

FLEXIS

SMART ENERGY FOR OUR FUTURE
YNNI CALL AR GYFER EIN DYFODOL

May 2018
Advisory Board Report



UNDES DDIWRODIO
EUROPEAN UNION



Llywodraeth Cymru
Welsh Government

**Cronfa Datblygu
Rhanbarthol Ewrop
European Regional
Development Fund**



**Swansea University
Prifysgol Abertawe**



**University of
South Wales
Prifysgol
De Cymru**

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Foreword



WEFO investment in FLEXIS has created a critical mass of expertise in smart and flexible energy systems. FLEXIS principal investigators are world-renowned experts in their fields. Through their membership of National Science Academies, the Academy of Europe and the Research Councils of the UK and their active involvement with the Welsh and UK governments as well as key industrial players, they are shaping and influencing technology development trends, funding programmes and relevant policies and regulations.

Since FLEXIS took shape in 2016, we have made significant progress in terms of meeting our overall goal of enhancing the energy systems research capability in Wales with almost £9m won in research funding and 50 new researchers recruited across Cardiff and Swansea Universities and the University of South Wales.

Our partnerships with industry and local government continue to flourish. In January we met with key representatives of Tata Steel UK in order to build governance capacity and a working framework. Following a further meeting with Mr Bimlendra Jha, Chief Executive Officer of Tata Steel UK, five short-term projects with dedicated FLEXIS and Tata representatives have been defined with the first report due in July.

Recent highlights of our monthly Operational Management Group meetings include focussing on the industrial priorities for the FLEXIS demonstration area and a joint statement of Neath Port Talbot Borough Council's commitment to both the project and demonstrator.

FLEXIS work on the potential for the sequestration and retention of carbon in Welsh soils with the universities of Aberystwyth and Bangor is ongoing. Collaboration across the FLEXIS team is growing with the establishment of a heat-related group, development of a carbon capture and sequestration team and a cross-cutting themes working group bringing together representatives from across all work packages.

Our profile continues to be raised through our presence at national and global events, most recently at the Nigeria Energy Forum 2018 and Building Consortia for Energy 2018-2020 (Vision 2020). Later in the year we will be attending the Utility Week Wales Energy Conference, edie LIVE, The Royal Welsh Show and National Eisteddfod. A FLEXIS research project - Seren - was also shortlisted for an award celebrating Europe's most innovative regional projects in the category of 'Smart Specialisation for SME Innovation' at the RegioStar 2017 Awards.

A direct impact on the energy agenda has already been achieved by close engagement with the Royal Society. I had the honour of chairing the Royal Society's recently issued policy briefing on low-carbon hydrogen production work, which also involved other members of the FLEXIS team.

Thanks to well-established partnerships with intergovernmental agencies such as UNESCO, IEA, IAEA, UNIDO and global energy organisations like CIGRE, FLEXIS experts are involved in activities of global importance, helping to coordinate international energy policies and promoting Welsh expertise world-wide.

Prof Hywel Thomas

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.

Prof Hywel Thomas

Lead Principal Investigator and PI of Sustainable Earth Energy

Dr Aleksandra Koj

Project Manager

Principal Investigators

Prof Nick Jenkins

Network & 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 Andrew Barron

Energy safety research
Swansea University

Prof Manu Haddad

Alternative environmentally-friendly gas for electrical networks insulation
Cardiff University

Profs Nick Pidgeon & Karen Henwood

Public response to energy systems technologies
Cardiff University

Dr Petar Igic

Power electronics
Swansea University

Partners



British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Advisory Board

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Director, Chiltern Power Ltd

Prof Paul Beasley

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Research, Development and Technical
Director for Tata Steel UK

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Prof Bill David

Professor of Chemistry at
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Gallium Nitride Programme Manager,
Compound Semiconductor Centre

Roger Hey

Future Networks Manager at
Western Power Distribution

Prof Ron Loveland

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Electricity Transmission Owner

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EA Technology

Prof David Slater

Honorary Professor, School of
Engineering, Cardiff University

Nick Smailes

Head of Business Development
at Energy Systems Catapult

Mahesh Sooriyabandara

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

Dr Mark Winskel

Chancellor's Research Fellow
on Energy Innovation, Science
Technology and Innovation Studies,
University of Edinburgh

