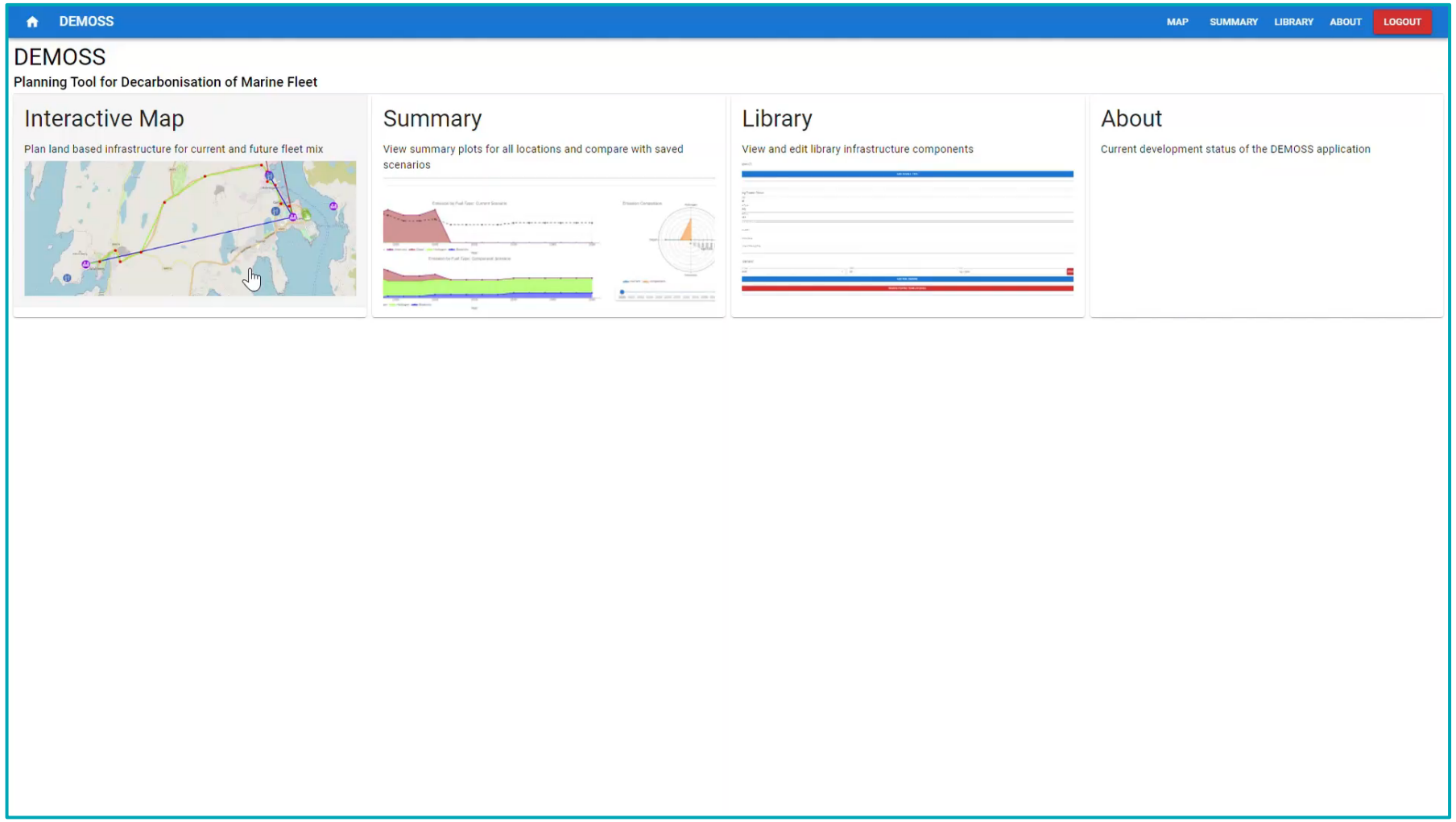
DEMOSS TOOL



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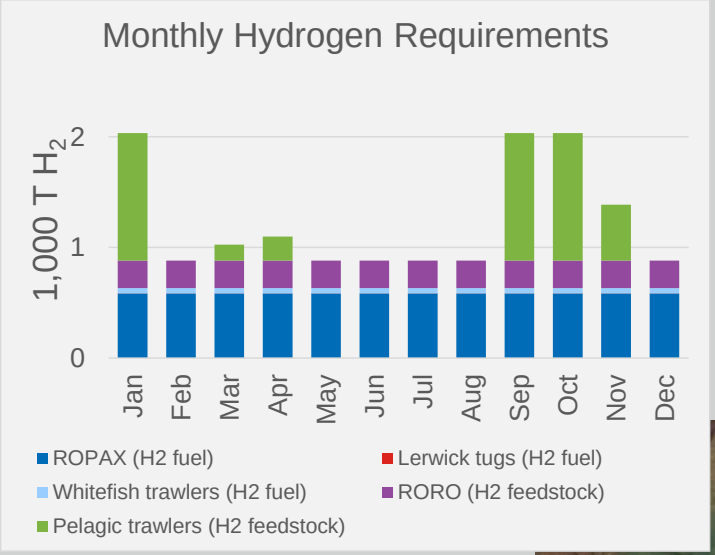
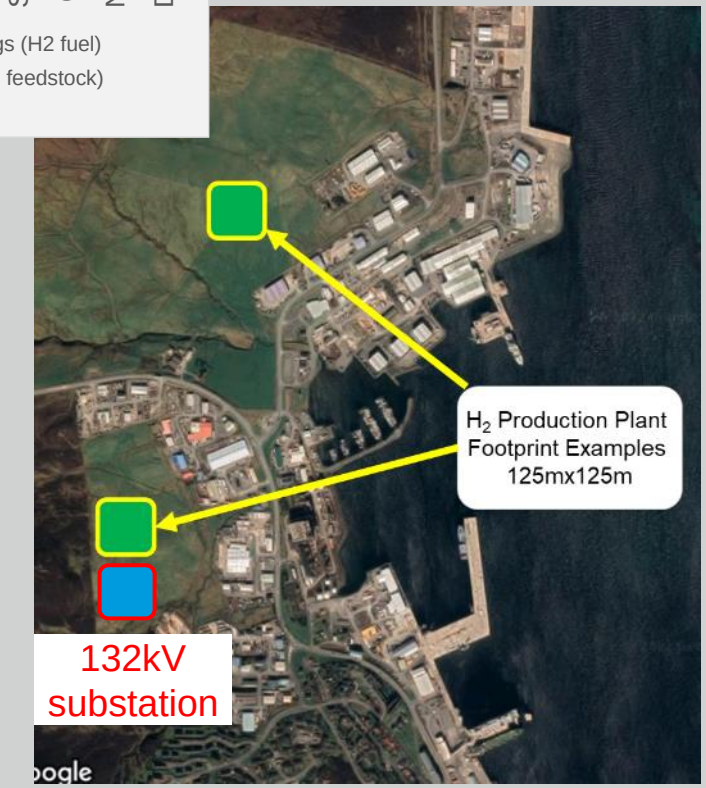
HYDROGEN PRODUCTION

- The Shetland fleet requires **~50T/d hydrogen**
  - Equivalent to **<u>140MW electrolysis</u>**
- Allowing for some safety factor, 65m^2/MW, leads to a plant ~**<u>125m x 125m</u>**
  - The modular nature of electrolysers could mean this area being procured, with a lower initial capacity
- This area is too large to fit within the port – fortunately Shetland has not only ample wind but ample space
  - May be more problematic for ports in more built up areas
- Hydrogen pipelines will extend to the port for refuelling of vessels and potentially vehicles
  - Similar to domestic natural gas pipes





