LowCVP Connect Collaborate Influence
Low Carbon Vehicle Partnership

Sheffield City Council

Low Emission Cities Workshop

Best practice measures for increasing the take up of low pollution and carbon vehicles in cities

Wednesday, 18th November 2015, Sheffield

INTRODUCING HYDROGEN VEHICLES & INFRASTRUCTURE IN THE UK

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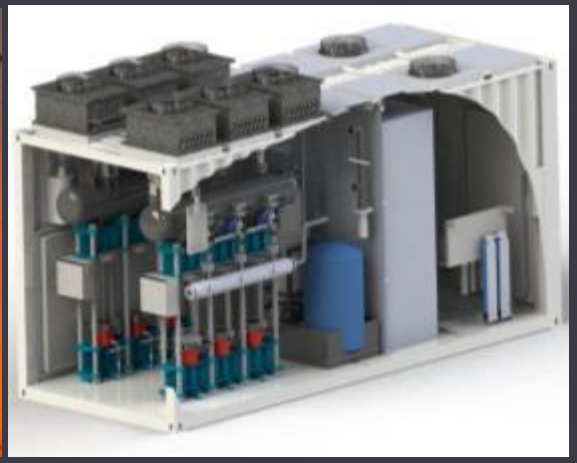
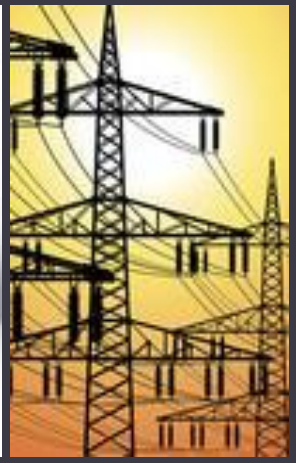
INTRODUCING H2 VEHICLES & INFRASTRUCTURE

LOW EMISSION CITIES WORKSHOP - SHEFFIELD





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INTRODUCING H2 VEHICLES & INFRASTRUCTURE

LOW EMISSION CITIES WORKSHOP - SHEFFIELD

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- Hydrogen Infrastructure
- Cars
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- “The Road to Sustainability”

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ITM POWER PLC

DESIGN AND MANUFACTURE ENERGY STORAGE & CLEAN FUEL SYSTEMS

ITM Power | History

- First AIM listed fuel cell & hydrogen company
- 2004 IPO | £10m | ITM.L
- 2006 Secondary | £30m
- 2012 -14 Expansion | £17m
- 2015 JCB £4.9m Strategic Investment
- Two facilities in Sheffield | 70 staff
- Manufacturing business model

ITM POWER
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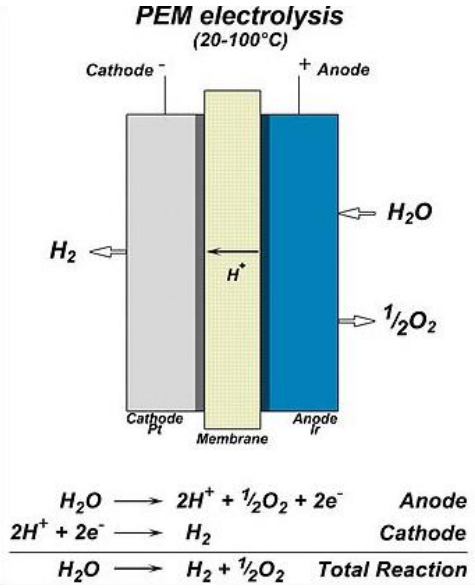
WHY HYDROGEN FUEL?

WHY HYDROGEN FUEL?

The Perfect Fuel

- Made from renewable power and water
- Energy storage for renewable power
- Zero carbon footprint



WHY HYDROGEN FUEL?

ENERGY STORAGE | CLEAN FUEL

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UK H_2 Mobility

Development of a national HRS plan

- Full report published April 25th 2013
- Phase 2 underway
- An initial roll out of 65 refuelling stations of 80kg/day each
- 50% electrolysis

Air Liquide · ITM Power · BOC
Johnson Matthey · Toyota · Nissan
Daimler · Vauxhall · Hyundai
SSE · Intelligent Energy · Dept for Business Innovation & Skills
Dept of Energy & Climate Change · Morrisons · Sainsburys

CLEAN FUEL | ENERGY STORAGE | RENEWABLE HEAT

PEME Convert surplus renewable electricity into chemical energy (green hydrogen)


