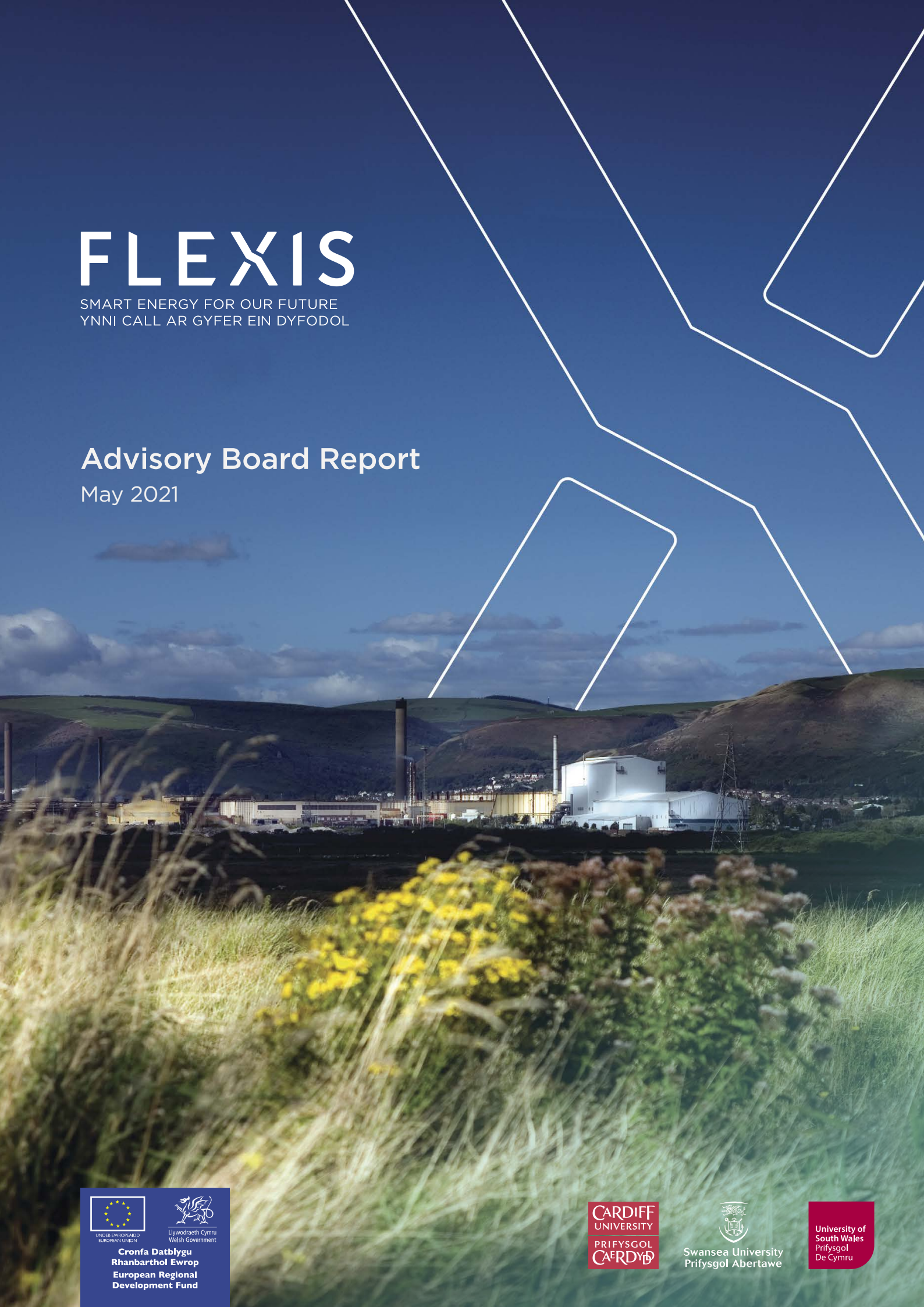
FLEXIS

SMART ENERGY FOR OUR FUTURE
YNNI CALL AR GYFER EIN DYFODOL

Advisory Board Report

May 2021



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Foreword

Prof Hywel Thomas

Shortly after the last FLEXIS Advisory Board meeting, as you will all know by now, we received the very welcome news from WEFO that they were of a mind to grant us a two year extension. We were invited to enter into discussions with them around the framework of a funding extension of £4M from the "West Wales and the Valleys" area budget and £1M in East Wales. As you might imagine we have worked closely with WEFO since then to prepare the two Business Plans needed to secure the funding. Our consortium of strategic partners - Cardiff University, Swansea University, The University of South Wales, Neath Port Talbot Borough Council and Tata Steel UK, remains the same but the detailed funding package is different, with the majority of the Extension funded from the "West Wales and the Valleys" budget. Our office, established during the first phase of FLEXIS in the Baglan Innovation Centre, forms the base for a great deal of our future work.

Much of the contents of this report is dedicated to a description of the Extension, so I will only provide some headlines here. The major changes that you will see are the inclusion of new colleagues from Swansea University in the team. As I'm sure you will recall Professor Petr Igic left Swansea University some time ago for a post at Coventry. Also Professor Andy Barron's team's work has focussed strongly on the Industrial Decarbonisation agenda, leading to the award of the major RICE project, which now forms a significant area of work. Three new Swansea University colleagues have joined the team, namely Professors Dave Worsley, Paul Meredith and Mike Jennings. We are delighted to be working with them closely.

The original FLEXIS project finished on February 28, 2021. During its lifetime, the project generated over £29M in research income, recruited over 100 new researchers into Welsh universities and invested over £2.4M into research equipment and technology to aid current and future research. We published 575 papers, shared FLEXIS outputs at 250 conferences and delivered 100+ research projects with government, industry and academia from across the world. In addition to this, we collaborated with over 250 industrial partners. An independent evaluation of our work has been commissioned and Innovation Partnership Ltd, who won the work, have completed the task. A Draft report is currently under consideration by WEFO.

This is the first FAB of the new "era" and I am delighted to welcome Dr. Mike Colechin as the new Chair of the Board.

I look forward very much to continuing the FLEXIS journey for another two years, building on all the hard work and results achieved previously.

I would also like to extend my thanks to all of you for agreeing to remain on the Board. Your advice during the course of the original FLEXIS was invaluable. We would not have achieved our goals without your input; of that I am quite sure.

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

Prof Alan Guwy

CymruH2Wales2 Hydrogen and fuel cells

University of South Wales

Prof Manu Haddad

Alternative environmentally-friendly gas for electrical networks insulation

Cardiff University

Dr Aleksandra Koj

Project Manager

Cardiff University

Prof Phil Bowen

SMART-POWER: enabling integrated energy systems

Cardiff University

Prof Nick Pidgeon
Prof Karen Henwood

Public response to energy systems technologies

Prof Nick Jenkins

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

Cardiff University

Prof Dave Worsley

Mobile Energy Stored as Heat Research Programme (MESH)

Swansea 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

Ben Burggraaf
Energy Operations Manager at Dwr Cymru Welsh Water

Phil Clements
Director Technical at Tata Steel UK

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

Paul Gallagher
Innovation Manager/Engineering Services Manager for National Grid Electricity Transmission

Francis Griffiths
CEO, Maiple Ltd

Robert Harper
Gallium Nitride Programme Manager, Compound Semiconductor Centre

Chris Harris
Head of Regulation and Compliance at Npower

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

Ian Wilkinson
Programme Manager at Siemens Energy

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:

Mike Colechin

Mike set up Cultivate in 2017 to provide on-going support for organisations and individuals in industry, academia and the public sector who are delivering innovative, low carbon energy solutions.

Prior to this he worked as Partnership Manager for the Energy Technologies Institute (ETI), an organisation that brings together engineering projects to accelerate innovation and help the UK meet its long-term energy objectives. He still delivers this role on a part-time basis, ensuring that the ETI creates value for its funders (both public and private) and the wider community of industry, public sector and academic players involved in energy in the UK. This is about informing policy, supporting companies developing the solutions, and building investor and industry confidence in new approaches to energy.

Mike is a Chartered Mechanical Engineer with over 20 years' experience in the energy sector. Before joining the ETI, he spent 15 years with E.ON, first as a Combustion Engineer and subsequently as a member of E.ON's R&D Management Team.

Steve Edwards

Steve has been involved in the energy sector since 1992 and has nearly 30 years' experience. Steven led the first "RIIO" business plan submission for Wales & West Utilities resulting in an agreed settlement with Ofgem for the next 8 years.

As a previous chair and member of the ENA Gas Futures Group, Steve has helped shape a number of contributions to UK energy policy. In 2011 Steve gave evidence on behalf of Energy Networks Association to the Energy Select Committee on the future role for gas in the UK. Energy is also a key issue for the devolved nations and Steven is a past member of the Welsh Government Energy and Advisory Panel. Steven is a Fellow of the Institute of Gas Engineers and Managers (IGEM) and was President of IGEM 2018/19. Steve is currently the Commercial Director at Milford Haven Port Authority and is an Executive Member of the UK Parliamentary Group for Energy Studies (PGES).

Karen Jones

Karen Jones is the Chief Executive of Neath Port Talbot County Borough Council

Prior to taking up her role on 1st January 2021 Karen was the Assistant Chief Executive and Chief Digital Officer. It was in this role that Karen was first introduced to the Flexis programme.

Karen has worked across the public service during her career, holding senior roles at Cardiff City Council, South Wales Police and Estyn.

Karen holds two masters degrees in Business Management and Human Resources Management.

New Members

Richie Hart

Richie works for Tata Steel and has over 30 years experience in the steel industry under varying ownership.

Starting within the R&D function of British Steel in Sheffield, he has spent his career working with control systems and data to optimise steel production processes. He has also held operational positions within the manufacturing function of the business as manager of the Hot Strip Mill in Llanwern, and as Technical Manager of the blast furnaces at Port Talbot.

His current position of Process Technology Manager involves managing a team implementing process improvements across Tata Steel's plants in South Wales, and developing capital investment proposals particularly on the subject of decarbonisation of the business. He has a first degree in engineering from Cambridge University, an MSc from Sheffield University and an MBA from Warwick Business School.

