IDRIC x EPSRC Centre for Doctoral Training in Green Industrial Futures Conference 2025

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Thursday 12th June 2025

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Theme A: Carbon Dioxide Removals (CDR)

Poster A1

Integrating greenhouse gas removals (GGR) into the UK Emissions Trading Scheme (UK ETS)

Presenter: Antigoni Theocharidou (Imperial College London | CDT-GIF)

Email: antigoni.theocharidou21@imperial.ac.uk

Themes: CO_2 removal technologies; Policy and regulation; Net zero economics

Abstract:
Meeting the UK's net-zero target by 2050 will require carbon dioxide removal (CDR) technologies, especially in hard-to-abate sectors. While the UK Emissions Trading Scheme (UK ETS) provides a market-based mechanism for decarbonisation, there is limited clarity on how removals can be effectively integrated. This research addresses that gap by evaluating the economic, environmental, and policy impacts of incorporating engineered removals—such as biochar, direct air capture, and bioenergy with carbon capture and storage—into the UK ETS.

A multi-sector emissions allocation and abatement model was developed to simulate the effects of cap reductions and phase-outs of free allocation on carbon prices and CDR deployment. Preliminary results suggest that integrating removals could help stabilise prices at £90–£110/tCO_2 by 2030. Marginal abatement costs are quantified for key CDR options, showing how carbon pricing could drive investment in removals—especially as the auctioned allowances decline by 12.4% annually.

Stakeholder consultation responses reveal strong industry support for including CDR in the UK ETS, contingent on robust certification and performance-based incentives. These findings suggest that integration is both feasible and desirable, provided policy safeguards maintain market stability and complement emissions reductions.

The research offers evidence-based recommendations for enhancing the UK ETS's design and aligning it with emerging EU and international carbon pricing frameworks. A well-integrated approach could position the UK as a global leader in incentivising net-negative emissions through hybrid market mechanisms that combine both reductions and removals.

Poster A2

A BECCS hub in the UK context – logistical, policy, regulatory and community dimensions.

Presenter: Diarmaid Clery (University of Manchester)

Email: diarmaid.clery@manchester.ac.uk

Themes: CO_2 removal technologies

Abstract:
The industrial clusters have a vital role to play in achieving the UK's net zero targets, not just in delivering industrial decarbonisation but also bringing the potential to deliver carbon dioxide removals. By the 2030s, Bioenergy with Carbon Capture and Storage (BECCS) is expected to provide a significant portion of engineered removals, in alignment with global pathways to net zero. However, gaps remain in our understanding of the suitability of different types of BECCS

for meeting multiple decarbonisation, sustainability and local development objectives. BECCS is a key pillar of the UK net zero strategy but many remaining challenges and uncertainties to its deployment are non-technical in nature and dependent on specific supply chain configurations. A coordinated strategic approach to the co-location of facilities in regional BECCS-hubs will enable opportunities such as access to shared infrastructure and developing specialist expertise in the region, to be balanced against competition for resources between facilities. This research considers the potential for a BECCS hub within the NW UK cluster, aiming to advance understanding in certain critical areas, namely: spatially explicit supply

chain configuration and performance; regulatory environments and the overarching policy frameworks which will govern and finance their development; community perceptions of BECCS. The results provide a detailed assessment of 5 prospective supply chains co-located in NW England, connecting to the CCS infrastructure planned within the UK Cluster Sequencing Process. The supply chains investigated all exploit feedstocks using waste and residues generating a variety of energy vectors. The research reveals the implications of different strategies for feedstock resourcing and supply chain transportation, identifying key policy and regulatory issues alongside specific local concerns based on engagement processes with relevant stakeholders and community leaders respectively.

Poster A3

The cost of direct air capture with electrochemical regeneration can be competitive!

Presenter: Ashween Kaur Virdee (Heriot-Watt University)

Email: akv1@hw.ac.uk

Themes: Carbon capture, utilisation, transport and storage; CO_2 removal technologies; Net zero economics

Abstract:
Absorbent-based direct air capture (DAC) with electrochemical regeneration presents a promising pathway for carbon dioxide removal (CDR) from the atmosphere, offering advantages such as verifiability and durability. However, DAC is currently estimated to cost between $350 – 3000 / tCO2 net removed, with energy demand and capital expenditure as the primary cost drivers—posing significant barriers to large-scale deployment. Carbonic anhydrase (CA) enzymes have gained significant attention for their ability to accelerate CO_2 absorption kinetics and potentially reduce solvent regeneration energy demands. However, their integration into DAC systems remains largely unexplored, making it unclear what process conditions CA must be engineered to withstand, and what their economic benefits might be.

