FLEXIS

SMART ENERGY FOR OUR FUTURE
YNNI CALL AR GYFER EIN DYFODOL

Advisory Board Report

November 2021

UNDEB EWROPEAIDD
EUROPEAN UNION

Llywodraeth Cymru
Welsh Government

Cronfa Datblygu Rhanbarthol Ewrop
European Regional Development Fund

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Swansea University
Prifysgol Abertawe

University of South Wales
Prifysgol De Cymru

Contents

Foreword

Prof Hywel Thomas

It is my pleasure to welcome you to the second Advisory Board meeting of the FLEXIS Extension. We are now some 9 months into the two-year extension and as such firmly into the delivery phase of the project. All partners are contributing strongly as always. Our consortium of strategic partners – Cardiff University, Swansea University, The University of South Wales, Neath Port Talbot Borough Council and Tata Steel UK.

I would like first of all to welcome two new members to the Board: Dr. Eric Brown from the Energy Systems Catapult and Professor Martin Brunnock from Tata Steel UK. Further details of both are included in this report and I am sure you can see that their experience will add enormously to the work of the Board. To be precise, I should in fact welcome Martin back to the Board since he was heavily involved with the project during its formation and was a leading member of the Board during its early years.

This meeting is dedicated to presentations and discussions of a number of projects that are related to FLEXIS. These are FLEXISApp; the Swansea Bay City Deal; the South Wales Industrial Cluster (SWIC), and the South Wales Industrial Transition from Carbon Hub. (SWITCH). By way of an introduction, I provide a brief overview of each project below.

FLEXISApp's vision is to drive green economic growth. Through strong industrial partnerships the project develops the world-leading research from FLEXIS into innovative projects to deliver net zero solutions and drive economic growth. Also funded by WEFO, FLEXISApp started in mid 2019 and is scheduled for completion in February 2023. Some examples of current projects will be presented.

The Swansea Bay City Deal is a major programme of investment in the Swansea Bay City Region, which is made up of Neath Port Talbot, Carmarthenshire, Swansea and Pembrokeshire. "Supporting Innovation and Low Carbon Growth" is a recently announced £58.7 million programme designed to support the creation of a decarbonised and innovative economy, with a targeted focus on the Port Talbot Waterfront Harbourside area.

The South Wales Industrial Cluster (SWIC) is already a well-known and well-established organization that has established itself strongly in South Wales. Working with South Wales leading industrial, academic, legal, and public and private organisations, SWIC are exploring routes to decarbonisation of the region's industrial cluster making it the world's first net zero emissions industrial zone by 2040.

The South Wales Industrial Transition from Carbon Hub (SWITCH) is the successor programme to FLEXIS, currently under development. It brings together FLEXIS expertise with other major projects such as SPECIFIC. Through international standard decarbonisation research and innovation, SWITCH will deliver novel low carbon and net zero products, thus generating and supporting high value, highly skilled jobs.

The intention of this meeting therefore is to describe the wider context within which FLEXIS work is now being conducted here in South Wales.

Who's Who

FLEXIS is made up of approximately 100 academics, researchers and administrative staff from three of Wales' leading universities – Cardiff, Swansea and the University of South Wales.

Principal Investigators

Prof Hywel Thomas

Lead Principal Investigator and PI of Sustainable Earth Energy

Cardiff University

Dr Aleksandra Koj

Project Manager

Cardiff University

Prof Nick Jenkins

Network and grid integration of renewables; low carbon energy infrastructure in Wales

Cardiff University

Prof Alan Guwy

CymruH2Wales2 Hydrogen and fuel cells

University of South Wales

Prof Phil Bowen

SMART-POWER: enabling integrated energy systems

Cardiff University

Prof Dave Worsley

Mobile Energy Stored as Heat Research Programme (MESH)

Swansea University

Prof Manu Haddad

Alternative environmentally-friendly gas for electrical networks insulation

Cardiff University

Prof Nick Pidgeon and Prof Karen Henwood

Public response to energy systems technologies

Cardiff University

Prof Paul Meredith

Semiconductors for Clean Energy System and Efficient Electronics

Swansea University

Partners

Neath Port Talbot County Borough
Bwrdeistref Sirol Castell-nedd Port Talbot

TATA

1872 PRIFYSGOL ABERYSTWYTH UNIVERSITY

PRIFYSGOL BANGOR UNIVERSITY

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Swansea University
Prifysgol Abertawe

University of South Wales
Prifysgol De Cymru

Advisory Board

Dr Mike Colechin (Chair)
Director of Cultivate Innovation Ltd

Prof Paul Beasley
Head of R & D UK at Siemens

Paul Brodrick
Business Development Director at Siemens plc

Eric Brown
Chief Technology Officer at Energy Systems Catapult

Martin Brunnock
Communication and Public Affairs Director at Tata Steel UK

Ben Burggraaf
Energy Operations Manager at Dwr Cymru Welsh Water

Prof Bill David
Professor of Chemistry at the University of Oxford

Ceri Davies
Executive Director – Knowledge Strategy and Planning at Cyfoeth Naturiol Cymru / National Resources Wales

Steve Edwards
Commercial Director at Milford Haven Port Authority

Francis Griffiths
CEO, Maiple Ltd

Robert Harper
Gallium Nitride Programme Manager, Compound Semiconductor Centre

Chris Harris
Visiting Industrial Fellow at Bath University

Richie Hart
Process Technology Manager at Tata Steel UK

Roger Hey
Future Networks Manager at Western Power Distribution

Karen Jones
The Chief Executive of Neath Port Talbot County Borough Council

Dr Martin Kenny
Sustainability Director for Tarmac

Prof Ron Loveland
Energy Advisor to the Welsh Government

Dr John Newton
REFHYNE Project Manager at ITM Power

Tony Parton
Managing Director of CR Plus

Nicola Pearce
Corporate Director of Environment and Regeneration at Neath Port Talbot County Borough Council

Steven Phillips
Independent Consultant

Martyn Popham
Managing Director at Cenin Group

Dave Richardson
Project Director for Costain

Dave A Roberts
Technical Director, EA Technology

Prof David Slater
Honorary Professor, School of Engineering, Cardiff University

Mahesh Sooriyabandara
Associate Managing Director at Toshiba Telecommunications Research Laboratory, Toshiba Research Europe Ltd

Dr Chris Williams
Head of Industrial Decarbonisation at Industry Wales

Bethan Winter
System Operation Manager at Wales&West Utilities

James Yu
Future Networks Manager at SP Energy Networks

New Members

FLEXIS extends a warm welcome to the following new members of the advisory board:

Eric Brown
Chief Technology Officer at Energy Systems Catapult

Eric joined the Energy Systems Catapult when it was established in April 2015. He became Chief Technology Officer in April 2019 having previously been Innovation Director. In his time at the Catapult, he has focussed on programmes and initiatives that respond to the challenges and opportunities of energy system transformation.

Eric became involved in the energy sector after having gained many years' experience in the telecommunications industry. He began his career in product and technology roles with major international organisations including Nortel Networks and Hewlett Packard.

He then worked as an independent consultant with start-up network operators in various European countries as they sought to build the infrastructure that would enable them to deliver innovative digital services in competitive markets. This led to co-founding a company that supported operators and their partners in defining, designing and delivering systems to respond to the demands of substantial technology and business change.

Educated in Canada, Eric has a BSc in Mathematics and Physics, a BEng in Electrical Engineering and an MSc in Electrical Engineering. He is a Chartered Engineer, a Fellow of The IET and a Fellow of the Energy Institute.

Martin Brunnock
Communication and Public Affairs Director at Tata Steel UK

Martin is currently the Communication and Public Affairs Director for Tata Steel UK, focusing particularly on the industry's decarbonisation strategy.

In a career spanning over 25 years, Martin has undertaken senior executive roles within Tata Steel, Corus and British Steel including Technical Director, Manufacturing Director and most recently Hub Director for Strip Products UK, running the largest integrated steelworks in the United Kingdom in Port Talbot.

Martin is a Fellow of the Institute of Materials, Mining and Minerals, an Honorary Professor of Swansea University, and a Chartered Engineer.

He also has an MBA from Warwick University and an Engineering Doctorate in Galvanising Technology from Swansea University.

In an organisation which continues to have such great potential to positively impact society and the environment, Martin's latest role is central to the future sustainability of the UK steel industry, its supply chains and its communities.

As part of the global Tata Group—one of the world's most ethical companies—the opportunities to share best practice and benefit from shared technologies are greater than ever, and the Company is starting to be recognised in Europe for its major contribution to the environmental agenda.

New Starters

We're delighted to welcome FLEXISApp Administrative Officer, Natasha Scowen, to the team.

Natasha Scowen

What is your role at FLEXISApp?

My role is to provide administrative support to the FLEXISApp management team. This includes being involved in the process of new projects being approved and maintaining our administrative system.

I am still fairly new to the role, but a big part of my responsibilities is going to revolve around the monitoring of the FLEXISApp projects. This currently is in its early stages, and we are working on finalising a process for this that can then be applied to all projects going forwards.

What attracted you to this role?

I was looking for change in direction after spending 3 years coaching accounting apprentices through their qualifications. It's important to me to feel that my work is contributing to something worthwhile, so I was interested when I found the opportunity to join the FLEXISApp team. Working towards a green future is going to continue to be so important, and it is a great feeling to be contributing towards this.

What are your interests outside of work?

I moved back to Cardiff earlier this year and have enjoyed getting back into attending events I had missed, like going to support the Cardiff Devils at their games.

