Sustainable Hydrogen

CENTRE FOR DOCTORAL TRAINING

Annual Report 2021

University of Nottingham
UK | CHINA | MALAYSIA

Loughborough University

UNIVERSITY OF BIRMINGHAM

Ulster University

UKRI Engineering and Physical Sciences Research Council

SH CDT

Student Training 13,116 Hours

OVER THE PAST YEAR

564 PhD Applications

27% Female Students - Cohort 3

2021 Target 50%

Students in Nottingham 17

Loughborough 10

Birmingham 4

3 Ulster

BAME

Cohort 3

45%

Target 18%

International Collaborations

six

91 Stakeholder Interactions

Student Number Target 67

- Cohort One 9
- Cohort Two 14
- Cohort Three 11
- Cohort Four 17
- Cohort Five 16

Research Themes

Presentations and Publications 11

2020-2021 The Year in Numbers

Director's Report

I write this report with COP26 on the horizon. It is recognised globally the need to decarbonise in order to avoid catastrophic climate change and hydrogen is seen as an important part of the solution. It can help decarbonise sectors like transport and heat as well as providing a scalable energy storage solution for renewable energy. In the UK, the Government has published its Hydrogen Strategy showing the ambition to increase hydrogen generation to 5 GW by 2030 and indicating a timeframe for deployment with the UK's first hydrogen village by 2025 and hydrogen for industrial use and transport in the 2030s.

For SusHy CDT, this has been a challenging year. The restrictions imposed because of the pandemic have hindered access to research facilities and teaching has remained online. But despite this, the students have had a successful year with 13 first years successfully completing their taught programme and the second year students advancing their individual research projects. Cohort building activities included the highly successful Power Trader Game from Heuristic Games, which was a valuable experience of energy markets, balancing affordability and carbon intensity of energy whilst still making a profit.

The recruitment for our third cohort was successfully completed using a strategy for recruiting diverse teams which was developed in consultation with Diversity by Design. Assessment of candidates now considers the contribution candidates can make to the CDT in addition to their potential as an excellent researcher. SusHy also increased the number of research projects on offer to PhD applicants from female supervisors and from early career researchers. I was very impressed with the quality of the candidates invited to interview and am pleased to welcome cohort 3 to the CDT, 11 talented individuals from diverse backgrounds who will make significant contributions to our growing, vibrant sustainable hydrogen community.

In looking towards the coming year, SusHy will be working to bring the students together and provide networking opportunities which have not been available during the pandemic. SusHy will also explore the opportunities available to our students through our international collaborator with the Australian Research Council Training Centre in Global Hydrogen Economy, running joint training activities and providing a network to develop new research collaborations. The recruitment for 2022 (cohort 4) will start in November 2021. SusHy is still expanding the range of PhD projects in collaboration with stakeholders. An important aim this year is to improve further the gender balance of the cohort, one step towards achieving this will be to offer all female students a stakeholder role model who would act as a mentor for the student during their PhD. We will also work with our partners the Women's Engineering Society and Women in Science and Engineering to enhance SusHy inclusivity.

Professor Gavin Walker
Director, Sustainable Hydrogen CDT

Our Vision

Our vision

Moving beyond 2030 – hydrogen facilitated deep-decarbonisation.

Our objectives

- Deliver high quality transdisciplinary training, covering fundamental science, applied engineering, and systems issues and build an appreciation of societal barriers to innovation.
- Through innovation opportunities, build initiative and stimulate an entrepreneurial mindset.
- Deliver “industry ready” doctorates who have a comprehensive skill set and experiences.
- Co-create research ideas and undertake in partnership with our stakeholders, cutting edge investigations of hydrogen-based solutions to deep decarbonisation of the energy system.

Equality, Diversity and Inclusivity

Why diversity matters

At the SusHy CDT we appreciate that diverse teams are more successful which is why Equality, Diversity and Inclusivity (EDI) are at the heart of our operations. The positive evidence for this is all around: companies with diverse workforce are more productive and those with diverse boards are more profitable. Ignoring diversity has negative impacts, e.g. products failing certain sections of the customer base.

The SusHy programme aims to train the energy leaders needed to meet the net-zero global challenge, which will require leading successful innovation teams informed by diverse perspectives.

What SusHy is doing

SusHy has recruited amazing individuals from a diverse talent pool who are contributing to the success of the CDT. Our recruitment is guided by EDI best practice and this year we have worked with Diversity by Design consultants to develop a strategy focussed on recruiting a diverse cohort. The CDT has an EDI training framework for everyone—students through to supervisors—and supports students, early career academics and those returning after a career break. Some examples include a student EDI forum where issues can be raised, supporting student-led initiatives (e.g. buddy scheme and the International Women’s Day SusHy Seminar), being responsive to care responsibilities outside of work and an EDI fund to assist students where mobility would otherwise prevent participation in CDT activities. SusHy has become proud partner of Women’s Engineering Society (WES) and Women in Science and Engineering (WISE) and offers free membership to both societies for our students and staff.

Challenges for SusHy

SusHy is always seeking to improve and aims to strengthen the supportive environment so that everyone feels equally valued and no one is impeded from achieving their full potential. The recruitment stretch-objective is to have a cohort which reflects the diversity of the UK. This has been achieved for ethnic minority groups and other measures of diversity, but gender parity has yet to be achieved. The new recruitment strategy increased interest from potential female applicants and the focus this year will be converting that interest into applications.

CDT Team Members

Prof Gavin Walker
Director

gavin.walker@nottingham.ac.uk

Dr Kandavel Manickam
Program Manager

manickam.kandavel@nottingham.ac.uk

Ms Linsday Holowka
Administrator

lindsay.holowka@nottingham.ac.uk

Mrs Lorraine Hammond
Marketing Manager

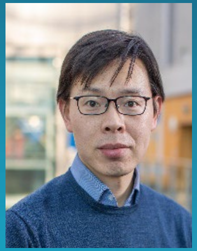
lorraine.hammond@nottingham.ac.uk

Management Board

University of Nottingham
UK | CHINA | MALAYSIA


Prof. Gavin Walker
University of Nottingham


Prof. Elena Besley
University of Nottingham


Dr. Sanliang Ling
University of Nottingham

Loughborough University


Prof. Upul Wijayantha
Loughborough University


Prof. David Saal
Loughborough University


Prof. Monica Giulietti
Loughborough University

University of Birmingham


Prof. David Book
University of Birmingham


Prof. Lynne Macaskie
University of Birmingham


Dr. Rafael Orozco
University of Birmingham


Dr. Daniel Reed
University of Birmingham

Ulster University


Prof. Vladimir Molkov
Ulster University


Dr. Dmitriy Makarov
Ulster University

Our Students

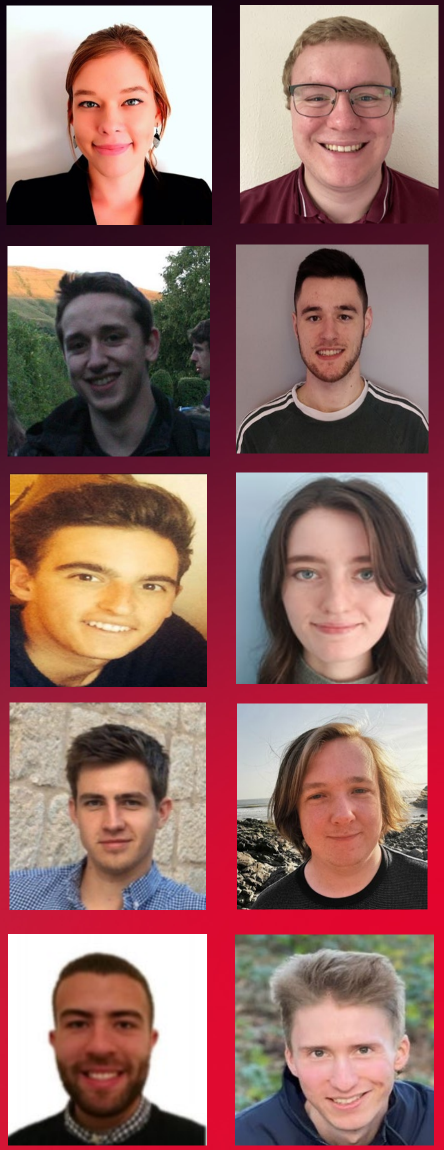
Combustion

Distribution

Safety

Production

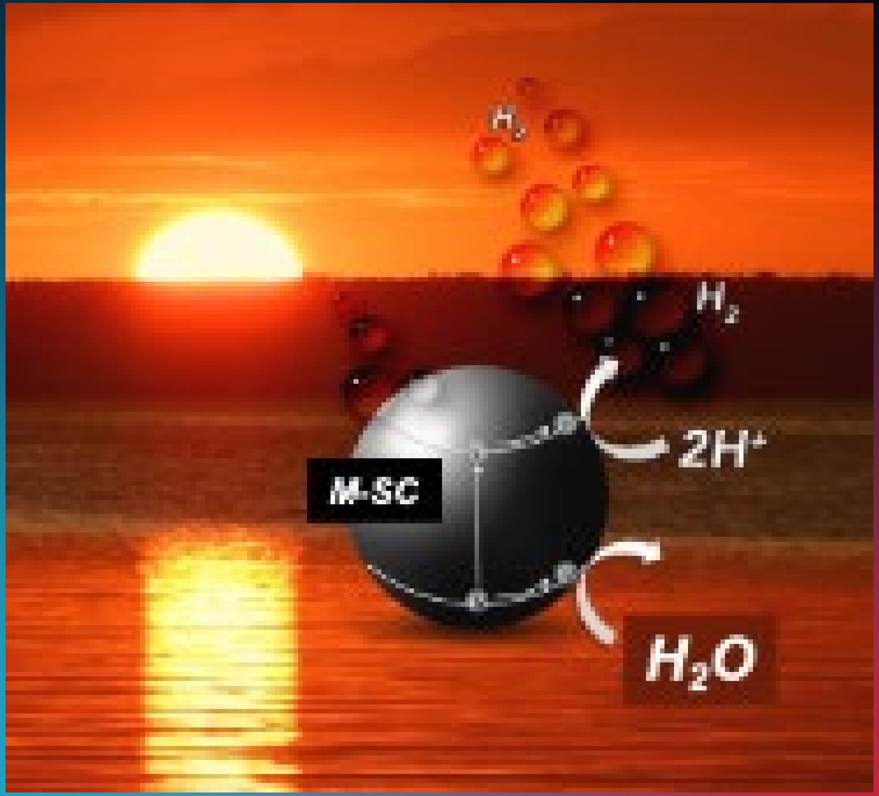
Storage



Systems

Upgrade

Ruth Atkinson
School of Chemistry
University of Nottingham



Designing efficient charge-transfer metal-semiconductors heterojunctions for hydrogen generation

This project will assess a wide range of metal-semiconductor combinations for their suitability as photocatalysts for the generation of hydrogen from water, replacing current catalysts based on expensive precious metals. In particular, we will explore materials based on Nb semiconductors in conjunction with metals such as Co, Cu, Ni or Mo. Materials will be synthesised, fully characterized and tested towards the photogeneration of hydrogen from water.

