

The role of hydrogen in the low carbon future vision in the United Kingdom: practical steps

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**SUSTAINABLE
GAS INSTITUTE**

H₂FC SUPERGEN
THE HYDROGEN AND FUEL CELL RESEARCH HUB

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**Imperial College
London**

Outline

- * About H2FC Supergen Hub and Sustainable Gas Institute
- * UK goals for reducing CO₂ emissions net-zero target, drivers for switching to H₂
- * UK government steps towards decarbonisation
- * H₂ trials and demonstrators on hydrogen deployment
- * Spinout companies that emerged in the H₂-FC sector in the UK
- * What constitutes great company?

H2FC SUPERGEN Hub - aims and objectives

- The Hydrogen and Fuel Cells (H2FC) **SUPERGEN** hub funded by the Research Council's UK Energy Programme, (three phases over May 2012 – January 2021)
- **SUPERGEN** is part of the UK Energy Programme's **Sustainable Power Generation and Supply** initiative

Three primary functions:

Transformational Research

that enables the application of hydrogen and fuel cells in the energy landscape

Informing Stakeholders

of the roles and benefits of hydrogen and fuel cell technologies

Building Networks

between the academic research base and industry, builds partnerships across the sector



~500

NETWORK MEMBERS



400+

PAPERS IN HIGH IMPACT JOURNALS



32

PROJECTS FUNDED



34

INDUSTRIAL PARTNERS



21

UK UNIVERSITIES



8

INTERNATIONAL UNIVERSITIES



4

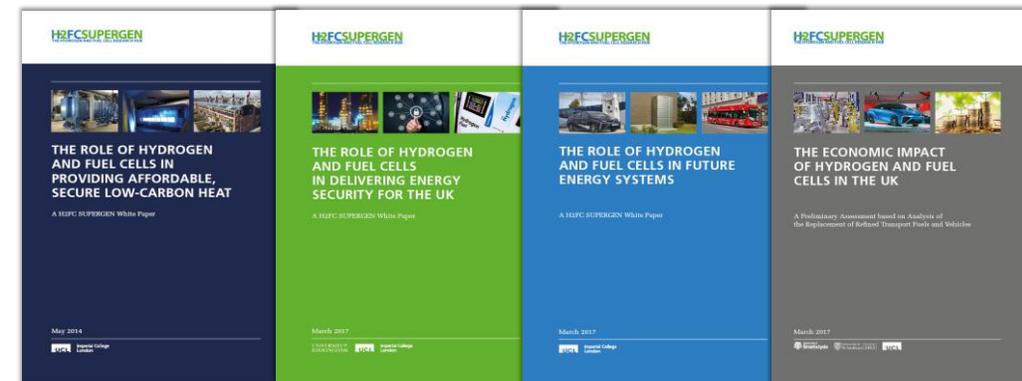
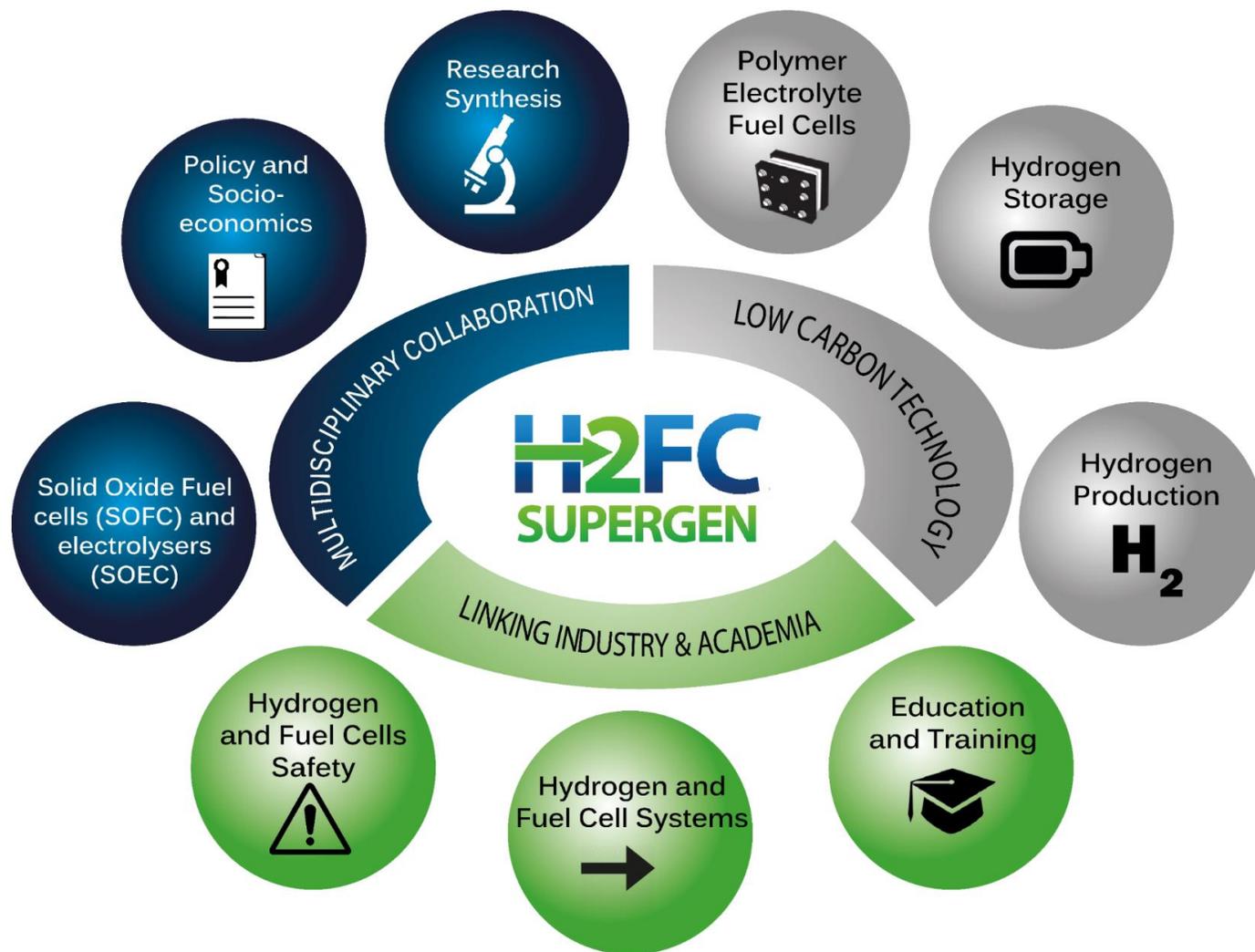
PATENTS