Phil Clements

Phil is currently Director Technical for Tata Steel UK and as such is the R&D and Technical function head for the UK.

He has almost 32 years of UK-based and international experience in the industry, much of it in technology-based roles. Prior to his current posting, he was Managing Director of Cogent Power Group, a fully owned subsidiary business of Tata Steel UK.

Phil is a member of the UK Steel R&D Committee, the Worldsteel Technology Committee and is also a board member of the Centre de Recherches Metallurgiques (CRM) in Belgium. He has a PhD in metallurgy and is a fellow of the Institute of Materials, Minerals and Mining.

Steven Phillips

Steve retired as Chief Executive of Neath Port Talbot Council at the end of 2020 after eleven years in post.

Previously he held senior posts with Cardiff Council and in the Welsh Government. Earlier in his career he worked for the then Department of Trade and Industry in London and the North East of England as well as the Foreign and Commonwealth Office and the City Takeover Panel.

New Members

Chris Williams

Chris is a Fellow of the IMechE and the Energy Managers Association.

Chris has 30 years experience in the steel industry that initiated in R&D, then Maintenance Management, Energy Optimisation before being seconded to the FLEXIS project in 2016. During his time in FLEXIS Chris worked with academia and Industry to initiate the development of the South Wales Industrial Cluster (SWIC). Chris was seconded to Industry Wales in 2020 to continue to lead and formally establish the governance structures for SWIC.

Tony Parton

Tony is the Managing Director of CR Plus, offering a wide strategic perspective centred around risk & opportunity.

He delivers the best returns for the investments made by his industrial clients, focusing on process improvements, energy efficiency & decarbonisation. His 35+ yrs experience in challenging areas provides a solid foundation to progress state of the art innovative solutions.

Bethan Winter

Bethan has over 20 years' experience in the gas industry having joined Transco in 1997. She joined Wales and West Utilities in 2009 when control centre activities moved across from National Grid after network sales, and now heads up the system operation team.

Her role includes managing the control centre which operates the WWU gas networks, long-term planning, and some aspects of future of energy including gas quality and DN entry.

New Members

Nicola Pearce

Nicola leads on the delivery of all major regeneration and investment projects throughout the county borough, including town centre regeneration and major transport and infrastructure developments.

Her portfolio also includes Planning and Public Protection, Streetcare and Neighbourhood Services, Property and Asset Management and management of the South Wales Trunk Road Agency.

Paul Brodrick

Paul is Business Development Director for Siemens working in both the Smart Infrastructure and Siemens Advanta businesses in the UK. He is driving Digital Transformation by co-creating new business models and Digital Services in partnership with Customers.

Enabled by the Siemens ADV capability and utilising Siemens extensive and diverse divisional portfolio Paul is developing new solutions for the Digital Age. He is a key player in the emerging digital and smart city markets and a disruptive agent of change.

tWith a proven track record of creating and winning truly innovative projects he has a unique breadth of experience across Utility, IT, Communications, Technology and SME sectors creating and delivering successful projects across these verticals. Before joining Siemens Paul was Managing Director of a start-up developing sustainable smart energy projects. Prior to that he was the Business Development Director for Utilities at Cable & Wireless Worldwide and also spent 10 years at ELEXON where he managed the wholesale electricity market.

FLEXIS Extension

As the FLEXIS project entered its final quarter, the FLEXIS team engaged in a discussion with WEFO regarding a possible extension of the project. After due consideration and based on an evaluation of FLEXIS' performance, WEFO indicated approval in principle, subject to availability of funds. All of the WEFO budget lines had been fully allocated, but FLEXIS was told that it was "on the waiting list" and at the "front of the queue". In late 2020, WEFO were able to identify a suitable source of funds and FLEXIS received notification that Business Planning could proceed.

The original FLEXIS operation received an ERDF grant of £15.18M. The Extension yields an additional ERDF grant of £4.70M, which takes the total FLEXIS grant to £19.88M. This allows the project to continue for a further 24 months, resulting in a total project duration of seven years. The total FLEXIS ERDF budget over the seven years will be £31.86M, with an ERDF grant of £19.88M, as stated above.

Following the additional funding, the performance targets for FLEXIS were increased. The table below presents the original targets and new total targets (for FLEXIS and FLEXIS Extension):

The new targets are based on an uplift from the targets achieved during the first five years of the project, not the original targets.

As mentioned previously there are some changes to the Principal Investigator team. In particular we welcome Professor Dave Worsley, Professor Paul Meredith and Dr. Mike Jennings, all from Swansea University.

Also Professor Hywel Thomas' role will be mainly one of that of the Lead PI, rather than also working on his own research agenda.

Prof Dave Worsley, is Vice President (Innovation) at Swansea University. He leads a number of UKRI funded programmes delivering research and innovation in advanced materials and solar energy. He is the PI on the £20M SPECIFIC Innovation and Knowledge Centre which links UK universities with manufacturing organisations in the area of solar powered buildings. SPECIFIC links to research projects such as the £8M SUNRISE project, which is taking the solar power agenda to an international venue in India, Africa and south America.

Prof Paul Meredith is a Ser Cymru National Research Chair, Professor of Materials Physics and leader of the Centre for Integrative Semiconductor Materials at Swansea University. His expertise lies in the area of energy technologies and sustainable advanced materials with low embodied manufacturing energy. He is closely engaged with the regional semiconductor industry and also has considerable experience in the development of renewable energy policy.

Dr Mike Jennings research interest lies in the field of new semiconductor materials for power electronics applications. He currently holds a Royal Academy of Engineering Industrial Fellowship (3 years), based at Newport Wafer Fab. He is also the principal investigator on a collaborative (industrial and academic partners) Horizon 2020 cubic silicon carbide project, leading the power devices theme.

TARGETS	ORIGINAL FLEXIS	ORIGINAL PLUS EXTENSION	ACHIEVED IN ORIGINAL FLEXIS*
Co-operation	50	100	84
Income	£26.012M	£35.533M	£29,668,009
Researchers	86	112	90.95 FTE

*The figures as of February '21. The figures are still being verified by the FLEXIS M&E team.

Heating Buildings Using Stored Waste Industrial Heat

Dave Worsley and Jon Elvins, from Swansea University,
discuss their plans for the work during the Extension.

Dave Worsley

Jon Elvins

1.0 Introduction

The MESH project will investigate 1.) the capture of waste heat and its efficient reuse as space heating using thermochemical storage materials, 2.) the economic and environmental feasibility of transport of the energy from industry to end user and 3.) the operational performance of the heating system via upscaled heat delivery units and the development of a digital twin.

Hot water supply and space heating accounts for 23% of the energy demand within the UK housing stock and approximately 21% of the carbon emissions (~98 MtCO2e). Combustion of natural gas fossil fuel is the primary energy source, accounting for 75% of domestic fuel, but continued provision of heat in this way is unsustainable as government targets require a significant reduction in CO2 emissions and other greenhouse gases by 2030.

Figure 1 details the total gas (blue line) and electrical (red line) daily demand for the UK between 2017-2020. Peak daily gas consumption is between 3.5 and 4 times greater than the electrical demand, and total reliance on electricity for heat is presently impossible due to generation limitations, and other alternatives such as LPG and oil are both expensive and high carbon options. Hence, alternative solutions to both heat from fossil fuels and heat from electricity must be considered for future domestic heat and hot water supply.

Heavy industry such as steel making are UK CO2 emissions hot spots and release up to 50% of consumed energy as waste heat. The Port Talbot steelworks alone produces waste heat at a continuous 760MW, which is equivalent to the combined annual heating demand of over 500,000 homes and the capture and reuse of this heat would offset more than 1,000,000 tonnes of CO2 annually.

To utilise this resource, the waste heat must be captured and distributed in an efficient, economic and environmentally friendly manner. Heat storage materials known as Salt in Matrix (SIM) are being studied as potential solutions to these problems. SIM's comprise of a chemical salt that is synthesised into the pores of a host matrix material. Dehydration and rehydration of the salts then provides the storage and release mechanism for heat energy via endo- and exothermic reactions.

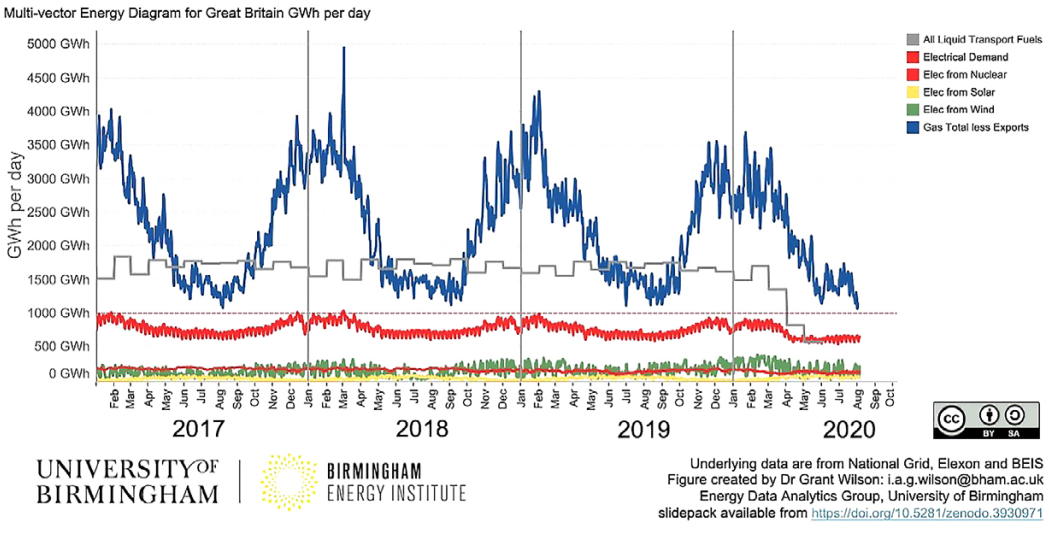


Figure 1. UK daily gas and electrical demand between 2017 and October 2020

Over the preceding years the heat storage team at SPECIFIC IKC have successfully investigated the discharge of heat from multiple SIM variants, honing the assessment methodology to enable the upscaling of the systems from a lab reactor containing up to 300g of SIM (140mm x 140mm x 60mm, Figure 2) through to a large demonstration system holding ~10 Kg (600mm x 600mm x100mm, Figure 3) with minimal performance variation.

