

The Rapid Commercialisation of Hydrogen and Fuel Cells

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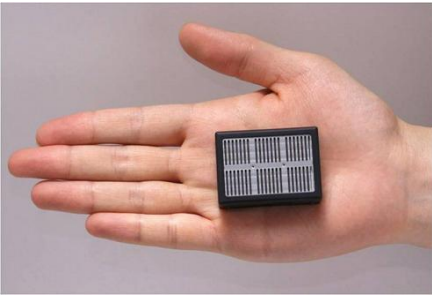


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- The case for Fuel Cells
- Global Market for Fuel Cells - Current Status
- Policy support for Fuel Cell implementation
- Hydrogen and Fuel Cell R,D&D in Wales

The case for fuel cells



Reduced Emissions of Greenhouse Gas and Toxic Pollutants

High Energy Efficiency

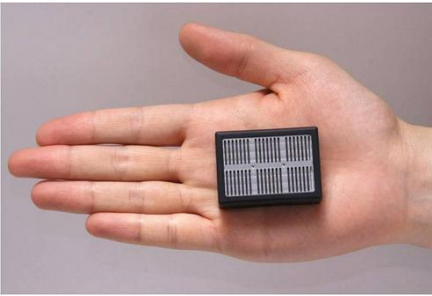
Improved Energy Security - differentiation of sources & decentralised power supply

Encourage development of renewable energy

Significant potential from by-product heat

Major source of sustainable economic growth in Europe

The challenges for fuel cells



Cost reduction

Product development

Reliability & durability

Infrastructure

Support measures

Global Market for Fuel Cells Current Status

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Market Development – Small stationary Fuel Cells (<math><10\text{kW}_e</math>)



