WALES & WEST UTILITIES

NextGen Electrolysis

– Wastewater to Green Hydrogen

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Hydrogen is widely recognised as an important pillar in a net zero energy system, and gas distribution networks are preparing their infrastructure so it can deliver clean industry, power generators and homes. However, green hydrogen remains relatively expensive and the costs and impacts of the technology need to be reduced to accelerate its deployment and support decarbonisation. This project has built initial development activity to assess whether less pure water can be used in the production process of green hydrogen and develop concepts for physical demonstration of the technology.

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The project team consists of:

Lead Network:

Wales and West Utilities:

(WWU) operate the extensive gas network throughout Wales and the South West of England to transport gas to 2.5 million households and businesses. WWU invest £2m every week across the network, connecting new homes and businesses, and upgrading old metal gas pipes to new plastic ones to ensure communities receive a safe and reliable gas supply for generations to come.

Partners:

HydroStar Europe:

A dynamic and innovative company focussed on developing the Next Generation of resilient hydrogen technologies which reduce operational barriers to widescale green hydrogen uptake and lower hydrogen costs substantially.

National Grid Electricity Distribution:

The UKs largest electricity distribution network serves nearly 8 million customers in the East and West Midlands, South West and Wales, delivering essential power to millions of homes and businesses across its regions.

Dwr Cymru Welsh Water (DCWW):

Responsible for providing over three million people with a continuous, high quality supply of drinking water and for taking away, treating and properly disposing of the wastewater that is produced.

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Needs Case

Green hydrogen is currently primarily achieved through alkaline and polymer electrolyte membrane (PEM) electrolysis, using carbon-free electricity to split water. Current PEM and alkaline electrolysers require highly purified water, and generally contain electrodes made from rare metals, and complex membranes to separate hydrogen from oxygen.

NextGen Electrolysis – Wastewater to Green Hydrogen is investigating using water that is less pure, such as rain and effluent from manufacturing processes and even sea water, to reduce the cost and carbon impacts from purifying water. The technology uses a co-axial membraneless electrode coupled with a novel non-toxic electrolyte, which is tailored and matched to the wastewater input.

Alpha

The Alpha phase has successfully continued the development of NextGen Electrolysis technology and created concepts suitable for larger scale demonstration.

The project team investigated using innovative coaxial membraneless electrolysis technology containing no rare metals in the device design, using a green, non-corrosive and patented electrolyte that can be adjusted to suit specific types of wastewaters. An innovative control system was designed by HydroStar as part of the Alpha work. This system, using sophisticated AI algorithms, allows an additional 10% of hydrogen to be produced from the same sized stacks when connected to solar power. The control system effectively demonstrated power switching, with data feedback being identified as essential for further control system development. The voltage and variable current relationship was found to be vital in achieving higher purity hydrogen from different water types.

Discovery Phase:

an 8-week feasibility phase.

1st April – 31st May 2023

→

Alpha Phase:

a 6-month proof-of-concept phase.

1st October – 31st March 2024

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Beta Phase:

Full scale demonstration of the project for up to 5 years.

1st September 2024

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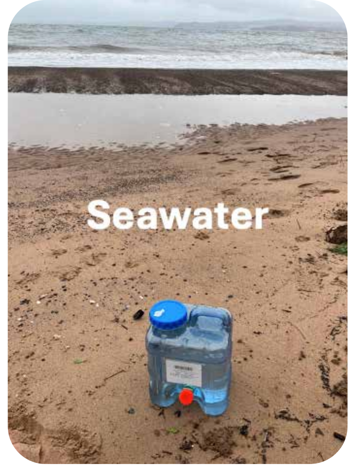
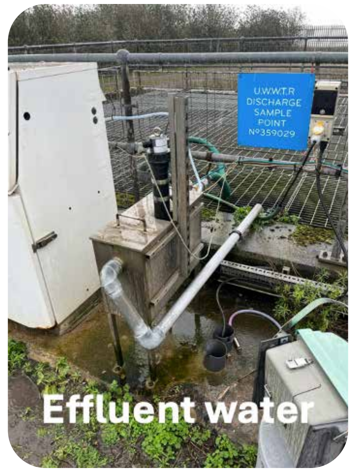
In collaboration with Cardiff university and Durham university, HydroStar undertook electrolyser development, producing 2kW electrolyser testing units and multiple smaller 500W devices which formed part of the control system testing. Gas chromatography analysis was used to measure the hydrogen purity from different water types. Electrolyte usage was also modelled across a range of water types with different concentrations of ions. Welsh Water advised on wastewater sources as well as providing analysis of which of their sites could be used for co-location production purposes.