Wind Power


Grid


Solar Power


Electrolyser


Clean Fuel


Energy Storage


Renewable Heat

RAPID RESPONSE INTEGRATION

HYDROGEN ENERGY SYSTEMS

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MARKET OFFERING

Rapid Response | High Pressure | High Efficiency | MW scale

- Rapid response: less than 2s; for primary grid balancing
- High pressure: up to 80bar; for direct injection
- High efficiency: 75% measured by third parties in the field
- MW scale: 1MW modules available today
- Compliant: EU, USA and Asia

Das große Plus für alle

ITM Power's HGas System brings together rapid response and self-pressurising PEM electrolysis into a fully integrated package which injects hydrogen into the gas distribution network at the Mainova Aktiengesellschaftsite, Frankfurt, utilising pre-existing compliant gas mixing and grid injection infrastructure. The plant has undergone an extensive acceptance, compliance and commissioning phase before going live in December 2013. The sale was the result of a competitive tender, based on price and performance, and was commissioned ahead of schedule. Capable of addressing MW scale Power-to-Gas applications, and accommodates fluctuating power profiles while generating hydrogen at pressures suitable for either direct injection into natural gas networks or via methanation processes without additional compression.

POWER-TO-GAS

ENERGY STORAGE | CLEAN FUEL

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RWE

ITM Power's HGas System was delivered to RWE within 10 weeks of receiving the order, which was won as part of a competitive tender. The system is a second generation ITM Power PEM electrolyser system using a higher current density, permitting higher hydrogen output per stack. The system efficiency is also increased by simplification of the balance of plant.

POWER-TO-GAS

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ISLAND HYDROGEN

EMEC | Orkney

- £1.8m sale
- Competitive tender
- 0.5MW electrolyser + storage
- Complete hydrogen energy system
- Eliminate island grid constraints for tidal testing site
- Largest system to date
- Many follow on projects

ENERGY STORAGE | CLEAN FUEL

CLEAN FUEL

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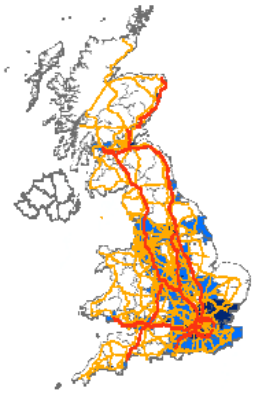
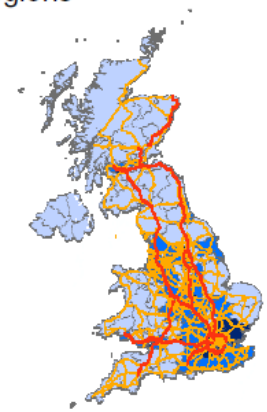
1 The proposed HRS network provides full coverage of major UK roads by 2025, reaching 955 stations by 2030

Tier 1 roads — Tier 2 roads — Tier 1 — Tier 2 — Tier 3

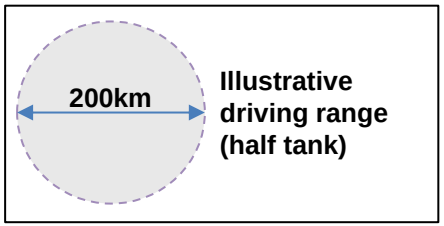
	Tier 1 (2015-19) – Major cities and key motorways	Tier 2 (2020-24) – Full coverage of major roads	Tier 3 (2025-29) – Full population coverage
Objective	▪ Focus on **major population centres**, enable long distance **travel between Tier 1 regions**	▪ Extend close-to-home refuelling to **70%** of the population, **full coverage** of major road network	▪ Extend close-to-home refuelling to the **whole of the UK**, including less populated regions
			