Two major markets, CHP & UPS

Total supplied in 2009 ~5000 units

Year-on-year increase of ~30-35%

Cumulative ~16000 small fuel cell units supplied worldwide

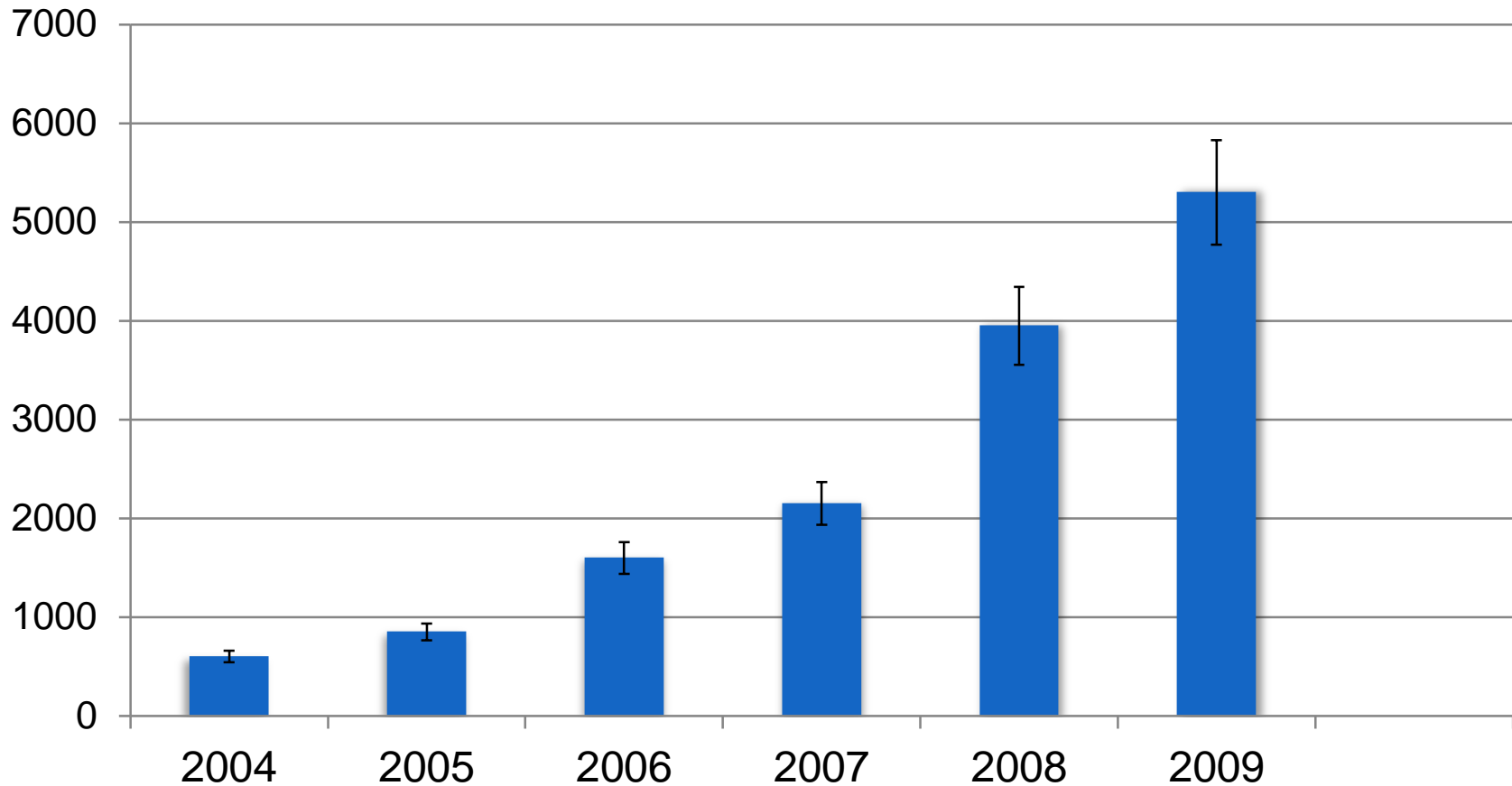


PEM units now dominate this sector in preference to SOFC

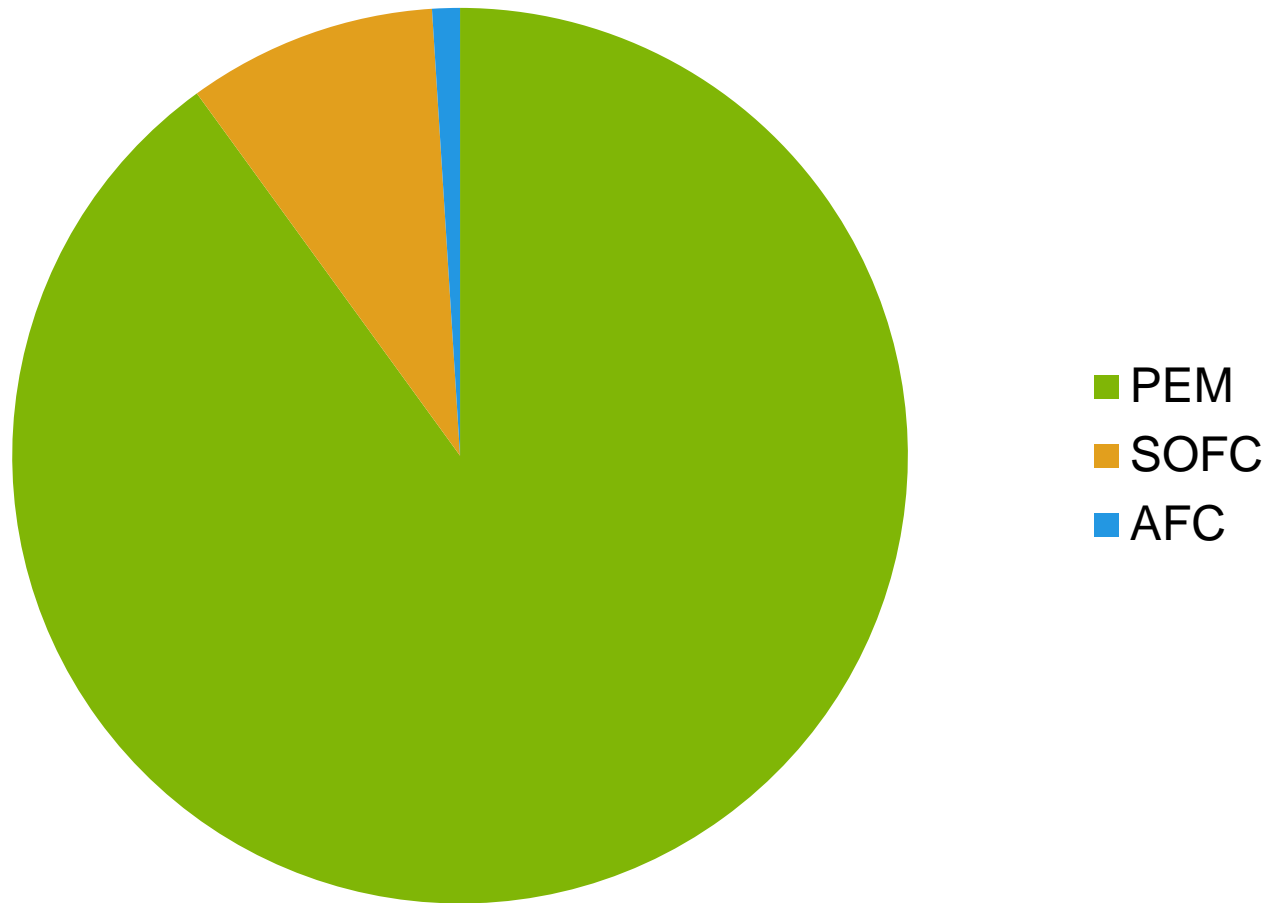
UPS dominates use in America and Europe, particularly promoted by US Govt. policy