I'm always on the lookout for a new type of craft to have a go at - during lockdown I tried my hand at embroidery. I also enjoy karate and swimming.

New Starters

We're delighted to welcome FLEXIS Administrative Officer, Christian Gillard, to the team.

Christian Gillard

What is your role at FLEXISApp?

The main aspect of my role is to provide support to the FLEXIS Advisory Board and Operational Management Team through arranging meetings and ensuring provisions are in place to ensure their smooth running, working closely with the Lead Principal Investigator and Chairman of the Board. I will be first point of contact for queries related to FLEXIS via a variety of means, supporting colleagues with training in certain procedures, collaborating with external bodies and building a positive rapport with key contacts and the wider team.

What attracted you to this role?

In recent years, the growing evidence and understanding of the impact, we as a society, are having on the environment is becoming clear along with the urgency of needing to redress the balance with the world around us. With this in mind I have become passionate about wanting to participate in something that will help change things for the better and I feel this role will help facilitate that by supporting this important project.

Coming from Neath and working in Swansea, I feel particularly proud that these areas of Wales are apart of this endeavour and encourages a feeling of familiarity with this established project.

What are your interests outside of work?

Fitness is a big part of my activities outside of work, I'm regularly seen at the gym out running or trying to maintain the plank in Pilates. In addition, I enjoy reading and recently took on the challenge to get through all 16 Charles Dickens novels, though being a slow reader, it may take me some time! Otherwise, I enjoy the usual socialising, eating out and spending time with my family.

FLEXIS IMPACT

SMART ENERGY FOR OUR FUTURE
YNNI CALL AR GYFER EIN DYFODOL

Creating research capacity and cutting carbon emissions

PEOPLE

153 employees

106 researchers recruited

20 ♀ 86 ♂

44 Academics on the project

Professional associations and memberships/chairs of profs connected to FLEXIS

50+

7 GoWales work placements

60 PhD students associated with FLEXIS research themes

INVESTMENT

£36,140,007
Generated in **grant income**

113x research grants
£30,150,198

37x industrial grants
£5,989,809

8x grants **over £1m**

£2.4m investment in **equipment and technology**

44.2% success rate
150 grant awards out of 339 bids

PARTNERSHIPS

265 industrial collaborations

166 academic collaborations

PERFORMANCE

600 papers published

100+ research projects underway

261 conferences attended

Cronfa Datblygu Rhanbarthol Ewrop
European Regional Development Fund

FLEXIS is part funded by the European Regional Development Fund and wishes to acknowledge the support provided by the Welsh European Funding Office (WEFO).

www.flexis.wales

FLEXIS App

Collaborate | Commercialise | Decarbonise
Cydweithio | Masnacheiddio | Datgarboneiddio

FLEXISApp is a £4M WEFO funded research, development and innovation programme that is focussing on industrial decarbonisation and economic growth.

FLEXISApp is the commercial development route for the research programme undertaken in South Wales via the FLEXIS research programme.

Further details of FLEXIS are given below. Like FLEXIS, FLEXISApp brings together academia (Swansea University, University of South Wales and Cardiff University), local government and industry to develop innovative energy technologies to achieve net zero targets by 2050. The project supports several Welsh Government and UK initiatives including 'Science for Wales', 'Innovation Wales' and the UK's Clean Growth Strategy.

FLEXISApp projects – Centre of Excellence, MESH and H2ACE – drive net zero solutions via strong industrial partnerships with companies that use FLEXIS' world-leading research and resources in energy systems. More information on FLEXISApp may be found on www.FLEXISapp.wales

As stated previously, FLEXISApp arose from FLEXIS, a £25M WEFO funded research operation, which has developed a culture of research and innovation in the energy sector across Wales, building on the world class capability that already exists in Welsh universities. FLEXIS is a consortium of strategic partners – Swansea University, the University of South Wales, Cardiff University, Neath Port Talbot Borough Council and Tata Steel UK. FLEXISApp builds on FLEXIS expertise and experience, taking forward research ideas towards commercial exploitation. More information on FLEXIS may be found on www.FLEXIS.wales

Centre of Expertise in Data and Smart Energy Systems

What is Centre of Expertise project?

The centre of expertise in data and smart energy systems is a FLEXISApp partnership project with Cardiff University and artificial intelligence (AI) software company, Maiple. By bringing academia and industry together, the project will develop world-leading artificial intelligence and machine learning algorithms that power smart energy solutions for global application.

A corner stone of these solutions will be the ability to harness the vast amounts of data that in some cases already exists and combine these data sets with new data that is generated by the collaborators within FLEXIS. Maiple will provide rapid prototyping, development and testing of commercial solutions that accelerate successful outcomes. A large amount of this activity will take place at Swansea University's AI Doctoral Training Centre.

What does the project hope to achieve?

The project hopes to improve the affordability of clean energy by creating new technology to provide multisector energy forecasting solutions. This technology will help with industrial decarbonisation and make a sustainable difference within the local environment, throughout Wales, the UK and the world.

A big focus for FLEXISApp is to increase employment opportunities and attract top talent to West Wales and the Valleys. This project will soon be recruiting data scientist and AI/Machine learning engineers to help shape this rapidly growing sector

As a result of product and IP delivered through this project, significant follow on investment from partners and leading technology companies in the area of AI and machine learning, including Amazon, Nvidia and Mathworks is expected.

This project is led by Principal Investigator Hywel Thomas and Maiple's Founder and CEO Francis Griffiths.

By 2023, this project will:

- **Create IP related to Smart Energy Building Management algorithms**
- **Launch several cutting edge new to market products for Smart Energy Management**
- **Create and launch a Smart Energy product targeted at adjacent industries such as manufacturing, process and utilities**

Who are MAIPLE?

MAIPLE was formed in January 2018 with the vision to simplify the use of Artificial Intelligence and Machine Learning technologies focussing on Energy, Healthcare and the Industrial sectors including Utility providers. Our technology platform brings together big data, secure cloud infra-structure, smart sensors, and cutting-edge AI technology.

We help organisations to adopt the technology, adapt their processes and accelerate decision making to improve their own, and their customers outcomes. Whether the challenge is to reduce carbon emissions, lower operational costs or improve patient treatments we believe combining these technologies with human-centric expertise will have a transformative impact on our world.

Maiple provides SaaS (software as a service) solutions using state-of-the-art deep convolutional neural networks (DCNN), Recurrent Neural Networks (RNN) and traditional Machine Learning algorithms for advanced image analysis and time series forecasting. We partner and build solutions using Microsoft Azure, Amazon Web Services (AWS), Google Cloud and Nvidia to deliver integrated solutions.

Maiple has strong collaborative partnerships with FLEXIS, Cardiff University and Swansea University and continues to support its industrial and utility customers in Wales.

Expert opinion

FLEXISApp Principal Investigator, Professor Phil Bowen, adds:

Working with FLEXIS collaborators, industrial partners and the local community, the goal is to establish a centre of excellence in Wales to develop world leading AI and Machine Learning algorithms that power smart energy solutions and contribute to carbon reduction. This opportunity aims to make a sustainable difference within the local environment, throughout Wales, the UK and beyond.

A corner stone of these solutions will be the ability to harness the vast amounts of data that in some cases already exists, whilst combining these data sets with new data, enabling Maiple to provide their rapid prototyping, development and testing of commercial solutions that accelerate successful outcomes.

Francis Griffiths, Founder & CEO of Maiple adds:

Rapid digitalisation offers a huge opportunity to combine new and existing data sets across the energy supply and consumption networks that can lower energy costs, improve performance of assets and reduce CO_2 emissions.

Establishing a centre of expertise in Wales will build core competencies in big data management and processing of this data with cutting-edge machine learning and deep learning algorithms. The cloud-based platform will provide a secure and scalable solution for accurate forecasting of both generation and demand cycles for use in intra-day and day-ahead energy requirements. Building this expertise in combining cloud, big data and AI technologies opens up a vast array applications for energy aggregation in grid balancing, smart building management systems and modelling within digital twins.

MESH

Mobile Energy Storage as Heat

What is MESH?

Mobile Energy Storage as Heat (MESH) is an 24 month, FLEXISApp funded project that will investigate and optimise the capture, storage and release of heat from industrial waste air streams using thermochemical storage (TCS) materials.

Originally developed for capture of solar energy as part of the INTRESTS (IUK 101223) and SPECIFIC project, FLEXISApp will subsequently use the acquired data to model the viability of the reuse of the captured heat from a technological, environmental and economic viewpoint.

What does MESH hope to achieve?

Through working in partnership with Tata Steel UK, the ultimate aim is to be able to transport this previously wasted energy and release it in a controlled way to provide low carbon or zero carbon process heat or space heating in either industrial buildings or domestic abodes.

This project is being led by Principal Investigator David Worsley, Dr Jonathon Elvins (SPECIFIC IKC), Mr Paul Jones (Swansea University) and industrial expert Dr Laura Baker from Tata Steel UK.

By spring 2022, this project will have:

- **Quantified the available waste heat energy from Tata Steel in Port Talbot**
- **Developed and tested process optimised SIM materials**
- **Assessed the environmental impact that this approach may have in South Wales**

Who are TATA?

Tata Steel UK employs more than 8000 people with an annual turnover of £2bn. With its largest site at the Port Talbot integrated works it is a key foundation industry supporting critical supply chains into UK manufacturing and key export markets.

