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Liquid Hydrogen Safety

Stuart Hawksworth

Head Centre for Energy & Major Hazards, HSE

hySafe

CONTENTS

- Introduction to HSE
- The Role and Perception of Liquid Hydrogen
- International Safety Collaboration
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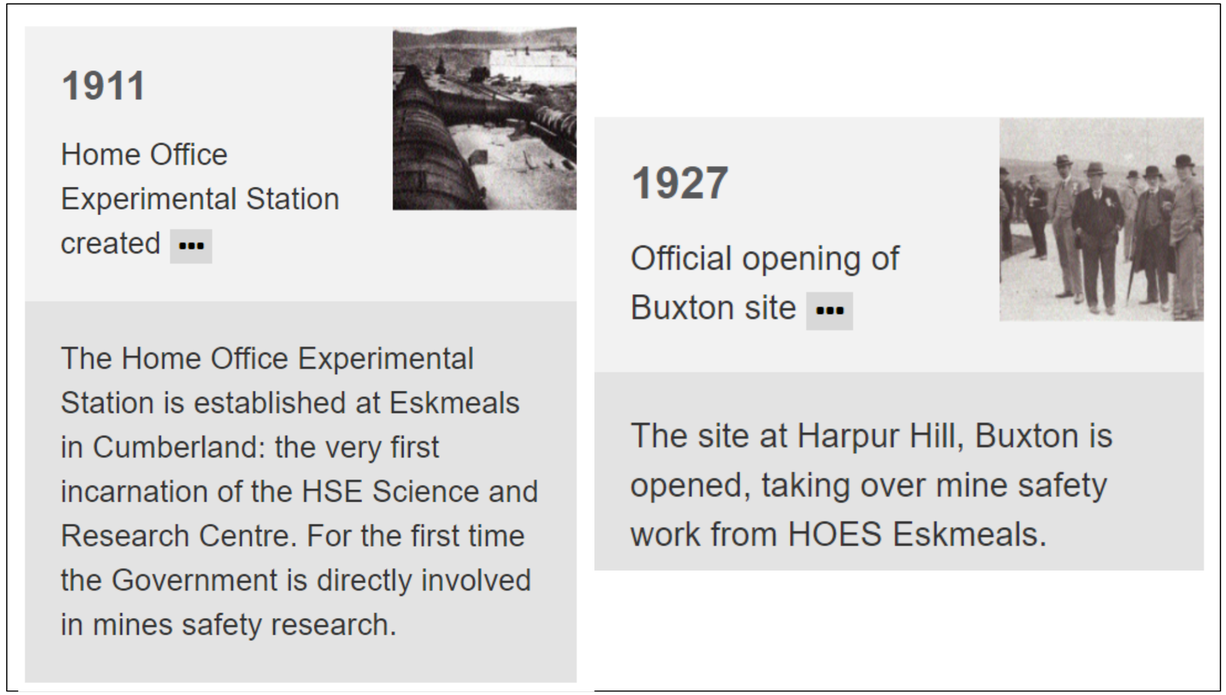
THE HSE SCIENCE AND RESEARCH CENTRE

- 550 acre site in Buxton, Derbyshire
- Laboratory building and outdoor, large-scale testing facilities
- Unique testing capabilities



