MILFORD HAVEN: ENERGY KINGDOM (MH:EK)

For APSE Wales – Moving Forward to Net Zero

21st May 2024

Dan West
Pembrokeshire County Council
www.pembrokeshire.gov.uk/mh2-energy-kingdom

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Vision: – Pembrokeshire is home to a vibrant clean energy cluster, the bedrock for the UK's hydrogen economy

(PCC and PoMH vision, supported by ORE Catapult and the Milford Haven Waterway Future Energy Cluster).

FLOW - Crown Estate Celtic Sea proposal is targeting 4 GW FLOW operational by 2035. 50 GW attainable. 3,000 jobs and £682m in supply chain opportunities for Wales and Cornwall by 2030. In the vanguard is the 96MW Erebus project led by Total and Simply Blue Energy with their follow on 300MW Valorous project and plans for the Pembrokeshire Demonstration Zone to co-locate floating wind and wave technology.

Wave - Pembrokeshire has the highest concentration of wave resource in Wales - indicative capacity of up to 5.6 GW. (e.g. Bombora/Marine Power Systems)

Tidal Stream – as an example tidal streams around the west of Ramsey Island and within Ramsey sound can each up to 4ms providing an indicative capacity of ~150 MW. (e.g. Cambrian Offshore Ltd)

Tidal Range – proposed Tidal Lagoon Swansea Bay (Blue Eden) one of the world's first, man-made, energy-generating lagoons, with a 320MW installed capacity. Severn Barrage could provide up to 10% of UK electricity.

Pembrokeshire Demonstration Zone (PDZ) element of City Deal Pembroke Dock Marine (PDM) project is targeting of 1GW High Voltage AC from FLOW and Wave technologies and will be spending the next few years assessing the PDZ areas for suitable locations for aggregated grid connection points (on or offshore).

GreenLink will be investing in High Voltage DC infrastructure to enable the 500MW interconnector between ROI and Pembrokeshire.

Huge renewable electricity potential. Electricity grid and ports infrastructure upgrades needed. Heat & Transport emissions hardest to action.

Hydrogen - Industry around the Pembroke HVAC and HVDC infrastructure have high hydrogen demand (Valero) or high hydrogen demand or distribution and storage potential (RWE / Puma / National Grid / WWU). There is great potential for green hydrogen to service transport.

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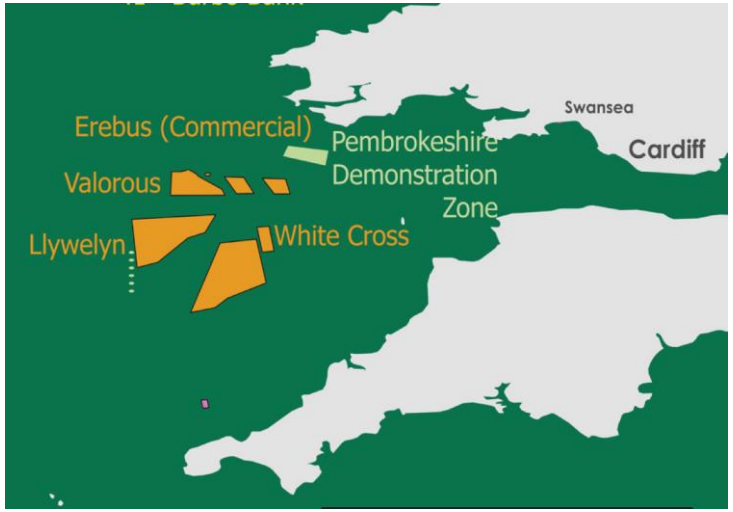
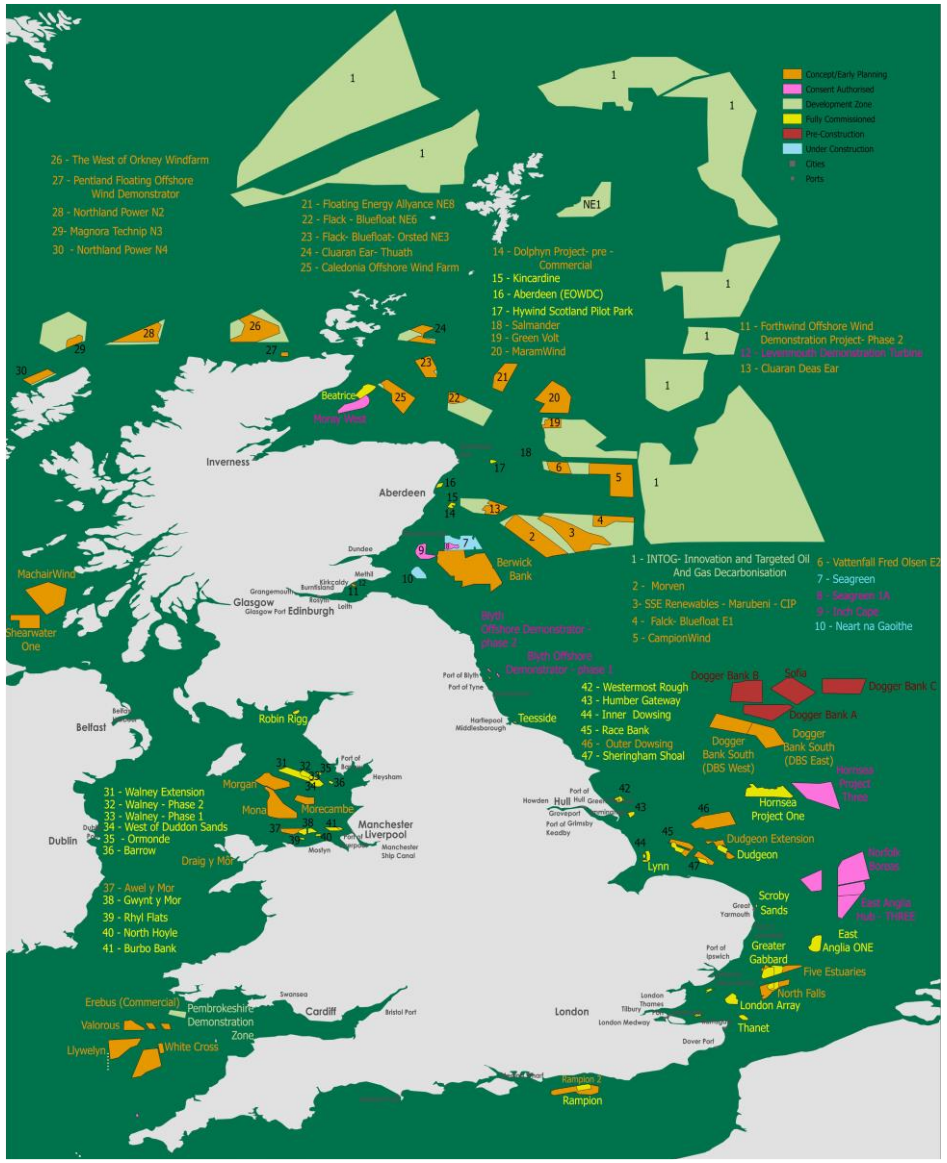
UK Offshore Wind Map 2022