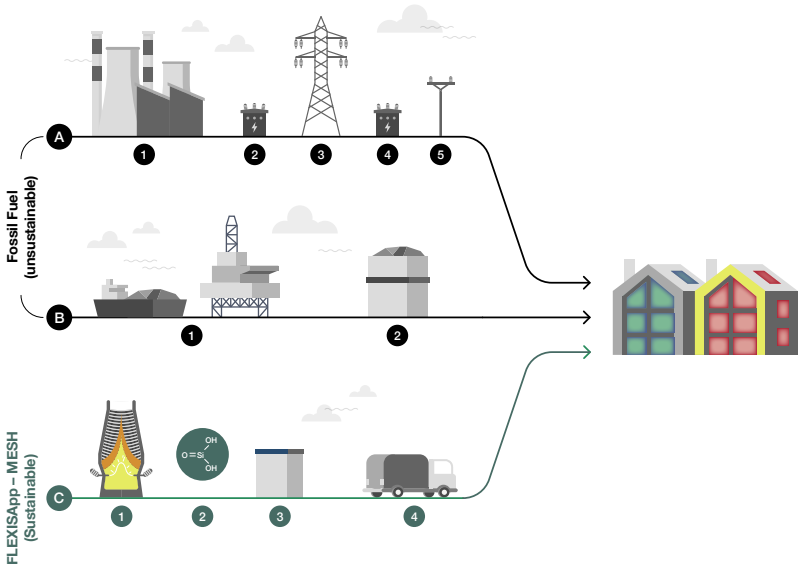
Tata Steel UK is committed to an ambitious programme to deliver net zero steel making by 2050 at the latest, and to exploring how the various by- and co-products of the manufacturing process (heat, hydrogen, carbon dioxide, carbon monoxide, slags and so on) can be captured or converted into products for other sectors.

With 60% of the steel produced being used in the UK, the product range is also vital for the circular economy with steel effectively capable of multi-cycling and being a key element in all renewable energy projects as well as e-mobility schemes.

With increasing opportunities for the de-carbonised electricity grid and green hydrogen production there is significant momentum in establishing new routes to producing high quality strip steel materials to support automotive electrification, modernising construction and for packaging materials with little or no environmental impact at end of life.

Tata Steel UK is engaged with university research groups and emerging technology companies to explore carbon capture and conversion which will create new carbon-based raw materials and fuels (for example for aircraft) and waste heat capture and storage for reuse in de-carbonising building heating systems.

Tata Steel UK is collaborating with FLEXIS and FLEXISApp project in Wales to support several of these de-carbonisation themes through engaging a vibrant community of younger researchers and graduates as well as the annual appointment of more than 300 apprentices and 80 graduate trainees.



Expert opinion

FLEXISApp Principal Investigator, Professor Dave Worsley, adds:

This project will provide a new, ultra-low or zero carbon route for heating homes. It will maximise the viability of the Welsh steel industry and support a substantial part of Wales' decarbonisation targets.

By working in partnership with the Welsh steel industry, we will minimise the industrial heat that is released into the atmosphere, reducing CO_2 emissions, whilst identifying the potential deployment of year-round heating without the use of fossil fuels.

Dr. Samir Boudjabeur, Applications & Engineering Department, TATA Steel adds:

Tata Steel is already amongst the most CO_2 efficient steel making companies in the world and is helping to lead further efforts to decarbonise the industry. Steel making will continue to be an energy intensive process and this makes it all the more important to recover as much energy from the waste streams as possible. The MESH programme supported by FLEXIS App is a vital contribution towards our Net Zero Plans.

The MESH programme excites me as it provides an opportunity to focus on the low grade waste heat sources which would typically be either very difficult or prohibitively expensive to recover. This programme opens new opportunities at three UK production facilities; Port Talbot and Trostre in South Wales and Shotton in North Wales. Converting waste heat from our Welsh plants can provide potentially heating solutions for hundreds of thousands of properties. This is true net zero heating too using waste heat and is also complimentary with our solar wall air heating system and in this case the heating systems in homes will be resilient being charged either by waste industrial heat or stored solar power from the summer season.

However, the successful project completion will not only be limited to these sites as the technology could potentially be rolled out into any production facility with similar waste streams.

H2ACE

Separation of Hydrogen in Industrial Wastes Gases and Conversion into Acetate, a Key Platform Chemicals

What is H2ACE?

H2ACE is a 18 month partnership project with The University of South Wales SERC, Tata Steel and Dwr Cymru. It will help tackle industrial decarbonisation by extracting hydrogen and carbon from waste industrial syngas streams.

This will be explored using enhanced water gas shift processes and a range of syngas feeds, including waste gases from Tata Steel in Port Talbot and Dwr Cymru Welsh Water.

To avoid negative environmental impacts, H2ACE will also look at conversion and reuse technologies to utilise the carbon generated from various industrial syngas conversion processes to create platform chemicals such as acetate and other short chain carboxylates commonly known as volatile fatty acids (VFAs).

These are the green building block chemicals that can be used to produce products for the chemical industry, such as films and coatings for product packaging and structural plastics for things like furniture and consumer electronics.

What does H2ACE hope to achieve?

Through working in partnership with industrial stakeholders, the H2ACE project's ultimate aim is to develop and demonstrate a biorefinery concept where recovered hydrogen and green hydrogen energy, can be used to convert waste gas streams into green platform chemicals.

Direct participation and support by companies such as Tata Steel and Dwr Cymru Welsh Water ensure that these unique bio-conversion and extraction technologies will be developed at scale in direct collaboration with industries, allowing technology and methodologies to be adapted to their needs.

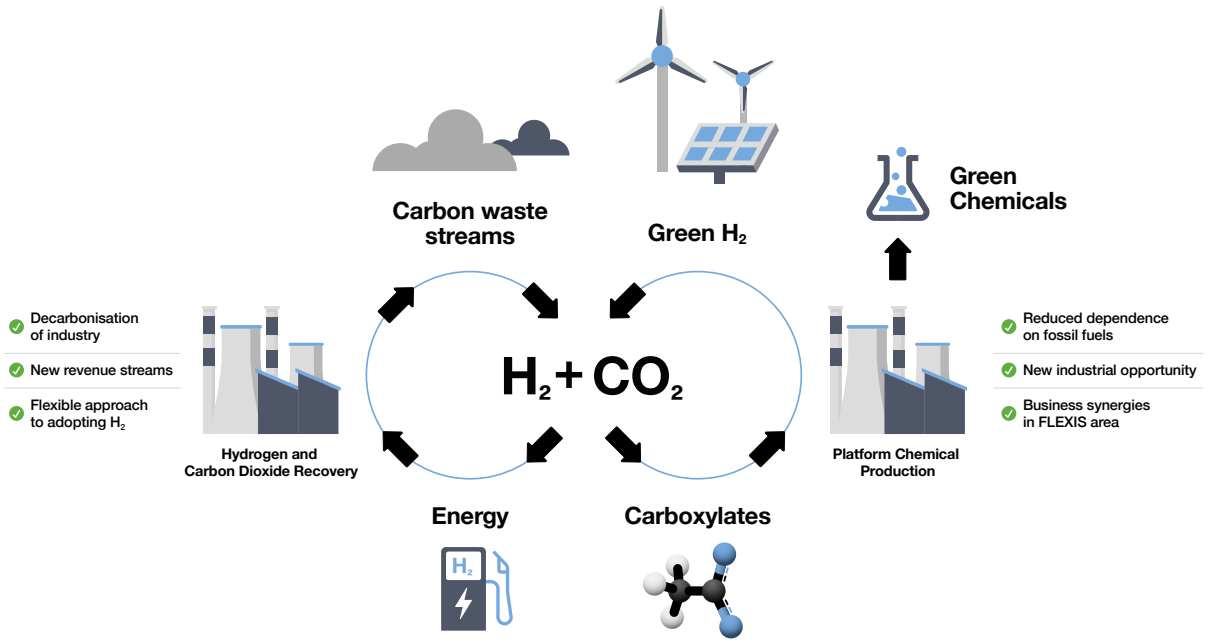
The outcomes of this project for a wide range of industries will be to add flexibility, synergy and value to adopting clean, non-polluting energy vectors and ending reliance on fossil fuels.

By moving to hydrogen as an energy vector and reducing carbon emissions, H2ACE aims to create a strong opportunity for synergy and flexibility in solutions to decarbonise steel production and other industrial processes. Producing sustainable platform chemicals for a market currently worth €1.34 billion per annum.

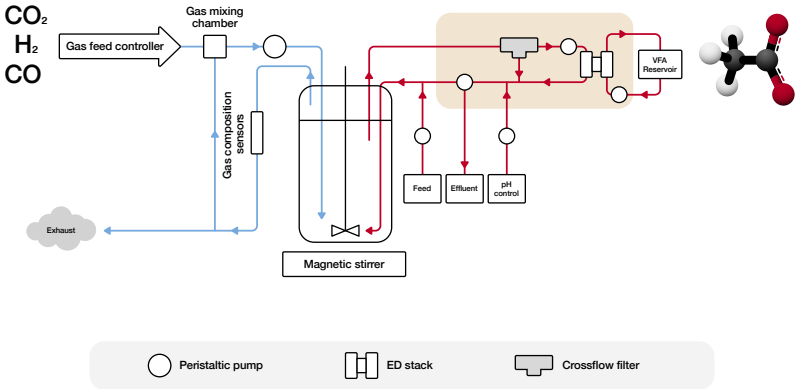
This project will demonstrate at pilot scale the integration of state of the art technology for separating and purifying the VFAs from the bioreactor liquor. Through work undertaken in SUPERGEN H2FC and FLEXIS, SERC has already demonstrated the technical feasibility at bench scale.