Supervisors – Dr Anabel Lanterna, Prof Elena Besley

Will Bowling
Faculty of Engineering
University of Nottingham

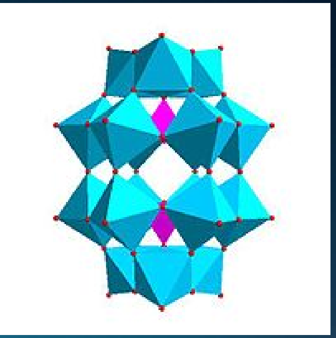
Experimental Study of Advanced Ammonia Fuelled Heavy Duty IC Engines under Low Load Operation

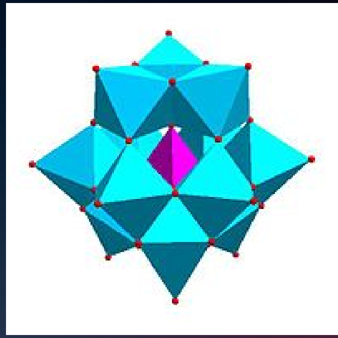
Figure 1 - Volvo D8 Engine Rig

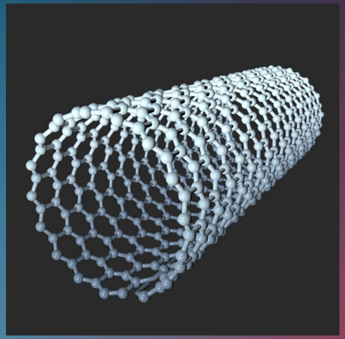
Will is carrying out an experimental research project utilising advanced combustion methods such as turbulent jet ignition and dual fuel operation to enable the operation of ammonia fuelled heavy duty internal combustion engines, with a specific focus in low load operation, during which the combustion is the most challenged. The investigations will be carried out using a constant volume combustion chamber to investigate the fundamental combustion phenomena occurring during ignition as well as applied studies in the form of engine testing.

Supervisors – Prof Alasdair Cairns, Dr Antonino La Rocca
Dr Richard Jefferson-Loveday

Jack Castle
School of Chemistry
University of Nottingham







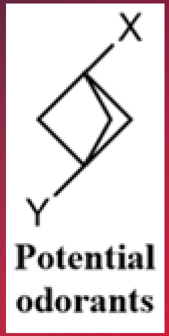
Sustainable electrocatalysts for H_2 generation

Jack carries out research into the development and use of polyoxometalates (POMs) as electrocatalysts that facilitate both the oxygen and the hydrogen evolution reactions during electrolytic water splitting. He is particularly interested in the development of POM-carbon nanotube composites.

Supervisors – Dr Darren Walsh, Dr Graham Newton,
Dr Ming Li

Harvey Craddock-Monroe
Department of Chemistry
Loughborough University

Figure: i-substituted bicyclopentane



Development of odour additives for use in H_2 technology

The remit of the project involves the design, synthesis and testing of novel compounds for use in hydrogen storage. A number of potential odorants will be selected and compared with the novel compounds, as well as some odorants present in literature. The tests will consist of hedonic tone and odour character tests to ensure the suitability of an odorant's scent before fuel cell tests are performed to test which odorants don't poison the catalyst. So far, work on the novel compounds has been fully focussed on the bicyclopentane framework due to its volatility and broad substrate scope.

Supervisors – Dr Marc Kimber, Dr Gareth Pritchard

Antonia Dase
School of Chemistry
University of Nottingham

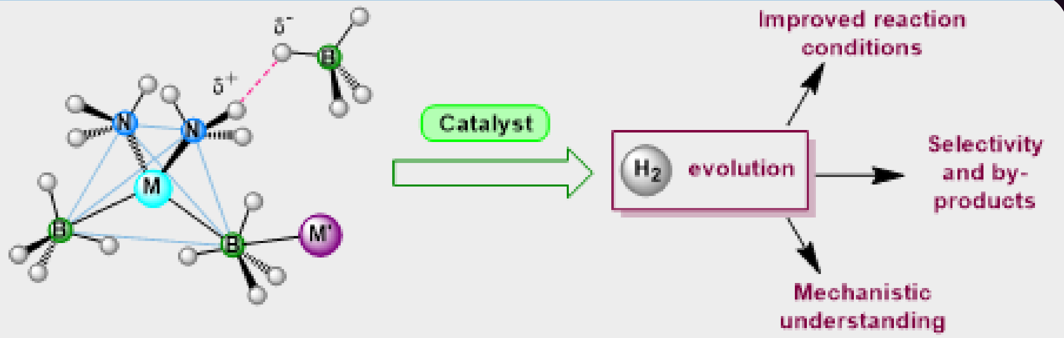


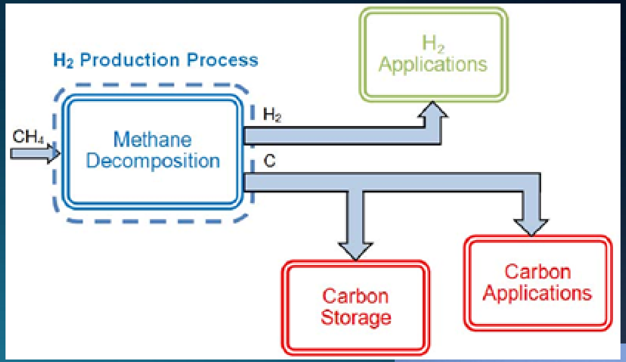
Figure 1. Catalytic dehydrogenation of mixed metal borohydride ammoniates.

Dehydrogenation catalysis of mixed metal borohydride ammoniates

Antonia is developing novel catalysts for the dehydrogenation of mixed metal borohydride ammoniates and seeks to elucidate the mechanisms involved in order to improve reaction conditions and selectivity.

Supervisors – Prof Deborah Kays, Prof Gavin Walker

Mickella Dawkins
Department of Chemistry
Loughborough University



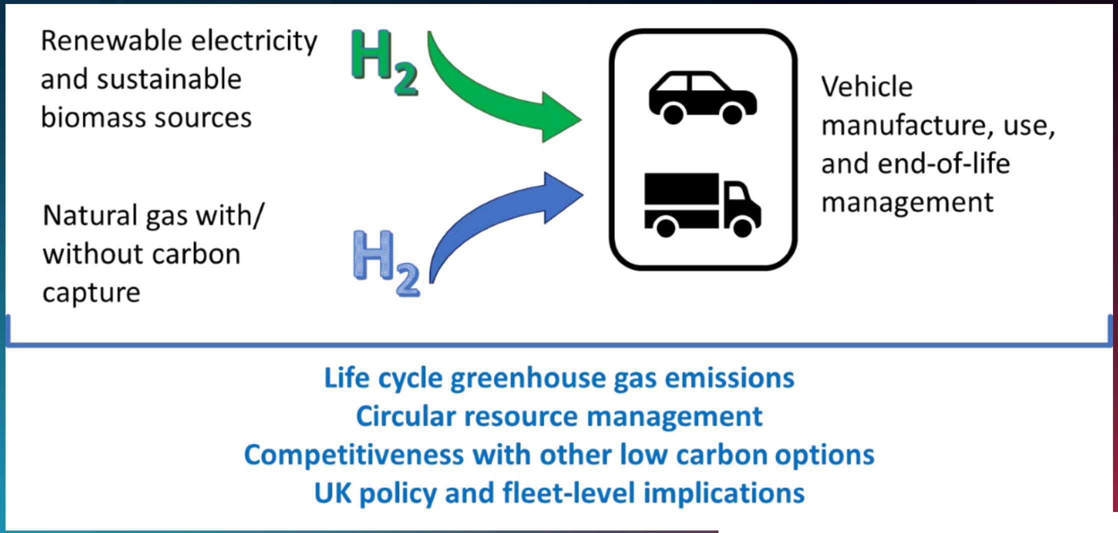
Stakeholder collaboration : Catapult

Hydrogen enrichment of natural gas by thermo-catalytic decomposition of methane

Decomposition of the methane from natural gas is being developed as a method of hydrogen production with low CO_2 emissions. There has been considerable research into the reaction parameters such as catalyst and reaction temperature which, determine the yield of the products and the type of carbon produced. This research looks at the use of iron oxide from a natural source as the catalyst for the thermo-catalytic methane decomposition process.

Supervisors - Prof Upul Wijayantha, Prof David Saal

Cheryl Duke
Faculty of Engineering
University of Nottingham



Saudi Aramco

Stakeholder collaboration : Saudi Aramco

Quantifying Environmental and Resource Impacts of the Future UK Hydrogen Fuelled Vehicle Fleet

This project will develop novel LCA models to assess the resource and environmental implications of deploying hydrogen fuelled vehicles in the UK's light duty and heavy duty road fleets. The comprehensive approach will consider current and future mix of hydrogen production routes; vehicle manufacture; use; and end-of-life vehicle management (e.g., recycling). Beyond more common LCA studies comparing technologies on vehicle level, this project will consider the turnover of UK vehicle fleet and uptake of hydrogen technologies to quantify cumulative resource and environmental implications.