- UK Govt target for 50 GW of operational offshore wind by 2030 (with 5GW from FLOW).
- Crown Estate Celtic Sea proposal is targeting 4 GW FLOW operational by 2035. (50 GW attainable).
- 96MW Erebus project led by Total and Simply Blue Energy with their follow on 300MW Valorous project (operational 2027-2030).
- Plans for the Pembrokeshire Demonstration Zone to co-locate floating wind and wave technology.





Perspective:

- UK baseload power consumption 32 GW
- Peak 47 GW (www.gridwatch.co.uk)

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Huge renewable electricity potential. Electricity grid and ports infrastructure upgrades needed. Heat & Transport emissions hardest to action.

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An 'early mover' example

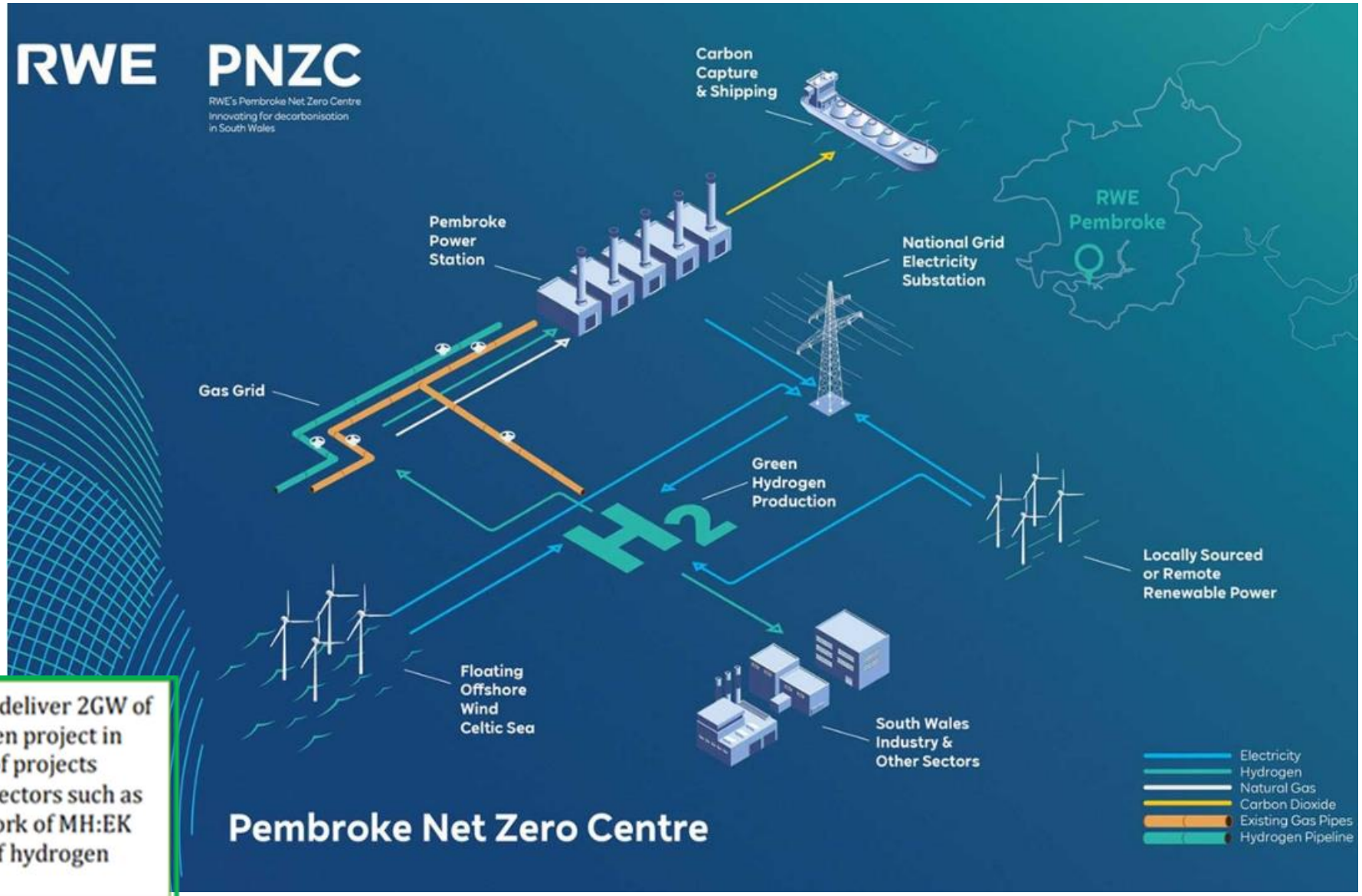
RWE Pembroke Net Zero Centre

• Green hydrogen production, including the development of an electrolyser on the Pembroke site, the development of floating offshore wind (FLOW) in the Celtic Sea. 110 MW green H2 electrolysis (by 2026) and up to 1GW (by 2030). (UK target for 10 GW by 2030)

• H2 for fleet, transport, industry, grid.

• Decarbonisation of Pembroke Power Station, including studies for carbon capture.