By working at pilot scale on location at Tata Steel in Port Talbot, where SERC has already deployed a similar pilot scale bioreactor converting carbon monoxide to acetic acid, this project will advance that technology further, intensifying yields and production rates, and advancing it to higher TRLs.

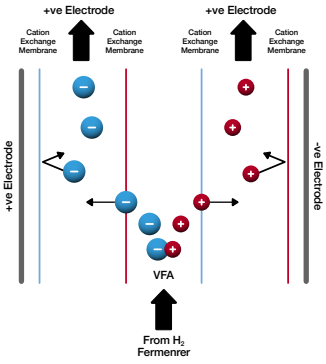
Overview of H2ACE for production of energy and green chemicals



Schematic of H2ACE bioconversion process



Separation of Acetic acid via electrodialysis



By January 2023, this project will have:

1. **Recruited additional people to support the scale up, implementation and training centred around new conversion technologies**

2. **Modelled how recovered hydrogen together with green hydrogen generation can be harnessed to aid conversion of syngas to hydrogen and carbon dioxide**

3. **Generated a detailed understanding of the syngas production rates and flows in the South Wales Area using Aspen+ process models of water gas shift and separation process options**

4. **Developed and demonstrated two new technologies for carbon capture and utilisation:**
   - Novel biotechnologies for the biorefining of CO_2 into valuable platform chemicals such as acetic acid using novel separation technologies developed by SERC
   - Design a novel on-line system for optimisation of volatile fatty acid production

5. **Examined usage scenarios and quantified economic, environmental and societal benefits of decarbonising key industries, facilitating hydrogen as an energy vector, creating new industrial opportunities in green chemical manufacture and displacing fossil fuel usage**

6. **Prepared a proposal to take forward installation of an advanced water gas shift/ separation test facility**

Dwr Cymru Welsh Water

Dwr Cymru Welsh Water (DCWW) is a not for profit company that supplies water and wastewater services to the majority of Welsh homes and businesses. It has 3 million customers and employs over 3000 staff.

DCWW's involvement in the project will allow the technologies being proposed to be evaluated and developed with a view to advancing and extending the scope of their existing bioconversion processes. This will give them great flexibility in how to both treat waste streams with greater efficiency, move to carbon free energy vectors such as hydrogen, and potentially access new revenue streams such as the manufacture of green platform chemicals. As the largest operator of anaerobic digestion facilities in Wales their participation is a significant indication of their engagement with the development of greener and more circular approaches to energy usage and generation, as well as waste treatment and recycling.

DCWW is very active in collaborative research with academia. Together with the University of South Wales it has been active in a number of European Research Projects addressing the challenges around biorefining, decarbonisation of energy vectors and the valorisation of waste products. These include FLEXIS, RICE and ResUrbis together worth £35m. DCWW has also sponsored and supported several PhD projects at the University of South Wales and other Welsh Universities.

Tata Steel

Tata Steel UK employs more than 8000 people with an annual turnover of £2bn. With its largest site at the Port Talbot integrated works it is a key foundation industry supporting critical supply chains into UK manufacturing and key export markets.

Tata Steel UK is committed to an ambitious programme to deliver net zero steel making by 2050 at the latest, and to exploring how the various by- and co-products of the manufacturing process (heat, hydrogen, carbon dioxide, carbon monoxide, slags and so on) can be captured or converted into products for other sectors.

Tata Steel UK is collaborating with FLEXIS and FLEXISApp project in Wales to support several of these de-carbonisation themes through engaging a vibrant community of younger researchers and graduates as well as the annual appointment of more than 300 apprentices and 80 graduate trainees."

Expert opinion

Gareth LLoyd, Process Engineering and Functional Safety Manager, TATA Steel, adds:

We are very conscious of the steel industry's responsibility to help meet the global climate targets. We are committed to transforming the way in which steel is produced and used, so that it remains the material of choice for our customers in a circular and low carbon economy.

Steel is an essential material to for society and the UK needs a sustainable steel sector. We continue to search for a decarbonisation route for UK steel making operations and a sustainable future for steel production. Our ambition is to reduce carbon dioxide emissions and reduce the impact of steelmaking on the environment as quickly as possible. This ambition can only be achieved using innovative solutions that don't currently exist within our industry.

TATA's involvement in the H2ACE project will enable the development of technology to substantially reduce its carbon emissions by using them as substrates for biorefinery technologies that can convert them into green sustainable platform chemicals which themselves have a significant financial value. TATA will benefit from a program of research that tailors these technologies to their needs to reduce and derive value from its carbon emissions.

FLEXISApp Principal Investigator, Professor Alan Guwy, adds:

Tata Steel, Welsh Water and other industries within the South Wales Industrial Cluster (SWIC) are significant emitters of greenhouse gases (GHGs) including CO_2, CO and CH_4. These industries are actively seeking to decarbonise these emissions and have committed time, funding and resources as part of this project to do so. From previous research, we've identified that the economic costs of decarbonisation are reduced if carbon is converted to valuable platform chemicals such as carboxylates e.g acetate.

There is a large market for VFAs valued at over €1.3 billion growing at 15% p.a. The USW team has demonstrated the feasibility of these processes, but challenges remain concerning intensification and scaleup to accommodate large carbon emissions from industry alongside technical challenges.

The flexibility of this FLEXISApp project will mean that it can support a wide range of industries in decarbonising their activities to meet 2050 net zero targets

Ben Burggraaf, Head of Energy at Dŵr Cymru Welsh Water, adds:

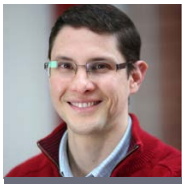
Earlier this year, Welsh Water committed itself to reducing its total carbon emissions (including embedded emissions from its capital program) with 90% by 2030 and to reaching net zero by 2040.

As certain emissions sources will be challenging or even impossible to reduce to zero by 2040, there is a need to find cost-effective ways to capture, store and utilise (biogenic) carbon di-oxide and turn it into a value-added product, to offset the remaining emissions.

The Bio-ACE and H2ACE projects incorporate at its heart this circular thinking and are innovative projects that could create potentially create carbon-sinks (i.e. remove more carbon from the atmosphere than emitted and offset some of the emission sources that are difficult and/or not cost-effective to abate.

Ammonia

Building towards demonstration of a new candidate for zero carbon fuel



Agustin Valera-Medina

Phil Bowen

Ammonia is already utilised at large scale in the agricultural and industrial and manufacturing sectors. However, a new wave of excitement is building around ammonia as a potential fuel to power the zero carbon energy systems of the future.

Why Ammonia?

Ammonia is a versatile compound employed around the world in vast quantities for fertilization and refrigeration. In recent years it has been steadily gaining support as both a storage vector to support a green hydrogen economy and an alternative fuel in its own right. The greatest benefit of ammonia as a fuel is that it does not contain carbon and therefore emits no CO2. It can be liquified at low pressures and relatively high temperatures which do not require significant energy or infrastructure to achieve. Ammonia is also a convenient way to store hydrogen, having the chemical formula NH¬3 (1 nitrogen and 3 hydrogen atoms).

These characteristics are complimented by a mature global distribution network and low cost which has begun to attract major economic groups, with special interest from the marine and power generation sectors. However, utilising ammonia still has some unresolved challenges:

- **Cheap and large-scale production using alternative energies (wind, solar, marine, etc.);**
- **Utility scale conversion for power and propulsion generation with low emissions and high stability;**
- **Adequate public perception that enables large deployment whilst supporting community development;**
- **Beneficial economics that ensure high investment at various levels.**

In recent years Cardiff University has been at the forefront of the study of ammonia as an energy vector.

This has been driven primarily through the Cardiff based Combustion Lab on the main engineering campus and the Gas Turbine Research Centre in the FLEXIS Demonstration Area at Port Talbot.

Cardiff's current research has been focused on the understanding of combustion profiles, development of concepts for power, and public perception studies to determine how ammonia can be utilised without incurring harmful emissions, reach high power profiles competitive to fossil fuels, and understand the views of potential users, respectively.

This work has been complemented by a vast network developed by Cardiff's research group, leading to a vast reservoir of journal papers of high impact, books and book chapters, a couple of Royal Society Policy briefings, and initiatives such as the first academic journal on Ammonia Energy (published by Cardiff University Press) and the first Symposium on Ammonia Energy, most partially sponsored by FLEXIS.