This study presents a prospective techno-economic analysis of an absorbent-based DAC system integrating electrochemical pH-swing regeneration and investigates the enhancement potential of CA enzymes. Using a detailed process model developed in Aspen Plus and a bottom-up costing framework with top-down technological learning projections, we assess the performance of DAC systems using KOH and K_2CO_3 solvents with electrochemical regeneration across a wide range of operating conditions. The study aims to identify and optimise key process parameters to minimise DAC contactor footprint, electrolyser stack requirements, and overall energy consumption when using CA-enhanced absorbents. Moreover, this work defines key CA performance targets and outlines pathways for achieving DAC costs below \$300 /tCO_2, with the ambition of striving for \$100 /tCO_2 by 2050.

Theme B: Policy, skills, social change and economics

Poster B1

Researching the Role of SMEs in Net Zero

Presenter: Kayleigh Hepburn (University of Bath | CDT-GIF)

Email: klh86@bath.ac.uk

Themes: Policy and regulation; Skills, just transition and socio-behavioural change; Net zero economics

Abstract:
As the global focus on net zero continues to grow, there is much debate around the requirements for greenhouse gas emissions reporting and other environmental management tools for small and medium-sized enterprises (SMEs). There are approximately 5.5 million SMEs in the UK providing significant economic benefits, however as a group they may also have more environmental impact than large businesses. The quantifiable contribution to pollution from SMEs is not fully known and therefore we need action to measure and understand the environmental impact of SMEs.

In my first study, I am planning a series of focused interviews with a sample of the SME population. These will explore the SME organisational perspective, including needs and drivers for emissions reporting. My second study will look at the wider societal perspective towards how SMEs navigate the net zero transition, with input from policymakers and other actors via interviews. This will consider the requirements of consumers, government procurement, the financial sector, value chain, voluntary standards and potential new regulations. I plan to conclude with case studies to examine best practice, with recommendations for implementation and wider adoption.

I am planning to start data collection in Summer 2025 so please come and talk to me if you are interested in my research, represent SMEs or simply have some feedback. I want to raise the profile of sustainability for SMEs to ensure that this group is supported and can realise benefits from the net zero journey.

Poster B2

How do stakeholder needs and values shape the successful implementation of hydrogen energy systems within regional decarbonisation strategies?

Presenter: Tom Gray (University of Bath | CDT-GIF | CGI)

Email: tom.gray@cgi.com

Themes: Skills, just transition and socio-behavioural change; Hydrogen and sustainable fuels; Systems planning, energy and resource efficiency

Abstract:
This poster presents pioneering research into the role of stakeholder requirements in shaping the adoption of hydrogen energy systems within regional decarbonisation transitions. Focusing on a major industrial cluster, the study addresses a critical gap in the integration of technical feasibility and social acceptance, as highlighted by leading scholars in energy transitions. By leveraging the multi-level perspective (MLP) framework, the research systematically examines interactions across niche innovations, regime actors, and landscape pressures, providing a holistic view of transition dynamics.

A mixed-methods approach underpins the investigation: a systematic literature review establishes the theoretical foundation, followed by documentary analysis of regional decarbonisation initiatives and baseline emissions. Stakeholder mapping and semi-structured interviews elicit the diverse needs and values of key actors, while a novel application of the "3C framework" (Cost, Convenience, Carbon) extends the Technology Acceptance Model to capture the complex interplay of economic, behavioural, and environmental factors influencing hydrogen uptake. Scenario development, employing modified Delphi techniques and systems modelling, integrates stakeholder perspectives into robust transition pathways.

This research delivers an evidence-based framework for understanding stakeholder engagement in hydrogen adoption, offering actionable insights for policymakers, industry leaders, and regulators. The findings will inform the design of inclusive, regionally tailored decarbonisation strategies, supporting the UK's ambition to lead global industrial decarbonisation efforts. By foregrounding stakeholder priorities, this work advances socio-technical transitions theory and provides practical guidance for accelerating the deployment of hydrogen technologies in pursuit of net zero.

Poster B3

Engaging marginalised communities in energy developments

Presenter: Lisa Zhang (University of Bath | CDT-GIF)

Email: lmz23@bath.ac.uk

Themes: Skills, just transition and socio-behavioural change

Abstract:
Decarbonising industry is crucial to meet net zero targets, and many countries have adopted policies and roadmaps to achieve this. However, a green industrial transition must also be a just and fair transition. Industrial clusters are often located in more socially disadvantaged areas, and such communities are more likely to disproportionately bear the burdens of technological hazards. Yet, these marginalised and vulnerable groups are less likely to have their voices heard in decision-making, which may sustain or exacerbate injustices. Research has found that public engagement and participation is hardly referred to in industrial decarbonisation roadmaps, and industry engagement practices are fragmented and deficient to date.

Using a mixed-methods approach, the project aims to: (1) critically examine public engagement approaches in both their processes and outcomes; (2) explore perceptions of fairness and just transition, and experiences of engagement across different stakeholders; (3) develop novel, inclusive engagement spaces for marginalised groups. Proposed methods include a scoping review, documentary analysis of roadmaps, qualitative interviews with stakeholders, quantitative surveys at local and national scales, and participatory research. Preliminary findings of the scoping review on the role of public engagement and participation in supporting a just transition may be presented. The project intends to have both academic and societal impact by investigating a research area that has lacked dedicated focus, and by informing industry practitioners and policymakers in designing effective engagement approaches.