Role of LH2

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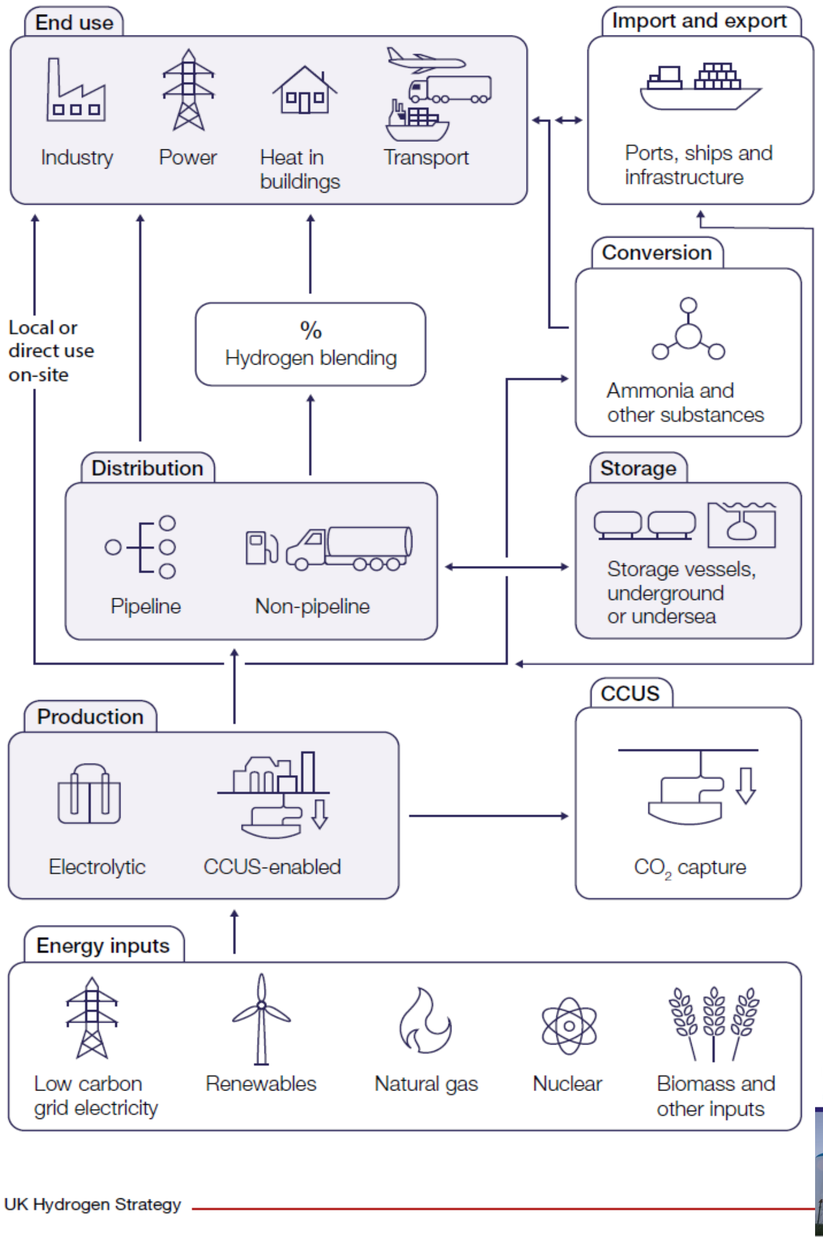
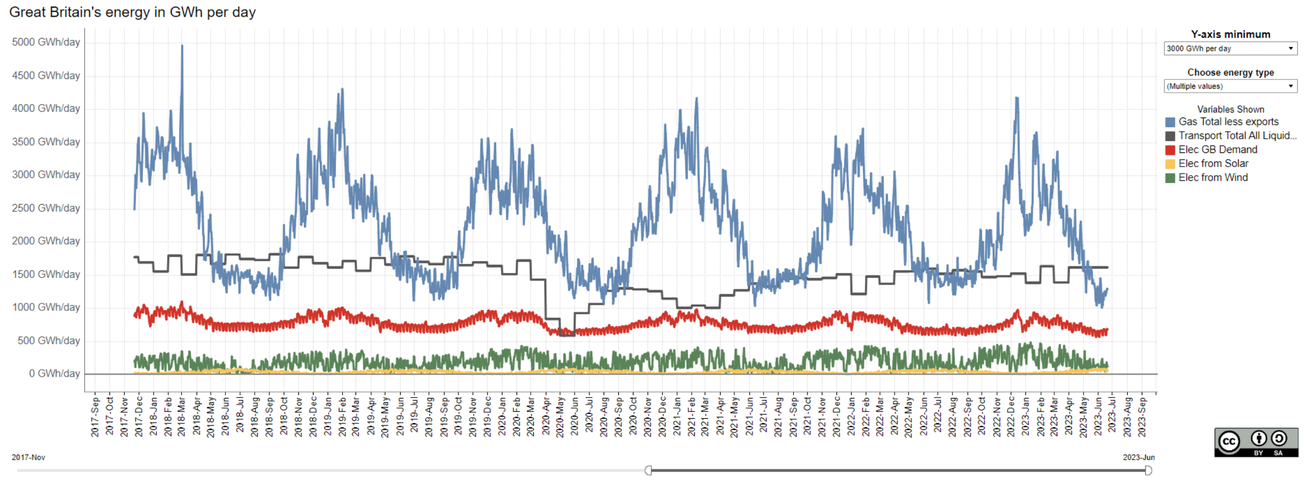
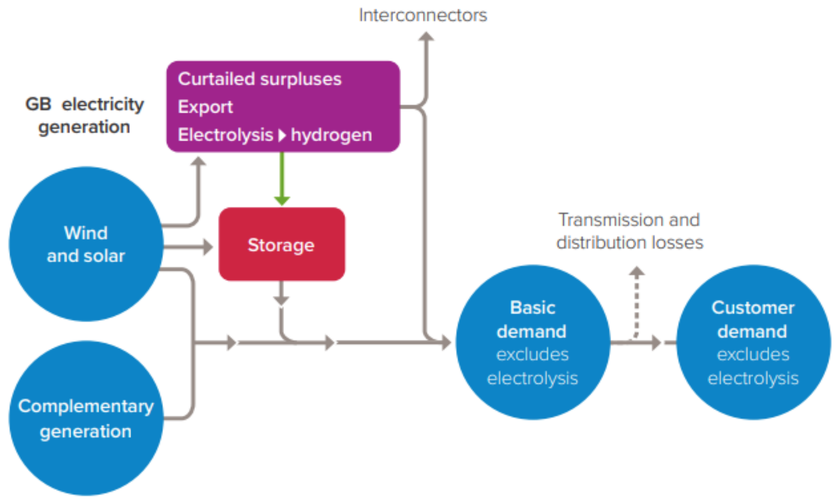
Figure 2: The hydrogen value chain





