MILFORD HAVEN: ENERGY KINGDOM (MH:EK)

WLGA Transition & Recovery Series - 'Transport & Mobility' – Hydrogen Fuel Cell Electric Vehicles

19th January 2022

Steve Keating
Pembrokeshire County Council
www.pembrokeshire.gov.uk/mh2-energy-kingdom

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MILFORD HAVEN:ENERGY KINGDOM

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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 involves consumer trials of hydrogen fuel cell electric vehicles and hydrogen-ready hybrid heating systems.

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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.

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 and created through fracking. 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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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.

RWE Pembroke Power Station 2200MW Combined Cycle Gas Turbine

Valero Pembroke Refinery 270,000 bpd, 10.5m barrels storage

Valero Pembrokeshire Oil Terminal 8.7mb petroleum products storage facility

Dragon LNG Liquefied Natural Gas terminal

South Hook LNG Liquefied Natural Gas Terminal

Puma 1.4m m3 storage facility

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

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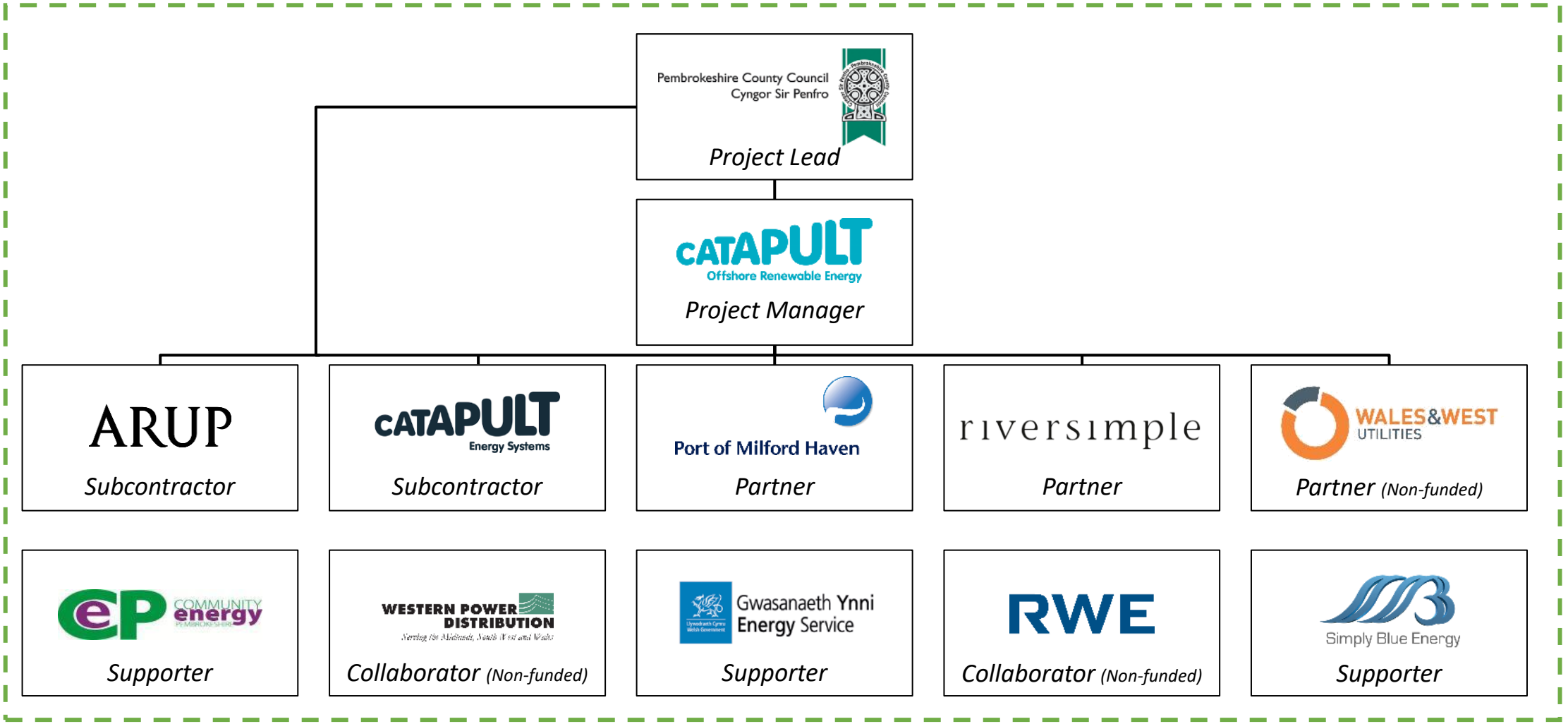
Project Team