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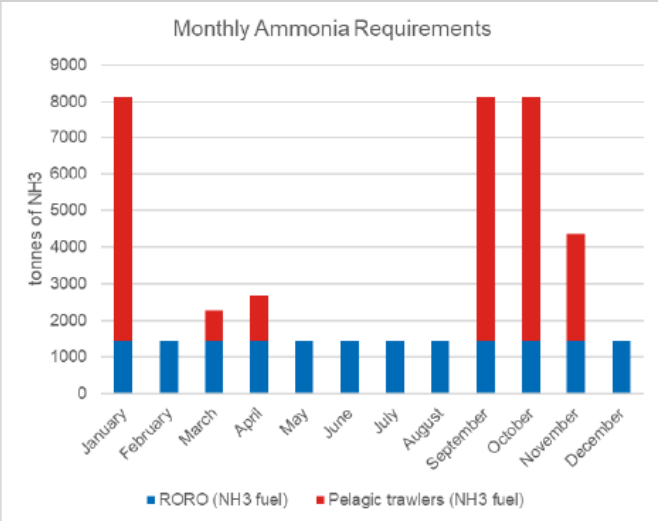
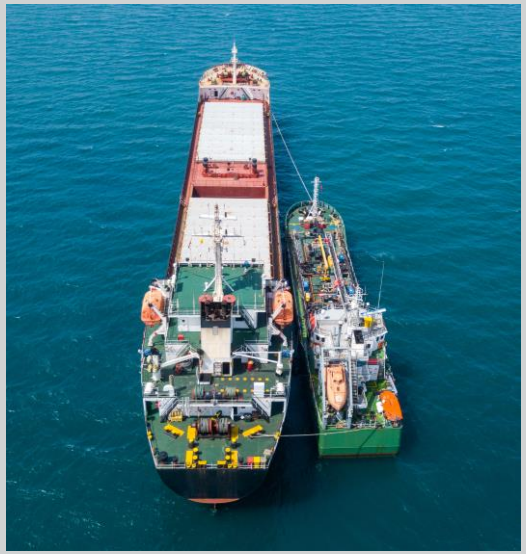
AMMONIA PRODUCTION

- More acceptable to have truck delivery from Sullom Voe Terminal however local NH_3 production investigated
- NH_3 production is a continuous process so storage needs to smooth the spikes in demand vs flat supply – **<u>20,000 tonnes</u>**
- Lots of waste heat for Lerwick district heating network
- Plant/refueller *<u>cannot be located</u>* close to populated areas – Greenhead (to the North) is a suitable location
- Other ports *<u>without this luxury</u>* will have challenges, may require bunker barges which are expensive. More research needed





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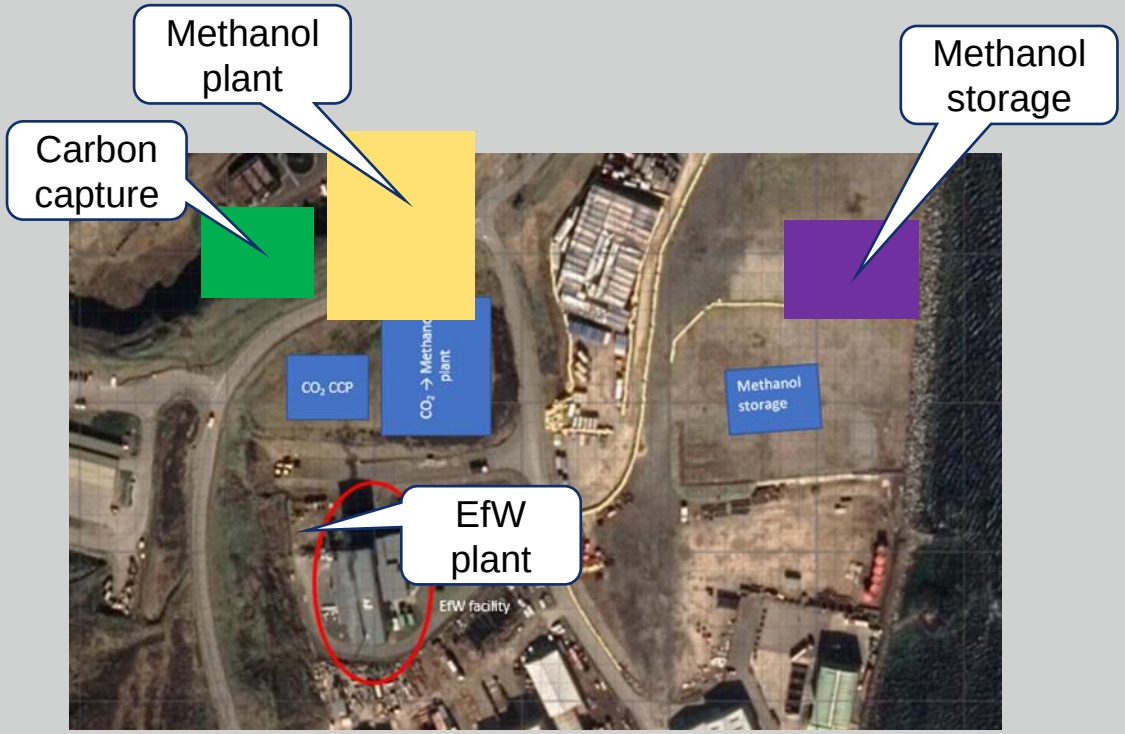
METHANOL PRODUCTION

