Hydrogen Offtake Assessment

Final Report for Freeport East

PA Consulting

February 2023

CONTENTS

FreeportsHub

FOREWORD

While specific use cases may individually carry some uncertainty, it is already clear that hydrogen will be a key part of the future low carbon economy.

Freeport East aspires to be the UK's leading centre for global trade, green energy, innovation and technology. This means we will always be looking to the future for opportunities for increased investment, productivity and employment opportunities. What we are lucky to have in our immediate region is an existing clean energy powerhouse that makes the potential for large-scale production of green hydrogen a realistic ambition.

Freeport East wants to act as a key facilitator in bringing together the breadth of stakeholders required to deliver a hydrogen economy. Our definition of a green hydrogen hub combines our geographic focus with bringing together the components of a hydrogen economy, not only supply and demand but also by focussing on the investment, skills, local supply chain and supporting infrastructure needs.

One part of this role is to produce relevant analysis and insights which others can act on. This independent analysis is only the start of that process but begins to set out an understanding of how green hydrogen could be deployed across our region and what that might mean in terms of the scale of investment needs, but also the opportunity for job creation, skills and local business.

We already have many businesses in our region that are actively involved in green hydrogen projects, or have the capability, skills and expertise to be active in the future. This also applies to our innovation clusters – the hydrogen economy will require innovations in robotics, data science, logistics, artificial intelligence, control systems and much more – these are already strengths of our region and an opportunity to ensure we build economic value from the energy transition.

We are grateful for the financial support for this report from the Department for Levelling up, Housing and Communities who sponsor the Freeports programme. We hope you find the report useful. We would welcome feedback, especially in terms of what would be useful for Freeport East to do next. Please also get in touch if you are interested in the opportunities that green hydrogen may present and to be part of ongoing discussions about possible pilot opportunities.

Yours sincerely

Steve Beel
Chief Executive
Freeport East

01

INTRODUCTION & REQUIREMENTS

FreeportsHub

INTRODUCTION & BACKGROUND

In January 2023 Freeport East was given final approval as a Freeport by the UK government.

The UK Government has a stated ambition of 10GW of low carbon hydrogen production by 2030. Given the volume of energy industry activity in the region, including proximity to some of the biggest Offshore Wind and nuclear projects in the UK, Low Carbon Hydrogen production and its associated value chain is seen as a vital component to attract stakeholders to the region and help facilitate creation of the Hydrogen ecosystem.

PA Consulting were commissioned for a 4 week assignment to map the potential demand sources for hydrogen across the Freeport East economic zone and the surrounding areas. The work was completed across 3 main tasks detailed below. The sources of data used have been PA's proprietary tools, databases and knowledge bank, desktop research, and stakeholder interviews across industry and local government authorities.

TASK 1

Identifying the key offtake segments and initial analysis incl. time to maturity assessment and demand assessment framework.

TASK 2

Demand mapping incl. interviews of stakeholders and research to assess potential hydrogen volumes and mapping of the offtakers.

TASK 3

High level design for potential pilots. These pilots are for engagement with potential partners and will require scoping out further, once levels of interest are ascertained.

02

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

01 | DEMAND SEGMENTATION AND TIME TO MATURITY ASSESSMENT

11 segments with potential hydrogen use cases within Freeport East area & the immediate region were identified as part of initial review

Short term (pre-2025)

HGVs | Buses | FMCG

Medium term (2025 – 2030)

Off-highway | Fertiliser | Port Ops | Refinery

Long term (post 2030)

Rail FOCs | Shipping | Rail TOCs | Ferries

02 | DEMAND MAPPING

140 tonnes per day of hydrogen offtake potential could be accessible across the region by 2030. Based on high level estimates this would require circa 550MW of installed capacity using typical electrolyser efficiencies as of 2023.

Noteworthy potential offtakers identified from the modelling could include Bus operations/depots (c. 3.5tns/day) HCS refinery (c.7tns/day), HHA (c. 1.5tns/day), Hutchison Ports' onshore / offshore operations (c. 8tns/day) & individual major FMCG plant in the region (c. 23tns/.day).

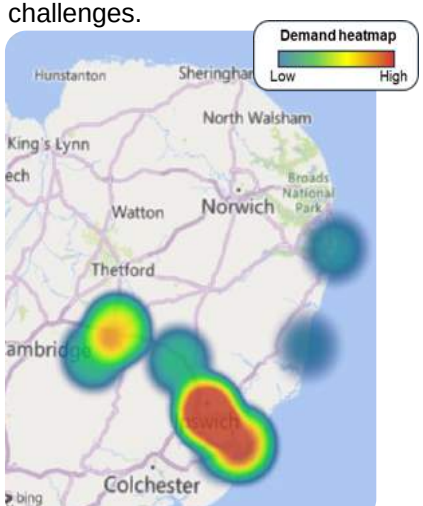
Beyond 2030, technology development becomes less certain; there may be sizable volumes (>100 tns/day) needed by HGVs especially given the large number of movements in and out of the regional ports. But there is competition from other technologies, e.g. electrification. Shipping fuels in the form of hydrogen derivatives such as ammonia could drive huge demand, as emphasis on decarbonising deep-sea shipping sector gathers momentum.

Offtakers are hub-based within the Freeport & dispersed beyond. Infrastructure barriers exist for both

Hydrogen demand hubs could emerge within the ports for refuelling of port operations & goods transport vehicles entering site – e.g. HGVs & Rail. Further afield, potential offtakers such as FMCG plants, Sizewell C etc., are more dispersed and require different storage & transport solutions. Infrastructure is currently limited, both within the economic zone, and in Eastern England. Strong demand potential and a coordinated strategy (e.g. with Project Union, a National Gas venture, and the Bacton Hydrogen Hub) is a key pre-requisite to drive infrastructure investment and development.

Key insights and commentary from our initial analysis:

- HGVs, Buses and FMCG can be early adopters in the region, making them attractive for pilot projects
- Maritime is a long term opportunity for derivatives, but port ops could come sooner if there is strong support from stakeholder groups
- Refining & fertilisers segments have credible offtakers who can benefit from fuel switching to hydrogen
- Rail at a national level has a weak case, but it's a viable alternative in East England due to preponderance of freight, & local electrification challenges.



EXECUTIVE SUMMARY

03 | POTENTIAL PILOT PROJECTS

Pilot projects have been outlined to initiate engagement with local stakeholders across the hydrogen value chain

Pilot 1 - HGV & Port Ops refuelling hub at Felixstowe
Proves concept of multi-modal handling and refuelling

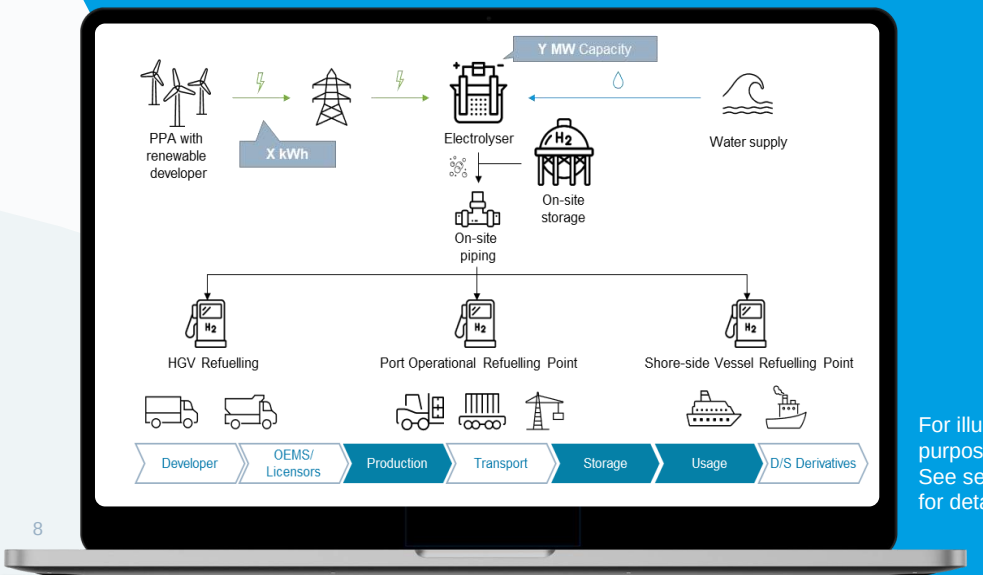
Pilot 1A – Maritime refuelling Hub at Felixstowe
In addition to pilot 1, it proves concept of multi-modal refuelling of various vessels. Potentially encompassing CTVs, tugboats, service vessels etc.

Pilot 2 - Production and delivery to dedicated industry within Freeport area
Proves concept of delivery to a dedicated external offtaker via pipeline

Pilot 3 - Production at port and delivery via tube trailer to an offsite offtaker
Proves concept of storage at production & offtake sites, along with tube trailer deliveries

At the pilot scale, typical PEM electrolysers are currently available in stacks of 2MW capable of producing 30kg/hr of hydrogen.

1. Engage with potential pilot project stakeholders to determine interest in a partnership to develop pilot projects.
2. Gather data from interested parties to assess the scale of demand they would require from a pilot.
3. Identify funding schemes and mechanisms with strategic fit and initiate application for funding, if applicable.
4. Given Felixstowe is the UK's busiest container port, initiate a deep dive study on potential shipping volume for hydrogen and derivatives.
5. Scope pilot projects to further detail, including electrolyser sizing in MW, electrolyser technology, delivery mechanism and frequency (tube trailer deliveries per week, pipework infrastructure sizing), green electricity volumes, specific offtake volumes per partner offtaker, LCOH and techno-econometric modelling, identify HSE considerations and skills gaps (list not exhaustive)



For illustrative purposes only, See section 5 for details

RECOMMENDED NEXT STEPS

03

OFFTAKE SEGMENTATION

TASK 1

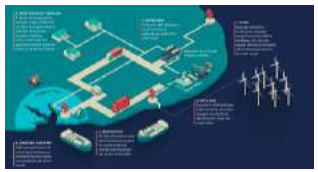
FreeportsHub

OUR APPROACH

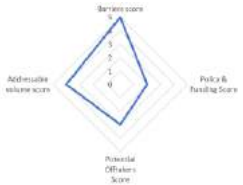
01
Sector Segmentation

02
Geographical Screening

Sectors with low likelihood of applicability near the Freeports Area



03
Segment Demand Assessment Framework



04
Time-to-market assessment

05
Summary and Final Conclusions → **Segments (demand users) identified for Task 2**

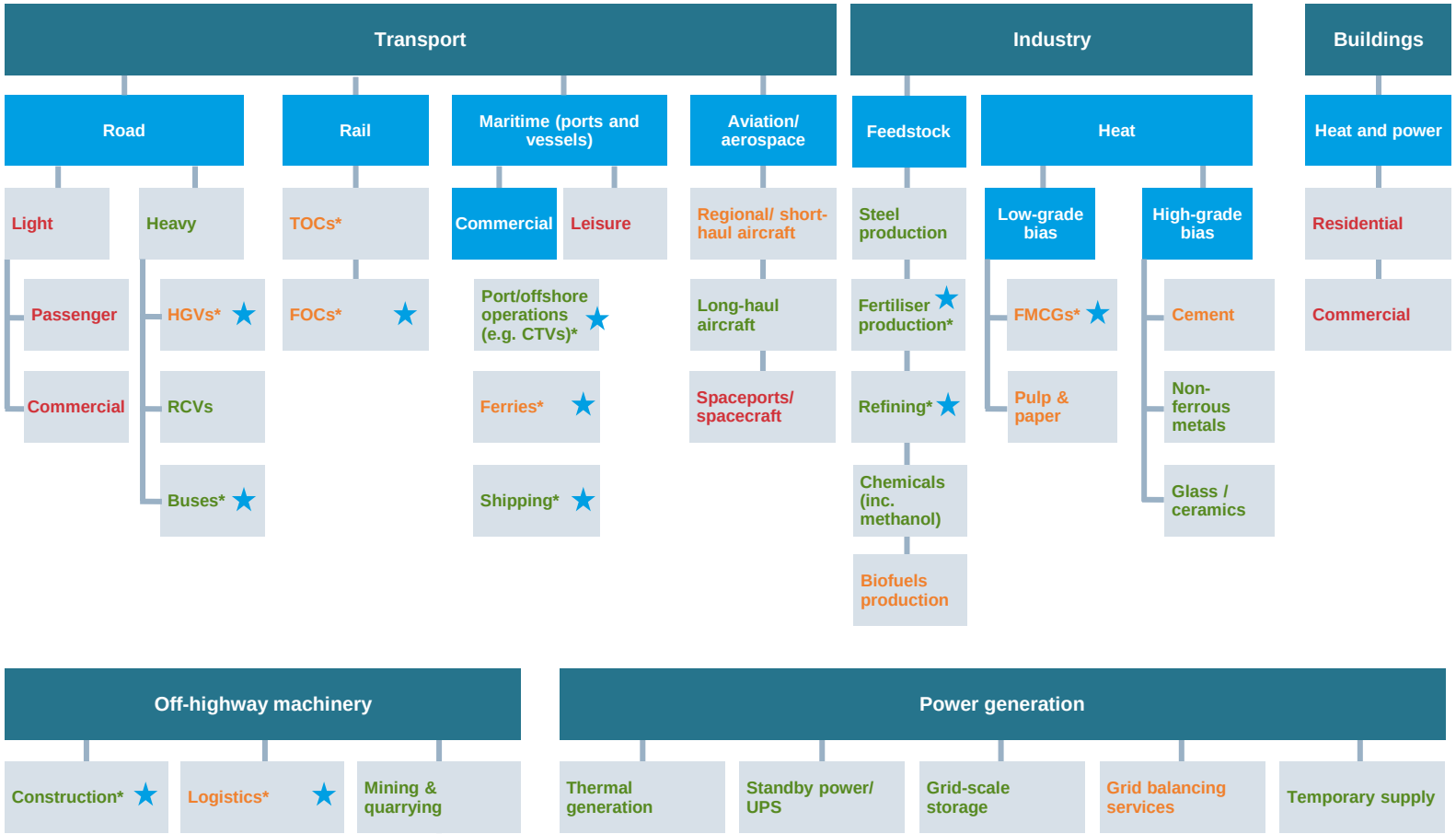
For Task 1, the following activities were undertaken in a structured manner to identify, analyse and shortlist segments with optimal low carbon hydrogen use case potential to take into Task 2:

1. Prepare ***offtake segmentation chart*** highlighting sectors with potential hydrogen use case.
2. Perform ***geographical screening of segments*** in proximity to Freeports East (e.g. steel is located far away so has been discounted despite having a good hydrogen use case)
3. Prepare ***demand assessment frameworks*** for screened segments covering key aspects i. e policy & funding schemes available; the potential offtakers and their likelihood of adopting hydrogen; barriers to fuel switching; and addressable hydrogen volumes.
4. Perform a ***time-to-market assessment*** for hydrogen use cases to reach maturity.
5. Based on analysis and findings from points above **finalise segments to focus on for Task 2 demand mapping.**

INITIAL HYDROGEN SEGMENTATION CHART

Demand potential exist across multiple segments within the region both in the short and long term

- Light road vehicles are ranked low due to the emerging dominance of BEVs
- Residential and commercial heating are likely to be covered by heat pumps. A final decision is to be made in 2026, but National Grid FES forecasts made in 2022 removed hydrogen as a use case for domestic & commercial heating.[22]



Likely potential case for Hydrogen use:

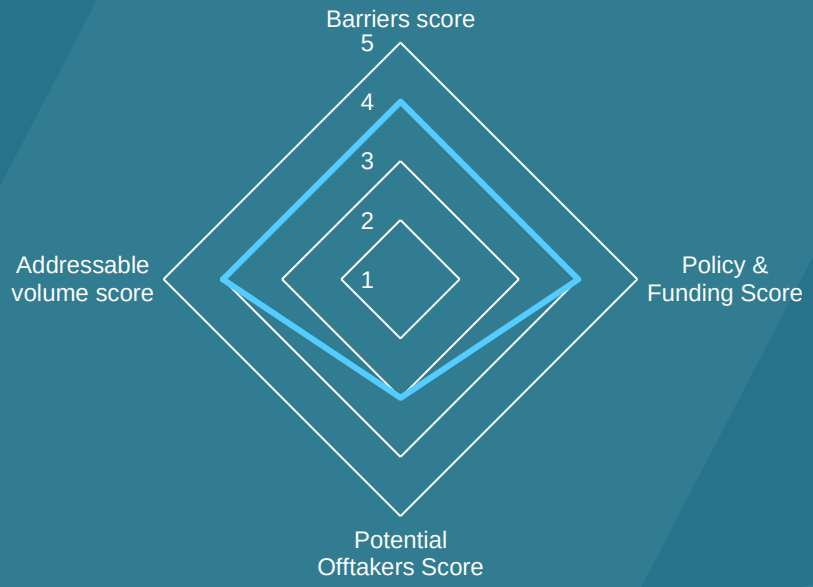
HIGH MED LOW ★

* Segments have been determined to be most implementable according to industries present near the Freeports East area [0] and have been assessed in the demand assessment framework and time to maturity assessment

DEMAND ASSESSMENT FRAMEWORK

Assessment criteria were defined for key segments and each one scored against this standardised approach.

- The scores are based on desktop research, reviews of publications and PA's expert view
- It is recognised that there are variations within segments and scores are generalisations – the level of granularity has been set at a balanced level. It also must be noted these are initial scores before deeper analysis into local demand mapping was undertaken
- In task 1, the determination of hydrogen volume has been done qualitatively using reported fuel consumption and from case studies caried out on hydrogen use cases by PA at a national level. In task 2 we will further analyse addressable volumes in the Freeports East region
- The segments have been grouped to overall industry sectors where possible



BARRIERS

5. Hydrogen offers an almost like-for-like swap with existing fuel
4. Minor changes required to allow for switching
3. Asset designs need evolving, and transformation of operations required
2. Asset designs need transforming to allow switching
1. Alternative decarbonisation options are more cost effective making use of hydrogen prohibitive.

POLICY & FUNDING

5. Policies are in place and supported by appropriate financing
4. Policies are in place and partially supported by financing
3. Policies are being developed and a pipeline of future regulation exists
2. No specific policies are in place, with only targets and generic funding
1. No policies, specific targets or funding available

POTENTIAL OFFTAKERS

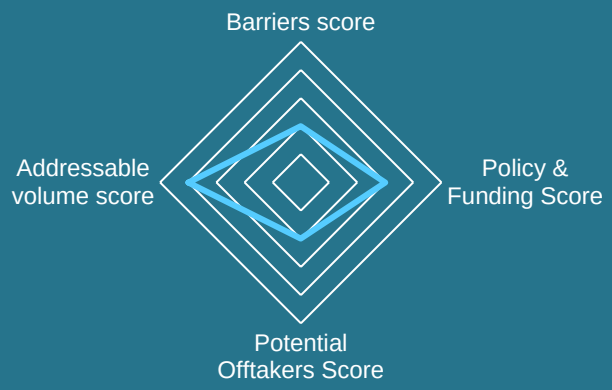
5. Clear incentive for companies to pay a premium - high-end providers facing consumer & policy pressure with no viable alternative fuels
4. Incentive for companies trying to gain green competitive edge with hydrogen being a clear leading option
3. Level premium and playing field with other decarbonisation options
2. Hydrogen not being considered as a premium, and alternatives are significantly better placed to serve this segment
1. Offtakers are willing to pay premium for alternatives over hydrogen & alternatives are already capturing the market

ADDRESSABLE VOLUME

5. Addressable annual volume of hydrogen is above 80% of the total range
4. Addressable annual volume of hydrogen is between 60-80%
3. Addressable annual volume of hydrogen is between 40-60%
2. Addressable annual volume of hydrogen is between 20-40%
1. Addressable annual volume of hydrogen is below 20%

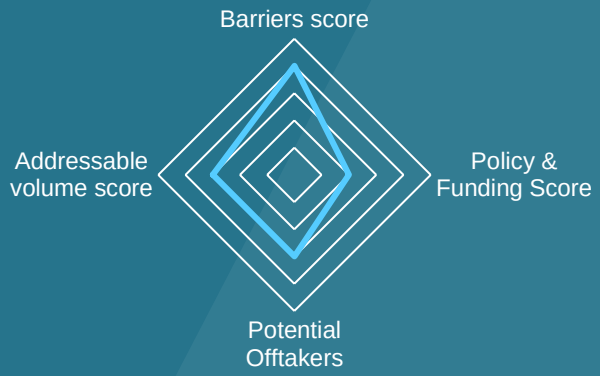
MARITIME SEGMENTS

SHIPPING



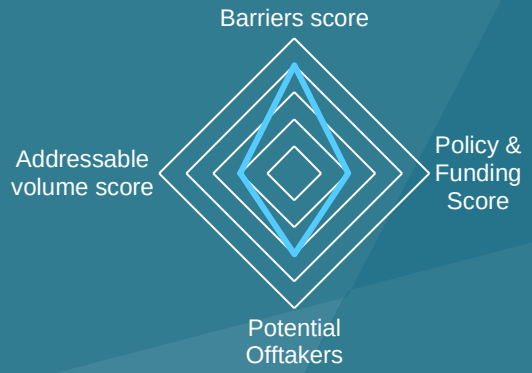
- Requires large amounts of ammonia for long distance. Ammonia is seen to be the most effective and cost effective, although methanol is also being considered.[62].
- There is industry experience in handling the products and infrastructure in place already, however larger storage tanks would be required due to the energy capacity of ammonia.
- UK SHORE and Innovate UK are delivering £77 million in match-funding to support high TRL research in close to commercial clean maritime technology. Funding will be made available to cover the construction and set-up of projects until March 2025,. Funding provided across 3 Strands

PORT/OFFSHORE OPERATIONS



- UK aiming to be a world leading zero maritime sector by 2035, according to clean maritime plan
- On-site renewables and hydrogen production may be possible, with some large port operators already installing renewable power for electrification[63]
- Electrification or hydrogen being considered, with optimal solutions varying by port and the availability of hydrogen and grid capacity

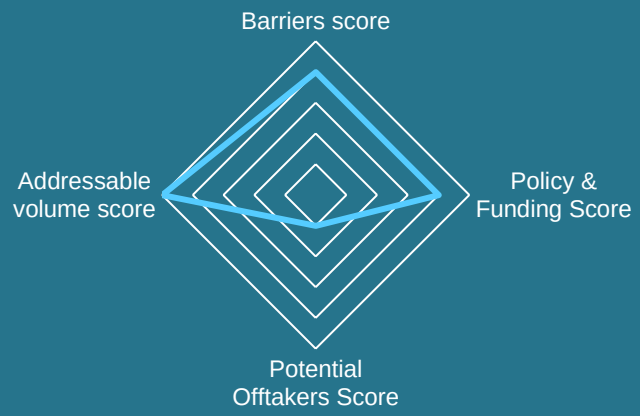
FERRIES



- Trial in Orkney to explore solutions for decarbonising ferries, with a test being run on a pure hydrogen ferry.
- Ammonia is seen to be the most effective and cost effective, particularly for longer distance routes.
- Significantly lower volumes than other maritime segments.
- There is industry experience in handling the products and infrastructure in place already.

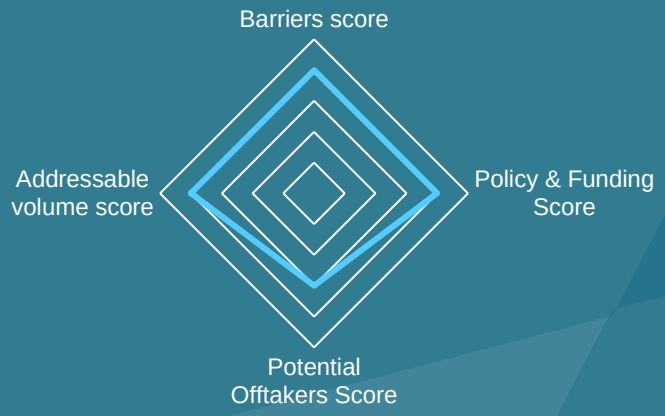
ROAD TRANSPORTATION SEGMENTS

HGVs



- HGVs being decarbonised through battery electric and hydrogen fuel cells. Will require very high volumes relative to other sectors.
- Long distance HGV operations, without returning to base, are more suited to hydrogen than battery electric.
- New HGVs sold to be zero emission by 2040, but logistics companies likely to wait as long as possible to decarbonise.
- Significant funding available: £140m funding for zero emission road freight demonstrator programme (ZERFT). Up to £4.8mn for the Holyhead Hydrogen Hub, a demonstration hydrogen production plant and fuelling hub for HGVs to serve freight traffic at Holyhead and port-side vehicles with aim to deliver in 2023.

