



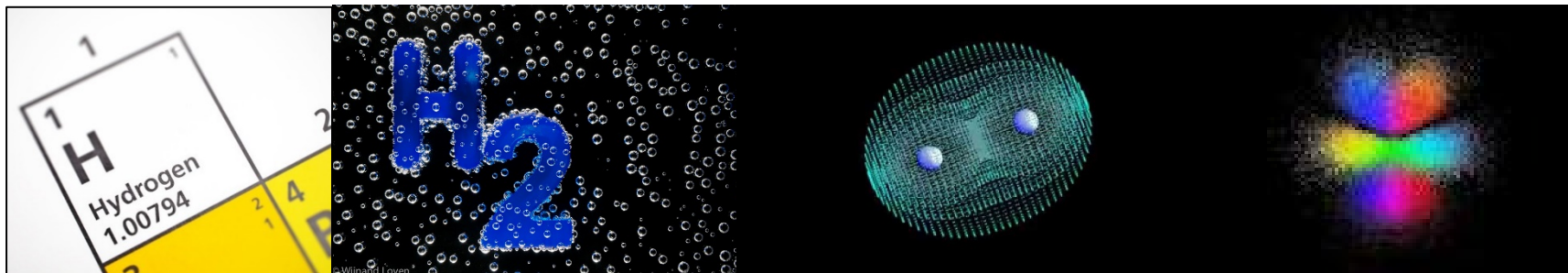
Hydrogen and Fuel Cells

- how councils can get involved

Beth Dawson, Major Projects Manager, FCSL

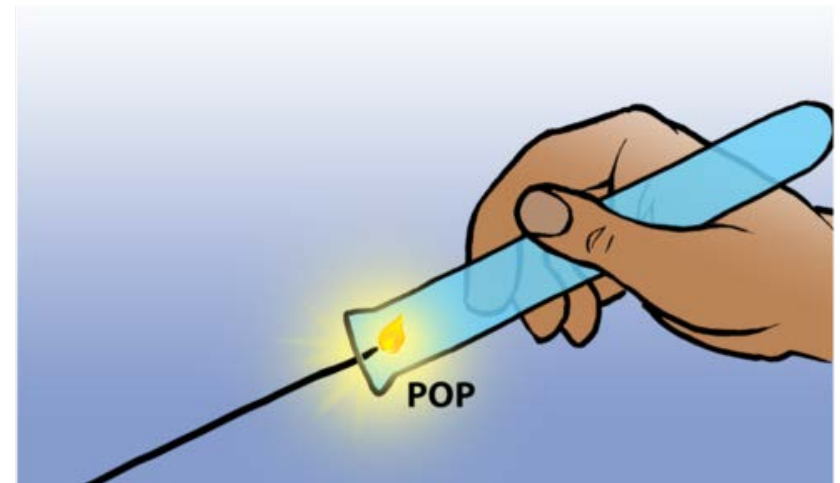
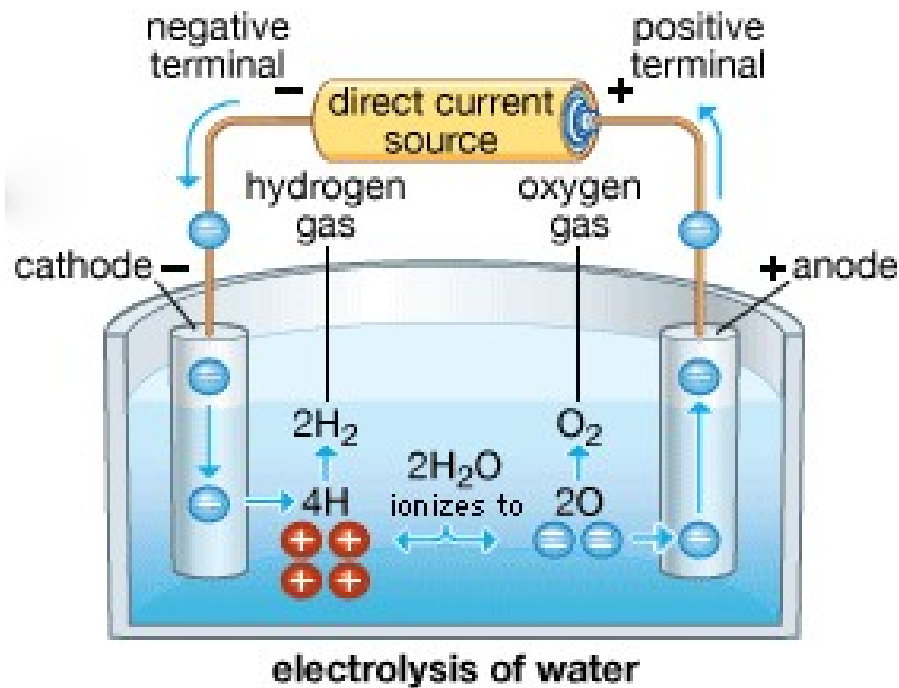
Hydrogen