Poster B4

The role of market interventions in deploying deep decarbonisation solutions for heavy sectors

Presenter: Gbemi Oluleye (Imperial College London)

Email: o.oluleye@imperial.ac.uk

Themes: Net zero economics

Abstract:
A central challenge in accelerating deep decarbonisation across hard-to-abate sectors such as iron and steel, cement, chemicals, petrochemicals, refining, heavy-duty transport, shipping, and aviation is the persistent lack of demand-pull for technologies such as carbon capture, utilisation and storage (CCUS), blue and green hydrogen, direct air capture (DAC), electrification, and synthetic fuels. Hence, they remain largely uncompetitive due to high costs. This absence of sustained demand inhibits their market viability. This poster presents an overview of my group's research into market-based mechanisms that can generate sufficient demand-pull and help drive these solutions toward economic tipping points. I will present our methodology on geospatial-temporal market viability assessment, a global overview of current market mechanisms, and a case study showing financing gaps around the world for cleaner steel. This case study shows findings from a global study assessing the economic viability of low-carbon steelmaking technologies specifically retrofitting BF-BOF plants with CCUS and transitioning DRI-EAF plants to green and blue hydrogen. The analysis spans 385 plants across 39 countries. Results reveal that under current market-based mechanisms, only 98.7 Mt of CO_2 is economically viable for capture, while optimal MBM design combining emissions trading systems, carbon taxes, investment incentives, and grants could make 814.5 Mt CO_2/yr economically viable. The research highlights the role of these mechanisms in aligning risk, reward, and capital flows across public and private actors for deep decarbonisation.

Poster B5

An integrated framework for levelled up and low carbon industrial clusters.

Presenter: Nadine Moustafa (Imperial College London)

Email: nm1217@ic.ac.uk

Themes: Skills, just transition and socio-behavioural change; Net zero economics; Carbon capture, utilisation, transport and storage; Systems planning, industrial heat, and energy & resource efficiency

Abstract:
The UK Industrial Decarbonization Challenge (IDC) aimed at combining the need of transitioning to low-carbon industrial clusters with the UK government's broader levelling-up agenda. Driven by the IDC proposition, previous assessments have primarily focused on quantifying the socio-economic value associated with decarbonizing major industrial clusters, this work introduces an advanced approach that integrates a supply chain analysis and a socio-economic analysis utilizing the Jobs and Economic Development Impact (JEDI)-UK framework. The goal is to provide a comprehensive understanding of the economic implications, investments required, and job creation potential associated with diverse low-carbon solutions across UK industrial clusters.

We present an analysis that addresses the socio-economic aspects of decarbonising UK industrial clusters and provides a detailed account of the supply chain dynamics involved. By focusing on higher TRL alternatives and employing the JEDI-UK framework, this study aims to enhance the applicability of economic assessments and tailor low-carbon solutions to the specific needs of each industrial cluster. The inclusion of regional dependencies ensures a comprehensive understanding of the socio-economic impacts, contributing valuable insights for policymakers and industry stakeholders. This study spans various sectors in the different UK clusters which allows for a holistic understanding of the economic implications of decarbonization, enabling stakeholders to assess and prioritize interventions effectively.

Theme C: Systems integration (including industrial heat, energy & resource efficiency and circular economy)

Poster C1

Location, Location, Location

Presenter: Jainaba Conteh (University of Bath | CDT-GIF)

Email: jc4258@bath.ac.uk

Themes: Hydrogen and sustainable fuels; Systems planning, energy and resource efficiency; Circular economy and life-cycle assessment

Abstract:
In transitioning to low-carbon energy systems, to what extent has strategic consideration been given to the spatial planning of infrastructure, what is built, where, and why?

Meeting international commitments under the United Nations Framework Convention on Climate Change and Kyoto Protocol, necessitated the development of the Industrial Decarbonisation Strategy 2021. This strategy aims to reduce industrial emissions by two-thirds by 2030, promote low-carbon technologies and deploy infrastructure development. The original idea of spatial planning stemmed from the Electricity Networks Commissioner and the Transmission Acceleration Action Plan, in which the recommendations led to the commissioning of the National Energy System Operator (NESO) to develop a Strategic Spatial Energy Plan. NESO has also advised towards the Clean Power Action Plan, which outlines the plan to advance the building of energy infrastructure by 2030.

As part of the transition to clean energy, spatial planning will consider the spatial constraints and opportunities that influence identifying the most suitable locations to build energy infrastructure. This research employs quantitative modelling techniques, integrating Geographic Information Systems (GIS), Lifecycle Assessments (LCA), and Technoeconomic Assessments (TEA) within a whole systems thinking approach. The model will provide spatial guidance detailing the optimal locations, quantities and types of low-carbon fuel infrastructure.