UNIVERSITY OF BIRMINGHAM | INTERDISCIPLINARY DATA SCIENCE AND AI | BIRMINGHAM ENERGY INSTITUTE

Underlying data are from National Grid ESO, National Gas, Elexon and DESNZ
Figure created by Dr Grant Wilson: i.a.g.wilson@bham.ac.uk
Energy Systems and Data Group, University of Birmingham



Large-scale electricity storage Issued: September 2023 DES8702 ISBN: 978-1-78252-666-7 © The Royal Society

Perception Of LH_2

- Rocket Fuel……. Similar To LNG?
- Established In Certain Applications
- Cold -253 ^{o}C
- The Silver Bullet!
- No Infrastructure?
- Limited “real world data”
- Materials Technology Needs To Develop To Meet Requirements Of New Applications.

HSE PROJECTS TIMELINE

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2000s

HSE sits on the organising committee of the **1st International Conference on Hydrogen Safety** (2005)

HSE publishes first hydrogen research paper 'Spontaneous ignition of hydrogen leaks: A review of postulated mechanisms' (2005)

HSE publishes 'The Hydrogen Economy - Evaluation of the materials science and engineering issues' (2006)

HSE begins work on the HYPER project. IPG for Hydrogen and fuel cell stationary applications. (2006)

H2 Hazards in Nuclear Waste (2007)

HSE publishes research report RR615: review into the spontaneous ignition of hydrogen. (2008)

HSE is a partner in HyApproval . Hydrogen Refuelling Stations. (2008)

Early phase of HSE research into safety of liquid H2 (2008)

HSE is a founding member of the International Association for Hydrogen Safety. (2009)

HSE publishes Research Report 715: 'Installation permitting guidance for hydrogen and fuel cell stationary applications: UK version' (2009)

HSE publishes research report 769: Hazards of liquid hydrogen (2010)

HSE helps the ETI to understand the safe use of hydrogen (gas turbines, reciprocating engines and combined heat & power systems) (2011)

HSE joins advisory board of H2FC Supergen (2012)

HSE partners in Hyindoor project - pre-normative research into the safe indoor use of fuel cells and hydrogen systems (2012)

HSE partners in project SUSANA - , SUpport to SAfety ANalysis of Hydrogen and Fuel Cell Technologies (2013)

HSE partners in FireCOMP - thermo-mechanical behaviour of high pressure vessels when exposed to fire conditions (2013)

HSE publishes research report 986:Releases of unignited liquid hydrogen (2014)

HSE publishes research report 987: Ignited releases of liquid hydrogen (2014)

HSE publishes research report 985: Modelling of liquid hydrogen spills (2014)

HSE publishes research report 1047: Injecting hydrogen into the gas network– a literature search (2015)

2010s

HSE partners in HyDeploy consortium - a pioneering hydrogen energy project designed to help reduce UK CO2 emissions and reach the Government's net zero target for 2050 (2016)

HSE partners in PreslHy - pre-normative research into the safe use of liquid hydrogen (2017)

HSE partners in H21 - a suite of gas industry projects designed to support conversion of the UK gas networks to carry 100% hydrogen (2017)

HSE hosts The Future of Gas conference. (2018)