4

WHITE PAPERS

H2FC SUPERGEN hub – research scope



low-carbon heat energy security future energy systems economic impact for the UK

- UK industrial strategy opportunities from H2&FC
- Delivering negative emissions from biomass derived H2



SGI Mission

**SUSTAINABLE
GAS INSTITUTE**



Established in 2014 to provide thought leadership and authoritative interdisciplinary evidence and analysis on the role of gas* in future low carbon energy systems.

*natural gas, hydrogen, biogas/biomethane



What do we do?

SUSTAINABLE GAS INSTITUTE



Evidence-Based Reviews

Deliver evidence based **white papers** that inform the debate around the role of natural gas.



Hydrogen Research

Explore the role of **hydrogen** in the energy system.



Methane Research

Understand **methane emissions** and their mitigation.



Modelling Gas Futures

Develop a unique **energy systems simulation tool (MUSE)** to analyse the energy system, and the role of technologies within it.



Gas Technology Briefings

Focus on the translation of our research into **industry and policy impact**. Publish our work in the open literature – **40 papers** to date.



Member-Specific Research

Help our **members** with specific enquiries

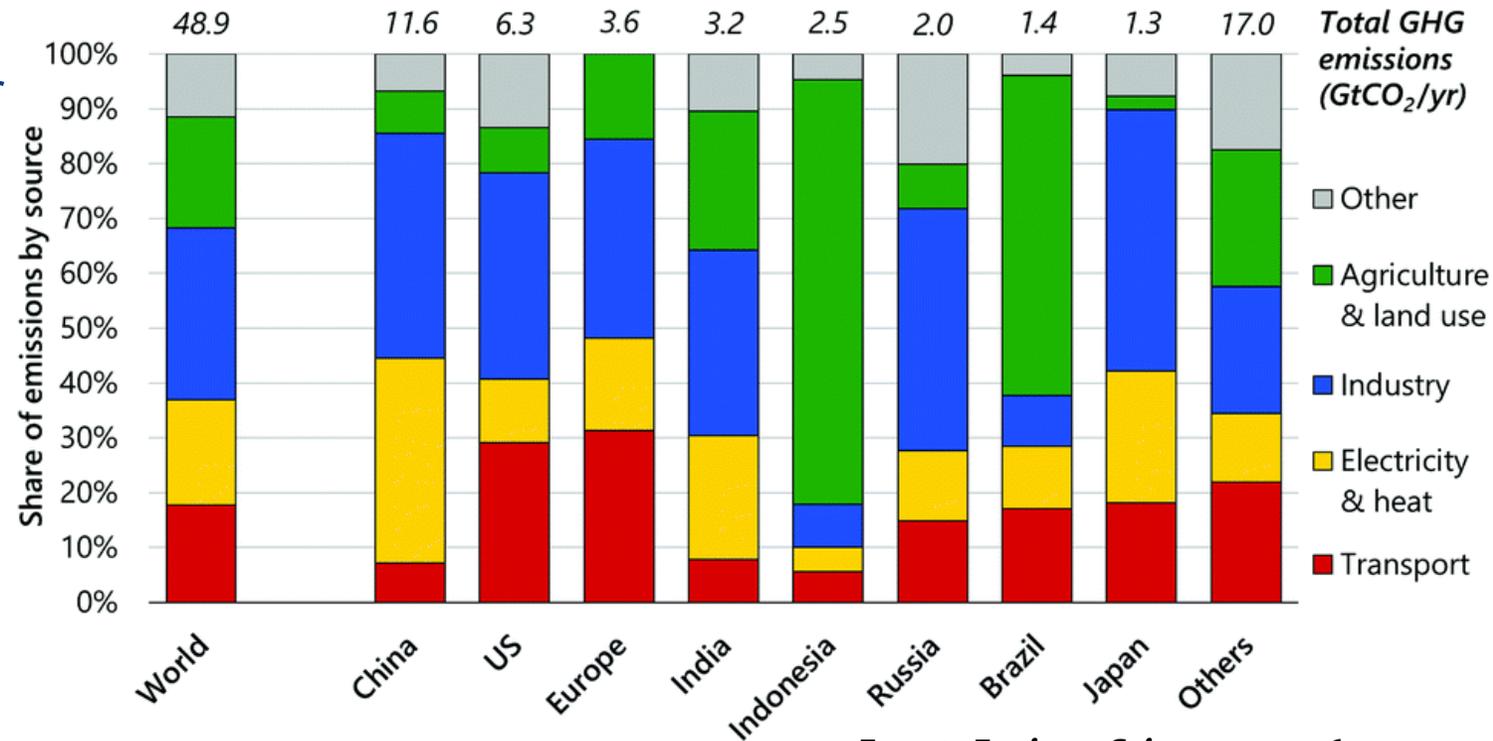
www.sustainablegasinstitute.org



UK goals for reducing CO₂ emissions

- * The UK has committed to **reducing all greenhouse gas (GHG) emissions by 80% in 2050** compared to 1990 as agreed under the Climate Change Act in 2008
- * UK's government goal is to achieve a **net-zero target by 2050** meaning that total emissions from homes, transport, farming and industry will have to be avoided completely or offset by eliminating CO₂ from the atmosphere.

Global greenhouse gas emissions in 2014, broken down by sector and by major countries