James Yu

Future Networks Manager at
SP Energy Networks

FLEXIS in figures

Since our launch in 2016, FLEXIS has achieved the following highlights:

£8,565,426
VALUE OF GRANTS AWARDED

50%/86
RESEARCHERS RECRUITED

106
GRANTS WON

112
CONFERENCES

226
SCIENTIFIC PAPERS
PUBLISHED

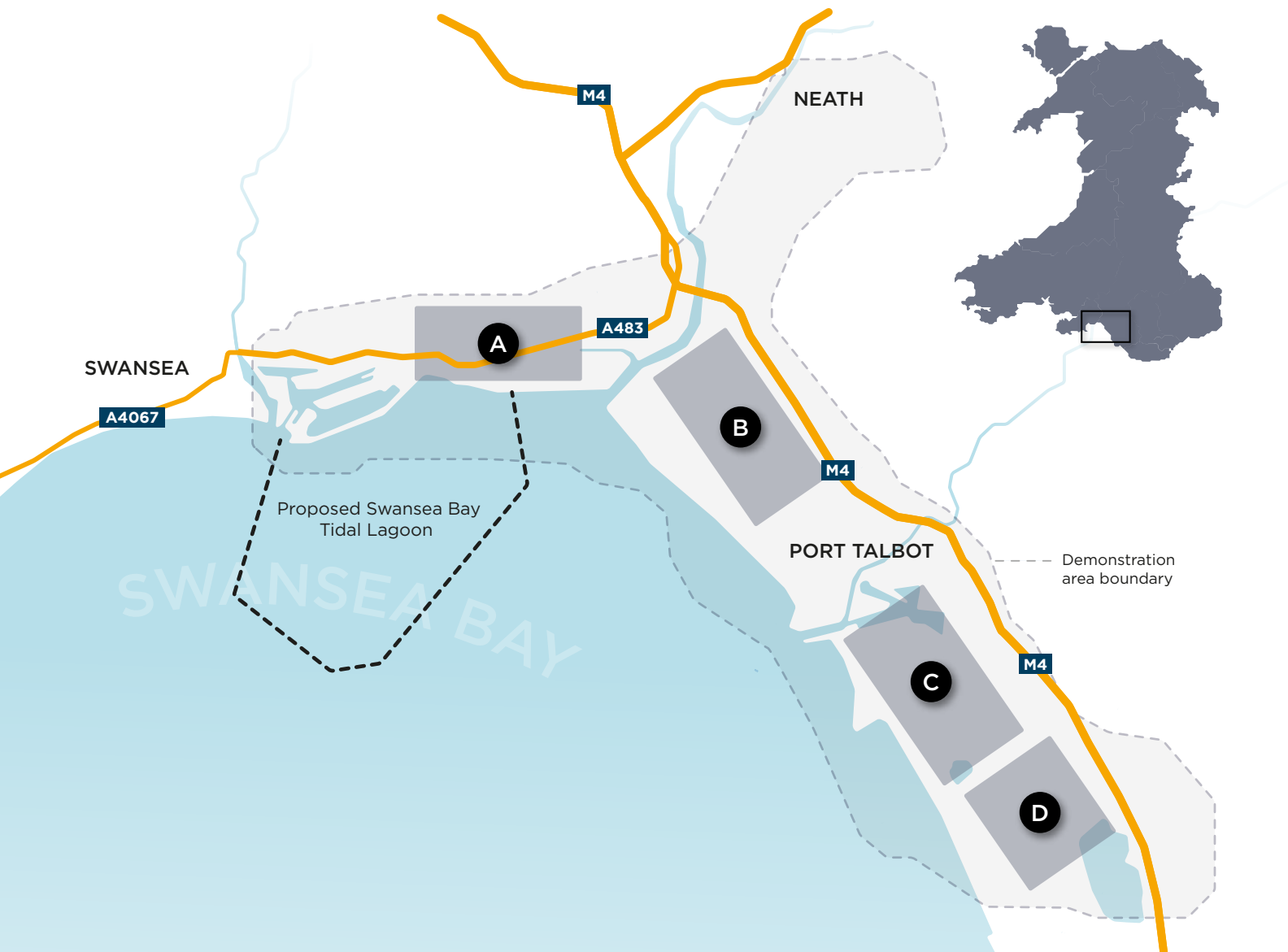
30+
EVENTS

421
ENGAGEMENTS
WITH STAKEHOLDERS

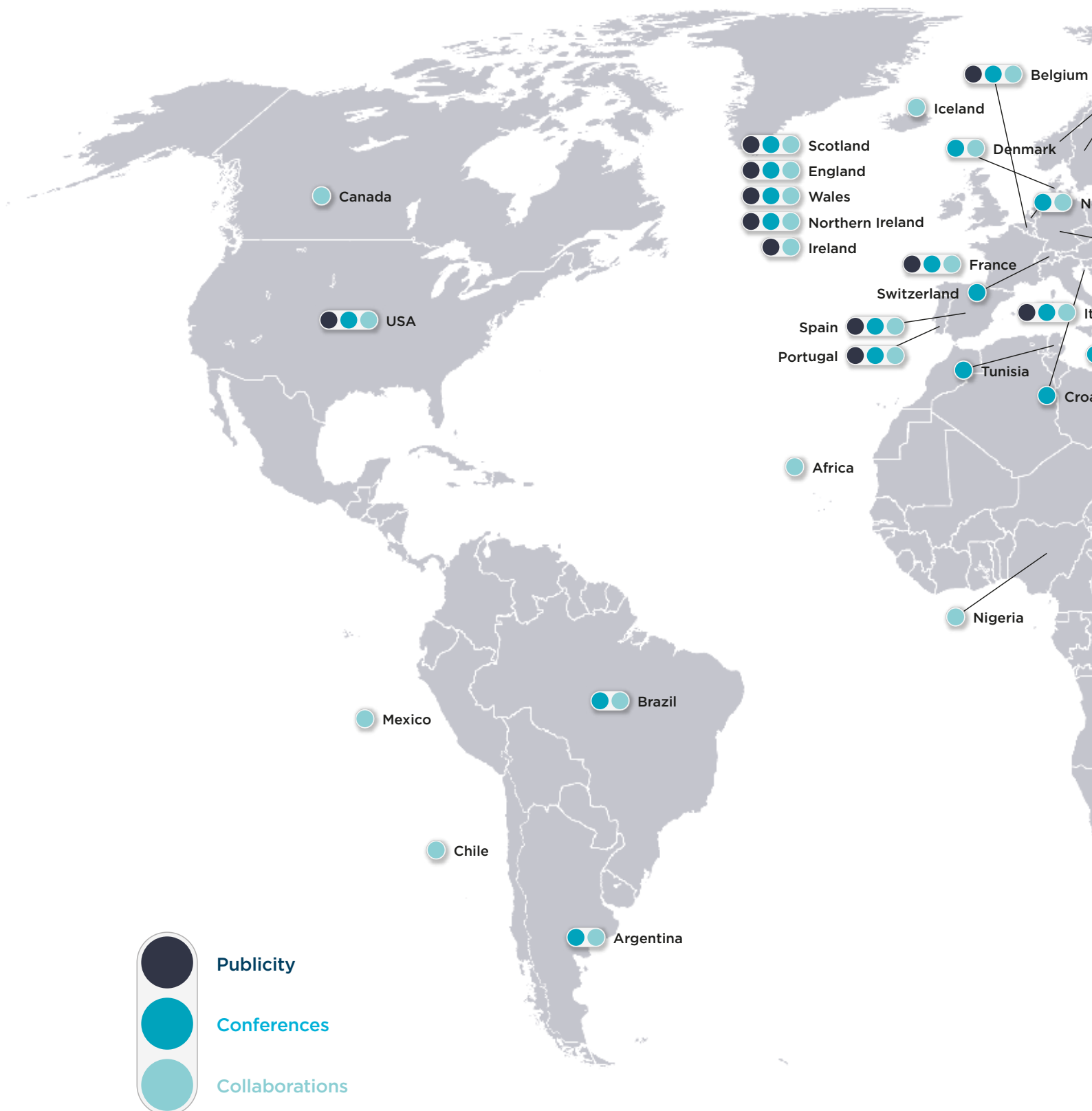
153
