



FIRE AND BLAST INFORMATION GROUP

WEBINAR 001 PROCEEDINGS

UPDATE ON HYDROGEN RESEARCH AT SPADEADAM

23rd April 2020

Daniel Allason

DNV GL

E: daniel.allason@dnvgl.com

W: www.dnvgl.com



For further information on FABIG Webinar Proceedings or any other FABIG activities, please contact:

Guillaume Vannier

SCI

Silwood Park

Ascot, Berkshire SL5 7QN

United Kingdom

T: +44 (0) 1344 636 579

E: fabig@steel-sci.com

www.fabig.com



Hydrogen @ Spadeadam Research and Testing

Dan Allason, DNV GL



Historic Projects

AIR PRODUCTS



OSAKA GAS GROUP

Current Projects



H2I NIC – Phase 1



FFI Forsvarets
forskningsinstitutt
Norwegian Defence Research Establishment

Future Projects



H2I Phase 2/H2I Field Trials



LH2@SCALE

Air Products / NaturalHy Transmission Fires



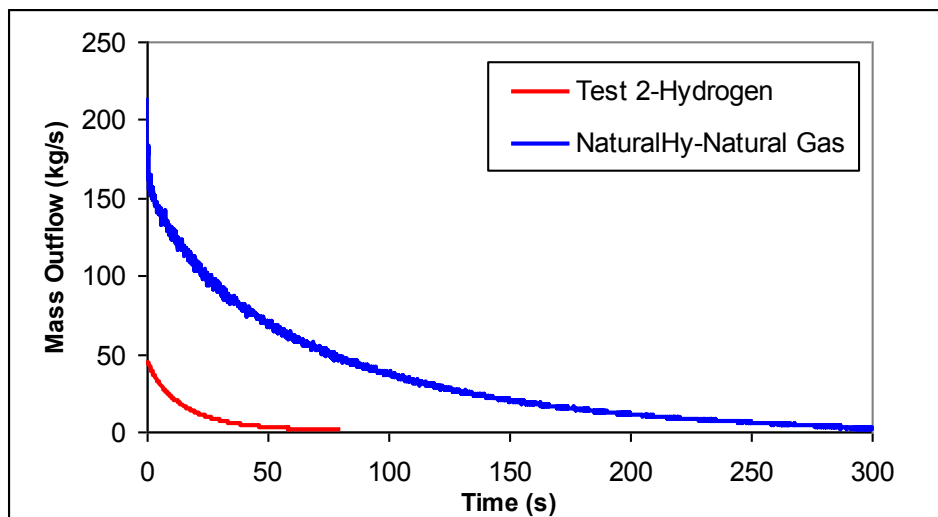
- Transmission releases up to 150mm double ended @ 70bar
- Outflow, thermal and overpressure measurements



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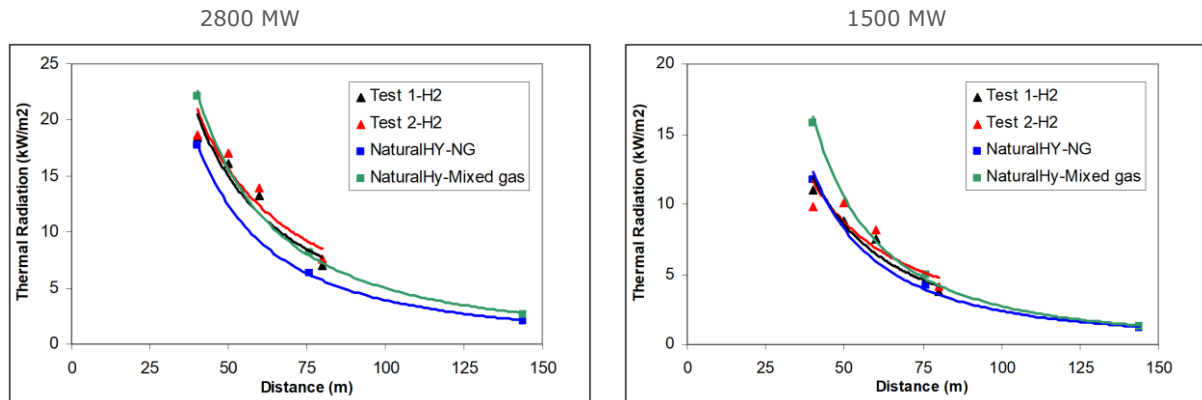
AP / NaturalHy Transmission Fires: Key Finding



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Air Products Hydrogen Transmission Fires: Key Findings