Domestic units dominate in Asia (esp. Japan CHP demonstration programme)

Small Stationary Fuel Cell Installations 2004-2009



Market Development – Small stationary Fuel Cells (<10kW_e)



Sources: Fuel Cell Today, PWC

Market Development – Large stationary Fuel Cells (>10kW_e)



On or off grid installations

CHP, CCP or electricity generators

MCFC and PAFC commercial with subsidy

SOFC attracting most significant R&D expenditure



Market is relatively steady at present 50-60 units p.a.

Average size of each unit has grown to ~1MW



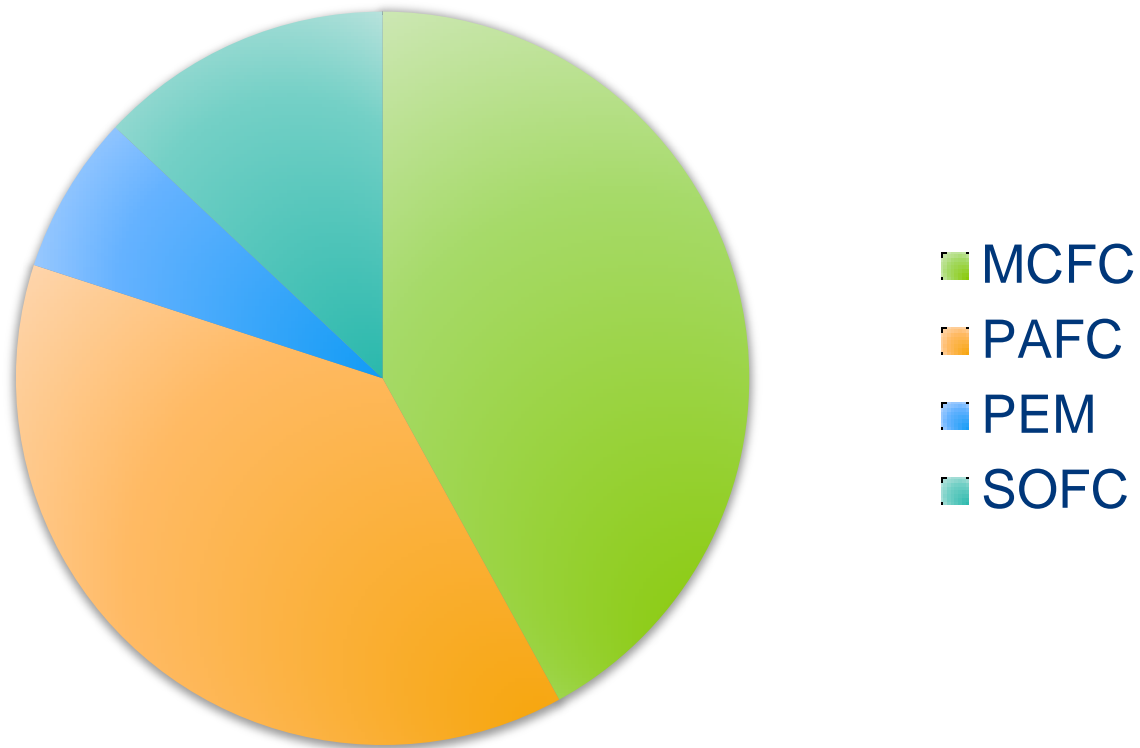
Market Development – Large stationary Fuel Cells (>10kW_e)