SOCIAL MEDIA
FOLLOWERS

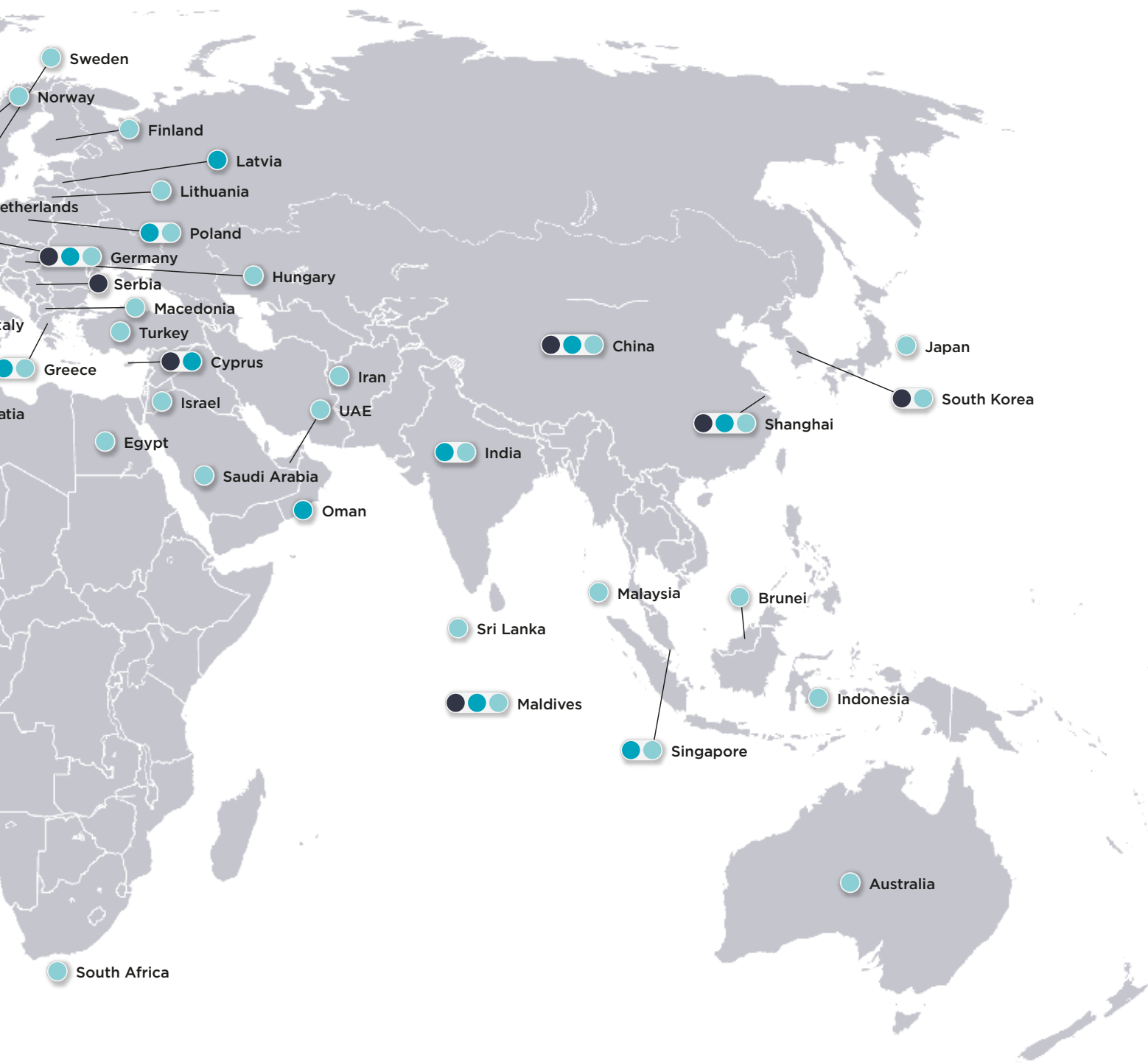
282
COLLABORATIONS WITH INDUSTRY

The FLEXIS demonstration area



International engagement





Hydrogen transport

Hydrogen is starting to emerge as one of the most promising candidates for low carbon energy and transport. The FLEXIS project is enabling further ground-breaking research in hydrogen technologies, building on the established R&D activities of the Sustainable Environment Research Centre at the University of South Wales (USW), together with industrial, academic and government partners.

As a bridge between renewable electricity production and zero carbon transport, hydrogen offers a mechanism for electricity storage and balancing between intermittent supply and demand, as well as offering zero-carbon and zero-local pollution road and rail transport.