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Osaka Gas Filling Station Project



- Full scale filling station and plant room
- Culmination of more idealised explosion experiments

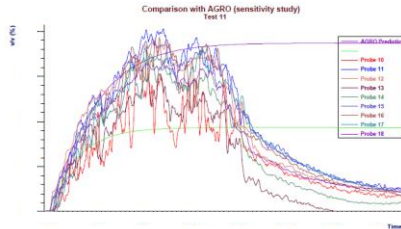
- Release pressure of 100bar, nozzle sizes up to 1.6mm (flow up to 20 g/s)
- Partially ventilated enclosure, monitored accumulation / venting



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Osaka Gas Filling Station Project: Headlines



- Accumulation largely predictable by existing phenomenological models
- No real surprises when compared to other buoyant gases (e.g. NG)

- Explosions range from benign to extreme for relatively minor changes in ventilation, outflow rate, confinement and congestion



8% H₂



26% H₂

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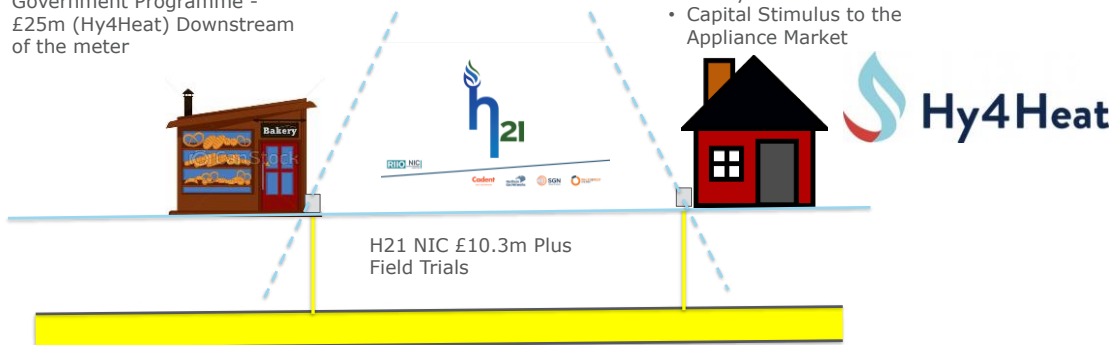
Introduction to the Current projects: H21 and Hy4Heat



Government Programme -
£25m (Hy4Heat) Downstream
of the meter

Government Programme -
£25m (Hy4Heat) Downstream
of the meter

- Safety evidence
- Capital Stimulus to the
Appliance Market



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HyStreet: A Distribution and Domestic Gas Research Facility



Network



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HyStreet



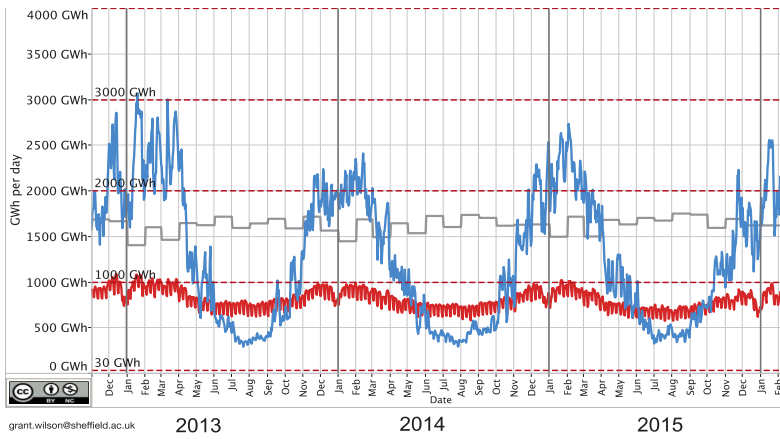
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Location



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H21: Motivation



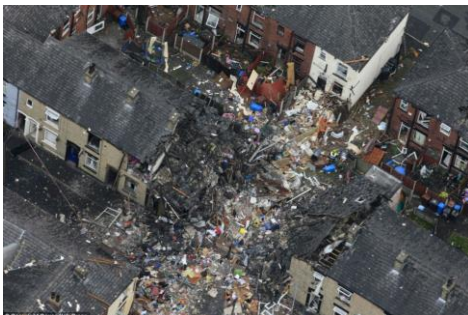
- UK Government now committed to net-zero by 2050
- Energy needs must be met
- Gas infrastructure most suited
- Must be shown to be of manageable risk (i.e. equal or lower to natural gas)