- Hydrogen makes up about 75% of the mass of the universe. It is found in the sun and most stars.
- Hydrogen is the simplest and lightest element on the periodic table.
- Hydrogen gas is almost always bonded to itself or something else. That is why hydrogen gas is represented as H₂.
- Hydrogen is odourless, colourless, tasteless, non toxic and non-poisonous.
- Hydrogen is highly flammable but will not ignite unless an oxidizer (air) and ignition source are present.
- Hydrogen has been safely produced, stored, transported, and used in large amounts in industry by following standard practices that have been established in the past 50 years.



Hydrogen

You are very likely to have handled hydrogen already in school experiments.



Hydrogen

The hydrogen refuelling station (HRS) at Honda in Swindon is essentially a large version of the water electrolysis that you may have done at school.

It uses electricity produced by a nearby solar array to split water. It can produce 50kg of hydrogen per day, which it stores in a battery of onsite pressurised tanks.

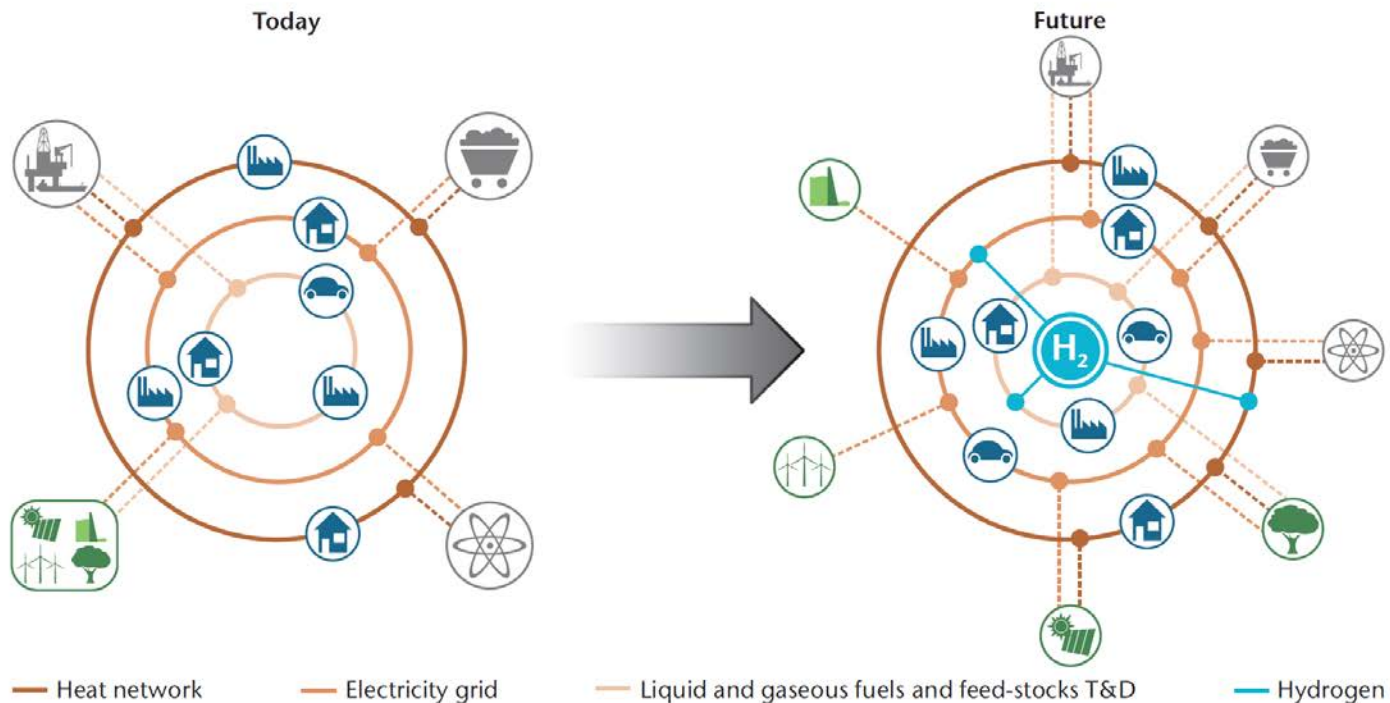
Other HRS sites use wind turbines. Some use industrially produced hydrogen from steam reforming natural gas.



Why bother?

Hydrogen is an **excellent** energy carrier.