Figure 2 emphasises the fast response of the SIM system, with the local temperature raising from 20°C at t=0 mins up to 50°C at t= 6 mins all from ~120 g SIM after the onset of a humified airstream.

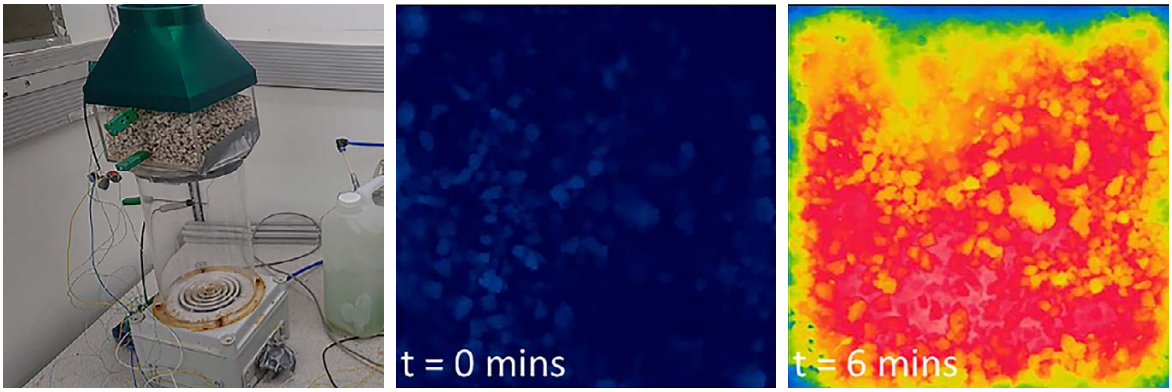


Figure 2. SIM assessment apparatus and material response visualised through thermal imaging.

The heat release from the upscaled system is presented in **figure 3**. Again, the peak temperature reaches over 50°C, and a significant temperature uplift over the ambient is observed throughout the experimental period and these data are being used to develop a demonstration system that will eventually be located in SPECIFIC's Active Classroom

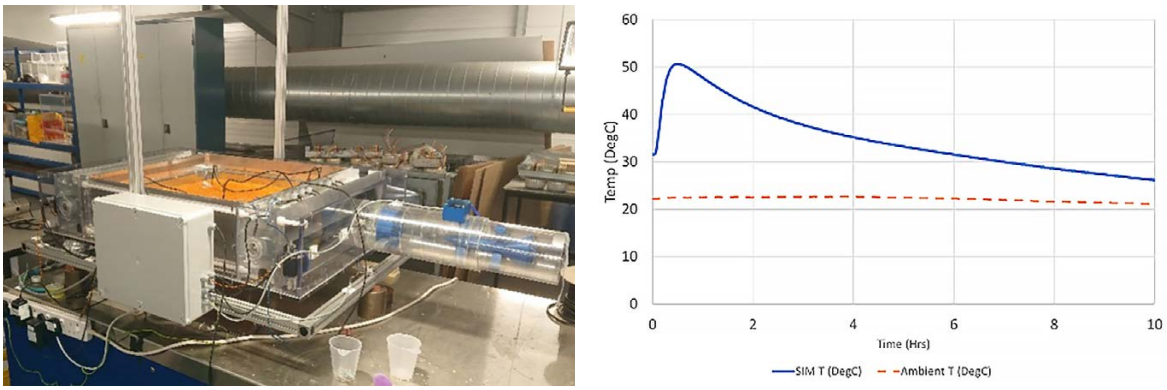


Figure 3. Upscaled SIM assessment apparatus with charted thermal response

2.0 Advancing heat storage capabilities with the aid of Flexis

Whilst the heat release aspect of the project is relatively advanced, studies investigating the capture of heat energy are at an early stage within our own group, and largely ignored within literature providing a niche area for exploration.

The Flexis funding will enable the evaluation of available energy from three Tata Steel production sites located in Wales, fine tuning of novel salts to provide a medium to capture the waste heat energy and ultimately, a modelled assessment of the environmental impact and operational performance of the concept via a digital twin.

2.1 Assessment of available energy

Working closely with industrial partners Tata Steel UK, the gaseous waste streams from production processes at Port Talbot, Shotton and Trostre works will be assessed for the quality and quantity of energy available.

These investigations will provide the basis for the overall project potential (magnitude of available energy that can be offset from primary production), and define the temperature bands through which optimised storage efficiency for improved energy density SIM materials can be achieved. The gathered data will also be utilised within a sister project funded through the Industrial Decarbonisation Research and Innovation Centre (IDRIC). Here the data will be combined with that from other key UK industrial sites to evaluate the potential scale of impact on a broader national level.

2.2. Optimisation of heat storage materials and system design

The MESH project will dovetail seamlessly with the ongoing activities of the heat storage group at SPECIFIC. Already ongoing are the primary investigations into the critical factors that determine a fast and effective charge of SIM materials. MESH provides the opportunity to upscale these activities from a small scale laboratory assessment to demonstration level, with the design and construction of a prototype unit for large scale evaluation.

As with the current upscaling activities described earlier, there will always be one eye on the end goal ensuring that the prototype is economically viable and fit for purpose. Further to this, working with industrial waste streams opens new avenues for research into alternative salts that require charge temperatures beyond that achievable with solar thermal generation systems. The utilisation of more exotic salts opens the possibility to higher storage densities and more efficient storage, hence improving the overall impact of the MESH concept.

2.3 Impact modelling and digital twin development

The impact modelling element will focus upon the economic and ecological viability of the proposed end uses of fully charged SIM. This will first investigate the cost of synthesis of SIM materials and associated delivery systems, ultimately producing a figure of £/m3 and £/kWh for the virgin materials and the CO2 impact/ km from point of capture. Working on the basis that each of the three industrial partner sites is the local point of generation, the impact model will determine the distance from site at which the transport of heat becomes economically and environmentally unviable, and therefore the overall concept viability. An analysis of plausible end uses for the SIM will be considered, based around industrial reuse and space heating scenarios, and the long-term financial implications of these solutions.

Demonstration of the operational performance will be included via the creation of a digital twin of SPECIFIC's Active Office, which is a demonstration building located on Swansea Universities bay campus. The building has several integrated technologies and services that are extensively monitored, recording measurements such as air flow, temperature and energy consumption.

The Active Office therefore serves as an ideal platform for creation of an energy flow model, looking at air flows, predicted demand and energy generation and control regimes. In the first instance a virtual model of the building and it's space heating systems will be created and the air flow throughout modelled.

Space heating requirements will be modelled and correlated to the actual building using the physical data collected to validate and improve the models accuracy. Thermal demands based on weather forecasts and optimised control of the thermal store and thermal generation systems will be included as the model progresses. Once the model is validated for the current building configuration a 'model thermochemical heating system' will be added.

This will serve to inform the design specifications of a suitably sized thermochemical store charged from industrial waste heat. There are many ways in which a working thermochemical store could be integrated into such a building and having a validated digital twin of the system will enable theoretical impact studies to be completed prior to the selection of any physical changes or integration of a working storage system.

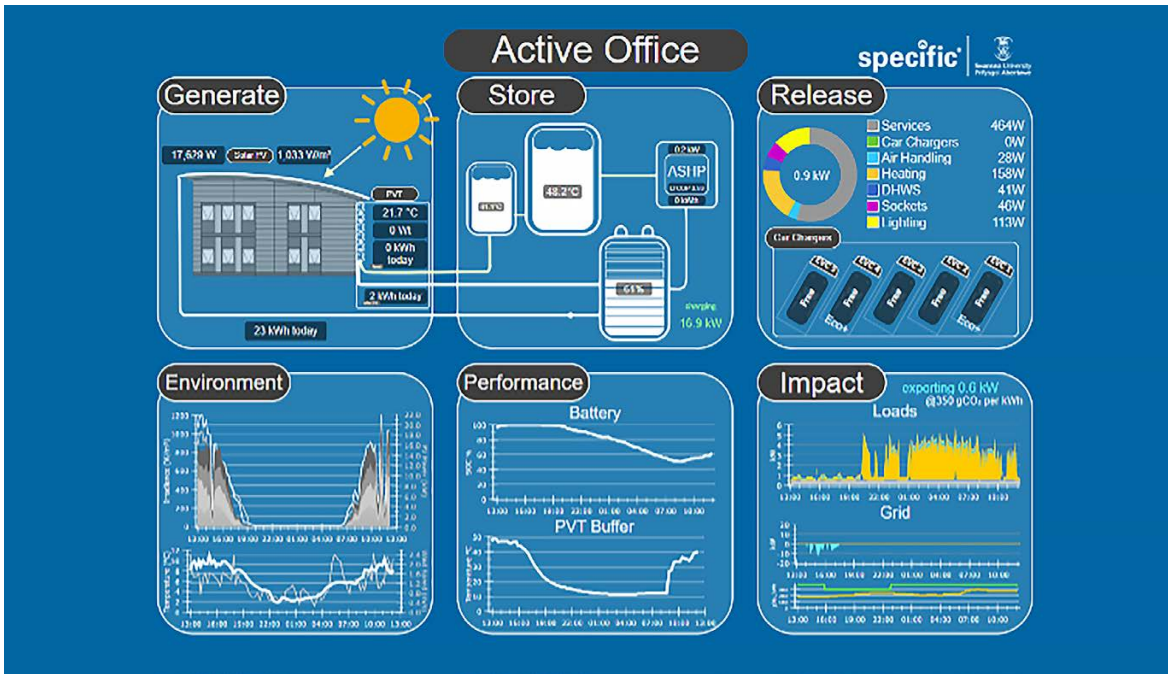


Figure 4 : Simplified energy flow dashboard of the Active Office

Power Electronics for a Low Carbon Economy (WP20)

Paul Meredith and Mike Jennings, from Swansea University, on the research to be conducted during the Extension.