• The feasibility of hydrogen as a fuel



"RWE has a hydrogen business and we are looking to deliver 2GW of hydrogen projects by 2030, including a green hydrogen project in Pembrokeshire. Key to this is the economic viability of projects producing hydrogen for use across a wide variety of sectors such as transport, power and industry. RWE welcomes the work of MH:EK in helping to make the storage, use and distribution of hydrogen cost effective." Jeremy Smith, RWE.

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MH:EK is exploring the potential of zero carbon hydrogen alongside renewable electricity to meet all of our future energy needs for buildings, power generation and fuelling transport.

MH:EK is gathering detailed insight into the whole energy system around the Milford Haven Waterway, to identify and design a future Smart Local Energy System. We are exploring how to make using and distributing green hydrogen financially viable within the different energy sectors of buildings, industry, power and transport all backed by comprehensive energy systems architecture.

MH:EK is one of the chosen "detailed design" projects within the Prospering from the Energy Revolution (PfER) programme of works funded by UKRI as part of their Industrial Strategy Challenge Fund (ISCF).

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Project partners

Port of Milford Haven

CATAPULT Offshore Renewable Energy

CATAPULT Energy Systems

riversimple

ARUP

WALES&WEST UTILITIES

Electrolyser and refueller providers

FUEL CELL SYSTEMS

GRIFFITHS civil engineering and construction

The project involved consumer trials of hydrogen fuel cell electric vehicles and hydrogen-ready hybrid heating systems.

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$$H_2 + O_2 \longrightarrow 2H_2O + \text{Energy}$$

HYDROGEN FACTS

- Hydrogen makes up about 75% of the mass of the universe. It is found in the sun and most stars.
- It is the simplest and lightest element on the periodic table.
- It is also odourless, colourless, tasteless, non-toxic and non-poisonous.
- If released, hydrogen is not a greenhouse gas.

Is hydrogen safe?

Hydrogen has been safely produced, stored, transported, and used in large amounts within industry - over 60 million tons per year globally - by following standard practices that have been established over the past 50 years.

Hydrogen is just as safe as other transport fuels. Compared to petrol, you would need three times the amount of hydrogen within air to create a flammable mix. This is difficult to achieve when every molecule is trying to escape skywards at 45 mph!

If hydrogen is set alight, it burns with a very hot pale blue flame, but with a low radiant heat. This means it is unlikely to set fire to anything nearby.

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The "colours" of hydrogen

- Brown – hydrogen produced by using coal where the emissions are released to the air.
- Grey – Using steam-methane reforming, currently the standard industry process, it involves extracting hydrogen from fossil fuels such as coal or gas while releasing carbon monoxide and carbon dioxide.
- Blue – Blue hydrogen is grey hydrogen but separates the CO2 emissions for re-use or underground or subsea storage. Seen as a transitional approach while demand cannot be met fully by green hydrogen, some environmentalists oppose this option.
- Green – Using renewable electricity sources (solar/wind/hydro etc) to power electrolysis to make hydrogen. This could include offshore wind operators developing floating electrolysis plants.
- Yellow - a relatively new phrase for hydrogen made through electrolysis using solar power.
- Turquoise - Also called low-carbon hydrogen and so far very small scale, this is hydrogen generated from natural gas but using pyrolysis where the gas is passed through molten metal, producing solid carbon as a by-product with useful applications.
- Pink - Pink hydrogen is generated through electrolysis powered by nuclear energy. Nuclear-produced hydrogen can also be referred to as purple hydrogen or red hydrogen.
- White - Naturally-occurring geological hydrogen found in underground deposits. There are no strategies to exploit this hydrogen at present.

Hydrogen can be stored, piped, or carried by tankers to consumers, for example to serve hydrogen filling stations or for heating, hot water and cooking. Hydrogen can also be used to balance gas as electricity grids as it is an excellent energy storage medium. It can also be used to generate power.

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Why here? Milford Haven Waterway – The UK's Largest Energy Port

Circa 25% of the UK's energy imports with a huge opportunity to lead the transition from a fossil fuel to renewables based economy.

4,000 jobs (40% of total local employment around the Port)

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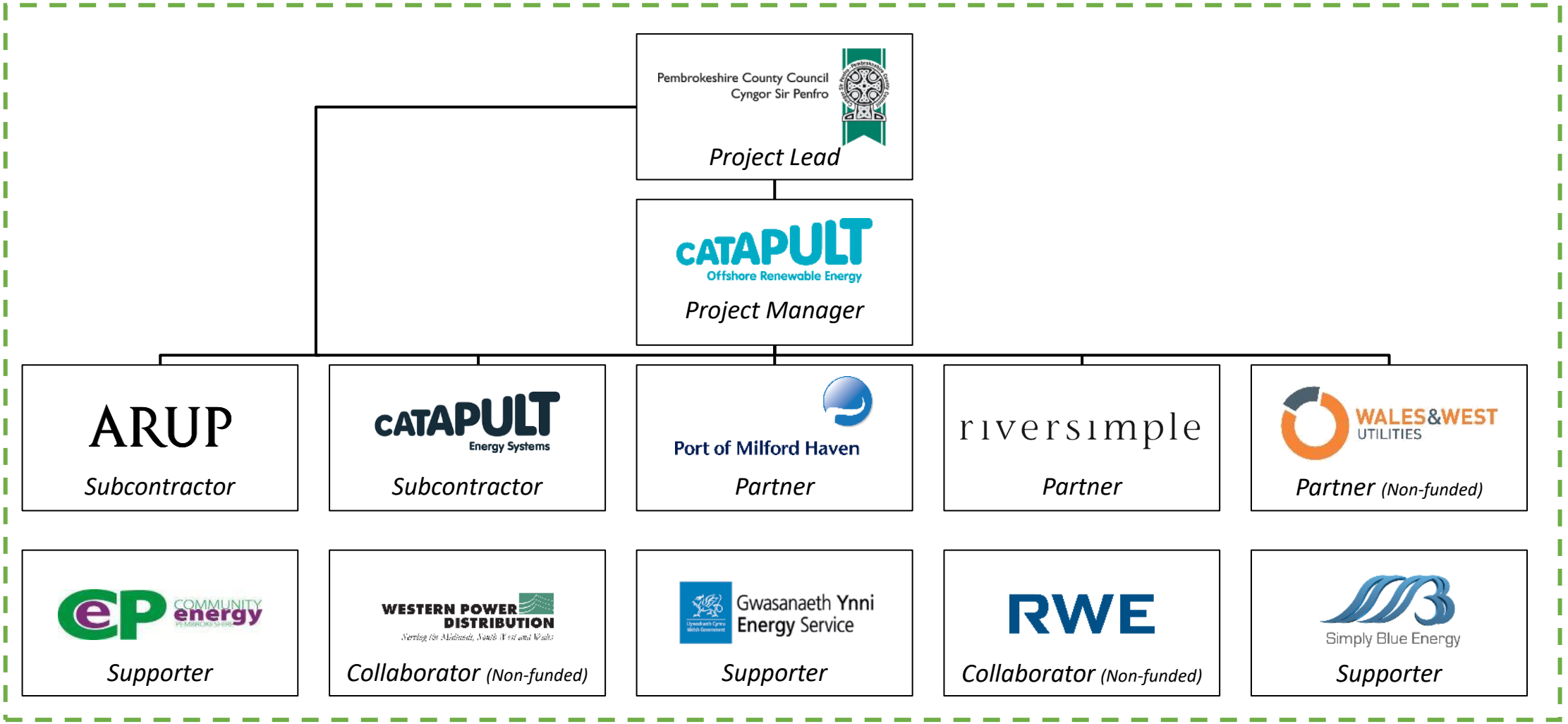
Project Team