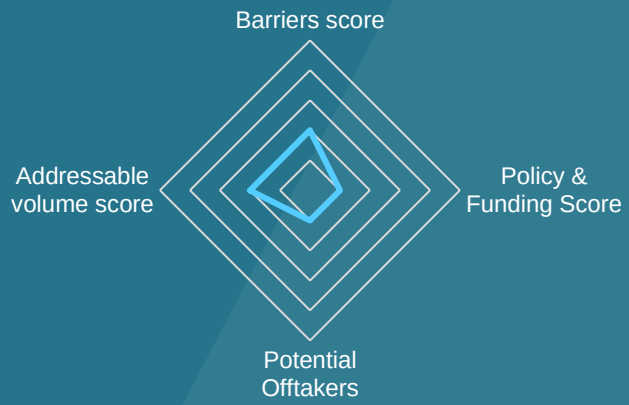
Buses



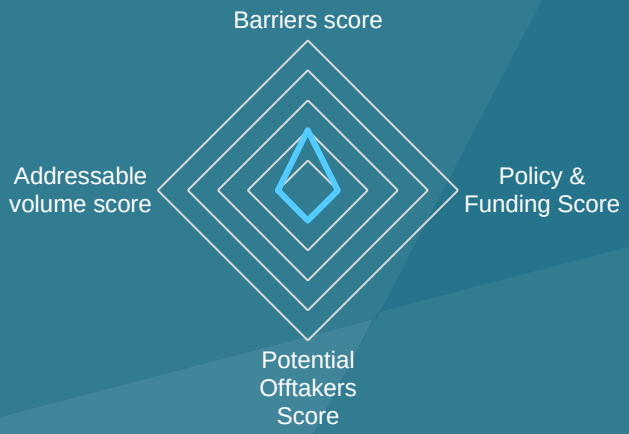
- Hydrogen rollout already occurring with buses being trialled.
- Unlike cars and HGVs, government has not yet set a date for the banning of the sale of new ICE powered buses and coaches.
- A DfT consultation in 2022 sought views on a preferred dates between 2025-2032.
- Battery electric seems to be preferred option, with hydrogen being a solution for areas with low grid capacity and limited supply.
- Zero Emission Bus Regional Areas (ZEBRA) scheme (£198m) in 2022 awarded 12 local transport authorities funding towards 4,000 new zero emission buses, either hydrogen or battery electric, and infrastructure needed to support them.
- Birmingham currently has the UK's largest hydrogen bus fleet – 100 plus vehicles when all those funded by the ZEBRA scheme are delivered.

RAIL TRANSPORTATION SEGMENTS

TOCs



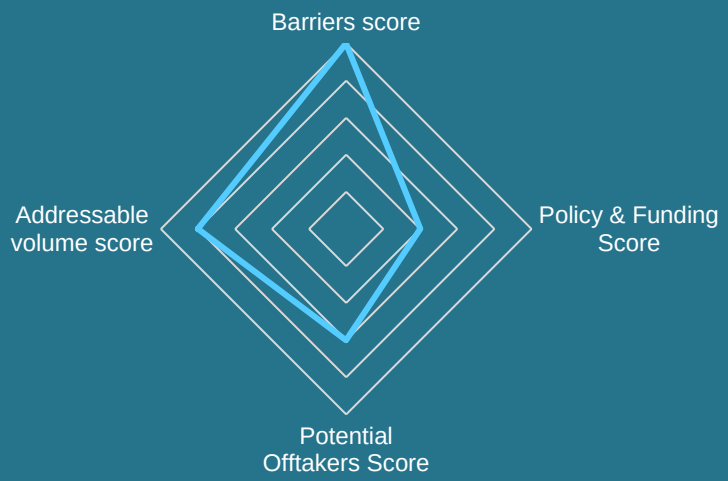
FOCs



- Would require large overhaul of infrastructure for hydrogen conversion, this will not replace networks already electrified.
- Of the routes currently unelectrified, the DfT committed to net zero rail by 2050, and the removal of diesel only trains by 2040. Network rail's Traction Decarbonisation Strategy published in 2020 outlines routes to decarbonisation.[25].
- Strategy states: *'To decarbonise currently unelectrified parts of the network, electrification will likely be the best solution'.*
- There are a handful of lines where Network Rail state a preference for hydrogen (Route A on image to left). These are mainly served by dual-mode Greater Anglia passenger trains.
- Greater Anglia trains operating on route B currently use diesel despite being diesel-electric locomotives.
- Key freight routes from Felixstowe to the ECML are planned to be electrified.(Routes B and C)[25]. But this is unlikely to be before 2040 as these are some of the lowest priority lines for electrification, and it is realistic that freight operators will want to decarbonise sooner which, owing to their business models, will only be practical with hydrogen.

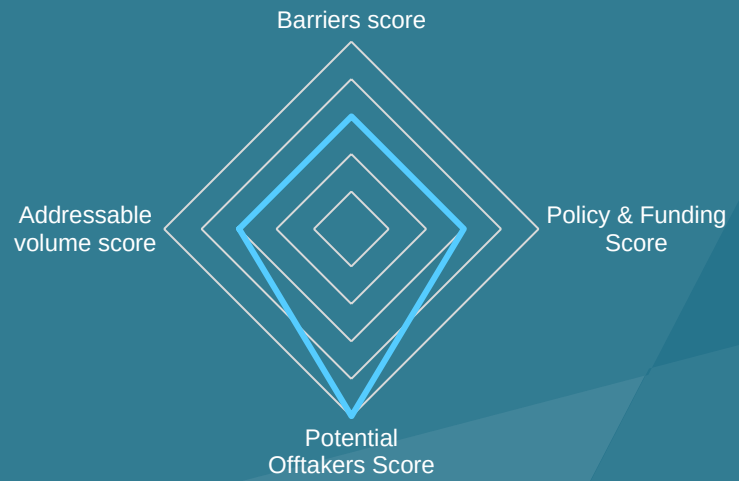
INDUSTRIAL SEGMENTS

FERTILISERS



- Few barriers as it is a drop-in replacement for grey hydrogen.
- There is industry experience skilled in handling the products, compliance with standards and infrastructure in place already.
- High volumes and little competition from other feedstocks.
- Dependent on CCUS advancements and renewable energy capacity. Expectation that procurement will be in bulk from external sources and that h2 will not be produced at point of use.
- Many funding initiatives: Industrial Hydrogen Accelerator, Industrial Fuel Switching, Industrial Energy Transformation Fund (IETF)

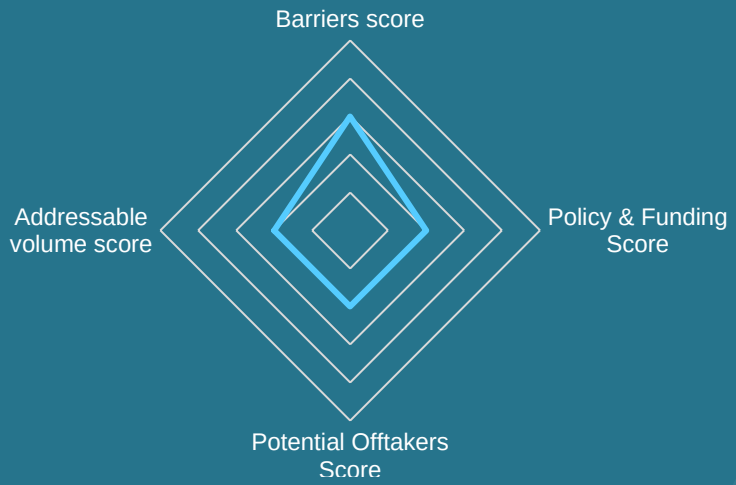
FCMG (FOOD PROCESSING & BREWERIES)



- Brewing industry aiming for net zero 2040.
- Trials at Scotland as heat for distilleries. Also ongoing projects to decarbonise breweries in Wales.
- Relatively low volumes.
- Offtakers can charge customers a premium for a low emissions product, increasing their willingness to pay a premium for green hydrogen – electrification not a full solution: lack of competition.
- Pathway is to convert existing boilers to use a blend of hydrogen first, before advancing to 100%.
- Limited support: £11m funding from Green Distilleries competition.

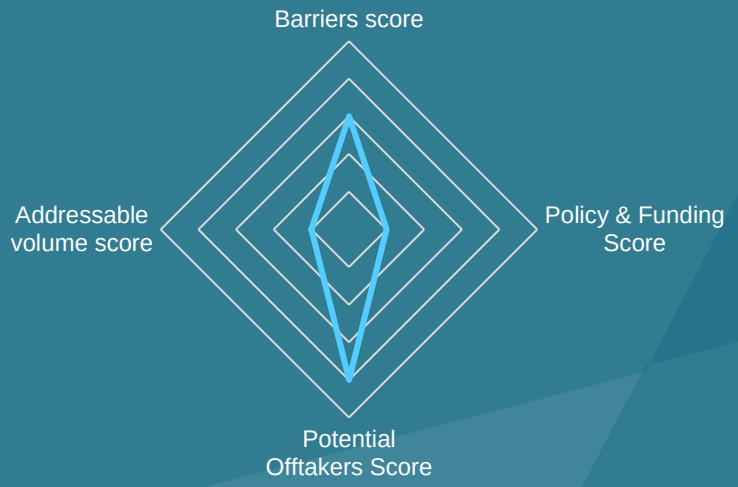
CONSTRUCTION & LOGISTICS SEGMENTS

CONSTRUCTION



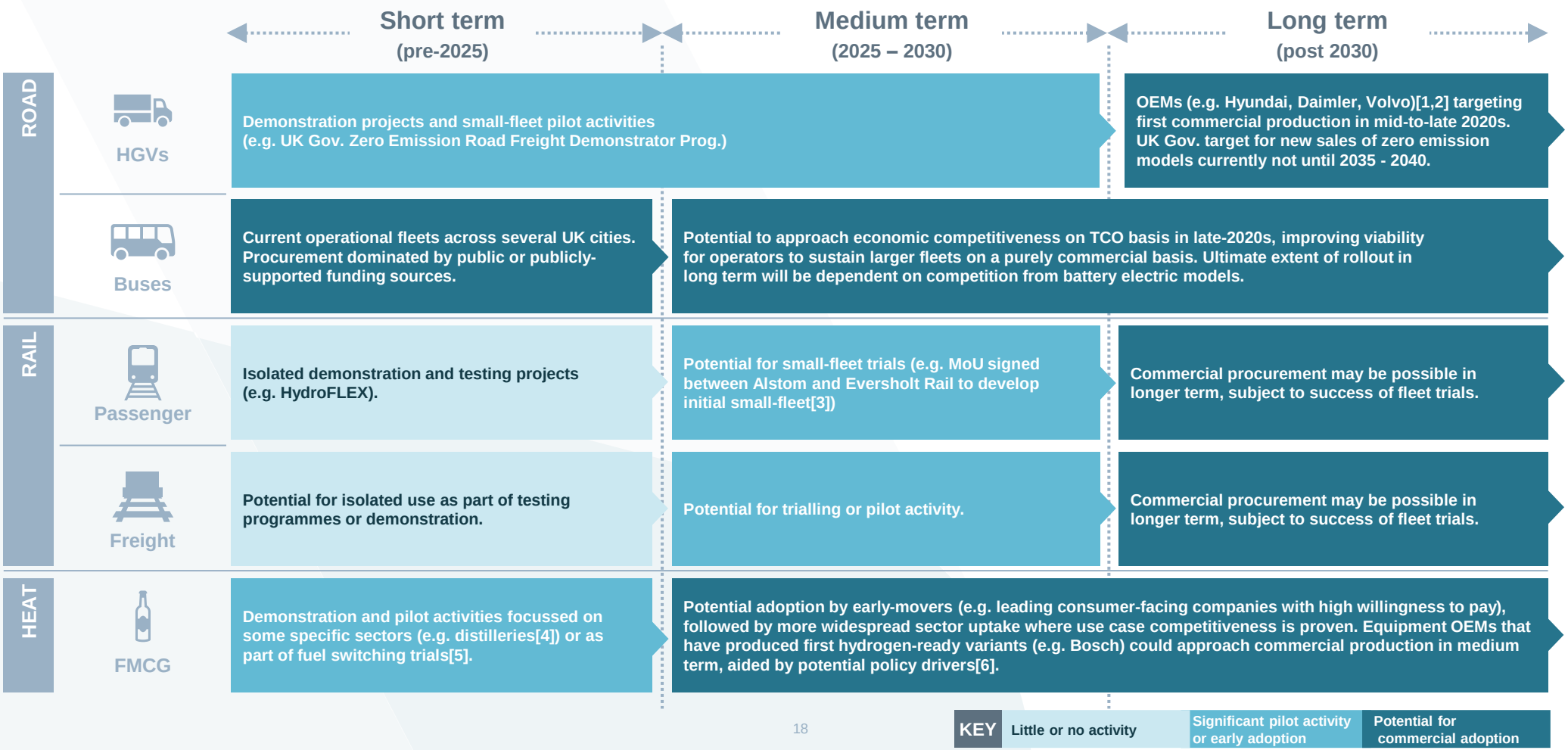
- Red diesel no longer able to be used for non-road mobile machinery.
- Red Diesel Replacement Competition (£40 million) to develop technologies switching red diesel to hydrogen or low carbon fuels.
- Biofuels from waste is likely the preferred option due to ease of switching/availability, but in longer term hydrogen may replace.
- Comparatively low volumes and limited major construction activity in local area other than Sizewell C and Lower Thames Crossing.