The output will include spatial maps to guide policymakers, industry stakeholders, and investors. The research will also explore economic implications, investment needs, potential risk factors, and environmental costs of infrastructure placement, which offers contextual settings for decision-making. This approach aims to support a sustainable transition to a low-carbon energy system.

Poster C2

Digital Twins for Business Parks: Hybrid Renewables and Storage in Edinburgh Park

Presenter: Gift Udoh (Heriot-Watt University | CDT-GIF)

Email: geu2000@hw.ac.uk

Themes: Systems planning, energy and resource efficiency

Abstract:
The transition to a low-carbon, sustainable energy system requires innovative technologies for optimising energy production, storage, and consumption. To support Scotland's 2045 net-zero target, this research introduces a Digital Twin (DT) framework to transform industrial clusters into resilient, low-carbon hubs, with Edinburgh Park as a pioneering case study. Collaborating with Scottish Renewables, SP Energy Networks, and the ENSIGN Project team, this study investigates the potential of Digital Twin technology to optimise energy management at Edinburgh Park by integrating 200 MW of offshore wind (Seagreen Wind Farm) and a Solar Farm (Edinburgh Airport Solar Farm) with hybrid energy storage.

Drawing on data from operational wind and solar farms, a DT model was developed, incorporating real-time energy data and AI-driven analytics to forecast demand and optimise renewable-storage synergies. Three storage technologies were evaluated: Battery Storage (25 MWh, 85% efficiency), Thermal Storage (50 MWh, 70–75% efficiency), and Hydrogen Storage (15 MW electrolyser, 60% efficiency). Simulation results reveal that Battery Storage excelled in short-term peak shaving, reducing grid imports by 24% during high-price periods (£120–£200/MWh), while Hydrogen Storage converted 78% of curtailed wind into seasonal reserves, cutting 12,500 tCO_2 annually. A hybrid Battery-Hydrogen system achieved 85% energy autonomy and reduced annual operational costs by 32% (£2.1M). By incorporating real-time spot market pricing (£40–£300/MWh), the DT's AI algorithms automate energy trading, shifting 30% of industrial loads to low-price windows (<£60/MWh) and reducing consumer bills by 15–20%, while stabilising grid import costs below £80/MWh for 92% of operational hours.

This research demonstrates a scalable framework for smart business parks, aligning with Scotland's Hydrogen Action Plan and 2045 Net-Zero Target. By bridging policy and technology, the DT model positions industrial clusters as hubs of equitable decarbonisation, advancing the UK's leadership in renewable innovation.

Poster C3

From CHP to heat pumps: Modelling cost and emissions trade-offs for industrial heat decarbonisation

Presenter: Omid Shahrokhi (Heriot-Watt University)

Email: lmz23@bath.ac.uk

Themes: Skills, just transition and socio-behavioural change

Abstract: Decarbonising heat (about 70% of total industrial emissions [1]) is a critical pillar of the UK's industrial decarbonisation strategy and accounts about 13% of total UK emissions [2]. Industrial clusters and public-sector estates currently rely on Combined Heat and Power (CHP) systems that co-generate heat and electricity from natural gas producing 7.6% of all electricity in UK in 2024 [3]. As electricity grids decarbonise, Air Source Heat Pumps (ASHPs) emerge as a promising low-carbon alternative. This study compares the carbon emissions and operational costs of CHP systems and ASHPs delivering equivalent heating loads, accounting for fuel costs, grid carbon intensity, and offset emissions from CHP-generated electricity.

Four UK locations—Peterhead, Edinburgh, Liverpool, and London—are selected to represent diverse climate conditions and regional energy contexts for Scottish, HyNet and Solent Clusters. Monthly heat demand data from three Heriot-Watt University buildings are used to develop a temperature–demand correlation model, which informs district-scale demand profiles (~30,000 MWh/year) for all sites. These profiles are used to evaluate the emissions and economic implications of switching from CHP to ASHPs.

Results confirm the emissions benefits of heat pumps, especially as the grid continues to decarbonise. However, the economic feasibility of large-scale deployment is shaped by capital costs, return on investment (ROI), and site-specific factors—posing key barriers to retrofitting.

This analysis supports place-based, data-driven decision-making and forms part of the ENSIGN project's digital twin framework, which aims to guide heat and industrial decarbonisation on the back of previous IDRIC projects. Insights are directly relevant to local authorities, industrial cluster stakeholders, and energy network operators seeking to develop cost-effective, low-carbon heat strategies.