It's not a primary energy source but can be used to store, transport and provide energy. Its energy density is high per unit mass. One of the advantages of hydrogen is that it can store energy from all sources, both renewable, fossil and even nuclear power – it's very flexible. Hydrogen is very likely to play a key role in the necessary transition from fossil fuels to a sustainable energy system.

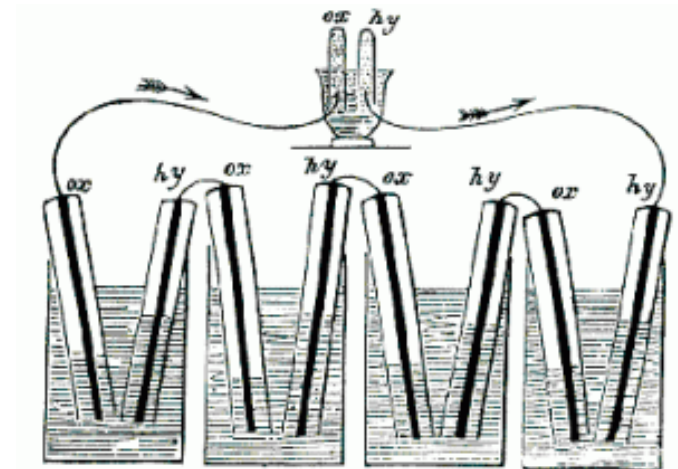
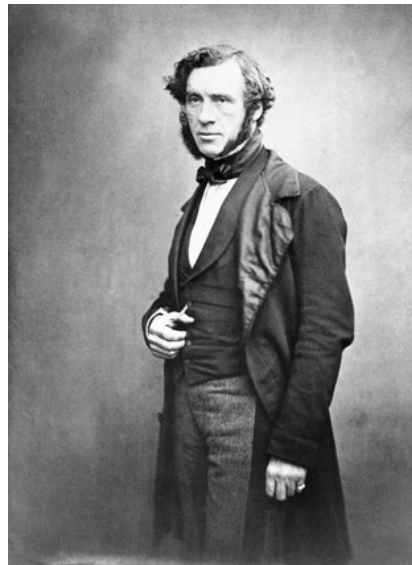
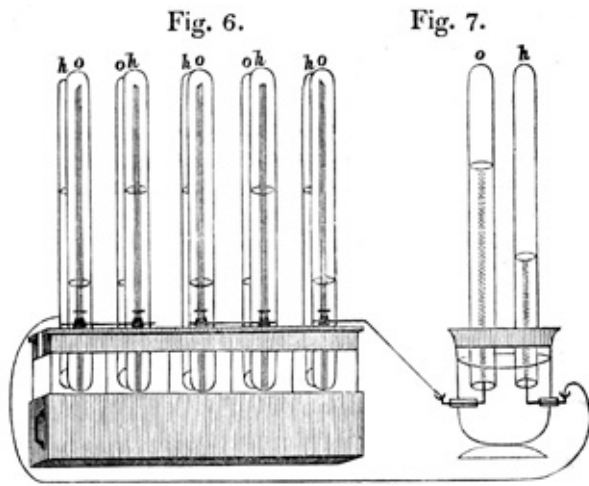


Ok, so what's a fuel cell?

A fuel cell is an energy converter that efficiently transforms the chemical energy in hydrogen to electricity and heat. The only other product is pure water.

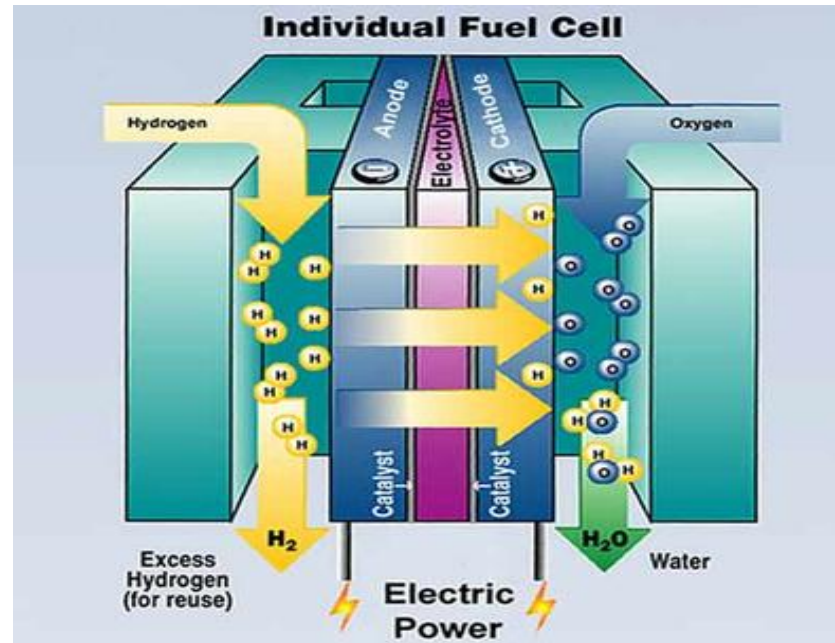
The fuel cell reaction is the equal and opposite reaction to electrolysis.