LOGISTICS (E.G. FORKLIFTS)



- Niche market has already been identified for hydrogen with commercially attractive options already available.
- Use of hydrogen forklifts already common without government support – as a consequence little available government policy.
- Hydrogen forklifts provide efficiency benefits over EVs, such as constant performance until fully drained, lower maintenance costs, and faster refuelling speed.

TIME TO MATURITY ASSESSMENT



TIME TO MATURITY ASSESSMENT

FreeportsHub

		Short term (pre-2025)	Medium term (2025 – 2030)	Long term (post 2030)
MARITIME	Port/offshore operations	Some potential for isolated low number early adoption of specialist vessels (e.g. Crew Transfer Vessels[7]). Isolated examples of shore-side demonstration activities.[8]	Potential for trialling or early adoption of equipment and vessels (e.g. similar initiatives to SHAPE UK project[9] or announced plans by Shoreham Port[10]).	Potential for ongoing commercial fleet replacement of specialist vessels (e.g. CTVs) and adoption of shore-side equipment subject to competitiveness.
	Ferries	Low number of small vessel showcase projects.	Potential for isolated demonstration projects or early adoption (e.g. HYSEAS III project[11]).	Adoption on commercial basis as part of fleet replacement may be possible in longer term.
	Shipping	Current research and demonstration activities are predominantly based internationally[12], with a few isolated initiatives supported by recent DfT funding[13].	Potential for pilot and trial programmes.	Prominent industry analyses suggest uptake of hydrogen-based fuels in the maritime sector expected from 2030[14][15]
OFF-HIGHWAY MACHINERY	Construction	Hydrogen combustion construction equipment under development by OEMs (e.g. JCB[16], Volvo[17], CMB.TECH [18]). Potential for isolated in-market trials in short term.	Potential for fleet trials and early adoption in medium term. Phase 2 of BEIS Red Diesel Replacement programme[19] finishes in 2025, which could accelerate options to market.	Potential for ongoing fleet replacement on commercial basis in longer term.
	Logistics	Some materials handling equipment (e.g. forklift trucks) commercially available. Adoption isolated in UK currently, but with potential to grow in the short term	Potential for increasing commercial adoption from medium term.	
FEED-STOCK	Fertiliser production	Low number of UK production sites with no clear publicly announced programmes for transition to green production. Some current activities exploring implementation of CCS[20].	Activities to transition current facilities to low carbon production (using either green or blue ammonia) could begin in medium term. Persistent challenges in natural gas markets could make blue adoption challenging. Some UK green NH3 production projects are expected to be operational in the medium term, although offtake uses are not yet clear.	

KEY: Little or no activity | Significant pilot activity or early adoption | Potential for commercial adoption

TASK 1
SUMMARY OF KEY FINDINGS

Further to the qualitative demand assessment framework and time to market maturity analysis, the 11 segments mentioned below were identified for detailed Task 2 demand mapping of specific offtakers, their infrastructure needs and their potential volumes.

We also received input from stakeholders that there is interest from a small scale refinery in Harwich, hence it was added to the list below. Another potential application put forward in the Freeport East region was around agricultural usage. Its been discounted in the report for further assessment in Task 2 as there is lack of clarity around UK policy and regulation pertaining to this sector . Also its needs detailed analysis of relevant Hydrogen handling and storage considerations which wasn't undertaken in this work.

Short term (pre-2025)	Medium term (2025 – 2030)	Long term (post 2030)
HGVs	Off-highway	Rail FOCs
Buses	Fertiliser	Port Ops
FMCG	Refinery	Shipping
		Ferries
		Rail TOCs

04

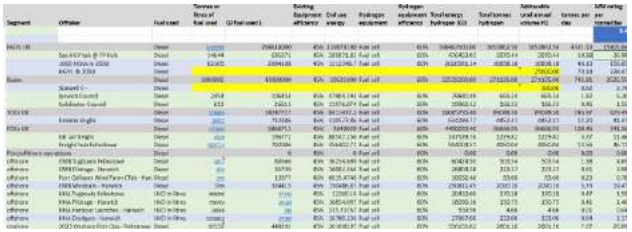
DEMAND MAPPING

TASK 2

FreeportsHub

OUR APPROACH

01
H2 Volume Assessment Model Build



02
Review of Local Industry Players

03
Energy Consumption Data Gathering

- **Desktop research of local & national industrial energy demand (e.g. DUKES)**
- **Bottom-up data from stakeholder interviews**

04
Modelling & Demand Mapping

05
Summary and Final Conclusions

→ **Identify pilot offtake opportunities for Task 3**

Due to the time constraints of the project, the stakeholder interviews were conducted after the initial volume assessment had been completed and were used to verify our models.

1. ***Repurposing, for the Freeport Area, our proprietary model*** for converting energy demand from various industrial and transportation requirements into hydrogen and electrolysis requirements.[23]..
2. ***Review of the key players within the 11 identified industrial segments*** by means of both desktop research, our internal databases and stakeholder engagement and interviews.
3. If available, ***bottom-up estimates of energy demand*** from potential local offtakers were obtained. In absence of this data, ***national data was gathered and scaled*** to the local area according to our model & the methodology on the next slide.
4. ***Volumes*** for each offtaker were ***plotted as heatmaps*** on the local area to identify clusters, aiding infrastructure definition.
5. Further analysis of the offtakers, volumes and time-to-market assessment from task 1 was completed to define ***3-4 use cases which could be deployed in the short term as pilot*** proof of concepts.

VOLUME SIZING METHODOLOGY

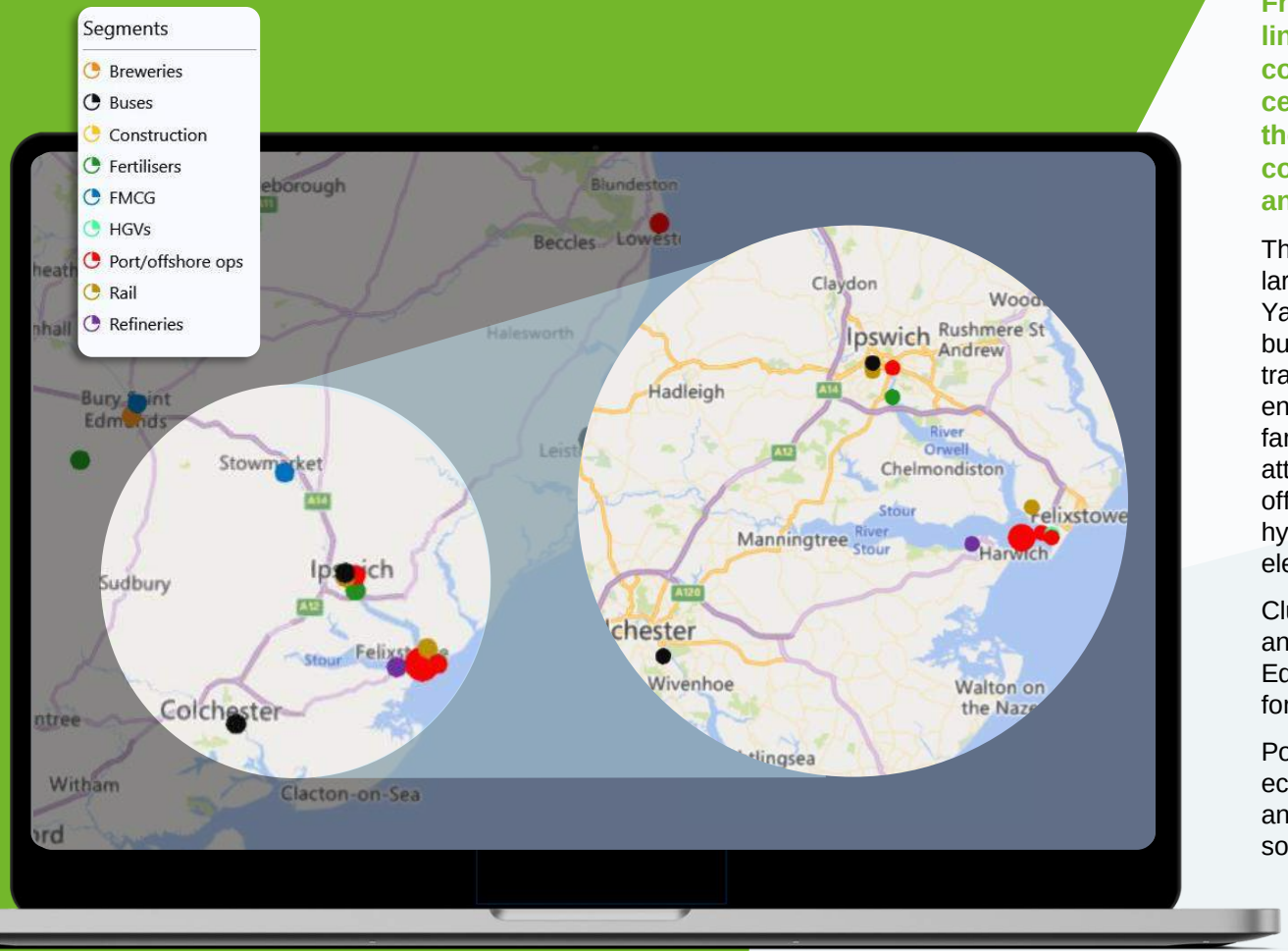
Offtakers were identified through desktop research, government statistics and stakeholder interviews.

Following this identification, volumes in local areas were estimated for each offtaker using the various methods stated below. Where available, these estimates have been corroborated with data from regional stakeholders.

Data sources are in section 08.

Segment	Method	Volume sizing methodology
Port/offshore operations	**Data from Freeport E**	Hutchison Port's onshore vehicles diesel consumption obtained [42] and converted to hydrogen using our standard conversion model. For seaborne vessels we found typical fuel consumption for tugboats, CTVs and wind farm service vessels [33] [34] and estimated their annual diesel usage based on service life of their engines [35]. These numbers were then verified with reported HVO usage in 2022 [43] for the lower end of the estimate presented in this report.
HGVs	**Scaled from national data**	List of licensed HGV operators & number of vehicles with those operating in the Freeport area located to estimate ratio of Freeport HGVs relative to national. This ratio used to scale National HGV fuel consumption figures [21] and forecasted conversion to h2 by 2030 [22] to estimate Freeport HGV h2 volumes.
Buses	**Scaled from national data**	Bus national fuel consumption figures [30] used and scaled to Freeports area by taking ratio of buses operated by Ipswich and Colchester[31], to the national bus stock published[32], arriving at a local diesel consumption for buses, which was then converted to hydrogen using our standard conversion.
Rail	**Data from Freeport E**	For passenger rail, national diesel consumption for rail found [27], and scaled to Freeports area by finding the ratio of rolling stock operated by Greater Anglia [28], which is then converted to hydrogen using our standard conversion model. A similar method was used for freight rail, based on the ratio of freight movements out of the port (provided by Freeports East team) compared to publicly available national freight movements and fuel consumption data to scale. [27] Verified by GB railfreight data, one of three operators[44]
Off-highway machinery	**Bottom-up estimate**	EDF confirmed SZC construction machinery requirements are similar to HPC. Construction for HPC was found from a 3rd party source to use 5mn litres of red diesel per annum[47]
FMCG	**Hybrid**	Total number of breweries and ratio of Freeport area breweries found.[24] Energy consumption of brewing sector determined nationally and aforementioned ratio used to scale this energy figure for industry in local area, then this aggregated value was split evenly amongst the 118 small local breweries. For sugar processing, sugar input/output for Bury St Edmunds plant found [36], then relationship for heat energy input per tn of output obtained from technical literature[37], this energy then converted to h2 using standard conversion. For Muntons malt, UK heat energy requirements published[41] and converted into h2 by standard conversion (halved due to unknown split between 2 UK sites).
Refineries	**Data from Freeport E**	Haltermann Carless is the only site. Its natural gas energy consumption was estimated via Freeport East. This was converted according to typical hydrogen incineration efficiency [23] to an equivalent tonnes of h2 per day to deliver same amount of energy to the site.
Fertiliser	**Bottom-up estimate**	Fertiliser output in tonnes for specific site in our proprietary database used to create ratio of size to output for all other sites. With output determined, electricity input was calculated as 36GJ/tonne fertiliser, from this and using typical electrolyser efficiencies, hydrogen input could be determined. [42 & 43]
Ferries & Shipping	**Qualitative**	A qualitative assessment of volumes owing to the uncertainties around use of fuels, the long term nature of the solutions, and the different derivatives that could be used.