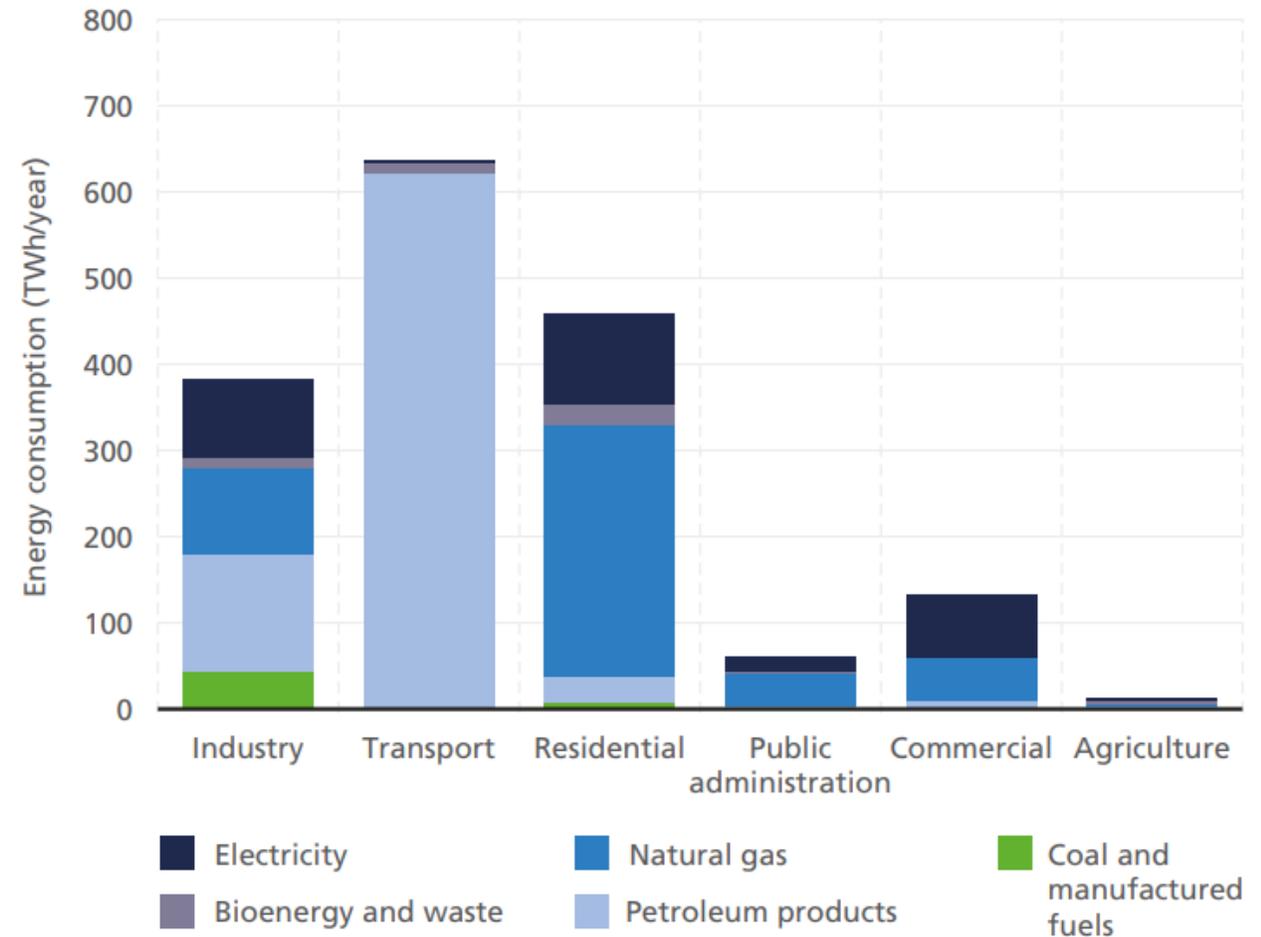
Energy Environ. Sci., 2019,12, 463-491

Decarbonised gas (H₂ and biogas) and deployment of CCUS (carbon capture usage and storage) can make manufacturing more sustainable, minimise disruption to families and deliver negative emissions.

The challenge – mitigating climate change

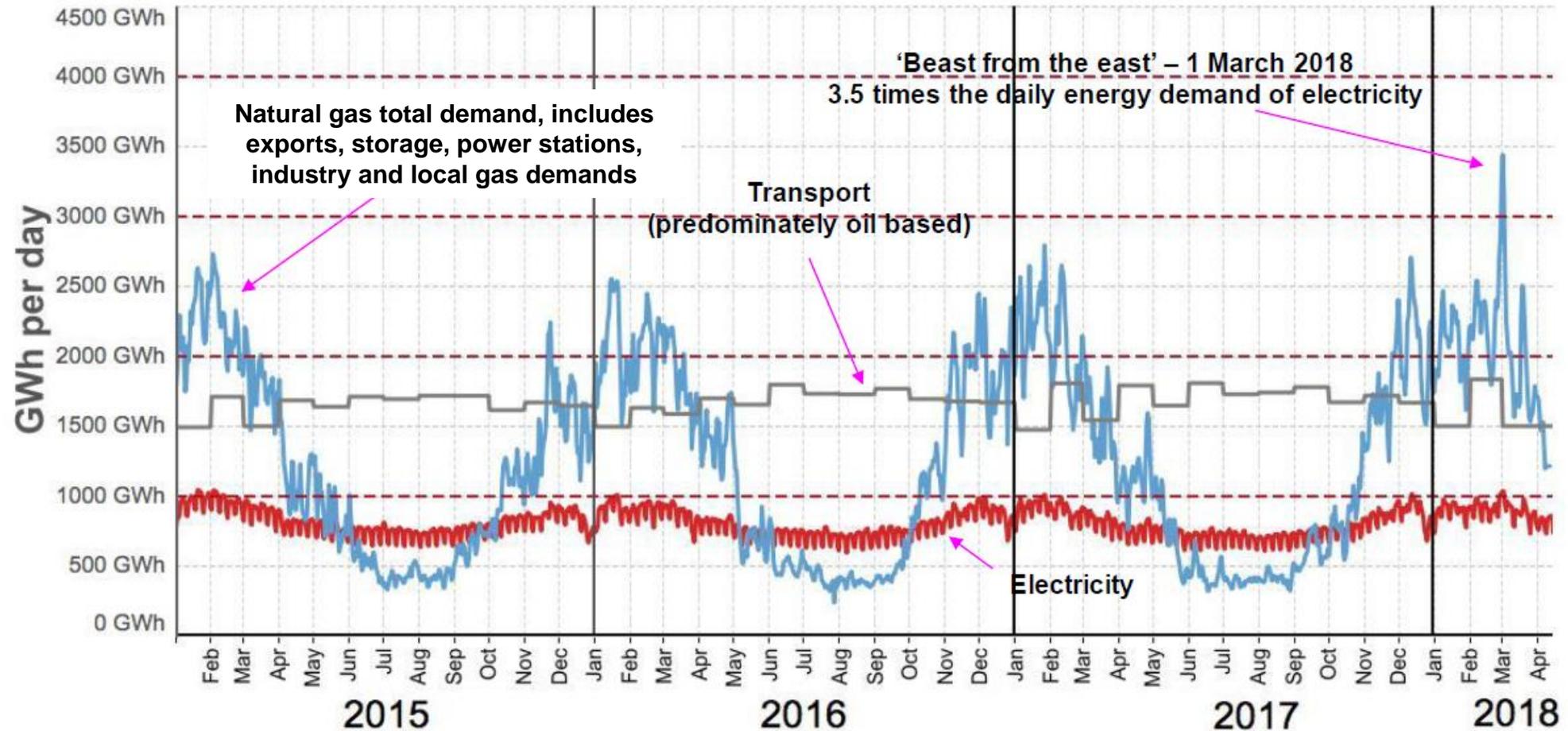
- * **80% of homes** use natural gas; **21 million households** and **2 million commercial gas boilers** in the UK
- * **Heating UK homes** is about **half all energy consumption** and a **third of carbon emissions**
- * **Third of the total emissions** coming from **transport sector**
- * **Heating and transport sectors** are “**hard**” to decarbonise