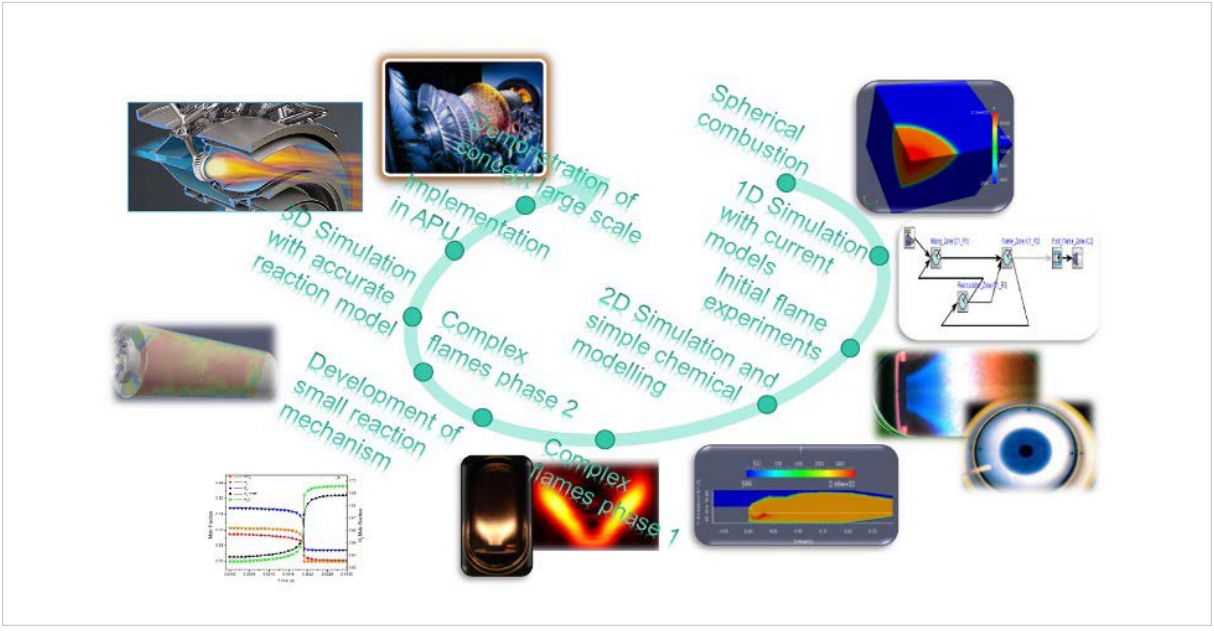


Fig. 1. SAFE Program for the development of Ammonia/Hydrogen Gas Turbine cycles.

The use of ammonia combustion has been explored over decades since the 1960's. However, the high levels of emissions and low flame speeds led to the replacement of this fuel in automotive, power and aerospace applications. Climate change and pollution have given ammonia a refreshed opportunity to play a critical role in decarbonisation portfolios worldwide.

Therefore, novel methods of combustion and reaction are required to tackle the issues that the molecule presents. Some of these will require innovate technologies such as plasmas coupled with advanced reaction kinetic mechanisms and numerical modelling that will serve to improve designing processes.

Cardiff University, in collaboration with the University of Birmingham and Lund University, are currently engaged in a program to fully understand the transient processes related to ammonia plasmas.

Similarly, with leadership of the University of Hertfordshire and in collaboration with the University of Connecticut, a project based on advanced modelling seeks to establish the methodology to create reduced kinetic mechanisms that will resolve the reaction of tertiary ammonia-blends (with hydrogen and methane) for easy implementation in advanced numerical modelling, enabling faster computational calculations for more efficient designing processes.

This work has also led to further collaborations with SANDIA National Laboratories, U.S.A., where innovative computational fluid mechanics (CFD) will be developed for stratified injection of ammonia blends. These works, funded mostly by the prestigious Fullbright scheme and partially by FLEXIS, will enable Cardiff University's students to create new turbulence mechanisms in collaboration with Siemens PLM.

Knocking out NOx at high power efficiencies

The term NOx, short for Nitrogen Oxides, refers to a group of compounds that are unwanted by-products of most combustion. Lowering NOx emissions is a major goal of governments around the world, and this poses a challenge to using ammonia in traditional combustion scenarios. Interestingly, when ammonia is burned in the presence of an excess of fuel the surplus ammonia molecules react with the NOx created by the combustion, eliminating each other and leaving behind hydrogen. Cardiff University's research into this phenomenon, funded by industrial partners, InnovateUK, EPSRC and FLEXIS, has laid the necessary foundations to scale up the concept of ammonia-hydrogen flames to large scale demonstrations. This work has led to the award of the £1.9M project SAFE (Stored Ammonia For Energy), funded by the EPSRC.

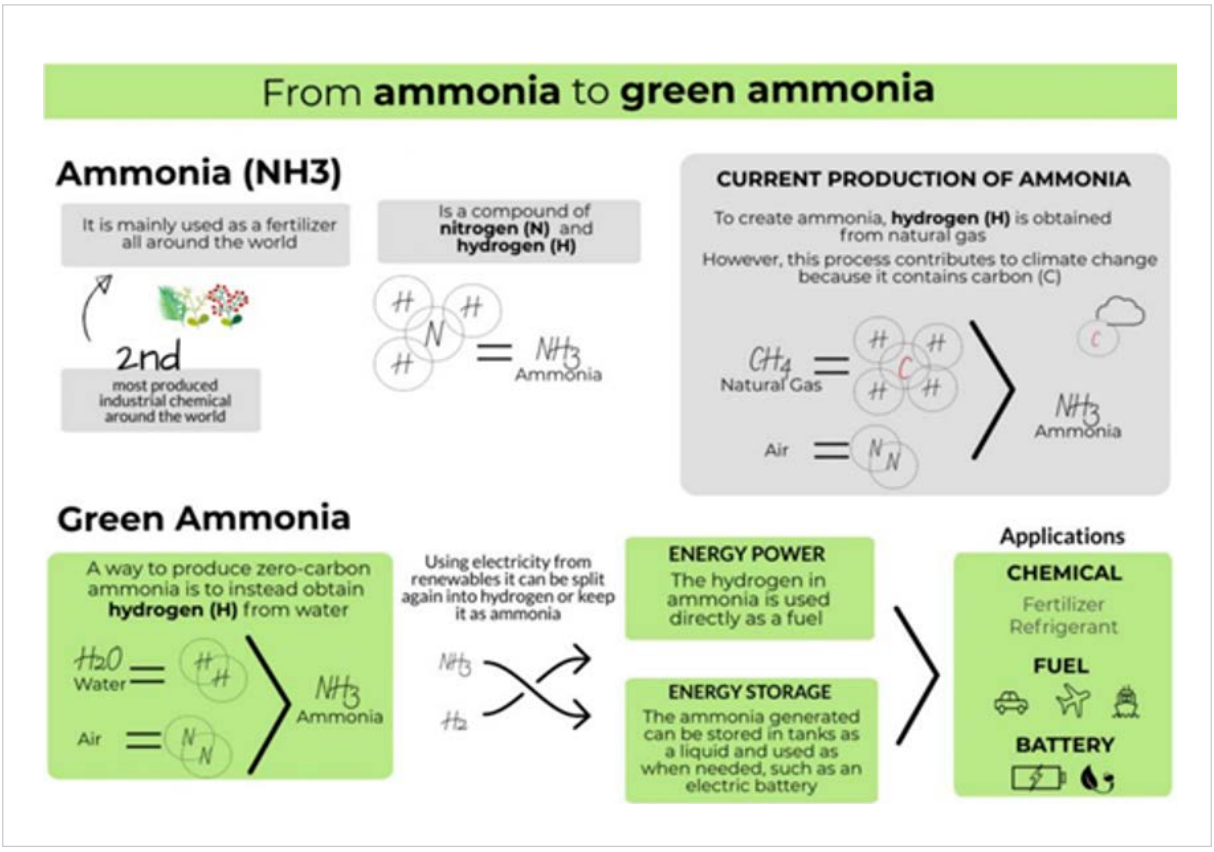


Fig. 2. Public perception of ammonia as an energy vector.

The project aims to produce low-NOx combustors in the range of 20-50 kW within the first phase. Critical to achieving this is the control of a bespoke micro gas turbine and development of an innovative combustor which is currently under patent protection. This research will set the foundations for the development of units capable of an order of magnitude higher energy output at 0.50 MW (500 kW) by the middle of the decade, whilst establishing the knowledge needed to expand to 5-20 MW by the end of the 2020s.

In collaboration with the University College London and Imperial College, and supported by Siemens Turbomachinery, Hieta and CoolDynamics, this research will become the first to ensure efficient combustion of ammonia/hydrogen blends whilst delivering cooling (for food), power, heat, drinking water and fertilizing streams, all key components in a circular economy.

Retrofitting large power plants to store ammonia as backup power

A major rationale for the use of ammonia as an energy vector is its stability over large periods of time and its higher energy density when compared to pure hydrogen. Therefore, the project FLEXnCONFU (a £12M grant, no. 884157) seeks to create the innovation, integration and demonstration of using ammonia as a hydrogen carrier to support off-peak power operations at utility scale.

The research, partially seeded by FLEXIS, will ensure that the power plant at Ribatejo, Portugal, operates using green hydrogen, whilst ongoing studies determine the most suitable combination of ammonia-hydrogen facilities to reduce costs and maximise efficiency.

Simultaneously, Cardiff University's contribution as leader of the combustion workpackage has delivered state-of-the-art research to untangle the complexities of using ammonia at various concentrations in industrially representative units. High power at high pressure and temperature have been combined with fundamental studies for turbulent and swirling flow states, whilst bespoke numerical simulations using highly advanced models (ie. Direct Numerical Simulation) will be correlated for the creation of new turbulent models suitable for combustors design. These works will be expanded to recognise the global impact of using ammonia in support to the design of unique abatement NOx technologies.

Use of ammonia at a "City Gate" level

The recently awarded project "OceanREFuel" (£10M), led by Strathclyde and in collaboration with a 32 partners, will complement all these efforts by providing a platform to evaluate the most efficient use of ammonia as a hydrogen carrier. Hydrogen produced from offshore platforms will be analysed through different distribution paths, once being ammonia produced from Orkney, Scotland. The study will permit the development of novel technologies such as highly efficient internal combustion engines fired with ammonia blends in combination with analyses of bespoke heating applications for domestic and industrial purposes. These works will be complemented by several workshops to understand the public perception of the concept across the communities where ammonia deliveries might go through.