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H21: Phase 1B Methodology

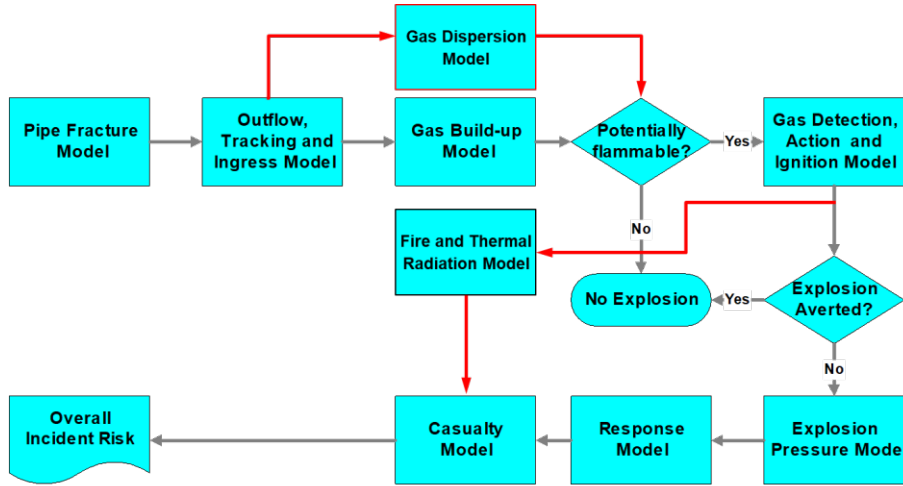
- Risks of Natural Gas Distribution known and managed
- Current predictive methodologies can be measured against statistics => risks can be quantified, mitigated and accepted
- How does a change to Hydrogen impact this?



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H21: Phase 1B Methodology



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H21 WBS1: Small Releases

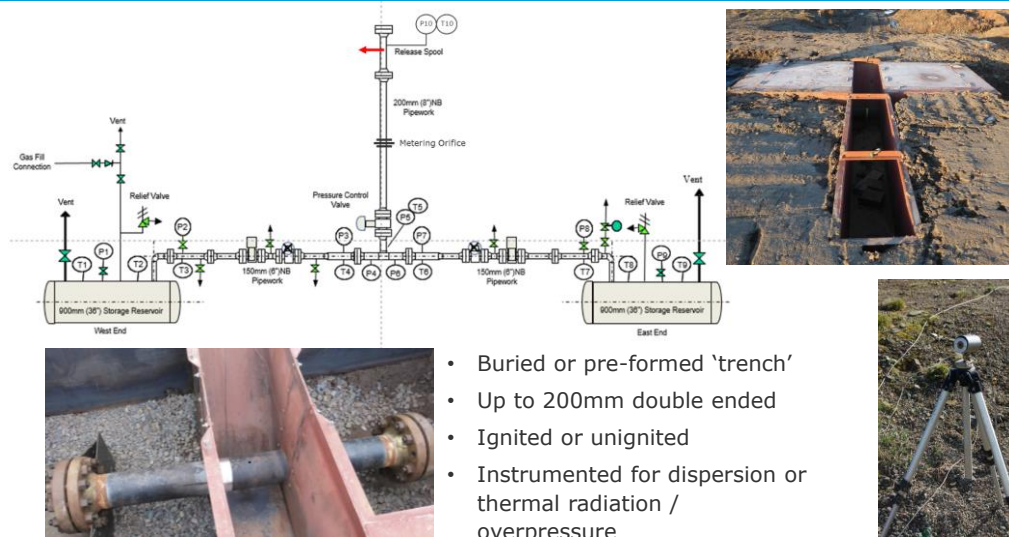


Test ID	Diameter (mm)	Orientation	Mflow (SLPM measured)	Gas	SP01	SP02	SP03	SP04	SP05	SP06	SP07	SP08	SP09	SP10	SP11	SP12	SP13	SP14	SP15	SP16	SP17	SP18	SP19	SP20	SP21	SP22	SP23	SP24	SP25
SRA02	20	Side		methane																									
SRA01	20	Side		hydrogen																									
SRA03	20	Side		methane																									
SRA04	20	Side		hydrogen																									
SRA06	20	Side		methane																									
SRA07	20	Side		methane																									
SRA05	20	Side	▼	hydrogen																									

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H21 WBS2: Large Releases



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H21 WBS2: Presented at ICHS 2019

All open excavation experiments, upwards from 20mm hole:

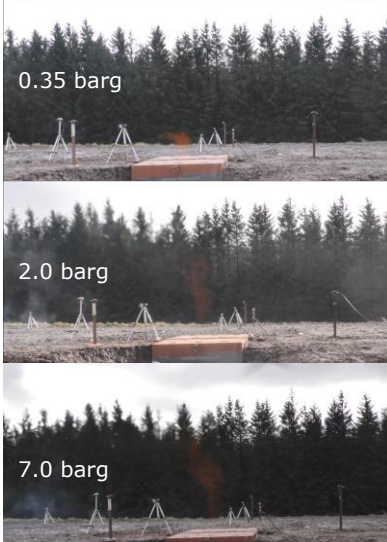
Test ID	Diameter (mm)	Orientation	Outlet Pressure (barg)	Outlet Pressure (stdev)	Mflow (kg/s)	Mass Flow (stdev)	Power (kW)
LR051	20	Up	0.355	0.003	0.019	0.0002	2482
LR053	20	Up	1.973	0.014	0.048	0.0005	6055
LR055	20	Up	7.447	0.080	0.146	0.0031	17245
LR055R	20	Up	6.684	0.100	0.135	0.0019	15679

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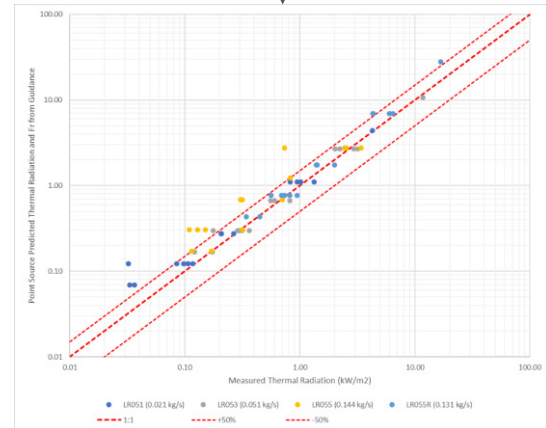


H21 WBS2: Presented at ICHS 2019



$$I = \frac{QF_r}{4\pi r^2}$$

Very simple point source check



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H21 WBS3: Ignition Testing



- Items relevant to incident response prioritised
- Established fact that H2 << NG MIE
- Here aim is to investigate real devices and 'Ignition Potential'

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H21 WBS4: Explosion Severity

- Limited explosion studies
- Concerned with finding show-stopping events in likely scenarios
- None found in cases considered



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H21 WBS5: Operational Safety

- Flow loop commissioned for demonstrations of network operations:
 - Purging / venting
 - Flow stopping
 - Excavation



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Hy4Heat WP7: Lots 2 and 3



- Concerned with domestic leakage downstream of ECV
- Room Level Leakage and Property Level Leakage



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Release Points



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Control and Metering



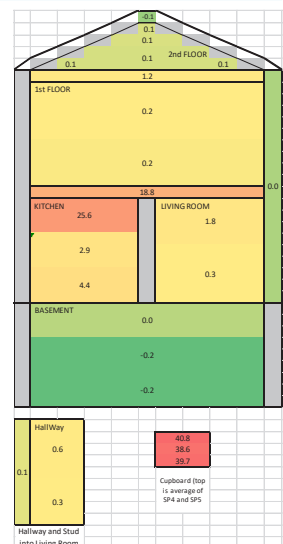
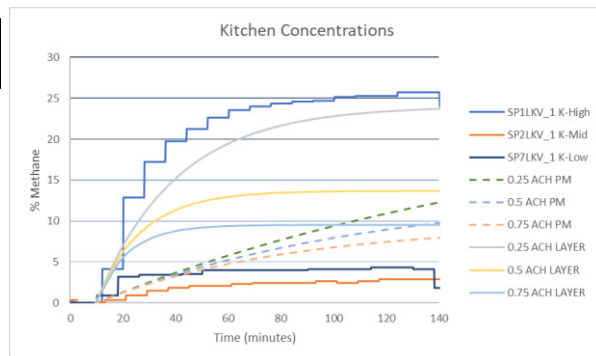
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Simple Model: Versus Methane

$$C = \left(\frac{100Q_g}{Q_a + Q_g} \right) \left\{ 1 - \exp \left[- \left(Q_a + Q_g \right) t / V \right] \right\}$$