Two USW projects, enabled by FLEXIS, demonstrate different aspects of hydrogen transport R&D.

Under the UK Government Office for Low Emission Vehicles (OLEV) Hydrogen Refuelling Station Infrastructure Grants Scheme, USW were awarded £402,800 for the Hydrogen M4 West project to upgrade the existing hydrogen refuelling facility at the University's Hydrogen Centre at Baglan. The USW Hydrogen Centre site is unique in the UK in having a range of electrolytic hydrogen systems that harness renewable electricity from on-site photovoltaics, as well as hydrogen produced from more conventional natural gas reforming.

The OLEV award is facilitating the integration of existing systems and the addition of a 700bar hydrogen vehicle refueller to the existing 350bar system. This is enabling a broader range of vehicles to be filled at the Hydrogen Centre and USW have worked with a range of public and private organisations to secure hydrogen vehicles in the region, including the Mid and West Wales Fire and Rescue Service, Western Power Distribution and FLEXIS partner, Swansea University. This activity extends the work that USW has done over the last decade to develop and promote hydrogen vehicle refuelling infrastructure in the UK, together with the Welsh and UK Governments and industrial partners such as ITM Power.

The second project concerns reducing unnecessary weight - a key factor in vehicle performance - which is particularly important where hydrogen fuel is being produced from limited renewable electricity. Through FLEXIS, the University of South Wales has been working with Welsh hydrogen vehicle developer Riversimple and precision engineering company Presreg Valves to advance the performance of on-board hydrogen handling, improve safety and reduce component weight. This has led to the successful award of £226,400 from the InnovateUK Niche Vehicle R&D Programme for the Integrated Hydrogen Container Manifold and Regulator project.

The project has led to the design and development of a high pressure hydrogen component research and testing facility at USW's Hydrogen Centre, which is being used as the basis for R&D into automotive and stationary high pressure hydrogen equipment. There is no other facility like this in the UK, hence it will benefit future R&D projects supporting the development of hydrogen energy and vehicle technology in Wales.

Academic paper

Carr, S., Zhang, F., Liu, F., Du, Z. and Maddy, J.: Optimal operation of a hydrogen refuelling station combined with wind power in the electricity market

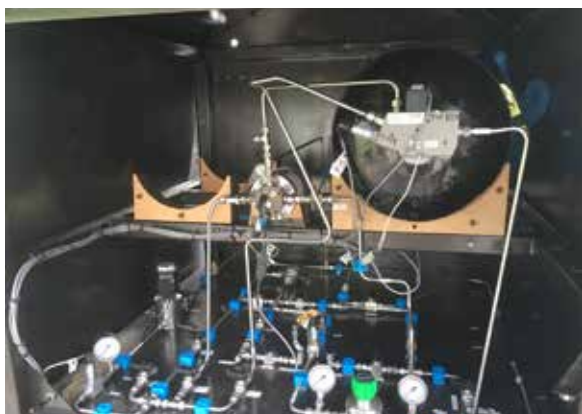


Figure 1: High pressure H2 test rig



Figure 2: USW Baglan Hydrogen Centre

Case studies

Improving power quality in transmission and distribution systems

Based at Swansea University's Energy Safety Research Institute (ESRI), Dr Grazia Todeschini moved into academia after working for six years in the power industry for companies including General Electric and EnerNex LLC. Interested in using her experience to solve challenges relating to the integration of power electronics devices in transmission and distribution systems, Dr Todeschini is part of the FLEXIS Smart Energy Management work package. Her main research focus is related to investigating power quality phenomena resulting from integration of renewable energy sources in the power grid.

Power quality is vital for the delivery of energy to customers and is based on system characteristics such as voltage levels, frequency and harmonics. Low power quality can not only cause malfunctioning of or damage to customers' equipment, but may also result in significant costs for utility companies, the manufacturing sector and society in general. Power quality is becoming a concern for modern power systems because of increasing levels of non-linear loads and sources which degrade voltage and current waveforms.

Following a trip to the Cockrell School of Engineering at The University of Texas at Austin, partially funded partially by FLEXIS, Dr Todeschini is working with Dr Surya Santoso.

Co-author of the handbook 'Electrical Power Systems Quality' and IEEE Fellow, Dr Santoso is one of the world's leading experts in power quality for energy systems.

