SIF Round 3 Project Registration

Date of Submission

Jun 2024

Project Reference Number

SIF_WWU_3_2 (3)

Initial Project Details

Project Title

ALCHEM (Advanced Low Carbon Hydrogen and Energy Management)

Project Contact

Henry James

Challenge Area

Enabling power-to-gas (P2G) to provide system flexibility and energy network optimisation

Strategy Theme

Net zero and the energy system transition

Lead Sector

Gas Distribution

Other Related Sectors

Electricity Distribution

Project Start Date

01/03/2024

Project Duration (Months)

3

Lead Funding Licensee

Wales & West Utilities

Funding Licensee(s)

Wales & West Utilities

Funding Mechanism

SIF Discovery - Round 3

Collaborating Networks

Wales & West Utilities

Technology Areas

Carbon Emission Reduction Technologies

Hydrogen

Low Carbon Generation

Energy Storage

Storage

Gas Distribution Networks

Project Summary

Due to high energy requirements, the cost of producing green hydrogen throughcommercially available technology remains three times higher than the productionof grey hydrogen. Additionally, current green hydrogen production technologystruggles with ramping up, and down, when renewables are intermittent for risk ofcreating dangerous hydrogen and oxygen mixtures.

The ALCHEM (Advanced Low Carbon Hydrogen and Energy Management)project addresses both problems through its innovative biomass electrolysistechnology, which uses liquid waste biomass to produce green hydrogen andgreen chemicals with no oxygen, using 75% less energy than conventional waterelectrolysis.

Project Budget

£97,152.00

SIF Funding

£87,436.00

Project Approaches and Desired Outcomes

Problem statement

The UK Hydrogen Strategy emphasises the pivotal role of low carbon hydrogen in achieving net-zero targets, especially in challenging sectors like heavy industry, transportation, and power. Ambitious government targets aim to deliver 2GW of low carbon hydrogen by 2025 and 10GW by 2030.
One problem with meeting these targets is the current cost of producing low carbon hydrogen, which is three times more than grey hydrogen. A significant cost reduction is imperative to meet targets without imposing burdens on industries, taxpayers through subsidies, or energy billpayers.
Another problem faced by low carbon hydrogen technologies is system inflexibility. The only mature technology for producing green hydrogen (no carbon emissions) is alkaline electrolysers for water electrolysis, which uses renewable electricity to split water into hydrogen and oxygen. This technology is not only incredibly energy intensive, but also has difficulty using intermittent power such as from wind/solar. This is due to the production of both hydrogen and oxygen, which can cross-mix during the ramping up and down of the electrolyser, forming a potentially dangerous mixture.
The ALCHEM (Advanced Low Carbon Hydrogen and Energy Management)project addresses both of these challenges through innovative biomass electrolysis technology, which uses liquid waste biomass to produce green hydrogen and green chemicals.
The major advantages are:
Optimises electrolyser deployment and operation by requiring 75% less energy compared with conventional water electrolysis.
Demonstrates electrolyser's capability for providing system services by producing green hydrogen at cost parity with grey hydrogen (£1.5/kg).
Increase electrolyser participation in flexibility services by being compatible with direct intermittent renewable power.

The users of the biomass electrolysis technology include biomass producers (breweries, distilleries, paper pulp industry, and the agricultural industry) that can convert their waste into higher value products. It also includes users of green hydrogen, who can now purchase zero emission hydrogen at £1.5/kg, compared with the status quo of £5/kg. Biomethane producers may also benefit from this technology, as the ALCHEM system could replace ageing biomethane production equipment where an existing feedstock and network connection is already established.
This project will address the three innovation challenge aims below:
Demonstrate electrolyser and similar technologies capability for providing system services
Increase electrolyser participation in flexibility services
Increase consideration of system aspects such as constraints management when siting electrolysers
This funding application builds upon State Aid funding of £15,118.70 through the Undaunted Greenhouse accelerator programme and £11,753.40 through the Birmingham Climate & Innovation Platform.