[1] UK Industrial Decarbonisation Strategy, BEIS 2021, p62

Theme D: Carbon capture, utilisation and storage (CCUS)

Poster D1

Development of generalised multi-well CO_2 storage proxy models for saline aquifers and depleted gas reservoirs in CCUS networks

Presenter: Efsion Andre (Imperial College London | CDT-GIF)

Email: ea122@ic.ac.uk

Themes: Carbon capture, utilisation, transport and storage

Abstract:
Designing a subsurface storage system for a Carbon Capture, Utilisation, and Storage (CCUS) project involves considering numerous factors, such as geological structures, reservoir properties, and fluid types (e.g., aquifers or depleted gas reservoirs).

Developing CO_2 storage projects in saline aquifers presents challenges due to the limited availability of data. One key challenge is managing pressure: since the initial pressure in saline aquifers is already high, any additional pressure from CO_2 injection must remain below the formation's fracture pressure.

Although depleted gas reservoirs typically offer extensive reservoir data, they still pose technical challenges. For instance, the Joule-Thomson cooling effect can lead to hydrate formation and induce thermal stress.

Well planning is particularly complex and significantly impacts storage capacity. Adding new wells or changing well locations does not always produce predictable outcomes due to interactions and interference between wells. Additionally, the volume of CO_2 injected is not constant—it varies depending on supply. For example, injection rates may decrease during maintenance periods or increase as more industries join the cluster.

Reservoir simulations are commonly used to predict the outcomes of CO_2 injection under various subsurface conditions and development plans. However, running simulations for every possible scenario is resource-intensive. To address this, proxy models have been proposed. Despite significant advancements, a notable gap remains in proxy models specifically designed for multi-well scenarios and variable injection rates.

Therefore, this research aims to develop generalised proxy models for multi-well CO_2 injection systems with variable injection rates.

Poster D2

Post-combustion CO_2 capture solvents: addressing the knowledge gap with long-term testing

Presenter: Michael Ownsworth (University of Sheffield | CDT-GIF)

Email: MJOwnsworth1@sheffield.ac.uk

Themes: Carbon capture, utilisation, transport and storage

Abstract:
One key application of Carbon Capture and Storage technologies is the removal of carbon dioxide from industrial and combustion gases before they enter the atmosphere, e.g. from combined cycle gas turbine power plants, energy from waste plants and industrial facilities in cement, steel, chemical, glass, paper and ceramics.

UK environmental guidance states "You must work out the performance of your solvent, including reclaiming requirements and modelling emissions to atmosphere. Determine this through realistic pilot (or full scale) tests using fully representative (or actual) flue gases and power plant operating patterns over a period of at least 12 months". This requirement can be satisfied by information from tests or operational data at similar plant.

There is little information easily available about successful strategies for the recovery and management of carbon capture amines. This is especially true for long term operation. Available information is mostly related to natural gas sweetening.

The poster will describe a small-scale pilot test rig (SMART) intended to facilitate such testing in an industrial setting on a real flue gas.

The project will investigate improved monitoring of solvent, process performance, and atmospheric emissions. Leading to optimized solvent management strategies, leading to more efficient and environmentally sustainable CCS operations. It will allow advance knowledge and understanding of relevant instrumentation techniques to support the permitting of new post-combustion CO2 capture facilities.

The outcome of the project will be of interest to Regulators, future industrial users and technology developers.

Poster D3

Evaluation of Coriolis Meter Performance for Flow and Density Measurement of Supercritical CCS Fluids

Presenter: Amir Jahanbakhsh (Heriot-Watt University)

Email: a.jahanbakhsh@hw.ac.uk

Themes: Carbon capture, utilisation, transport and storage; Hydrogen and sustainable fuels

Abstract:
Coriolis metering technology is highly regarded for its capability to directly measure mass flow, making it widely utilized in natural gas flow applications. The performance of Coriolis meters, as reported in various studies, demonstrates their potential for measuring CO2 and CO2 mixtures under relevant transport conditions of Carbon Capture and Storage (CCS) projects, encompassing gas, liquid, and supercritical states. The majority of the recently reported measurement errors fall well within the required accuracy envelop of ±2.5%, as stipulated in the EU/UK Emission Trading Scheme (ETS). This indicates that Coriolis meters are suitable candidates for accurate measurement in CCS applications. Numerous studies have been conducted to evaluate the performance of Coriolis meters for CO2 flow measurement. However, only a few of these studies have used representative CCS mixtures. To delve deeper into the fundamental shift in Coriolis meter performance under CCS supercritical metering conditions, a targeted study is imperative. This work involves a robust investigation to assess the performance of Coriolis meters for both flow and density measurement. Using a gravimetric calibration facility developed at Heriot-Watt University, and adopting a start-stop approach, a commercial Coriolis meter was experimentally evaluated under supercritical flow conditions for multicomponent CO2. The composition of the investigated multicomponent CO2 was selected such that they mimic typical stream compositions for CCS pipeline transportation. Moreover, to assess the reliability of the meters for density measurement, the densities obtained from the meters were compared to dedicated equations of state for gas mixtures and some experimentally measured densities. This study provides a comprehensive understanding of Coriolis meter behaviour under supercritical CO2 conditions which will help in ensuring adherence to relevant CCS contract development schedules and CCS network development.