HSE partners in the Hy4Heat programme - replacing natural gas with hydrogen in residential and commercial buildings and gas appliances. (2018)

HSE publishes research report 1133: Maintaining the integrity of process plant susceptible to high temperature hydrogen attack. Part 1: analysis of non-destructive testing techniques. (2018)

HSE publishes research report 1134: Maintaining the integrity of process plant susceptible to high temperature hydrogen attack. Part 2: factors affecting carbon steels. (2018)

HSE partners in H100 - designed to demonstrate the safe, secure and reliable distribution of 100% hydrogen in our gas network (2019)

HSE hosts The Future of Gas 2 - HSE hosts The Future of Gas 2 at the IET in London. It's the second event in the Safety Excellence in Energy series. (2019)

HSE partners in HyTunnel - pre-normative research for safety of hydrogen driven vehicles and transport through tunnels and similar confined spaces (2019)

2020s

HSE publishes research report 1159: International Association for Hydrogen Safety 'Research Priorities Workshop'. (2020)

HSE partners in HyNTSFutureGrid, - hydrogen test facility to demonstrate the National Transmission System (NTS) can transport hydrogen (2021)

HSE partners in MultHyFuel - to contribute to the effective deployment of hydrogen as an alternative fuel – hydrogen refuelling stations (2021)

HSE hosts Safe Net Zero 2021 - Hydrogen online. (2021)

HSE hosts 'Hydrogen Safety - Achieving Safe Net Zero' webinar (2021)

HSE helps FlyZero via hydrogen safety assessment work (2021)

H2 SAFETY - INTERNATIONAL COLLABORATION

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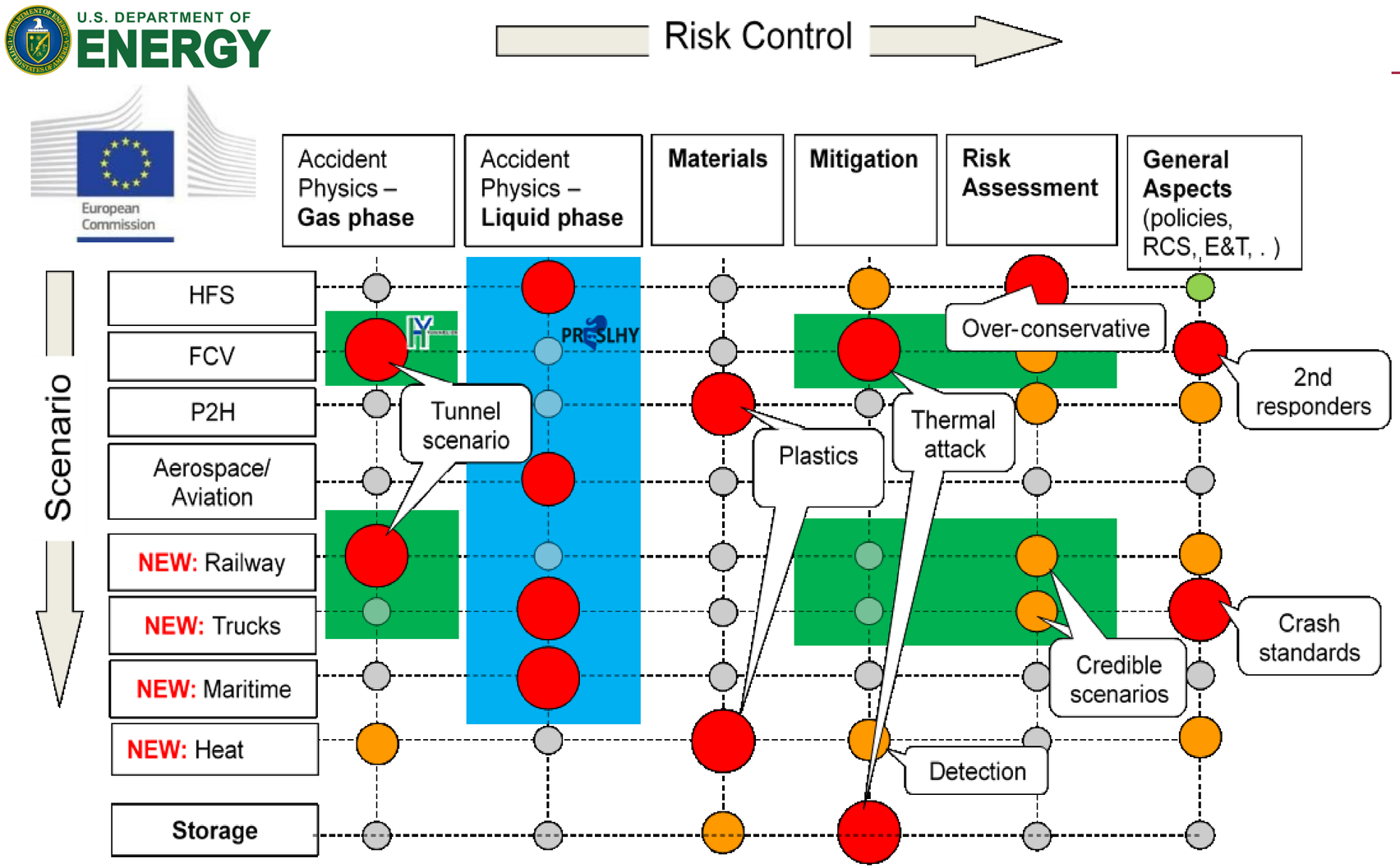