Video Description

https://www.youtube.com/watch?v=pGXaqD9Tb_8

Innovation justification

The ALCHEM project showcases the commercial feasibility of biomasselectrolysis, a novel technology that replaces the oxidation side of an electrolysisreaction with liquid biomass instead of water. This process, utilising feedstock fromvarious sources like brewery waste and agricultural residue, boasts advantagessuch as the absence of oxygen production, enabling the use of alkalineelectrolysers powered directly by intermittent renewable electricity withoutconcerns of dangerous oxygen-hydrogen crossovers. Fundamentally, this reactionrequires up to 75% less energy than traditional water electrolysis.
The technology is innovative compared with the state-of-the-art competing hydrogen production technologies because it is much more efficient and flexiblewhilst still producing zero carbon emissions. Current water electrolysers require around 55kWh of electricity to produce 1kg of hydrogen. While this can be furtherreduced, there is a fundamental minimum limit of 39kWh/kgH2. Biomasselectrolysis has a much lower fundamental minimum limit down to 10kWh/kgH2.The project is targeting a total system efficiency of 25kWh/kgH2.

project technology builds on the University of Cambridge postdoctoralresearch of the technical lead from Ki Hydrogen (https://ki-hydrogen.com/).

Current level: Estimated level at end of Discovery phase
IRL 1:2
CRL 1:4
TRL 3:3
The project is proposed to be a 3MW pilot plant to produce commercial-scalehydrogen. This is aligned with the Innovation Challenge of 'enabling power-to-gas(P2G) to provide system flexibility and energy network optimisation' because it willconvert biomass waste and renewable electricity into green hydrogen with energyefficiency and flexibility beyond state-of-the-art.
The project is a high-risk venture based on innovative technology that will notqualify for debt-financing. Ki Hydrogen is solely focused on commercialisingbiomass electrolysis and will not have revenue streams to finance the project untilit is operational to become business as usual.
In the UK, current baseload electricity prices are at ~£80/MWh with greenhydrogen costing £5/kg. The industry counterfactual of achieving £1.5/kg greenhydrogen with current technologies is relying on electricity prices to fall to £10-20/MWh. Biomass electrolysis can achieve £1.5/kg with electricity prices of£80/MWh.
Alternative waste-to-hydrogen technologies include gasification/pyrolysis andmicrobial electrolysis. These technologies first produce a syngas which needs tothen be separated, treated, and requires a separate carbon capture module. Eachstep brings complexity, efficiency losses, and added capital equipment costs. Biomass electrolysis converts waste to pure hydrogen in one step, wherehydrogen is the only gaseous product.

Impacts and benefits selection (not scored)

Financial - cost savings per annum on energy bills for consumers

Impacts and benefits description

Financial -- cost savings per annum on energy bills for consumers
The UK aims to have at least 5GW of electrolytic hydrogen capacity by 2030. Thatconverts to approximately 0.4Mt of green hydrogen production per year. The business-as-usual counterfactual is water electrolysis to produce all that green hydrogen, with an estimated levelised cost of production of £5/kg2. That equatesto a direct cost to the network and its consumers of £2 billion every year to meetthis demand.
Through biomass electrolysis, the levelised cost drops drastically to £1.5/kg,meaning it would only cost £600 million every year to produce the same amount ofhydrogen. This is a direct saving of £1.4 billion every year to the network and itsconsumers while meeting its net zero targets enabled by green hydrogen.
In turn, this cost reduction, driven by a reduction in energy usage, will translate to2.5GW of reduced need for upstream electricity grid infrastructure to still meet theUK electrolytic hydrogen target by 2030.
Environmental -- carbon reduction -- direct CO2 savings per annum
14.5kg of CO2e emissions are directly emitted for every 1kg of hydrogen producedusing today's preferred means of industrial hydrogen production, steam methanereforming technology, which represents essentially all the UK's domestic hydrogen production.
In comparison, the project technology will have 0.5kg of CO2e per 1kg of greenhydrogen produced, mainly associated with the production and transportation ofthe biomass feedstock. Not only does this meet the UK's Low Carbon HydrogenStandard, but also meets the more stringent Green Hydrogen Standard as definedby the Green Hydrogen Organisation. This means that biomass electrolysis is alsocompetitive with water electrolysis which is predicted to emit 0.4-0.8kg of CO2eper 1kg of green hydrogen produced.
Considering the UK currently produces around 0.7Mt of grey hydrogen, convertingit all to biomass electrolysis would directly mitigate 10Mt of CO2e emissions everyyear.
Revenues - creation of new revenue streams
Hydrogen is the only gaseous product of biomass electrolysis. All the carbon staysin liquid form and breaks down into valuable chemical co-products such as aceticand formic acid. These are chemical commodities that can be sold as anadditional revenue stream. Today, these chemicals are derived from fossil fuels.Since the carbon is biogenic, the technology would be making "green" versions ofthese chemicals at cost parity.

