

# MILFORD HAVEN: ENERGY KINGDOM (MH:EK)

August 2022

Regional picture for renewables/hydrogen, and project outputs

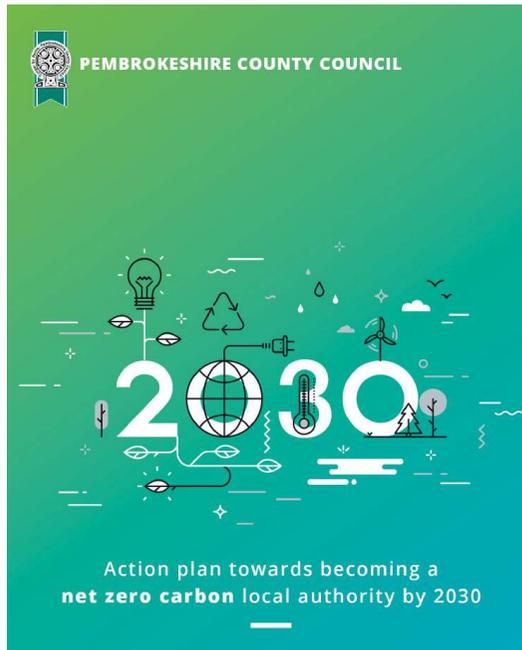
Steve Keating

Pembrokeshire County Council

[www.pembrokeshire.gov.uk/mh2-energy-kingdom](http://www.pembrokeshire.gov.uk/mh2-energy-kingdom)

**MH<sub>2</sub>**  
ENERGY KINGDOM  
DEYRNAS YNNI

# Climate Change - Action Plan Towards Becoming a net zero carbon LA by 2030



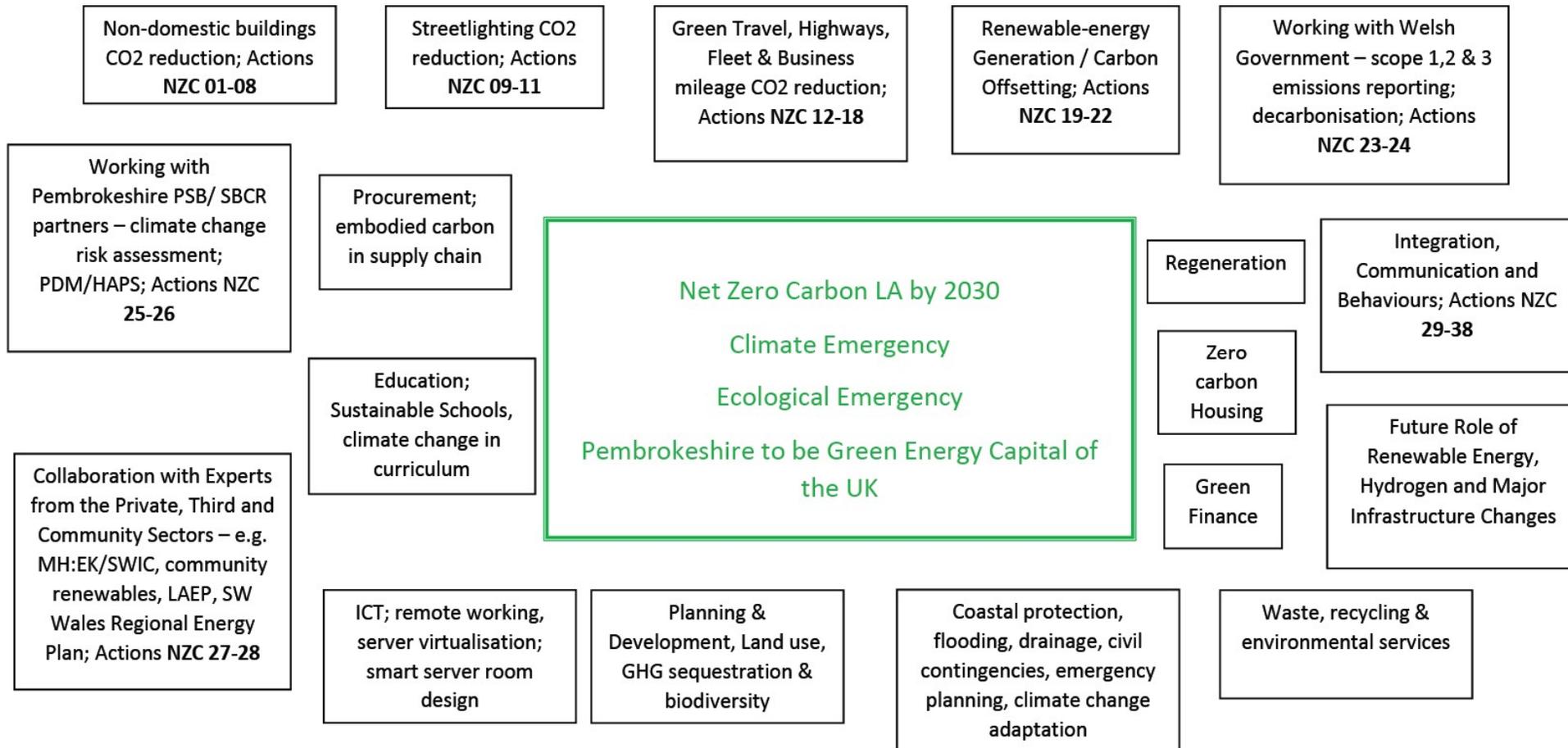
Action: Collaboration with experts from the private, third and community sectors – MH:EK is an example of this.

- In May 2019 members of PCC voted to declare a climate emergency, and in July 2019 members voted to create an action plan to steer Pembrokeshire County Council towards becoming a net zero-carbon local authority by 2030.
- The 38 actions in the plan are the first step in a range of measures the Council is looking at, to help address climate change.
- It is intended to be a living document and will evolve over time.
- This is a long-term plan for the next eight years and, as such, more proposals will be added as it develops. Further technological breakthroughs will inevitably come forward in due course, but the most important thing is that the Council has started on this crucial path.
- We want everyone in our communities to be involved in this journey. We look forward to reducing emissions from our own activities and, more widely, to working with partners in order to bring about equal change.

[Full Action Plan Towards Becoming a Net Zero Carbon Local Authority by 2030](#)

# Climate Change is a monumental agenda

## Net zero carbon, renewable energy, climate & ecological emergency, impact mitigation & adaptation work streams



## **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.

The Celtic Sea is also home to the **first ever floating offshore CfD award**, going to [Hexicon](#)'s innovative [TwinHub](#) design. The 32MW project built between 2025 and 2027 will become the first FLOW development of many predicted in the Celtic Sea region.

**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). **In another first CfD award** Spanish tidal stream developer, [Magallanes Renovables](#), will now be deploying 5.62 MW to the [Morlais](#) tidal stream project off Anglesey, producing their first power to grid in 2025.

**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.



# MH<sub>2</sub>

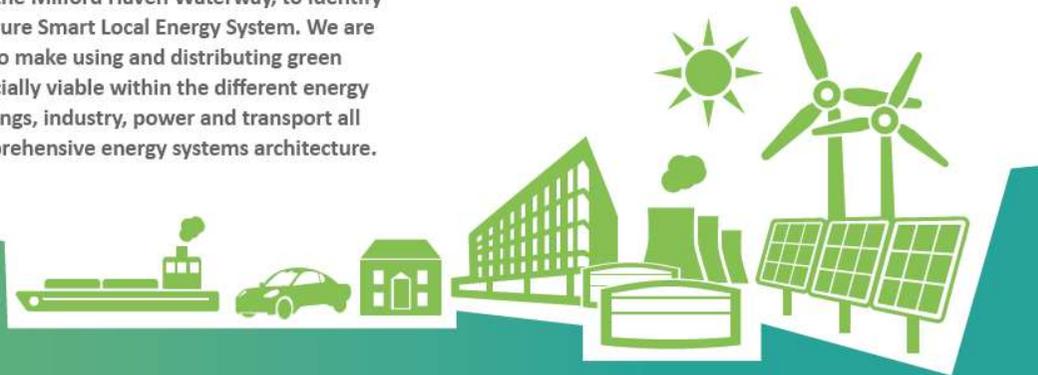
ENERGY KINGDOM  
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## MILFORD HAVEN:ENERGY KINGDOM

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 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).

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.



<https://www.pembrokeshire.gov.uk/mh2-energy-kingdom> The project involves consumer trials of hydrogen fuel cell electric vehicles and hydrogen-ready hybrid heating systems.

MILFORD HAVEN:ENERGY KINGDOM  
READ MORE: [www.pembrokeshire.gov.uk/mh2-energy-kingdom](http://www.pembrokeshire.gov.uk/mh2-energy-kingdom)



### Project partners



### Electrolyser and refueller providers



## 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 CO<sub>2</sub> 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. (Very interesting to SWIC and steel works).
- **Green** – Derived from renewable sources which could include offshore wind operators developing floating electrolysis plants. Green hydrogen can be stored, piped, or carried by tankers to consumers, for example to serve hydrogen filling stations. Hydrogen can also be turned into synthetic methane with qualities identical to natural gas for heating, hot water and cooking. Biomethane derived from fermented crops/AD can also play a role in the gas grid. 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. (Very interesting to MH:EK & SWIC).
- **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 (Very interesting to SWIC and steel works).

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

Circa 20% of the UK’s energy imports with a huge opportunity to lead the transition from a fossil fuel to renewables based economy.



**Marine Renewables  
A Major Future  
Contributor**

**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**

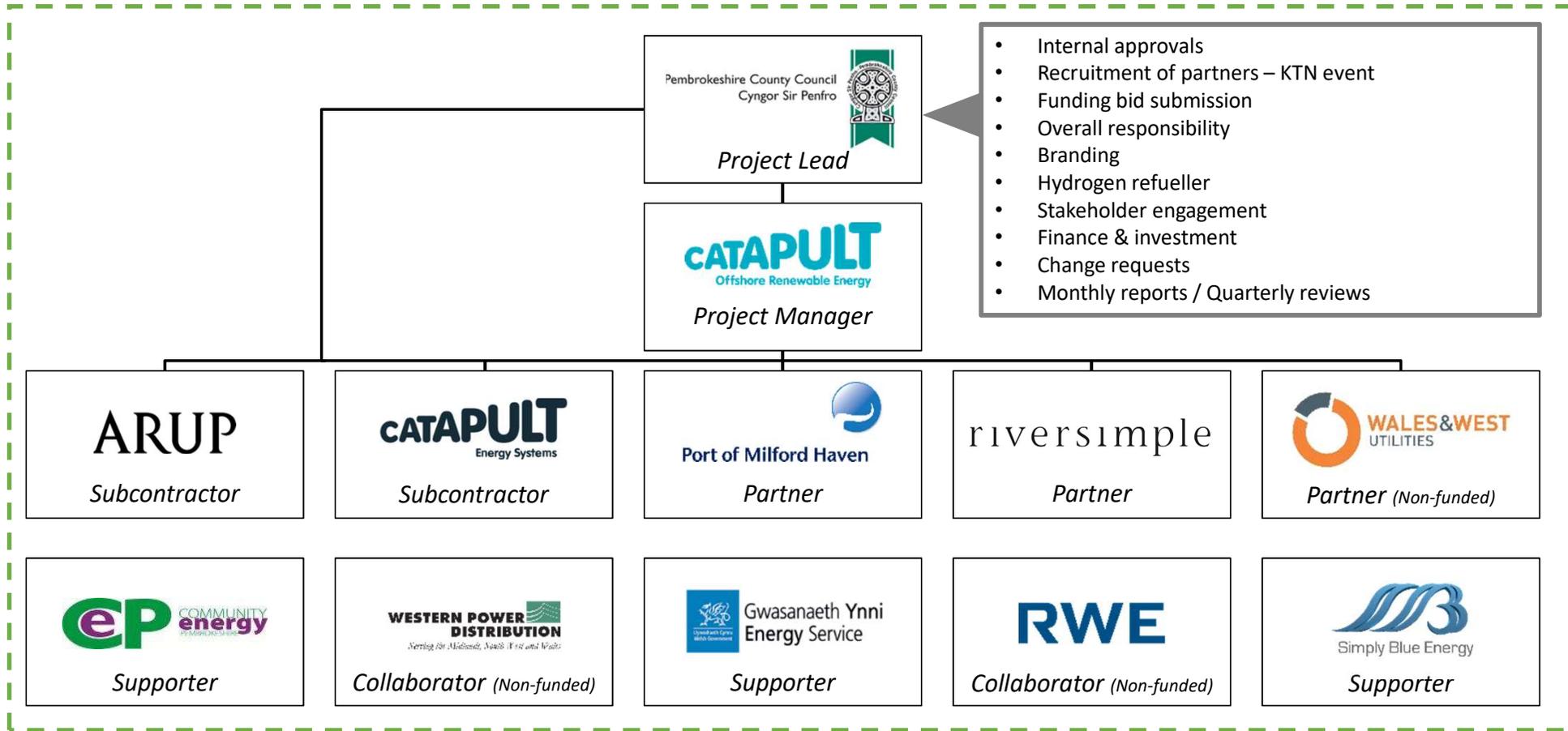
**Dragon LNG  
Liquefied Natural  
Gas terminal**