SEGMENTATION MAPPING



Freeport East is located at a nexus between transport links via ship to the rest of the world and to the A14 corridor leading to major population and industrial centres in the UK. At its heart is the port of Felixstowe, the UK's busiest container port, handling over 4mn containers (TEUs) per year, with numerous short term and long term hydrogen offtake opportunities. [61]

The coastline across the region contains several other ports, the largest of which are Great Yarmouth, Harwich and Ipswich. Great Yarmouth and Ipswich predominantly handle liquid bulk and dry bulk cargo, while Harwich serves larger volumes of roll-on/roll-off traffic. Ports in the region also serve as a base for vessels engaged in offshore commercial operations (e.g. offshore wind farm access). This includes crew transfer vessel (CTV) fleets, an attractive use case for hydrogen. On the production side, planned offshore wind and nuclear assets could facilitate low carbon hydrogen production by providing access to plentiful green electricity.

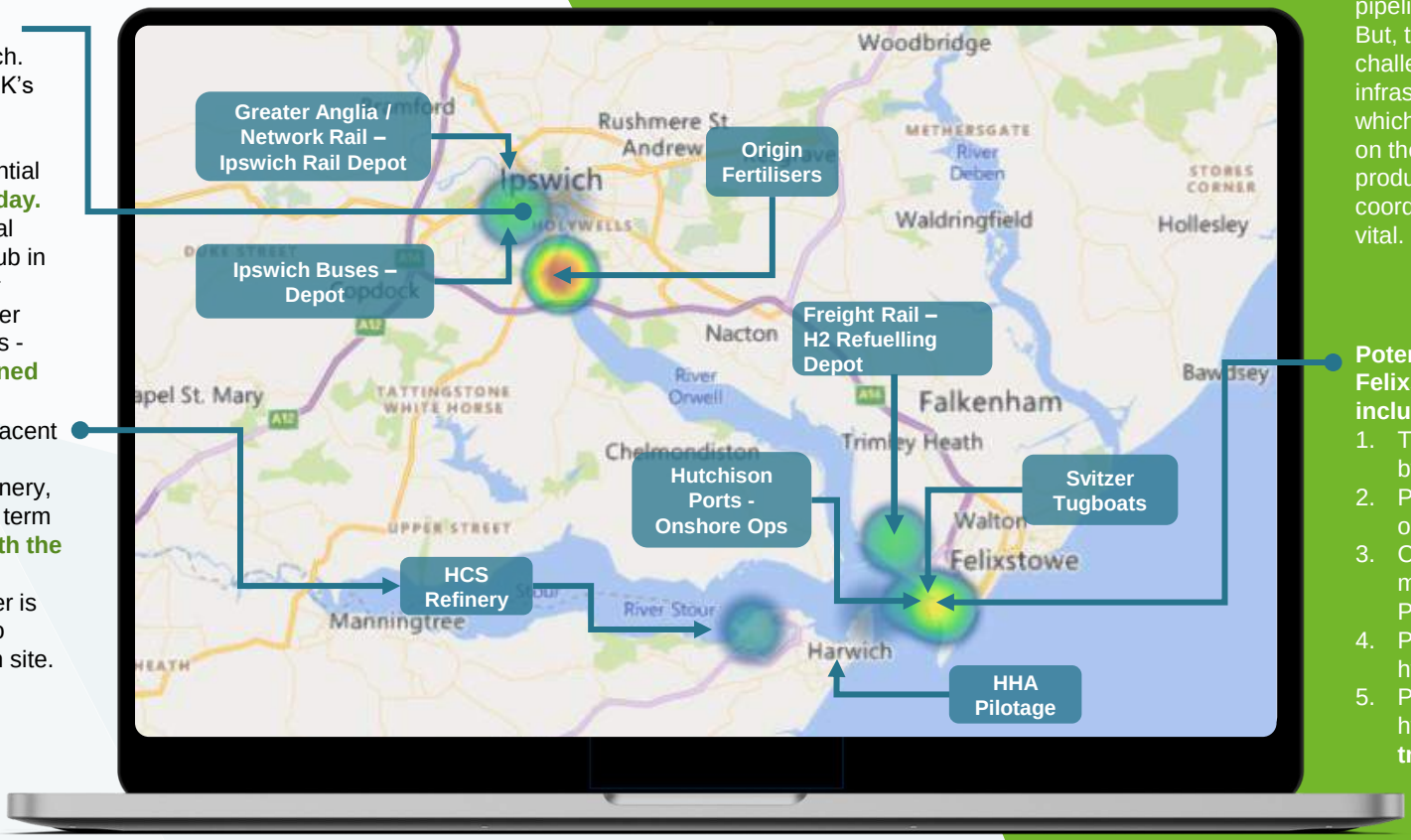
Clusters of potential offtakers exist in the corridor from Felixstowe and Harwich, through Ipswich and along the A14 to Bury St. Edmunds. Further afield there are opportunities at Sizewell C and for integration with the growing wind economy off the East coast.

Port operations form the core of future hydrogen demand in the economic area. Refineries, fertiliser producers, food producers, and transport operators (HGVs, trains and buses) are other likely sources of demand.

POTENTIAL OFFTAKER VOLUMES MAPPING – FREEPORT AREA

There are two potential major offtakers in Ipswich. The first, is one of the UK's three major fertiliser manufacturers: Origin Fertilisers. It has a potential demand of **up to 38 tn/day.** The second is a potential multi-modal refuelling hub in the centre of Ipswich for Greater Anglia passenger trains and Ipswich buses - **Up to 12 tn/day combined**

A large sole offtaker adjacent to Harwich port is the Haltermann Carless refinery, which could in the short term require **c. 7 tns/day, with the potential for future expansion.** The offtaker is also exploring options to install an electrolyser on site.



In the long term, installation of pipelines is more economical than delivery by tube trailer. Due to the proximity and stakeholder characteristics, the demand within the economic area could be served by dedicated hydrogen pipelines, storage & refuelling facilities. But, there are long-standing regional challenges concerning gas infrastructure as well as water scarcity which will have a unfavourable impact on the local rollout of hydrogen production and distribution. A coordinated cross-sector approach is vital.

Potential offtakers within the port of Felixstowe and Harwich compound include :

1. Tugboats at Felixstowe operated by Svitzer – **c. 1.5 tns/day**
2. Pilotage vessels at Harwich operated by HHA – **c. 0.6 tns/day**
3. Container handling mobile machinery operated by Hutchison Ports – **up to 8 tns/day**
4. Potential refuelling hub for hydrogen HGVs – **10-70 tns/day**
5. Potential refuelling hub for hydrogen freight rail – **c. 14 tns/day**

OFFTAKER POTENTIAL VOLUMES MAPPING – WIDER REGION

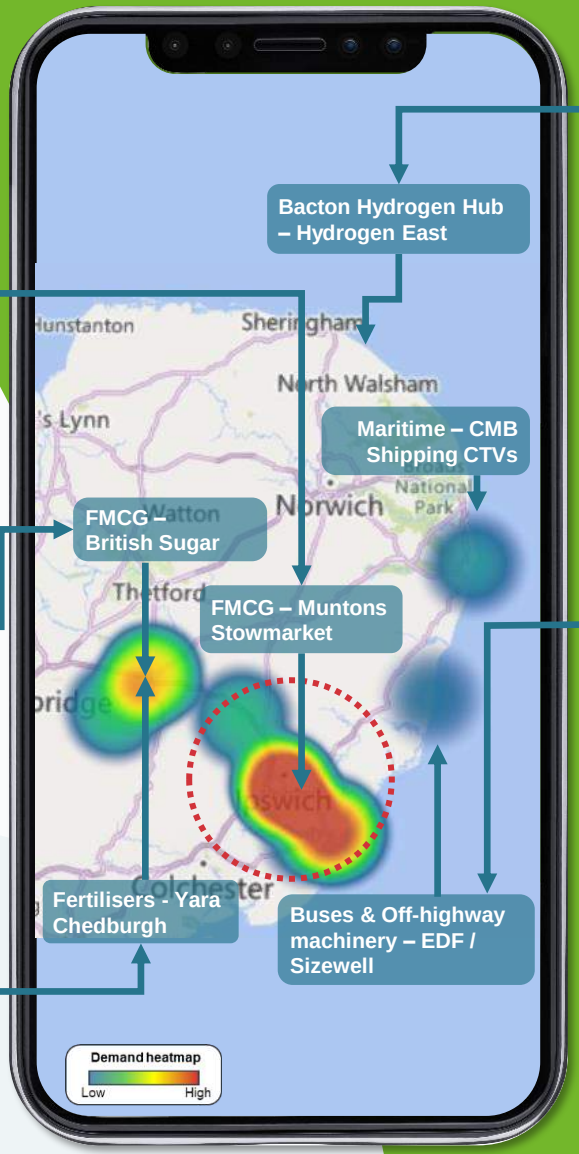
In Nuclear, we are focussing on what we access to – Primary Heat. We see ourselves firstly as potential consumers of Hydrogen during construction. We are investigating the most effective use cases of our heat resource once nuclear generation is underway

Energy transition financing & regulation manager of a nuclear project developer

Muntons malt processors, like British Sugar, have a significant heat requirement for their food processing. **Est. 9 tns/day.** In 2021, they installed a 14MW biomass boiler to provide their heat requirements. Deliveries by tube trailer to Muntons and British Sugar could potentially require 10-35 trucks per day, so a pipeline should be considered if projected volumes can be realised.[53]

British Sugar are enacting plans to decarbonise by using by-products of sugar beet to power CHP engines to supply renewable energy to the grid.[36] For sugar processing, large quantities of heat are required to boil water for the refining process, this is currently provided by natural gas boilers. If replaced with hydrogen, potential demand up to **c. 23 tns/day** exists.

Potential demand from Yara fertiliser manufacturers near Bury St. Edmunds. Based on PA modelling, there could be a requirement of **c. 11 tns/day** of hydrogen as a drop-in replacement for fertiliser feedstock.



Hydrogen East, an industry body, is very active to the north of Freeports East, where it plans to develop a hydrogen hub at Bacton. Here there could be export opportunities. This hub is planned to tie into the local region at East down to Freeport East. There is an opportunity for synergies, particularly on pipeline infrastructure connecting into the wider network and to Europe. Infrastructure, (pipelines, roads and commercial land) is lacking across the region & could be a growth barrier.[51][52]

Potential demand hub at Sizewell C construction site. Potential demand for off-highway machinery used for construction activities. There is also likely to be a need for private shuttle hydrogen buses for the workforce over the proposed 10yr+ construction period **(1.6 tns/day).**

CMB Shipping operate circa 50 WindCat servicing vessels across the North Sea, many based in Lowestoft & Great Yarmouth. They want to switch these immediately to hydrogen dual fuel engines but are unable to do so due to a lack of hydrogen available locally.[49] Modelling suggests up to **6 tns/day** would be required.

RESULTS OF DEMAND MODELLING
INDUSTRY

Total potential demand across all industrial segments in:
- **Short term (up to 2030) – circa 100 tns / day**
- **Long term (Beyond 2030) – circa 140 tns/day**

S: Storage; **P**: Pipeline; **D**: Derivative Processing; **T**: Trailer ; **t/d**: Tonnes/day

Segment	Timeline	Demand spread	No. of potential offtakers	Potential Volumes t/d	Likely Infrastructure				Key Offtakers and Insights
					S	P	D	T	
FMCG	Short	Dispersed	>100	32-49	✓			✓	British Sugar at Bury St Edmunds & Muntons Malt manufacturers at Stowmarket are largest offtakers. Additionally there is dispersed demand from Greene King Brewery, along with over 100 local smaller breweries in the area.
Fertilisers	Mid	Dispersed	2	49	✓		✓	✓	Origin Fertilisers in Ipswich. Further afield there is the Yara fertiliser plant at Chedburgh. Depending on offtaker needs, h2 could be supplied in raw form or as ammonia
Refineries	Mid	Sole offtaker	1	7		✓			Haltermann Carless (HCS) at Harwich would be the sole offtaker. Short term possibility of fuel switching from natural gas to hydrogen for existing processes, and this could scale up in line with HCS expansion opportunities
Off-Highway Machinery	Mid	Hybrid	1-3	3-9	✓	✓		✓	Major mega-size construction projects such as Sizewell C (SZC) and Lower Thames Crossing (LTC). Using Hinkley Point C as a yardstick[47], each large site may require high volumes during peak phases, however demand will be transient and ramp up and down according to a bell curve, with SZC ending c. 2034 and LTC c. 2031. Other mid-size projects e.g. Bathside Bay, Felixstowe Tax Site Development could also possibly drive demand in the region.

Due to longer term uncertainties in terms of offtakers and hydrogen distribution infrastructure, we have mostly included a range of potential volumes per segment. The lower figure typically represents volumes that are potentially achievable in the next few years as the technology exists and we have verified with Freeport East and stakeholders that there is hydrogen demand. The upper estimates tend to be uncertain and dependent on the choices of stakeholders further down the value chain and further into the future.