-  Annual number of units installed
-  Average size in MW per unit installed

Source: Fuel Cell Today

Market Development – Large stationary Fuel Cells (>10kW_e)



European and UK support for Fuel Cell implementation

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Targets for 2020:

Cutting greenhouse gases by at least 20% of 1990 levels
(30% if other developed countries commit to comparable cuts)

Increasing use of renewables to 20% of total energy production
(currently \pm 8.5%)

Cutting energy consumption by 20% of projected 2020 levels
(by improving energy efficiency)

Cogeneration Directive

- 11% -13% of Europe's electricity supplied by cogeneration
- Fuels include gas, coal, waste, biomass (and hydrogen)
- Cogeneration Directive 2004/08/EC
 - **Fuel cells included**

Energy Performance of Buildings

- Residential & tertiary sectors >40% final energy consumption
- Directive 2002/91/EC
 - Covers energy for heating, hot water, cooling, ventilation, lighting
 - Heat recovery and renewables
 - Recommends consideration of micro-CHP & fuel cells

Europe: fuel cell development

- Fuel cells (and hydrogen) leading new strategic energy technologies
- Joint Technology Initiative Hydrogen and Fuel Cells launched Oct 2008
- €1 billion over 6 years (cf. €7bn “required”)
- Mass market rollout before 2020

Europe: Implementation targets

| | Portable FCs for handheld electronic devices | Portable Generators & Early Markets | Stationary FCs Combined Heat and Power (CHP) | Road Transport |
|--|--|---|--|---|
| EU H2/FC units sold per year projection 2020 | ~ 250 million | ~ 100,000 (~ 1 GW _e) | 100,000 to 200,000 (2-4 GW _e) | 0.4 million to 1.8 million |
| EU cumulative sales projections until 2020 | n.a. | ~ 600,000 (~ 6 GW _e) | 400,000 to 800,000 (8-16 GW _e) | 1-5 million |
| EU Expected 2020 Market Status | Established | Established | Growth | Mass market roll-out |
| Average power FC system | 15 W | 10 kW | < 100 kW (Micro CHP) > 100 kW (industrial CHP) | 80 kW |
| FC system cost target ² | 1-2 €/W | 500 €/kW | 2,000 €/kW (Micro) 1,000-1,500 €/kW (industrial CHP) | < 100 €/kW (for 150,000 units per year) |

- Push for EU emission reduction target to 30% by 2020.
- Increase energy from renewables target
- Establish full system of feed-in tariffs in electricity + banded ROCs.
- Increase energy from waste through AD.
- Create a green investment bank.
- Reform energy markets to deliver security of supply and investment in low carbon energy, and ensure fair competition including a review of the role of Ofgem.
- Encourage community-owned renewable energy schemes

