Wales' Progress on Hydrogen Energy

Making Way for Scotland's Hydrogen Economy

Edinburgh Council Chambers 29th September 2010

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University of Glamorgan
Prifysgol Morgannwg

Wales' Progress on Hydrogen Energy

Hydrogen R&D in Wales

Demonstration and Deployment

National and Regional Cooperation

Hydrogen Energy R&D in Wales

PRIFYSGOL BANGOR UNIVERSITY 1884

LCRI
Low Carbon Research Institute

glyndŵr
PRIFYSGOL GLYNDŴR CYMRU
GLYNDŴR UNIVERSITY WALES

UNIVERSITY OF GLAMORGAN
PRIFYSGOL MORGANNWG

PRIFYSGOL ABERYSTWYTH UNIVERSITY

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Swansea University
Prifysgol Abertawe

Hydrogen Energy R&D in Wales

PRIFYSGOL BANGOR UNIVERSITY

Marine Energy
Sustainable Materials

PRIFYSGOL ABERYSTWYTH UNIVERSITY

Energy from Biomass

Swansea University
Prifysgol Abertawe

Marine Energy
Power Electronics

LCRI
Low Carbon Research Institute

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PRIFYSGOL GLYNDŴR CYMRU
GLYNDŴR UNIVERSITY WALES

PV, Photoelectronics

UNIVERSITY OF GLAMORGAN
PRIFYSGOL MORGANNWG

Hydrogen, Fuel Cells & AD

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Low C built environment
Large scale power

SUPERGEN UK Sustainable Hydrogen Energy Consortium (UKSHEC)

- Major hydrogen energy research platform enabling hydrogen to become fully integrated into the UK's energy economy.
- Co-ordinated & collaborative fundamental and applied research in the sciences, engineering and socio-economics.
- Partnership with industry, commerce and policymakers.
- Universities of Bath, Birmingham, Cambridge, Glamorgan, Glasgow, Manchester Nottingham, Oxford, Salford, Strathclyde, UCL & STFC ISIS

www.uk-shec.org.uk

University of Glamorgan

- Phase 1 (2003-2007) – Lab scale fermentative hydrogen production, reactor construction, pilot plant, hydrogen / renewable electricity interface
- Phase 2 (2007-2011) – Develop fermentative hydrogen from biomass, system integration and modelling

SUPERGEN BioFuelCell Consortium

- Aiming for major advances in biological fuell cells (Produce electricity directly from biological materials and air)
  - Microbial fuel cells (MFCs) micro-organisms convert organic materials into fuels that can be oxidised in electrochemical cells
  - Enzymatic fuel cells electricity is produced as a result of the action of an enzyme (a biological catalyst).
- Universities of Surrey, Oxford, Glasgow, Glamorgan, East Anglia, and University College London

SUPERGEN BioFuelCells

www.biologicalfuelcells.org.uk

University of Glamorgan

Phase 1 - Leading on the microbial fuel cell theme, Developed and investigated lab scale MFCs

SUPERGEN XIV – Delivery of Sustainable Hydrogen

Two groups at Cardiff University active in this consortia

- Welsh School of Architecture/LCRI (Prof. Eames) leading work on socio-technical analysis and appraisal of hydrogen production, and comparative analysis of Hydrogen innovation systems.

- Cardiff Chemistry (Prof. McKeown) developing organic membranes based upon Polymers of Intrinsic Microporosity (PIMs) for separation & delivery of high purity hydrogen.

SUPERGEN HDelivery

www.st-andrews.ac.uk/supergen

Hydrogen Energy R&D at the University of Glamorgan

- Bio Hydrogen
  - Microbial Fuel Cells
    - Biocatalytic H_2 Production
      - Hydrogen Energy Systems
      - Hydrogen Vehicle R&D
    - Economics of Hydrogen Energy
  - Environmental Analysis
- Hydrogen Storage

Progress on Biological Hydrogen Production

Lab scale research on continuous biohydrogen production from a range of real feeds, including*;