The principle was first demonstrated by Sir William Grove in 1842





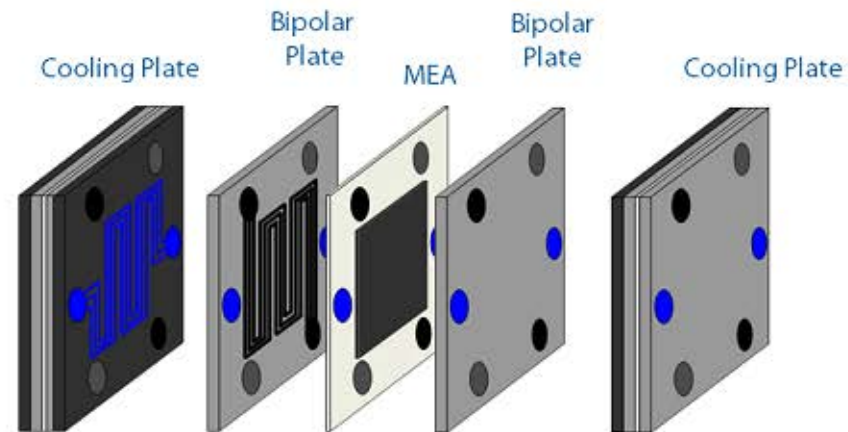
FUEL CELL SYSTEMS[®] How does it work?



Fuel Cell Stack



Single Cell



Cell Components

It's just power...





Available systems

40W – 2MW

Multi Technology

(Hydrogen, Methanol, Propane, Natural Gas, Biogas)

Low Temperature

- DMFC – Direct Methanol – 75°C
- PEM – Proton Exchange Membrane – 75°C
- AFC – Alkaline Fuel Cells – 80°C

High Temperature

- PAFC – Phosphoric Acid - 200°C
- MCFC – Molten Carbonate Fuel Cell – 600°C
- SOFC – Solid Oxide Fuel Cell – 1000°C



	25W – 100W	100W – 1kW	1kW – 10kW	10kW - 100kW	100kW – 200kW	400kW – 1.2MW	1.4MW – 3.7MW
FUEL USED							
Methanol	○	○	○				
Hydrogen		○	○	○	○		
Propane		○					
Natural Gas						○	○
TECHNOLOGY							
DMFC	○	○					
PEM		○	○	○	○		
SOFC		○	○				
AFC			○				
PAFC						○	○
MCFC							○
TYPE OF POWER							
Stationary	○	○	○	○	○	○	○
Portable	○	○					
Motive				○	○		
APPLICATION							
Standby Power	○	○	○	○			
Prime Power	○	○				○	○
Off-grid telemetry	○	○					
Off-grid CCTV	○	○					
Portable Signage, Lighting	○	○					
Automotive				○	○		
Telecommunications Backup			○				
Small Computer Room Backup			○				
Large Computer Room Backup				○			
Data Centre Backup					○		
Prime Power (CHP)						○	○



**FUEL CELL
SYSTEMS®**

Commercial Applications





SWISH2

Fuel Cell Systems Ltd design and deliver the UK's first fully integrated portable building powered by fuel cell and solar generated hydrogen.