Their collaboration is based on topics related to the improvement of power quality in transmission and distribution systems, including the development of solutions to further increase the interconnection of distributed resources to the power system, and the development of digital signal processing techniques to identify power quality disturbances. They are also studying the next generation of alternating current (AC) transmission systems to improve system flexibility and reduce power losses.

Figure 1 shows an example of one of their studies. The diagram represents a sample distribution system with solar PV panels installed at multiple locations.

The voltage at each bus is calculated for different levels of solar irradiance. If it exceeds a pre-determined value, it is flagged as a 'violation'. A potential solution to mitigate these violations through the use of flexible alternating current transmission systems (FACTS) devices has been investigated in a paper on increasing PV hosting capacity.

It is now a year on from the start of their alliance and Dr Todeschini and Professor Santoso will be presenting a paper on increasing PV hosting capacity as well as others on methods for determining inception and recovery points of voltage variation events at the 2018 IEEE PES General Meeting.

With journal papers on load-flow for multiple-frequency systems and data analytics under review, as well as supporting PhD students with their dissertations, research is well underway.

Academic papers accepted for presentation at the IEEE PES General Meeting:

[1] A. F. Bastos, G. Todeschini, and S. Santoso: Comparison of Methods for Determining Inception and Recovery Points of Voltage Variation Events

[2] H. V. Padullaparti, S. Jothibas, S. Santoso and G. Todeschini: Increasing Feeder PV Hosting Capacity by Regulating Secondary Circuit Voltages

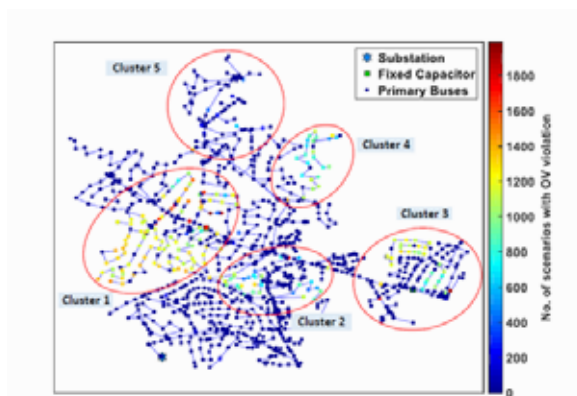


Figure 1: Distribution of overvoltage violations for a distribution system with PV units



Figure 2: Solar panels

Project impact: collaborations

We are proud to be collaborating with over 280 organisations.



Project impact: conferences and events

Over the past year FLEXIS has presented at over 166 conferences and attended over 30 events including:

ICAE 2017 (9th International Conference on Applied Energy)

The global launch of FLEXIS took place at the ICAE, hosted by Cardiff University in August 2017.

Royal Society policy briefing

FLEXIS Lead Principal Investigator Prof Hywel Thomas chaired a Royal Society Workshop as part of the Policy Briefing 'Options for producing low-carbon hydrogen at scale', attended by Profs Alan Guwy, Andrew Barron, Phil Bowen and Jon Maddy.

RegioStars Awards 2017

FLEXIS Sustainable Earth Energy project Seren 2020 was a finalist in the European Commission's RegioStar Awards 2017 celebrating Europe's most innovative regional projects.



Global launch of FLEXIS at the ICAE 2017, attended by Jane Hutt, AM



Accepting the RegioStar's 2017 Award for 'Smart Specialisation for SME Innovation'



EXIS

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OF THE BUSINESS

Stakeholders

Local communities

The FLEXIS social science team is conducting three linked streams of research. Interviews with experts and external stakeholders, including industry partners, are helping the team to map future uncertainties and potential obstacles to which the project may need to adapt. Interviews with communities within demonstrator areas have begun, starting with residents in Caerau near Bridgend. Here, a district heating scheme that will use minewater as heat source is being developed as a partnership between FLEXIS, Bridgend County Borough Council, and the Energy Systems Catapult.

Community interviews will enable the team to better understand the importance of energy within the everyday lives of residents, as well as how new innovations may affect people. Finally, a series of workshops with communities and other stakeholders within demonstration areas, starting with Neath Port Talbot, are being planned to explore the impacts, expected benefits and potential unintended consequences of large scale energy system change.