Wider stakeholder & investor engagement

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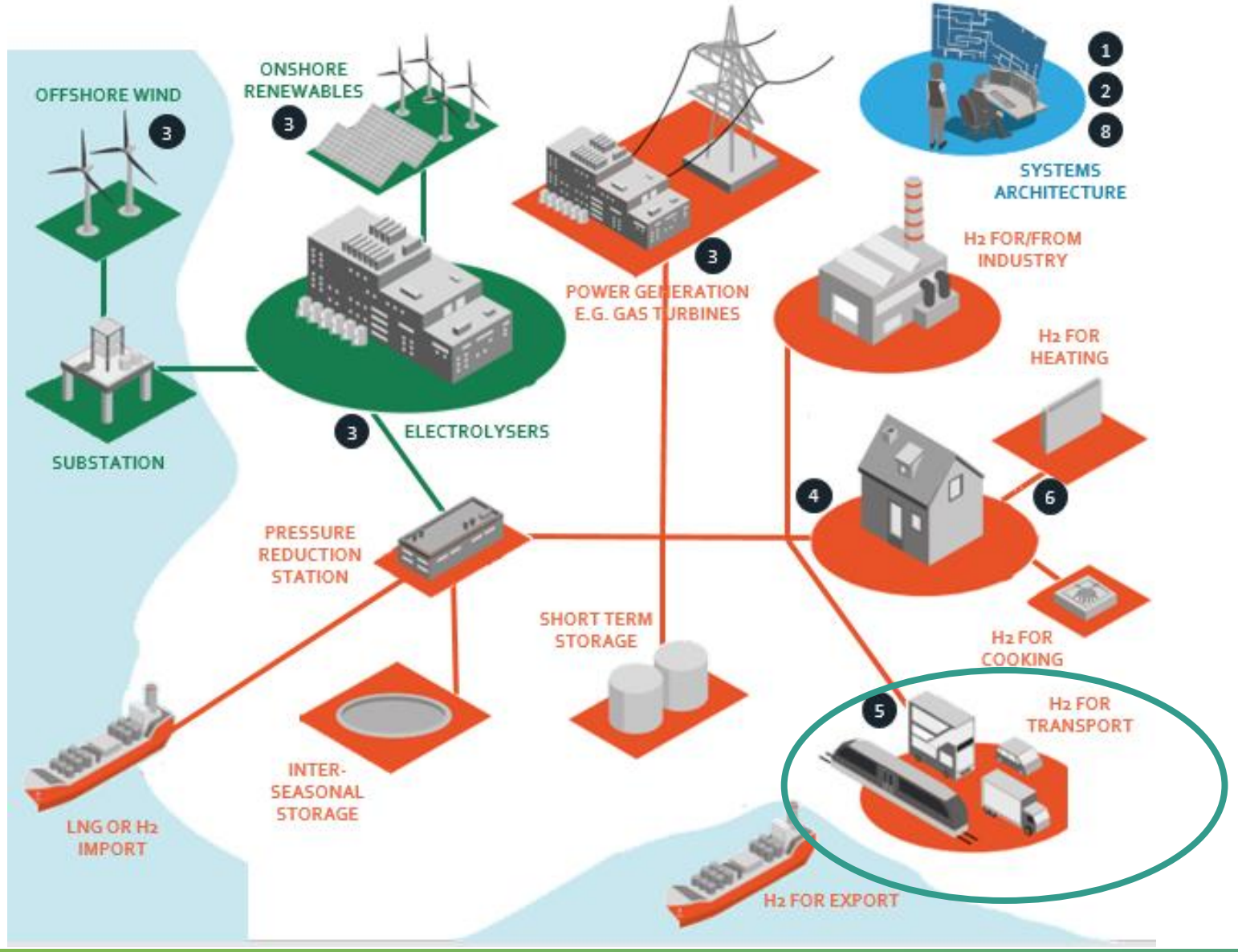
MH:EK in the wider context of a hydrogen economy



MH:EK intends to provide a detailed design blueprint for an investible, local, hydrogen-based energy system on the Milford Haven Waterway that will allow for the integration of heat, power and **transport.**

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Systems Architecture & H2 Trading platform