Room Length	5	m
Room Width	3	m
Room Height	2.4	m
Leak Height	2.0	m



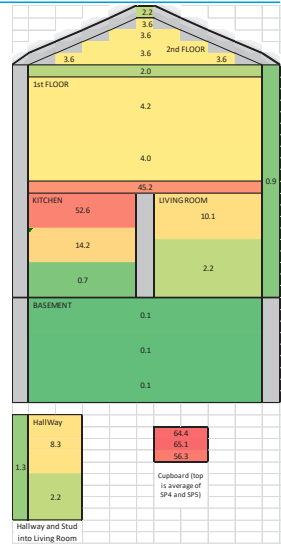
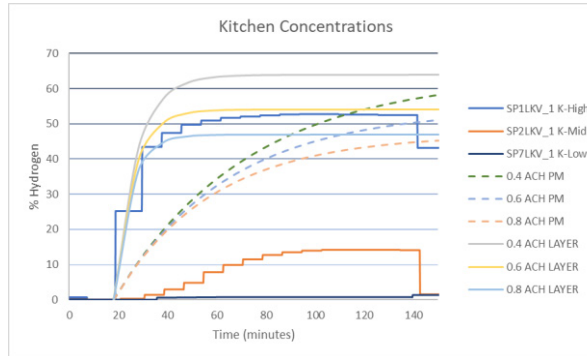
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Simple Model: Versus Hydrogen

$$C = \left(\frac{100Q_g}{Q_a + Q_g} \right) \left\{ 1 - \exp \left[- \left(Q_a + Q_g \right) t / V \right] \right\}$$

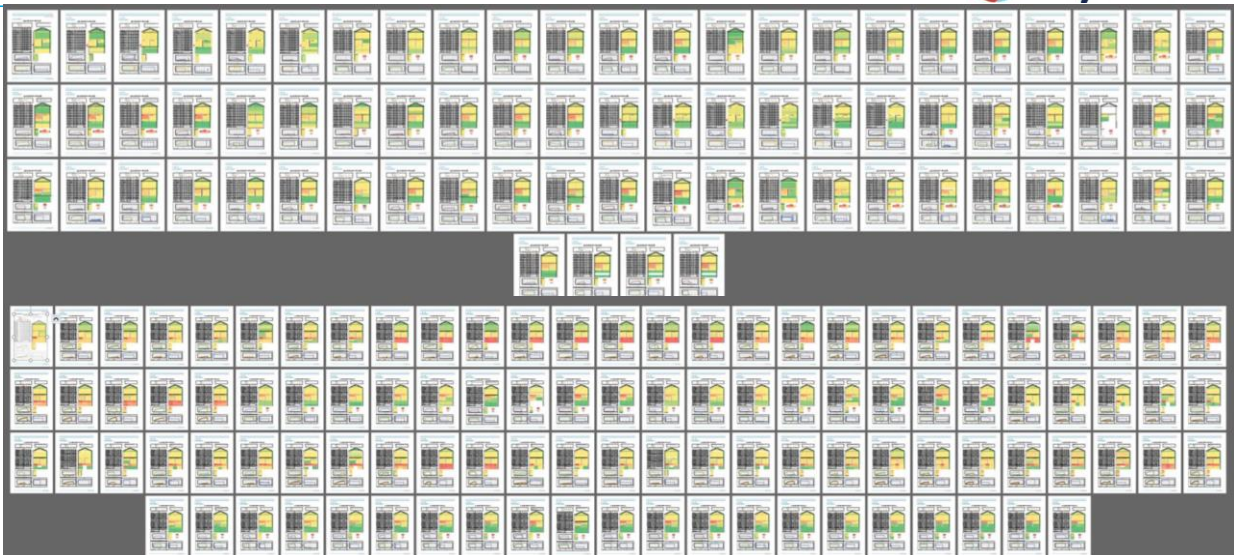
Room Length	5	m
Room Width	3	m
Room Height	2.4	m
Leak Height	2.0	m



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All Tests



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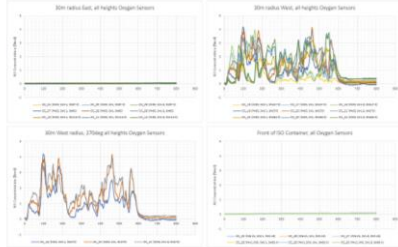
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Relevant Experience: LH₂ (FFI)