**South Hook LNG  
Liquefied Natural  
Gas Terminal**

**Puma  
1.4m m3  
storage facility**

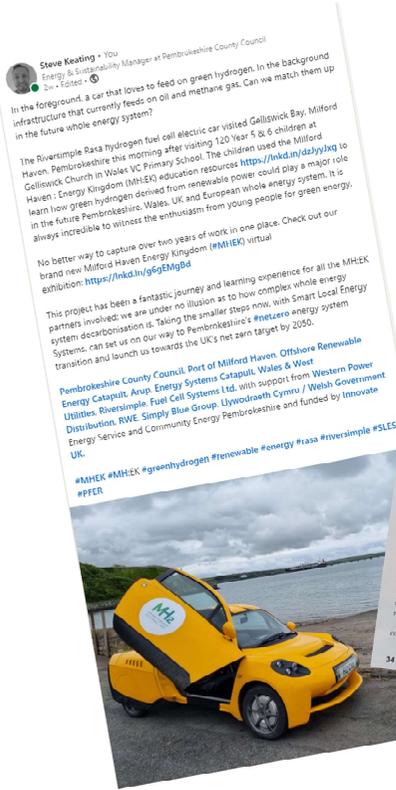
**4,000 jobs (40% of total local employment around the Port)**

# Project Team



Wider stakeholder & investor engagement

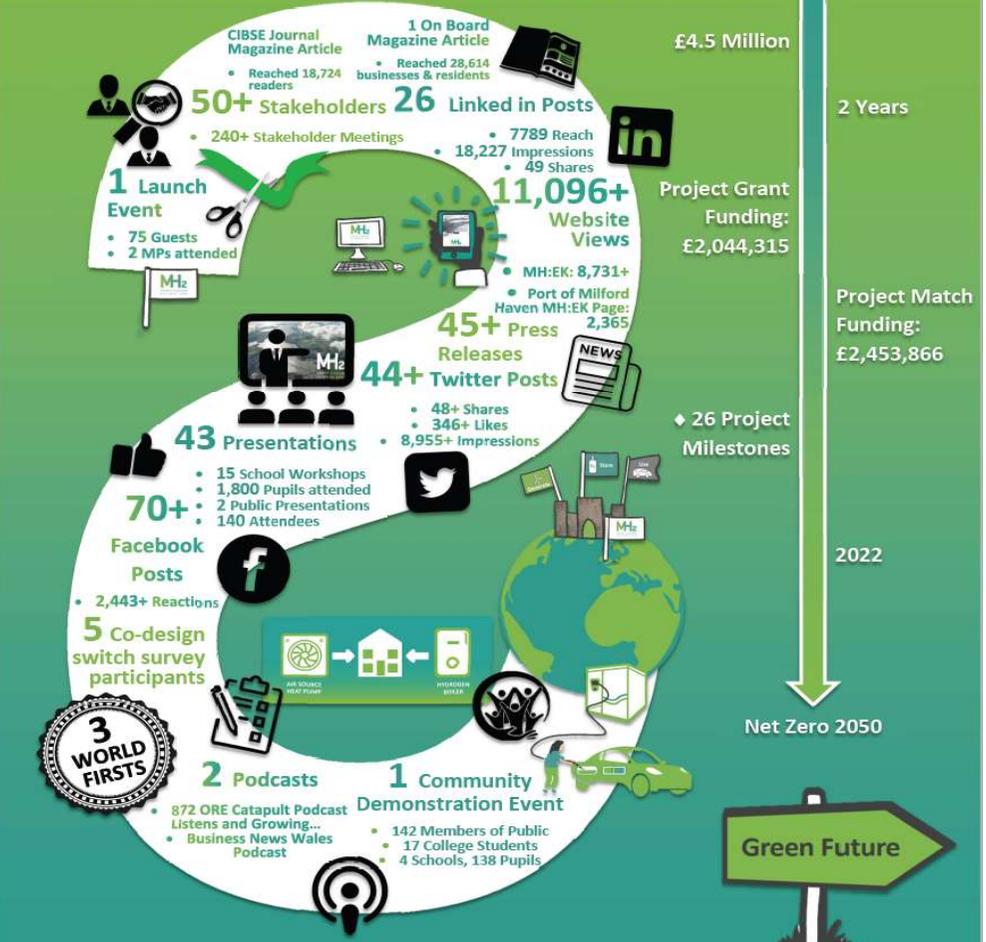
# Stakeholder engagement



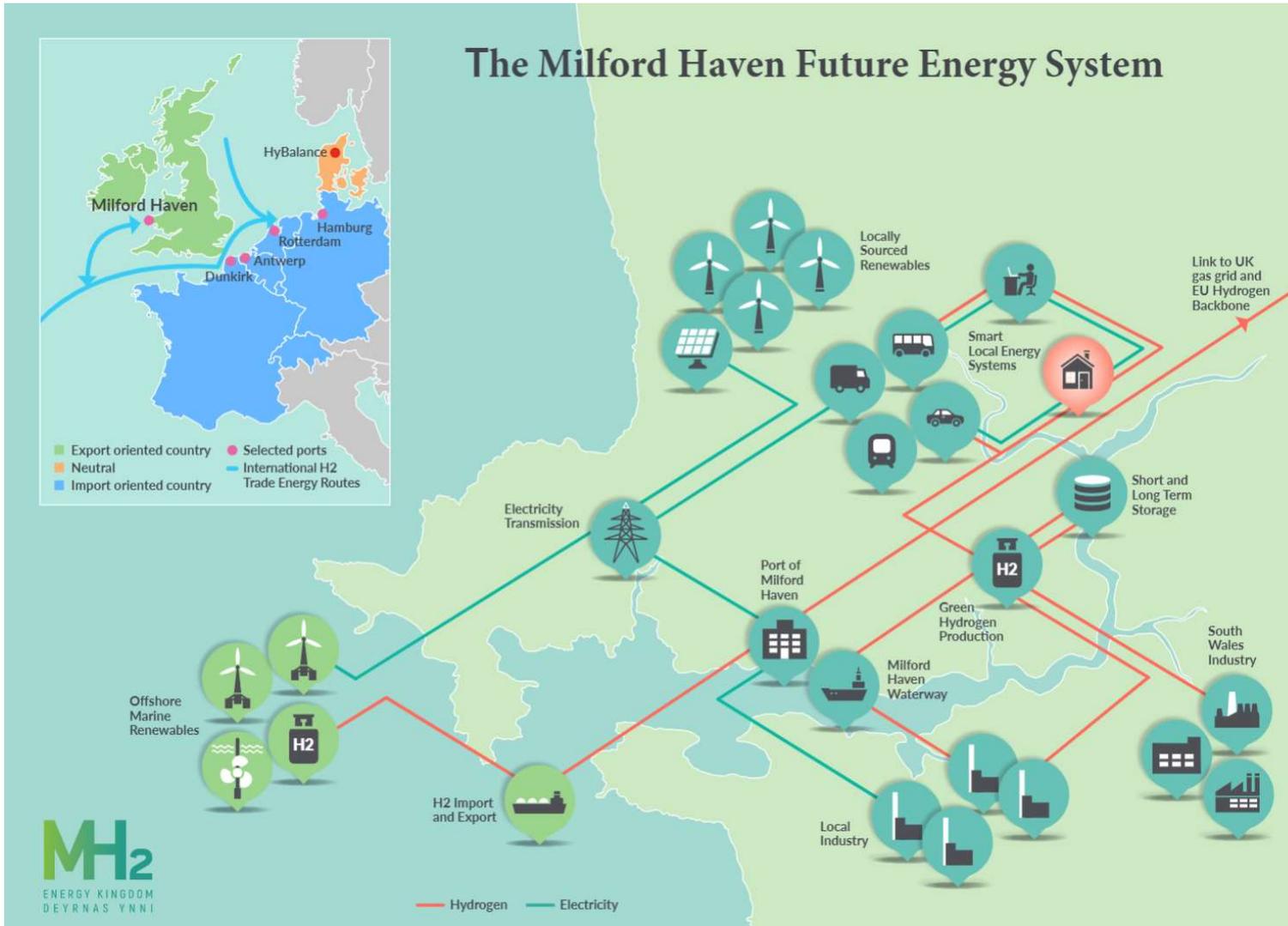
# MILFORD HAVEN: ENERGY KINGDOM (MH:EK)

# MH2 ENERGY KINGDOM DEYRNAS YNNI

## STAKEHOLDER ENGAGEMENT



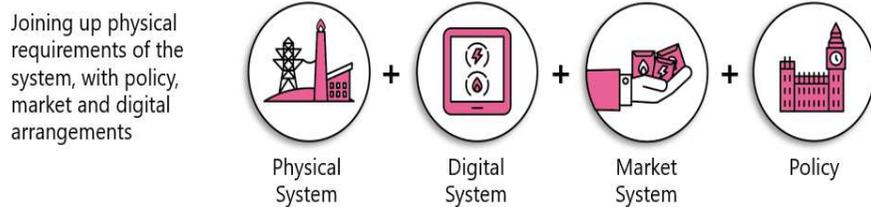
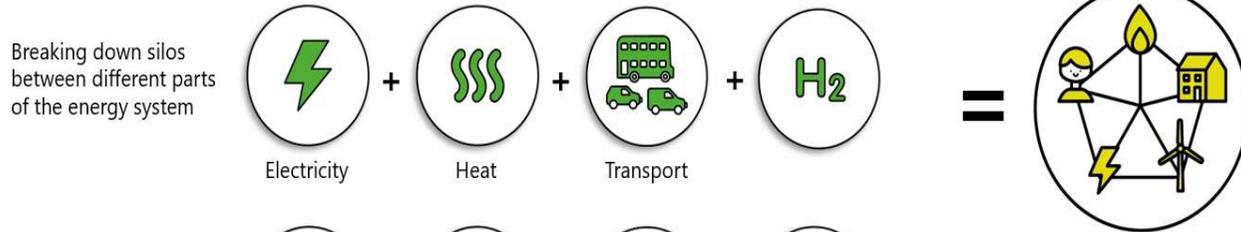
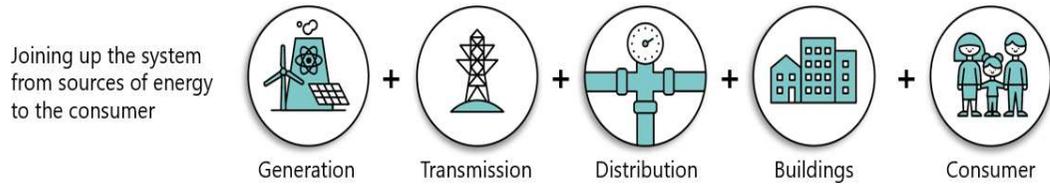
# MH:EK visual overview of The Milford Haven Future Smart Local Energy System



MH:EK 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.