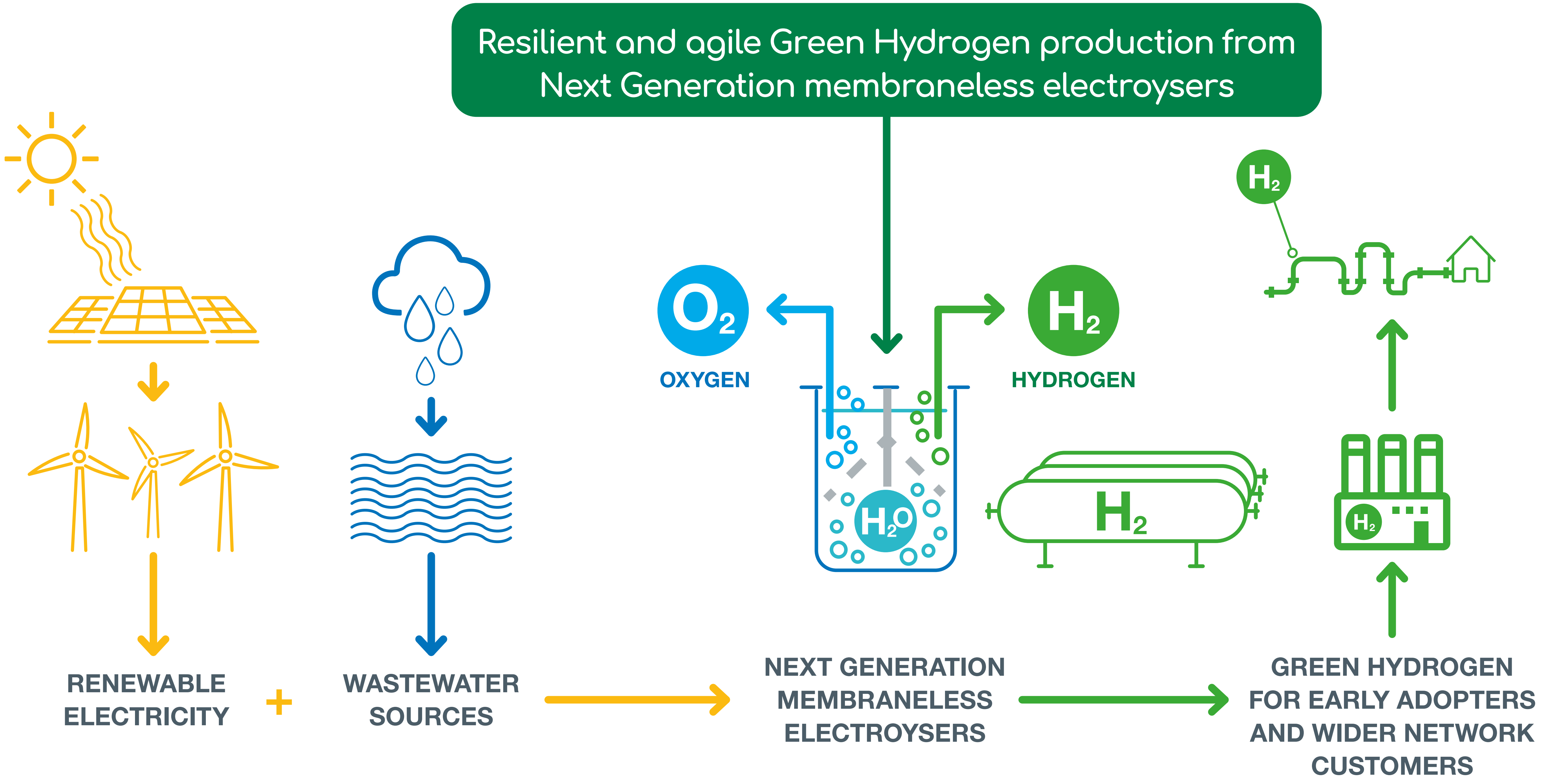
The project aimed to ensure that the technology, electrolyte and control system could handle a variety of different water types from across the UK and as such tested multiple different water sources outside of those that would be utilised at the selected industrial partners sites.

The completion of the 'Alpha' phase saw the NextGen electrolyser successfully produce hydrogen from nine different impure water sources (including seawater/final effluent/rainwater) with at least 94.4% pure hydrogen being produced from all those tested.