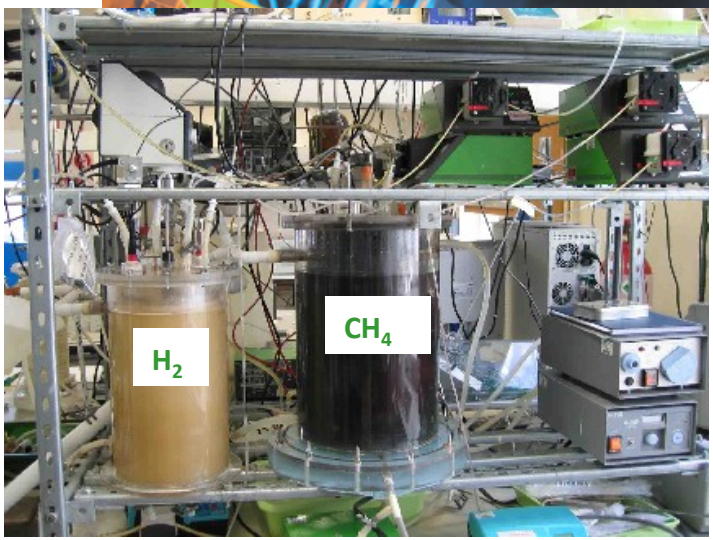
- Food wastes
- Energy Crops
- Sewage sludge

Extending to include more mesophilic and thermophilic modes

Modelling potential biomass resources

Investigating feedstock treatment to optimise H_2 and CH_4 yields

Work in Microbial Fuel Cells has led to investigation of biocatalytic hydrogen production



*Funding from a number of sources including EPSRC SUPERGEN UKSHEC, SUPERGEN BioFuelCell, Carbon Trust and ERDF Convergence. Collaboration with a number of academic and industrial partners.

Progress on Biological Hydrogen Production

R&D extending to pilot scale:

- Industrial systems
- Energy balance
- System design, control & optimisation

Installing high rate digestors to understand process intensification

Pilot scale biohydrogen plant at IBERS Aberystwyth using rotated crops

Pilot scale biohydrogen plant at Barry using wheatfeed (*above*) and at Glyntaff using Sewage sludge (*below*)

*Funding from EPSRC SUPERGEN UKSHEC (Crops), European Framework Programme (Sewage Sludge) Carbon Trust (Wheatfeed)

University of Glamorgan Hydrogen Centre

The University of Glamorgan's Renewable Hydrogen Research and Demonstration Centre at Baglan builds on the University's established research into hydrogen energy

The Centre enables further R&D:

- Hydrogen production from renewables
- Fuel cell applications
- Hydrogen energy systems
- Hydrogen vehicle development & refuelling

But also as a key link for hydrogen and fuel cell business development

Link with the Welsh Assembly Government Technium programme

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Prifysgol Morgannwg

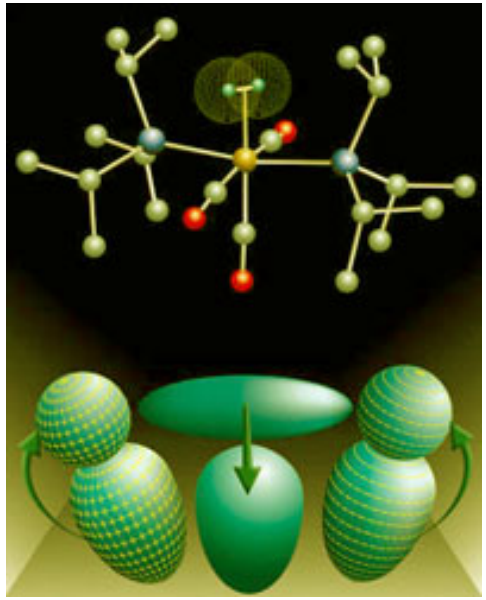
Progress on Hydrogen Energy Systems

Techno-economic investigation has demonstrated that storing as H_2 increases the amount of renewable energy accepted onto networks*

Investment in Baglan Hydrogen Centre extends this work:

- H_2 System Optimisation
- Electrolytic system improvements
- System and component modelling
- Optimisation of control
- H_2 interface with various renewable feed configurations
- Further techno-economic and life cycle analysis

*Dr SJ Carr PhD Thesis & via EPSRC SUPERGEN UKSHEC



Kubas hydrogen binding to transition metal complex

Hydrogen Storage

Extremely promising results using novel materials / Kubas binding

Prof D Antonelli

Hydrogen and H_2 / CNG Refuelling at Baglan

Hydrogen produced on site from Solar PV & electrolysis

350bar compressed H_2 as a vehicle fuel

Semi-automated H_2 fuel dispenser installed by Air Liquide enables a range of hydrogen vehicles to refuel with renewable hydrogen