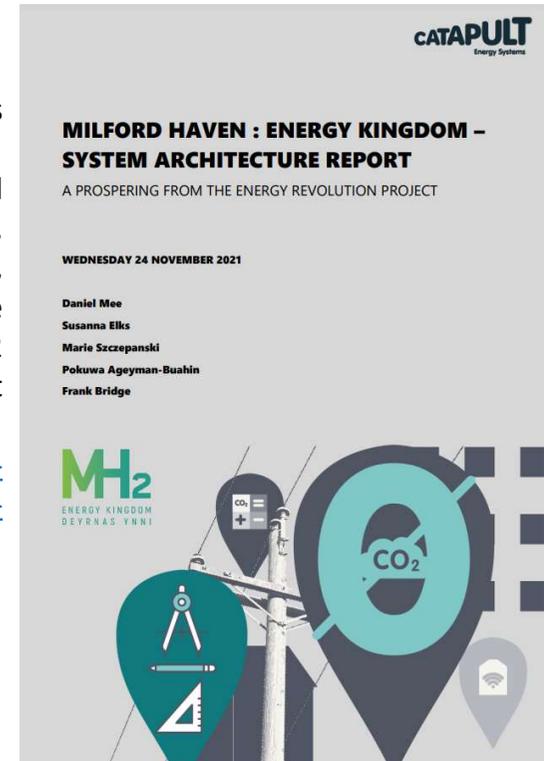
# Systems Architecture & H2 Trading platform

## 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](#)



## Co-designing a switch to hydrogen with customers

### Objective:

Repurposing the gas grid to supply hydrogen instead of natural gas could help solve perhaps the toughest Net Zero challenge: "decarbonising domestic heating".

- To build public support for a switch we need to know how to solve practical challenges like:
  - What will people do if they need to use gas during the 1-2 days it may take to switch them over?
  - What if the switchover takes longer due to unforeseen circumstances?
  - What will happen to people with gas boilers, hobs, ovens or fires that are not hydrogen-ready? (for whatever reason)
  - What will happen to homes that are vacant (e.g. second homes, residents are in hospital)?
- We must address consumers' concerns to roll out, at scale, successfully

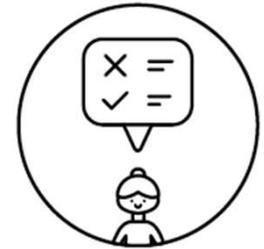
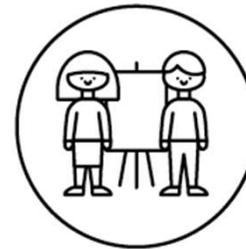
### How this fits into the wider project and Hydrogen Future:

**Insight**, understanding how to solve the challenges that could put consumers off Hydrogen

**Capability**, practical steps that will build consumer's confidence in switching to Hydrogen

**Deliverable**, a clear report with consumer testimonials

**Consensus**, collateral that builds consensus on how to switch places to Hydrogen



# Milford Waterfront - key focal point, project catalyst & demonstrators



Project elements	
①	Hydrogen Refueler Demo → August 2021 – Sept 2022
②	Hybrid Heating Demo → July 2021 – Sept 2022
③	Phase 1 and Phase 2 Detailed Design → Complete by Sept 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.

# 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.

PCC M&E and Energy Team procured and supervised the design & build

Capex £290,000



# Hydrogen FCEV – The Riversimple Rasa



# Hydrogen Fuel Cell Electric Vehicle (HFCEV) demo

## THE RIVERSIMPLE RASA



REGENERATIVE BRAKING INTO SUPER CAPACITORS

WEIGHS ONLY 655KG

4 IN WHEEL MOTORS, GIVING DIRECT 4 WHEEL DRIVE

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.



MILFORD HAVEN: ENERGY KINGDOM  
 READ MORE: [www.pembrokeshire.gov.uk/mh2-energy-kingdom](http://www.pembrokeshire.gov.uk/mh2-energy-kingdom)



## Electrolyser & Refueller

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 commissioned. H<sub>2</sub> first produced by electrolysis Friday 9<sup>th</sup> July 2021. Now in daily use



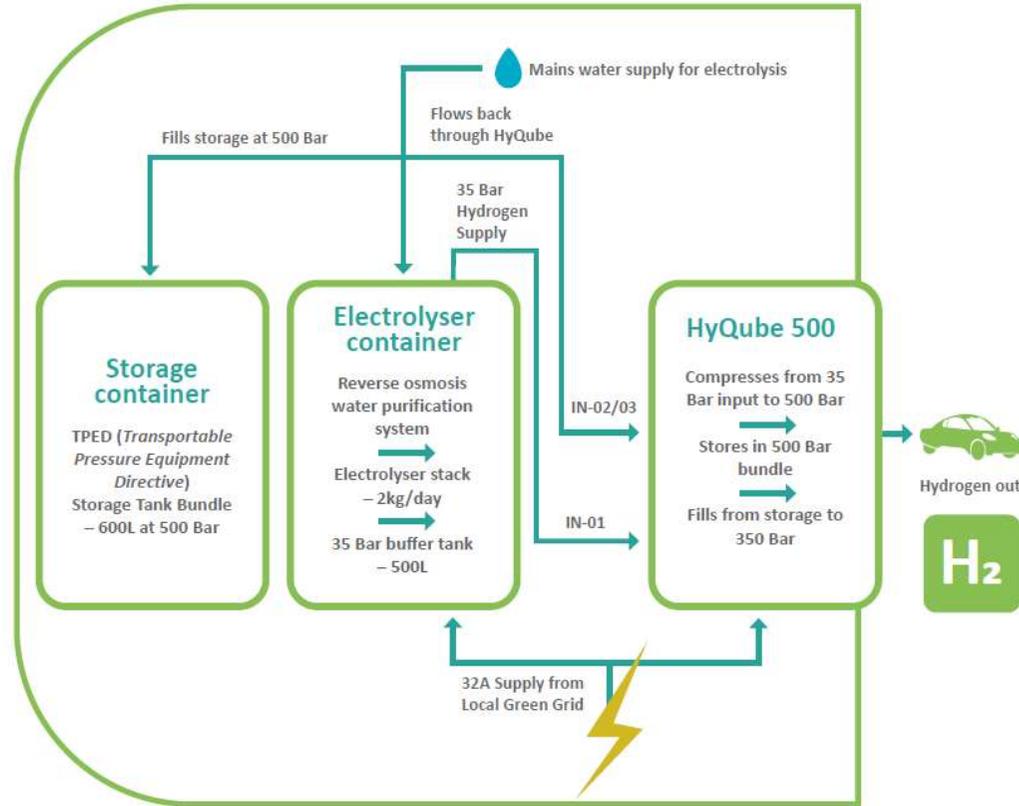
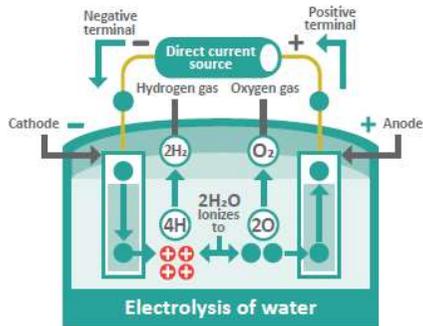
- 2 x 2.1 kW Enapter electrolyzers capable of producing 2 kg of H<sub>2</sub> per day at a cost of circa £8-18 (depending on availability of renewable power).
- Gas multi cylinder pack storage.
- Fuel Cell Systems Ltd 'HyQube' 350 Bar Refueller.
- 2 x Riversimple Rasa's capable of running for 240 miles on 2 kg of H<sub>2</sub> – 500 miles for Circa £40.
- 20 litres of water used to produce hydrogen in 24 hours run time.
- 360° virtual tour demonstrators: <https://www.pembrokeshire.gov.uk/mh2-energy-kingdom/mh2-demonstrators>

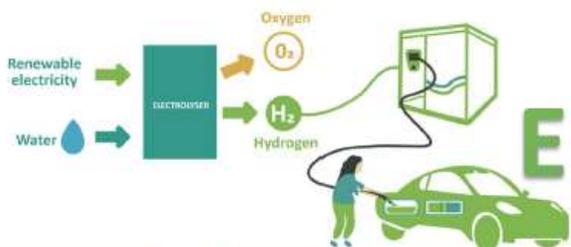
# HYDROGEN PRODUCTION AND DISPENSING

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.





# MILFORD HAVEN: ENERGY KINGDOM (MH:EK)

# MH<sub>2</sub>

ENERGY KINGDOM  
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<https://www.pembrokeshire.gov.uk/mh2-energy-kingdom>



# We influenced Pembrokeshire CC's and Swansea Bay Ultra Low Emission Vehicle Strategies



## PEMBROKESHIRE ULEV STUDY

Strategy Document

SEPTEMBER 2022

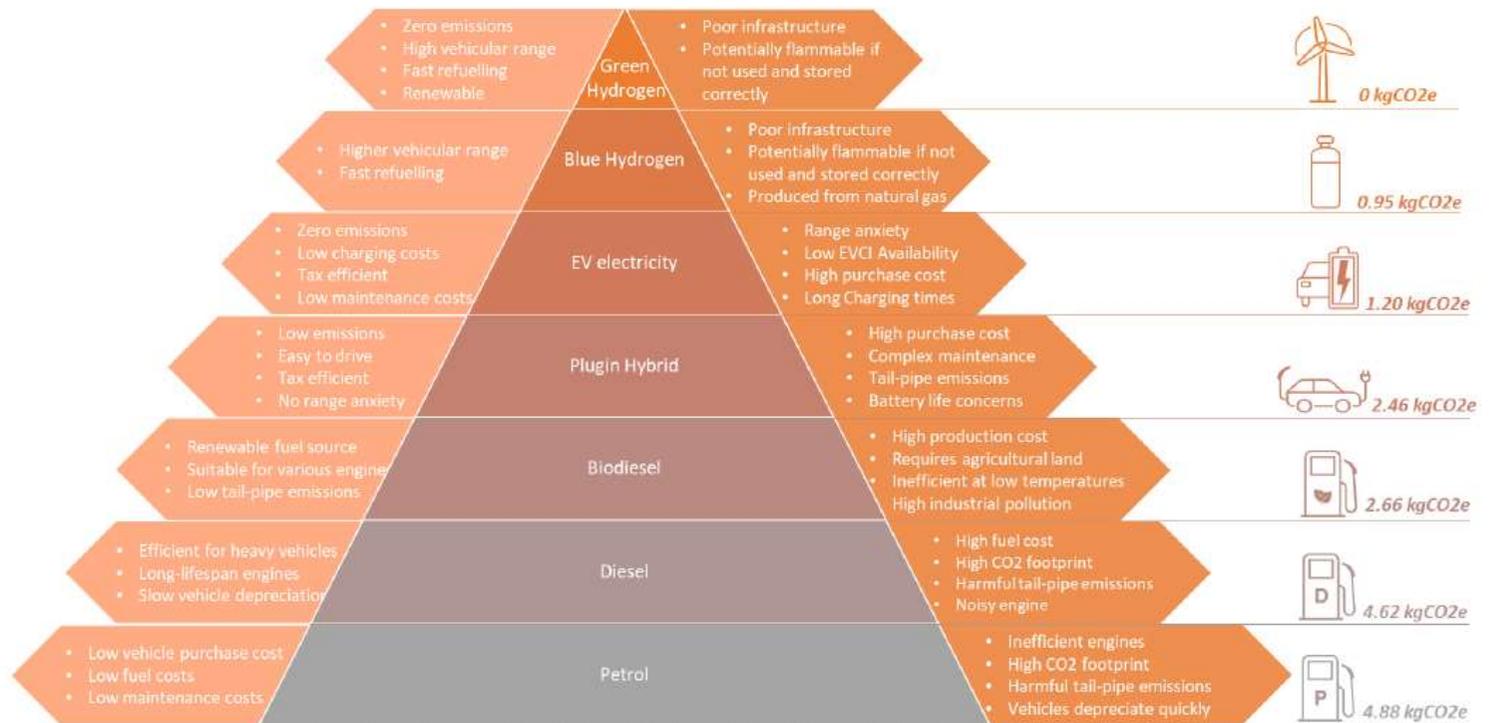


Figure 3: Fuel Hierarchy Pyramid and Equivalent Carbon Emissions (direct and indirect) per Trip (14.8miles average trip length)