Number of stations	**183**	**603**	**955**
Population coverage	30%	70%	100%

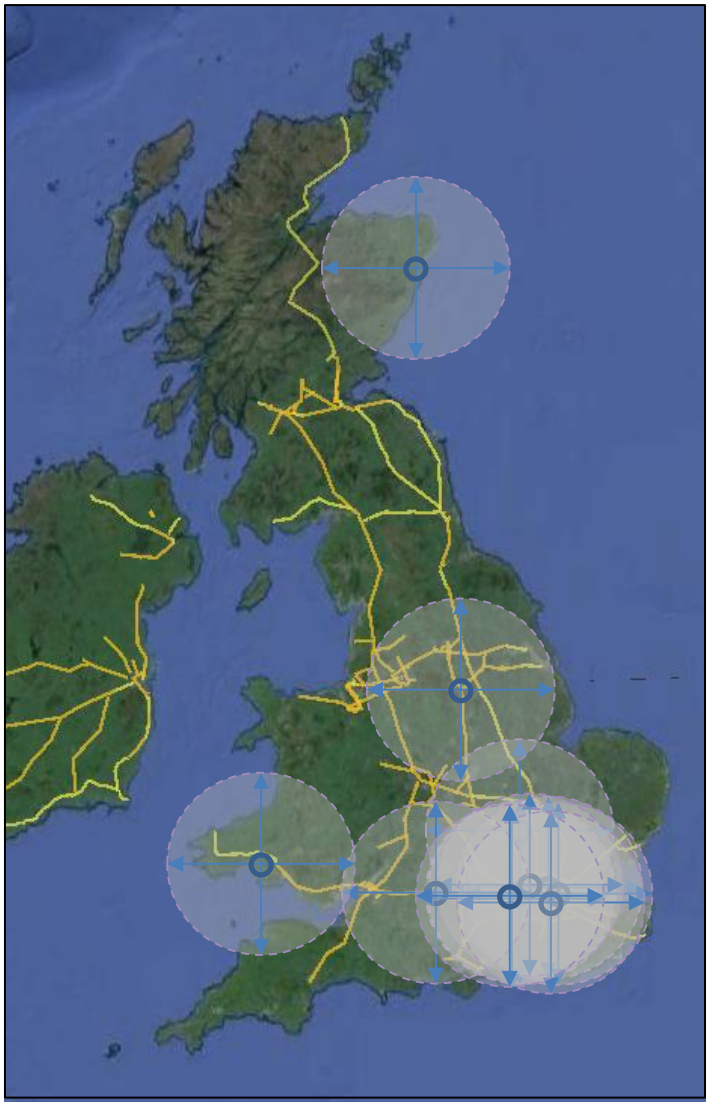
SOURCE: UK H_2Mobility

UK H_2 Mobility

Existing and Funded UK HRS

HRS Provider	Location
Air Products	Hendon, London
Air Products	Temple Mills Bus station, London (buses only)
Air Products	Hatton Cross, Heathrow
Baglan Energy Centre	Port Talbot
BOC	Swindon, Honda manufacturing centre
BOC	Aberdeen
ITM Power	M1, Sheffield
ITM Power	Teddington, London (under construction)
ITM Power	Rainham, London (planned)
ITM Power	London (planned)
ITM Power	South East (planned) Shell
ITM Power	South East (planned) Shell





Demonstration scale refuelling equipment also exists in (not shown):

- Coventry
- Birmingham
- Nottingham
- Loughborough
- Millbrook
- Isle of Wight

M1 WIND HRS

Launched September 2015

- Located on the Advanced Manufacturing Park
- M1 Junc. 33 Rotherham
- H2 Production 80kg/day
- Upgraded to 350 & 700 bar spring 2016
- 24/7 swipe card access

HyFive is an EU funded project which will see hydrogen stations being deployed to European cities as well as 100 fuel cell vehicles from 5 OEM's. ITM Power was awarded three stations, all of which will be 80kg/day refuelling at 700bar. These stations will be deployed in London in Q3 2015.