Paul Meredith

Mike Jennings

The Opportunity & Case for Next Generation, Efficient Power Electronics:

The electrification of transport is one clear example of where efficient power electronic circuitry will play a central role in decarbonisation of the global economy. In particular, next generation power electronics based upon wide band gap (WBG) materials such as SiC and GaN are delivering more efficient drive systems in electric vehicles (EVs) – longer ranges and more effective utilisation of the current storage technologies.

The market growth and potential of WBG power electronics in sectors like automotive are impressive – see for example the UK's Advanced Propulsion Centre's report 'Strategic UK Opportunities in Passenger Car Electrification' which predicts a £10bn opportunity for the UK.

More broadly, efficient, low energy consumption power electronics are also at the heart of renewable energy generation (often requiring DC to AC conversion) and will be increasingly mandated in all electrical systems including consumer electronics and industrial control systems. The reason that WBG materials provide an enhanced solution versus current silicon-based power electronics is demonstrated in Figure 1 where the current and voltage requirements for different stationary and mobile power systems are mapped.

WBG materials and devices can operate at higher voltages and currents due to the fact that they have higher dielectric constants and thus breakdown voltages relative to narrower gap semiconductors. In addition, WBG materials have higher thermal conductivities and can tolerate higher temperature operation above 200°C. All of these properties mean that WBG power electronic components can be more efficient, smaller and more robust and reliable.

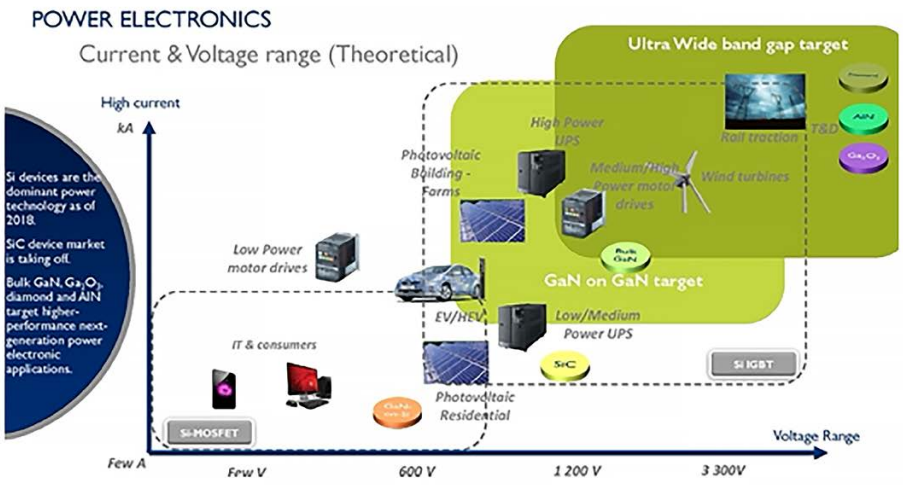


Figure 1 : The Power Electronics Roadmap plotting requirements for applications ranging from consumer electronics to grid-scale power management and rail drive electrification. Adapted from Yole Development CCRCD Workshop on Compound Semiconductors Market Overview (CS Connected ©2019).

The WBG Power Electronics Roadmap:

As shown in **Figure 1**, current IT and consumer electronics are driven by silicon-based MOSFET (metal oxide semiconductor field effect transistor) technology – low voltage and current operation. Indeed, Generation 1 electric vehicles rely upon similar technology, but GaN-on-Si SiC components are gaining prominence with Tesla (for example) who are completely reliant on SiC. In the medium-term, >1000V operation will be enabled by homoepitaxial SiC and GaN-on-SiC, with new innovations such as vertical transistor architectures. This technology will drive additional efficiency gains in renewable energy converter systems, dramatic extensions of EV ranges, and electrification of heavy vehicles and rail. Into the future, so called ultra-wide bandgap (UWBG) materials such as gallium oxide (Ga2O3), diamond, and aluminium nitride (AlN) will push the power envelope even further impacting grid-scale power management.

Connecting FLEXIS:

The FLEXIS Extension is an excellent opportunity to connect these advances in power electronics with the broader regional (and indeed UK) decarbonisation agenda. This is the overall goal of the new FEXIS Extension Work Package 20 which specifically focuses on the development of next generation WBG materials and components for renewable energy – a relatively nascent and untapped opportunity. The primary application target will be the design and prototyping of solar photovoltaic inverters based upon SiC – utilising the semiconductor's ability to withstand higher temperatures and voltages than silicon to create more reliable and versatile components. Other longer-term opportunities such as the use of GaN to deliver more compact, higher frequency inverters will also be considered as 'drawing board' concepts, as will blue-sky thinking around the use of β-Ga2O3 to form transparent conductors allowing a higher degree of integration between generation and power delivery systems.

Whilst the scope and resources available to pursue this innovative WBG PE agenda is limited within the FLEXIS Extension, the program will provide a powerful springboard for future innovation funding opportunities, further support our industrial clusters in launching their WBG PE manufacturing efforts and help firmly establish the region as a centre for semiconductor efficient power electronics R&I excellence

Regional and National Power Electronics Innovation:

These opportunities are clearly recognised in the transformation roadmaps of most industrialised economies but are specifically highlighted in the UK's Industrial Strategy within specific priorities such as Transforming Construction, Prospering from the Energy Revolution, Future Flight, Driving the Electric Revolution and the Faraday Battery Challenge. Collectively, these Challenges represent >£2bn of potential innovation investment to stimulate UK capabilities in the space. To date, our regional (South Wales) capacity in next generation power electronics has been somewhat limited. This is changing rapidly with Efficient Power Electronics being a key theme in Swansea University's new £30M Centre for Integrative Semiconductor Materials, and the expansion of the South Wales Semiconductor Industry (IQE, Microchip, SPTS and Newport Wafer Fab) tooling-up for scale-manufacturing into these markets.

In particular, and as part of the ISCF Wave 3 Driving the Electric Revolution (DER) Challenge and recently awarded Strength in Places Fund (SIPF) program, a regionally coordinated response is being implemented to drive both inward investment and capacity building in power electronics. Notably, Swansea University was recently awarded £4.84M from the DER Industrialisation Centres to create a Wide Bandgap Power Electronics Component Industrial Pilot Line – an industrial prototype line to be housed at the new CISM facility and at Newport Wafer Fab. The line will be in place and operational in the first half of 2022 and will be a nationally leading R&I capability placing South Wales at the heart of the WBG power electronics revolution. CISM and other members of the CS Connected Semiconductor Cluster are now collectively involved in a further 12 current and pending WBG PE-focused projects from a diverse range of funding sources including the ISCF, UKRI, the Advanced Propulsion Centre (APC), Aerospace Technology Institute (ATI), EPSRC, Welsh European Funding Office and Royal Academy of Engineering.

Principal Investigators – Point of View

Nick Jenkins
WP1

During the extension, WP1 team will be looking into the issue of the transition of domestic and commercial heating from natural gas, which will require increased use of electricity. We can already see signs of greater use of electricity for cooling. This increased load can only be managed cost-effective when both of the supply and demand of electricity are considered together.

Using data-driven and machine learning methods and building on an earlier project with NG:ESO, we will quantify the potential of demand-side response (DSR) from heating and cooling in Wales under a range of decarbonisation scenarios. A model of the Great Britain's electricity transmission system will be used to investigate the role of DSR from heating and cooling to mitigate electricity network constraints in South Wales and obtain revenue from providing balancing services to the Electricity System Operator (ESO).

This research will pave the way for increased integration of renewable energy resources to the power system in Wales and the whole of the UK. We aim to work closely with industrial partners and particularly SMEs to ensure the planned research will be translated to impact.

Phil Bowen
WP2-4

WP2-4 (GTRC) will work with manufacturers and operators of power, heat and propulsion plant to de-risk utilisation of hydrogen (up to 100%). In support of this goal, and to seed potential economic opportunities, we aim to develop Additive Manufacture (AM) technology with potential IP opportunities to optimise zero-carbon fuel utilisation through novel equipment design and materials.

GTRC/FLEXIS will build upon its world-leading expertise in ammonia energy to de-risk this potential medium for zero-carbon energy storage and transportation, seeking economic opportunities for Wales. Utilisation of sustainable-alternative fuels for transport including shipping and aviation is also within scope.

Working alongside SWIC we aim to assist in decarbonising industry through strategies including fuel switching, carbon abatement, data analytics and demonstrators. This includes de-risking and/or supporting repurposing energy network infrastructure towards the integration of zero-carbon fuels.

Across our activities we undertake to quantify hazards and minimise risks associated with net-zero transition, ranging from network resilience, to emission quantification and safety analysis. These research activities support industry as well as regulators (e.g. HSE, EASA), leading to international standards with local and global impact.

Finally we will seek opportunities to enhance and expand our research facilities and infrastructure in support of the transition to net zero.

Principal Investigators – Point of View

Alan Guwy
WP5-7

USW will continue to investigate the role of hydrogen energy storage and electrolytic hydrogen production to enable decarbonization of the energy system, industry, and transport. We will further develop novel hydrogen storage materials and approaches to increase hydrogen energy storage density.

Building upon our VFA Factory concept, we will use novel separation and concentration methodologies to maximise the production of volatile fatty acids (VFAs), platform chemicals that could play an important role in decarbonizing chemical and plastic manufacture. We will also investigate the use of VFAs and recovered ammonia as potential fuels in solid oxide cells (SOCs). In addition, techniques for the amplification and efficient recovery of hydrogen (and CO2) from industrial syngas waste streams will be further developed. This will include detailed investigation of advanced water gas shift and adsorption-based separation techniques, combined with electrochemical purification and compression experiments at USW's Hydrogen Centre.

USW will continue research into the application of hydrogen for the decarbonization of industrial processes, the power supply system, heating, and transport. This will involve experimental development and collaboration with academic, industrial and government partners to deploy hydrogen solutions at scale.

Manu Haddad
WP16

We will focus on building confidence with alternative gases to replace SF6 on electrical networks. A target of 5-10 years should be achievable to have an SF6 -free electrical network.

We will work closely with manufacturers and utilities to address the optimised gas mixtures in terms of their electrical and thermal capabilities, compatibility with other insulating and conducting materials, global warming potential whilst minimising health hazard.