*“As the hydrogen market continues to develop, we expect to see a wider range of vehicles available on the market and increased investment into infrastructure to support generation and distribution of hydrogen fuel. As this occurs, hydrogen fuelled vehicles, given their improved environmental performance relative to EVs may become the preferred type of ULEV.”*



**Developing a business case for a publicly accessible hydrogen refueller**

# Hydrogen Vehicle Demo & Design

## Why collect this data?

### 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.



### 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.



### Ownership

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



### 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.



### 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



### 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



# 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.

**MILFORD HAVEN: ENERGY KINGDOM**  
**THE FUTURE OF ENERGY**  
IN PEMBROKESHIRE RIGHT NOW

**MILFORD HAVEN: ENERGY KINGDOM** is a Pembrokeshire based project. It shows how renewable energy can be turned into hydrogen fuel to meet our energy needs for heating and transport.

UK Research and Innovation

## Pembrokeshire - a county of energy!

Pembrokeshire's energy history reaches back before the time of coal, through the age of oil, now looking forward to a renewable future.

**1600's**  
From the 1600s Carew Tidal Mill used energy from the movement of the tides to turn wheat into flour.  
Water and windmills were at one time a common sight around Pembrokeshire to mill wheat into flour.  
Horses were used for transport. Their fuel was hay and oats grown on the farms.  
The Pembrokeshire coal seam stretches from Amroth to Newgale. Pembrokeshire coal was of the highest quality!

**1960's**  
From the 1960s to the present-day, oil and gas have been an important industry in the county.

**Present Day**  
Pembrokeshire is taking its place in a future powered by renewable energy.

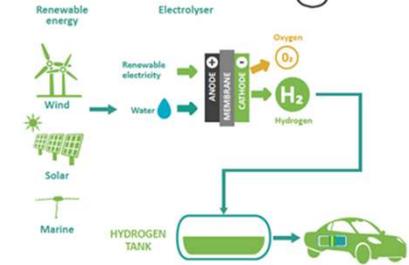


## Energy when we need it

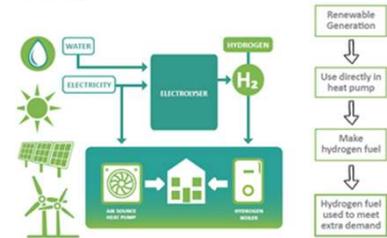
Renewable energy is used to make hydrogen in the electrolyser. The hydrogen fuel can be stored in a tank to power the hydrogen fuel cell electric vehicle or for heating.

## Why make Hydrogen Fuel?

- ✓ **Storage:** Energy is stored until it is needed.
- ✓ **Clean in Use:** No pollution or greenhouse gases.
- ✓ **Impact:** Lower impact to the environment than other types of energy storage.

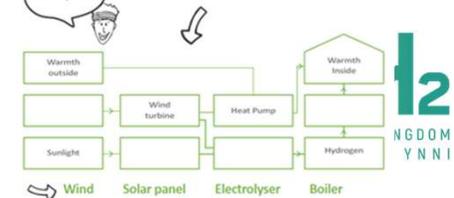


## Heating



The building's heating uses renewable energy to power a heat pump. The heat pump makes use of warmth in the outside air to create a comfortable temperature inside the building. This is even more efficient than using standard electric heaters. On very cold days a heating boost is provided by a hydrogen fuel boiler.

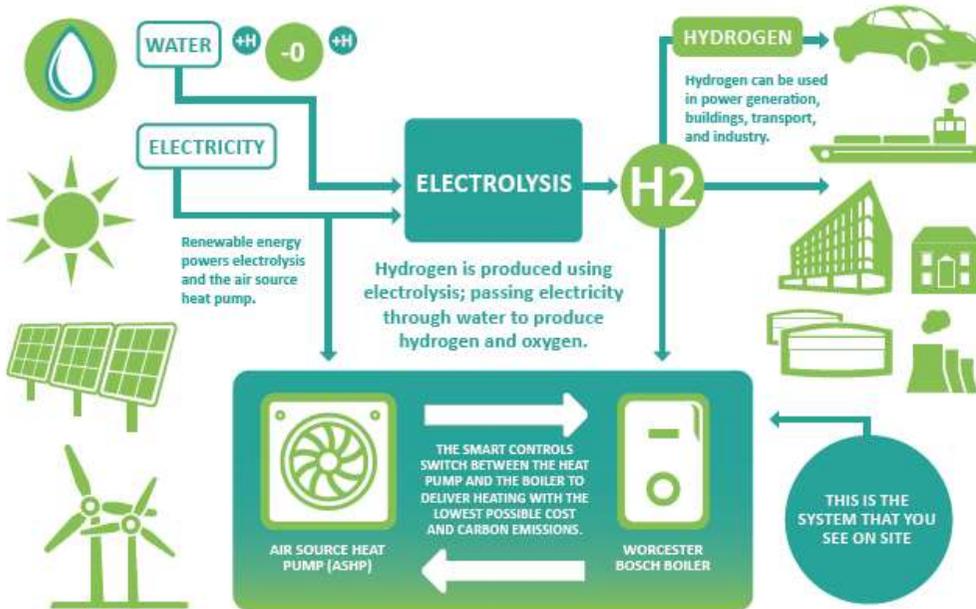
**Activity time!** Fill in the gaps in this flow chart



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# HYDROGEN HYBRID HEATING SYSTEM



MILFORD HAVEN: ENERGY KINGDOM is gathering detailed insight into the whole energy system around the Milford Haven Waterway, to identify and design a future Smart Local Energy System. The project is exploring how to make the distribution and use of green hydrogen financially viable within the different energy sectors of buildings, industry, power and transport.

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.

READ MORE: [www.pembrokeshire.gov.uk/mh2-energy-kingdom](http://www.pembrokeshire.gov.uk/mh2-energy-kingdom)

### Project partners



### Heating trial partners



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

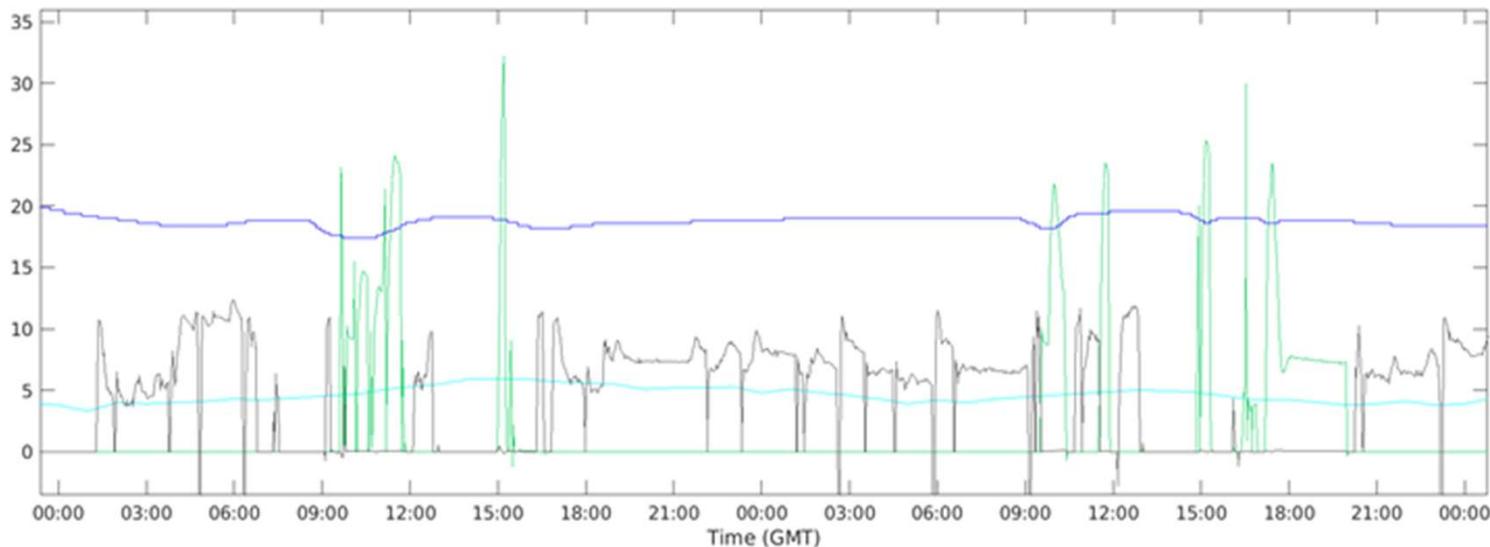
- Hydrogen trials completed in January
  - 20% blend hydrogen into methane
  - 100% hydrogen
- Partnership: MHPA, WWU, Passiv UK, Worcester Bosch, Kiwa.
- **Three world firsts for Milford Haven!**
- The first smart hybrid heating system in a commercial building.
- The first smart hydrogen hybrid heating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



## 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).

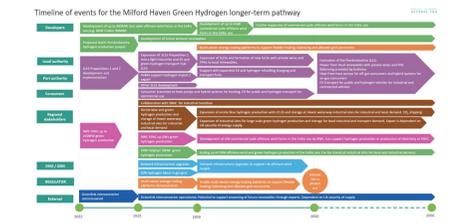
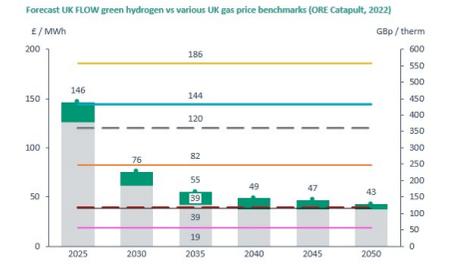
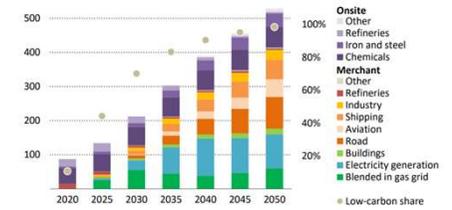
## MH:EK Community Open Day

- 18th May the MH:EK team showcased the Rasa and the hybrid heating demos.
- Over 300 people, 4 schools, Pembrokeshire College automotive, plumbing & mechanical engineering, students, Transport for Wales, PCC fleet managers, SWIC, Naked Energy, most and importantly local people.
- Four Rasa's buzzed people around and the refueller provided 7 fills of the Rasa's over an 18 hour timeframe.



# Investment Brochure

- Overview of investment opportunities
- Summary of the investments and returns from [1-3] near-term propositions
- Medium to long term Vision for the region
- Technology acceleration opportunities
- Investment context
- Summary of notable near-term funding mechanisms
- PESTLE analyses for key investment opportunities
- Detailed report on local and national political support for the vision
- Summary of notable local investments
- Summary of notable international investments impacting the medium-long term vision for Milford Haven.