UK final energy consumption by sector and fuel in 2015



The challenge – responding to fluctuations in energy demand

Great Britain's Energy Vectors – in GWh per day



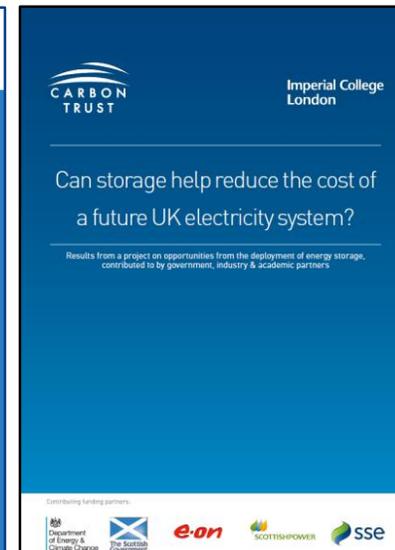
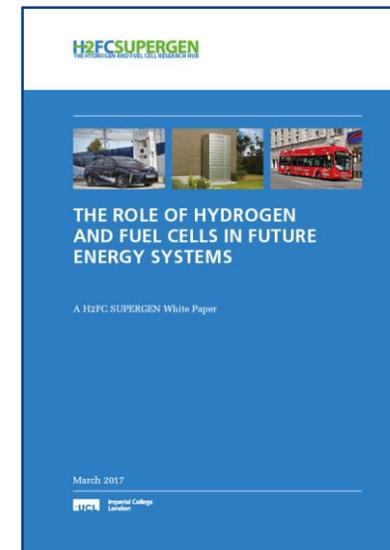
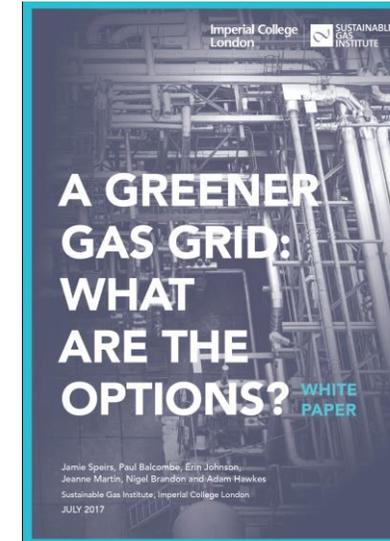
Data are from National Grid, Elexon and BEIS. Charts are licensed under an Attribution-NoDerivatives 4.0 International license
Charts can be downloaded from <http://bit.ly/energycharts>



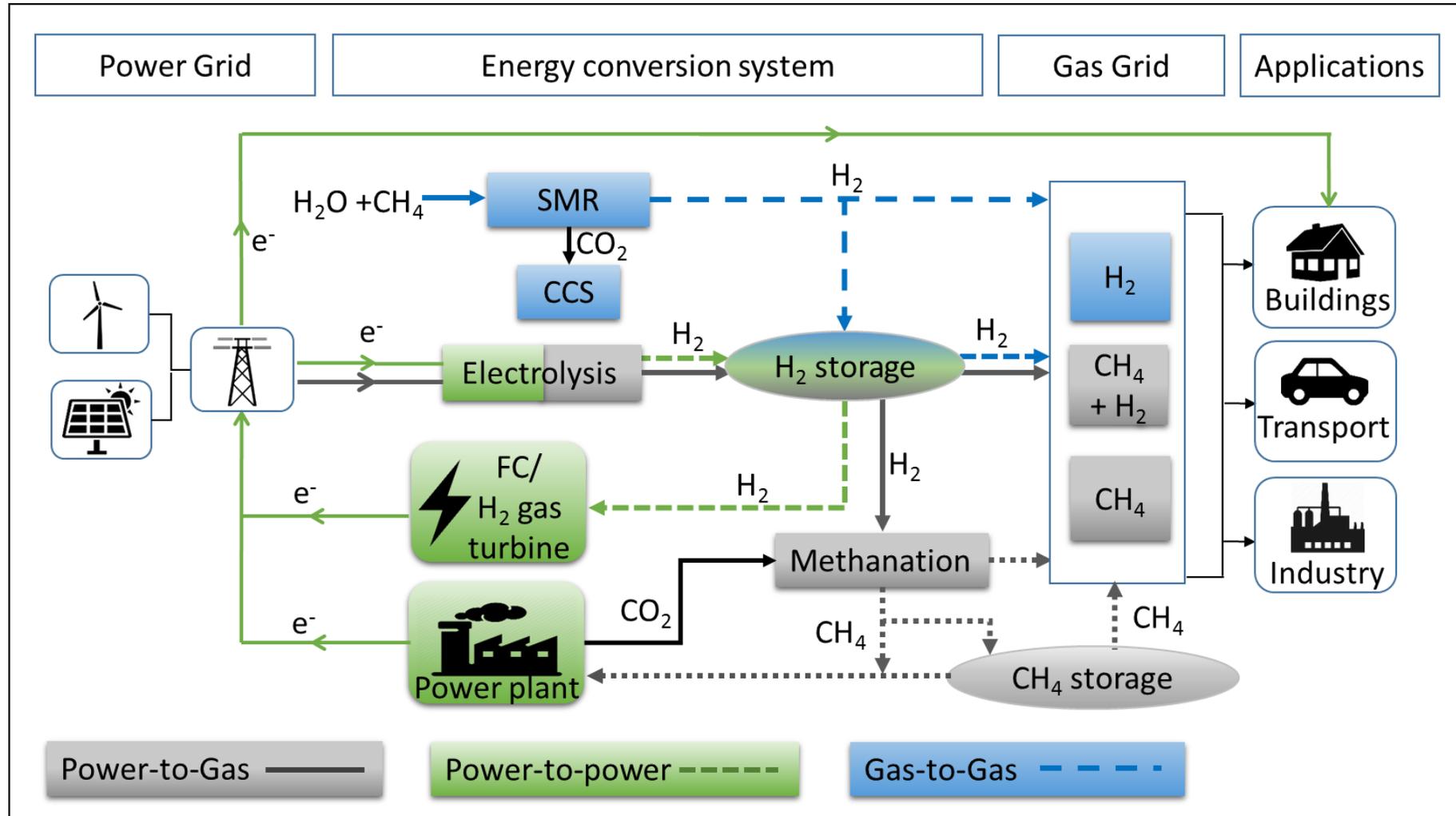
by Dr Grant Wilson grant.wilson@sheffield.ac.uk