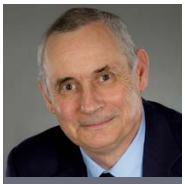
Finally, these works will culminate with the analysis of an "Ammonia City Gate" concept, where ammonia produced from green sources will be delivered to the outskirts of large cities for its reconversion into hydrogen/nitrogen and its posterior distribution to the grid. The project will benefit from the findings obtained through the project "Dock-to-Dock", an InnovateUK funded project that has been conceived to characterise several solutions to use ammonia and hydrogen at airports and large ports across South Wales and South West England for propulsion and energy production tasks. Partially seeded by FLEXIS, all these efforts will consolidate unique expertise to steer the ammonia agenda in the UK, Europe and beyond.

These works and further projects that are under scrutiny by several funding bodies will produce enough information to demonstrate the potential of ammonia as an energy carrier, ensuring that Wales is one of the key players in the transition towards a zero-carbon economy via "hydrogen through ammonia".

Decarbonising Britain

The future role of high-pressure gas networks

Meysam Qadrdan



Nick Jenkins

Natural gas is currently used for supplying fuel to industries, heating more than 20 million dwellings and generating almost a third of our electricity. In response to the net-zero target by 2050, the use of natural gas is expected to drop, however natural gas infrastructure can play crucial roles in the transition towards a decarbonised energy system.

Our team at the Centre for Integrated Renewable Energy Generation and Supply (CIREGS) is researching the future role of natural gas infrastructure in the GB.

In September, two of our PhD researchers Mr Amirreza Azimipoor (2nd year) and Mr Qikun Chen (1st year) presented their research projects in a competition organised by the Institute of Gas Engineers and Managers (IGEM). Mr Qikun Chen was selected as the winner and Mr Amirreza Azimipour became runner-up. Below are brief summaries of research conducted by Amir and Qikun.

Studying the operation of the gas network with different blends of hydrogen.

Conducted by Amirreza Azimipour

The South Wales gas infrastructure can be used to transport hydrogen across South Wales and to other parts of the GB. By simulating the South Wales gas network, we studied the operation of the network transporting different mix of natural gas and hydrogen: 20% hydrogen in 2030, and 100% hydrogen in 2050. Two research questions that we investigated were: how much power will the compressors consume? Do the fluctuations in hydrogen supply affect the network in any way?

By the year 2030, up to 20% volumetric hydrogen can be blended into the gas network. Adding 20% of hydrogen increases the volumetric flow rate of gas in the network, and results in up to a 30% increase in compressor power consumption.

By the year 2050, the gas network can operate with 100% hydrogen gas. In South Wales, up to 15% of this hydrogen could be produced by renewable wind generation. This supply of hydrogen could fluctuate during a day. Our simulation however shows that these fluctuations do not have any major impacts on the operation of the South Wales gas network as the linepack provides sufficient buffer that balances supply and demand at each time step. Also, when operating with 100% hydrogen, the power consumption of compressors increases up to 167%. This is a large increase, however, it is within the compression capacity available today.

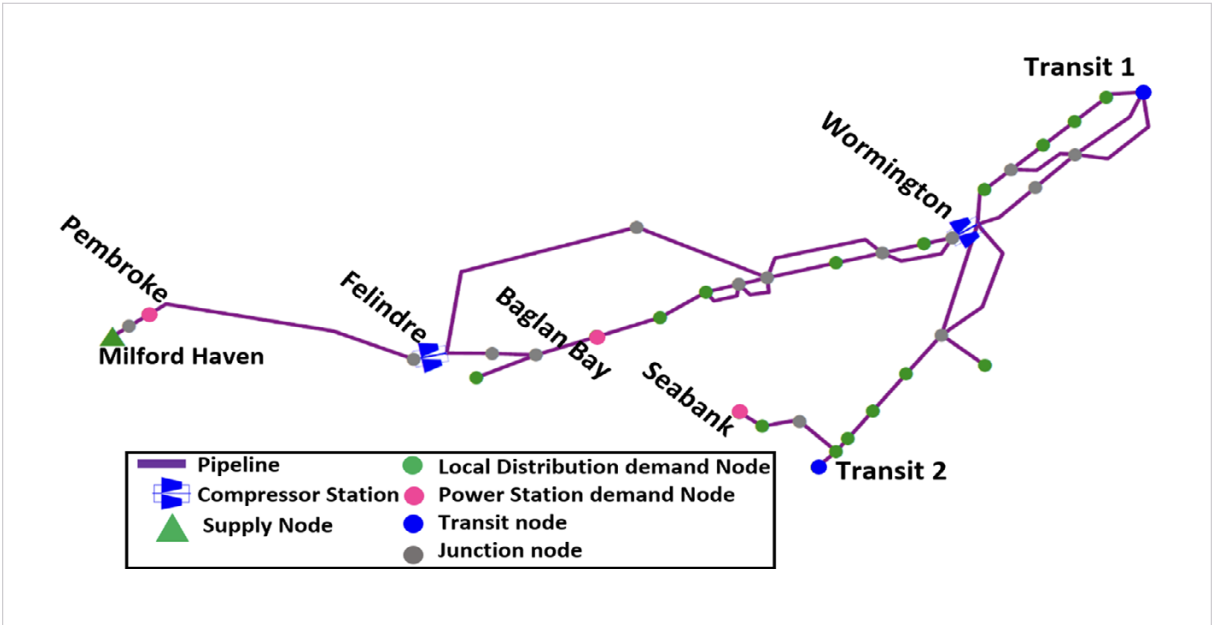


Figure 1: South Wales and South West high pressure gas network

Optimal operation of compressors in South Wales gas network.

Conducted by Qikun Chen

The operation of compressor stations results in a range of air pollutant and greenhouse gases which needs to be eliminated. Electric-driven compressors can be employed to boost the pressure without emitting any pollution. In 2019, there were 9 electric-driven compressors with a maximum capacity of 199 MW in the National Transmission System.

However, electricity prices are fluctuating, and the operation of electric-driven compressors can be high at some period, so how to achieve an optimal operation is significant.

Our team developed an optimisation model of the South Wales gas network considering the operation cost of compressor units. We assumed in each gas compressor stations shown in Figure 1 there will be one gas-driven compressor and one electric-driven compressor. By considering fluctuations in both electricity and gas prices, a coordinated operation of different types of compressor units were investigated.

The optimisation results show that the coordinated operation of electric and gas-driven compressors reduces the operating cost while it produces only 35% emission of that from using gas-driven compressors only.

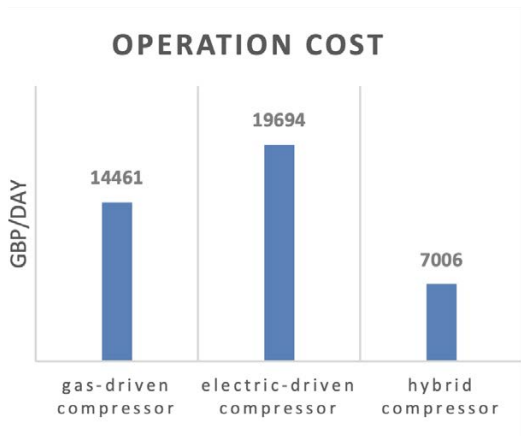


Figure 2: Operation cost of South Wales Compressors

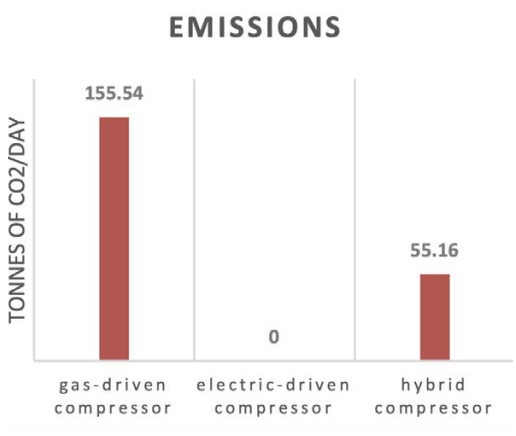
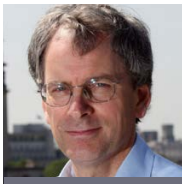


Figure 3: Emissions produced by South Wales Compressors

A Nuclear Future for Wales?

What can be learned from the past



Nick Pidgeon

One of the more controversial elements of any low carbon future would be the development of a generation of new nuclear power stations for the UK, and in particular Small Modular Reactors. Small reactors might in principle remove some of the funding, build complexity, and site overrun difficulties that make current reactor designs so hard to plan and complete. With the closure in the next ten years of all but one of the existing UK nuclear fleet a question arises about their long-term replacement? Already there are suggestions of renewing the existing sites in Wales with small reactors at both Wylfa and Trawsfynydd. Recognising that civilian nuclear fission technology and in particular the final disposal of its waste products has had a difficult history with publics around the globe a key question then is the extent to which new reactor types will encounter some of the acceptance difficulties encountered in the past?

Professor Nick Pidgeon was recently invited to discuss this question, in a three-day evidence session of the US National Academies to aid their inquiry into laying the Foundation for New and Advanced Nuclear Reactors in the USA. In Cardiff members of the FLEXIS Understanding Risk group have a 20-year track record of studying this issue in depth. Research shows us that the public wants a guarantee of very high safety standards for future nuclear plants and a long-term solution to be found for the waste issue. The work at Cardiff has also sought to understand how attitudes to nuclear power – a low carbon electricity source – may be changing in the light of rising climate change concerns amongst the public.