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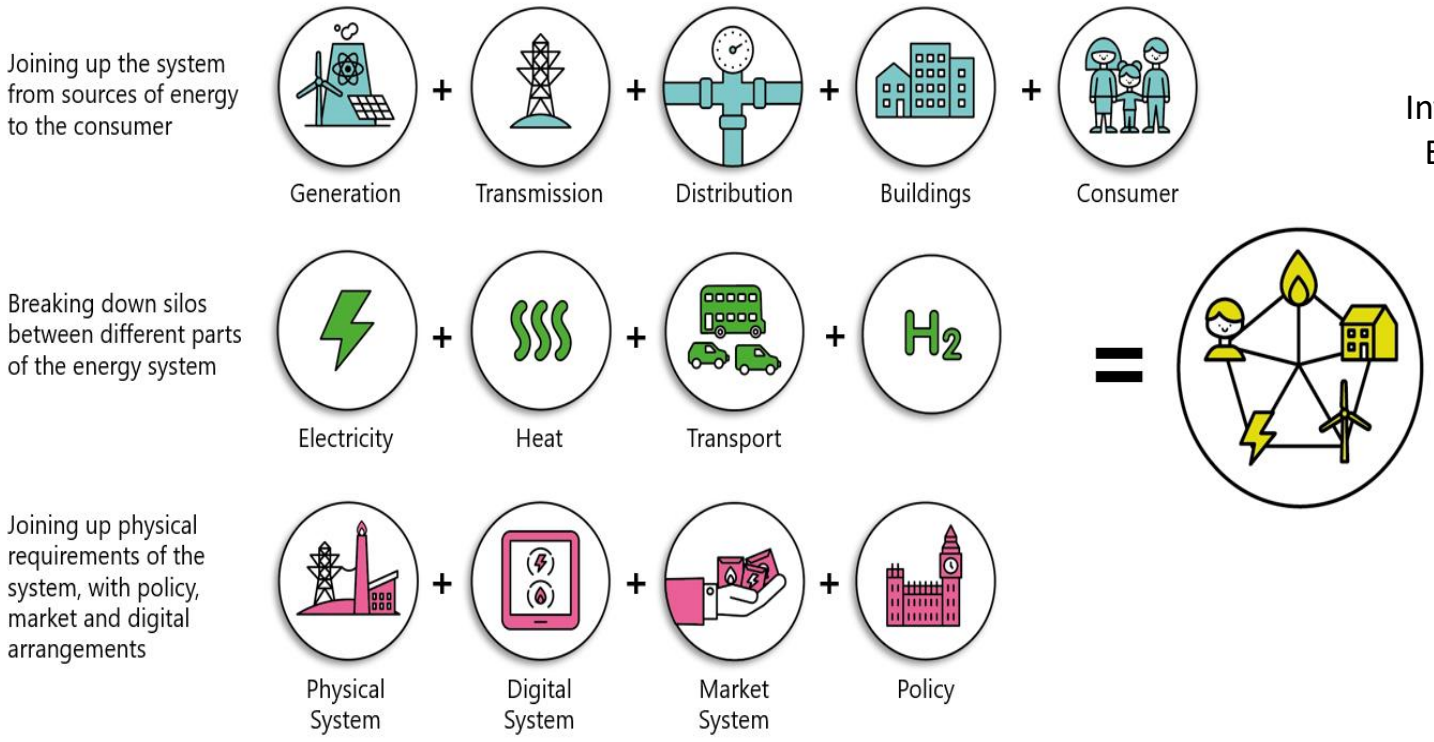
Co-designing a switch to hydrogen with customers

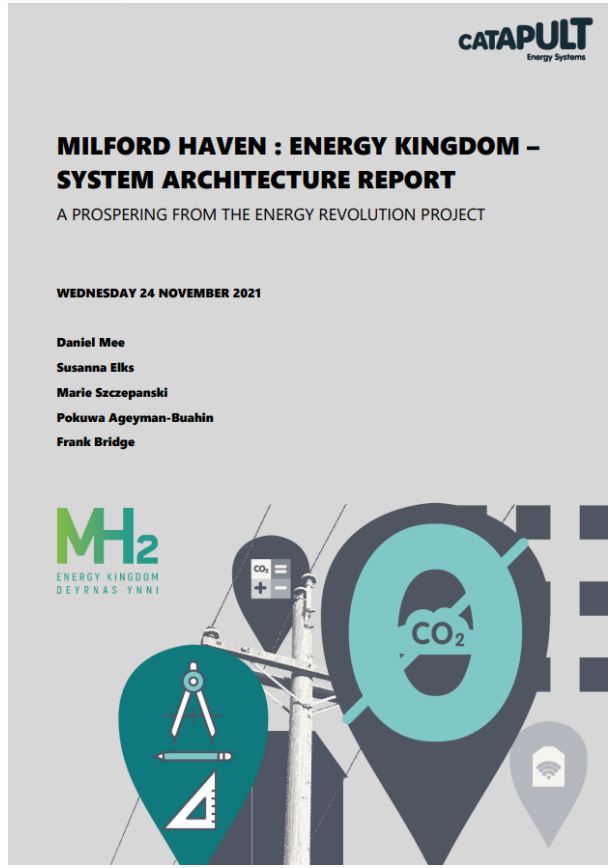
Proposal

What is whole system thinking?