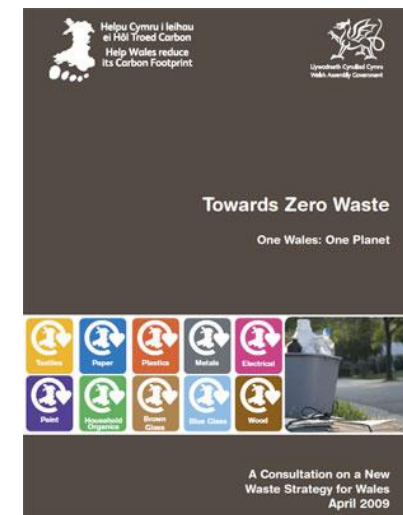
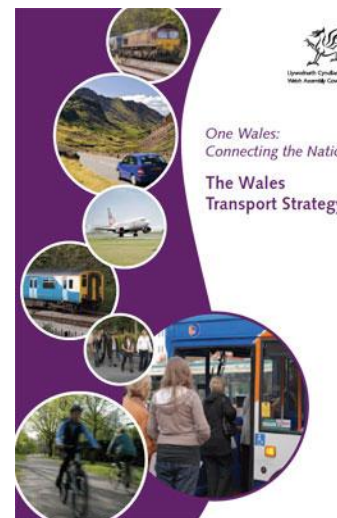
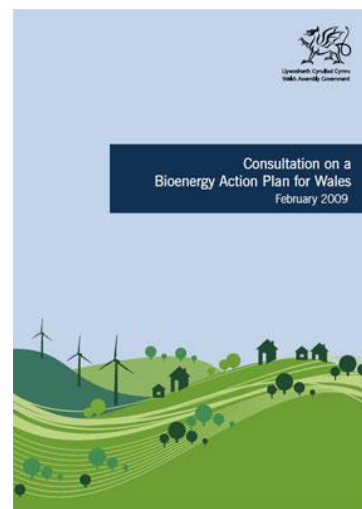
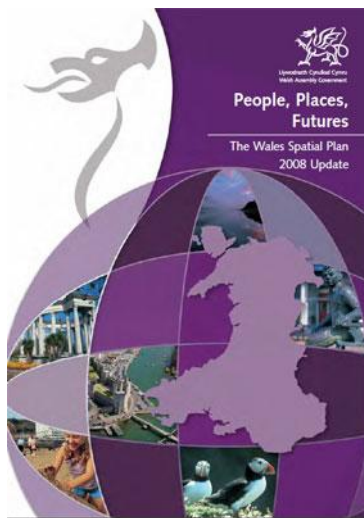
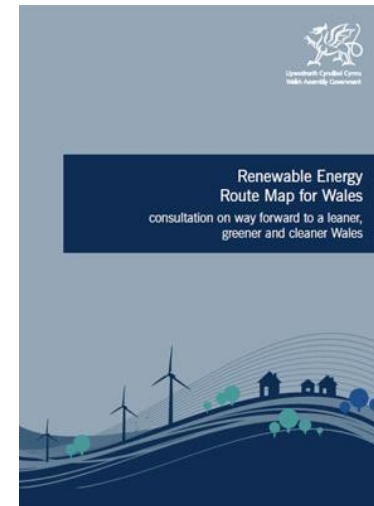
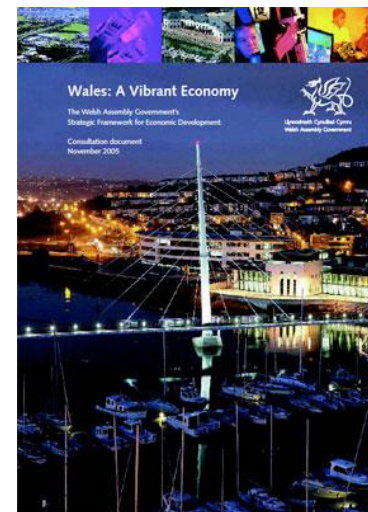
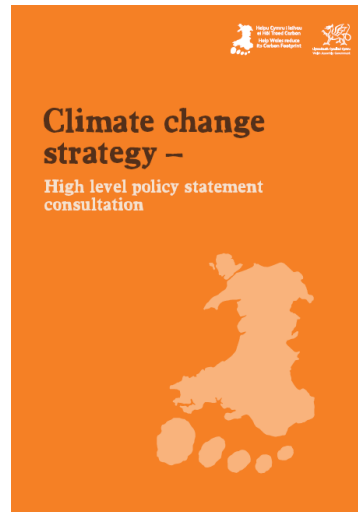
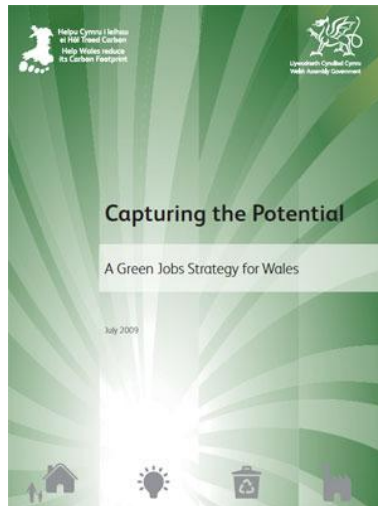
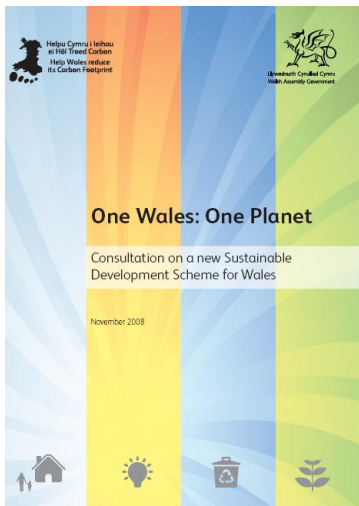
Micropower Certification Scheme: intention to include fuel cells under micro CHP strand – but no certified products or installers at present. Rules for certification heat led microCHP