UK H_2 Mobility

HYFIVE - VEHICLE REFUELLING

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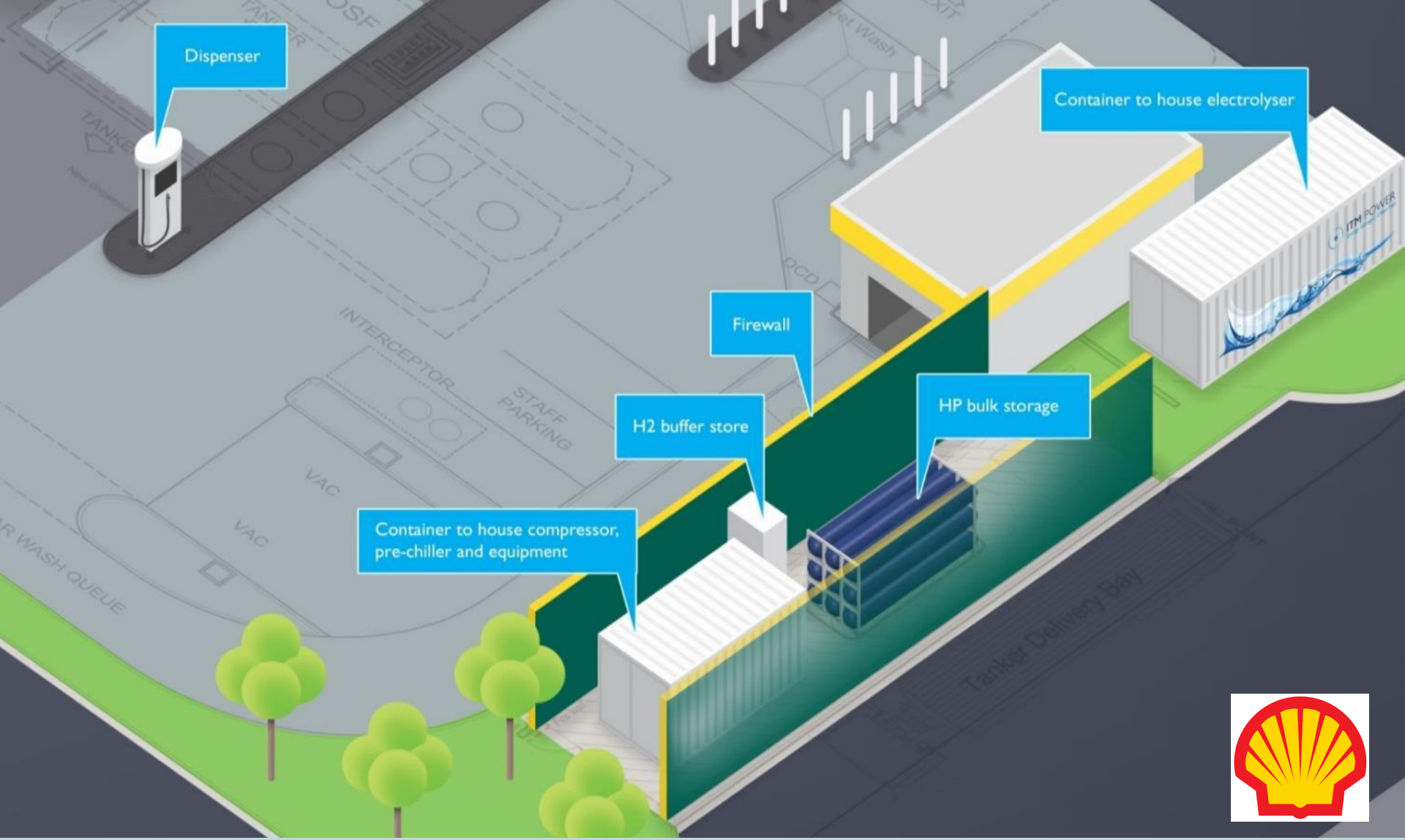
These activities have received funding from the European Union's Horizon 2020 Programme through the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) under grant agreement number 671438.



ON-SITE HYDROGEN PRODUCTION

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REGULATIONS, CODES & STANDARDS

A leading role in shaping hydrogen deployment

- Secretary of BCGA Technical Steering Committee 9
- Secretary and UK Expert to ISO Technical Committee 197
- UK Expert to ISO working groups…
- …for electrolysers, dispensers & H2 quality
- Next Chair of BSI PVE/3/8

Code of Practice 41: H_2 Fuelling Stations
Design & Construction
Maintenance & Operation

ISO 19880-1: H_2 Fuelling Stations
ISO 22734: Electrolyser
ISO 14687: H_2Quality

BSI PVE/3/8: H_2 Systems Standardisation
Production & Storage
Transport, Measurement & Use

HYUNDAI

ITM Power will supply an advanced 100kg/day refuelling station with ability to dispense at both 350 and 700 bar. The station will provide hydrogen for Hyundai's Tucson Fuel Cell fleet and fork lifts. Funded under the Californian CEC programme 2013.

ON-SITE HYDROGEN PRODUCTION

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ITM Power is to supply this 100kg per day station which will be located in Riverside, California. The station will be 33% Renewable and Expandable. The site is already offering existing alternative fuels so it is exciting to be adding hydrogen to the offering. The station will be operational in October 2015.