Report covers Physical Architecture, Organisational Structure, Investment and trading, Evolution of the whole energy system & H2 Market

[MHEK-full-report-External-Release-FINAL.pdf]



CATAPULT Energy Systems

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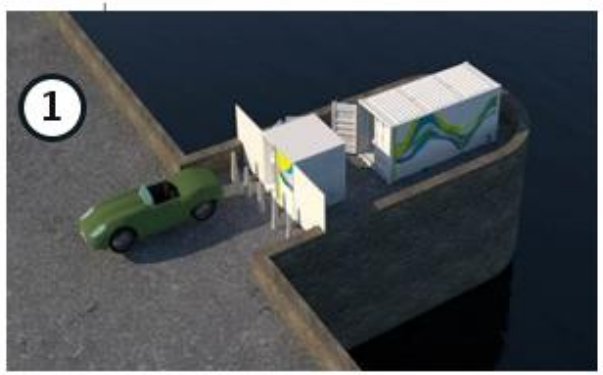
Milford Waterfront - a key focal point & project catalyst

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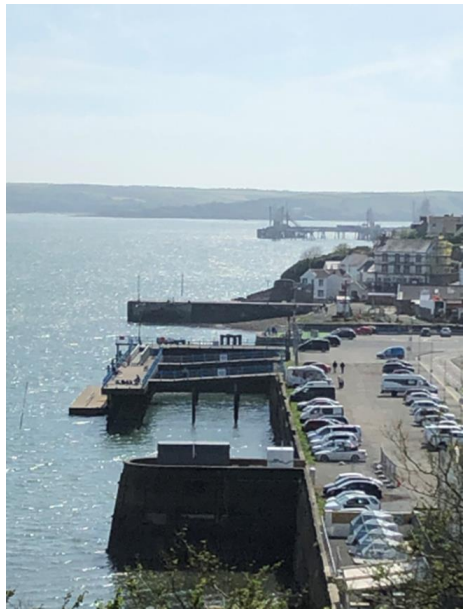
Hydrogen Refueller

Capex £290,000

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.



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Hydrogen FCEV – The Riversimple Rasa

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Hydrogen Fuel Cell Electric Vehicle (HFCEV) demo

HYDROGEN FUEL CELL ELECTRIC VEHICLE

The Riversimple Rasa is an electric car powered by hydrogen rather than batteries. The hydrogen passes through a fuel cell, where it combines with oxygen from the air to produce electricity. This electricity flows to small, lightweight electric motors, one in each wheel, which give the car 4 wheel drive. The only emission is water.

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Mobility as a service

Riversimple offers a subscription service for vehicles which offers a move away from vehicle ownership towards an all-inclusive, simplified and clean mobility experience.

To read more visit our website:
www.riversimple.com

Riversimple are a Welsh company pioneering in the design and development of lightweight, hydrogen fuel cell vehicles.

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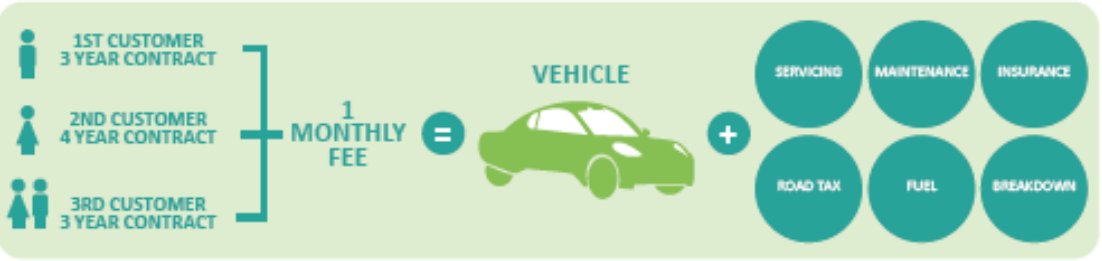
Hydrogen Fuel Cell Electric Vehicle (HFCEV) demo

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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www.riversimple.com