RESULTS OF DEMAND MODELLING
TRANSPORT

Total potential demand across all transport segments in:
- **Short term (Up to 2030) – circa 42 tns/day**
- **Long term (Beyond 2030) – circa 135 tns/day**

S: Storage; **P**: Pipeline; **D**: Derivative Processing; **T**: Trailer ; **t/d**: Tonnes/day

Segment	Timeline	Demand spread	No. of potential offtakers	Volume range t/d	Infrastructure				Key Offtakers and Insights
					S	P	D	T	
Ferries & Shipping	**Mid-to-long**	**Hubs**	>2	See comments	✓	✓	✓		Harwich Ferry (local) and Stena Line (Int'l ferries) - 4 daily sailings to Holland. [29] We have assessed this demand qualitatively due to the uncertainties surrounding the use of derivative fuels
Port / offshore operations	**Short-Mid**	**Hubs**	3	13-35	✓	✓	✓		Within the port there are 250 industrial tractors and other off road mobile machinery. For seaborne operations there are 6 tugboats, 4 pilotage and 4 harbour launches, 1 dredger, and 2 wind farm service vessels. [42][43]
Rail – TOCs	**Long**	**Hubs**	1	<12	✓			✓	Greater Anglia. There is a diesel refuelling hub at Ipswich station.[46] The estimate assumes a proportion of trains up to Norwich along difficult-to-electrify lines[25] will refuel with h2 at the Ipswich rail depot.
Rail – FOCs	**Long**	**Hubs**	3	3-14	✓	✓			Most freight routes are via London or Ely & Peterborough to electrified mainlines. There are 3 main operators, including GB railfreight. Freight operators may choose to decarbonise by switching existing diesel electric locomotives to Hydrogen electric ahead of planned electrification.
HGVs	**Short-Mid**	**Hubs**	>35	10-70	✓	✓		✓	Due to the nature of traffic flows to ports, it is sensible to take a refuelling hub approach. There would be over 35 major HGV offtakers and many more minor ones. By 2050 up to 70 t/d[59] is possible, but the most conservative short term estimates [22] indicate >10 t/d. For context, the diesel sales of one major HGV fuel retailer, Keyfuels, is equivalent to c. 17 tns/day of hydrogen.
Buses	**Short**	**Hybrid**	3	3.5	✓	✓		✓	The main potential offtakers could be Arriva Colchester, Ipswich Buses and the SZC site.

SHIPPING & FERRIES – QUALITATIVE ASSESSMENT

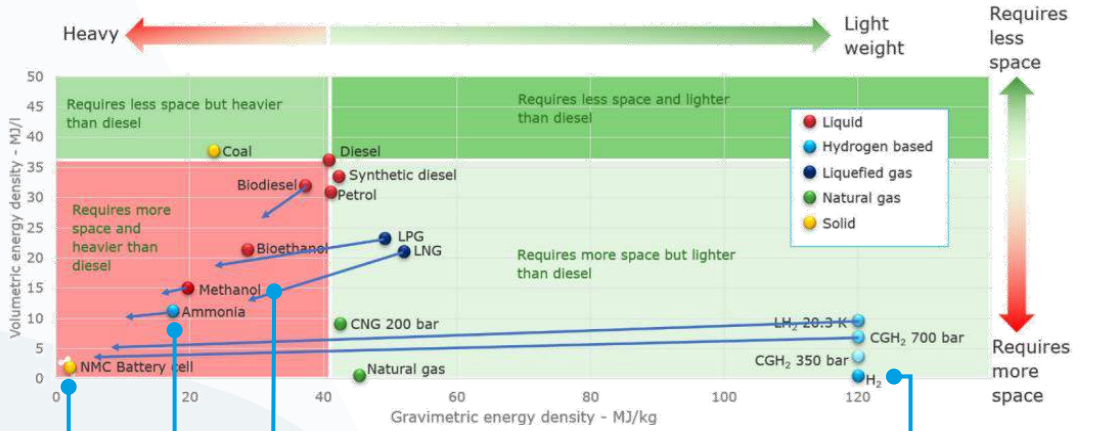
These segments will require a hydrogen derivative in most cases. Quantitative volume assessment is difficult due to the many uncertainties around the development of renewable derivative fuel production and needs a deep dive study.

We have assessed the potential opportunities qualitatively from our own knowledge base, desktop research, & stakeholder interviews. Technology deployment for decarbonisation of shipping is uncertain. Four potential technologies are assessed in the table below. [50] Analysis commissioned by the Department for Transport (DfT) estimated that by 2050 there could be 75-95 TWh of demand for hydrogen-based fuels (principally in the form of ammonia) from UK domestic and international shipping. [58] [59]

50-300 tns/day — Typical **diesel fuel used per day** by a large container ship [49][54][55]

Scale of shipping volume potential is huge, far beyond any other segment**.** The graph below shows that a single ship powered by **ammonia or methanol would require twice as much fuel as a diesel** counterpart.

Graph of power-to-density vs. power-to-volume [57]



Electric (LOW)
- Cost effective, easily deployable technology.
- Very poor energy density, very poor range

Ammonia (HIGH)
- Ease & speed of refuelling, handling technologies.
- Large capital investment, energy intensive, safety concerns

Methanol (HIGH)
- Simple technology conversion, seen as safer than other derivatives.
- Poor energy density, low availability, large capital investment, fire risk

Hydrogen (MID)
- Very high energy density, ease & speed of refuelling, fuel cell compatible.
- Very poor energy-to-volume expensive, safety issues

TASK 2
SUMMARY OF KEY FINDINGS

Potential offtaker volumes of 140 tonnes per day of hydrogen by 2030

- Large potential early offtakers include the HCS refinery, HHA, Hutchison Port's off & onshore port operations, SZC & British Sugar
- Post-2030, technology development becomes uncertain; there may be sizable volumes (>100 tns/day) needed by HGVs especially given the large number of movements in and out of the regional ports. But there is competition from other technologies, e.g. electrification. Shipping fuels in the form of derivatives such as ammonia could drive huge demand, as emphasis on decarbonising deep-sea shipping sector gathers momentum.

Demand equivalent to approximately 550MW* of electrolysis installed capacity by 2030 in the Freeport East region.

- Basic calculation of electrolysis capacity required based on aggregated local demand and assumptions*. Post-2030, significantly more capacity may be needed, depending on how hydrogen will develop as a decarbonisation solution in the region, particularly for Shipping and HGV applications.
- For context, the present UK national target for Green hydrogen production is 5GW of installed capacity by 2030.

Offtakers are hub-based within the Freeport & dispersed beyond. Infrastructure barriers exist for both

- Hydrogen demand hubs will emerge within the ports for refuelling of port operations and goods transport vehicles entering site – HGVs & Rail.
- Further afield offtakers such as the various FMCG sites, SZC etc. are more dispersed and would require different storage & transport solutions
- Infrastructure is limited both within the economic zone and in Eastern England. Strong demand needed to drive infrastructure development.

Pilot projects must prove demand potential and look to solve infrastructure challenges

- Any demonstrator must prove that the identified demand from task 2 can be served in terms of volumes & refuelling infrastructure. Offtakers must have technology that is sufficiently mature to allow proofing of the concept.
- In section 05 we propose 4 pilots testing different parts of the value chain to test solutions for the infrastructure challenges and offtake segments.

* This number is to be used as a yardstick only and is based upon current electrolyser efficiencies of 70% and assumes a dedicated offshore wind resource powering the electrolysers at 60% availability, to achieve low carbon hydrogen.

05

POTENTIAL PILOT PROJECTS

TASK 3

FreeportsHub

SUMMARY OF PROPOSED PILOTS

PILOT 1
HGV & PORT OPS REFUELLING HUB AT FELIXSTOWE

Proves concept of multi-modal handling and refuelling

PILOT 1A
ADDITIONAL MARITIME REFUELLING HUB AT FELIXSTOWE

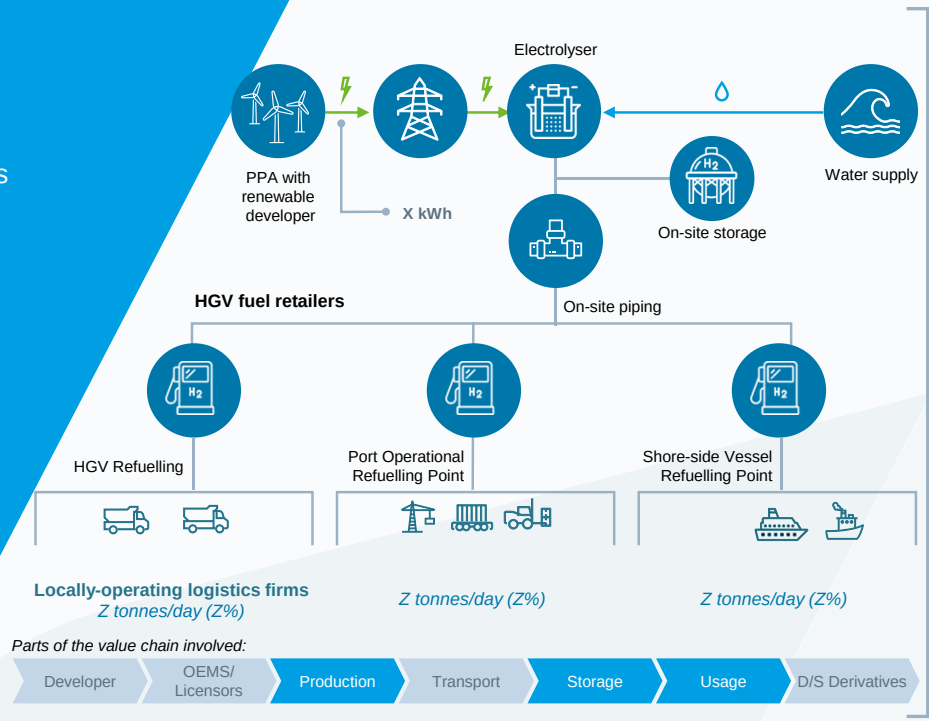
PROVES CONCEPT OF Multi-modal refuelling of various sizes of vessels: CTVs, tugboats, service vessels etc.

PILOT 2
PRODUCTION AND DELIVERY TO DEDICATED INDUSTRY WITHIN FREEPORT AREA

Proves concept of delivery to a dedicated local external offtaker via pipeline infrastructure

PILOT 3
PRODUCTION AT PORT AND DELIVERY VIA TUBE TRAILER TO AN OFFSITE OFFTAKER

Proves concept of storage at production & offtake sites, along with tube trailer deliveries offsite



Types & Names of Organisations

Value Chain Mapping (Type of Partnership)

Funding Sources Available

*Diagram is illustrative only of the opportunity, but the specific elements need to be scoped in more detail following further studies

PILOT 1
HGV & PORT OPS REFUELLING HUB AT FELIXSTOWE

WHAT IS IT?

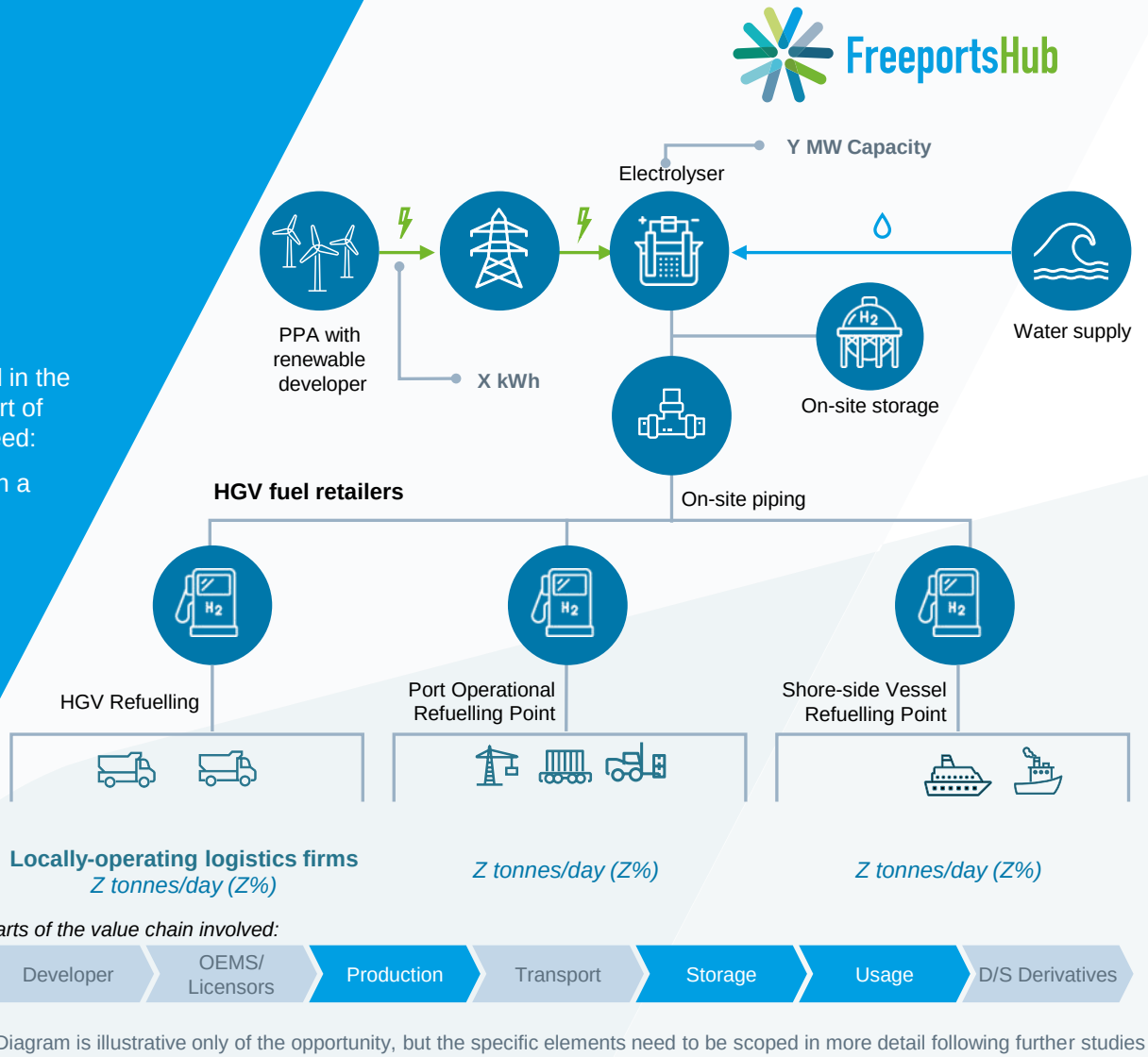
This pilot would test the concept of multi-modal handling and refuelling