Further compression to 450bar

Hydrogen export facility being installed

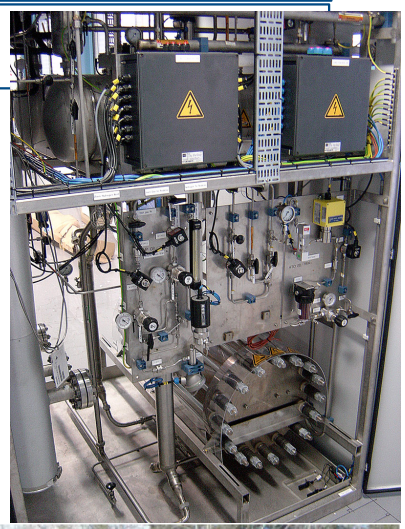
H_2/CNG fuel dispenser is also installed will allowing mixtures of up to 40% hydrogen in Natural Gas

Biomethane facility to be added as is an electric vehicle recharging point

2nd refueller at Glyntaff Campus being installed

Cymru H_2 Wales Project

Extending Hydrogen R&D for Economic Growth



£6.3 million* Cymru H_2 Wales project builds on the University's hydrogen expertise and investment to extend collaborative industrial R&D and experimental development

Overall **12 new Post Docs + 8 new RAs** to develop products, processes and services in the field

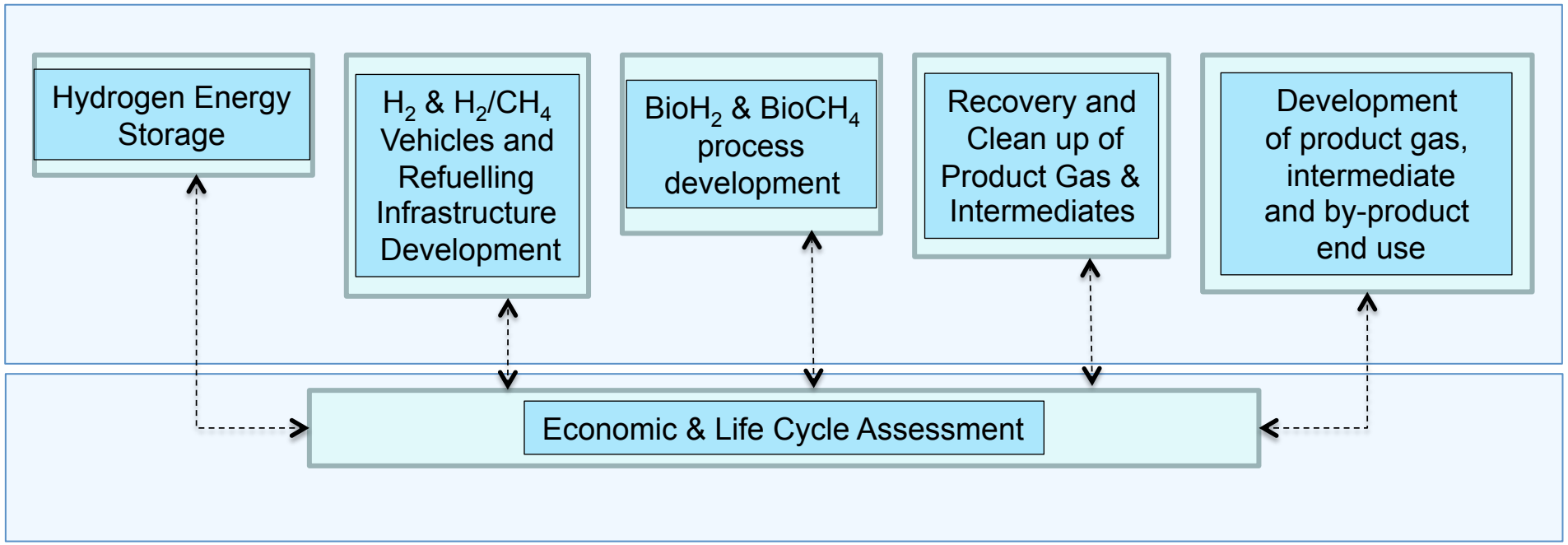
Cymru H_2 Wales Scope includes:

- H_2 Energy Storage
- H_2 ICE and Fuel Cell vehicle testing and development
- Infrastructure planning and deployment
- BioH_2 process development
- H_2 & CH_4 product use
- Bioplastics & other material development
- Gas clean up

*Funding from ERDF Convergence via LCRI with £3.3m investment from University of Glamorgan

Cymru H_2 Wales Project Structure

Technical Work Packages



ERDF
Llywodraeth Cynulliad Cymru
Welsh Assembly Government
Ewrop & Chymru: Buddsoddi yn eich Dyfodol
Cronfa Datblygu Rhanbarthol Ewrop
Europe & Wales: Investing in your Future
European Regional Development Fund

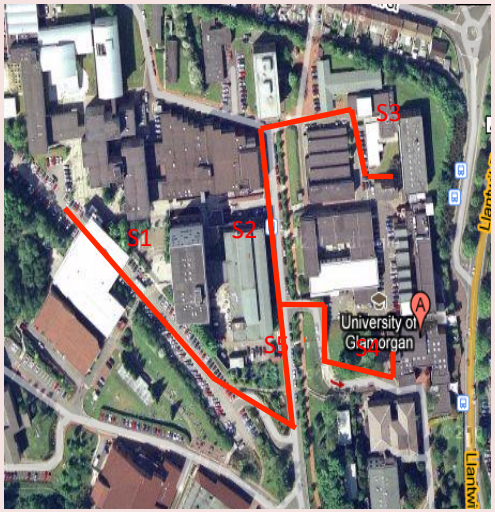
Advanced Powertrain Development Facility

APDF
(Advanced Powertrain Development Facility KTC)

ERDF
Llywodraeth Cynulliad Cymru
Welsh Assembly Government
Ewrop & Chymru: Buddsoddi yn eich Dyfodol
Cronfa Datblygu Rhanbarthol Ewrop
Europe & Wales: Investing in your Future
European Regional Development Fund

- 4WD/2WD vehicle dynamic drive cycling
- Engine/motor test stand
- Power electronics design and testing
- Controller software development
- Powertrain modelling and simulation
- HEV/EV full system design
- Certification advice and support
- Project Management
- Alternative fuel system development
- Fuel Cell system integration

Automotive Developments – Tribrid Fuel Cell Bus Project



Tribrid minibus CO_2 output		Diesel van CO_2 output	
mass of H2 used (kg)	0.48628	volume diesel used (l)	2.5
CO2 equivalence (CO2g/H2kg)	9742.8	CO2 equivalence (CO2g/Diesel litre	2730.37
distance travelled (laps)	17	distance travelled (laps)	17
CO2 output (g/ mile)	278.69	CO2 output (g/ mile)	401.525

Range	150 miles
Top speed	55 mph
Max Power Output	75 kW
Max Power Input	45 kW
Capacity Discharged	72 Ah
Energy Discharged	35.6 kWh