Supervisor - Dr Jon McKechnie

Hazhir Ebne-Abbasi
Belfast School of Architecture and
The Built Environment (BSABE)
Ulster University

Figure: Experimental facility

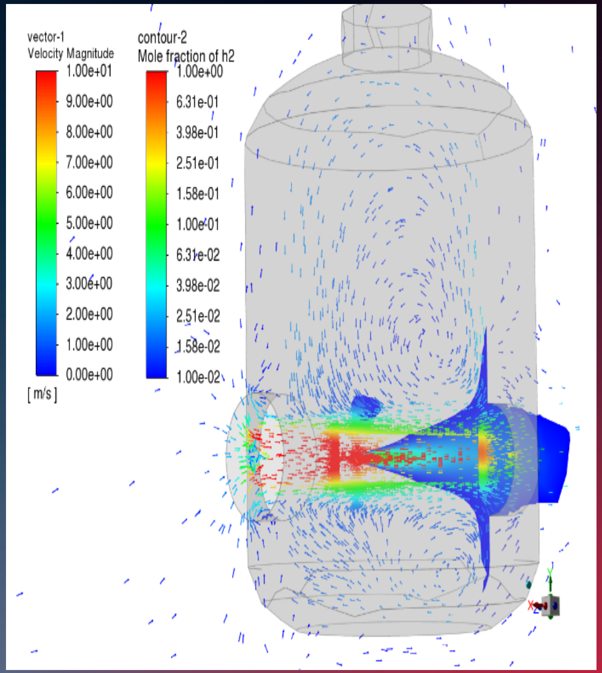


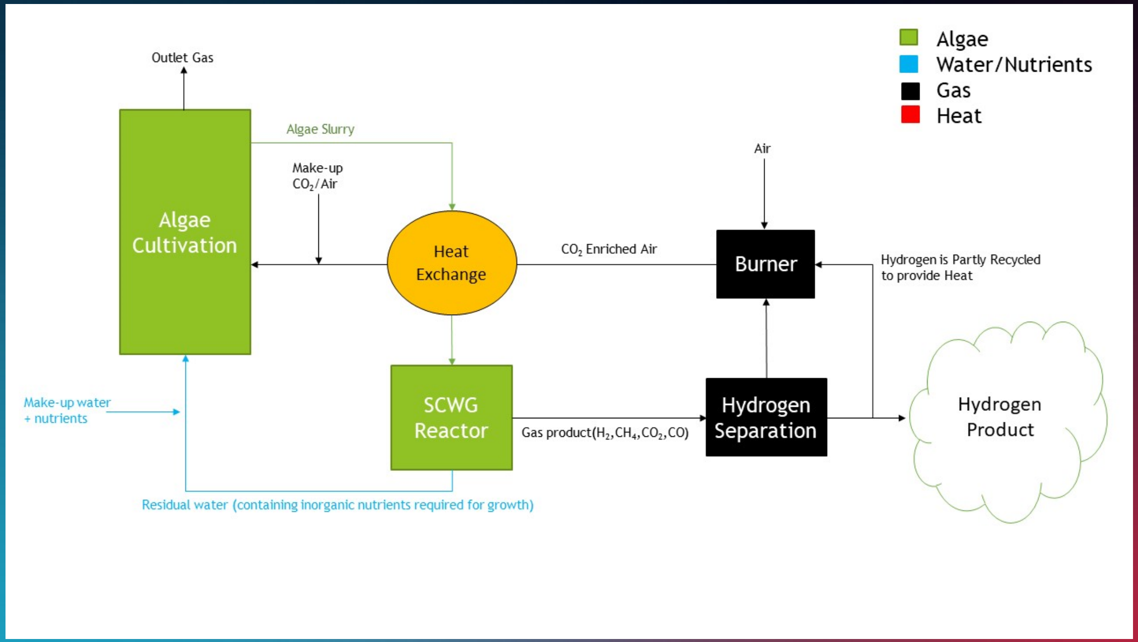
Figure: Simulated velocity vectors and hydrogen mole fraction distribution

Assessment and mitigation of hydrogen-fuelled vehicle hazards

Research within this topic has been developing in line with the ongoing HySAFER Centre project “Pre-normative research for safety of hydrogen driven vehicles and transport through tunnels and similar confined spaces”. Study of mechanical ventilation in a tunnel on hydrogen dispersion and mixing was undertaken in with NCSRD (Greece), KIT (Germany). Scaled experiments performed at PS GmbH were the subject of Computational Fluid Dynamics (CFD) benchmarking exercise undertaken jointly between Ulster University, NCSRD and KIT. Comparison of the results with the experimental data was published at the Int. Conference on Hydrogen Safety Sept 2021, Edinburgh.

Supervisors: Dr Dmitriy Makarov, Prof Vladimir Molkov
Dr Volodymyr Shensov

Kieran Heeley
Chemical Engineering
University of Birmingham



Algal biomass to hydrogen: a circular approach for green sustainable processing with enhanced efficiency and minimal waste

The project investigates hydrothermal conversion of algal biomass to H_2-rich gas in a sustainable circular approach. Optimising the Catalyst, Feedstock and operating conditions to increase the hydrogen yield, while maximizing the nutrient recovery

Supervisors – Dr Bushra Al-Duri, Dr Rafael Orozco, Prof Lynn Macaskie

Edward Jones
Department of Chemistry
Loughborough University

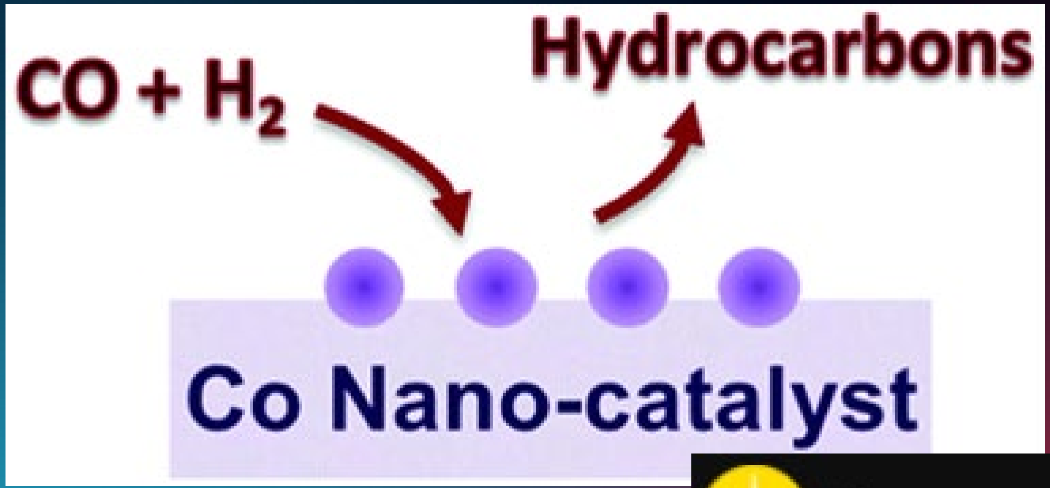


Figure: Recent developments in the application of nanomaterials to understanding molecular level processes in cobalt catalysed Fischer-Tropsch synthesis", Phys. Chem., 2014, 16, 5034-5043 DOI:10.1039/C3CP55030C

Stakeholder collaboration : Diamond

Neutron spectroscopy of surface intermediates on nanoporous metal catalysts for H_2 storage technologies

Ed is using inelastic and quasi-elastic neutron scattering techniques to study how Fischer-Tropsch reaction intermediates vary with co-adsorbed CO, as well as the mechanism of Fischer-Tropsch synthesis on a model skeletal cobalt catalyst.

Supervisors - Dr Simon Kondrat, Prof Sandie Dann,
Prof Ian Silverwood

Mina Kazemi
Belfast School of Architecture and the Built Environment (BSABE)
Ulster University

Prevention and mitigation of accidents with hydrogen-powered vehicles in confined spaces

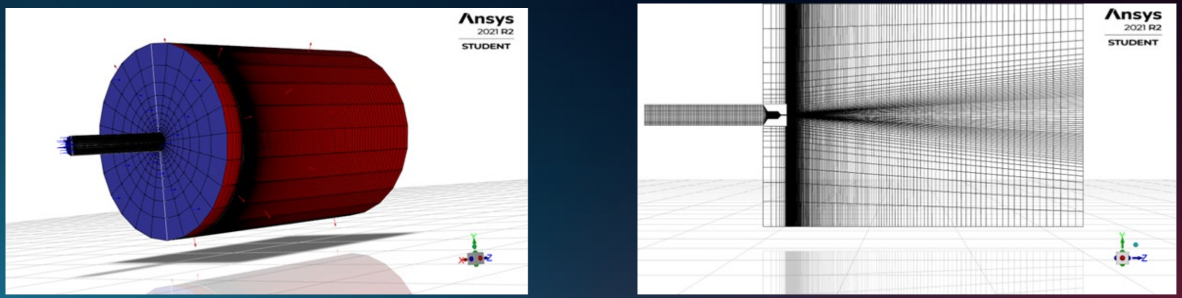


Figure 1. Generated mesh inside TPRD and domain (fully 3D and central cross-section image are shown)

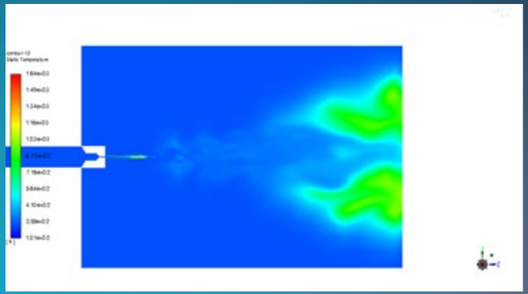


Figure 2. Temperature contour showing blow-off phenomenon related to a 0.2mm TPRD's diameter nozzle and reservoir pressure of 0.5 MPa