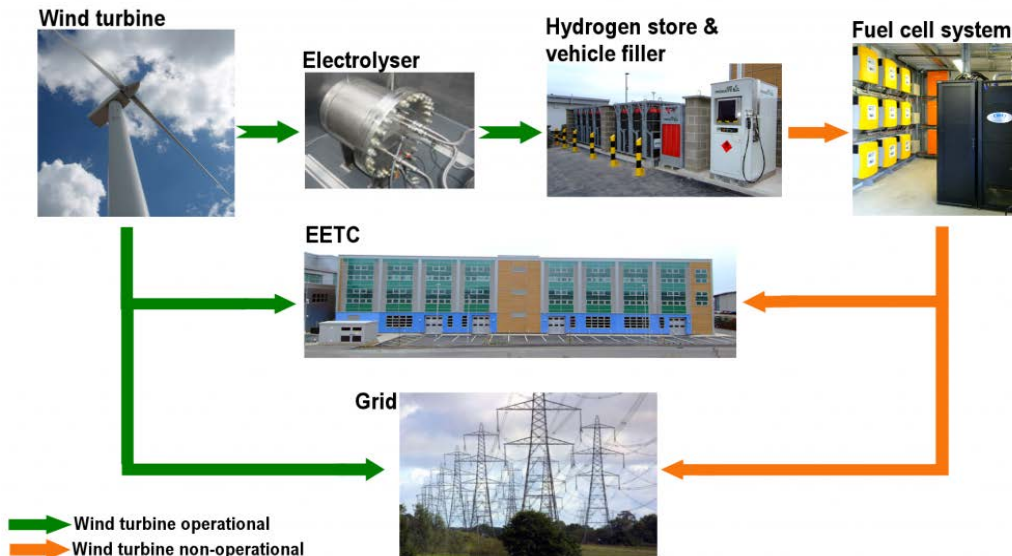


**FUEL CELL
SYSTEMS®**

Rotherham EECT

When energy consultants TNEI were asked to create the UK's first fully-hybridised, stand-alone and completely 'green' hydrogen mini-grid, Fuel Cell Systems Ltd were called upon to specify, supply, install and commission the fuel cell system designed to co-power the new Environmental Energy Technology Centre (EECT) in Rotherham, South Yorkshire.

The Hydrogen Mini-Grid System





FUEL CELL
SYSTEMS®

Larger stationary power



Palestra Building, Southwark

- £2.4M 200kW Combined Heat and Power (CHP) plant, provides electricity, heat and cooling, and hot water to the building.
- At times of peak energy use, the building generates a quarter of its own power, rising to 100 per cent off-peak.
- Cuts carbon emissions by up to 40 per cent and generates £90,000 cost savings per annum.
- Payback period of 10 years.