energy saving trust™

University of Glamorgan Hydrogen Activities in South Wales

Aberystwyth - BioH_2 from Crops Pilot Plant

Pontypridd – BioH_2 labs

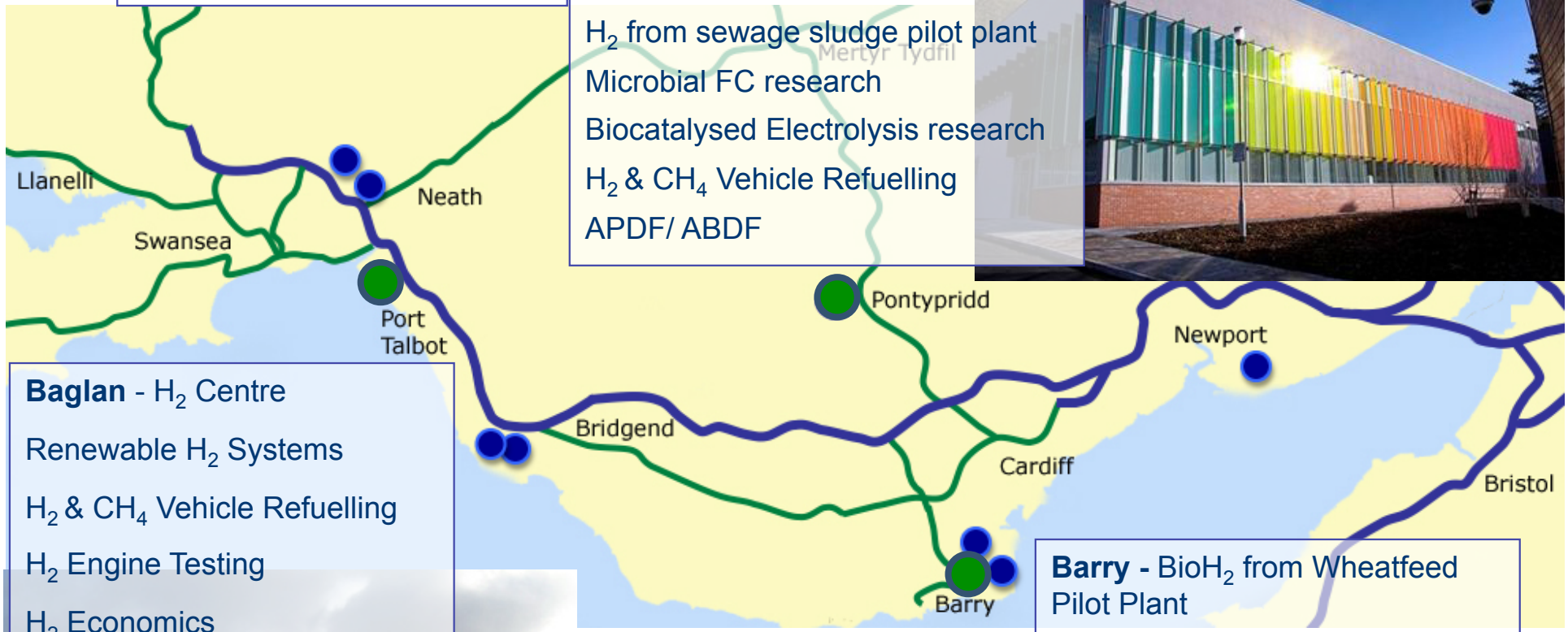
H_2 from sewage sludge pilot plant

Microbial FC research

Biocatalysed Electrolysis research

H_2 & CH_4 Vehicle Refuelling

APDF/ ABDF



Baglan - H_2 Centre

Renewable H_2 Systems

H_2 & CH_4 Vehicle Refuelling

H_2 Engine Testing

H_2 Economics

Barry - BioH_2 from Wheatfeed Pilot Plant

7 industrial hydrogen production facilities

4 University of Glamorgan R&D Centres

The establishment of a Low Carbon Economic Area in Wales

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

BIS
Department for Business Innovation & Skills

- LCEA centered on hydrogen technologies
- Awarded in February 2010
- Accelerate low carbon economic development activity
- Wales' ambition to be a leading player in hydrogen R&D and investment.
- LCEA alternative transport fuels corridor is based around the M4 initially.
- Builds on the investment already completed, e.g. at the Baglan Hydrogen Centre and at UoG

The establishment of a Low Carbon Economic Area in Wales

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

BIS
Department for Business Innovation & Skills

- Allow a test and demonstration facility for the automotive sector to develop products and alternative fuelled vehicles in real life situations.
- Stimulate further development, deployment and attract inward investment
- Complementary to other low carbon activities such as the Heads of the Valleys low carbon zone, especially for deployment of low carbon vehicles and hydrogen fuel cells for buildings.
- Linkage with other Low Carbon Economic Areas

The “Bristol Accord”

Agreement of UK regions to collaborate and share best practice related to alternative fuels infrastructure rollout

Consumer (fleet and general public) attitudes, business models, etc

Active interest in;

- Electrification of Transport for ULCV
- Hydrogen (UKHyNet) for ULCV
- Liquid fuels supporting hybrid vehicle deployment