LINK / SCOPE	ACTIVITY	FINANCING	MAJORITY
1	2025-2030	£1.5bn	100% UK
2	2030-2035	£1.5bn	100% UK
3	2035-2040	£1.5bn	100% UK
4	2040-2045	£1.5bn	100% UK
5	2045-2050	£1.5bn	100% UK



# Near term propositions modelled by ARUP

## The propositions



### Proposition 1 – The Milford Haven Marina SLES

Proposition 1 focuses on the assets owned by the Port of Milford Haven (PoMH). The proposition considers the existing Liddeston Ridge Solar farm as a key supply asset alongside prospective PV and wind extensions, as well as the potential for rooftop PV on the PoMH buildings. The demand assets across the heat, power and transport vectors include the existing and proposed buildings and the commercial vehicle fleet owned by PoMH.

The analysis showed that further expansion of renewable assets and closer integration between those assets and the demand at the waterfront would be beneficial. The preferred option for expansion is a 2.5MW wind turbine with a 3.5MW solar PV expansion as second preference. Either a power purchase agreement (PPA) or a private wire connection to the waterfront demand is also recommended.

Modelling for proposition 1 has been undertaken to a greater level of detail due to additional funding and therefore has only been run for the 2020 scenario at this higher level of detail.\*

2020 CAPEX with 66% Optimism Bias (£million)	2050 CO <sub>2</sub> emissions (kg/kWh)	2050 LCOE (£/kWh)	MCA Score
16.4	0.002*	0.081	3.4



Figure 1: Map overview of the Milford Haven Marina and Liddeston Ridge site with the proposition boundary.

\*CO<sub>2</sub> emissions are shown adjusted to a 2050 view and excluding gas heating emissions in order to compare like-for-like with proposition 2 and 3



### Proposition 2 – The Pembrokeshire Food Park SLES

Proposition 2 is centred around the Pembrokeshire Food Park, a planned development for a food distribution centre in Haverfordwest, alongside the planned 10MW Haverfordwest airfield solar PV, and PCC transport hub plans in Haverfordwest. There is strong interplay between the demand energy vectors (heating, cooling, electricity and hydrogen) and a significant opportunity to utilise local waste products to fulfil this demand.

As a new-build proposal, the food park could be designed to take advantage of no regret technologies, particularly anaerobic digestion, biogas cold climate heat pump and polyvalent heat pumps. These can be integrated via heating and cooling distribution networks.

Utilising excess PV generation to electrolyse hydrogen locally would be a cost-effective method of meeting some transport demand. If local hydrogen transport demand grows this proposition could form a local hydrogen transport hub.

2050 CAPEX with 66% Optimism Bias (£million)	2050 CO <sub>2</sub> emissions (kg/kWh)	2050 LCOE (£/kWh)	MCA Score
24.1	0.003	0.074	3.9



Figure 2: Visualisation of the proposed Pembrokeshire food park (©hacerdevelopments.com/)



### Proposition 3 – The Pembro Schools, Leisure Centre and Dock SLES

Proposition 3 is located in Pembrokeshire and is geographically closer to the hydrocarbon-based energy industries on the Haven waterway. As such, this proposition promotes a geographical spread with prospects on stepping up to a wider SLES in the long term as the industrial partners on the Milford Haven waterway seek to decarbonise.

The project considers potential incorporation of existing solar generation assets into the SLES and identifies opportunities for additional renewable generation.

The outcome of Proposition 3 suggests that it is not a strong SLES candidate as modelled. The outcomes mainly consist of a large capacity of solar PV that predominantly exports its generation to the national grid for income. There is little to no district-level integration between the buildings' heating systems and very limited interaction between energy vectors.

2050 CAPEX with 66% Optimism Bias (£million)	2050 CO <sub>2</sub> emissions (kg/kWh)	2050 LCOE (£/kWh)	MCA Score
22.2	0.001	0.030	2.1



Figure 3: Pembrokeshire Ysgol Harri Tudor School (© <https://www.ysgolharritudor.cymru/>)

## Investable propositions, next steps (PCC, PoMH and partners):

- taking the whole system energy modelling undertaken to date to the next stage of detail to support a more detailed design;
- exploration and use case testing of the SPV / partnership commercial model;
- specific stakeholder engagement to explore their appetite for such a model, and to better understand what risks or barriers there might be in implementing;
- exploring in more detail how the ESCo model would work in practice, what the relationship would be with other project partners, and the commercial relationship with entities outside of the SPV partnership perimeter;
- financial modelling to further understand the potential pay-back or revenue to different parties; and establishing a detailed management plan, including: an implementation programme, data management, risk management and contract management approaches

## Milford Haven hosts key energy infrastructure making it an ideal location for green hydrogen hub

### Milford Haven is an ideal location to be a green hydrogen pioneer

A global 'gold rush' for green hydrogen has begun.

Milford Haven Waterway has perhaps the best potential in the UK to become a global green hydrogen port/hub, using local Floating Offshore Wind.

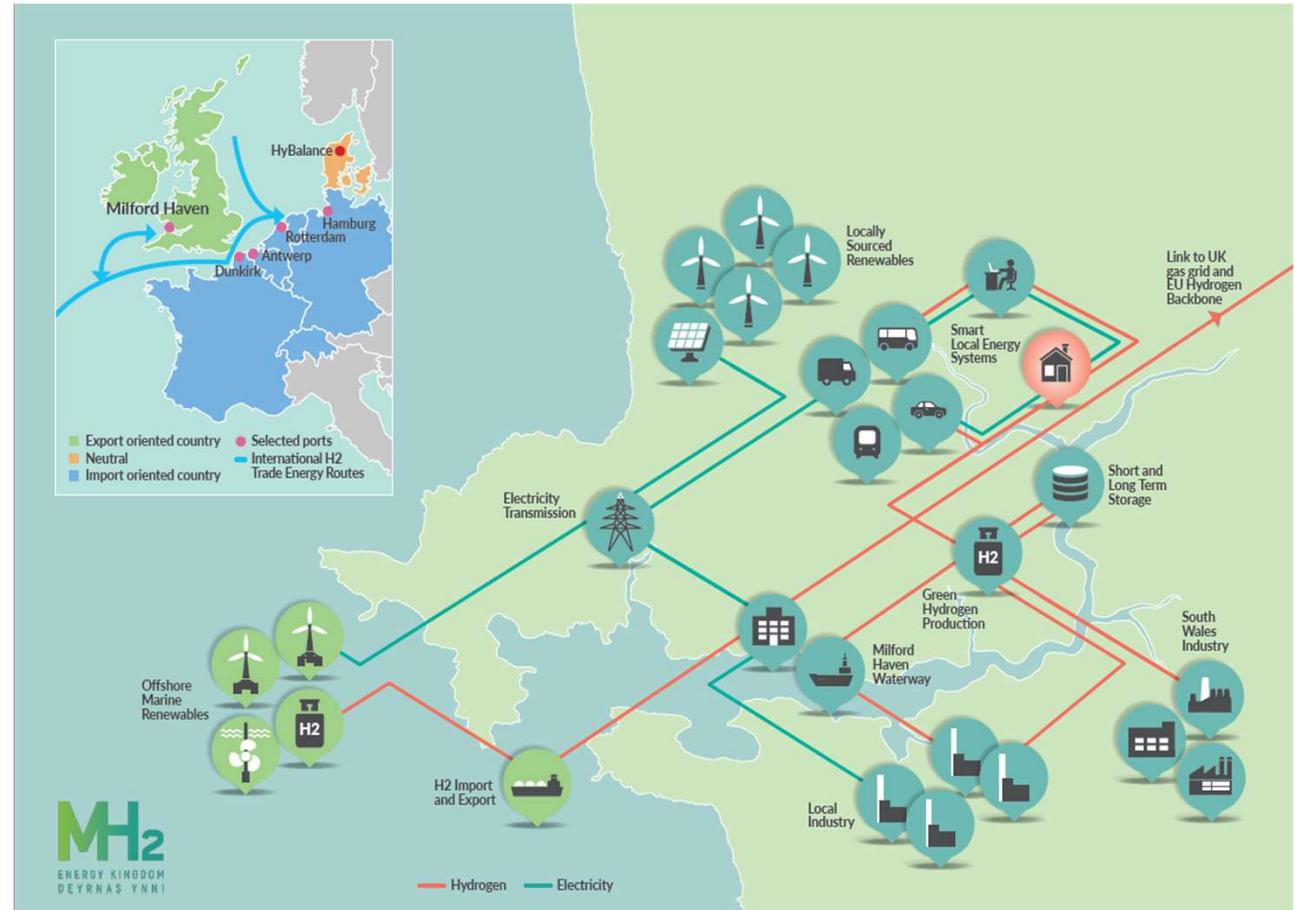
Green H2 can meet energy demand growth and bolster energy security for the UK and Europe

### Existing energy infrastructure is a tremendous platform for growth into green hydrogen

Gas industry on the MH Waterway has capacity to develop infrastructure for imports of affordable green hydrogen and to receive and process local offshore renewable hydrogen.

A proposed green hydrogen pipeline 'backbone' for GB can be built out from Milford Haven.

The public's acceptance of hydrogen is unusually high, due to familiarity with having a major energy industry cluster on the Haven for decades.



# Longer Time-Horizon Energy Generation Development Report

- Theme 1 – Technology Development
- Theme 2 – SLES Roadmap/Scenario Review
- Theme 3 – Larger Demonstration Proposals
- Theme 4 – MH:EK in a global green hydrogen market



## Life Project Summary

First 100% H<sub>2</sub> to homes, zero carbon network in the world (located at Levenmouth)



- Heating for around 3 2022 to 2025; using 1 produced by an elect our LDT
- Supply of hydrogen 1 Levenmouth at the f energy revolution
- Pricing terms agreed
  - PPA contract ex
- LDT has capacity to : (see Phase 2)
- Operational links wit being developed (Hy demonstrator)

## ENERGY SYSTEM

energy system requires 130TWhr /hr hydrogen in 2050, to integrate or more of offshore wind.

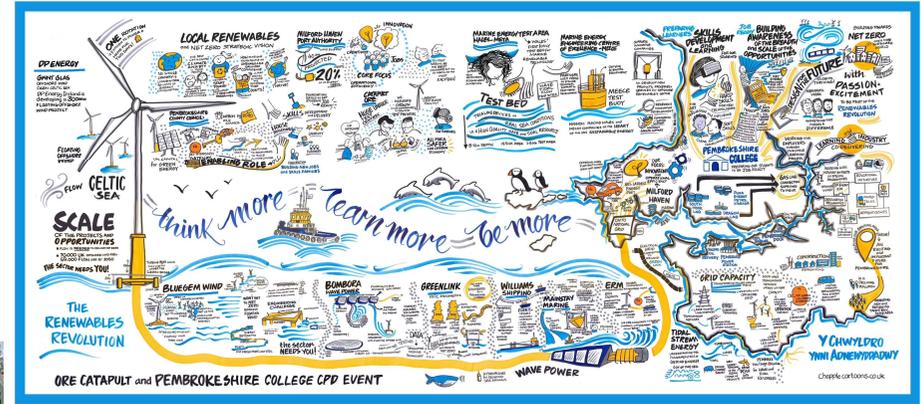
A diagram showing two overlapping circles. The left circle contains the text '130 to +200 TWh' and the right circle contains '+75 GW'. Arrows indicate a flow between the two circles.