Theme E: Hydrogen and sustainable fuels

Poster E1

Powering jets with CO_2: How ready are the electrocatalysts?

Presenter: Grace Chidimma James (Heriot-Watt University | CDT-GIF)

Email: gj2012@hw.ac.uk

Themes: Hydrogen and sustainable fuels

Abstract:
The aviation sector accounts for over 2% of global CO_2 emissions and remains one of the most challenging industries to decarbonise. With climate impacts projected to triple by 2050 under business-as-usual scenarios, Sustainable Aviation Fuel (SAF) has emerged as a critical tool in climate mitigation. However, SAF currently accounts for less than 0.1% of the global aviation fuel supply.

SAF production processes, including Hydro processed Esters and Fatty Acids (HEFA), Alcohol-to-Jet (AtJ), Fischer-Tropsch Synthesis (FTS), and Power-to-Liquid (PtL), offer varying levels of scalability and sustainability. Achieving our decarbonisation goals depends on the efficiency and readiness of the enabling technologies, particularly the catalysts. Among these technologies, PtL, which converts captured CO_2 into fuels using renewable electricity, holds the greatest potential for large-scale deployment. PtL, unlike the other technologies of HEFA and AtJ, is not limited by feedstock constraints such as land, crops, or waste materials.

Within the PtL approach, electrochemical CO_2 reduction (ECO_2RR) offers a direct, and potentially energy-efficient route to produce multi-carbon fuels.

This poster presents a literature-based investigation of catalyst approaches developed for ECO_2RR, focusing on those potentially producing the required C_8–C_{16} hydrocarbons. Catalyst synthesis methods and performance are critically reviewed using indicators like Faradaic efficiency, product selectivity, and operational stability.

By analysing recent advances in developing electrocatalysts for ECO_2RR, this review supports the selection of viable systems for future experimental work. It also contributes to the broader effort of producing jet fuel–range hydrocarbons and value-added products, through sustainable CO_2 conversion.

Poster E2

Powering jets with CO_2: How ready are the electrocatalysts?

Presenter: Julian Black (Imperial College London | CDT-GIF)

Email: julian.black24@imperial.ac.uk

Themes: Hydrogen and sustainable fuels

Abstract:
Bipolar membranes (BPMs) are a growing technology that consists of a cation exchange membrane, an anion exchange membrane, and a catalyst layer in between the two. This composite membrane can be used to perform water dissociation where an applied electric field drives H+ and OH- ions out of the BPM in opposite directions. The pH gradient developed by the BPM's water dissociation and ion transport enables chemical reactions that would otherwise require extreme conditions. BPMs can be used to operate the anode and cathode at a different pH, providing ideal conditions for electrocatalysts. This makes them a promising technology for electrolysers and fuel cells. BPMs are also being researched for use in CO_2 capture and electrolysis. Current industrial uses include desalination, pH adjustment in water treatment, acid-base synthesis, and a variety of other applications where a pH gradient is required.

In this poster we describe some of these applications, as well as go into the materials development and BPM fabrication techniques. We will discuss current applications for BPMs in industry, as well as promising technologies utilising BPMs. We will review the materials development for high performance BPMs, looking at how catalysts and membranes are developed and can work together to efficiently transport ions and perform water dissociation. Here we present some initial results on high free volume polymers for BPMs. Finally, we review different methods of fabricating BPMs for optimal performance.

Poster E3

Enhancing water oxidation with RuO_2–graphene composites for economical green hydrogen generation

Presenter: Michal Ciesielka (Heriot-Watt University | CDT-GIF)

Email: mac4001@hw.ac.uk

Themes: Hydrogen and sustainable fuels

Abstract:
Currently, approximately 96% of hydrogen is produced from fossil fuels, predominantly as grey hydrogen via steam reforming of natural gas (IRENA, 2022), releasing about 11.57 kg of CO_2 per kilogram of hydrogen (Hammi, 2024). In contrast, green hydrogen—produced using renewable energy—can emit less than 1 kg of CO_2 per kilogram, or potentially none if powered entirely by clean energy sources (Hammi, 2024). However, its high production cost (€3–7/kg) compared to grey hydrogen (€1–2/kg) remains a significant barrier to widespread adoption (Edge Branding, 2025). My PhD research addresses this challenge by developing low-cost electrocatalysts from non-critical raw materials to replace expensive platinum group metals (PGMs) such as ruthenium oxide (RuO_2), which costs approximately £85–100/g. In this work, a novel RuO_2–graphene composite was synthesized via a solvothermal method, reducing RuO_2 content by up to 15%. Linear sweep voltammetry demonstrated that an anode coated with the composite achieved a current density of ~77.8 mA/cm^2 at 2 V vs RHE, compared to ~53.9 mA/cm^2 for pure RuO_2 in 0.5 M H_2SO_4. Electrochemical impedance spectroscopy confirmed that the highly conductive graphene enhances charge transfer and water oxidation, while lowering catalyst costs. This strategy shows strong promise for reducing the levelized cost of green hydrogen production.