Climate Change Committee Report: little mention of Fuel Cell technology for the built environment

- Generally seen as a “Future Technology”

Hydrogen Fuel Cell and Carbon Abatement Demonstration Programme £15 million over 4 yrs – but – (so far) single stationary FC project (200kW in Havant)

Policy Support for Fuel Cells in Wales



Hydrogen Energy R&D in Wales

PRIFYSGOL
BANGOR
UNIVERSITY



LCRI
Low Carbon Research Institute

glyndŵr

PRIFYSGOL GLYNDŴR CYMRU
GLYNDŴR UNIVERSITY WALES

PRIFYSGOL
ABERYSTWYTH
UNIVERSITY



Swansea University
Prifysgol Abertawe



CARDIFF
UNIVERSITY

PRIFYSGOL
CAERDYDD



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PRIFYSGOL GLYNDŴR CYMRU
GLYNDŴR UNIVERSITY WALES

PV, Photoelectronics

Marine Energy
Sustainable Materials

PRIFYSGOL
ABERYSTWYTH
UNIVERSITY

Energy from Biomass



Hydrogen, Fuel Cells & AD



Swansea University
Prifysgol Abertawe

CARDIFF
UNIVERSITY

PRIFYSGOL
CAERDYDD

Low C built environment
Large scale power

Marine Energy
Power Electronics

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- Bio Hydrogen
- Microbial Fuel Cells
- Biocatalytic H₂ Production
- Hydrogen Energy Systems
- Hydrogen Vehicle R&D
- Economics of Hydrogen Energy
- Environmental Analysis
- Hydrogen Storage



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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Hydrogen and H₂ / CNG Refuelling at Baglan

Hydrogen produced on site from Solar PV & electrolysis

350bar compressed H₂ as a vehicle fuel

Semi-automated H₂ 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



H₂/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 H₂ Wales Project

Extending Hydrogen R&D for Economic Growth

£6.3 million* Cymru H₂ 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 H₂ Wales Scope includes:

- H₂ Energy Storage
- H₂ ICE and Fuel Cell vehicle testing and development
- Infrastructure planning and deployment
- BioH₂ process development
- H₂ & CH₄ product use
- Bioplastics & other material development
- Gas clean up