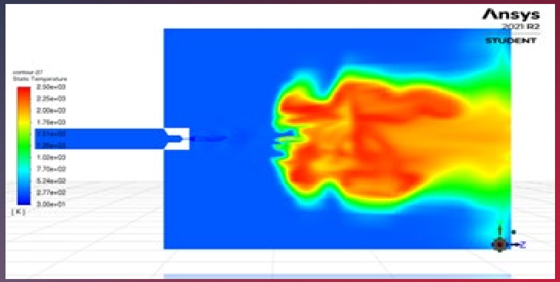
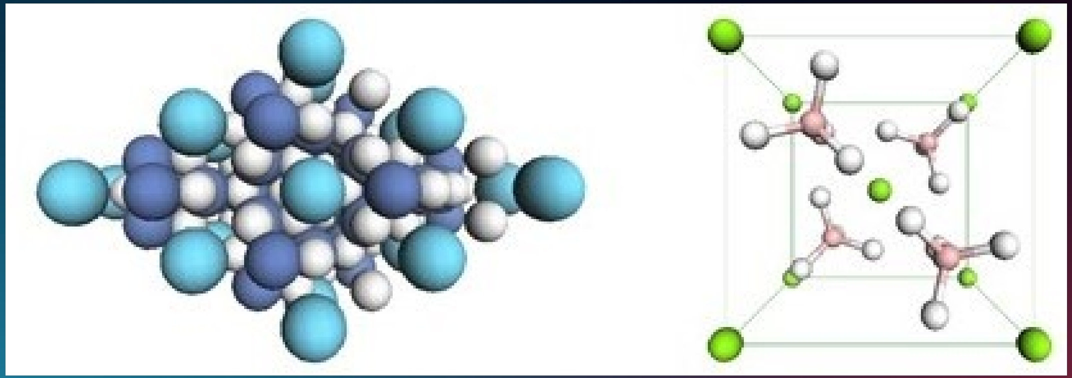


Figure 3. Temperature contour of a lifted flame in which hydrogen released from a 0.5 mm TPRD's diameter nozzle and reservoir pressure of 10 MPa

The scope of this doctoral study includes the identification and prioritisation of relevant knowledge gaps to develop innovative safety strategies to mitigate and prevent hydrogen-fuelled vehicles accidents in confided spaces. The first step is performing analytical and numerical studies to increase hydrogen-powered vehicles safety through improving TRRDs design to prevent pressure peaking phenomenon and blow-off phenomenon which both would lead to hydrogen deflagration or detonation and catastrophe in confined spaces.

Supervisors – Dr Sile Brennan, Dr Dmitriy Makarov, Prof Vladimir Molkov

Samuel Lines
Faculty of Engineering
University of Nottingham



Computational Modelling of Solid-State Hydrogen Storage Materials

This project aims to understand the composition-structure-property correlations of solid-state hydrogen storage materials through accurate density functional theory simulations of both existing and hypothetical materials. The most promising candidate materials discovered from the computational simulations will be synthesised and characterised, and their hydrogen storage properties will be validated by experiments.

Supervisors – Dr Sanliang Ling, Prof Gavin Walker, Prof David Grant

Stephen Marr
Department of Chemistry
Loughborough University

Image: *Gavin Walker*

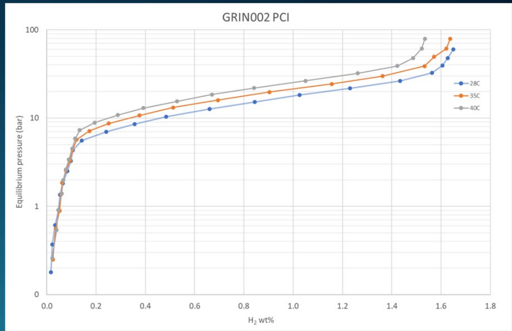
Stakeholder collaboration : Effectech

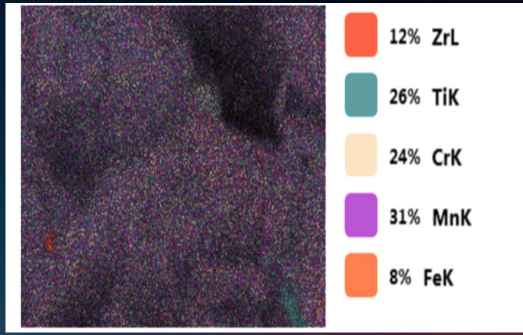
Development of techniques and methods for sampling, calibration and testing of hydrogen purity for fuel cell vehicles

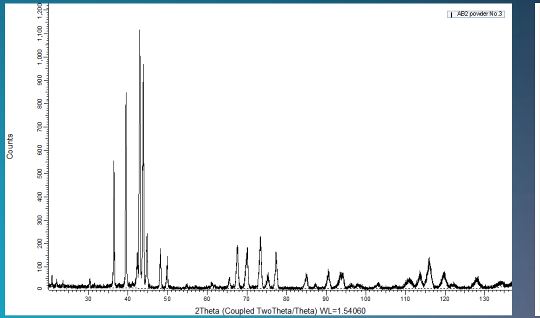
Measurement challenges for hydrogen fuel cells are preventing the overall sector from growing and this project aims to develop a cylinder passivation technology providing temporal stability data for the 14 trace contaminants outlined in ISO 14687-2.

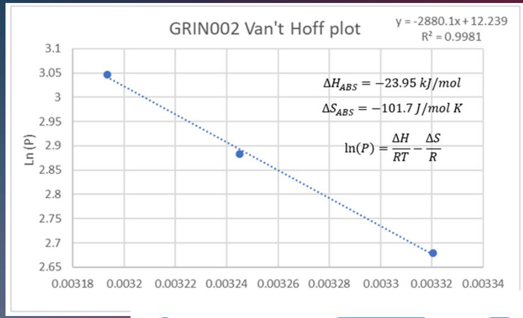
Supervisors – Dr Ben Buckley, Prof Upul Wijayantha, Prof Paul Holland

Alex McGrath
Faculty of Engineering
University of Nottingham









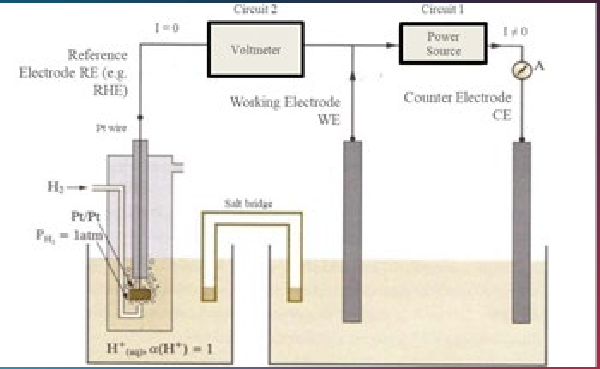
Stakeholder collaboration : Less Common Metals

Synthesis and characterisation of metal alloys for hydrogen storage and related applications

The majority of research this year has been used to characterise pre-existing metal alloys and explore the hydrogenation reactions of these alloys. Future work will investigate synthesising new metal alloy compositions that will have improved hydrogen storage properties, forming their hydrides and characterising their microstructures.

Supervisors – Prof David Grant, Prof Gavin Walker, Dr Sanliang Ling, Dr Kandavel Manickam

Adam McKinley
Department of Chemical Engineering
Loughborough University



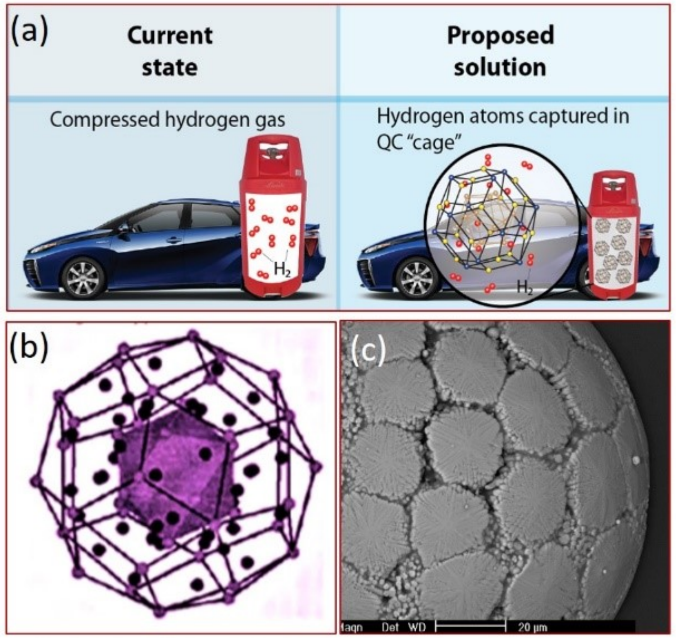
Schematic example of a 3-electrode configuration for an electrochemical cell. A standard hydrogen electrode (SHE) was used in this particular example. In this research a Mg/MgO or Ag/AgCl would be used instead. S. Bebelis, Thermodynamics and Kinetics of Electrochemical Reactions (2013).

Catalyst development for low-cost large-scale sustainable hydrogen production from seawater and renewable energy

Over the past year Adam's main focus has been using existing knowledge and research of the ethanol oxidation reaction (EOR) to gain a better overall understanding of the reaction kinetics and theory. With the data received Adam was able to identify which catalysts show significant promise for use in both hydrogen and oxidation evolution reactions (HER and OER). Adam hopes to gain valuable data in regards to single atom catalysts (SACs) in the near future.

Supervisors - Prof Wen-Feng Lin, Prof Jin Xuan,
Dr Darren Walsh

Zachary Menhinnit
Faculty of Engineering
University of Nottingham



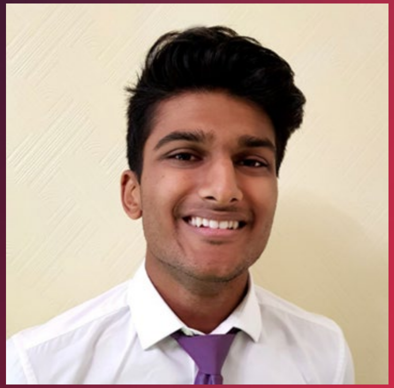
(a) It is proposed to use quasicrystals for on-board hydrogen storage, which is safer with higher volumetric efficiency compared to compressed gas. (b) Quasicrystal have potential to be a lightweight hydrogen storage material due to their unique multi-shell cluster structure which contains enormous hydrogen-favoured interstitial sites (represented by dark dots). (c) SEM image of Mg-based quasicrystals.

Nano-Quasicrystals for Hydrogen Storage

A major barrier to exploitation of hydrogen in energy applications especially vehicles is the lack of a safe, efficient and cost-effective storage system. Quasicrystal (QC) have potential to be a lightweight hydrogen storage material due to their unique multi-shell cluster structure. This project aims to develop high-performance nano QC materials for on-board vehicle hydrogen storage.