Poster E4

Flashback in Hydrogen-Fuelled Gas Turbine Combustors

Presenter: Iliana Dimitrova Dimitrova (Imperial College London | CDT-GIF)

Email: i.dimitrova24@imperial.ac.uk

Themes: Hydrogen and sustainable fuels

Abstract:
The global drive for large-scale, low-carbon energy generation is accelerating the transition towards hydrogen as a key fuel for decarbonising power systems.

Hydrogen's high reactivity and zero-carbon combustion make it attractive, while also introducing critical challenges, for widespread industrial adoption. One critical concern, particularly problematic in hydrogen combustion systems, is the undesired upstream propagation of the flame, namely flashback, outside the combustor, e.g. the fuel supply duct, or flame anchoring at wall surfaces or internal boundaries, leading to material degradation, component failure, and severe damage.

Flashback has been a topic of interest in the combustion community since the 1950s, and despite many efforts, the influence of localised chemistry and transport effects near solid boundaries under gas turbine combustor operating conditions are still not fully understood and are often approximated for practical reasons. Traditional models, including one-dimensional theory and three-dimensional numerical efforts, often struggle to accurately describe flame-flow interaction in the near-wall regions.

This research aims to address the gaps in literature through controlled experiments using burner geometries representative of gas turbine combustors, supported by high-resolution optical diagnostics to capture flame flashback dynamics near walls while also considering wall heating effects, differential diffusion and intrinsic flame instabilities.

Novel prediction strategies based on Deep Learning and Computer Vision, and concepts from information theory are also explored. These approaches, not previously applied to flashback detection, offer the potential for optimised early warning and advanced control, accelerating the transition to safe and reliable power generation operations.

Poster E5

Advancing underground hydrogen storage: A data-driven approach to site selection and performance optimization

Presenter: Abdolali Mosallanezhad (Heriot-Watt University | CDT-GIF)

Email: am3053@hw.ac.uk

Themes: Hydrogen and sustainable fuels

Abstract:
Hydrogen is expected to be a crucial component in global decarbonisation efforts and the UK's path to net-zero emissions. However, as hydrogen production scales up to meet government targets, a significant challenge remains in identifying suitable storage solutions for its efficient and reliable use. The underground geological storage of hydrogen has incredible potential to tackle this challenge. However, selecting suitable storage sites and optimising their performance poses significant challenges due to geological variability and operational uncertainties. To date, most studies have focused on the static properties of geological formations, including rock porosity, permeability, and risk factors such as seismic activity (Davies et al., 2024; Jahanbakhsh et al., 2024; Lewandowska-Śmierzchalska et al., 2018; Zeng et al., 2023). While these factors are crucial, hydrodynamic parameters—including hydrogen trapping, reservoir heterogeneity, and hysteresis in flow functions—also play a key role in determining more realistic storage capacity and efficiency.

This research integrates machine learning (ML) with static and dynamic screening methods to bridge this gap. By developing hydrogen flow dynamic correlation in porous media, we aim to enhance site selection criteria beyond conventional static evaluations. The study employs a multi-tiered screening process, where static screening relies on pre-existing geological datasets, while dynamic screening incorporates reservoir simulations to assess real-time hydrogen behaviour under varying operational conditions.

By integrating numerical simulations with advanced data analytics, this research refines hydrogen-rock interaction models and develops practical guidelines for industry application. The expected outcomes include enhanced site screening methodologies, improved storage efficiency, and a deeper understanding of hydrogen flow dynamics, supporting the scalability and reliability of UHS for a low-carbon energy future.

Poster E6

Synthesis and optimisation of nanoscale nickel sulfide catalysts for electrochemical hydrogen evolution.

Presenter: Michael Walsh (Heriot-Watt University)

Email: ww2011@hw.ac.uk

Themes: Hydrogen and sustainable fuels

Abstract:
Green hydrogen, produced through renewable-driven electrolysis, is one of the most promising clean energy carriers in the strive towards net-zero. However, green hydrogen is still significantly more expensive than traditional hydrogen production methods, showing the need for efficient and sustainable cost-cutting throughout various areas of the electrolysis process. One such area that can be deemed to be of significant cost is the use of precious metals, such as platinum, as common catalyst materials. Furthermore, the often limited supply of such materials can cause issues with availability and effect the supply chain. Metal chalcogenides, particularly nickel chalcogenides, are receiving significant attention due to their high activity for both the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER). Nickel's high activity, along with its relative low cost and vast availability, makes it an extremely viable alternative to traditional noble metal-based catalyst. We employed a facile solvothermal synthesis to fabricate a highly efficient nickel sulfide nanomaterial for the HER. The Ni:S precursor ratio, coating substrate, and reaction duration were all optimised and play a crucial role in determining the catalytic activity of NiS. We employed characterisation techniques such as XRD and SEM, displaying rhombohedral NiS crystals and highly porous nanostructures. NiS coated nickel mesh and stainless-steel cathodes displayed overpotentials as low as 554 mV and 852 mV to achieve current densities of -100mA/cm2. The next step in the catalyst progression is to apply a binder to improve the overall stability and increase the viability of scale-up and industrial application.