Conclusions from recent reports

- * Hydrogen can make an important contribution to long-term decarbonisation if combined with **greater energy efficiency**, cheap **low-carbon power generation**, **electrified transport** and new **'hybrid' heat pump** systems (Committee for Climate Change - CCC)
- * Hydrogen could replace natural gas in parts of the energy system, where electrification is not feasible or is prohibitively expensive, for example in providing **heat on colder winter days**, **industrial heat** processes and **backup power** generation (CCC)
- * Hydrogen's role depends on early Government commitment and better support to develop the UK's industrial capability (CCC)
- * The Department for Business, Energy and Industrial Strategy (BEIS) announced **£390 million government investment** in hydrogen and low carbon tech to help industry cut emissions as the UK moves towards net zero emissions by 2050



Hydrogen's role in the UK energy system is being investigated for decarbonising across sectors



UK trials to investigate hydrogen deployment in sectors

HyNet NW: Phase 1 £25m

- Converting industrial users to H₂
- H₂ production and storage, CCUS
- Decarbonizing: industry, heat and transport

Cadent and multiple partners companies

H100 Feed Study: BEIS £2m

- Demonstration of network and household conversion to 100% H₂
- SGN (Lead), OREC, Arup**

H21 Leeds City Gate/NE

- Feasibility study to support conversion of the UK gas networks to carry 100% H₂
- Cadent, Northern Gas Networks, SGN, DNV-GL, NPL, H&S Lab**

Milford, Energy Kingdom: BEIS £3m

- Whole energy system feasibility study to demonstrate transition of the cluster of major energy infrastructure to H₂ and renewables
- Decarbonizing: industry, heat and transport

OREC (lead), UoS, PNDC, PassivSystems (SME), Community Energy Scotland (CES)