NextGen electrolysis – Wastewater to Green Hydrogen



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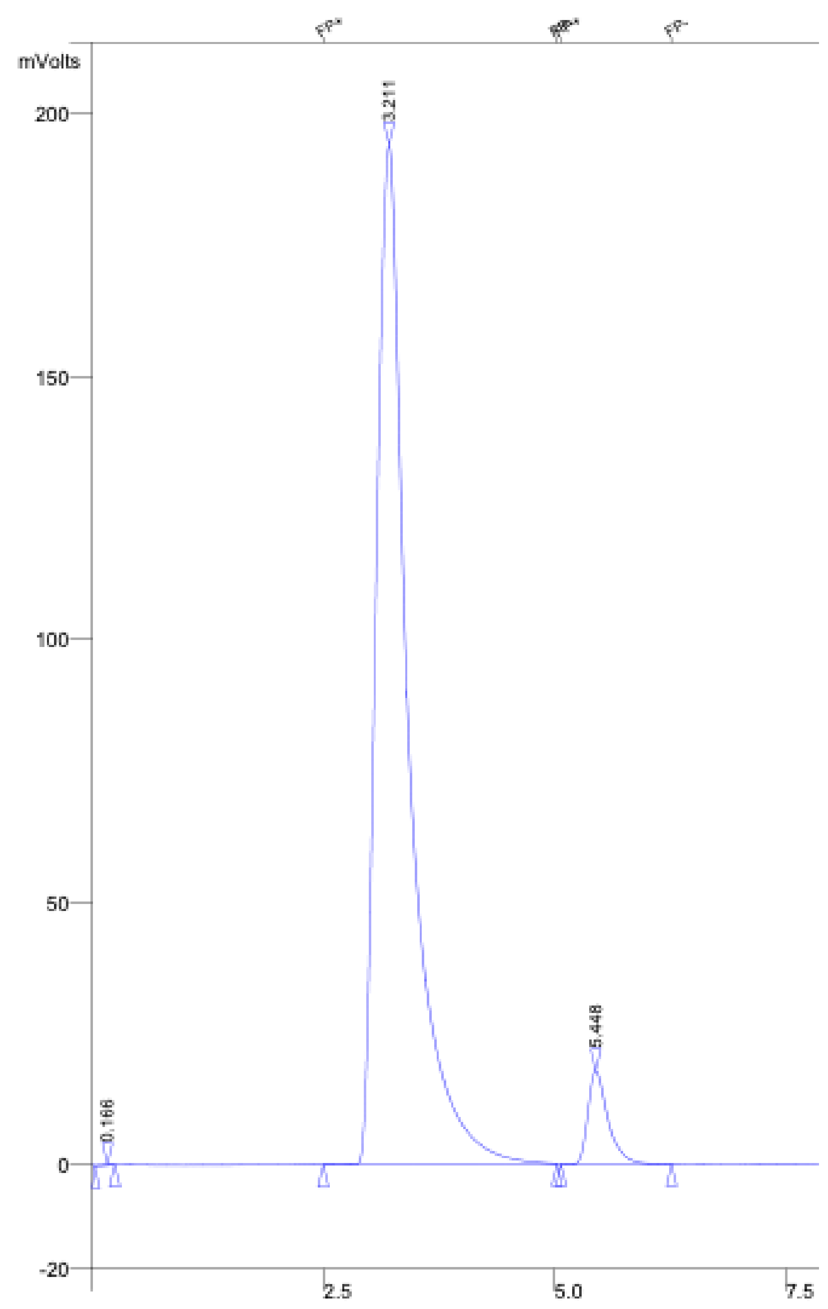
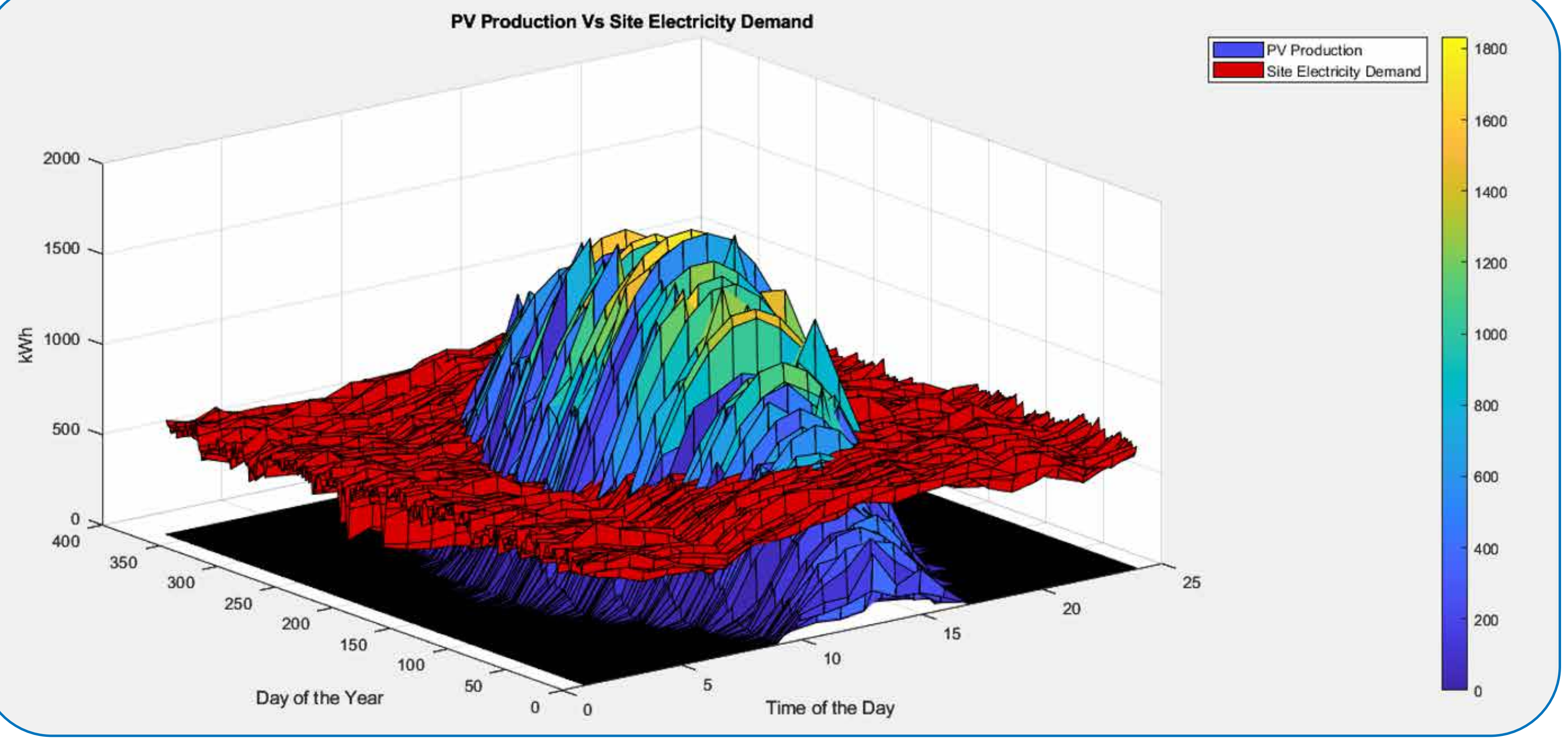
The focus on production was to ensure that excess renewables were used where available to avoid the need for a grid connection and to reduce the amount of time that renewable electricity already operational would be curtailed. A substantial techno economic model was developed to calculate hydrogen production directly from renewables, which was also expanded to take into account an industrial customers site parasitic demands as a primary use case. When combined with mapping high demand users across the network the basis for a distributed production can be seen.