Collaboration between UK regions under stewardship of CENEX

- Midlands, North East, South West and Wales

Desire to extend collaboration UK wide including Scotland & London

Accord aims to support OEMs in first phases of vehicle deployment

Contributing to UK H_2 Infrastructure Development

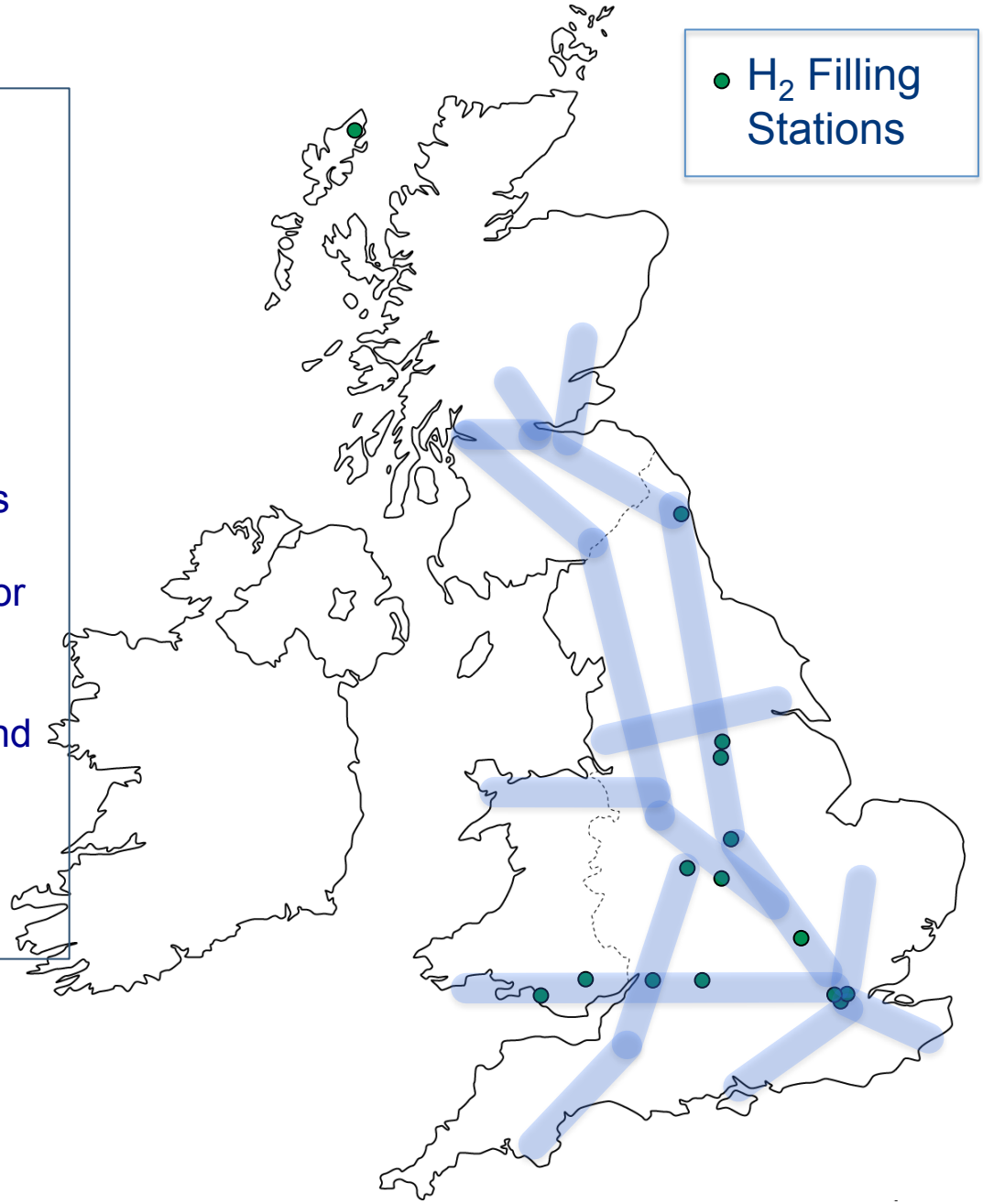
Glamorgan's H_2 refuelling stations at Baglan & Pontypridd initiate LCEA alternative transport fuels M4 corridor

Collaborative work with Welsh Assembly Govt and Industry to further develop in Wales

Further work with "Bristol Accord" regions to progress activity along major trunk routes and to work with Automotive Sector and fleet users to introduce H_2 vehicles

Academic research to model technical and economic transition

Work with partners to develop strategic plan



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