HSE Health and Safety Executive

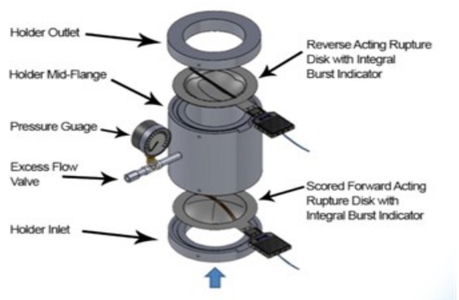
International Association for Hydrogen Safety 'Research Priorities Workshop', September 2018, Buxton, UK

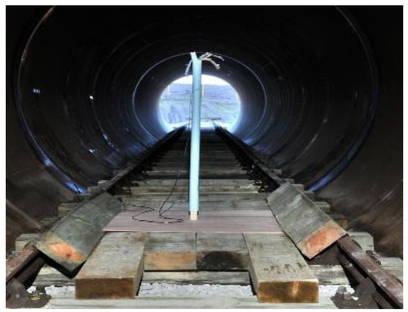
Prepared by the International Association for Hydrogen Safety and partners

RR1159 Research Report

https://www.hse.gov.uk/research/rrhtm/rr1159.htm

- Pre-normative research for safety of hydrogen driven vehicles and transport through tunnels and similar confined spaces
- Inter-disciplinary and inter-sectoral research by a consortium of academia, emergency services, research and standard development organisations
- Releases in a 70 m tunnel assessing mitigation systems, dispersion rates (TPRDs) and explosion prevention
- Effect of jet impingement on tunnel wall and road materials
- Fire engulfment tests on pressurised type IV tanks





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PRESLHY

CONGESTED EXPLOSIONS

THE FLYZERO CONCEPTS

FLY ZERO AEROSPACE TECHNOLOGY INSTITUTE

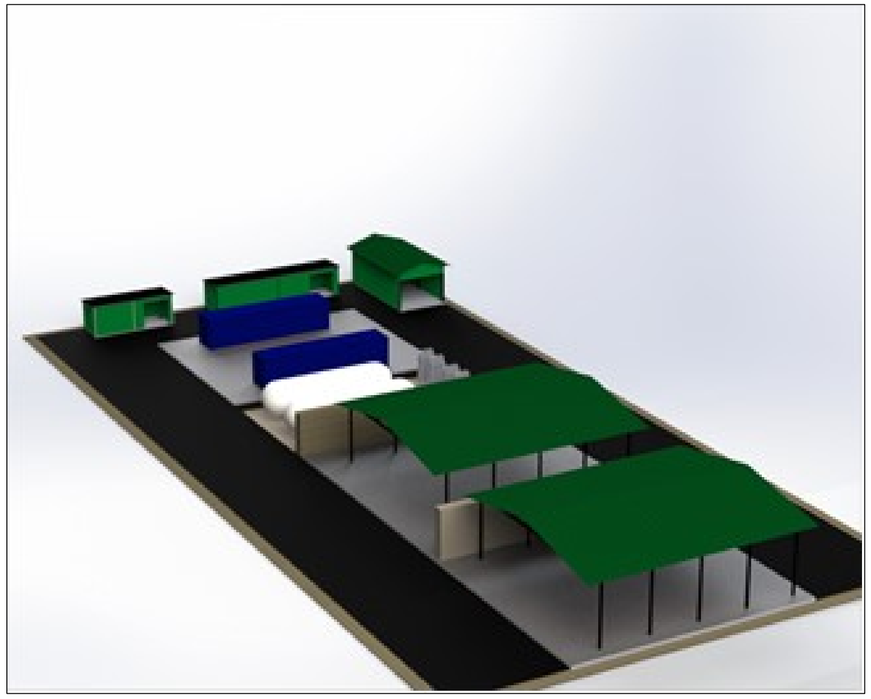
FlyZero concepts have been created to understand the technology potential and developments required.