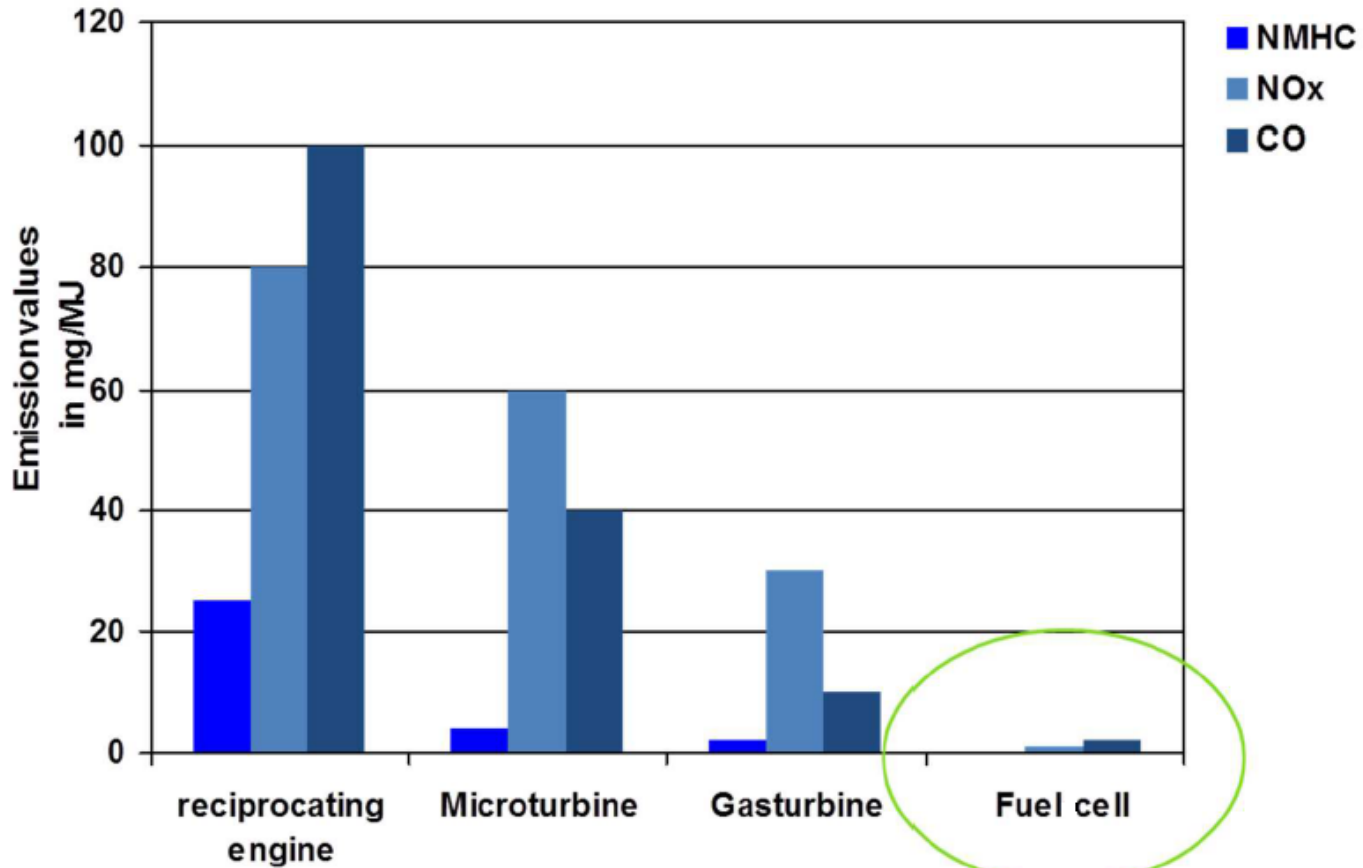
20 Fenchurch Street, EC3

- The Fuel Cell at 20 Fenchurch Street generates 300kW of low carbon, low emissions electricity
- The Fuel Cell is integrated into a Combined Cooling, Heat & Power (CCHP) configuration to efficiently support the building's essential services
- Conservatively, the Fuel Cell will reduce the carbon dioxide emissions of the building by at least 270 tonnes per annum





Relative Emissions





Seems like a lot of effort...

Yes, but it also solves a lot of problems:

Grid power and grid reliability are becoming more of a problem. Hydrogen and fuel cells can help.

Renewable power sources are increasing but this brings with it issues of grid balancing. Hydrogen and fuel cells can help.

Heating networks are already under strain. Hydrogen and fuel cells can help.

Air Quality is a major issue for many UK cities. Hydrogen and fuel cells can help.



Government Target:

Effectively zero tailpipe emissions for UK car fleet by 2050

Fuel Cell vehicles are highly likely to play a strategic role in meeting this target. Recent OLEV funding given to increase fuel cell car uptake across all manufacturers.



"We are always looking at new ways to make the vehicles of the future cleaner, and hydrogen fuel cells are an important part of our vision for almost all cars and vans to be zero-emission by 2050."

Andrew Jones, Transport minister



And the difference to me?

If you drive your averagely polluting combustion engine car 10,000 miles per year, then your car will emit 2.6 tonnes of Carbon Dioxide. If you wanted to offset this amount by planting trees you would need to plant at least 4 trees for every year you spend driving the car.

There is also the beneficial decrease in the nastier emissions – the NO_x, SO_x and particulates, which are proven to be so damaging to human health.



“40,000 deaths each year in the UK are attributable to exposure to outdoor air pollution. It is also evident that it is disproportionately the poorest of our communities which are most exposed and vulnerable to air pollution.”

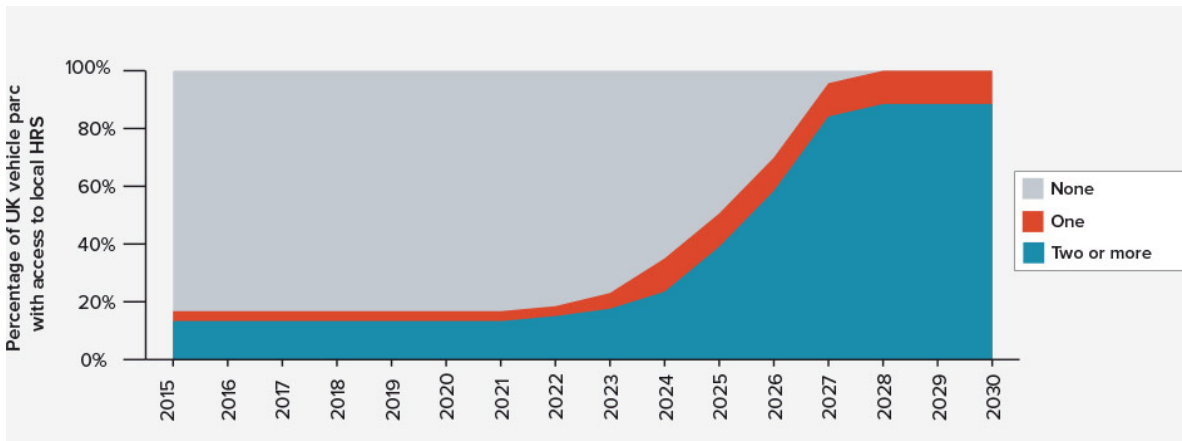
Professor John Middleton, President of the Faculty of Public Health

What's the H2 problem?