Supervisors – Prof Gavin Walker, Prof Elena Besley,
Prof David Grant

Jai-Ram Mistry
Department of Chemistry
Loughborough University



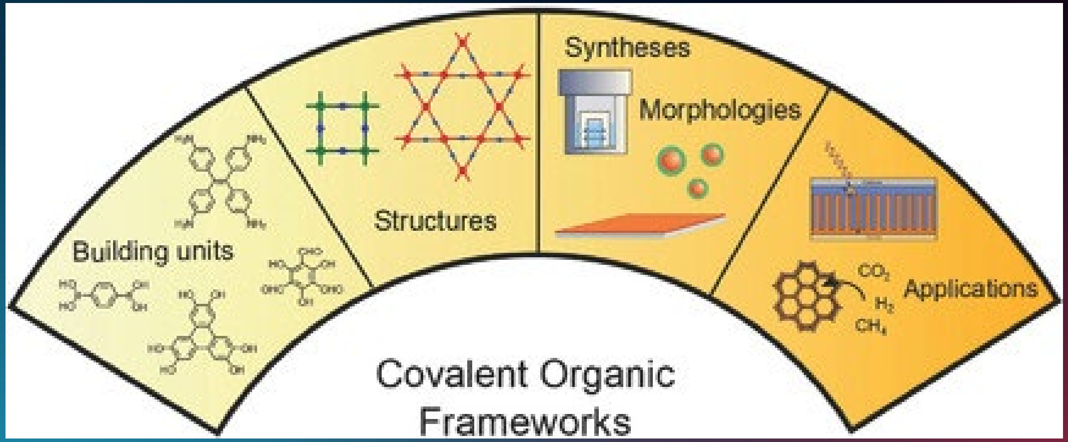


Figure: Adv. Funct. Mater. 2018, 28, 1705553.'

Photocatalytic covalent organic frameworks for hydrogen production and storage

Jai undertakes research into the use of covalent organic frameworks (COFs) for hydrogen production and storage as opposed to the popular MOF alternative. The project involves the synthesis of new molecules which can be functionalised onto the surface of covalent frameworks (COFs) creating photocatalytic and size-specific channels which will permit hydrogen production from water and selective ingress, storage and egress.

Supervisors – Dr Iain Wright, Dr Simon Kondrat

Oliver Morrison
Faculty of Engineering
University of Nottingham

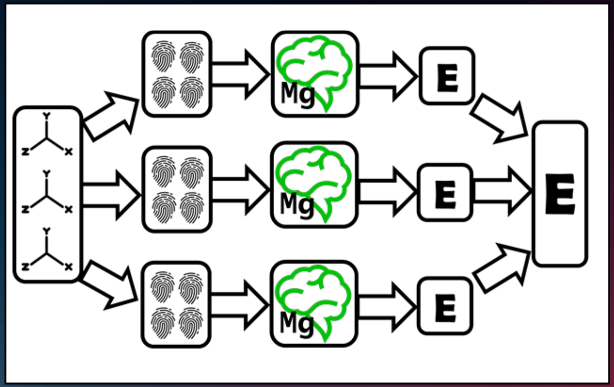


Figure 1: Schematic for the High Definition Neural Network used in Oliver's Research.

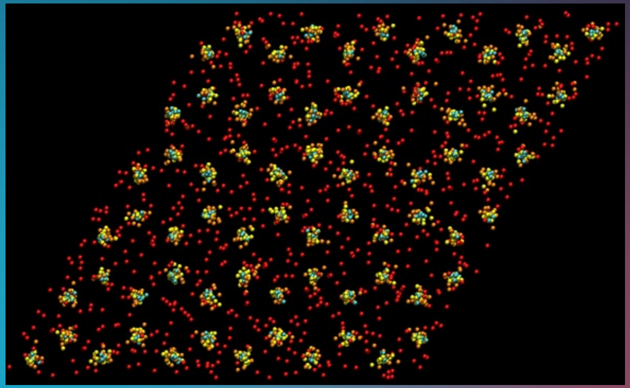


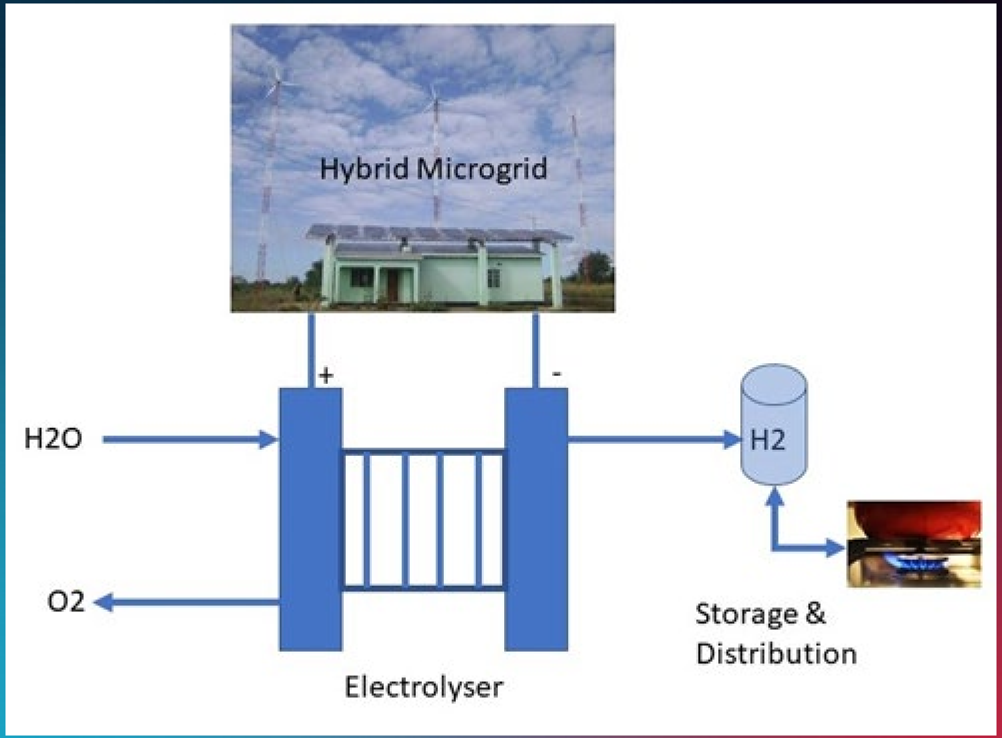
Figure 2: MD simulations of hexagonal magnesium at various temperatures overlayed on top of one another. (Red: 1100K, Orange: 800K, Yellow: 500K, Blue: 200K). These simulations, produced by a HDNN, correctly predict the melting point of magnesium (~900K).

Hydrogenation of storage materials

Oliver undertakes research in the training of High Definition Neural Networks (HDNNs), a type of machine learning model. Trained correctly, HDNNs are able to predict the cohesive energy of atomic structures to a high level of accuracy and can be used to perform Molecular Dynamics (MD) simulations of atomic environments. The HDNNs can produce long scale, accurate simulation runs that were not possible using more established methods. He has applied HDNNs to simulate magnesium systems and is currently working towards simulating hydrogen systems. Eventual magnesium-hydride simulations will give insight into the process of hydrogenation and may inform the selection of improved hydrogen storage materials.

Supervisors – Dr Sanliang Ling, Prof Gavin Walker,
Prof David Grant

Mulako Mulkelabai
Department of Chemistry
Loughborough University



Renewable hydrogen production to transition to clean cooking

The project aims to develop technical and business models and processes that will enable hydrogen produced from renewable energy to be utilised for cooking.This process is understood; however, the system needs not just the right technology, it also needs the development of the right business model, human capacity and social acceptance to bring about the transformation of traditional cooking practices.

Supervisors – Dr Richard Blanchard, Prof Upul Wijayantha
Dr Alastair Livesey

Una O’Hara
School of Metallurgy and Materials
University of Birmingham

Development of high-performance complex hydrides

Una is investigating thermodynamic tuning of boron and nitrogen-based complex metal hydrides (CMHs) synthesized by chemical and mechanochemical routes. Nano structuring by encapsulation in mesoporous-frameworks seeks to enhance cyclic stability, discharge and recharge rates whilst maintaining storage capacity. The materials will be characterised using a wide range of techniques to assess electrical, thermal and hydrogen storage properties.

Supervisors – Dr Daniel Reed, Prof David Book

Figure: Raman equipment at the University of Birmingham

Zoe Pallis
School of Psychology
University of Nottingham

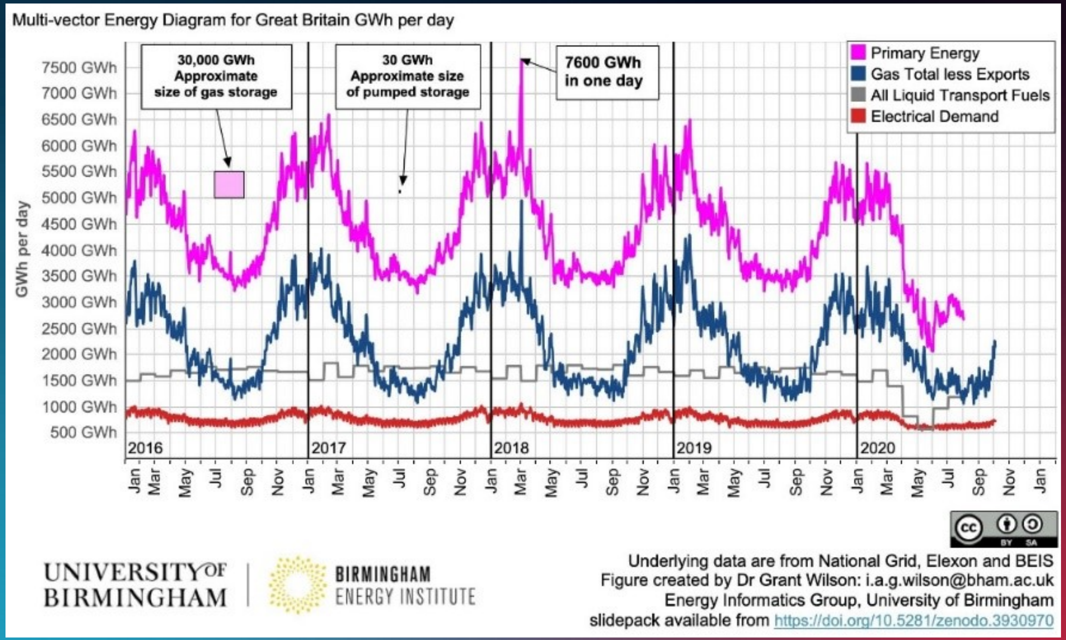
Image: Jake Melara on Unsplash

Public perceptions of hydrogen for heat

Zoe's mixed-methods research uses a combination of qualitative and quantitative approaches to explore factors which may drive or hinder public support for the use of hydrogen in domestic heating.