Wider stakeholder & investor engagement

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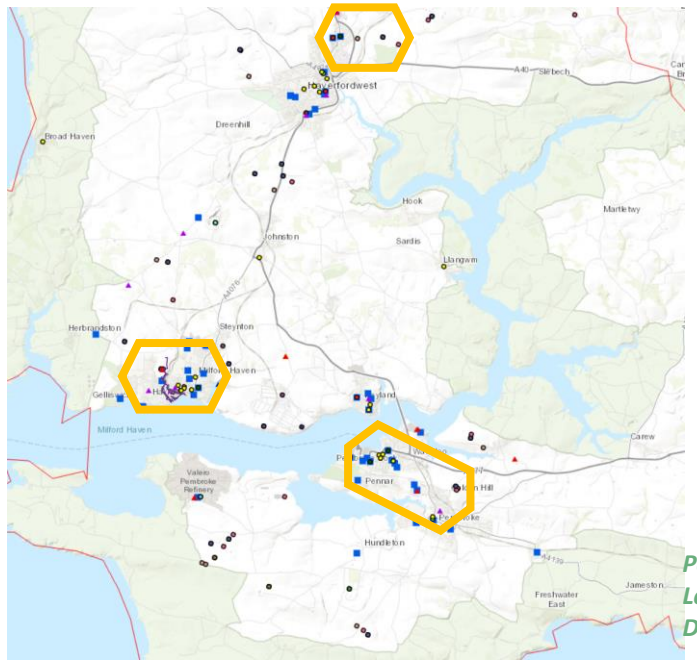
Near term investable propositions

What does a 2050 decarbonised MH:EK energy system look like and the short-term investments to achieve this, on the route to net-zero by 2050?

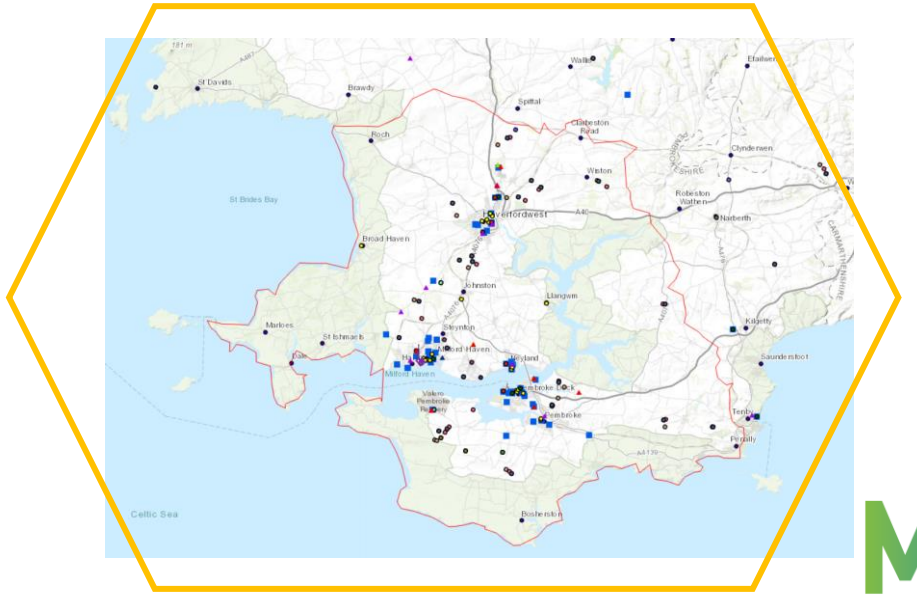
- ‘Stepping-stone’ projects to support broader Smart Local Energy System (SLES) transition in future – three investable propositions
- Economic viability demonstrated by techno-economic modelling
- Commercial models, risk assessments, policy & regulatory barriers and recommendations
- Multi-vector trading platform specification
- How are the propositions going to be delivered? Including data ecosystem
- Supported by insights from project demos & trials, systems architecture, consumer insights etc

Milford Haven Marina SLES



Pembrokeshire Food Park SLES

Pembroke Schools, Leisure Centre and Dock SLES



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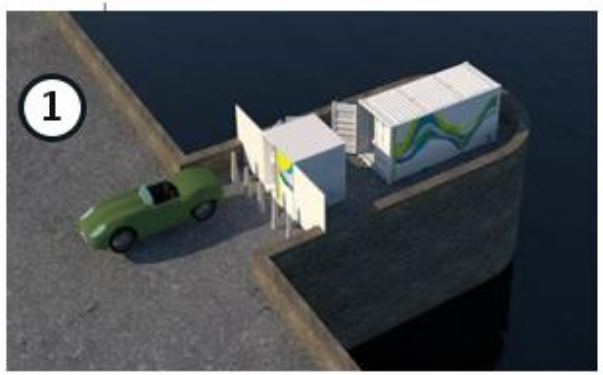
Milford Waterfront - key focal point, project catalyst & demonstrators

Project elements

1	Hydrogen Refueler Demo	August 2021 – May 2022
2	Hybrid Heating Demo	July 2021 – May 2022
3	Phase 1 and Phase 2 Detailed Design	Complete by May 2022

Other assets

1	5MW Liddeston Ridge Solar Array



The project is demonstrating hydrogen-ready features and technologies such as a refueller for Riversimple's fuel cell Rasa cars (electrolysing green hydrogen on site), a hybrid heat pump and hydrogen-ready boiler demo for heating, allowing people to test real-world hydrogen vehicles and heating equipment.