The work with our strategic partner, National Grid, and other network companies, will also explore development of safe and efficient future practical procedures and measures to adopt the new gas for new equipment, retrofill of existing SF6 equipment, and ensure transition to business as usual using the new gas in the system.

Removing SF6 electrical equipment will reduce significantly the harmful emissions through leakages and faults, and contribute to the Net Zero carbon targets.

FLEXIS: Energy and Data

Phil Bowen

Since last years' initial developments concerning the FLEXIS Energy Data platform (Figure 1), a new project framework (Figure 2) has been developed entitled 'Low-Carbon, Prosperous Industrialised Towns Enabled by Digitally-based Decision Making' (CAPITAL-DM) which proposes and develops a 'digital' vision for the NPT region to 2030 and beyond.

CAPITAL-DM is focussed on the industrialised region of Neath/Port Talbot, with the goal of developing methodologies that could be applied to other similar towns throughout UK.

The vision and framework was developed over several meetings by a sub-group of the FLEXIS advisory board including Maiple, NPT, Cultivate, Siemens and FLEXIS academic partners in multi-vector modelling, phenomenological modelling and the understanding risk group. Additional South-Wales academic expertise was added comprising business modelling, data science and data analytics. The vision and ideas have been developed into a RCUK proposal which passed the first 'pre-outline' assessment, and FLEXIS are working closely with funding bodies to find potential funding routes.

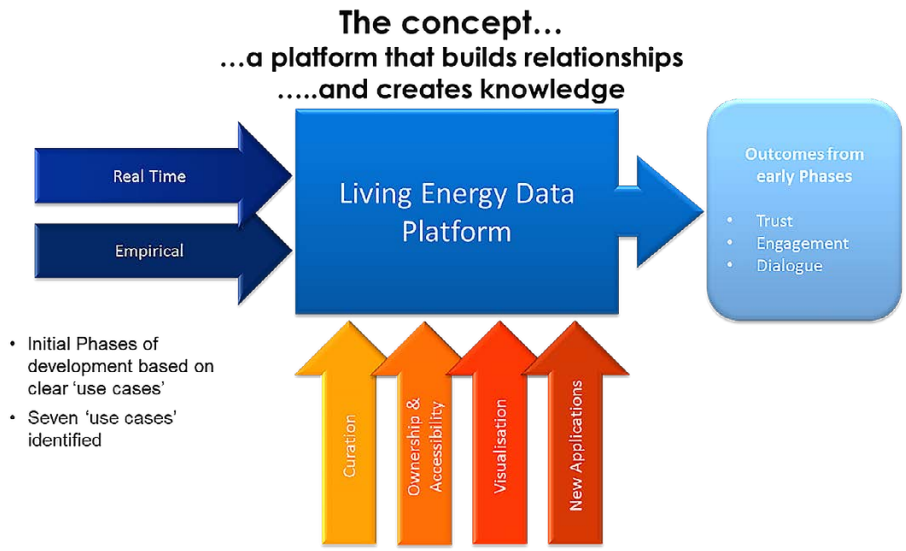


Figure 1. Enhancing the FLEXIS Living Energy Data Platform Concept (Cultivate, 2020)

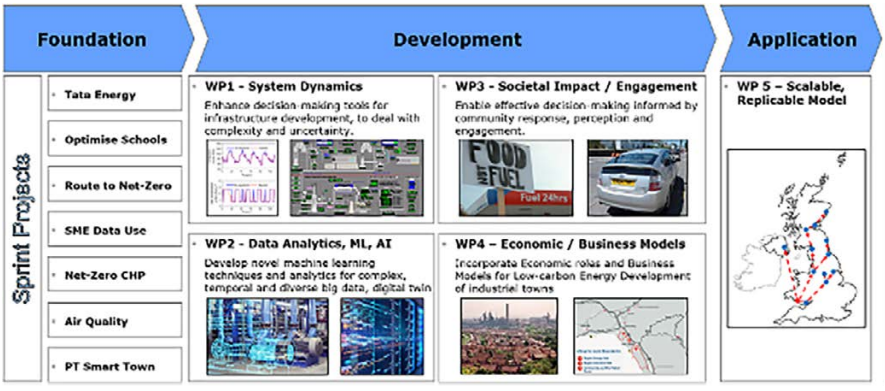


Figure 2. 'Low-Carbon, Prosperous Industrialised Towns Enabled by Digitally-based Decision Making'

The concept of so-called 'Sprint Projects' was conceived and promoted by the industrial participants, defined as projects were identified that could be feasibly developed and progressed by the FLEXIS team whilst funding for CAPITAL-DM and related projects was sourced. These sprint projects are appraised against the previously-developed FLEXIS project selection criteria, and Cultivate has developed 'Scoping Documents' for several sprint projects to identify the project objectives, potential sources of funding, timescales, etc.

Seven sprint projects have been identified, building upon preliminary studies and concepts : 'Optimising Energy Use in the Public Sector'; 'Route to Net Zero (NPT)', 'SME Data Use', 'Net Zero CHP', 'TATA Energy', 'Air Quality', and 'PT Smart Town'. Each sprint project provides a specific example of an Energy and Data use case.

Access to data, IP and related issues has been highlighted as a common hurdle for energy & data projects. Whilst challenging, these potential barriers have been shown to be surmountable by previous FLEXIS academic/private sector projects, for example, the TATA/Cardiff University Centre of Excellence project facilitating access to the TATA data management system for the visualisation and analysis of real-time and historic site data. Access to local authority data for public buildings has also been facilitated during FLEXIS. Similarly, negotiations are underway between stakeholders including NPTC, EA Technology and WPD regarding access to data from VisNET hubs; for the monitoring of selected low voltage substations associated with the public sector sprint projects.

Figure 3. Port Talbot School Proposed for FLEXIS Energy Data Analysis

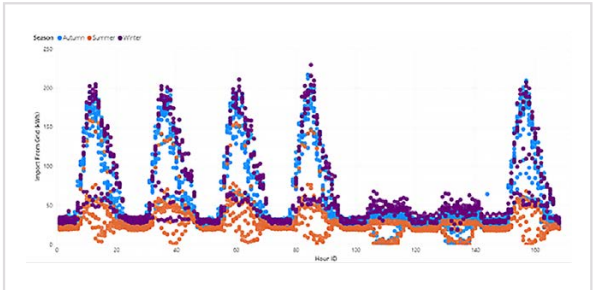


Figure 4. Seasonal Hourly Electrical Import Data for a Port Talbot School

Examples of sprint projects progress include:

Sprint Project Example 1: Optimise (NPT) Schools Performance

Schools are an integral part to the Neath/Port Talbot community, whilst also one of the largest components of NPTC energy expenditure within its operational building portfolio. Writing in the Financial Times in November 2020, Boris Johnson targets investment in 'green' schools and their bill reduction under point seven of his ten-point plan.

Against this backdrop, in consultation with NPTC, Cultivate developed a scoping document, and identified three sub-projects ('Use Cases') :

Project 1A
Using Energy Data to Optimise Building Performance: the outputs from a range of energy monitoring and analysis tools will be used to propose and test operational improvements and predictive maintenance activities that reduce building energy consumption and consequential greenhouse gas emissions.

Project 1B
Using Energy Data for Educational Outreach: a feasibility study to establish the potential for subsequent delivery of a range of educational materials. These would use the school's own energy data to enhance and contribute to the curriculum across a range of subject areas and applications, raising awareness of decarbonisation and net zero solutions in the wider community.

Project 1C
Using Energy Data to Support Procurement: develop a better understanding of the timing, volume and potential flexibility in the school's energy demand to establish opportunities for reducing energy costs through participation in aggregation and demand side management schemes.

Two Schools in Port Talbot have been identified to focus developments. Of interest is the installation of PV, supplemented by electrical power imports from the grid (Figure 4).

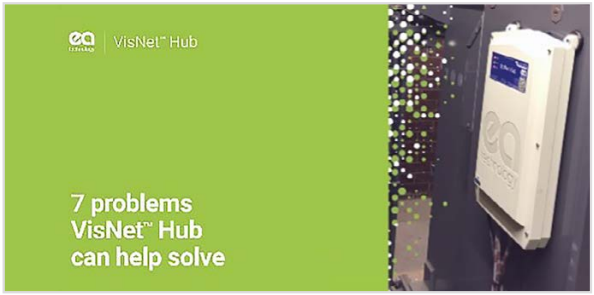


Figure 5. EA Technology 16kHz 'VisNet' Hub Installed at Port Talbot Sub-Station

EPSRC post-graduates from the Energy Systems Doctoral Training Centre at Cardiff have been identified as a resource to progress this project, with potential industrial sponsors EA Technology and Cultivate.

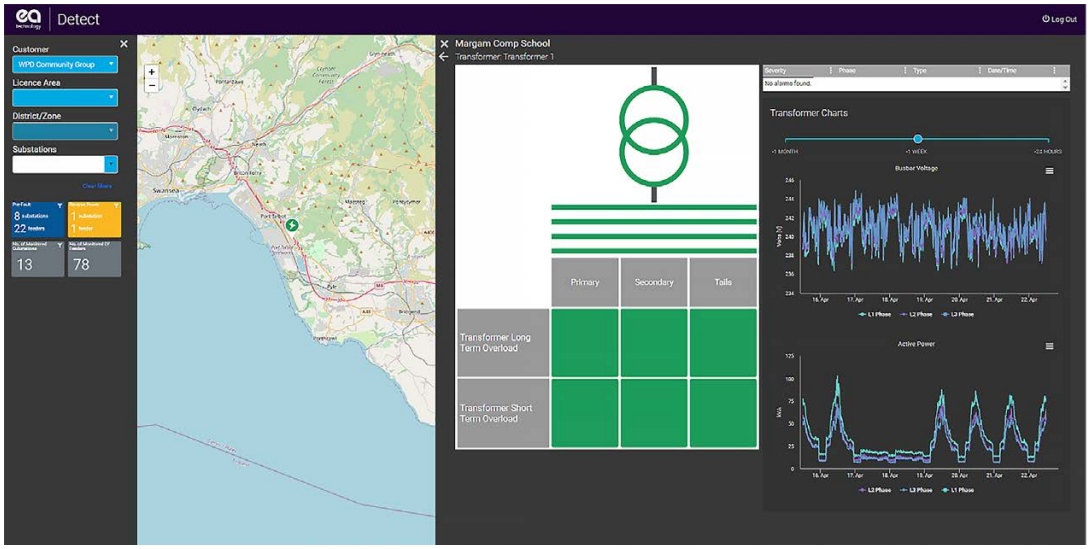


Figure 6 : Visual Interface of data from 'VisNet Hub' (EA Technology) Installed at Port Talbot School Sub-Station

Sprint Project Example 2:
Net Zero Combined Heat and Power System Demonstrator

FLEXIS has been offered the loan of a hydrogen compatible 0.5MW CHP generator gratis from a European OEM. Building upon the previous public sector sprint project, the conceptual integration of this CHP source into a net-zero system was proposed by a FLEXIS early career researcher (Figure 7).