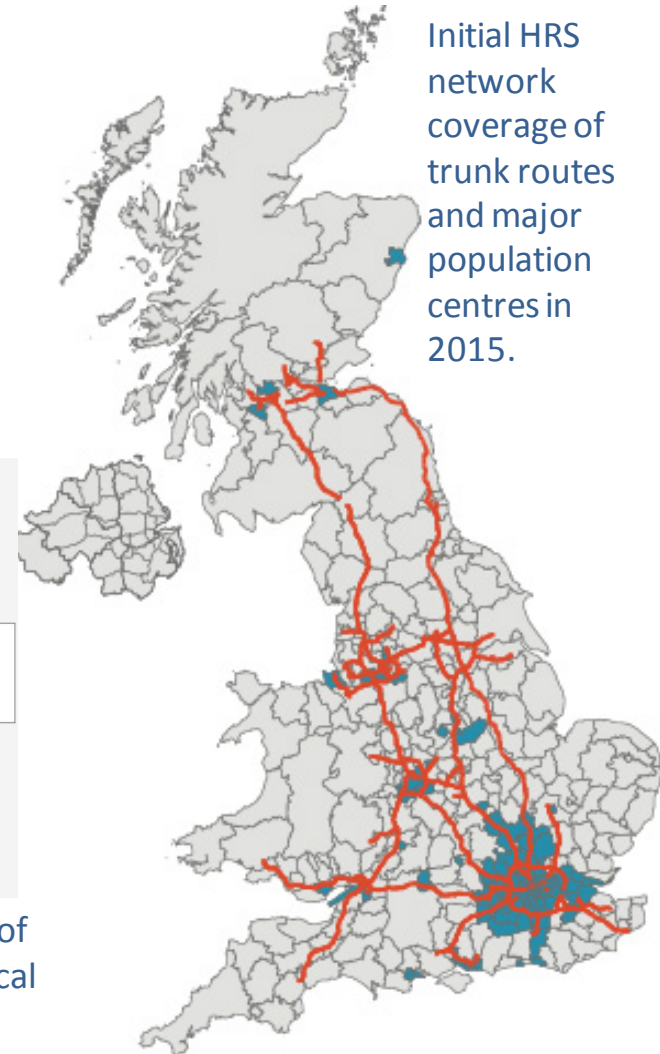
UK H2 Mobility target: 65 hydrogen stations across the UK by 2020

Current publicly accessible sites:
Heathrow, Hendon, Swindon, Teddington (NPL),
Rainham, Rotherham, Aberdeen, Baglan (USW)

Plans in place for another 5-10



The development of local HRS network coverage in terms of the proportion of the UK vehicle parc with access to zero, one and two or more HRS in their local district.





**FUEL CELL
SYSTEMS®**

Refuelling product spectrum

Mini hydrogen dispenser (WIP)

Single fill dispenser (a full fill from a larger tank)



Small multi-fill dispenser (3-4 fills, to fit into a transit van)

Medium multi-fill dispenser (FCSL/OLEV refuelling truck)



Hydrogen-producing multi-fill dispenser (a truck with an electrolyser)

Hydrogen-powered multi-fill dispenser (dual fuel or FCEV truck)

Semi-static containerised station

Fully-static installed station





What can we do...?

- Include hydrogen and fuel cells in your energy strategies.
- Consider electrolysers next to renewable installations – to use excess energy and create hydrogen (that useful energy vector).
- Encourage hydrogen refuelling projects in your area.
- When you have hydrogen available, you unlock a multitude of emission-free fuel cell applications: buses, cars, fork lift trucks, building site power (also other options e.g. dual-fuel transit vans and rubbish trucks; pushing excess hydrogen into the gas grid).
- Ask your planning department to encourage hydrogen and fuel cell use for new developments.
- Ask your transport team to consider fuel cell vehicles alongside BEVs



Local initiatives

Hydrogen London, run by the GLA.

Their encouragement has led to fuel cell buses and a good number of fuelling stations around London. Some authorities include fuel cells in their planning calls.

Aberdeen City Council have a hugely successful bus project and plans for a second refuelling station – and work with...

Fife Council and Bright Green Hydrogen for their Levenmouth Energy Project, including dual fuel refuse trucks and fuel cell range extended vans.

Rotherham have their Hydrogen Mini Grid, sited on the Advanced Manufacturing Park.

Leeds have their H21 project with Northern Gas Networks who intend to demonstrate conversion of the gas grid to hydrogen.