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

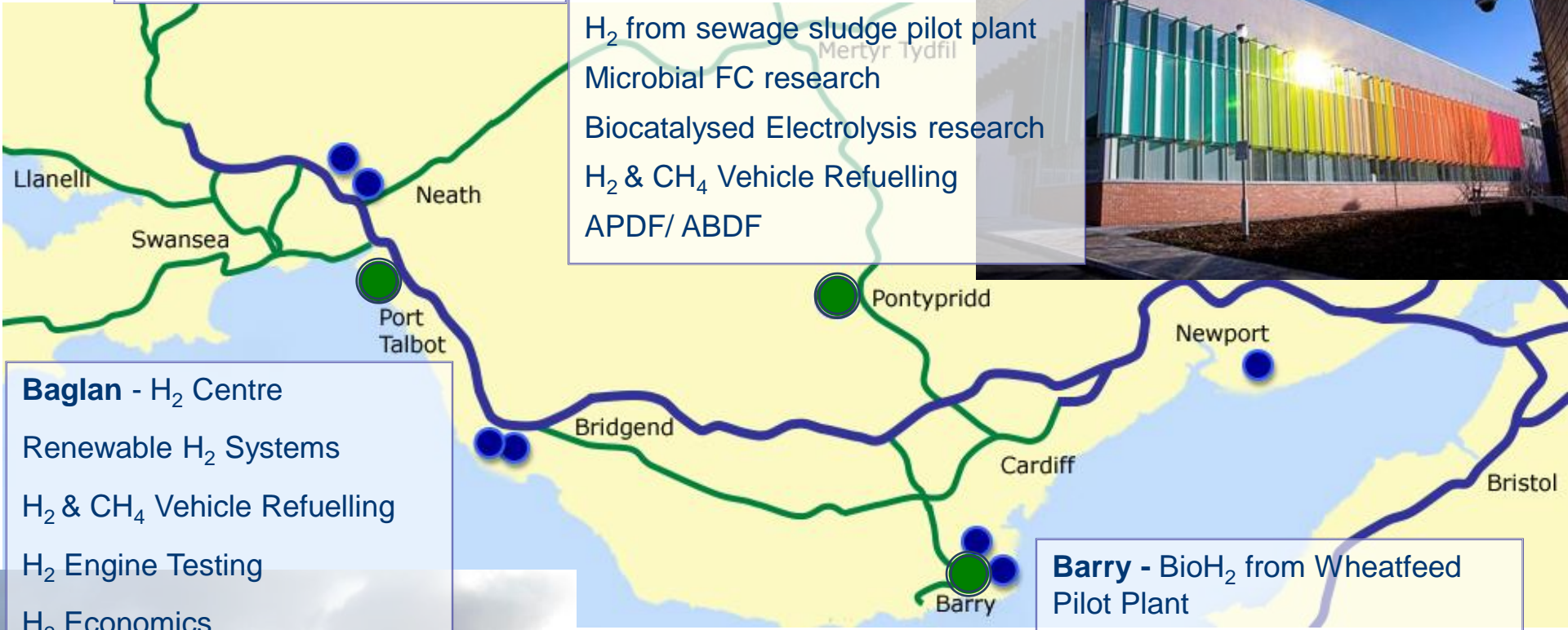


University of Glamorgan Hydrogen Activities in South Wales

Aberystwyth - BioH₂ from Crops Pilot Plant

Pontypridd – BioH₂ labs

H₂ from sewage sludge pilot plant
Microbial FC research
Biocatalysed Electrolysis research
H₂ & CH₄ Vehicle Refuelling
APDF/ ABDF



Baglan - H₂ Centre

Renewable H₂ Systems
H₂ & CH₄ Vehicle Refuelling
H₂ Engine Testing
H₂ Economics

Barry - BioH₂ 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.
- **Includes stationary application . . . Fuel Cells**
- 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

- Test and demonstration facility to develop products 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

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