Teams and resources

Ki Hydrogen is the developer of the novel biomass electrolysis technology. They are an organisation with capability in hydrogen production and use optimisation. Ki Hydrogen recently closed a fundraising round of $1M to accelerate the commercialisation of biomass electrolysis. The three team members who will be working on the project are:

Project Manager -- Koji Muto. He has industrial experience leading teams, having drove development for the UK's largest hydrogen project worth $800Mas a senior engineer at ExxonMobil. Koji holds an MBA from London Business School.

External Relations Manager -- Carl Banbury. He has over 10 years' experience driving businesses with emerging technologies into multi-million revenue generating products in cross-functional teams. Carl holds a multi-disciplinary PhD from the University of Birmingham.

Technical Lead -- Michael Stanton. He has a strong scientific and research background, covering materials engineering, chemistry, and a PhD in physics/nanotechnology from the University of Cambridge. His recent work focused on novel methods for generation of green hydrogen from waste materials.

The resources needed for this stage of the project are primarily workforce hours for secondary and primary research, modelling, and analysis.

Wales and West Utilities (WWU) own and operate the pipes that keep the gas flowing to heat homes, power businesses and keep the lights on across Wales and south west England. They don't sell gas; but instead use their network of pipes to transport gas. They respond to gas emergencies, connect new homes businesses, and invest £2m every week so the gas network is fit for the future. WWU is a regulated gas distributor that is committed to net zero and transitioning its network to transport green gases such as biomethane and hydrogen. They have a strong track record in supporting hybridised technologies that use both gas and electricity to support consumer cost efficiency.

Project Manager -- Henry James is a Chartered Engineer and responsible for delivering WWU's contribution to industrial cluster projects such as the South Wales Industrial Cluster, including the HyLine Cymru hydrogen pipeline.

EDF Hynamics is an operator of hydrogen electrolyser or other green power-to-gas assets connected to the energy networks and will be supporting the project through their expertise in project development, deployment and scalability.

Project Plans and Milestones

Project management and delivery

The Discovery phase of the project will follow the agile project management methodology to ensure a successful and innovative outcome. Key work packages will be broken down into smaller well defined tasks or stories, labelled according to each work package. These are then scored in terms of difficultly amongst the team and prioritised according to key deliverable timelines and prerequisites. Daily standups and organising the work packages into sprints ensures measurable progress and the ability to respond quickly to delays, changes or results from prior tasks and milestones. Each card will be assigned a lead member responsible for delivery so that expectations and ownership of tasks are clear. A scrum master will be defined to triage and operate sprints and ensure alignment with all key stakeholders.

The Project Management Template (PMT) and a Gantt chart have been attached to this application. The Gantt chart outlines key milestones and deliverables for the project as well as highlighting interdependencies.

Risk management is provided by the separated nature of the early WPs and the known capability and capacity of the project participants. The PMT risk register will be monitored throughout the project, with risks added if identified throughout the course of the project.

The UK Hydrogen Strategy sets an ambitious roadmap to promote technology-agnostic innovations towards economical low-carbon hydrogen. The project requires this holistic, supportive regulatory framework quantified through emissions associated with hydrogen production. The project is not aware of any regulatory plans to change the government position away from hydrogen or towards one specific hydrogen technology.

No derogations, or requests for changes to regulation will be required for the Discovery phase but will be assessed within the Discovery phase in preparation for the later phases of the project.

Once the project progresses towards deployment, it will use off-the-shelf electrolyser components with multiple suppliers to mitigate supply chain risks. The Discovery phase will be used to contact these suppliers to establish early relationships and identify key blockers such as long lead times.

The project will only use biomass waste as a feedstock. Its success will not be dependent upon integration within an existing core process, but instead sitting at the end of it. This minimises operational risk and disruption to our proposed consumer base.

Key outputs and dissemination

The expected key outputs will align with the work package structure:

Waste biomass landscape: Assess the availability of suitable waste streams from key industry verticals, with specific attention paid to location and volume in the UK.

Off-taker market assessment: Assess market size and opportunities for hydrogen and chemical co-product off-takers in the UK.

Techno-economic model: Techno-economic assessment of levelised cost of green hydrogen through biomass electrolysis and current technologies (counterfactual).