The pilot would work as follows:

Demonstrator for small volumes for HGV and port refuelling. First of a kind in the UK. Consisting of an electrolyser based at a suitable location within the port of Felixstowe feeding a storage tank with on-site pipework infrastructure to feed:

- Land based HGV refuelling point potentially operated in partnership with a fuel retailer organisation.
  - HGV OEMs, along with a HGV operator looking to decarbonise should be sought as a partner for the ultimate end users. OEMs could be engaged to reach HGV operator market, as they offer a turnkey service.
- Land based port operational vehicle refuelling point – covering various port vehicles operated by Felixstowe Port: industrial tractors, RTGCs, forklifts etc.

Typical PEM electrolyser stacks are 2MW generating circa 30kg /hour of hydrogen.[56] The next step would be to adequately scope this pilot to size the various elements (X, Y and Z on diagram) based on potential partner offtakers demand at a pilot scale.



PILOT 1A
ADDITIONAL MARITIME REFUELLING HUB AT FELIXSTOWE

WHAT IS IT?

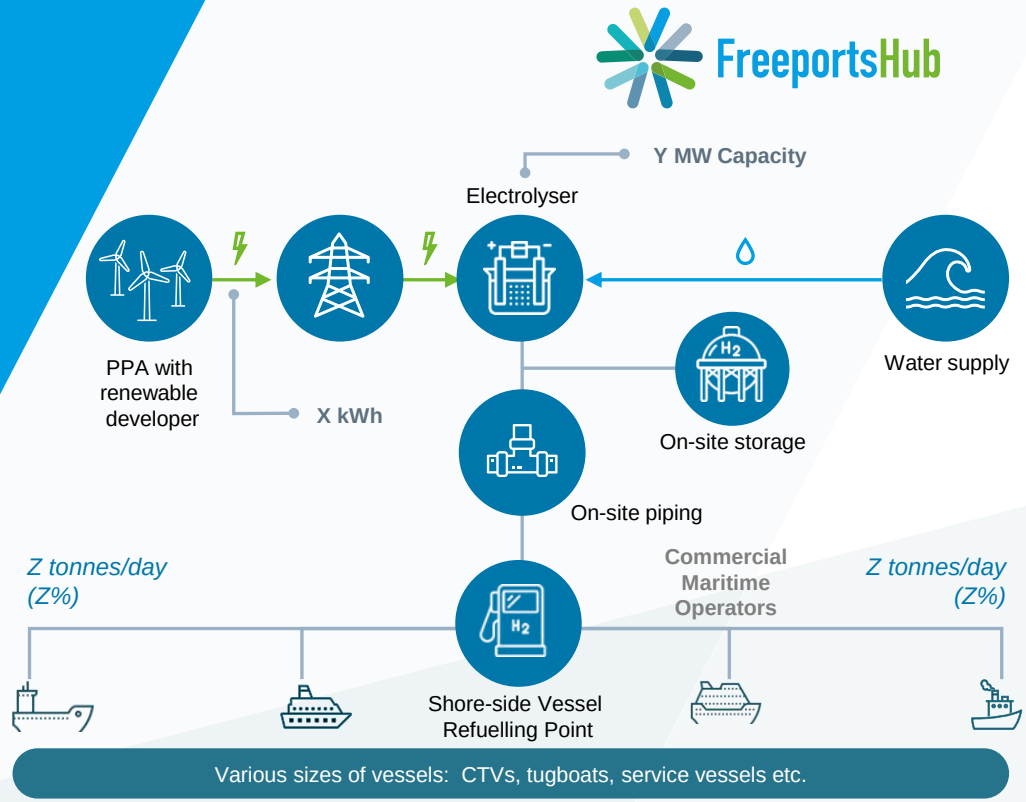
This pilot would test the concept of multi-modal refuelling of various sizes of vessels: CTVs, tugboats, service vessels etc.

The pilot would work as follows:

This pilot is a variation of the previous pilot with additional shore-side refuelling for the tugboats operated out of Felixstowe port. It could be a standalone pilot, (shore-side refuelling of tugboats only) or fully multi-modal, with HGV and land based port operational machinery.

Pilotage vessels and CTVs are operated out of Harwich so inclusion of these in the pilot would require a delivery of hydrogen from Felixstowe, most likely by road.

Typical PEM electrolyser stacks are 2MW generating circa 30kg/hour of hydrogen.[56] The next step would be to adequately scope this pilot to size the various elements (X, Y and Z on diagram) based on potential partner offtakers demand at a pilot scale.



Potential Sites / Partners / Sectors

Primary:

- Tugboat /vessel operator – Felixstowe Port

Parts of the value chain involved:

Developer | OEMS/ Licensors | Production | Transport | Storage | Usage | D/S Derivatives

*Diagram is illustrative only of the opportunity, but the specific elements need to be scoped in more detail following further studies

PILOT 2
PRODUCTION AND DELIVERY TO DEDICATED INDUSTRY WITHIN FREEPORT AREA

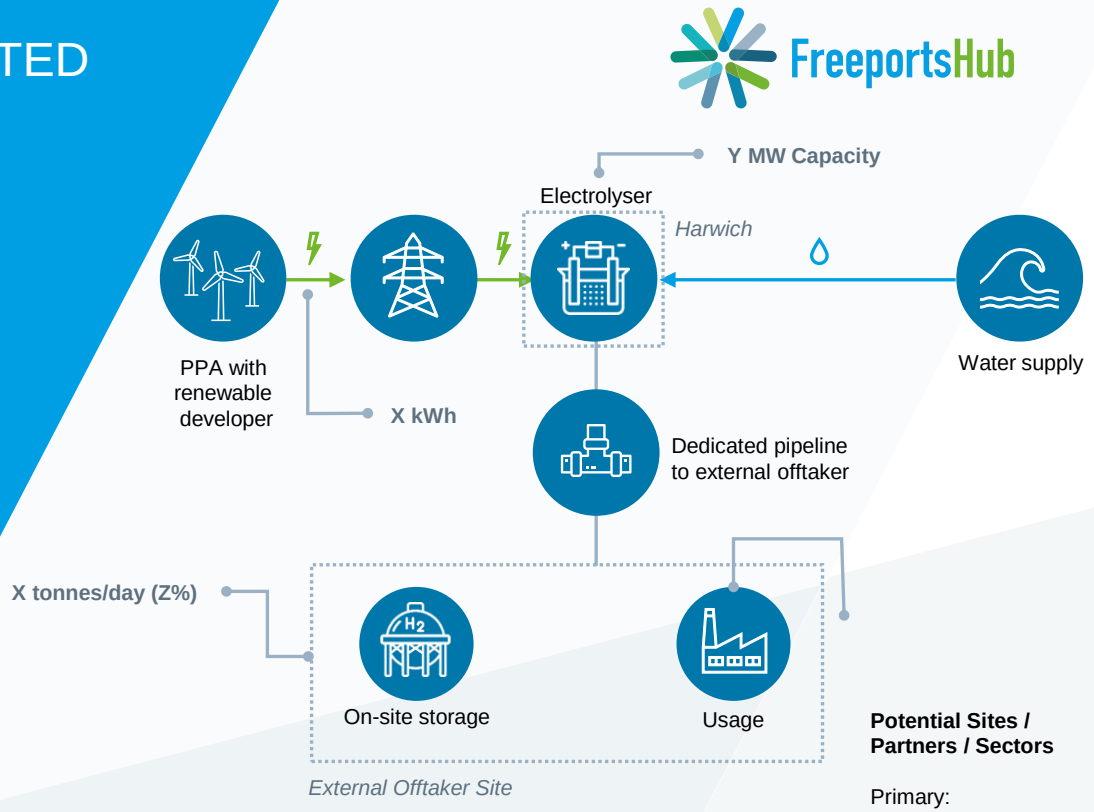
WHAT IS IT?

This pilot would test the concept of delivery to a dedicated local external offtaker via pipeline infrastructure

The pilot would work as follows:

Dedicated electrolyser for a sole offtaker within Freeport: Most attractive option is the Haltermann Carless (HCS) Refinery, immediately adjacent to Harwich ferry terminal – allowing for a short pipeline feed from a nearby production site. HCS have two footprints of land within their current site where an electrolyser could be installed. Pipework could be installed to points of use within the site, with optional storage if the use case requires it.

Typical PEM electrolyser stacks are 2MW generating circa 30kg/hour of hydrogen.[56] The next step would be to adequately scope this pilot to size the various elements (X, Y and Z on diagram) based on potential partner offtakers demand at a pilot scale.



Parts of the value chain involved:

Developer | OEMS/ Licensors | Production | Transport | Storage | Usage | D/S Derivatives

*Diagram is illustrative only of the opportunity, but the specific elements need to be scoped in more detail following further studies

PILOT 3
PRODUCTION AT PORT AND DELIVERY VIA TUBE TRAILER TO AN OFFSITE OFFTAKER

WHAT IS IT?

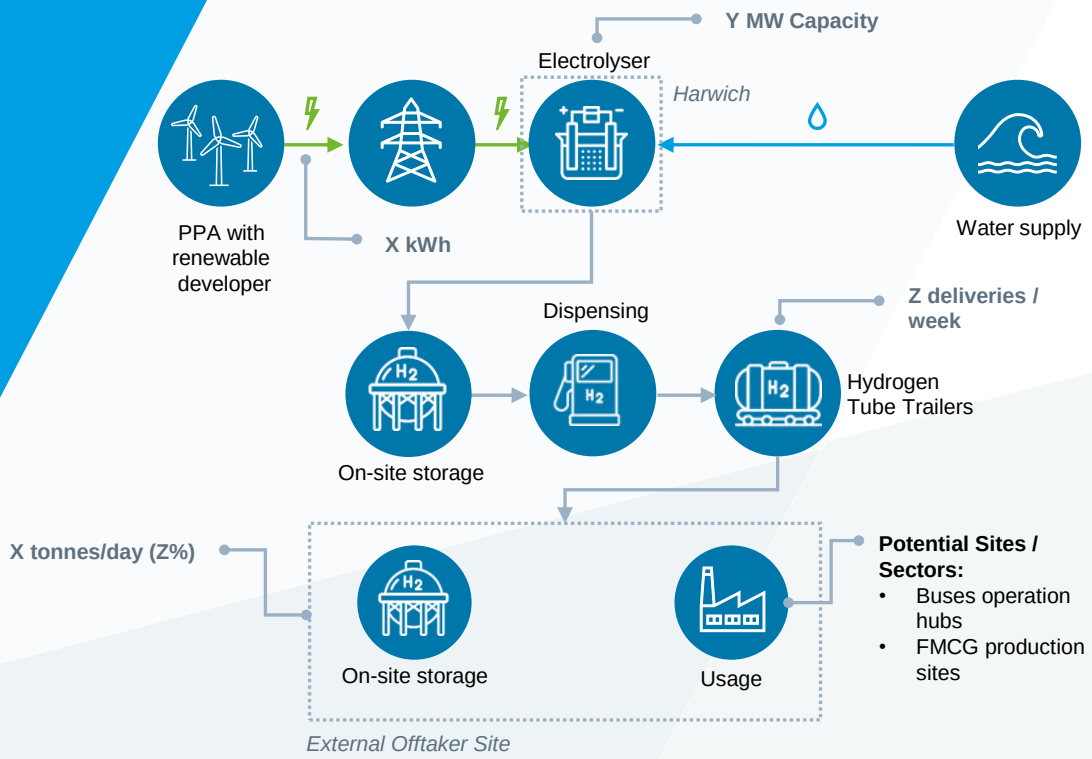
This pilot would test the concept of storage at production & offtake sites, along with tube trailer deliveries

The pilot would work as follows:

Production on port premises via electrolyser. Storage infrastructure required, with filling of tube trailers for delivery to a storage and/or refuelling hub, e.g. local bus depots. Alternative suitable offtakers in the shorter term could be organisations across the FMCG sectors in the region. Road transport of hydrogen will be the key aspect of this pilot so offtakers with suitable road links should be investigated and targeted for partnerships for a pilot.