Poster E7

Transformation of Plastic Waste into Hydrogen and Solid Carbon using MagIC (Magnetic Induction Catalysis)

Presenter: Manuel Ojeda (Heriot-Watt University)

Email: m.ojeda@hw.ac.uk

Themes: Hydrogen and sustainable fuels; CO_2 removal technologies; Carbon capture, utilisation, transport and storage

Abstract:
To achieve the transition to a net-zero circular economy for plastics, alongside existing recycling methods, the chemical transformation of waste plastic into new products, such as platform molecules and energy carriers, has gained significant attention from the scientific community in the recent years. Using a less energy-intensive technology like induction heating could reduce the energy demand for plastic transformation by 80% and make the process more cost-competitive compared to conventional pyrolysis using electric furnaces. Unlike other methods, the higher efficiency of induction technology is based on contactless electromagnetic energy to heat metallic particles, significantly reducing energy loss compared to typical convective methods. The use of induction heating in catalytic reactions has been previously reported for various applications, such as hydrolysis and cross-coupling. However, research on high-temperature catalytic induction heating reactions remains limited. This work will show the induction system, and the results obtained from the conversion of waste plastic using a magnetic induction catalytic system to produce hydrogen and solid carbon.

Poster E8

Integrated electrocatalytic wastewater treatment and carbon utilisation using Pd-based nanocatalysts

Presenter: Shagbaor Hycent Amool (Heriot-Watt University)

Email: sa2274@hw.ac.uk

Themes: Hydrogen and sustainable fuels; Carbon capture, utilisation, transport and storage

Abstract:
The integration of carbon utilisation with wastewater treatment presents a promising pathway toward addressing climate and water pollution simultaneously. This study investigates Pd-based electrocatalysts for the electrochemical degradation of N-nitrosodiethanolamine (NDEA) in wastewater, with potential application in CO_2 utilisation. Five Pd nanomaterials were synthesised using CO-assisted methods with varying precursor concentrations. with the optimised sample exhibited highly uniform morphology and highest phase purity, achieved the best performance—degrading 78.88% of NDEA at –1.5 V. HPLC analysis of treated samples confirmed the transformation of NDEA into Diethanolamine (DEA) and Monoethanolamine (MEA), which are known precursors of NDEA. Their identification validates a chemically consistent reverse degradation pathway. Despite its low electrochemical surface area, Sample 1 demonstrated superior activity, long-term stability, and efficiency across varying concentrations (200-400 ppm). These findings highlighted the importance of surface quality over surface area and support the feasibility of Pd-based nanomaterials for integrated water treatment, CO_2 resource recovery, aligning with circular economy and sustainability objectives.

Poster E9

Optimisation of green hydrogen production plant to minimise the LCOH (Levelised Cost of Hydrogen)

Presenter: Roya Eidi (Abertay University)

Email: r.eidi2100@abertay.ac.uk

Themes: Hydrogen and sustainable fuels

Abstract:
I am currently completing my PhD at Abertay University in Dundee, where I focus on the techno-economic optimisation of large-scale green hydrogen production in Shetland, Scotland.

The plant is designed to produce up to 100,000 tonnes of hydrogen annually without relying on battery storage or traditional grid connections. By using an integrated optimisation tool linked to NASA's meteorological databases, the model successfully reduces the number of required wind turbines, enhances system reliability, and achieves an estimated LCOH of £2 per kg. Additional cost savings are possible through the sale of surplus electricity to the grid.

Unlike traditional renewable projects that treat hydrogen as a by-product, this system is designed with hydrogen production as the core objective. The modelling process begins with a comprehensive site assessment, factoring in local energy potential, meteorological conditions, and policy constraints, to identify the optimal mix of renewable sources. The simulation uses energy-based equations to align hydrogen output with variable renewable inputs, aiming to optimise system performance and cost.

Multiple design scenarios are generated, which can be customised based on client priorities and site-specific policies. A final sensitivity analysis assesses system robustness under varying conditions, such as demand fluctuations or CAPEX changes, ensuring adaptability and long-term feasibility.

This research offers practical and scalable solutions for energy companies aiming to decarbonise through green hydrogen, particularly in remote or off-grid areas during the feasibility phase of hydrogen projects. The approach can be further developed to support subsequent stages, including the design basis and detailed engineering of green hydrogen production facilities.