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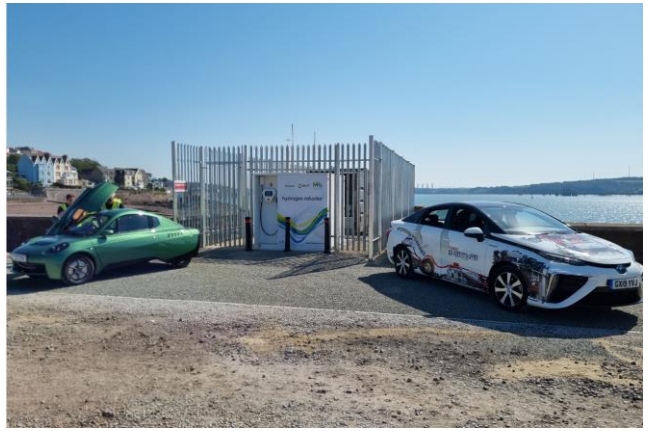
At the inaugural Earthshot Awards screened on BBC1 on 17th October Enapter's AEM Electrolyser won the 'climate' prize - MH:EK featured in the live prize winners video montage.

Electrolyser & Refueller

- Electrolyser & Refueller commissioned. H_2 first produced by electrolysis Friday 9th July 2021



- Successful first refuel of Rasa and a visiting Toyota Mirai 7th September. Now in daily use.
- 2 x 2.1 kW Enapter electrolysers capable of producing 2 kg of H2 per day at a cost of circa £8-18 (depending on availability of renewable power).
- Gas multi cylinder pack storage.
- Fuel Cell Systems Ltd 'HyQube' 350 Bar Refueller.
- 2 x Riversimple Rasa's capable of running for 240 miles on 2 kg of H2
- 20 litres of water used to produce hydrogen in 24 hours run time.

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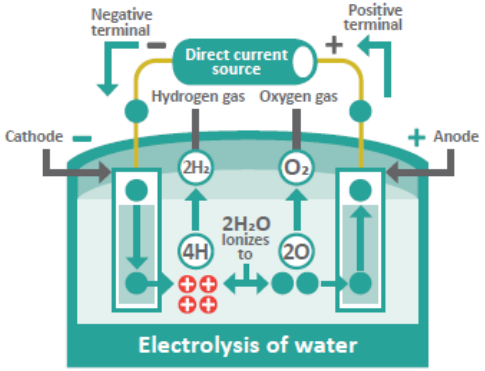
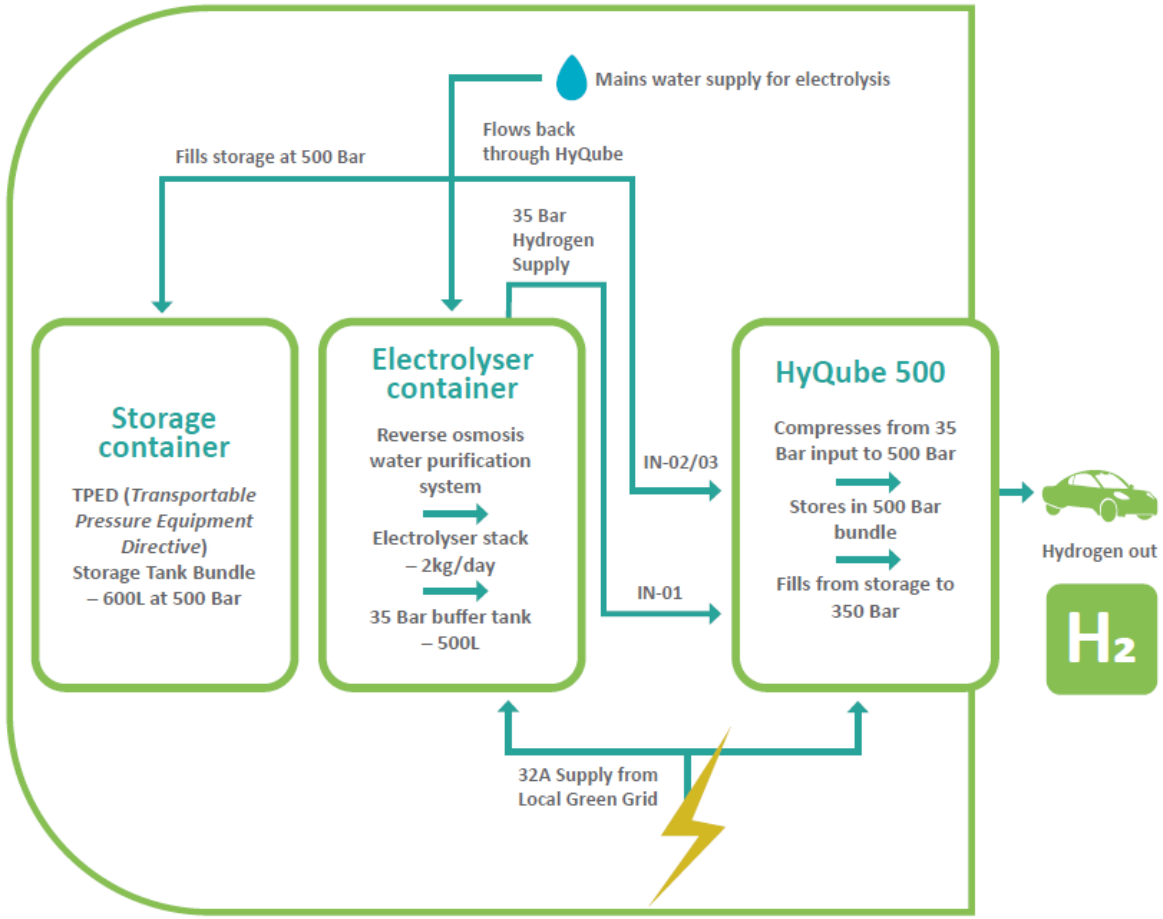
HYDROGEN PRODUCTION AND DISPENSING