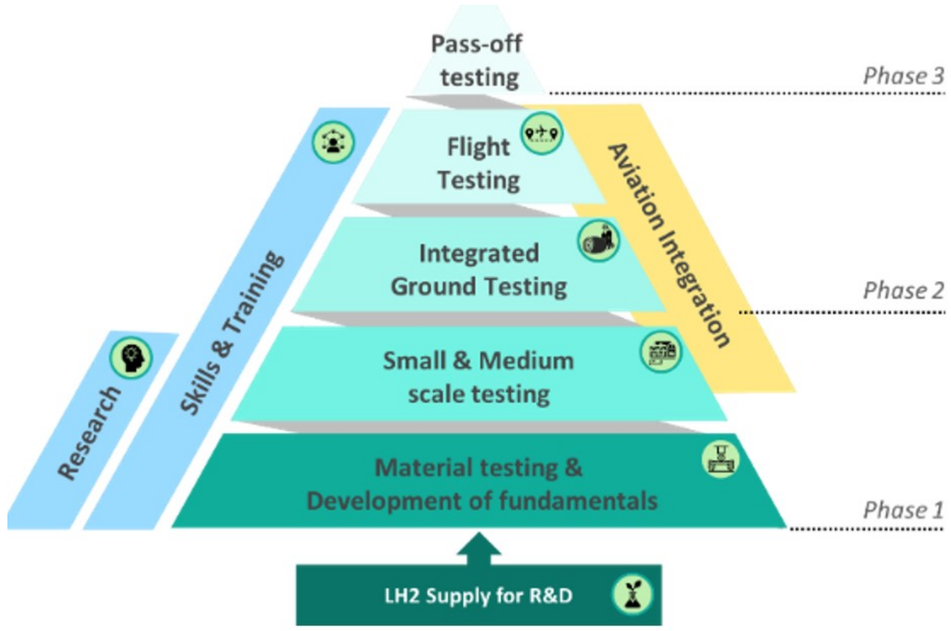
- **Regional FZR:** hydrogen fuel cell electric, 75 passengers, 800 nmi design range (Edinburgh to Prague)
- **Narrowbody FZ-N:** hydrogen gas turbine, 179 passengers, 2,400 nmi design range (Manchester to Tel Aviv)
- **Midsize FZ-M:** hydrogen gas turbine, 279 passengers, 5,750 nmi design range (London to San Francisco)

National LH2 Facility

HSE: National Cryogenic Centre of Excellence Test Facility

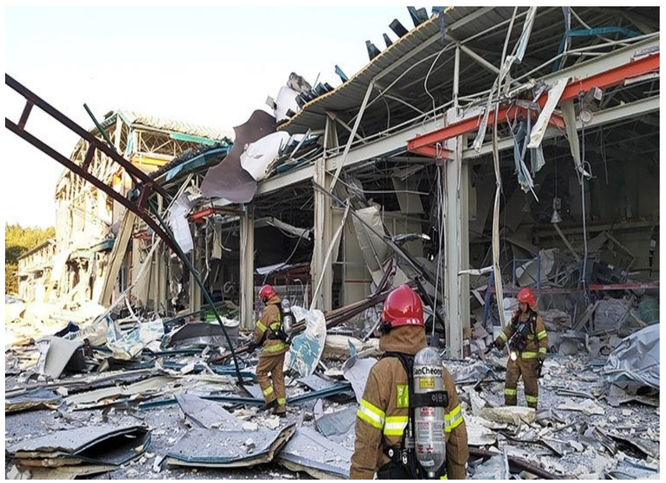
- Liquid Hydrogen
- Gaseous Hydrogen
- Liquid Nitrogen





LH2 SUMMARY

- A Role In Future Energy Supply (20-30% in UK by 2050)
- Help Meet Challenges Of Transport And Large-Scale Storage
- Collaboration and Coordination - Essential!
- Holistic Approach – Standards, Regulations, Training & Skills Need To Keep Up.



Thank You For Listening

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Stuart.Hawksworth@HSE.GOV.UK

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