- Heating for around 3 2022 to 2025; using 1 produced by an elect our LDT
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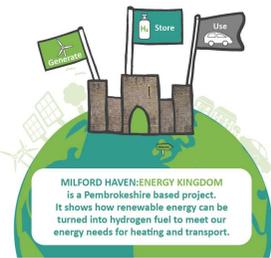


# Community / Education Work

- Visits to 27 local schools/colleges
- Pembrokeshire College events
- Sir Sero (Zero County) event
- IGEN Wales branch technical visit.
- British & Irish Council visit
- WG/BEIS visit
- RWE Pembroke 10 year anniversary event
- 'Destination Renewables' course at Pembrokeshire College
- Community open day
- Demonstrator launch event

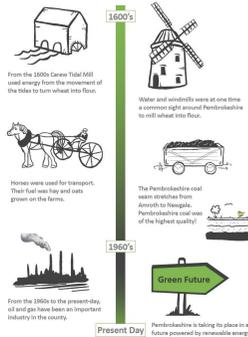


MILFORD HAVEN: ENERGY KINGDOM  
THE FUTURE OF ENERGY  
IN PEMBROKESHIRE RIGHT NOW



### Pembrokeshire - a county of energy!

Pembrokeshire's energy history reaches back before the time of coal, through the age of oil, now looking forward to a renewable future.

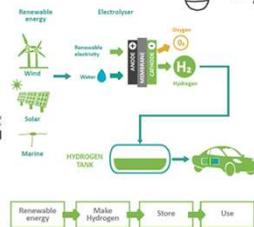


### Energy when we need it

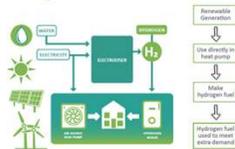
Renewable energy is used to make hydrogen in the electrolyser. The hydrogen fuel can be stored in a tank to power the hydrogen fuel cell electric vehicle or for heating.

### Why make Hydrogen Fuel?

- ✓ Storage: Energy is stored until it is needed.
- ✓ Clean in Use: No pollution or greenhouse gases.
- ✓ Impact: Lower impact to the environment than other types of energy storage.

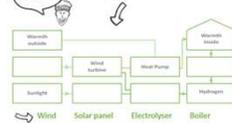


### Heating



The building's heating uses renewable energy to power a heat pump. The heat pump makes use of warmth in the outside air to create a comfortable temperature inside the building. This is even more efficient than using traditional electric heaters. On very cold days a heating boost is provided by a hydrogen fuel boiler.

Activity time Fill in the gaps in this flow chart



## 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.



## The Bigger Picture



[Milford Haven Waterway Future Energy Cluster – Delivering an accelerated transition to a Net Zero future - 2023 on Vimeo](#)

This video from the newly launched Milford Haven Waterway Future Energy Cluster articulates the opportunity and momentum that has been mapped through MH:EK



# Milford Haven Waterway Future Energy Cluster

## Milford Haven Waterway Future Energy Cluster

### Delivering an accelerated transition to a Net Zero future

The Milford Haven Waterway aims to support the UK by achieving...

20% of UK Government low carbon hydrogen production target by 2030

At least 10% of UK Government floating offshore wind target by 2035

The Milford Haven Waterway is a critical national energy asset, attracting billions of pounds in investment for over sixty years and supplying 20% of the UK's annual energy demand.

The Waterway has a pivotal role to play in delivering the UK's net zero ambitions, offering a whole energy cycle solution that will unlock accelerated transition, while stimulating economic growth. This is an opportunity that will repurpose existing assets, skills, rail connectivity,

transmission and pipelines to deliver a future focused on hydrogen (blue and green), floating offshore wind (FLOW), marine renewables, sustainable alternative fuels, CO<sub>2</sub> shipping, and energy storage.

The benefits are clear. Continued investment and support will create and stabilise thousands of jobs and supply chain opportunities, levelling up the coastal communities across South Wales. It will strengthen UK energy resilience while establishing new export opportunities. And, it will stimulate inward investment providing clear line of sight on returns for investors, ensuring the Milford Haven Waterway remains a major energy innovation hub capable of competing globally.

#### Government support is needed:

- + Expand South Wales' grid capacity by 10GW by 2030
- + Implement a fast-tracked consenting regime
- + Back a South Wales Green Freeport bid
- + Introduce mechanisms to de-risk the Celtic Sea FLOW opportunity
- + Back a South Wales Floating Offshore Wind (FLOW) infrastructure bid
- + Support the Milford Haven Waterway SuperPlace ambition, including both blue and green hydrogen
- + Support prioritisation of South Wales in National Grid's Project Union
- + Support a BEIS Cluster Sequencing Track 2 bid
- + Incentivise the production and use of low carbon fuels
- + Back a Skills Accelerator programme
- + Back a Supply Chain Accelerator programme

The Milford Haven Waterway Future Energy Cluster brings together private and public sector operations to deliver UK and Welsh Governments' energy ambitions.



**Blue Gem Wind**

The pioneer of floating wind in the Celtic Sea.



Delivering the Ramsey Sound regeneration of a tidal energy deployment site, including a grid connected, subsea tidal turbine, sub-station and associated infrastructure.



Renewable energy developer DP Energy has a 30 year track record with a global portfolio spanning wind, solar and ocean energy, operating in the UK, Ireland, Australia and North America.



Dragon LNG, an LNG import terminal, is a critical national infrastructure site with the capacity to supply 10% of the UK's power demand.



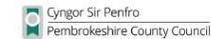
Developers of the 300 MW ERM Dolphyn offshore hydrogen project generating green hydrogen from floating offshore wind, piped directly back to Milford Haven. ERM will be trialling the system offshore in Summer of 2023 with the commercial start-up of the field planned for 2028.



Marine Energy Wales brings together technology developers, the supply chain, academia and the public sector to establish Wales as a global leader in sustainable marine energy generation, making a significant contribution to a low carbon economy.



The UK's leading technology innovation and research centre for offshore renewable energy.



Pembrokeshire County Council will use all levers at our disposal to maximise Pembrokeshire's Economy and ensure the aims of the Haven Waterway Future Energy Cluster are met. This is essential to continue Pembrokeshire's key place in delivering 30% of the UK's energy, making Pembrokeshire the UK Capital of Green Energy and the bedrock for the UK's hydrogen economy.



Connecting renewable energy projects with investment to create opportunity.



The UK's largest energy port.



Developing a world leading truly sustainable cluster benefiting the societal needs for 2030, 2040, 2050 and beyond.

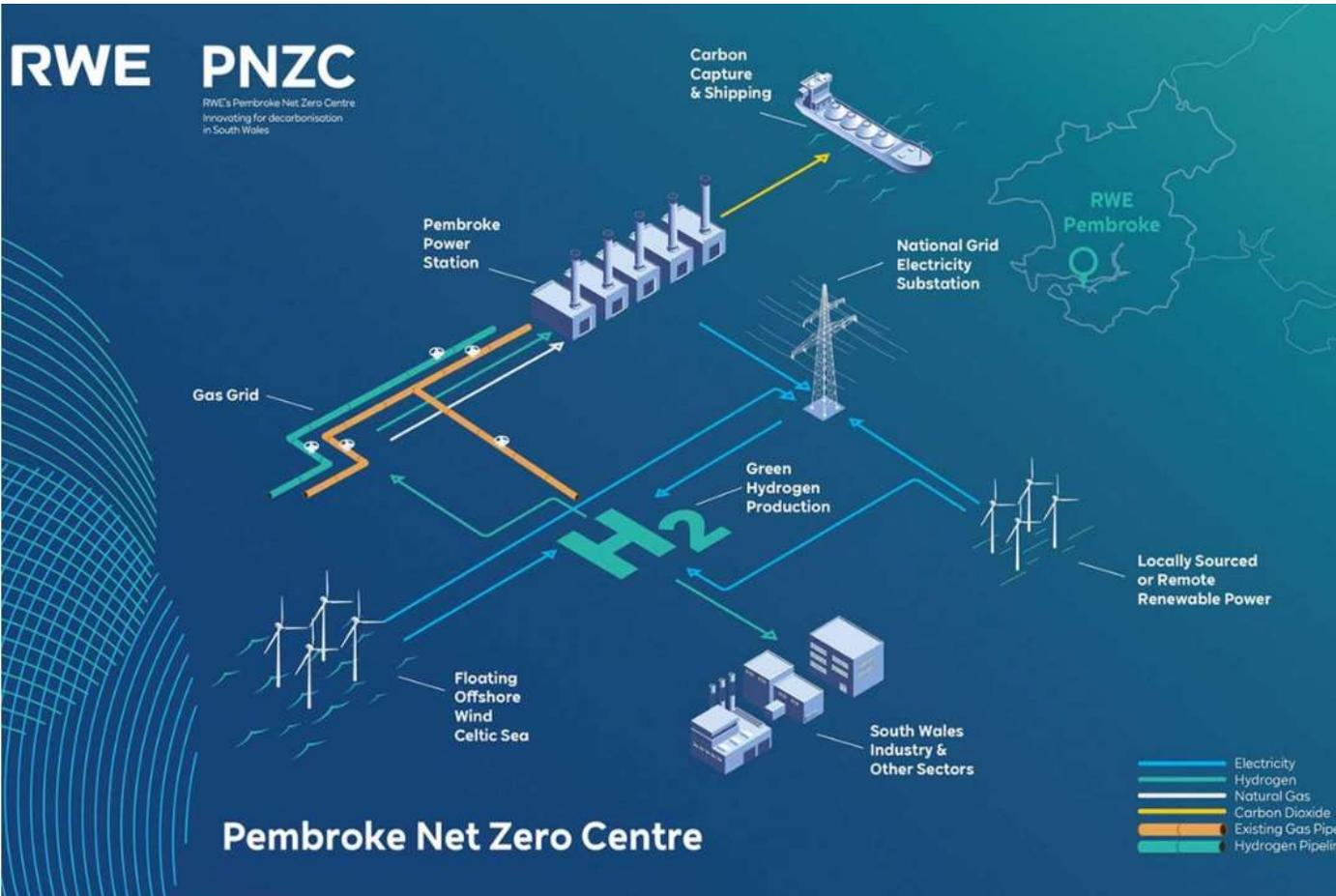


RWE is the largest power producer in Wales and the country's number one renewable energy generator, with over 3GW of capacity. RWE's flagship Pembroke Power Station hosts the Pembroke Net Zero Centre, looking at future decarbonisation opportunities including hydrogen and floating wind in the Celtic Sea.



Valero owns and operates Pembroke Refinery in south-west Wales, which is one of Europe's largest and most complex refineries, supporting over 1,000 jobs in Pembrokeshire. A major supplier of retail, commercial and aviation fuels, supported by our investments in supply infrastructure across the UK, Valero is also one of the world's largest producers of renewable liquid fuels

## Industry '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 H<sub>2</sub> electrolysis (by 2026) and up to 1GW (by 2030). (UK target for 10 GW by 2030)
- H<sub>2</sub> 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.

# Statkraft - Trecwn



Trecwn Green Energy Hub is being developed by Statkraft, Europe's largest generator of renewable energy, and is the company's first green hydrogen project to be announced in the UK

A 15MW green hydrogen electrolysis plant to generate three tonnes of green hydrogen a day. (Enough to run a single bus for over 40,000 miles, or the equivalent of making 350 journeys from Fishguard to Cardiff)

Green hydrogen will be used to power trains running on railway lines west of Swansea and it could also power the Council's fleet of HGV lorries and local buses, with the site able to produce enough green hydrogen to run around 170 buses every day, when operational

If the planning application is successful, construction would take around 15 months, so the site could be generating green hydrogen by 2026.