Joint principal investigator Karen Henwood: "As social scientists within FLEXIS, we're exploring how energy system transformation will matter to citizens, communities, scientists and society. People's relationships with energy infrastructures are going to change in the coming years, along with the spaces in which both energy production and consumption take place. Our investigations will gain momentum as we embed them within demonstrator sites, such as Port Talbot, where facilitating debates about the potential benefits and risks that energy system change might bring will be a key focus for us."



Public engagement meeting for the minewater district heating project in Caerau

Our other stakeholders include:

3M	Electronic Systems Design Centre (ESDC), Swansea University	Loughborough University	Swansea Bay City Deal
ABB Group		Low Carbon Swansea Bay	Swansea University
Akzo Nobel	Energy Systems Catapult	Materials Processing Institute	Tampere University of Technology
Airbus	Energy Saving Trust	Minister of State for Climate Change and Industry	Tata Steel UK
Amazon	Engineering and Physical Sciences Research Council (EPSRC)	National Grid	Tecnia
Bangor University	Energy Technologies Institute (ETI)	National Physical Laboratory (NPL)	The Behavioural Insights Team
BIS Group	Future Generations Commissioner for Wales	Neath Port Talbot County Borough Council	Tianjin University
Bridgend County Borough Council	Global Challenges Research Fund (GCRF)	Natural Environment Research Council (NERC)	Tidal Lagoon Power
BP	General Electric (GE)	Newcastle University	Torfaen County Borough Council
Calon Energy Baglan Bay Power Station	Gexcon AS	Port of Milford Haven	Toshiba
Carbon Conversations	Grid Solutions	Port Talbot Waterfront Enterprise Zone	TNEI
Cardiff County Borough Council	GW4 Alliance (Bath, Bristol, Cardiff & Exeter Universities)	Power Networks Research Academy (PNRA)	UCL (University College London)
CCS (Carbon Capture & Storage Association)	Honeywell	Ofgem (GB Electricity Distribution Network)	UKCCS Research Centre
Celsa Steel UK	Indian Institute of Technology Roorkee	Queen's University Belfast	UK Energy Research Centre (UKERC)
Centre for Radiation, Chemicals and Environmental Hazards (CRCE), Public Health England	Initiative for Managing Policymaker-Academic Cooperation and Transfer (IMPACT), Swansea University	REHAU	UK Power Networks
CIIA (Centro de Investigacion e Innovacion en Ingenieria Aeronautica), UANL (Mexico)	Imperial College	Renishaw	UK Research and Innovation
Climate Change, Environment and Rural Affairs Committee, National Assembly for Wales	Innovate UK	Rhondda Cynon Taf County Borough Council	Uniper SE
Compound Semiconductor Centre	Institute of Electrical and Electronics Engineers (IEEE)	Ricardo plc	University of Bath
Cranfield University	Institute of Welsh Affairs	RICE	University of Bristol
Cyfoeth Naturiol Cymru / Natural Resources Wales	Council on Large Electric Systems (CIGRE)	Riversimple	University of Edinburgh
Department for Environment, Food & Rural Affairs (UK Government)	Integral	RMIT University	University of Leeds
Department for Business, Energy & Industrial Strategy (UK Government)	Intellectual Property Office	Rolls-Royce	University of Manchester
Department for Transport (UK Government)	International Energy Agency (IEA)	Royal Society	University of Nottingham
DNV GL	ITM Power	RRI Tools	University of Reading
Dwr Cymru Welsh Water	Jaguar Land Rover	RWE nPower	University of Sheffield
EA Technology	Khalifa University	Schneider Electric	University of Southampton
EERA (European Energy Research Alliance)	Kingsmill Industries (UK) Ltd	SSE plc	University of Strathclyde
eCORP International, LLC	KU Leuven	SP Energy Networks	University of Warwick
Ecole Centrale de Lyon	Lancaster University	SER Cymru II	Virgin Atlantic
	Life Sciences Hub Wales	Severn Trent Water	Wales Council for Voluntary Action (WCVA)
	Liverpool John Moores University	Shell	Wales and West Utilities
	Local Partnerships LLP	Siemens	WEFO (EU funds in Wales)
		SINTEF	Welsh Government
		SPECIFIC Buildings as Power Stations	Westminster Energy, Environment and Transport Forum
		SP Energy Networks	Western Power Distribution
		Stainless Metalcraft Ltd	WRAP Cymru
		Supergen Bioenergy	ZF







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