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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Early data on cost of H2 production/motoring using MH:EK refueller:

HFCEV model	Combined miles per kilogram H2 (mpk)	H2 fuel cost per mile using locally supplied green electricity	H2 fuel cost per mile using grid supplied green electricity	H2 fuel cost per 500 miles using locally supplied green electricity (8 p/kWh)	H2 fuel cost per 500 miles using grid supplied green electricity (18 p/kWh)	Equivalent diesel cost per 500 miles in an average car at 45 mpg (£6.82/gallon)
Riversimple Rasa MH:EK Beta*	120	£ 0.03	£ 0.08	£ 17.05	£ 38.05	£ 75.77
Honda Clarity	66	£ 0.06	£ 0.14	£ 31.00	£ 69.18	£ 75.77
2021 Toyota Mirai Limited	64	£ 0.06	£ 0.14	£ 31.97	£ 71.34	£ 75.77
2021 Toyota Mirai XLE	72	£ 0.06	£ 0.13	£ 28.42	£ 63.42	£ 75.77
2021 Hyundai Nexo SUV	56	£ 0.07	£ 0.16	£ 36.54	£ 81.54	£ 75.77
2021 Hyundai Nexo Blue SUV	60	£ 0.07	£ 0.15	£ 34.10	£ 76.10	£ 75.77

** final production version of the Rasa aims to improve this to up to 200 mpk*

	Power input kW	Water input	Time period (hours)	Power input for 1 kg H2 (kWh)	Water input for 1 kg H2 (litres)	Locally supplied green electricity cost (p per kWh)	Grid supplied green electricity cost (p per kWh)	Water cost per litre (p/litre)	Cost of 1 kg of H2 from locally supplied green electricity (£)	Cost of 1 kg of H2 from locally grid green electricity (£)
Cost to produce 1 kg H2 at MH:EK electrolyser/refueller										
2.1 kW Enapter AEM electrolyser producing 1 kg H2 in 24 hours	2.1		24	50.4		8	18		£ 4.09	£ 9.13
20 litres of water required for 24 hours of electrolysis		0.83	24		20			0.3		

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Reports on Usage Patterns & User Experience

Where are we?

From the following data:

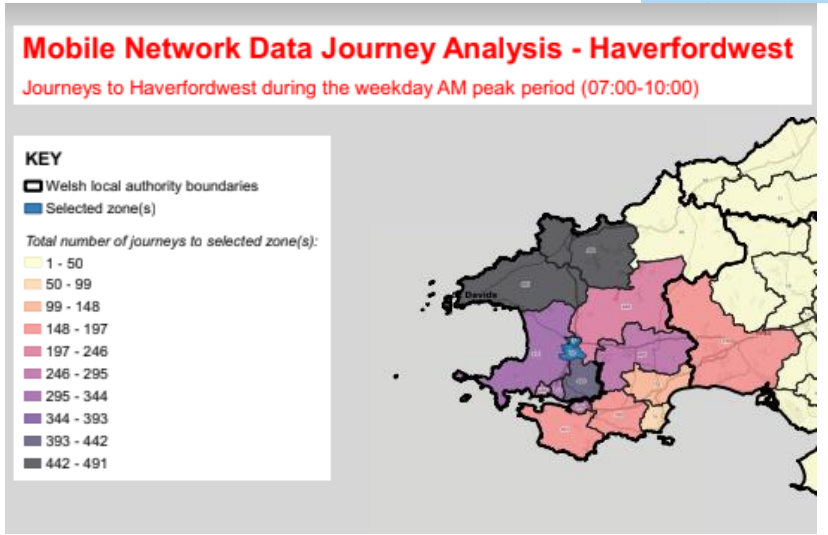
- >800 miles of fleet specific Rasa Beta driving data (H_2 consumption, journey distance/duration, driving style, topography)
- Baseline PoMH, NHS, and PCC fleet data (no. & type of vehicles, driver duty cycles, procurement decision making process, refuelling, vehicle use)