## Project summary

**H 15 MW**  
Hydrogen electrolyser

**14.4 MW**  
Three wind turbines up to of 150m (to blade tip)

**15 MW**  
Ground mounted solar arrays

**H 4 TONNES**  
Hydrogen storage

**H 100%**  
Clean, carbon-free hydrogen

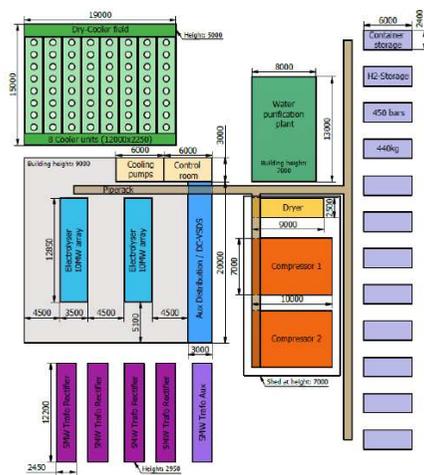
**£ £73k**  
Per year based on installed MW for a Community Fund\*

# Puma/Trafigura – Milford Haven 20 MW Green H2 Project

MILFORD H2 PROJECT

## Planned H2 production facility at Milford Haven

Draft Layout Milford 20MW H2 Plant



Artist's impression of a large scale hydrogen production plant

### Phase 1

- Location: Milford Haven, Wales, UK



- Electrolysis Capacity: 20 MW (import only)
- Daily h2 production: c. 4 tons
- Electricity source: new and operating wind farms in the UK
- Targeted CO2 savings: 15,000+ tons CO2e annually
- 15+ new green jobs created in Phase 1 alone; design life of >20 years
- Expected Timelines:
  - Q4 2022 - Submission of planning application
  - Q2/3 2023 – Financial Investment Decision (FID)
  - Q4 2025 – Commissioning Date



## Milford Haven H2 Project

## Milford Haven now clearly identified as part of Project Union

### Why Project Union is vital:



Urgency, pace and scale is required to ensure energy security and independence, benefitting all UK consumers to realise the UK's decarbonisation challenge and deliver legally binding net zero 2050 commitments



Low carbon hydrogen is required for all net zero scenarios



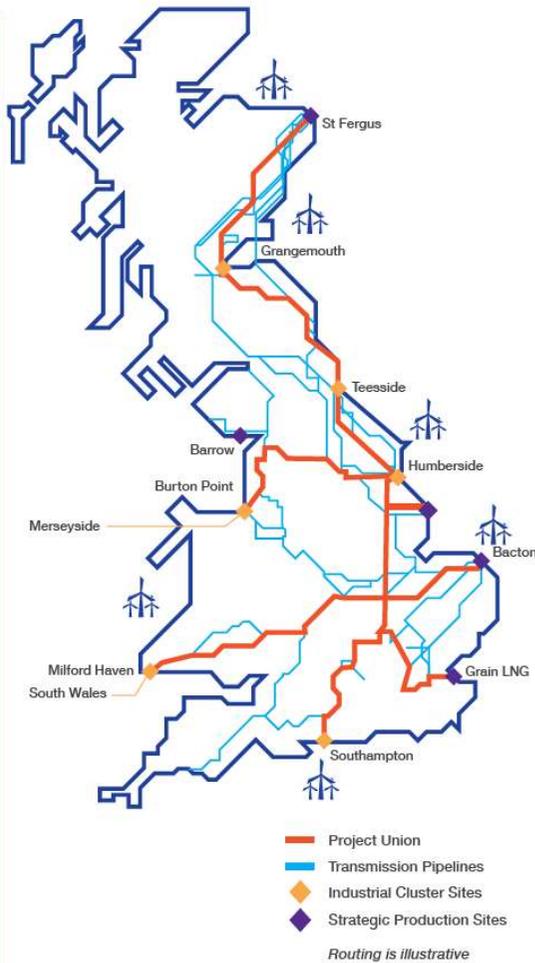
UK Hydrogen Strategy sets a target of 10GW of hydrogen production – equivalent to six million homes



Low carbon hydrogen can enable decarbonisation of industry and provide optionality for transport and domestic heating

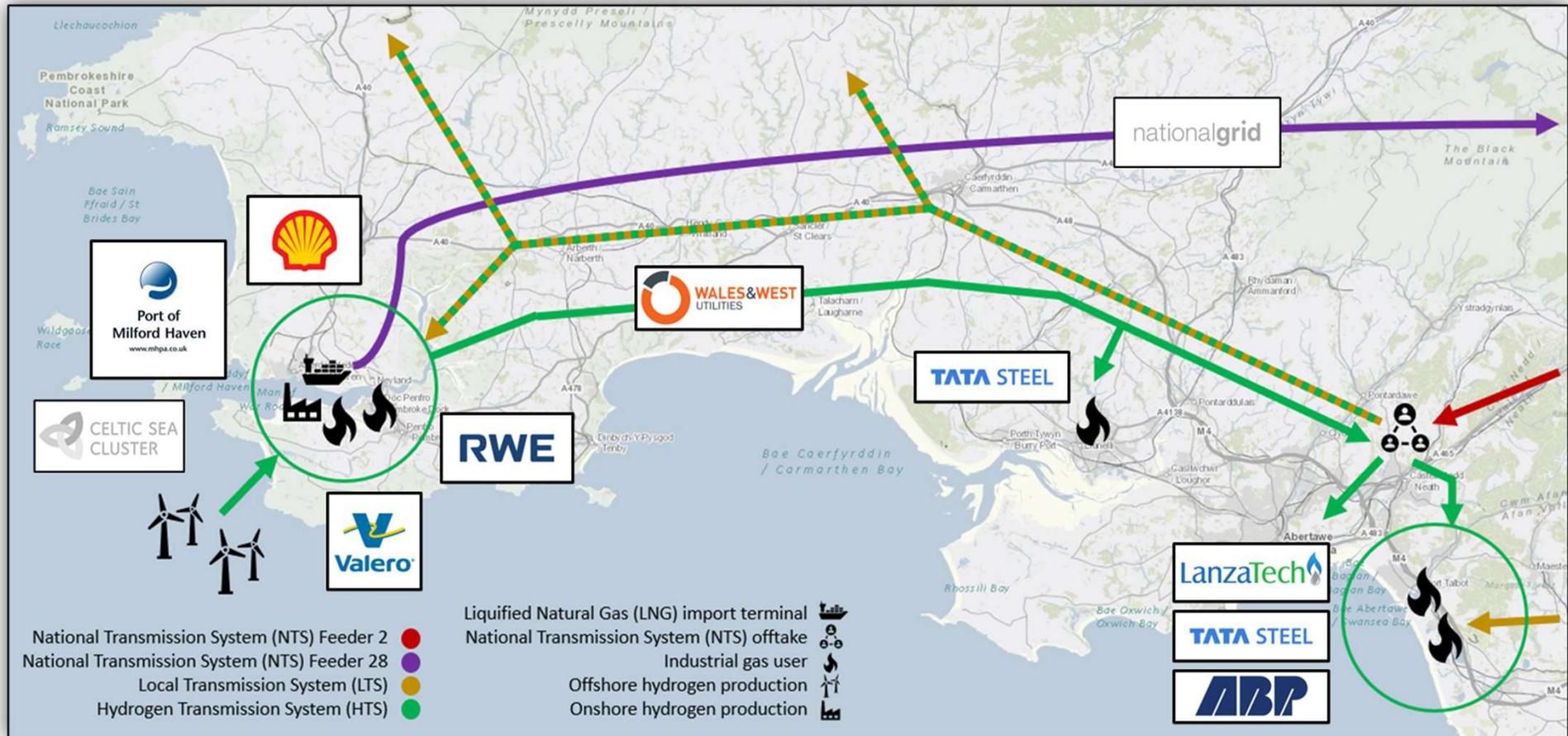


Investment in hydrogen transmission infrastructure is required to link supply and demand, de-risk investment decisions, and secure inward investment to realise a hydrogen economy and reduce the impact on the consumer

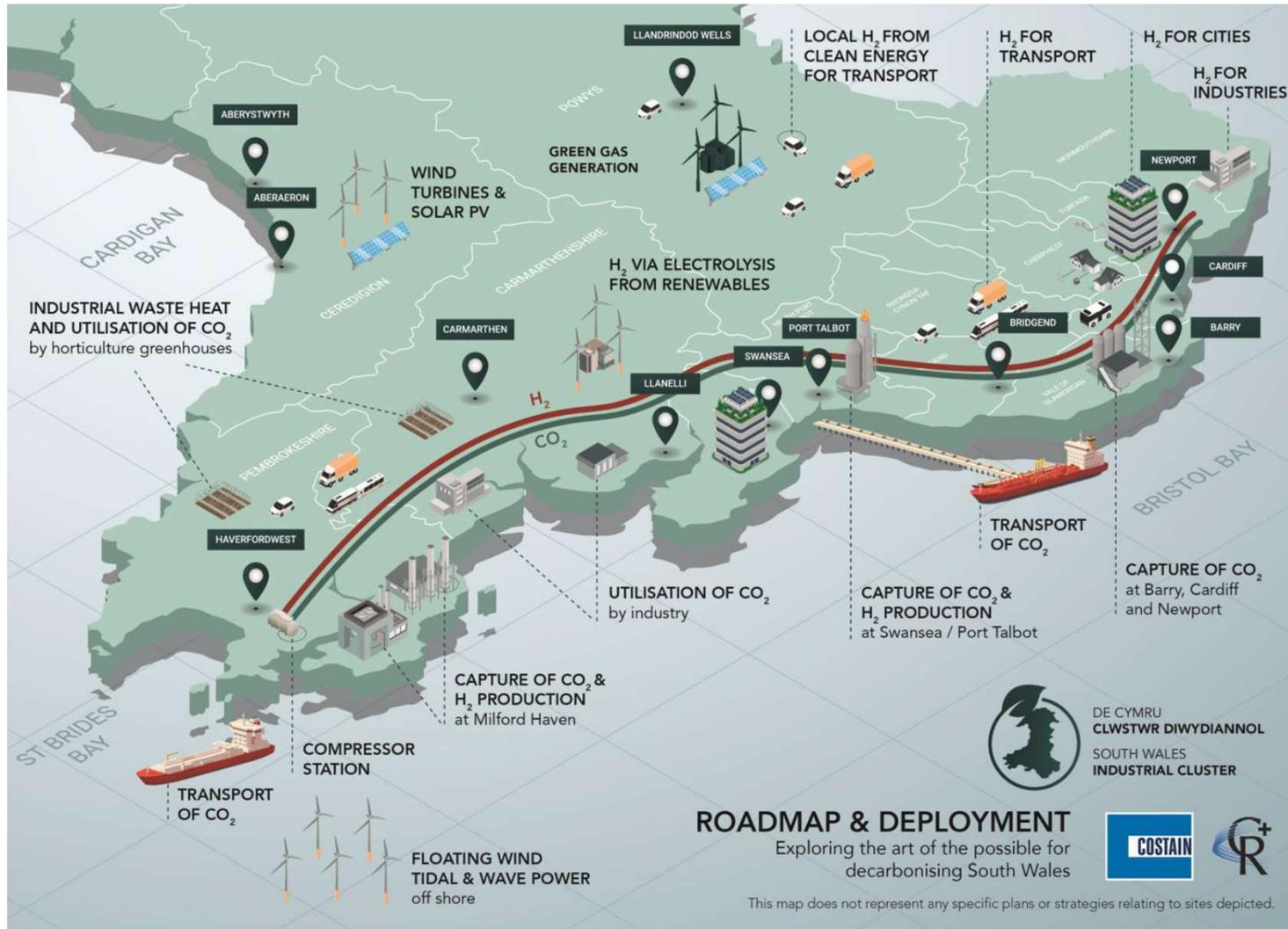


Project Union will connect hydrogen production, storage and demand to enable net zero and empower a UK hydrogen economy. Repurposing existing transmission pipelines will create a low-cost hydrogen ‘backbone’ for the UK by the early 2030s and connect to the proposed European Hydrogen Backbone. It will deliver a programme of ‘no-regrets’ investments with supporting evidence to inform energy policy that will enable the Government to make progress in realising its hydrogen ambitions.