That work had been the first to identify a discourse labelled as 'reluctant acceptance' of nuclear power – the idea that we may worry deeply about the technology, yet still accept, it if we believe it is both safe and making a genuine contribution to addressing global warming and energy security. Such a view had helped to explain the modest rise in support for nuclear energy in the UK in the decade prior to the Fukushima disaster.

Professor Pidgeon also pointed out at the evidence session that the public, when engaged about the question of future nuclear energy, will always want to consider the alternatives available to meet the goal of a sustainable energy future alongside any new nuclear proposals, signalling the need for a much wider public debate about the values people desire in a future energy system as a whole and whether nuclear fits in with those visions. This idea of taking a whole systems approach to understanding public beliefs about aspects of the energy transition is a methodological principle that has been built upon and carried over into the FLEXIS social sciences work with the community in the Port Talbot demonstration area.

Professor Pidgeon also discussed work conducted with Professor Henwood of FLEXIS eliciting biographical narratives from residents living close to three older UK civilian nuclear sites (Bradwell, Hinkley Point and Oldbury). Contrary to expectations, that work showed a very complex set of local views: for many the local station was viewed as an ordinary and unremarked presence in their everyday lives and the local landscape.

Levels of trust in the local plant management were also found to be high for many. Equally, everybody in the study, whether they supported nuclear power or not, could recount instances in which they were concerned or very worried about future safety at their local plant – e.g., after the New York 9/11 and London 7/7 terrorism attacks, or during a visible incident or unannounced emergency exercise at the local station. These incidents we interpreted in the research, drawing upon the work at Los Alamos of the anthropologist Joe Masco, as holding the potential to invoke a sense of 'nuclear uncanny' amongst residents.

The session with the National Academies concluded with a discussion amongst the panellists of the best means and methods for engaging the public about future nuclear technologies. If Wales is to take forward new civilian nuclear proposals, then that public debate would need to be conducted early, in depth, stress fairness and inclusion for affected local communities, with a view also to making coherent proposals for the wider energy system changes planned for Wales.

Link to the National Academies meeting:
https://www.nationalacademies.org/event/09-01-2021/laying-the-foundation-for-new-and-advanced-nuclear-reactors-in-the-united-states-meeting-7

FLEXIS Policy Unit Update

In March 2021, a group of experts from the FLEXIS Advisory Board was assembled to start to consider the current policy agenda here in Wales, against the background of net-zero considerations. Membership of the group was taken from the external members of the FAB, together with representatives from the Welsh Government, the Principal Investigators and colleagues who provide support for the group. The members of the group were:

From the FAB External membership:

Mike Colechin (Chair), Steven Phillips, Steven Edwards and Chris Harris.

From the Welsh Government:

Ron Loveland Welsh Government Adviser and member of the FAB, Eleanor Knight, Observer, Gethin While also Observer who took over from Eleanor when she retired.

The FLEXIS Principal Investigators:

Hywel Thomas (Co-chair), Nick Jenkins, Jianzhong Wu, Phil Bowen, Manu Haddad, Karen Henwood, Nick Pidgeon, Alan Guwy, Jon Maddy, Dave Worsley and Paul Meredith.

Support for the Group was provided by Karolina Rucinska and Wiktoria Tunska from the FLEXIS team.

The Group has met six times. The first meeting took place on the 22nd of March and operated as an introduction to the task and a chance to exchange information about the members' interests.

The unit met again on the 1st of April to discuss the potential scope of the work and decide the next steps. The third meeting took place on the 14th of March; the group focused on the top points for the policy proposed by each member. The fourth and the fifth meetings took place on the 22nd and 28th of April and were dedicated to deciding which of the proposed points should be priorities and, as such, included for further discussion.

The work of the Unit formed an item for discussion during the last FLEXIS Advisory Board meeting, held on the 13th of May 2021. Valuable input was obtained at that stage. A final meeting of the Group was then held on the 26th of May, when the document for submission was finalized.

Copies of the Submission (Appendix I) and the covering letter (Appendix II), which were submitted on the 14th of June were previously circulated to the FAB membership. They are included here for completeness. A response was received from the Welsh Government (Appendix III) on the 10th of August, which was also circulated to FAB members at the time. Again, that letter is included here for completeness.

UK Hydrogen Strategy

Briefing for the FLEXIS Advisory Group


Jon Maddy

The UK Government published its Hydrogen Strategy on 17th August, setting out the intended approach to developing a hydrogen economy in the UK. The strategy and the associated roadmap are intended to provide a clear statement of intent that hydrogen will play an essential part in the UK's approach to achieving net zero carbon emissions by 2050.

The stated purpose of the document is also to provide a clear indication to investors, developers and the potential UK supply chain of the UK's short, medium and longer term aims on hydrogen development.

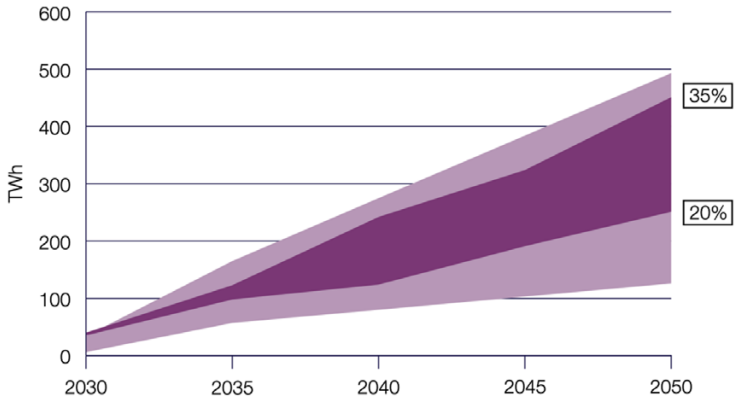
Initial Focus on the next decade

The strategy offers a plan for the implementation of hydrogen technologies at scale for the rest of this decade, targeting 5GW (~42TWh) of low carbon hydrogen production by 2030 as a platform to achieving the UK's sixth carbon budget and net zero obligations. Uptake of this quantity of hydrogen is estimated to deliver total emissions savings of around 41MtCO2e between 2023 and 2032.

BEIS analysis suggests 250-460TWh of hydrogen could be needed in 2050, representing 20-35 per cent of UK final energy consumption to meet the sixth carbon budget.

The key elements of the Hydrogen Strategy include:

- A 'twin-track' approach to enable low carbon hydrogen deployment, supporting green (primarily electrolytic) and blue (CCUS enabled) production.
- Outlines the development of an appropriate network infrastructure to allow transportation and storage of increasing volumes of hydrogen, from initial, local storage to meet a specific user need to large geological-based storage infrastructure to balance regional and national demands.
- Developing requirement for ammonia or other hydrogen carriers is also envisaged for higher fuel intensity uses such as shipping.
- Promoting end users to get ready for hydrogen adoption in the 2020s, anticipating that industry will emerge as the initial leading market, with increasing demands in the power sector, heavy transport and potentially in the commercial and domestic heating sector.
- Introduction of the proposed Hydrogen Business Model, which plans price and volume support to low carbon hydrogen producers. (This is the subject of one of the public consultations initially arising from the Hydrogen Strategy)
- The strategy estimates the economic opportunities from the adoption of low carbon hydrogen to the country even in the short term, suggesting the creation of 9,000 UK jobs and £900m GVA by 2030, with the potential to unlocking £4bn in investment by the end of this decade. This could rise to 100,000 jobs and a £13bn market value by 2050.



% = hydrogen as proportion of total energy consumption in 2050

Source: Central range – illustrative net zero consistent scenarios in CB6 Impact Assessment. Full range – based on whole range from UK Hydrogen Strategy Analytical Annex. Final energy consumption from ECUK (2019).

Figure 1.2: Hydrogen demand and proportion of final energy consumption in 2050

The Hydrogen Strategy deferred some aspects by putting out to public consultation, as follows:

1. Consultation on the preferred Hydrogen Business Model, proposed to provide price and volume support to clean hydrogen producers, thus providing encouragement to investment;
2. Consultation on the Net Zero Hydrogen Fund. Due to be launched in 2022, this is a £240m programme to support clean hydrogen developments;
3. Consultation on the implementation of a 'UK Low Carbon Hydrogen Standard', proposed as a threshold-based approach to defining low carbon hydrogen for potential use in other delivery mechanisms;

These three consultations all close on 25th October 2021.

A consultation is also planned on the introduction of hydrogen ready boilers in homes, as well as government reviews on the proposed twin track approach to production and a review of the development of necessary network and storage infrastructure for a growing hydrogen sector.

FLEXIS input to the development of the Hydrogen Strategy

The work of FLEXIS partners has provided a useful input to UK Government in the production of the Hydrogen Strategy and the supporting documents. Jon Maddy has been a representative on the Government's Hydrogen Advisory Council, meeting regularly with industry and government representatives to provide guidance on all aspects of hydrogen.

This has also included engagement in the Hydrogen Roadmap and Hydrogen Sector Development working Groups that continue to provide a plan for implementation and identify the path to develop the UK's hydrogen and related supply chain.

SWITCH Connect

South Wales Industrial Transition from Carbon Hub

The Universities of Swansea, Cardiff and South Wales are partnering on an ambitious programme to support decarbonisation and transitioning to net zero for industry, transport and buildings.

We have bold plans to be a catalyst for change, nucleating innovation, demonstration and deployment for the decarbonisation of the industrial base and communities in South Wales removing over 16Mt per annum UK emissions. This will also deliver novel low carbon and net zero products for key manufacturing sectors, delivering sustainable economic growth, to generate and support more than 11000 high value high skilled jobs and support global impact through international decarbonisation research and innovation missions.