Competitor analysis: Assess existing and emerging hydrogen production technologies.

Commercialisation risk registry: Identify risks associated with commercialisation and mitigation measures to progress into Alpha phase.

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These work packages, as outlined in the PMT, will verify the commercial feasibility and techno-economics through secondary and primary research. This will progress the project towards the Alpha and then Beta phases when the technology can be commercially deployed, and the benefits realised.

Ki Hydrogen will be responsible for the work packages in this phase. They will disseminate by consolidating the findings in written form and delivering them electronically to the relevant partners and stakeholders. Key deliverables will also be reviewed on a regular partners call as noted in the PMT. Feedback will be recorded and time has been allocated to incorporate the comments into the final versions of the deliverables.

WWU will disseminate the deliverables of this work through its usual channels, including existing gas and electricity network forums, conferences, and through LinkedIn and social media content. This will be reviewed as the project progresses1.

and reviewed at the end of the Discovery phase to ensure that planned activities are suitable.

The project will not undermine the development of competitive markets because there will remain numerous pathways to produce low-carbon hydrogen. The core benefit is ultimately cost. The aim is to become the cheapest form of green hydrogen production in this commodity market, but any other technology or competitor can enter the market and attempt to compete.

Commercials

Intellectual Property Rights (IPR) (not scored)

Appropriate management of Intellectual Property Rights (IPR) is of central importance to the delivery of the ALCHEM project.

All project Partners, and any tools or technologies that are developed during the delivery process, will adhere to the default Intellectual Property Rights (IPR)arrangements as set out within Chapter 9 of the SIF Governance Document.

In addition to complying with the default IPR arrangements, any data generated during the project will be shared and made openly available through knowledge dissemination to allow other parties to continue to benefit from the outputs.

Prior to starting the Discovery phase, each project Partner will make a declaration of background IP for the consortium agreement that will clearly define the background IP they bring to the project.

An IP Register will be created as part of the project kick-off process and will be developed and maintained throughout the project. Any restrictions on freedom to operate from individual components or know-how used in the ALCHEM project will be evaluated as part of the project delivery.

Specific IP issues arising during project delivery will be addressed by the project Steering Group.

Value for money

Ki Hydrogen: £86,400

WWU: £8,790

EDF Hynamics: £1,962

The 10% contribution in kind across all partners is funded through the resource assigned to the project whereby 10% of everyone's time is not funded by SIF.

The proposed innovation will be commercialised through a pilot project on site at biomass producer, such as a brewery. The innovation will allow for economical green hydrogen to be produced from the biomass waste and sold to the brewery for industrial decarbonisation. This would then become a self-sustaining, profitable business model to be moved into business as usual.

In the longer-term and once the technology has been demonstrated from technical and commercial perspective, there is an opportunity for a rollout in amore distributed fashion by strategically leveraging the gas networks distribution. This should be done at locations where there is excess gas and electricity network capacity, and whereby the gas network can be utilised to ensure gas and electricity network investments are optimised, thus maximising the benefits to consumers identified in the response to Q4.

One opportunity, driven by hydrogen demand, is a centralised biomass electrolysis facility at industrial clusters where hydrogen valleys are being developed with common transportation infrastructure. Economical green hydrogen can then be produced where the industrial hydrogen customers are located. Another opportunity, driven by feedstock availability, are biomass electrolysis facilities located alongside, or in replacement of, ageing biomethane facilities, capitalising on an existing source of feedstock and gas network connection.

Supporting documents

File Upload

WP5 Commercialisation Risk Registry V1.xlsx - 96.6 KB
WP4 Deliverable - Competitor Analysis V1.docx - 1.8 MB
WP3 Deliverable - Unit Economics V2.xlsx - 62.4 KB
WP2 Deliverable - Hydrogen and Co-product Key Metrics V2.docx - 20.0 KB
WP1 Deliverable - Biomass Key Metrics V3.docx - 301.1 KB
Condition 6_ Current Technology Status.docx - 293.4 KB
Condition 5_ Thermodynamic Principles.docx - 294.1 KB
Condition 4_ Stakeholder Engagement Plan.docx - 294.5 KB
ALCHEM Show and Tell Final.pptx - 4.4 MB
SIF Round 3 Project Registration 2024-06-06 8_08 - 59.6 KB

Documents uploaded where applicable?

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