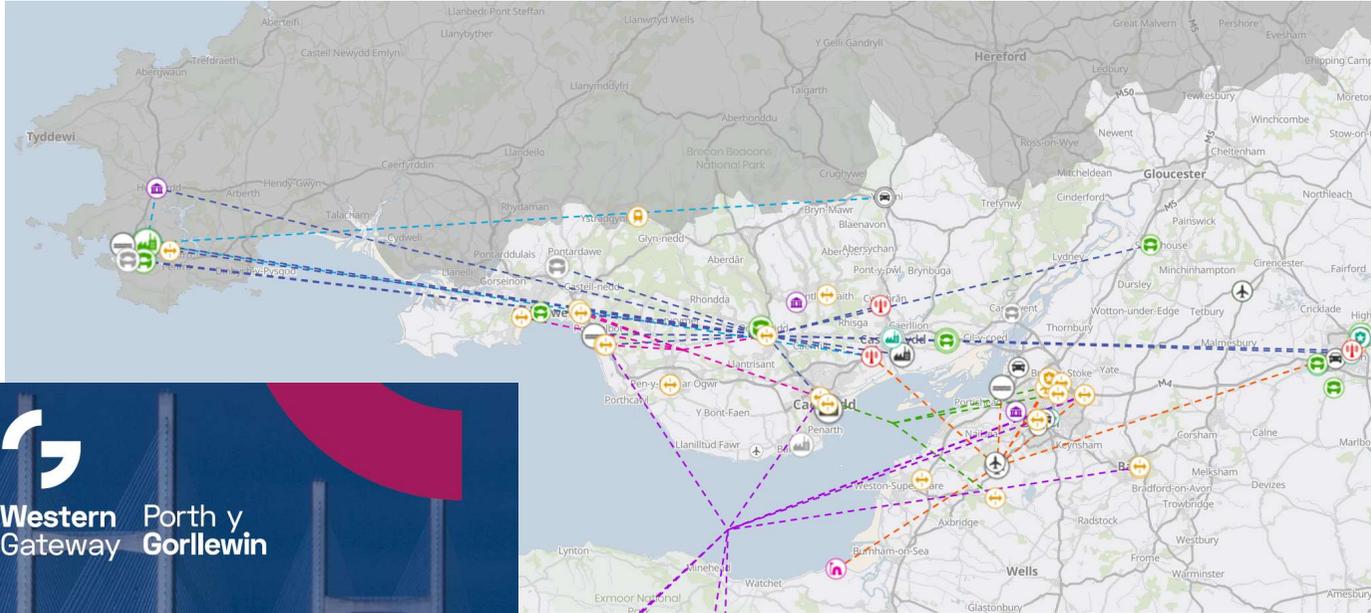
# WWU Hydrogen LTS Feasibility – Phase 1 – ‘HyLine Cymru’



# South Wales Industrial Cluster (SWIC)



## Western Gateway Hydrogen Network brochure and mapping



**Western Gateway Porth y Gorllewin**

**The Western Gateway Hydrogen Ecosystem**  
Providing the nation with a testbed for developing the UK hydrogen economy.

**Powering a greener, fairer future**

### [hydrogen brochure and mapping tool.](#)

“South Wales and Western England are already leading the way in developing Hydrogen as a clean fuel to help the world decarbonise to reach Net Zero. Through the Western Gateway Partnership, this new Hydrogen Ecosystem is helping to bring together the best of what these areas have to offer across the wide range of potential uses and helping to supercharge this work to meet the challenges we face.”

- **Milford Haven Energy Kingdom (MH:EK):** is a consortium of partners including the Port of Milford Haven, Pembrokeshire County Council, Catapult Energy Systems, Wales & West Utilities, Riversimple, Arup, and others within the South Wales Industrial Cluster (SWIC). MH:EK has developed plans to use hydrogen as part of a decarbonised smart local energy system alongside ambitious plans to harness offshore wind and tidal energy. The port of Milford Haven is one of UK's largest energy ports and is central to realising this initiative. It is home to the import and generation of 25% of the UK's energy and benefits from a natural harbour, vast offshore wind potential and the grid transmission infrastructure and as such, the area is well positioned to become a significant UK and European hub for hydrogen. The Milford Haven: Energy Kingdom project is paving the way to a renewables and hydrogen future for the Haven waterway and the Western Gateway.

## Green Energy Freeport bid

# South-West Wales launches a freeport bid consortium

A freeport bid consortium consisting of Associated British Ports, Neath Port Talbot Council, Pembrokeshire County Council and the Port of Milford Haven has been launched to explore the case for a green freeport in South-West Wales.

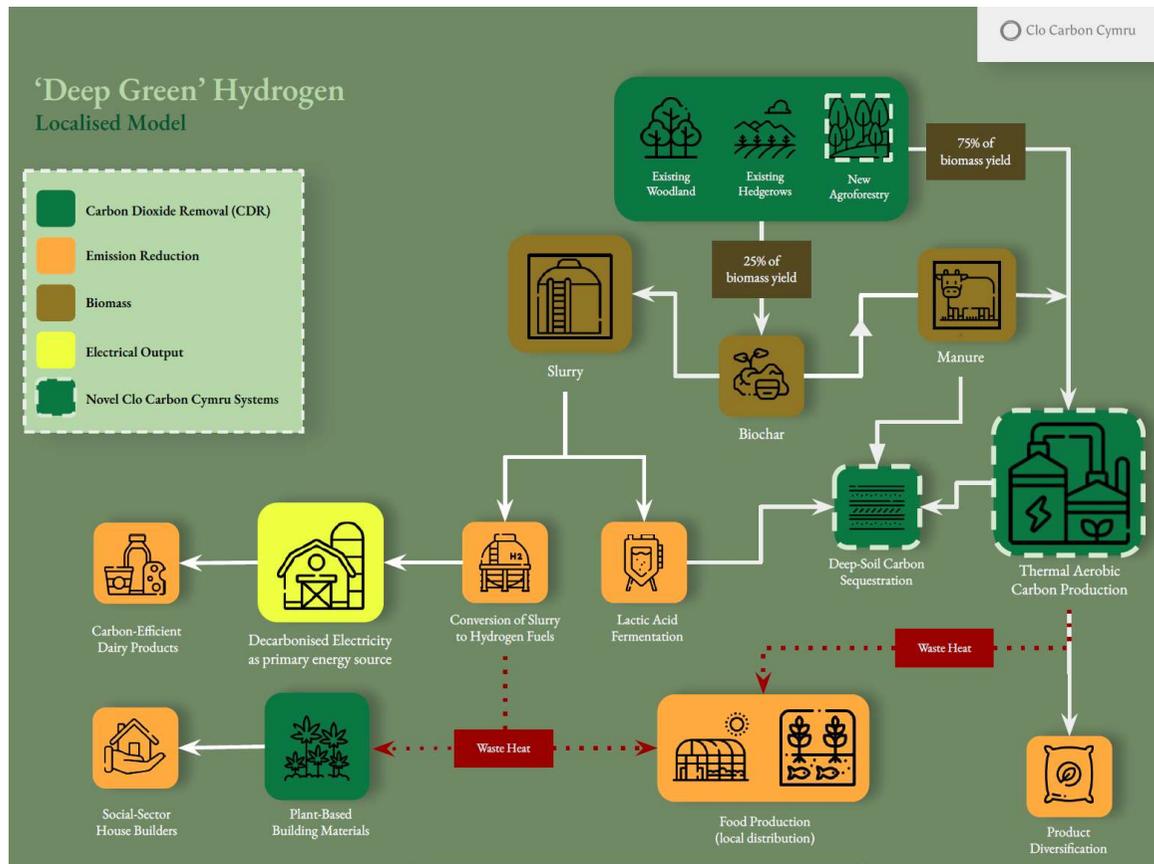
Both Neath Port Talbot and Pembrokeshire have exciting, shared opportunities for nationally significant energy infrastructure to support the development of floating offshore wind in the Celtic Sea, hydrogen and sustainable fuels. Combining this potential with the region's skill base, existing facilities and proximity to key markets offers a compelling argument for a potential freeport bid.

A South-West Wales freeport would bring together the ports of Port Talbot and Milford Haven to unlock the widest possible opportunity for Wales and for the UK by accelerating investment and fast-tracking modern skills development for new green industries. It would strengthen export opportunities while supporting Welsh and UK Governments' ambitions to drive economic growth.



## Clo Carbon hydrogen in agriculture

- Clo Carbon Cymru future opportunity for the production of hydrogen fuels from 'farm-waste' (waste-water and slurry) can drive the rural economy forward in Wales. The sustainable farming model proposed could also help with nitrate vulnerable zones, soil carbon sequestration, agroforestry, biochar etc.



## SW Wales Regional Energy Plan

*“Harnessing the region’s low carbon energy potential across its on and offshore locations, to deliver a prosperous and equitable net zero carbon economy which enhances the well-being of future generations and the region’s ecosystems, at a pace which delivers against regional and national emissions reduction targets by 2035 and 2050.”*

The priorities for achieving this vision are:

1. Energy efficiency
2. Electricity generation
3. Smart and flexible systems
4. Decarbonise heat
5. Decarbonise transport
6. Regional coordination

All of the local authorities in the Swansea Bay region are aligned to this vision and committed to action plans to become net zero local authorities by 2030.

The LA’s will be carrying out efficiency projects to decarbonise buildings, streetlighting, and transport. The authorities will be investigating and implementing renewable energy schemes. The LA’s will all be supporting innovation and green economic transition.

# Pembrokeshire Local Area Energy Plan (LAEP)

ARUP

Pembrokeshire County Council

## Pembrokeshire's Local Area Energy Plan

May 2022

*What is obvious is that the reality of decarbonising Pembrokeshire by 2050 is a monumental challenge. We need to achieve an energy efficiency and green energy revolution that will affect everyone in Pembrokeshire and beyond, and achieve this transition in a just way.*

*Pembrokeshire Council are responsible for LAEP strategic direction. The Public Service Board will provide steer of the project.*



**Retrofit whole buildings**  
Promoting a high investment package of measures 40,000 homes

**Pilot electrolyser and hydrogen villages**  
Demonstrate use of hydrogen through pilot projects

**Develop local onshore renewables**  
940MW of solar and wind capacity by 2050

**Decarbonise industry**  
Support industrial decarbonisation to retain economic benefits while achieving net zero targets

**Decarbonise transport**  
Develop EV charging infrastructure; support decarbonisation of heavy transport

**Reinforce electricity distribution network**  
Enabling new generation assets to come online

**Deploy heat pumps**  
Heat pumps prioritised in off gas properties (currently more than 25,000)

**“Develop a net zero energy system for Pembrokeshire by 2050, as the UK home of green energy”**

*This challenge can't be completed by the Council alone and it is not even possible without fundamental reforms. There are fundamental changes that are need in policy, funding, resourcing, skills & training, and infrastructure.*

## Pembrokeshire Climate Change Adaptation Strategy 2022

### PEMBROKESHIRE CLIMATE ADAPTATION STRATEGY (DRAFT v1)

20<sup>th</sup> June 2022



Pembrokeshire Public Services Board

Bwrdd Gwasanaethau Cyhoeddus Sir Benfro



This project is funded by the UK Government through the UK Community Renewal Fund

PSB's responsibility to implement the Strategy by 2027, with progress being scrutinised via a "Red, Amber, Green" (RAG) system and reported to the Pembrokeshire County Council Policy and Pre-decision Committee.

UK and Wales Climate Change Risk Assessments suggests that by mid-century (2040-2060)

- warmer and wetter winters
- hotter and drier summers
- high variability of extreme weather
- increased exposure to weather-related hazards
- increased frequency and intensity of wildfire
- increases in average and extreme temperatures, in winter and summer
- changes to rainfall patterns
- flooding and water scarcity
- increased coastal flooding and erosion
- sea temperature rise and ocean acidification

**39 climate adaptation priorities** split into four key areas:

- Infrastructural
- Natural Environment & Agriculture
- Communities
- Business & Industry



[www.pembrokeshire.gov.uk/mh2-energy-kingdom](http://www.pembrokeshire.gov.uk/mh2-energy-kingdom)