This demonstration proposal is to provide zero-carbon heat and power for local public sector buildings including a NPT School, and Welsh Government buildings with tenants including FLEXIS partners Cardiff University (GTRC) and Swansea University (SPECIFIC). Optimised use of the zero-carbon heat and power, along with development of a digital twin and use of local renewable energy sources, form part of the use case.

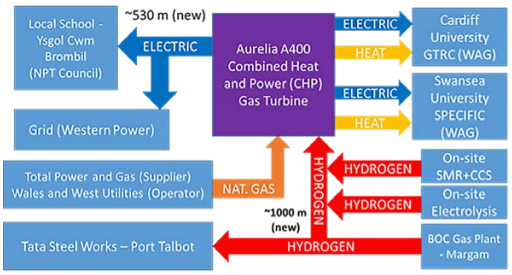


Figure 7. 'Net Zero CHP' Demonstrator in Neath/Port Talbot

Sprint Project Example 3:
'Port Talbot Smart Town' – FLEXIS Database and NPT Energy Data

Building upon the first two sprint project examples, and assisting NPTC move towards their aspiration of a 'Port Talbot Smart Town', FLEXIS researchers at the Centre for Integrated Renewable Energy Generation and Supply (CIREGS, WP1) have developed a centralised MS SQL database to collect, store and manage energy systems data. The database is hosted at Cardiff University's central IT data servers (Figure 8).

The database includes energy data for Neath Port Talbot Council and the FLEXIS demo area. A graphical dashboard and interactive data visualisations have been developed to provide access to collected energy asset data such as electrical power plants and electrical substations within the area, heat demand and local authority site energy data (see Figure 9).

The other sprint projects are at various stages of progress for example the FLEXIS/Maiple 'AI Centre of Excellence' funded via the 'FLEXIS-App' project.

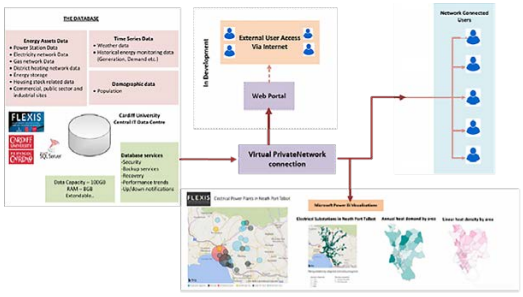


Figure 8. FLEXIS Database Structure

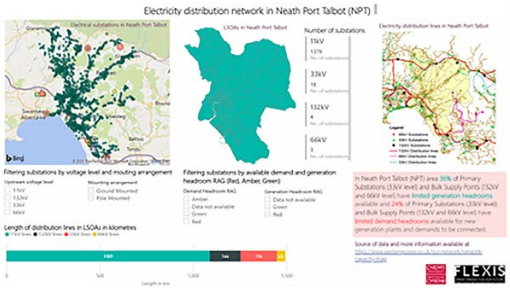
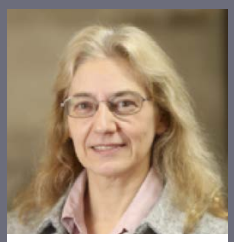


Figure 9: Dashboard for Energy Data in NPTC area and interactive data visualisation of the electricity distribution network in NPT

Briefing on FLEXIS and Responsible Research and Innovation (RRI)



Karen Henwood

Nick Pidgeon

Chris Groves

Flexis RRI objectives

As featured in a previous FAB report the FLEXIS social science team has undertaken research using qualitative longitudinal social research methods for elucidating lived experiences and dynamic processes of energy vulnerability, emphasising their importance in explaining some of the challenges that energy system transition to Net Zero may face. This briefing concerns another important facet of our work - public engagement with integrated energy system change – reflecting an interest in Responsible Research and Innovation (RRI). We explore why and how an RRI framework could be developed for flexible, integrated energy systems. This work will be of interest to Flexis stakeholders because it aims to i) enhance the social robustness and desirability of local place-based demonstrator projects; ii) support system- and national-level strategies for transitioning to low-carbon, flexible energy systems; and iii) guide further use of RRI strategies within energy systems development in Wales, the UK and internationally.

RRI & Energy Systems

Responsible Research and Innovation (RRI) is recognised by Research Councils UK and the European Commission as a means of making technology and engineering research more sensitive to societal concerns. It evolved out of initiatives that, since the 1970s, have been developed across the world to leverage social intelligence regarding the potential unintended consequences of innovation under the rubric of societal technology assessment. RRI goes further by engaging stakeholders across the innovation ecosystem, including industry, researchers in labs, policy practitioners at different levels (from local councils to national government), funding bodies, civil society organisations and the wider public. RRI starts early in innovation processes in gathering social intelligence to anticipate unintended impacts of innovation and to identify opportunities for increasing its value, and continues to engage iteratively as innovations emerge. Recent discussion within risk governance of the energy transition likewise focusses on the need to engage a range of stakeholders (including the public) in assessing potential unintended impacts of decarbonisation and reflecting on what values and priorities are driving the transition.

Anticipating Social Impacts of Energy System Change

Many complexities and challenges come with these approaches. Certainly this has been the case as we have conducted our own research programme and turned our attention to how we might construct from this a framework for RRI practice tailored to the scale of challenges involved in the energy transition. RRI has not been applied before to energy innovation at an energy systems level, so challenges are not surprising. Nonetheless, we have made significant steps forward by reflecting on cumulative understanding of potential problems and aspirations (for key insights arising from the research process see boxes 1&2).

- Engaging with stakeholders through expert interviews on the one hand, and interviews and workshops with the public on the other, has established that RRI for the energy transition requires an understanding of societal concerns and aspirations which are related to the social contexts in which demonstrator projects are to be deployed.
- The extent to which the energy transition reflects a range of values identified within localised contexts may improve its social robustness.
- The ways in which communities of end-users are thoroughly dependent on energy systems, and the ways in which people in their everyday lives experience this dependence, will influence how the localisation of energy systems plays out, in whatever forms it may take.

Our research findings have shown that the complexities of energy system change, both at system level and in particular localities, may produce unintended consequences – harmful or beneficial. RRI aims to ensure they are mapped in conjunction with the development of research and commercial activities - and their expansion into additional locations, priming institutional capacity to respond to such challenges and opportunities.

In addition, our research has engaged with different visions of integrated and flexible energy systems as manifested in islanding/energy independence on the one hand and dense interconnectivity on the other. Moreover, our methodologies have opened up to scrutiny values and priorities and enabled members of the public to ask questions about the desirability of system scale visions and dynamics of change. Consequently, our work provides support for system- and national-level strategies for transitioning to low-carbon, flexible energy systems and to guide further use of RRI strategies within energy systems development in Wales, the UK and internationally.

Box 1:
FLEXIS RRI key findings – Potential problems

1. Decentralised local energy systems may be perceived as being less resilient.
2. The potential financial impacts of energy system change on households that are vulnerable to lacking adequate energy services may be significant.
3. Inequalities in capabilities and competences between households may make it harder for some to engage with an increasingly ICT-based flexible energy system. Existing vulnerabilities may worsen.
4. Some technological pathways for system decarbonisation may entrench or create undesirable patterns of socio-economic development, with negative implications for well-being.
5. Socio-technical change, particularly in relation to vital services, can create trust problems: some private/public institutions may not be trusted to ensure benefits will be realised, or to ensure that safety/social impact risks are mitigated or avoided.
6. Particular places (as well as some people) can be more vulnerable to the impacts of energy system change than others. Demonstrator projects may negatively affect attachments to place and social relationships within communities.
7. Benefits may be highly localised, creating inequalities between demonstrator communities and others, which may cause disruption, such as encouraging people to move from rural to urban locations.

Box 2:
FLEXIS RRI key findings – Potential benefits

1. Decarbonisation and local demonstrators may create opportunities to promote locally beneficial forms of ownership and control over renewable energy resources.
2. Changes in the relationship between end-users and the energy system they rely on might expand opportunities for citizens to represent their interests within it.
3. Improvements in environmental indicators relevant to specific places and whole regions (e.g. air quality and environmental amenity), might be possible, potentially improving well-being and place character.
4. Decarbonisation may create localised opportunities for socio-cultural as well as socio-economic regeneration – e.g. linking tourism to environmental improvement or promoting links between a decarbonised energy system and Welsh socio-economic heritage.