This is Milford Waterfront. The Port's focus for energy innovation projects and the design of a smart local energy system with an abundance of renewable energy generation on a site connected by utility based networks. There is a good mix of consumers, ranging from industrial, commercial, independent and national retail.

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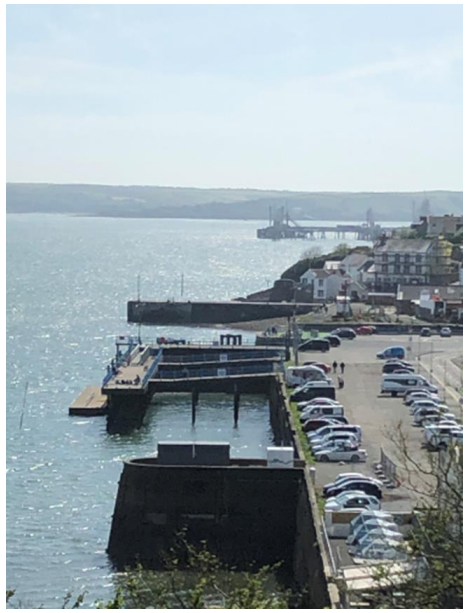
Milford Haven Energy Kingdom (virtual-engage.com)

Hydrogen Refueller

The hydrogen refueller and all associated works including electrolysers, compressors, water treatment units, dryer units as necessary to electrolyse, store and dispense green hydrogen on site at 350 Bar to serve 2 x Rasa HFCEVs has been completed as planned.

Capex £290,000



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Hydrogen FCEV – The Riversimple Rasa

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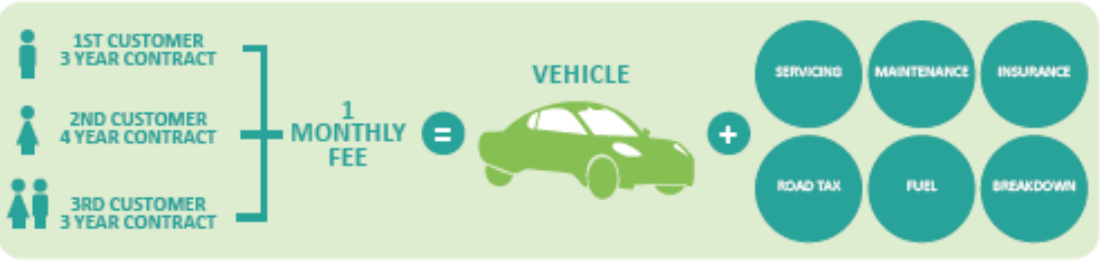
Hydrogen Fuel Cell Electric Vehicle (HFCEV) demo

THE RIVERSIMPLE RASA

- REGENERATIVE BRAKING INTO SUPER CAPACITORS
- 4 IN WHEEL MOTORS, GIVING DIRECT 4 WHEEL DRIVE
- WEIGHS ONLY 655KG
- EMITS PURE WATER VAPOR



All Riversimple vehicles will be offered under a service contract, a form of Mobility as a Service

Customers take a Riversimple vehicle from 1-5 years, paying a fixed monthly fee plus a mileage rate – which covers everything.

After each contract, the vehicle is returned to Riversimple where it is provided to the next customer and so on.

Refurbishments and software upgrades are factored in to keep the vehicles current.

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riversimple

www.riversimple.com

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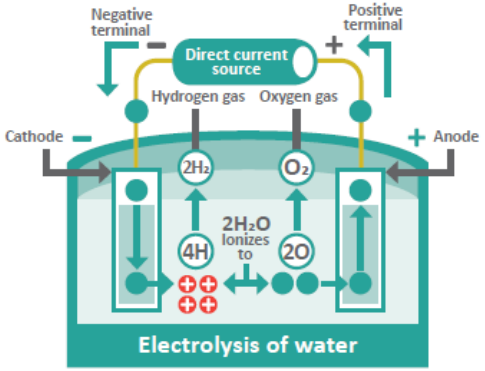
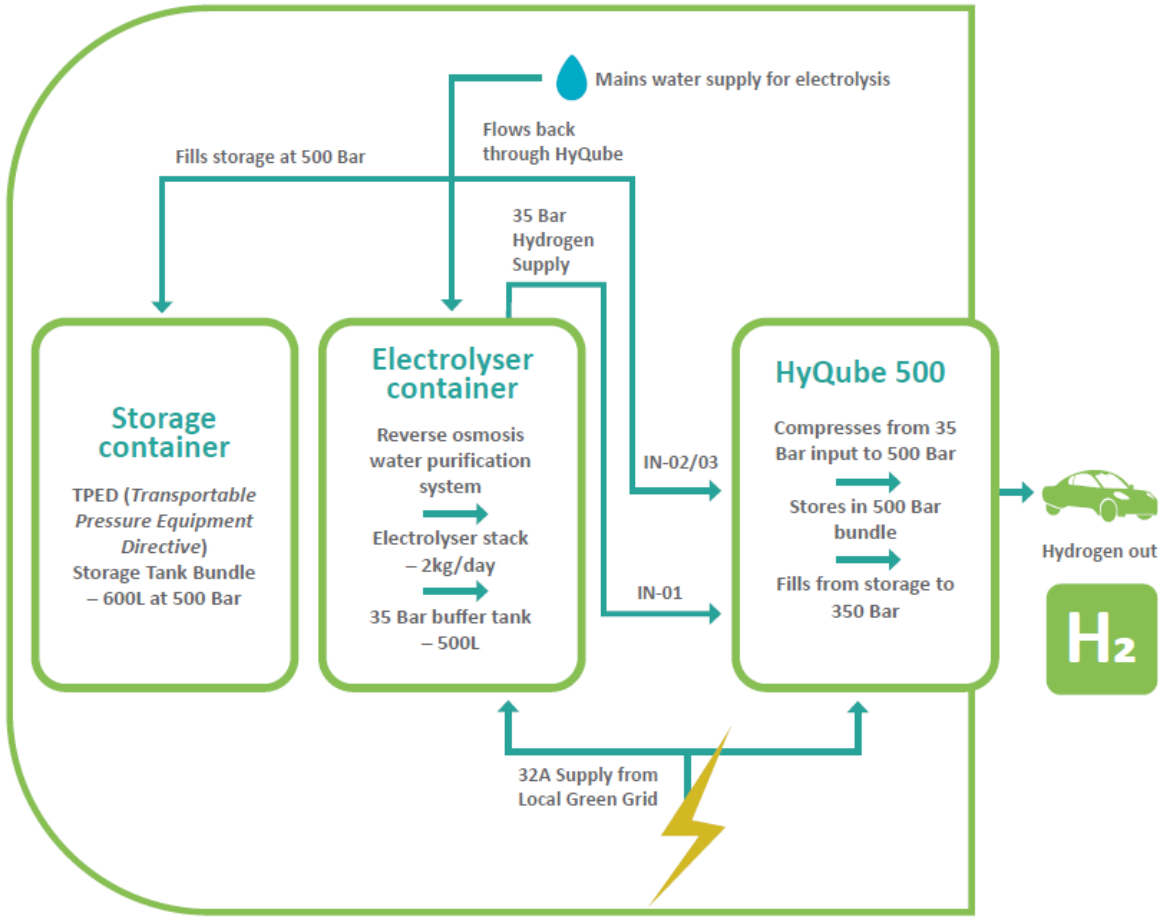
HYDROGEN PRODUCTION AND DISPENSING