ON-SITE HYDROGEN PRODUCTION

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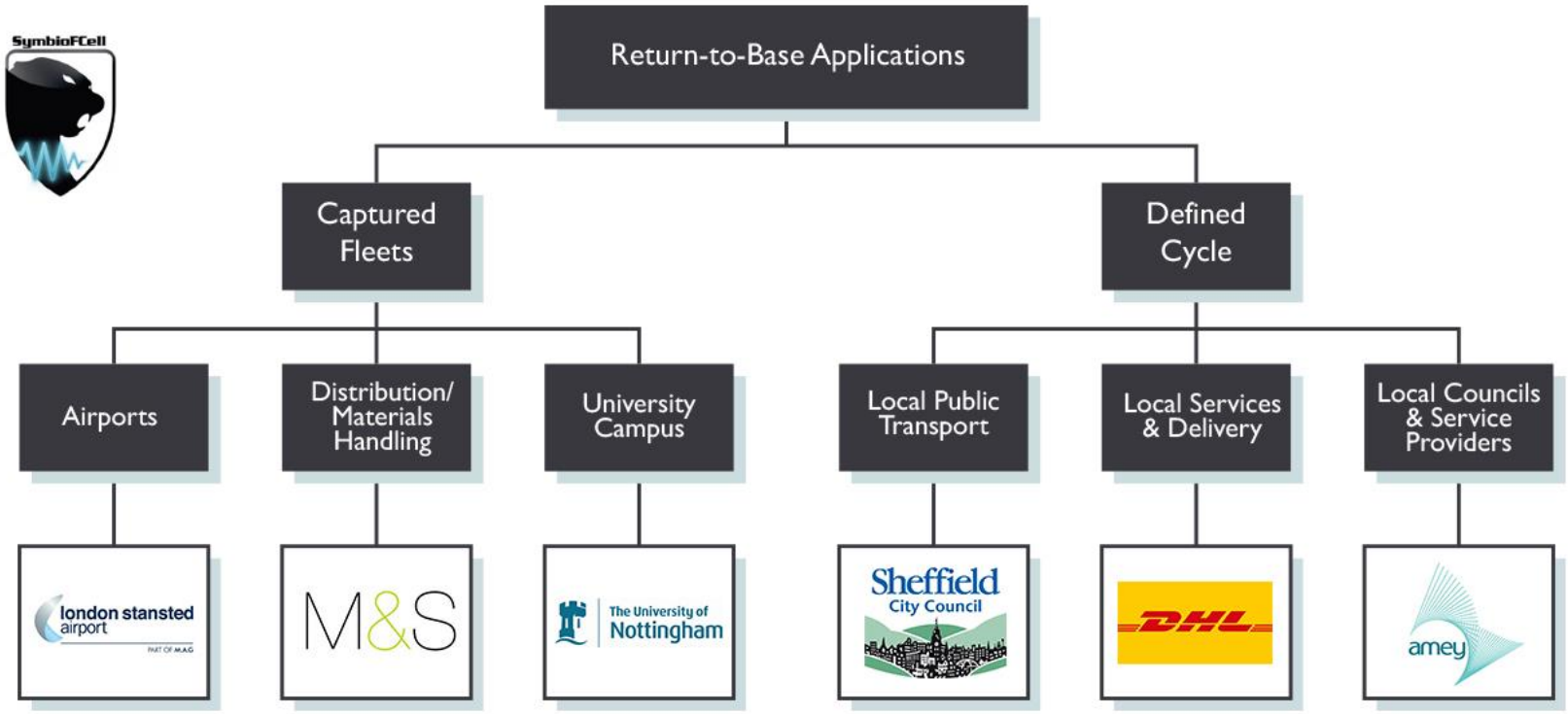
LOCAL CLEAN FUEL: THE EXPERIENCE



ON-SITE FUEL PRODUCTION

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HYKANGOO 5KW RANGE EXTENDER VAN

FC RANGE EXTENDER VAN

HYDROGEN ENERGY SYSTEMS

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A number of bus projects are underway across Europe

CHIC Buses – Over 50 buses

Aargau

5 EvoBus buses

Bolzano

5 EvoBus buses

London

8 Wrightbus buses

Milano

2 EvoBus buses

Oslo

5 Van Hool buses

Cologne

2 APTS buses

2 Van Hool buses

Hamburg

4 EvoBus buses

Whistler

20 NewFlyer buses

3 dedicated Van Hool projects are planned, of which two (**High V. Lo City and HyTransit**) have already deployed vehicles. Total of >40 buses involved.