Learning:

- The CO_2 and cost savings for both specific journeys and whole fleets
- The requirements for fleet vehicles and why BEVs are not always suitable
- What drives procurement decision making process and how the MaaS business model fits in
- How H_2 consumption varies with driving style & journey type
- Cost of refuelling with green H_2 and how this compares to other HFEVs, BEV charging and ICEs.
- There is lots of travel into the Haverfordwest and Milford Haven region suggesting these would be a good location for a permanent HRS.

This learning will continue as the trial continues and be combined with additional data on wider Pembrokeshire travel demand and refueller investment. It will form the basis of a **business case** for local use around a publicly accessible green electrolysed hydrogen central refueller using the MaaS business model as part of a whole energy system design.

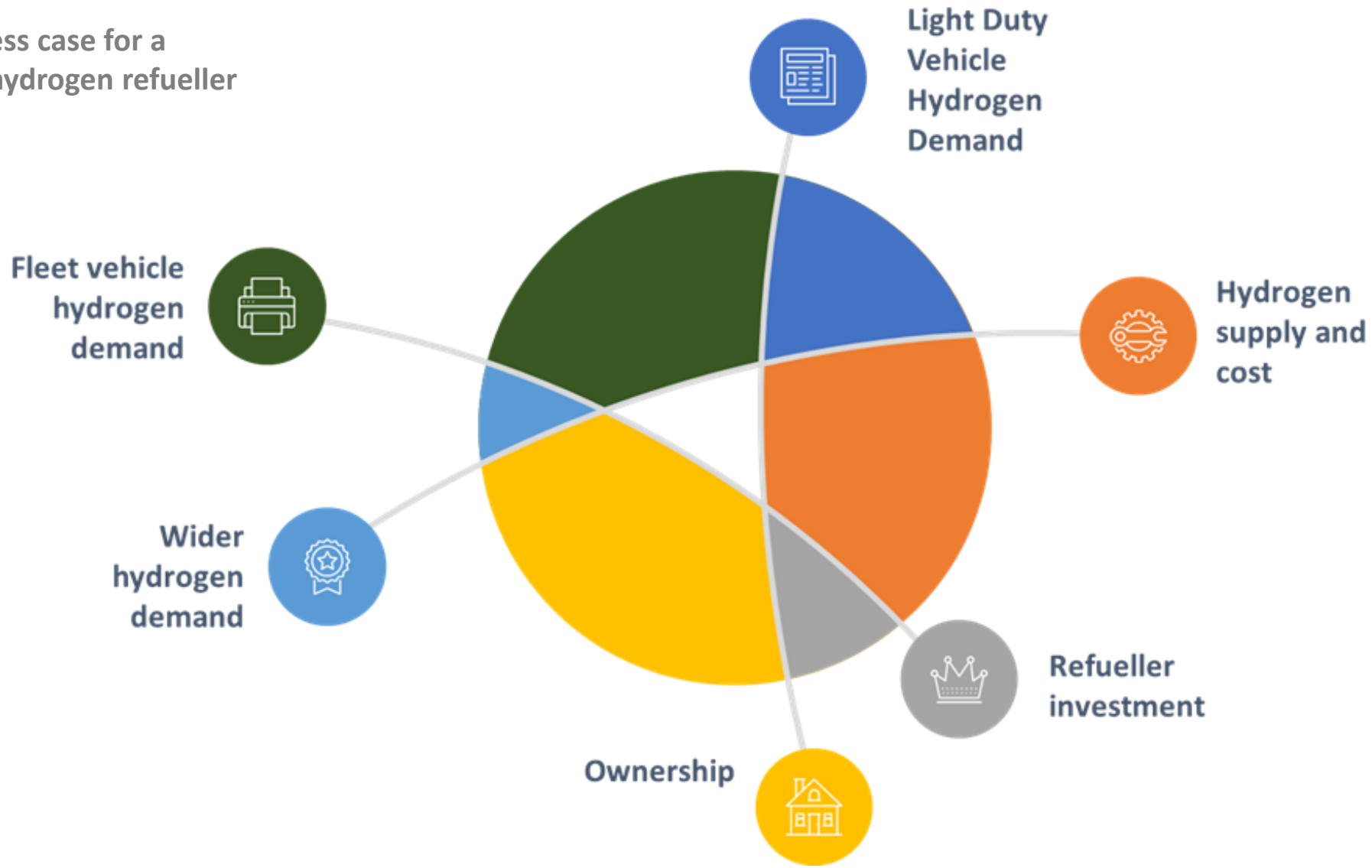
Task Start: August 2021/ Task Expected Completion Date: May 2022