The project also looked at the effects and potential blending up to 20% hydrogen into specific areas of our network and how that will affect our customers and producers.



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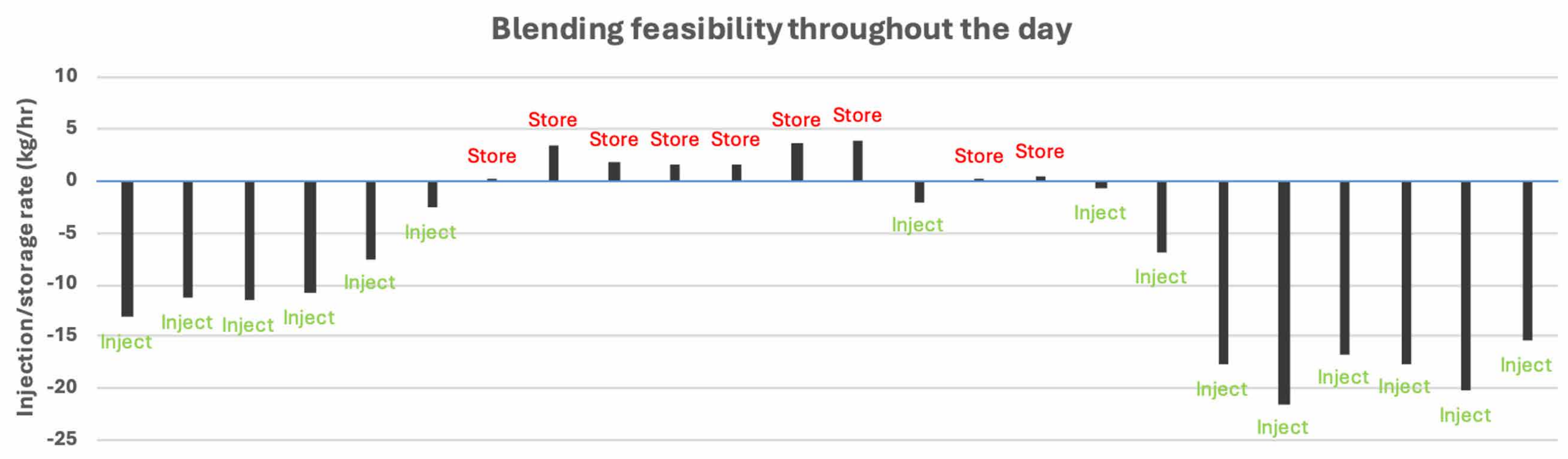
The project gained interest from a wide selection of stakeholders during an initial site selection process as part of alpha.