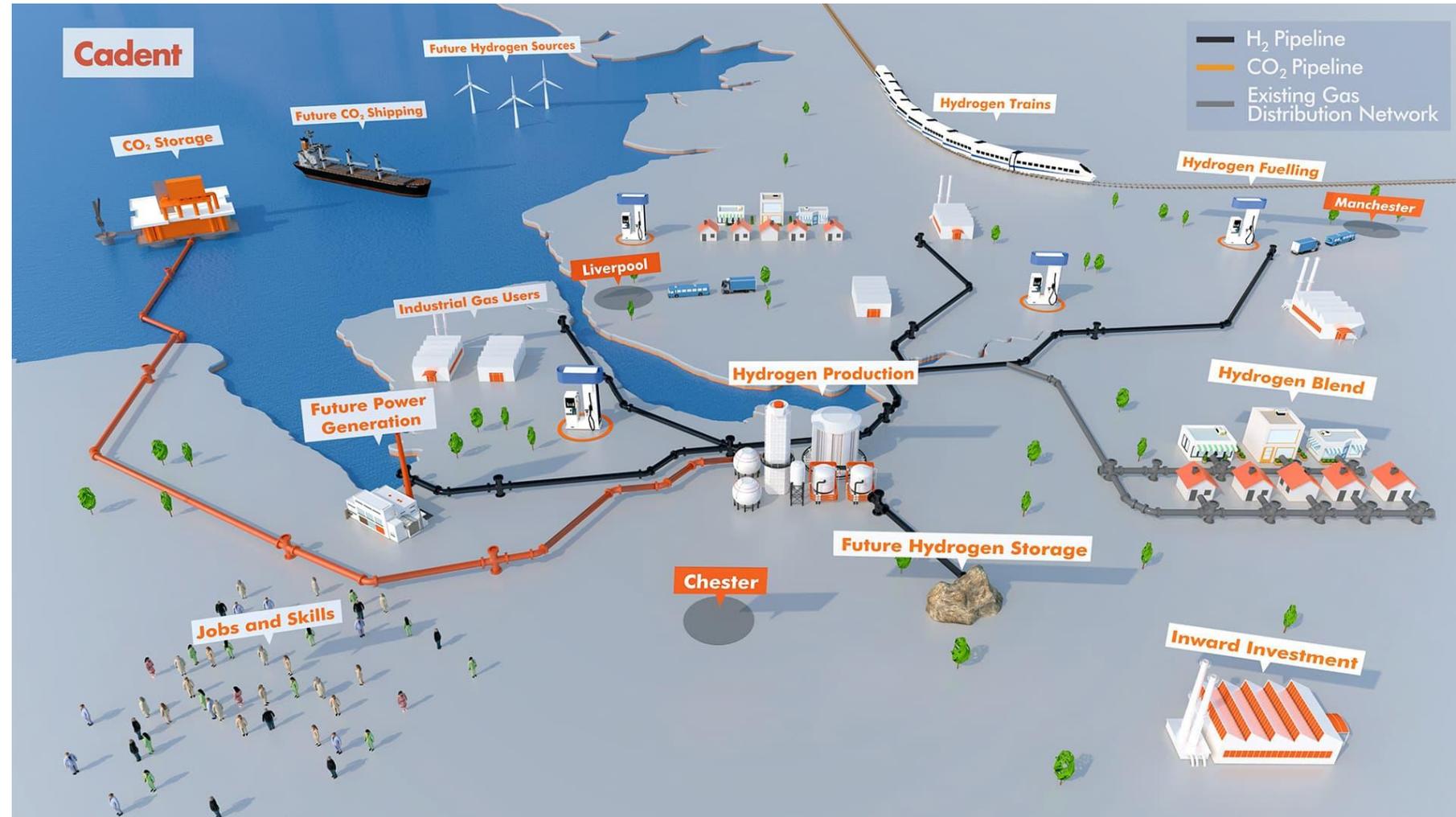
HyDeploy: £13.2m

- Injection of 20% H₂ into the public gas network
- Focus on safety and appliance conversion to H₂
- **Cadent, Kiwa Gastec**



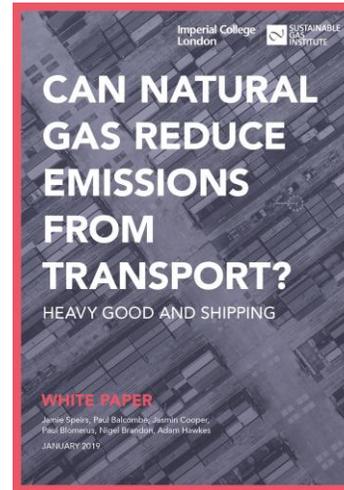
HyNet – to reduce carbon emissions from industry, homes and transport and support economic growth in the North West of England.

- * Featured at the 24th Conference of the Parties to the United Nations Framework Convention on Climate Change (**COP 24**)
- * Production of hydrogen from natural gas. Hydrogen would be produced in bulk at a central plant using established, proven technology.
- * Reduced cost CCUS infrastructure opportunity through the reuse of the Liverpool oil and gas fields. Estimated CO₂ storage capacity of 130 million tonnes. H₂ storage in salt caverns.
- * Renewable energy sources in the region offer potential for future hydrogen production to move towards 100% renewable energy.
- * A blend of hydrogen (up to 20% by volume) and natural gas could be delivered to customers and businesses on the surrounding gas network.



Hydrogen for transport programme – DfT

- * Trucks, trains and ships are less suited to batteries and mix of biofuels and H₂ and fuel cell technologies can help decarbonising these transport modes
- * **£23 million funding** to accelerate the uptake of H₂ vehicles and to create new refuelling stations