Reports on Usage Patterns & User Experience

riversimple

Developing a business case for a publicly accessible hydrogen refueller



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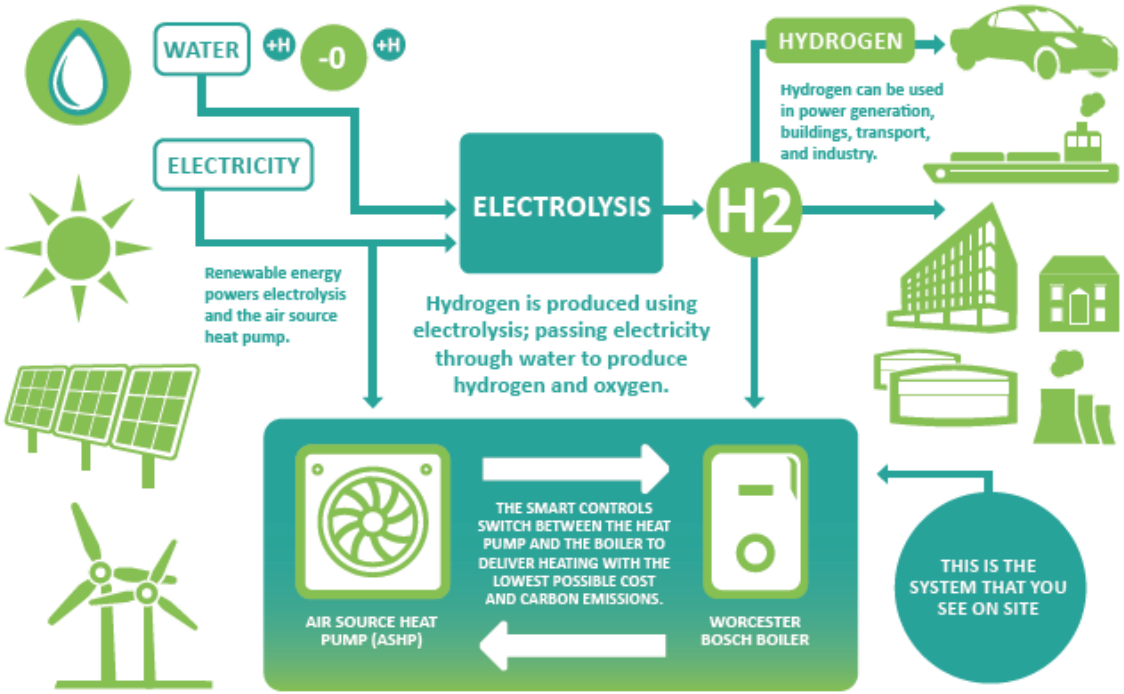
HYDROGEN HYBRID HEATING SYSTEM



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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.

READ MORE: www.pembrokeshire.gov.uk/mh2-energy-kingdom

Project partners

Port of Milford Haven

CATAPULT Offshore Renewable Energy

CATAPULT Energy Systems

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ARUP

WALES&WEST UTILITIES

Heating trial partners

Spire Renewables Simplifying Sustainable Heating

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Virtual Tour of the Demonstrators

You can also take a virtual tour of both demonstrators (please open in Chrome for full functionality – the information points do not work in Edge):

www.ccatproject.eu\MHEK-Hydrogen-Refueller

www.ccatproject.eu\MHEK-Hybrid-Heating-System

These innovative virtual tours enable us to reach a much broader audience and to communicate the exciting MH:EK hydrogen developments happening here. A more inclusive learning experience, the digital nature of the tours allows access to all - students, residents and industry staff alike (indeed, anyone with internet anywhere in the world) can now visit the facility in detail simply not possible in real life.

Early inclusion of the community can help increase support and awareness of the renewable energy developments happening right here in Milford Haven as part of Pembrokeshire's adaptation to climate change.

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