Typical PEM electrolyser stacks are 2MW generating circa 30kg/hour of hydrogen.[56] The next step would be to adequately scope this pilot to size the various elements (A, X, Y and Z on diagram) based on potential partner offtakers demand at a pilot scale.

FreeportsHub



Parts of the value chain involved:

Developer | OEMS/ Licensors | Production | Transport | Storage | Usage | D/S Derivatives

*Diagram is illustrative only of the opportunity, but the specific elements need to be scoped in more detail following further studies

06

CONCLUSIONS

FreeportsHub

CONCLUSIONS

TASK 1 – OFFTAKE SEGMENTATION

Our initial segment analysis and time to maturity assessment found the following opportunities in the Freeport East Area:

- **Pre-2025:** HGVs, Buses and FMCG.
- **2025-2030**: Fertiliser production, Refining, Off-highway machinery.
- **Post 2030**: Shipping, Ferries, Port operations, Freight and passenger rail.

TASK 3 - PILOT PROJECTS

- **Four pilots** have been proposed for engagement with industry, **covering segments such as HGVs, buses, port operations, refining and rail.**
- Each of the proposed pilots attempts to address a separate challenge and prove a particular concept:
  - Multi-modal refuelling within the port of Felixstowe
  - Pipeline & storage infrastructure for a dedicated local offtaker
  - Delivery via tube trailer to a dispersed offtaker/s

TASK 2 – DEMAND MAPPING

- Potential **local hydrogen demand up to circa 140 tonnes per day** could exist **by 2030.**
- Large potential offtakers include the HCS refinery, HHA, Hutchison Ports' off & onshore port operations & British Sugar
- A very high level calculation suggests **c. 550MW of installed electrolyser capacity required to service this estimated demand.**
- **Beyond 2030**, we see **potential for circa. 135 tns/day from transport and 140 tns/day from industry segments.** Transport activities around the port area i.e. HGVs switching from diesel and potential opportunities emerging in the rail sector could drive demand.
- Shipping is the great unknown at this stage but the volume potential is huge, and could significantly increase the potential figures presented in this report. **Shipping fuels in the form of hydrogen derivatives such as ammonia could drive huge demand** as emphasis on decarbonising deep-sea shipping sector gathers momentum.
- **Key challenges exist around pipeline infrastructure.** These need to be addressed as part of a wider coordinated transition to Hydrogen, especially with the proposed Blue Hydrogen Hub in the Bacton Terminal Area and National Gas Project Union which is looking to build a national Hydrogen pipeline backbone connecting the major industrial clusters around the UK, including connections into the Bacton terminal.

07

NEXT STEPS

FreeportsHub

RECOMMENDED NEXT STEPS

PILOT PROJECTS:

1. Engage with potential pilot project stakeholders to determine interest in a partnership to develop pilot projects.
2. Gather data from interested parties to assess the scale of demand they would require from a pilot.
3. Scope pilot projects to further detail, including electrolyser sizing in MW, electrolyser technology, delivery mechanism and frequency (tube trailer deliveries per week, pipework infrastructure sizing), green electricity volumes, specific offtake volumes per partner offtaker, LCOH and techno-econometric modelling, identify HSE considerations and skills gaps (list not exhaustive)..
4. Identify funding schemes and mechanisms with strategic fit and initiate application for funding, if applicable.

SHIPPING VOLUME POTENTIAL:

1. Given Felixstowe is the UK's busiest container port. Initiating a deep dive study on potential shipping volumes for hydrogen and derivatives would prove beneficial to engage relevant stakeholders and attract inward investment opportunities.
2. Based on the scale and significance of Felixstowe as the UK's leading deep sea container port, engagement with European ports on possible green corridor considerations to support shipping industry planning and the Clydebank Declaration.

LOCALISED DISPERSED HUBS:

1. Undertake more detailed location-specific analysis on demand to support built out smaller, dispersed hubs

ENGAGE AGRICULTURAL SECTOR:

1. Initiate engagement in the agricultural sector to raise awareness and explore the potential for hydrogen switching given the significance of that sector to immediate hinterland" within the region

Note: The above steps have been jointly developed in consultation with the Freeport East Team

08

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09

APPENDIX

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HYDROGEN IN THE UK
LOW CARBON HYDROGEN PRODUCTION RELATED FUNDS

	Net Zero Hydrogen Fund (NZHF)		NZHF & Hydrogen Business Model[*]	
	Strand 1	**Strand 2**	**Strand 3 (Proposed)**	**Strand 4**
Aim	Support development of new low carbon hydrogen production to grow the pipeline of projects in the UK.	Support low carbon hydrogen projects to take FID and begin deployment in the early 2020s, kickstarting the hydrogen economy.	Support electrolytic hydrogen projects to take FID and deploy at scale at the earliest opportunity	Support for CCUS enabled hydrogen projects. Must be able to connect to Track-1 clusters, as part of cluster sequencing
Activity	FEED and post-FEED costs	Permanent deployment	Permanent deployment	Permanent deployment
Funding	DEVEX grant 50% co-funding for FEED and post-FEED studies, Grant awards of £80k–£15m	CAPEX grant 30% co-funding, Grant awards of £200k–£30m[**]	CAPEX grant co-funding and ongoing revenue support via the hydrogen business model	CAPEX grant co-funding and ongoing revenue support via the hydrogen business model
Maturity	TRL 7+			
Location	UK Wide			
Scope	Low carbon hydrogen generation	Low carbon hydrogen generation	Low carbon hydrogen generation via electrolysis	CCUS enabled low carbon hydrogen generation
Application Window	Mar-Jun ’23 (Window 2 – TBC)	Mar-Jun ’23 (Window 2 – TBC)	Mar-Jun ’23 (Window 2 – TBC)	Jun-Dec’23 (TBC)
Anticipated Award	2023	2023	2023	2024

* The Hydrogen Business Model (HBM) is funded by the Industrial Decarbonisation and Hydrogen Revenue Support Scheme (IDHRS). The government has proposed a fund allocation process to allocate up to £100m in HBM contracts to support up to 250 MW of electrolytic projects in 2023.
** Project may receive revenue support via the Department for Transport’s Renewable Transport Fuel Obligation (RTFO) scheme

HYDROGEN IN THE UK

OVERVIEW OF SOME OTHER UK GOVERNMENT FUNDING SCHEMES [1/2]

SECTOR	SEGMENT	FUNDING	TIMELINE	DESCRIPTION
Transport	Road vehicles	£20m	Running Q1 2023 (Submission deadline : 15 Mar'23)	The Advanced Propulsion Centre (APC) provides funding, support, insight and foresight for the development of low emission transport solutions, and automotive technologies. It aims to support the UK's transition towards net zero product manufacturing and supply chain in the UK automotive sector. In this competition round APC is investing up to £20 million, for projects including 'fossil fuel free (at the point of use) internal combustion' & 'hydrogen storage and management systems'.
	Maritime	£77mn	Launched on 6th Feb'23 (Submission deadline : 19 Apr'23)	UK SHORE and Innovate UK are delivering £77 million in match-funding to support high TRL research in close to commercial clean maritime technology. Funding will be made available to cover the construction and set-up of projects until March 2025, with project partners covering all costs of demonstrating in an operational environment until March 2028. Funding provided across 3 Strands
	Buses	£198m	Commenced Q4'2021	Zero Emission Bus Regional Areas (ZEBRA) scheme (£198m) awarded 12 local transport authorities funding towards new zero emission buses, either hydrogen or battery electric, and infrastructure needed to support them.
	Freights	£140m	Applications Closed Oct'22	Zero emission road freight demonstrator programme (£140m). The three-year comparative programme will help decarbonise the UK's freight industry, with initial competitions for battery electric and hydrogen fuel cell technology.
	Maritime	£98m	Third round funding applications closed in Nov'22	Clean Maritime Demonstration Competition aims to accelerate the design and development of zero emission vessels in the UK and will lay the foundations for a network of technology demonstrations, fast-tracking maritime decarbonisation. Three rounds of funding held so far. Round 1 (~£23m), Round 2 (~£15m) and Round 3 (£60m)
	HGVs	£7.8m	Commenced Q1'2021	Holyhead Hydrogen Hub (£4.8m) a demonstration hydrogen production plant and fuelling hub for HGVs to serve freight traffic at Holyhead and port-side vehicles - could be operational by 2023. Hydrogen Transport Hub in Tees Valley (>£3m)- could be operational by 2025
	Aviation	£15m	Commenced Q4'2021	Green Fuels, Green Skies' competition (£15m) to support the production of first-of-a-kind SAF plants in the UK. Winners announced in Dec'2021.
	Aviation	£150m	N/A	ATI programme provides £150mil per year for mid-stage collaborative R&D. £3mil for Zero Emission Flight Infrastructure R&D. Government has laid out plan to utilise 10% SAF by 2030.
Off-Highway Machinery	Construction, Minning/Quarrying	£40m	Phase 2 open (Submission deadline : 30 Mar'23)	Red Diesel Replacement Competition (£40 million) - to fund the development and demonstration of innovative technologies that enable Non-Road Mobile Machinery (NRMM) used for quarrying, mining, and construction to switch from red diesel to hydrogen or other low carbon fuels. Phase 1 (£6.7m) closed in May'22 with winners announced. Phase 2 (£32.5m) applications open

Open Applications as on end of Feb'23

HYDROGEN IN THE UK

OVERVIEW OF SOME OTHER UK GOVERNMENT FUNDING SCHEMES [2/2]

SECTOR	SEGMENT	FUNDING	TIMELINE	DESCRIPTION
Industry	Industry-wide	£26m	Application closed 16 Feb'2023	Net Zero Innovation Portfolio: Industrial Hydrogen Accelerator (TRL 2-7) - competition supports projects generating evidence on end-to-end industrial fuel switching to hydrogen. It covers the full technology chain, from hydrogen generation and delivery infrastructure through to industrial end-use, including the integration of the components in a single project. The competition funds demonstrations (Stream 1 & 2B) and, where needed, feasibility (Stream 2A) and FEED studies (Stream 2b – open for projects completed feasibility via stream 2A)
	Industry-wide	£70m	Application closed 17 Feb'2023	Industrial Energy Transformation Fund (IETF) Phase 2 (TRL 7+-permanent deployment) - support the development and deployment of technologies that enable businesses to transition to a low carbon future. funding for deep decarbonisation deployment projects, engineering and feasibility studies
	Industry-wide	£4.5m	Launched Feb'23	Hydrogen storage and distribution supply chain collaborative R&D: will support the development of hydrogen storage and distribution systems, reducing the associated cost of hydrogen supply chains and encouraging the commercialisation and adoption of hydrogen storage and distribution innovation in the UK. Open till Apr'23
	Industry-wide	£170m	Commenced Q2'2021	Industrial Decarbonisation Challenge (£170m) - aims to accelerate the cost-effectiveness of decarbonisation across industrial clusters by supporting the development of low carbon technologies such as CCUS and hydrogen at scale.
	Industry-wide	£55m	Applications Closed Dec'22	Net Zero Innovation Portfolio: Industrial Fuel Switching (TRL 4-7) - Support development of fuel switching and fuel switch enabling technologies, including hydrogen, for UK industry. £55m (across elec., biofuels & H2)
	Industry-wide	£66m	Commenced in 2020	UKRI Transforming Foundation Industries Challenge (£66 million from 2020-2025) (Cement, Metals, Glass, Paper, Ceramics, Chemicals). The challenge aims to transform the UK's foundation industries by growing the sector by 2024 in an environmentally sustainable way, across material efficiency, energy efficiency and deep decarbonisation.
	Industry-wide	£20m	Commenced in 2020	Industrial Decarbonisation Research & Innovation Centre (£20m funding until 2024): Hub for research and innovation, as well as knowledge exchange, regulation, policy and key skills. One research pillar is 'large scale deployment of hydrogen systems for industrial decarbonisation

Open Applications as on end of Feb'23

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