Supervisors – Dr Alexa Spence, Prof Gavin Walker

Katarina Pegg
School of Chemical Engineering
University of Birmingham

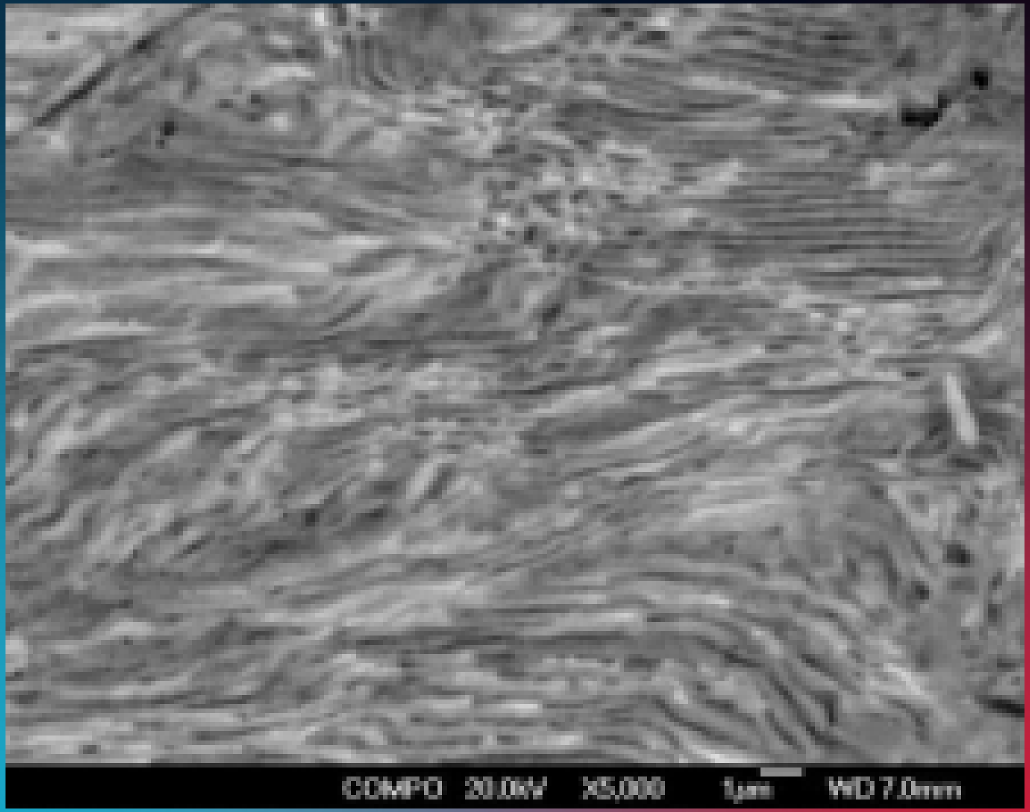


The role of green hydrogen in the West Midlands Combined Authority local energy system

Green hydrogen production from weather dependent low-carbon generation is an area of growth signposted in the Committee on Climate Change's 6th Carbon Budget. This research will focus on the advantages and disadvantages of green hydrogen generation at a local level, specifically within the West Midlands Combined Authority area.

Supervisors – Dr Grant Wilson, Dr Bushra Al-Duri

Patrick Powell
School of Metallurgy and Materials
University of Birmingham

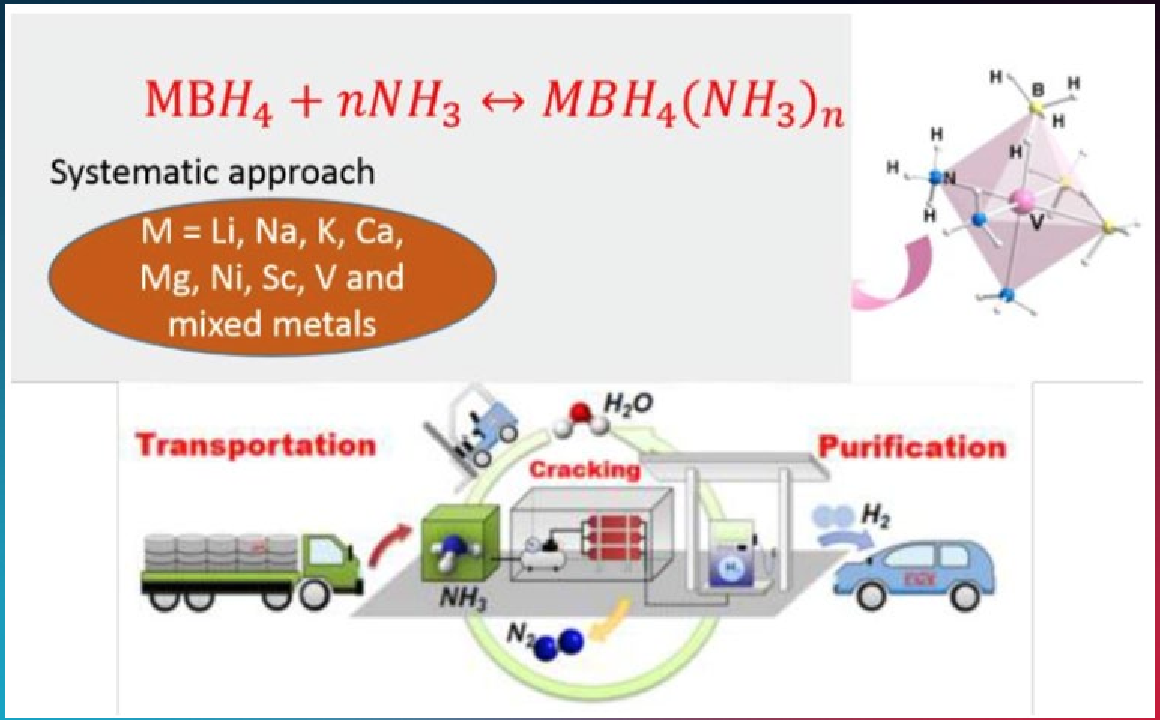


The use of hydrogen as a processing gas to produce rare earth magnets

Hydrogen is used in the conventional production of sintered (rare earth) neodymium-iron-boron magnets and in the recycling of these materials. In recent years new methods to manufacture rare earth magnets based on a process called hydrogen ductilisation has been found. This process reduces the number of steps, reduces waste and could give a significant economic advantage to magnet manufacture. However the process is far from optimised and the aim of this project will be to develop this process.

Supervisors – Prof Allan Walton, Dr Richard Sheridan, Prof David Book

Jacob Prosser
Faculty of Engineering
University of Nottingham



High Capacity Single and Mixed Metal Borohydride Ammoniates (MBA/MMBAs) for Hydrogen Energy Storage Applications

Jacob is interested in the synthesis and characterisation of novel MBA/MMBAs, increasing the hydrogen storage performance of these materials and elucidating the reaction mechanisms of the decomposition process. Currently he is assessing the influence of metal charge density and the number of ammonia ligands on the hydrogen storage performance.

Supervisors – Prof Gavin Walker, Prof David Grant,
Dr Kandavel Manickam

Courtney Quinn
School of Chemistry
University of Nottingham

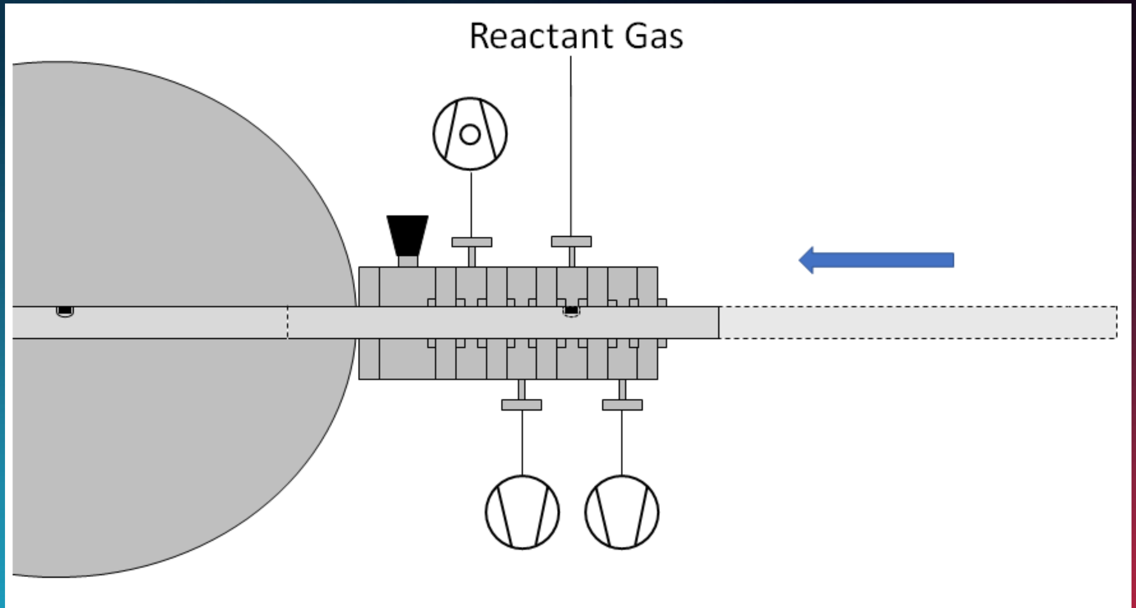
Image: engin akyurt on Unsplash

Sustainable hydrogen evolution catalysts

The development of composite systems based on molecular metal oxide nanoclusters and ionic liquids will be undertaken. The ionic liquids will allow the stabilisation of the molecular catalysts into thin films, membranes and 3D-printed superstructures. Then research will be undertaken to explore the stability and efficiency of these systems during prolonged electrolysis.