This site uses electrolysis to split water into hydrogen and oxygen.

Power is taken from the local green energy grid and run through the electrolyser units. The oxygen produced is vented to the air. The hydrogen is compressed and stored within suitable cylinders.

When a vehicle comes for a fill, the hydrogen is dispensed from the storage using standard industry protocols.





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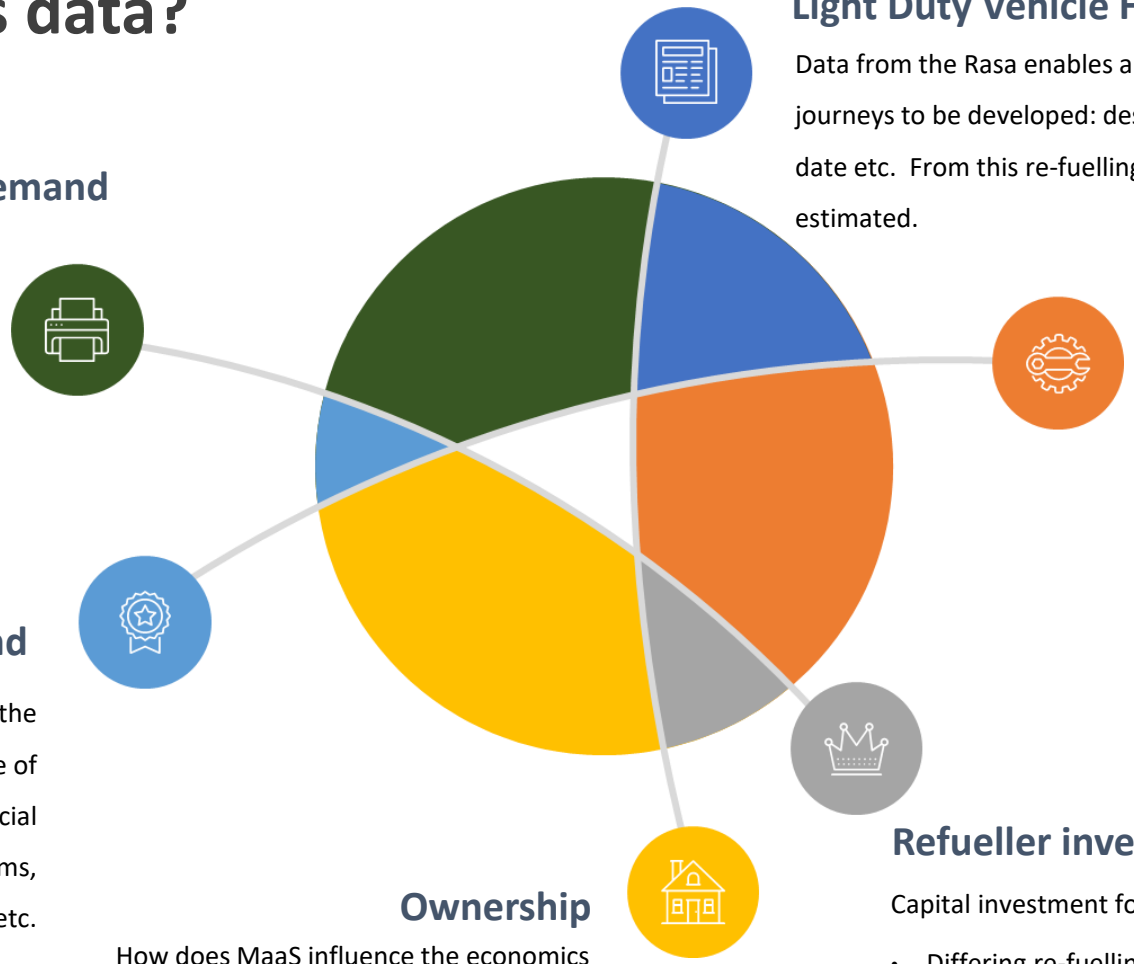
Developing a business case for a publicly accessible hydrogen refueller

Hydrogen Vehicle Demo & Design

Why collect this data?



Light Duty Vehicle Hydrogen Demand

Data from the Rasa enables a detailed understanding of typical journeys to be developed: destination, duration, topography, time, date etc. From this re-fuelling patterns and requirements can be estimated.