- Green methanol is an attractive future marine fuel as it requires few changes both onshore and on-vessel
  - However, the cost is *often considered prohibitive*
  - Fuel cost is *driven by* the price of hydrogen, electricity and CO_2 feedstock
  - Shetland presents an interesting opportunity for cheap hydrogen & electricity, with integration in the local EfW plant and district heat network for waste process heat as an income

- For Lerwick, the small waste volume leads to *unusually small CO_2 capture and methanol plants*, making them economically challenging
  - Despite this, methanol from using the EfW plant is modelled to be slightly cheaper than ammonia
  - Highly attractive for future vessels
  - Available volume & feedstock will be challenging

Approximate areas for methanol production



	CH_2 350 bar	Ammonia	Liquefaction	Methanol EfW plant	Methanol Direct air Capture
£ per MWh fuel	89	177	233	161	201

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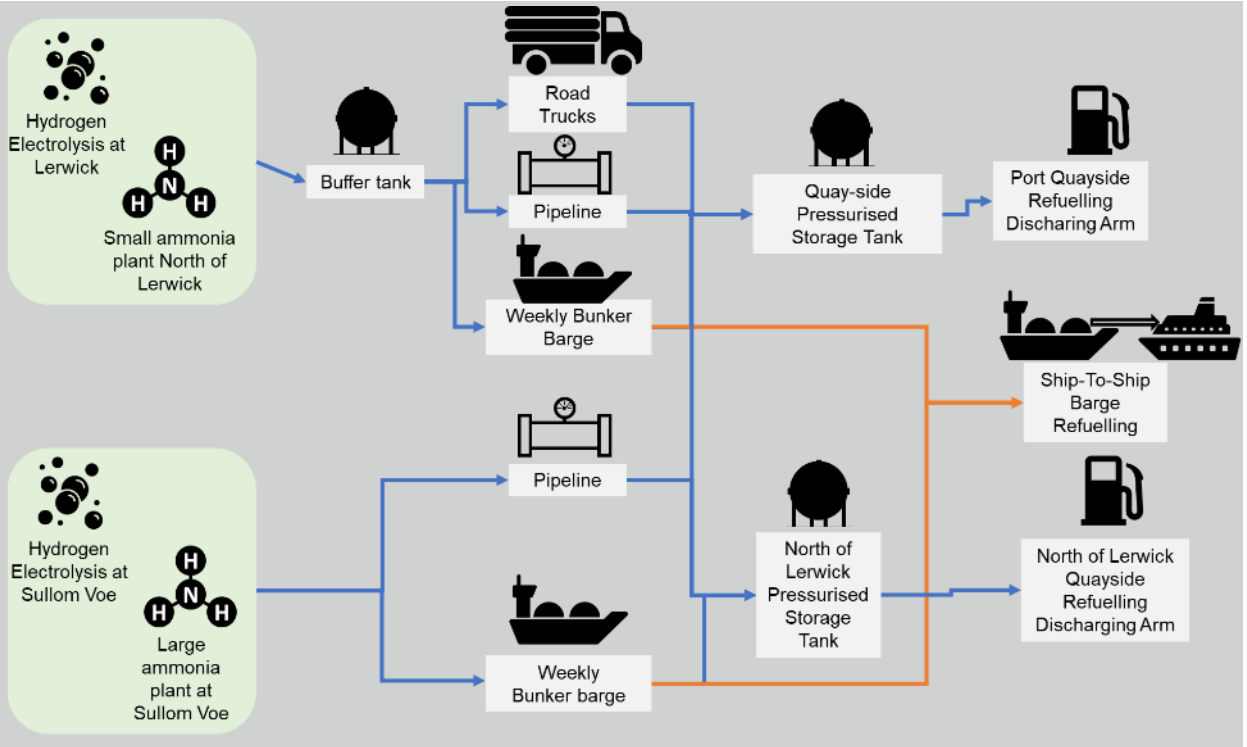
FUEL TRANSPORT & STORAGE