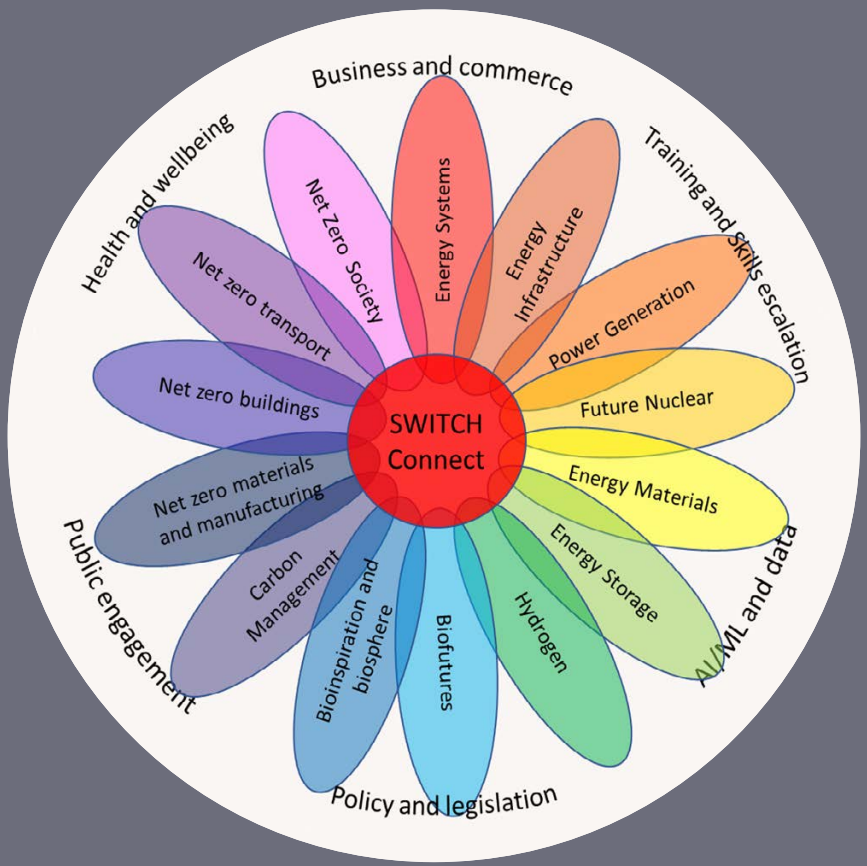
Above and beyond this we want to support additional power generation capability in the region for nuclear deployment and have linked with colleagues in Bangor University. In rural power we are linking with the innovation capability at Aberystwyth University that will deliver both demonstration capability at their in-house farm and connection and delivery capability with communities to ensure rapid adoption.

To support and deliver this we have brought together major assets from the university partnership, acquired new capital funds for a SWITCH facility and created a critical mass through combining together current energy related research and innovation vehicles notably FLEXIS and SPECIFIC together with a detailed plan on supporting skills and talent.

World Leading Facilities:

A new £20M facility (SWITCH Harbourside) is to be constructed to house equipment and research teams as part of the Supporting Innovation for Low Carbon Growth NPT City Deal.

This will also be adjacent to a manufacturing scale up centre and close the new Baglan Bay Technology Centre and the USW Hydrogen Centre. These add to existing and substantial assets over and about the SU Bay Campus including the CU Gas Turbine Research Centre (GTRC), the SU SPECIFIC Innovation and Knowledge Centre pilot production line and the Solar Heat Energy Demonstrator (SHED) next to GTRC.



Accelerating Research and Innovation:

The SWITCH Connect hub links to 14 detailed Themes underpinning societal and industrial net zero ambitions. The themes are interconnected to support a systems approach to decarbonisation. Much of the research builds on teams already in place as part of FLEXIS, SPECIFIC or other initiatives such as the SUSTAIN Manufacturing hub.

This means that the delivery of the SWITCH mission can commence immediately with expert teams and engaged industrial partners ensuring rapid progress. The partnership approach is essential with TRL 1-9 activity occurring simultaneously in an innovation ecosystem designed to accelerate delivery of net zero targets.

In addition, whilst work will clearly focus on Welsh targets the team will explore both national and international collaborations which can support rapid knowledge transformation to deliver Global change.

Skills and talent to adapt for change:

SWITCH on Skills will build on an existing training and skills escalator model which is aimed at delivering net zero skills at all levels from public engagement and schools interactions, apprenticeships, work based learning, and full/part time degrees/doctorates. The aim of this skills escalation is to provide a seamless ability for people to engage with training from bite sized knowledge capture to full time research programmes.

This supports the wider population to engage positively with the decarbonisation agenda and tailor their training and development to be flexible to their career development.

This approach to a flexible and adaptable skills escalation programme will enable no one to be left behind through gaps in knowledge or broader skills.

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TOWARDS A WELSH ROUTE MAP FOR NET-ZERO ENERGY SYSTEMS

Executive Summary

- Wales is rich in potential for renewable energy generation (wind, tidal, hydro, etc.); but has limited natural carbon capture and storage capacity, for example. The paper recommends six possible areas as priorities for Wales – without excluding other possibilities.
- The delivery of a vision over the next 15 years and beyond will require new strategic thinking, and the newly appointed Climate Change Minister provides a welcome focal point.
- However, the agenda is cross-cutting (across Government Departments); notably, the Economic brief as Wales remains disproportionately dependent upon energy-intensive industries; technology and innovation need to be harnessed to drive the Net Zero ambition. Moreover, this cross-cutting approach is effectively a requirement of the Well-being of Future Generations (Wales) Act 2015.
- There is already significant competition from other devolved administrations and English regions for investment and green jobs. The Levelling Up agenda is therefore both an opportunity and a threat.
- The policy levers (and the main interest groups of now and future) are a combination of devolved and non-devolved competencies. Thus, the Welsh Government can set a distinctive Welsh agenda; but will need to engage simultaneously with the UK Government and others. A close and strategic relationship with the various parts of the National Grid is imperative. Absent this, it is doubtful whether the vision is achievable in the required timeframe.
- Funding will be a challenge in the post-pandemic recovery period with intense competition for resources. Government – at any level - cannot realistically be expected to finance Net Zero on the scale required, so engagement with the private sector in Wales and beyond will be

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important. There is evidence of significant private sector investment in Wales already, but engagement with the sector in Wales and beyond is patchy and lacks coherence.

- There is further work to be done once the policy direction is set. For example, on integration and whole systems, multi-vector approaches to net zero. However, there was no support or technical justification offered for the concept of "islanding".
- In a Net Zero, future data will be as important as physical assets. The diverse landscape in Wales creates rich data sets and further opportunities to build a leading position in the delivery of innovative solutions through collaborations involving both private and public sectors with academia. These will also allow us to build a much-needed capability for specific modelling of the energy system in Wales.
- The social science around behavioural change will also be crucial in terms of enabling and incentivising the public to embrace change in a whole range of different ways that affect daily life.

2

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Cronfeydd yr UE: Buddsoddi yng Nghymru
EU Funds: Investing in Wales
UNDEB EWROPEAIDD EUROPEAN UNION
Llywodraeth Cymru Welsh Government

Dear Minister,

I am writing to you in my capacity as Lead Principal Investigator of the FLEXIS project.

As you may know FLEXIS has been funded for the last 5 years by the Welsh Govt via WEFO as an Energy Backbone project. Also we have just received further funding for another two years.

Our focus is on Energy Systems research, from generation through smart distribution to demand. Decarbonisation is thus a strong focus. We are a consortium of researchers from Cardiff University, Swansea University and the University of South Wales. We have worked very closely with Neath Port Talbot Borough Council and Tata Steel and have in fact established a Demonstration area in NPTBC.

For further information about us, please see our website: www.flexis.wales.

In light of the rapid developments taking place in this general area and with the rapidly approaching CoP26 meeting, on the advice/suggestion of Welsh Government colleagues on our Advisory Board, we have drafted a short document entitled “Towards a Welsh Route Map for Net-Zero Energy Systems”. A copy is attached for your attention.

I hope you will find our work of interest, alongside other policy advice documents you will surely be receiving now.

With best regards,
Hywel Thomas on behalf of FLEXIS.

Hywel Thomas

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Welsh Government

Ein cyf/Our ref: LW/10619/21

Professor Hywel Thomas
Lead Principal Investigator
FLEXIS

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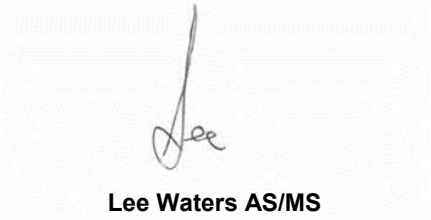
10 August 2021

Dear Professor Thomas,

Thank you for your letter of 14 June regarding the work of FLEXIS and the copy of your paper 'Towards a Welsh Route Map for Net-Zero Energy Systems'. Your report provides valuable insights and evidence to inform our approach towards a net-zero energy system for Wales.

We are currently developing our Emissions Reduction Plan for the current Senedd term which we aim to publish in October. The plan will set out actions for 2021-2025 but with an eye on the longer term transition required by 2030 and beyond to net zero in 2050. We are gathering input from a range of interested parties to inform our policy development. My officials, the Minister for Climate Change and I will give consideration to the conclusions and supporting evidence in the FLEXIS net-zero energy systems paper as we finalise the plan over the coming weeks.

Yours sincerely,



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