Fleet vehicle hydrogen demand

PCC, PoMH, NHS. Fleets Data covers passenger vehicles, small vans and larger commercial vehicles for both commuting and business use cases.

Hydrogen supply and cost

Availability of low-cost electricity to support electrolysis. Usage in H2 vehicles vs BEVs Green hydrogen cost now, 2030 and 2050

Wider hydrogen demand

Wider vehicle demand data from the region to build a complete picture of potential fuel demand: commercial fleets, hauliers, taxi firms, hire firms, tourism etc.

Refueller investment

Capital investment for re-fueller for different demand cases.

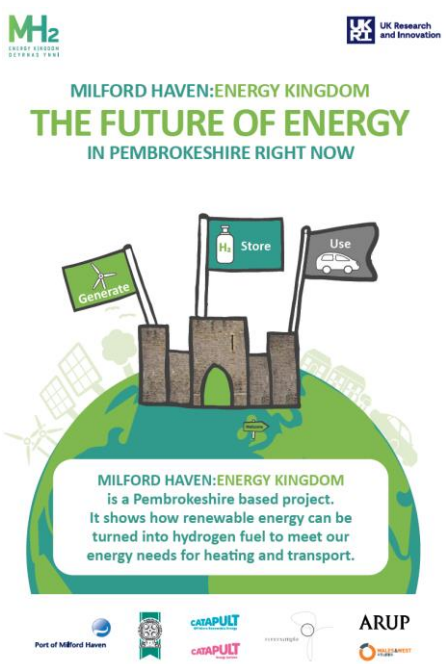
- Differing re-fuelling capacities – what are the investment breakpoints?
- Does the target market have an impact – for example the amount of fuel that each re-fuelling activity involves. i.e. serving HGVs vs passenger vehicles

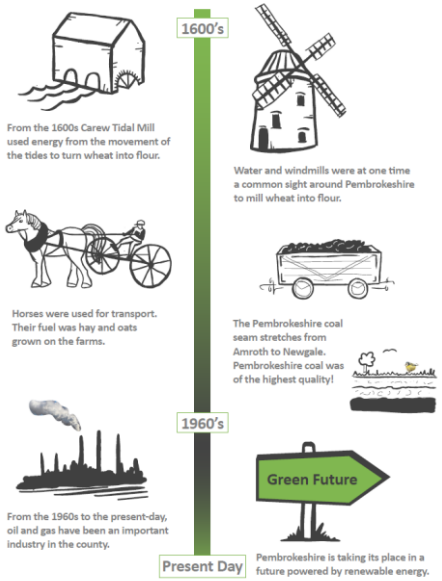
Ownership

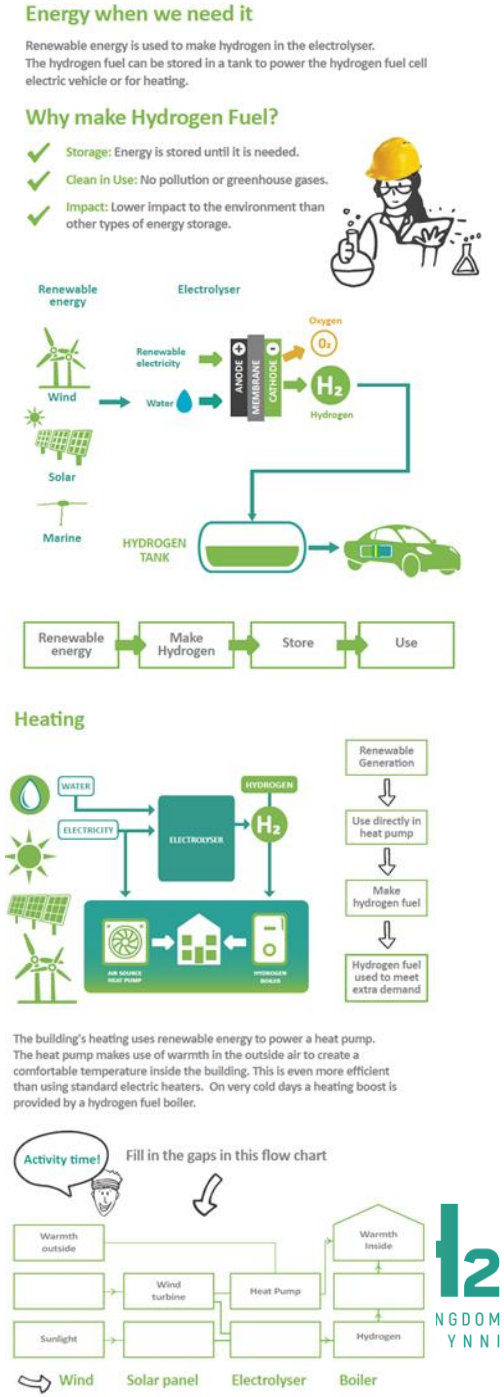
How does MaaS influence the economics associated with a transition to hydrogen in transport?

School visits

- Taking the Rasa HFCEV to engage staff and pupils using the MH:EK [education resources](#) .
- ***"It was absolutely super, thank you. The children and staff really enjoyed learning about the cars!"*** **Vicky Brown, Deputy Head, Redhill Preparatory School.**