There were multiple interested parties with a range of different sites and wastewater types who were interested in partnering as part of the Beta application and potential demonstrators. A selection process was undertaken to select two partners who would provide the most benefit to the project and generate evidence on the technology, benefit to the network and customers, near term blending opportunities and long term 100% hydrogen utilisation while also maximising the use of excess renewable generation available at the partners sites.



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Two industrial sites were selected, one in the Southwest of England and one in South Wales to partner for the Beta application and subsequent demonstrators.

The two sites offer different benefits and evidence as outlined below:

	Site 1	Site 2
Water Source	Production process water, captured rainwater, borehole/river.	Treated effluent water and sea water.
Hydrogen usage	Blend of up to 20% with natural gas to existing boiler onsite heat.	For on-site office heat and hot water via boiler.
Benefits / evidence	Proof of concept of the ability to blend into the network. Initial use for an industrial customer provides a showcase for other industries.	Using 100% hydrogen on-site to completely decarbonise the site office as well as improving efficiencies through the use in industrial process. The site also offers additional benefits through colocation and use of the electrolyser's byproducts.

Membrane-less Electrolyser vs. alternative technology

	Alkaline	PEM	Membraneless
What is the water quality requirement of the device?	Ultra pure	Ultra pure	Impure water works effectively within the device
Does the device require a membrane to operate?	Ion exchange	Polymer electrolyte and composite	No membrane required
What is the electrolyte and working condition within the device?	Strong alkaline (harsh conditions and disposal)	Strong acidic (harsh conditions and disposal)	Benign green chemistry
What are the electrodes made from?	Rare metals	Rare metals	Stainless steel (recycled)
What is the pressure requirement for the device?	Medium	High	No pressure required
What is the carbon footprint of device manufacturing?	Medium	High	Ultra Low
What are the maintenance requirements for the device?	Medium skilled	Highly skilled	Low level engineering

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Benefits

WWU operates a relatively rural network with pockets of industry outside of major 'clusters', but even areas with lower population density have a range of gas users who need solutions to decarbonise. The NextGen project is showcasing the possibility of a distributed hydrogen production model reducing the operational barriers for smaller scale hydrogen production.

The project is demonstrating a proof of concept in decarbonising early industrial users through hydrogen blending or use of 100% for on-site processes, heating and hot water. Scaling up to network blending in the near term future and a potential 100% future network conversion. This distributed production around industrial sites can be modelled and excess hydrogen has the potential to be blended into the local gas network in the future.

As well as addressing real-world manufacturing and operational constraints and reducing the cost for consumers, roll-out of this technology would also enable the production of green hydrogen in remote rural communities by co-locating with solar farms and wind turbines maximising the often curtailed solar and wind energy across the WWU geographical area to help lower the requirements of large electrical grid connections or new water grid infrastructure. It will also facilitate distributed generation across the network, reducing capital and operating costs. As with traditional electrolysis there is also opportunity to significantly reduce the cost of hydrogen through colocation and use of the waste heat and O2 produced.

By removing the need for purification, the project could save up to 8 billion litres of water per year per gigawatt of electrolyser capacity. Distributed generation would also reduce carbon emissions the equivalent of removing 17,600 cars from the road annually. Ultimately, the project will enable lower-cost green hydrogen that helps the UK hit its net zero targets while minimising disruption to the consumer as well as lowering the cost of hydrogen for the consumer in the long term.

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