Supervisors – Dr Graham Newton, Dr Darren Walsh,
Dr Lee Johnson

Chris Ryder
School of Physics & Astronomy
University of Nottingham

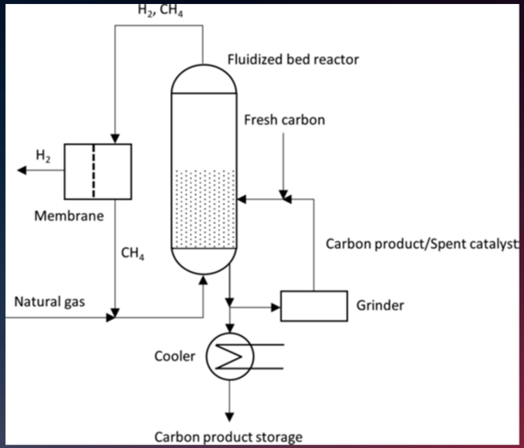


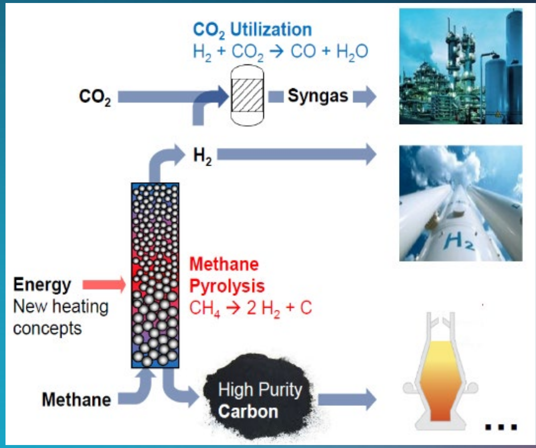
High-throughput cycling coupled XPS of hydrogen storage materials

Chris is designing a sample transfer device that enables rapid X-ray photoelectron spectroscopy (XPS) analysis of samples after reactions at elevated pressures. The device will soon be used to investigate various solid-state hydrogen storage materials, with a particular focus on their change in performance with increasing hydrogen cycles.

Supervisors - Dr James O’Shea, Prof Gavin Walker, Prof David Grant

Aryamman Sanyal
Department of Engineering
Loughborough University



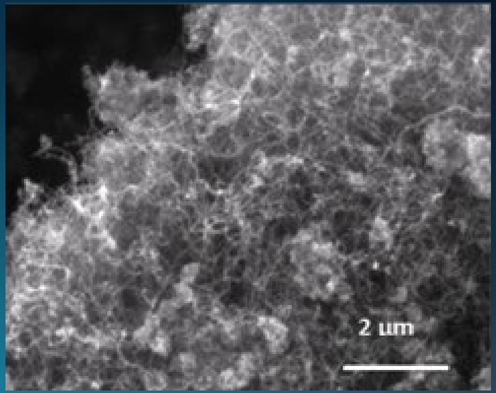


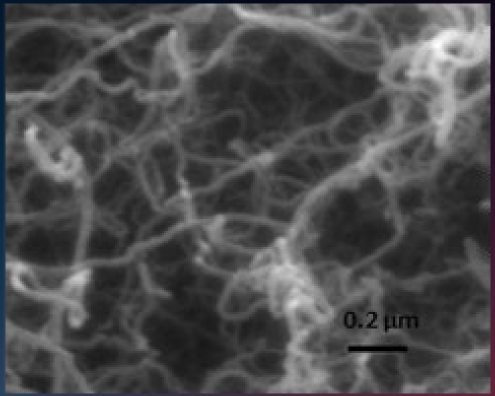
Reactor design and performance optimisation for catalytic hydrogen production from methane

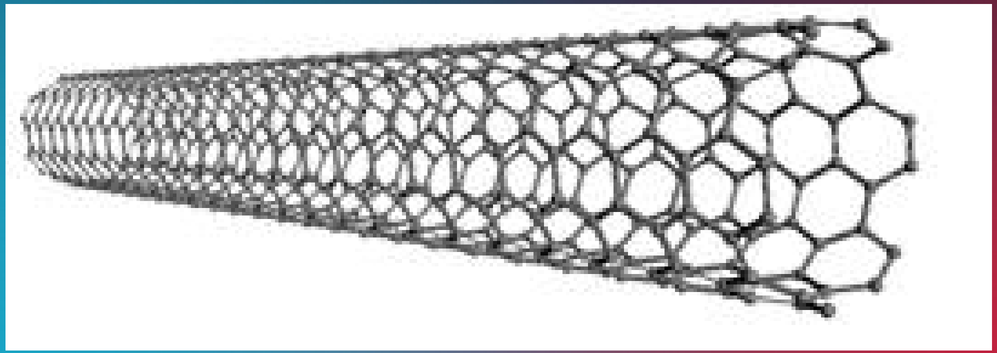
The project aims to design, develop and test hydrogen generation reactor suitable for advanced catalyst that demonstrate high H_2 yield and efficient carbon separation. Natural gas into hydrogen and graphite has the potential to be highly disruptive and presents substantial value if the process can be scaled up to commercial quantities.

Supervisors – Prof Weeratunge Malalasekera,
Prof Upul Wijayantha

Jack Shacklock
Department of Chemistry
Loughborough University





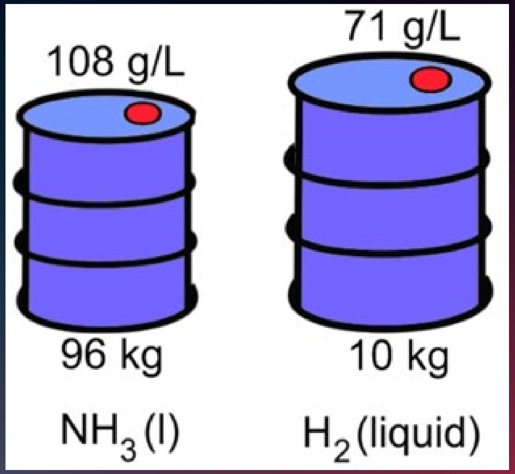


Lowering the H_2 cost in methane cracking technology by using solid carbon as an energy storage material.

Initial studies have been conducted to improve the methene cracking process to increase yield and longevity. By-product carbon has separated in batch processes and studied in electrochemical supercapacitors. They have demonstrated hi-rate performance compared to commercial carbon used for supercapacitor manufacturing. These results suggest that lowering the cost of turquoise hydrogen by finding applications for by-product carbon is promising. Further studies are currently underway to separate by-product carbon in real-time operation (as oppose to batch process) and evaluate their performance in applications.

Supervisors – Prof Upul Wijayantha, Dr Niladri Banerjee

Srinivas Sivaraman
Belfast School of Architecture and the Built Environment (BSABE)
Ulster University

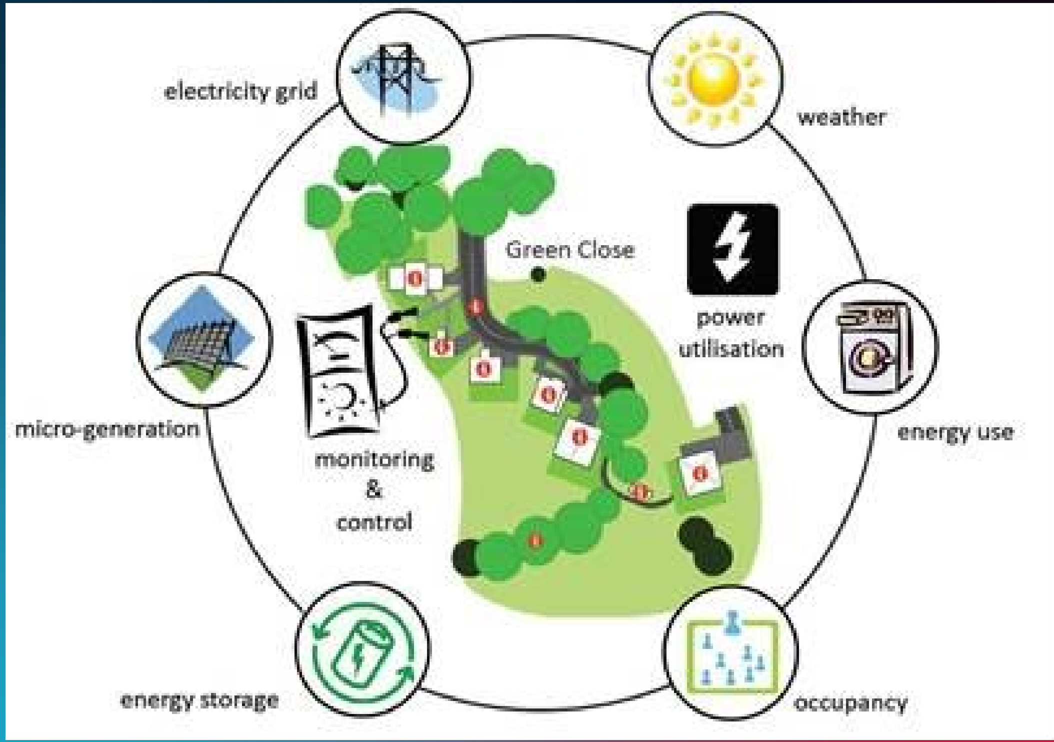


Safety of Using Ammonia in for the Hydrogen Economy

The experience use of ammonia in industries and its transportation around the globe offers practical, cost-effective means of storage and transport of large quantities of hydrogen. Using ammonia as hydrogen carrier, calls for a reassessment of hazards and risks. This project aims to develop safety strategies and engineering solutions for handling large quantities of ammonia used as a hydrogen carrier during transport and storage onboard and using relevant infrastructure. The project will review hazards, including toxicity effects, existing prevention and mitigation safety strategies when dealing safely with ammonia.