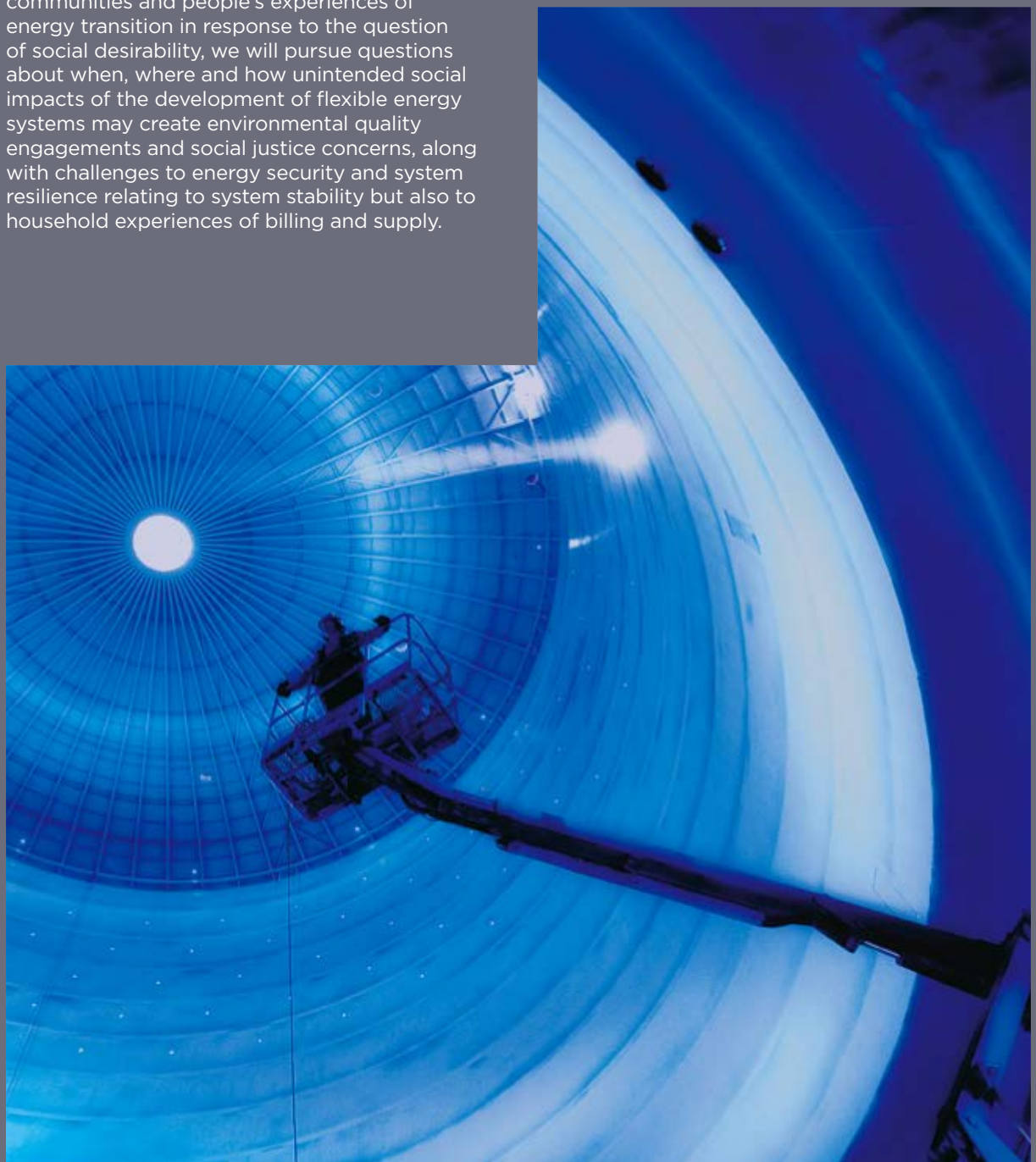
FLEXIS Social Science: where next?

Over the next 18 months - the duration of the Flexis extension - a central question facing public authorities regarding the energy transition is how to produce a vision and strategy to reach the goal of Net Zero carbon emissions that is both credible and socially desirable. Our ongoing research with FLEXIS experts and stakeholders will consider how the credibility of strategies for transition is seen by experts as depending on how they build new forms of flexibility into the system, and new ways of decentralising energy production and grid infrastructures in response to the problems of grid capacity.

In continuing to develop our research on communities and people's experiences of energy transition in response to the question of social desirability, we will pursue questions about when, where and how unintended social impacts of the development of flexible energy systems may create environmental quality engagements and social justice concerns, along with challenges to energy security and system resilience relating to system stability but also to household experiences of billing and supply.

In addition, we will identify how benefits for Welsh communities additional to those listed in the Pathway to Net Zero (Dec 2020) report may result from decarbonising the energy system in Wales in ways that speak to the Welsh Government commitments arising from the Wellbeing of Future Generations Act, including local ownership of energy infrastructure.

For details of the work published under WP17 please contact Prof Karen Henwood at **HenwoodK@cardiff.ac.uk**



South Wales Industrial Cluster (SWIC)

Jon Maddy


Chris Williams

Additional £20m funding for project to decarbonise industry in South Wales

The South Wales Industrial Cluster (SWIC) deployment project has been granted a second round of funding following the successful completion of phase one assessments. This second phase of the project involves engineering studies to explore the routes to decarbonisation, including the use and production of a hydrogen supply, carbon capture usage and storage (CCUS), and CO2 shipping from South Wales, which would be the first CO2 shipping industry in the UK, and would create an entire new industry for the region.

Led by Costain, the project has been granted £20m funding in addition to £18m industrial contribution to continue its development. The project is supported by a range of partner organisations from the industrial, academic, law, public and private sectors working across the region to create the world's first net-zero emissions industrial zone.

USW's Sustainable Environment Research Centre is supporting the project partners by investigating and initiating the detailed R&D required to support the decarbonisation schemes and the infrastructure required for a hydrogen economy in South Wales. In addition, USW is identifying and instigating the skills and training needs of the partners.

These activities will encompass close working with the Industrial Decarbonisation Research and Innovation Centre (IDRIC) and will continue and extend the collaboration with FLEXIS partners, in particular.

The South Wales Industrial Cluster (SWIC) arose from industrial/academic engagement on the FLEXIS project and includes a diverse mix of critical industry from the Pembrokeshire coastline to the Welsh/English border. The SWIC partners have converged with common objectives for decarbonisation and clean growth. Some of the sectors represented include:

- Steel making
- Oil Refining & LNG import
- Power generation
- Cement manufacturing
- Nickel manufacturing
- Insulation manufacturing
- Chemicals
- Paper industry and other general manufacturing

SWIC's goal is Net Zero Carbon (NZC) by 2040. Regional industrial CO2 emissions are 16 million tonnes annually (5% of the overall UK total), comprising 10 million tonnes direct from industry and 6 million tonnes from power generation. Achieving NZC will provide a significant contribution to the UK's goal of becoming net zero by 2050.

SWIC embodies the principle that NZC must be realised in the broader context of "People, Planet and Profit", achieved through sustainable clean growth, within a globally-competitive market, maintaining a growing and diverse industrial sector region. The scope of this industrial decarbonisation in South Wales will potentially protect over 100,000 existing jobs, with potential to grow this number through export of skills and services globally, from a centre of green excellence.

SWIC, through ongoing engagement, is actively supported by Welsh Government. There is also support for SWIC by local authorities, which aim to ensure that they can provide the necessary jobs to protect the future of their communities. SWIC is also actively working with other UK cluster regions to optimise decarbonisation outcomes.

FLEXIS Policy Unit

FLEXIS Policy Unit

In March 2021, a group of people 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 are:

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 will take over from Eleanor when she soon retires.

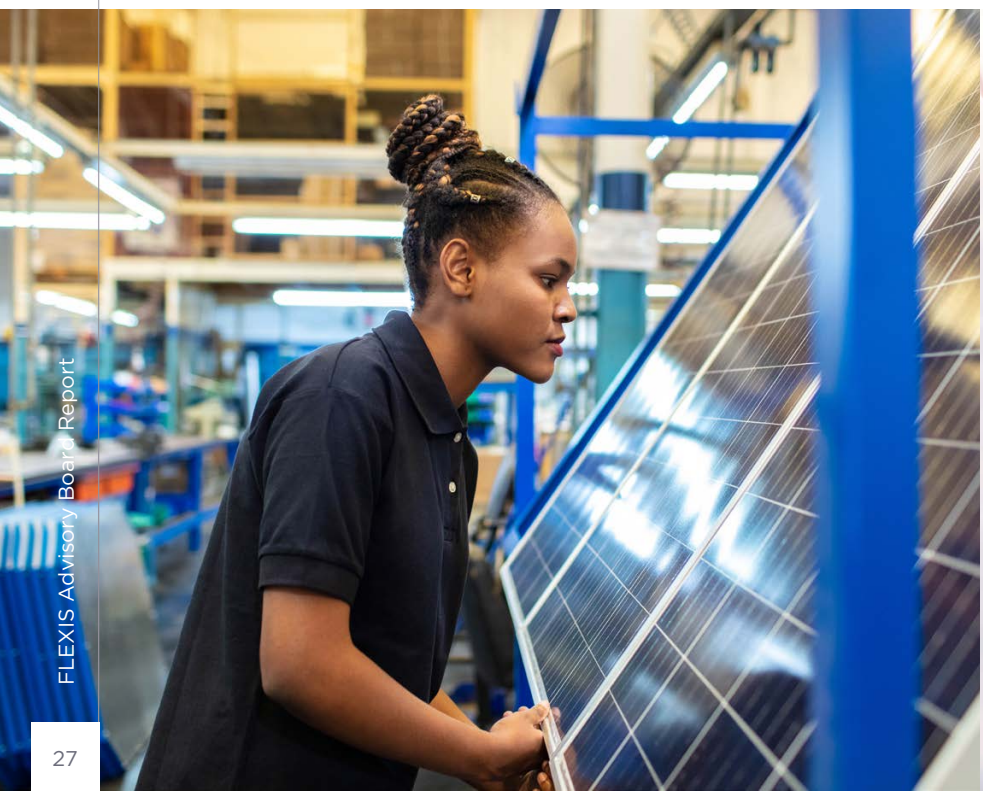
The FLEXIS Principal Investigators: Hywel Thomas (Co-chair), Nick Jenkins, Jianzhong Wu, Phil Bowen, Manu Haddad, Karen Henwood, Nick Pidgeon, Alan Guwy, Jon Maddy, Dave Worsley and Paul Meredith.

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

The Group has now met five 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 members. 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. So far, the overarching themes emerging from the group's conversations have been Leadership and Ambition; Society and People; Whole System Thinking; Innovation, Technology and Private-Public Sector; Partnerships; and Place.

The work of the Unit will form an item for discussion during the FLEXIS Advisory Board meeting.



FLEXIS – Ways Forward. Evaluation of the five-year progress.

An independent evaluation of FLEXIS was completed by the Innovation Partnership Ltd. This relates to the period leading up to the original project completion date. The overarching aim of the evaluation was to carry out an assessment of FLEXIS achievements and impacts to date. Following on from the news of the extension, the report produced by evaluators will now be an interim external evaluation and is currently under consideration by WEFO.