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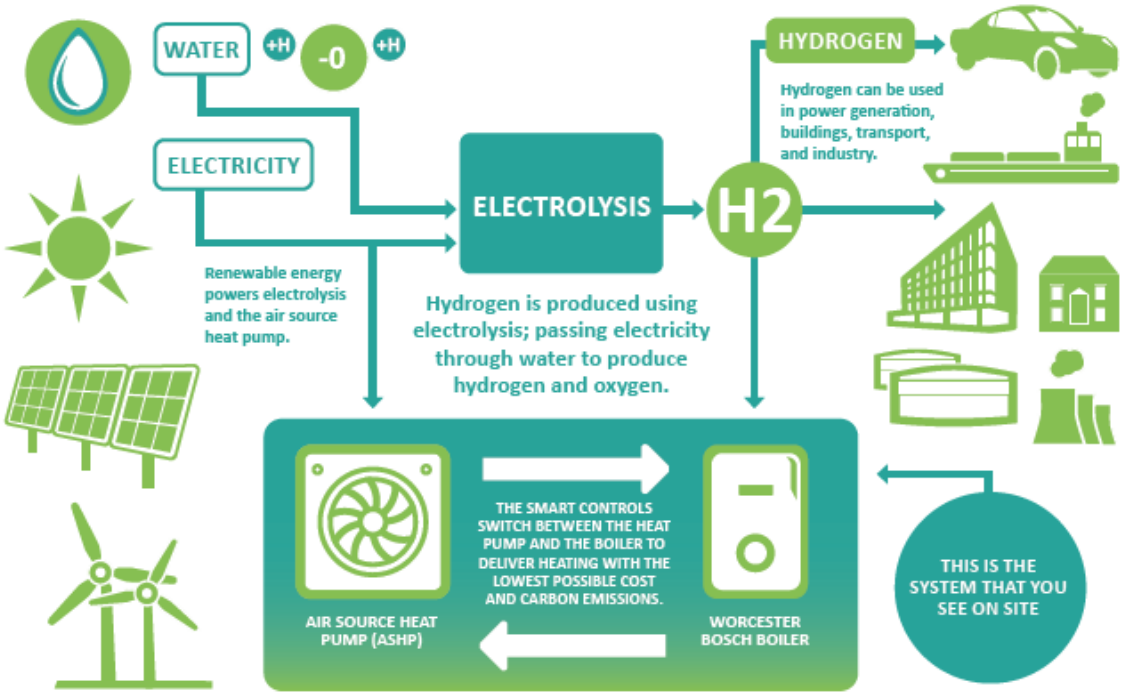
HYDROGEN HYBRID HEATING SYSTEM



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MILFORD HAVEN: ENERGY KINGDOM is one of the chosen detailed design projects within the Prospering from the Energy Revolution programme of works funded by UKRI as part of their Industrial Strategy Challenge Fund.

This world-first hydrogen hybrid heating system demonstrator will trial a hydrogen boiler and an air-source heat pump. The system intelligently selects between the heat pump and boiler to always deliver the most carbon efficient heat at lowest possible cost.

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Project partners

Port of Milford Haven

CATAPULT Offshore Renewable Energy

CATAPULT Energy Systems

riversimple

ARUP

WALES&WEST UTILITIES

Heating trial partners

Spire Renewables Simplifying Sustainable Heating

passiv

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Objective: Design, install, demonstrate and test the viability of a hydrogen-ready hybrid heating system.

- Hydrogen trials completed in January
  - 20% blend hydrogen into methane
  - 100% hydrogen
- Partnership: MHPA, WWU, Passiv UK, Worcester Bosch, Kiwa.
- **Three world firsts for Milford Haven!**
- The first smart hybrid heating system in a commercial building.
- The first smart hydrogen hybrid heating system combining an air-source heat pump and a hydrogen boiler.
- The first retrofit of a hydrogen boiler into an existing building.

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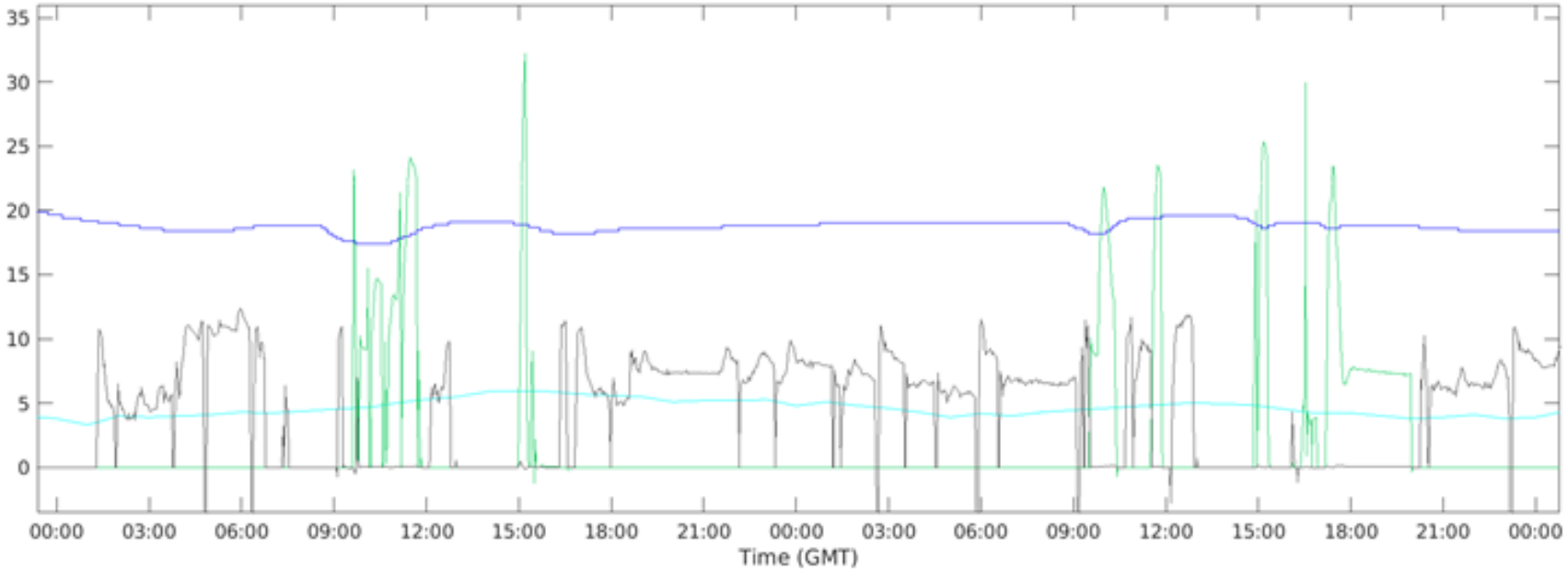
Trial implementation

Saturday: Hydrogen boiler used to provide blast of heat in the morning when temperature dropped. Peak tariff simulated at period 2-4pm so heat pump replaced by boiler

Sunday: Early boiler reheat, again peak tariff simulation leads boiler to supplement heat.



Blue line is room temperature zone 1, heat pump heat production in black and boiler heat production in green (kW).

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