Aberdeen

10 Van Hool buses

San Remo

5 Van Hool buses

Antwerp

5 Van Hool buses

FCEV BUS COMMERCIALISATION STRATEGY

Published September 2015

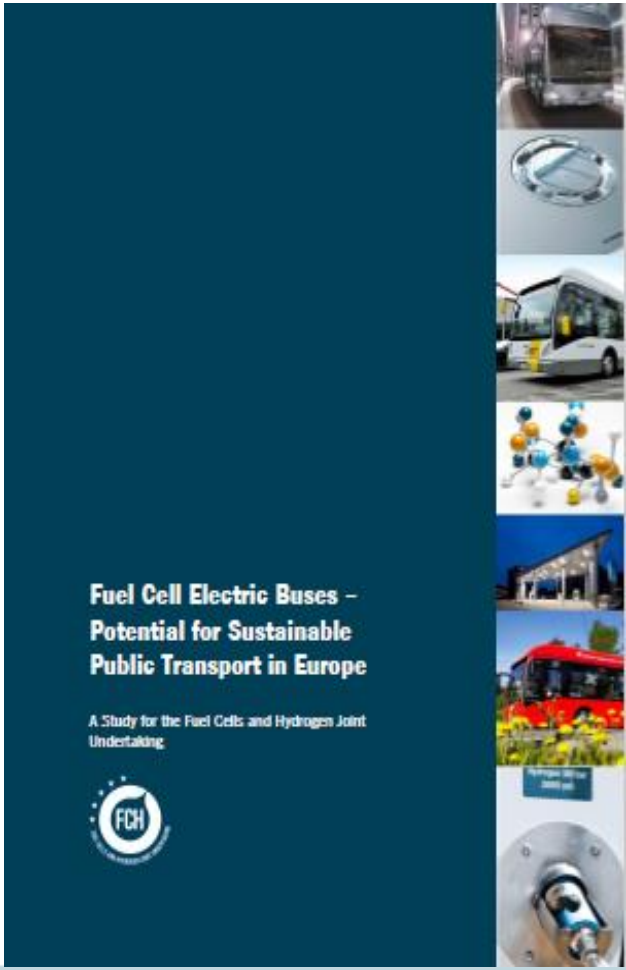
Coalition of stakeholders

- Bus Operators
- Infrastructure OEMs and hydrogen suppliers
- Municipalities
- Bus OEM & Technologies

Summary of Benefits

- Political – the need to reduce urban emissions
- Operational – most flexible zero emission technology option
- Environment – clean emissions
- Economic – Reduce external costs

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING



SUSTAINABLE PUBLIC TRANSPORT

HYDROGEN ENERGY SYSTEMS

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A SUSTAINABLE FUTURE- TODAY

Fuel Cell Cars

- Rapid 3-5 min refuelling
- 400 mile range
- Full power on-demand
- No disruption to normal routine - business or social
- Facilitates rapid adoption

PEM Electrolyser - Green hydrogen

- On-site production – no need for fuel deliveries
- High purity – made from water – “Fuel cell friendly”
- Utilises surplus RES for carbon free fuel
- Compliant, low footprint - forecourt integration
- Key enabling technology for infrastructure roll-out

Meets multiple policy goals - clean air and GHG targets

“THE ROAD TO SUSTAINABILITY”

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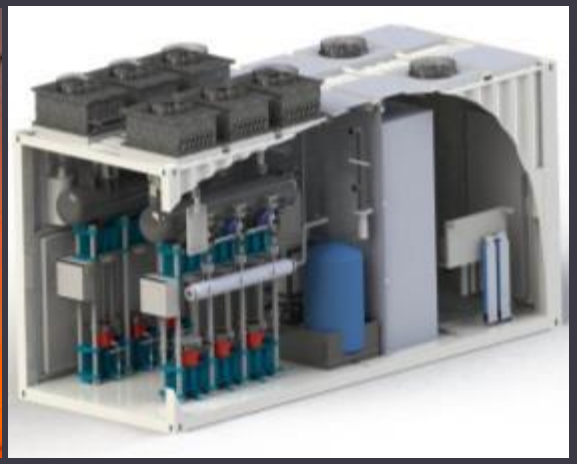

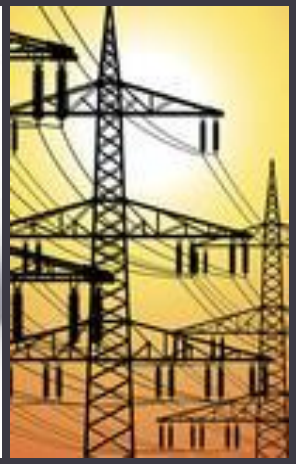

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