- Low volumetric energy density of future fuels is *often presented* as a **vessel challenge**

- However, it also presents a **landside challenge**
  - Interisland ferry needs 0.7T/d = 1 artic truck
  - Mainland ferry needs 9T/trip = not feasible by truck
  - Pipelines up to €1M/km in urban areas

- Need *30T hydrogen* storage near the port
  - 30x 40' shipping containers
  - 10km of 24" pipe at 100 bar in area 200x200m
  - In liquified state in 350-420 m^3 tank
    - Liquefaction very expensive: ~€50M for Lerwick

- Large scale ammonia storage is more mature and lower cost due to relatively easy liquefaction
  - But can't be located near population



250kg hydrogen trailer at Ricardo facility

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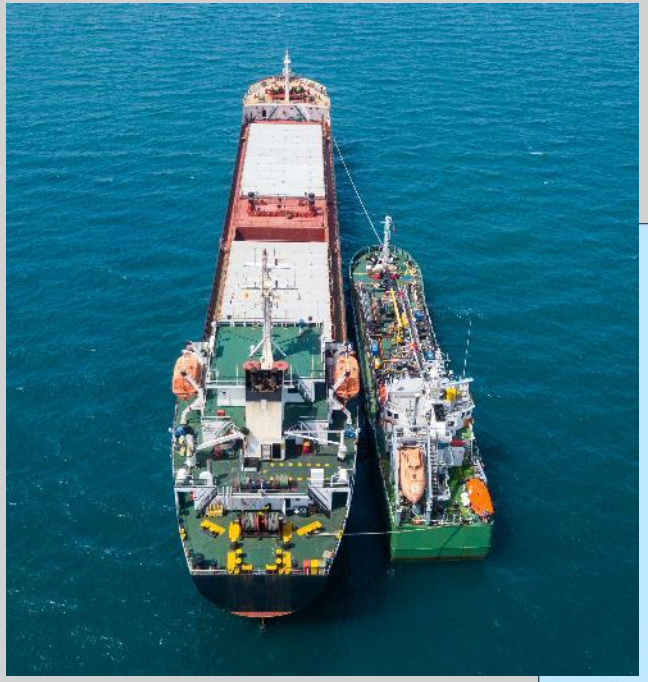
FUTURE FUELS BUNKERING

- Currently fishing vessels and inter-island ferries are conveniently and cheaply bunkered by truck, while larger vessels refuel from dockside pipeline
- BEV ferries should be able to charge overnight, from nearby 11kV cables: up to ~5MW, depending on local demand for heating, cars, etc
- For remote and infrequent H_2 ferries or fishing vessels, *mobile truck refuellers* may be appropriate, as dedicated HRS is ~€1M
- *Bunkering of ammonia/H_2 for large vessels* will be challenging – similar to LNG today, but more regular
  - The large safety distances will be challenging for compact ports, especially those in urban areas or with many on-site businesses
  - Bunker barges may be helpful, but expensive
  - This is an area for more research and cross-sector collaboration



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SUMMARY

- The project has *identified the most appropriate future fuel(s) for the existing fleet*
  - The most appropriate fuel for the same vessel may be different in a different location
    - Due to available feedstock or usage profile
  - We have created a tool which can be used to compare different scenarios

- *Local renewables* can be used to independently power Shetland's fleet
  - Positive for the just transition, economy and self-sufficiency

- *Land-side changes for future fuels* will be at least as challenging as changes to vessels:
  - Fuel storage and transportation will be far more challenging than today
  - Bunkering of potentially dangerous fuels, especially in compact ports, needs cooperation and development

- Shetland is unique, but *the findings of this study applicable to many other locations*
  - Excellent "sandbox" for future hardware trials

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THANK YOU

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