The evaluation exercise, spanning over 6 months, consisted of key stakeholder interviews and a desk research of the project delivery documents. The consultants analysed this information on project progress and impact to draw conclusions on overall project performance, formal outputs, wider impacts, policy and socio-economic context. The main findings have been summarised below and includes excerpts from the report:

Table 1: FLEXIS Output Indicators* (up to end of February 2021)

Output Indicator	Total	Target	Variance
Value of Research funding secured	£29,668,009*	£26,020,000	£3,648,009
No. of cooperating enterprises	84	50	34
New researchers working in supported entities	90.95 FTE	86 FTE	4.95 FTE
Additional Indicators			
No. of grants bid for	323	-	-
No. of grants won	132	-	-
No. of papers published	575	-	-
No. of conferences attended	252	-	-

*Note: all figures are verified to end of November 2020, the additional figures are undergoing verification.

FLEXIS has been successful in meeting and exceeding funding indicator targets set for the project (Table 1), and has also met the long-term benefits of delivery identified in the business plans for both regional operations.

The consultants stated that the significant level of performance against the 'number of cooperating enterprises' target is a reflection of the collaborative nature of engagement delivered by the project, and the strength of the networks built during its operational lifetime.

The outputs further shows that FLEXIS has been a success in securing research funding and also in developing the funding of associated initiatives, which is estimated to be a contribution "three or four times greater" than the research funding target achieved by the project. The significant wider impact of the project, over and above performance against stated indicator targets, is outlined in the main report.

- The work package approach of the project over its five-year period has allowed it to evolve to accommodate shifting policy and legislative priorities.

- The Demonstration Area concept was believed to be a fitting approach in delivering real-world solutions going forward, including contribution to the Government's aim of deploying Hydrogen and CCUS for net zero, with industrial-scale demonstration projects. Subject to pandemic restrictions, there are significant opportunities to make the DA a success.

- The integration of the social sciences alongside technical research has provided the project with a scope of activities necessary to drive the required energy transition. Qualitative, longitudinal work undertaken with the community of Caerau provides a blueprint for energy-related research, helping to "bring the public along" and facilitating the mitigation of socio-economic issues, such as increasing levels of fuel poverty.

- FLEXIS has set example of 'best practice', according to WEFO, on the Cross Cutting Themes, which the consultants also agreed the project has performed strongly on.

- Significant contributions have been made to several Well-being of Future Generations Act goals by attracting world class talent and research funding to Wales, especially in the renewable/environmental technology fields.

- In spite of the impacts of COVID-19, FLEXIS has established a platform to deliver future objectives, through the development of FLEXISApp and the two-year project extension.

- It was noted by all stakeholders, including representatives of Welsh Government, that the development of an established network of PIs across the three partner universities has moved the research landscape forward in Wales, providing an innovative, collaborative and inclusive approach to energy research and facilitates the changes necessary for the required 'energy transition' to take place. FLEXIS has also worked well with other European-funded programmes in the UK and that a continuation of this activity will be critical to future programme success.

The consultants proposed a number of recommendations going forward:

- Alignment with recent & imminent policy through continuous monitoring of technology-specific decarbonisation strategies to support the sustainability of the project and exploit associated funding opportunities.

- Influence on research and policy agenda by proactively taking ideas and opportunities to Welsh Government and leverage the existing network to showcase the results of FLEXIS research to achieve greater traction and increased buy-in at a national level.

- Expansion of activities through collaboration with other regions and other industrial partners for future project delivery. The scope of activities could be widened to include the supply chains of major industrial partners.

- Improve project promotion to create a higher profile and leverage on the close alignment of the work being undertaken by FLEXIS with critical UK-wide governmental priorities. FLEXIS expertise could be used to establish a permanent academic group examining energy systems and sustainability and this idea should be pitched at Welsh and UK-Government levels through FAB members and national contacts.

The complete report, by Innovation Partnership Ltd will be shared with FLEXIS stakeholders, following WEFO review.

FLEXISApp – Our Vision is to Drive Green and Economic Growth

Two major collaboration projects have been awarded under FLEXISApp:

Centre of Excellence – Artificial Intelligence and Machine Learning

Collaboration between Cardiff University and Maiple Limited. The goal is to establish a Centre of Excellence in Wales, focussed on the development of AI based algorithms for energy efficiency and optimisation of multi-vector energy systems for use in commercial applications within the region, across Wales, the UK and global markets.

A corner stone of these solutions will be the ability to harness the vast amounts data that in some cases already exists and combine these data sets with new data that is generated by the collaborators within FLEXIS. The work largely consists of three phases: data discovery, model development and finally model deployment. The aim is to work on implementations of these models that can be demonstrated within the Demonstration Area of Neath Port Talbot with a view to engaging commercial partners. The project aligns with the FLEXISApp decarbonisation agenda through its endeavour to improve the affordability of clean energy by creating new technology to provide multisector energy forecasting solutions, consequently lowering carbon footprint.

The project also involves Neath Port Talbot Council, Swansea University AI Doctoral Training Centre xThink GmbH, and leading technology companies which include Nvidia, Amazon, Google and Mathworks.

Mobile Energy Storage as Heat (MESH)

Collaboration between Swansea University and Tata Steel UK. MESH 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 SPECIFIC project and subsequently use the acquired data to model the viability of the reuse of the captured heat from a technological, environmental and economic viewpoint. The aim is to be able to transport 760MW of waste heat produced by Port Talbot steelworks and release it in a controlled way to provide process heat or space heating in either industrial buildings or domestic abodes.

MESH will address decarbonisation goals by;

1. reduction of CO2 emissions and natural resource usage,
2. minimised heat release into the atmosphere,
3. valorisation of waste streams,
4. improved industrial cost efficiency and
5. potential deployment of year-round heating without the use of fossil fuels.

To recap: What is FLEXISApp?

FLEXISApp is a £3M research, development and innovation programme focussing on industrial decarbonisation and economic growth.

Funded by the Welsh European Funding Office (WEFO), this project brings together academia, industry and government to develop innovative energy technologies to achieve net zero targets.

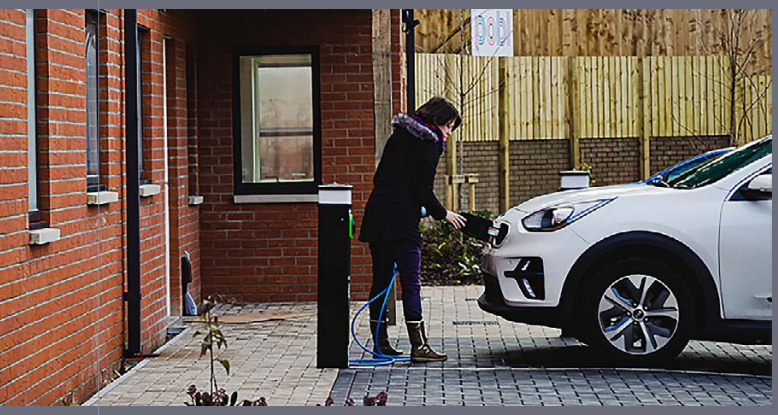
Partnership projects will include industry within West Wales and the Valleys. Development and testing of technologies will take place within the FLEXIS Demonstration Area in Neath Port Talbot.

Innovative energy technologies will be tested and optimised as component parts of a functioning energy system. This is to prove their commercial viability and to create a centre of expertise that's recognised internationally.

SWITCH Connect – South Wales Industrial Transition from Carbon Hub

The World is at a crossroads, with governments reaching the stark realisation during the pandemic that future economic success can only be based on 'green recovery'. Decarbonisation and true net-zero living are an opportunity for generational change that will have multi-layered technical, economic and societal benefits. Wales, with high carbon emissions (ca 12 tonnes per annum per head) is ideally placed to highlight a net-zero future to the World by driving a rapid transition to low-carbon living facilitated by close working between academia, industry and government.

FLEXIS has already supported decarbonisation progress and is expanding into new areas of industrial heat recovery (Section XXX) and power electronics (Section YYY) for industry and transport.



Wales is also home to the SPECIFIC® IKC focussing on novel materials for solar energy generation, storage and release for deployment in Active Buildings which can power-share in communities or into the transport vector. Other substantial decarbonisation initiatives include the EPSRC Future Manufacturing Hub (SUSTAIN) which is working with five UK steel producers on decarbonisation and opportunities in digital technology. The South Wales Industrial Cluster has recently formed (Section ZZZ) with a view to industrial decarbonisation; and Welsh industry and academic partners are also contributing to UK research efforts (e.g. through IDRIC and a variety of the EPSRC Industrial Strategy Challenge funded networks and initiatives).

Looking to the future, SWITCH-connect will link these key innovation and deployment vehicles, address key gaps in current support and long-term research capability and talent growth.

SWITCH-connect has one mission, societal decarbonisation, supporting three themes, Industry and Power, Buildings and Homes and Transport and Mobility. These are the primary and significant inter-related challenges that require a multi-vector approach with critical inter-dependencies, for example how we use industrial waste heat for homes, how we use mass vehicle deployment as a storage vector to take-up excess renewable power, the role of hydrogen as a new fuel source to replace fossil fuels and transitioning essential industrial activity to net-zero operation.

At its core, decarbonisation as a societal challenge must benefit our citizens. Therefore, central to the SWITCH-connect programme will be change management and social impact studies. The aim is to drive a prosperous Nation where an equitable distribution of opportunity is created for all members of society regardless of income brackets. This will be supported through elimination of economic and social blockers such as fuel poverty and new technologies (e.g. zero carbon transport). Through transitioning traditional industrial activities to net-zero operation, a sustainable economic platform will be created for materials supply, manufacturing and in delivering net-zero building and transport solutions.

SWITCH-connect will be an innovation ecosystem with industrial technologists and academics supported by business development professionals, underpinned by research students and early career staff thus ensuring a talent flow; In particular, supporting career migration between academic and industrial bases to maximise rapid transition of ideas into reality, enabling the low-carbon energy revolution to bring benefit to all Welsh society and support global leadership in net-zero living.

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

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