Local Initiatives

Swindon Hydrogen Hub, a council and industry deployment group

Working groups for: cars, materials handling, buses and buildings

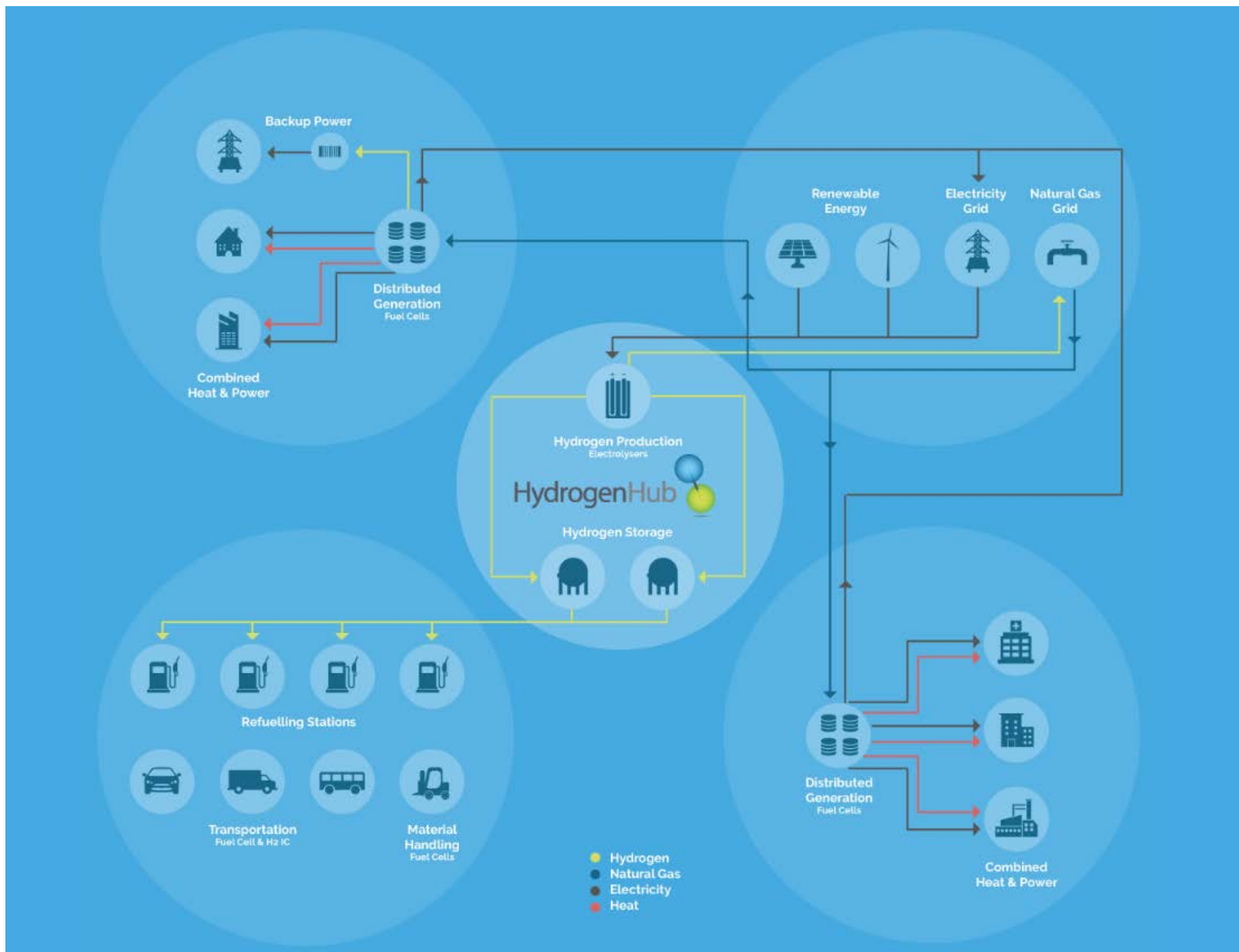
To date:

2 fuelling stations, 8 fuel cell cars, 4 fuel cell fork lifts, 4 dual-fuel vans. Actively searching for a building deployment.

Oxford Hydrogen Hub, a sister site to be launched next year.

Active submissions for fuelling stations in place. Further projects under review such as residential and commercial property developments, shuttle buses and service buses.

Two cities working together is very powerful for accessing funding as there's the 'additionality' effect. One plus one equals more than two.



Distributed Integrated Multi Use Energy System for urban developments

This 12 month feasibility project investigates the techno-commercial benefits of integrating energy and waste management infrastructure, with clean transport within the urban area of Bicester.

Project finishes end Nov 2017 – FCSL are project lead.

Objectives: to establish whether this method of utility-scale power generation can be cost-effective.

If it can be cost-effective and there are no hidden barriers, to provide a foundation for investors that will enable the project to become reality.



What's it going to cost?

Including thinking on hydrogen and fuel cells into your energy strategy is free – I highly recommend the IEA Roadmap on hydrogen and fuel cells.

Setting up a local initiative of some sort isn't expensive.

Installing the small fuel cell units is commercial on a whole-of-life basis for traffic signs, off grid CCTV, environmental monitoring etc

A 'suck it and see' trial car/van trial with mobile refuelling is possible and affordable.

Large infrastructure is expensive. Grants are usually available.



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Thank you

Beth Dawson

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