Supervisors – Dr Dmitriy Makarov, Prof Vladimir Molkov, Dr Volodymyr Shentsov

Samir Soares
Faculty of Engineering
University of Nottingham



Optimising decarbonised energy system usage for a rural community using metal hydride hydrogen storage

Samir is developing an understanding of rural energy requirements to develop a decarbonised rural energy model assessing the viability of multi vector hydrogen including metal hydride storage. Also developing a representative demonstrator green hydrogen model.

Supervisors – Prof Mark Gillott, Prof Gavin Walker

Salim Ubale
Faculty of Engineering
University of Nottingham

ITM POWER
Energy Storage | Clean Fuel

Stakeholder collaboration : ITM power

Optimisation of hydrogen fuelling station operation and maintenance to maximise performance and resilience of key infrastructure

It is obviously desirable to maximise performance of the Hydrogen Refuelling Stations not just for economic reasons, but in order to deliver the best customer experience. This project seeks to optimise the plant operation, where planning preventative maintenance can help reduce disruption to service and improve the commercial case of a plant.

Supervisors – Dr Rasa Remenyte-Prescott,
Prof Gavin Walker, Dr Matt Lees,
Philip Wilson

Amit Verma
School of Business and Economics
Loughborough University

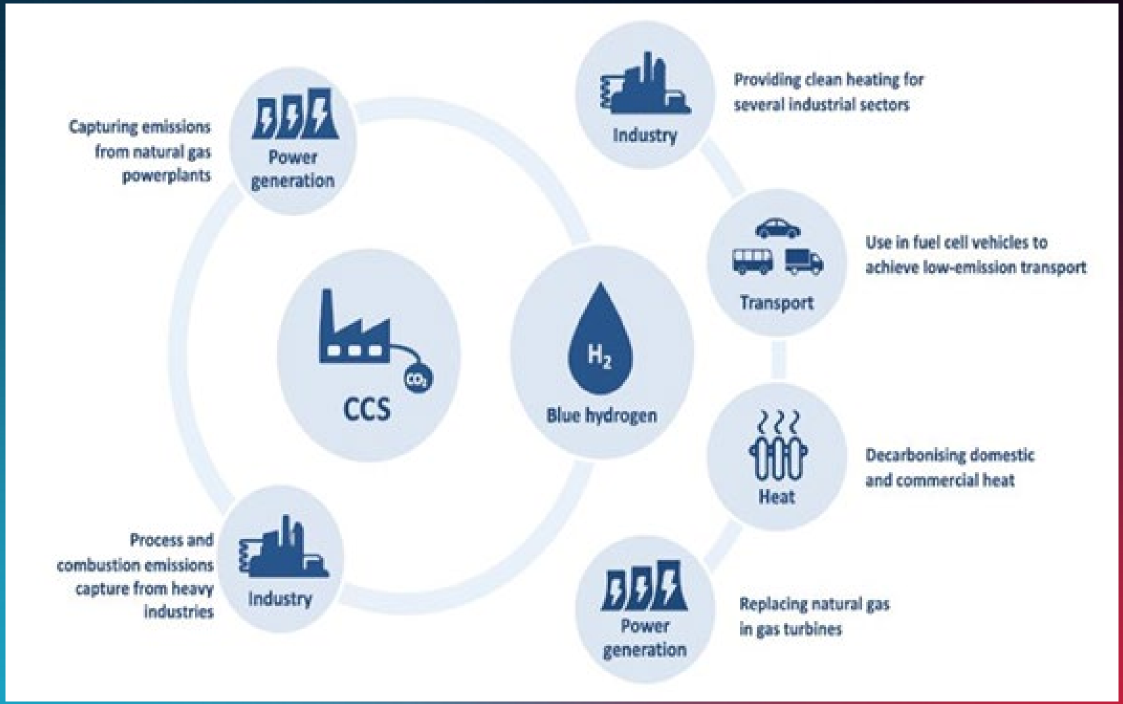


Figure: The role of hydrogen and CCS in UK Economy (Element Energy 2019)

Understanding the potential of hydrogen technology adoption in a complex challenging energy system

This project will identify relevant policy interventions necessary to achieve successful adoption of hydrogen technologies within the existing energy system. It will lead to the development of a framework to categorise these hydrogen technologies on economic, technological and engineering grounds providing strategic insights into the key factors (economic, regulatory, technological, social and political) which influence stronger adoption of these technologies with a focus to achieve decarbonisation of the heating sector.

Supervisors – Prof Monica Giulietti, Prof David Saal,
Prof Upul Wijayantha

Zak Waite
Faculty of Engineering
University of Nottingham

To a 100% hydrogen domestic boiler

This project seeks to redesign the domestic boiler so that hydrogen can be used as a network fuel. At the moment because methane which is currently used burns quite differently from hydrogen our current domestic boilers cannot be used.

Supervisors – Dr Donald Giddings, Prof David Grant,
Prof Robin Irons

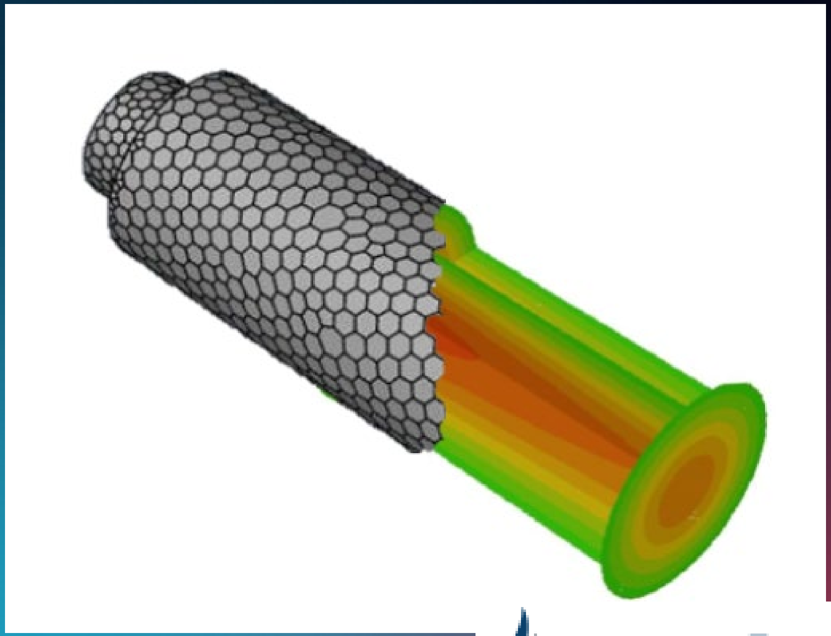
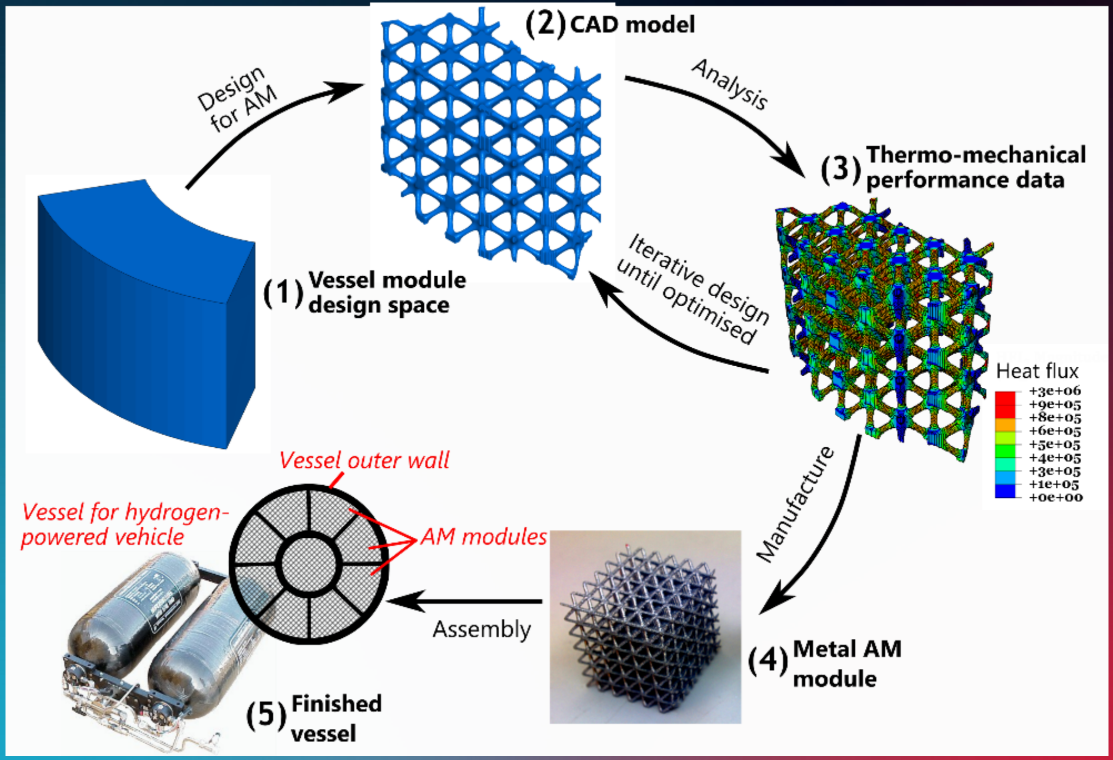


Figure: Temperature profiles in a CFD model of a micro-hydrogen partial premixed bluff body burner (PPBB burner)

Beckett
THERMAL SOLUTIONS

Stakeholder collaboration: Beckett

Yassin Ziar
Faculty of Engineering
University of Nottingham



Modular Additive Manufacturing for Next-Generation Hydrogen Storage

Compact hydrogen storage is a major challenge for hydrogen powered vehicles, with current state-of-the-art storage vessels being too large and operating at dangerously high pressures. Solid state metal hydrides (MH) can store large quantities of hydrogen in much smaller volumes and at lower pressure. However, MH stores have not made it to market because suitable vessels have not yet been developed. This project will investigate the design and manufacture of a new type of compact MH storage vessel – the Type S vessel.

Supervisors – Dr Ian Maskery, Prof Gavin Walker

Want to get involved?

We'd love to hear from you

e: beinspired@sustainablehydrogen-cdt.ac.uk

w: sustainablehydrogen-cdt.ac.uk