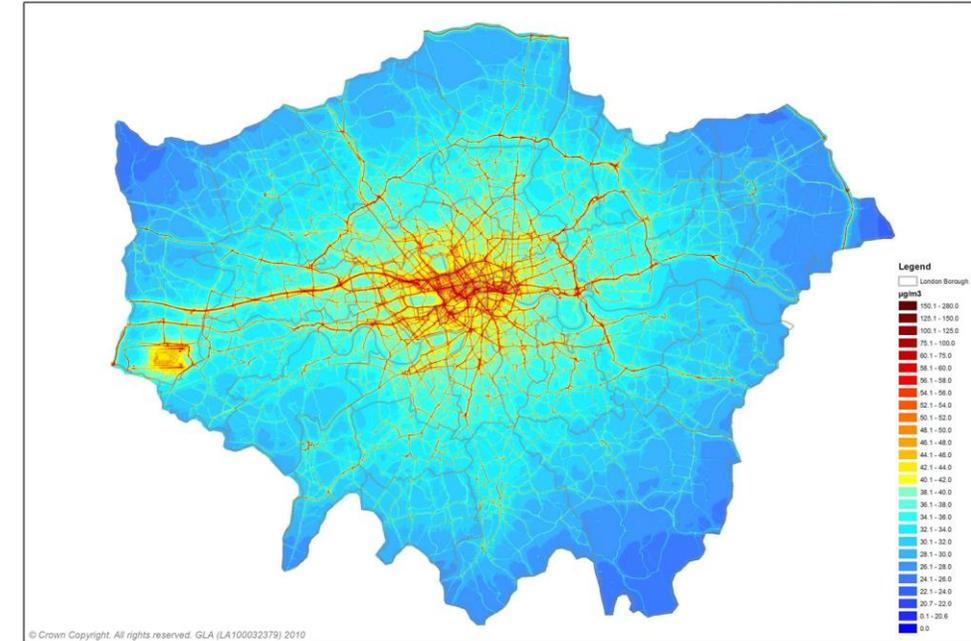


<https://www.sustainablegasinstitute.org/summary-can-natural-gas-reduce-emissions-from-transport/>

NO_x emissions in London

LAEI 2008: NO₂ Annual Mean - 2008

GREATERLONDONAUTHORITY



- * **Euro VI** standard for diesel buses introduced in 2014 reducing NO_x by 95% compared to previous
- * Since 2019, all new double-deck buses will be **hybrid, electric or hydrogen**
- * By 2037 at the latest, all **9,200 buses** across London will be **zero emission**.

Activities on H2 in Europe



- * “Currently, **over 100 UK companies**, as well as over 35 academic and contract research groups highly active in fuel cells and hydrogen, are contributing to the creation of this promising, global industry.” – UK H2 and Fuel Cells Association

(<http://www.ukhfca.co.uk/the-industry/>)

- * Over **US\$1bn** invested in low-carbon tech by Original Equipment Manufacturers (OEM) in the UK SMEs in the last 18 months

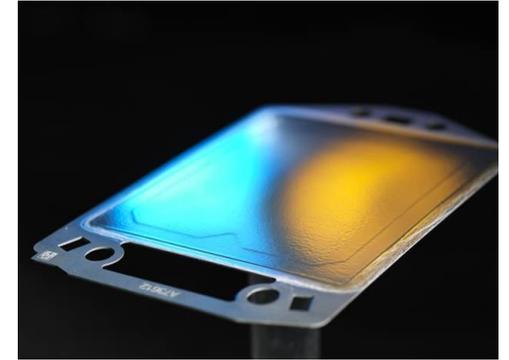
Emerged companies in the H2-FC sector to address whole energy system challenges

* Ceres Power

- * Fuel-flexible SteelCell® utilizing Solid Oxide Fuel Cell technology can generate power from conventional fuels like natural gas and from sustainable fuels like biogas, ethanol or hydrogen and it does at very high efficiency.
- * Combined Heat and Power (m-CHP) for commercial and residential buildings
- * Providing power for Data Centres and range extension for Electric Vehicles

* Partners:  潍柴动力 WEICHAI POWER  BOSCH 

CeresPower® 



* Bramble Energy

- * H2-fuelled printed circuit board fuel cells PCBFC™ utilizing PEM-FC technology
- * The only fuel cell company with the manufacturing capacity to supply gigawatts of fuel cell hardware
- * Wide range of applications from stationary or portable energy generation; automotive applications as prime mover or range-extender

Emerged companies in the H2-FC sector to address whole energy system challenges

* Intelligent Energy

- * PEM fuel cells for a range of markets including automotive, stationary power and UAVs. It is headquartered in the UK, with additional operations in the US, Japan, Korea and China.
- * Power for stationary and portable applications capable of delivering a range of power outputs from 1kW-4kW; range-extenders for electric vehicles; flight duration extenders for drones



Intelligent
Energy



* ITM Power

- * Highly-efficient PEM electrolyser stacks to produce high-purity, self-pressurised hydrogen gas. ~800kg of hydrogen production per day
- * Hydrogen as a fuel for cars, trucks, buses, ships, trains
- * Energy storage (grid balancing, power-to-gas, storing renewable energy)
- * Industrial H2 (refineries, methanation, steel, glass, mining, renewable methanol)
- * Operates a network of eight publicly accessible H2 refuelling stations
- * Partner: 

What constitutes a great company?

- * Innovative technology
- * Collaborate wise whilst focusing on core purpose: b2b, research, government, other countries
- * Know how you stand out
- * What is your potential to bring impact?
- * Find right team with diverse skills-set





Join us!

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