FFI Forsvarets
forskningsinstitutt
Norwegian Defence Research Establishment

Gas Concentrations

Time (s)	CH ₄ (%)	O ₂ (%)	CO (%)	CO ₂ (%)	H ₂ (%)
0	0.0	20.9	0.0	0.0	0.0
10	0.0	20.9	0.0	0.0	0.0
20	0.0	20.9	0.0	0.0	0.0
30	0.0	20.9	0.0	0.0	0.0
40	0.0	20.9	0.0	0.0	0.0
50	0.0	20.9	0.0	0.0	0.0
60	0.0	20.9	0.0	0.0	0.0
70	0.0	20.9	0.0	0.0	0.0
80	0.0	20.9	0.0	0.0	0.0
90	0.0	20.9	0.0	0.0	0.0
100	0.0	20.9	0.0	0.0	0.0
110	0.0	20.9	0.0	0.0	0.0
120	0.0	20.9	0.0	0.0	0.0
130	0.0	20.9	0.0	0.0	0.0
140	0.0	20.9	0.0	0.0	0.0
150	0.0	20.9	0.0	0.0	0.0
160	0.0	20.9	0.0	0.0	0.0
170	0.0	20.9	0.0	0.0	0.0
180	0.0	20.9	0.0	0.0	0.0
190	0.0	20.9	0.0	0.0	0.0
200	0.0	20.9	0.0	0.0	0.0
210	0.0	20.9	0.0	0.0	0.0
220	0.0	20.9	0.0	0.0	0.0
230	0.0	20.9	0.0	0.0	0.0
240	0.0	20.9	0.0	0.0	0.0
250	0.0	20.9	0.0	0.0	0.0
260	0.0	20.9	0.0	0.0	0.0
270	0.0	20.9	0.0	0.0	0.0
280	0.0	20.9	0.0	0.0	0.0
290	0.0	20.9	0.0	0.0	0.0
300	0.0	20.9	0.0	0.0	0.0
310	0.0	20.9	0.0	0.0	0.0
320	0.0	20.9	0.0	0.0	0.0
330	0.0	20.9	0.0	0.0	0.0
340	0.0	20.9	0.0	0.0	0.0
350	0.0	20.9	0.0	0.0	0.0
360	0.0	20.9	0.0	0.0	0.0
370	0.0	20.9	0.0	0.0	0.0
380	0.0	20.9	0.0	0.0	0.0
390	0.0	20.9	0.0	0.0	0.0
400	0.0	20.9	0.0	0.0	0.0
410	0.0	20.9	0.0	0.0	0.0
420	0.0	20.9	0.0	0.0	0.0
430	0.0	20.9	0.0	0.0	0.0
440	0.0	20.9	0.0	0.0	0.0
450	0.0	20.9	0.0	0.0	0.0
460	0.0	20.9	0.0	0.0	0.0
470	0.0	20.9	0.0	0.0	0.0
480	0.0	20.9	0.0	0.0	0.0
490	0.0	20.9	0.0	0.0	0.0
500	0.0	20.9	0.0	0.0	0.0



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The Future



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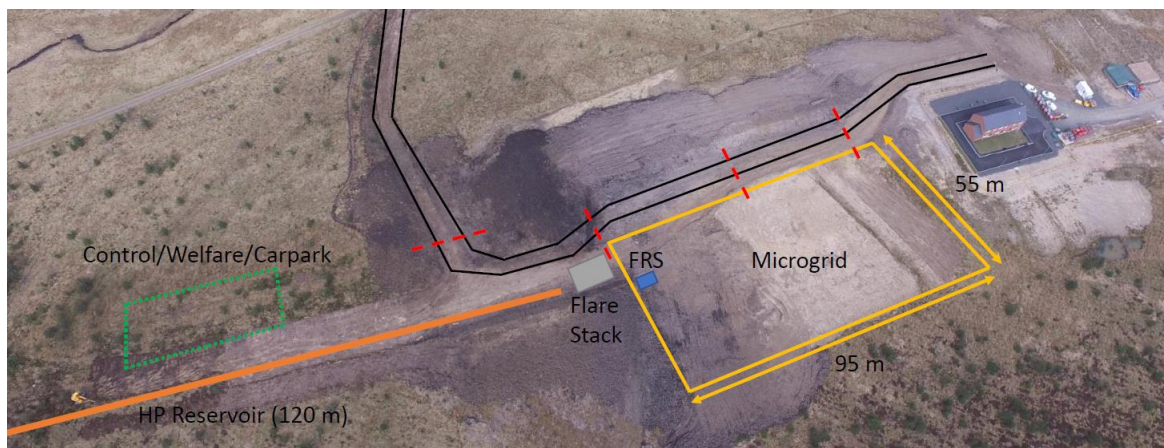
The Future



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H21 Phase 2: Microgrid

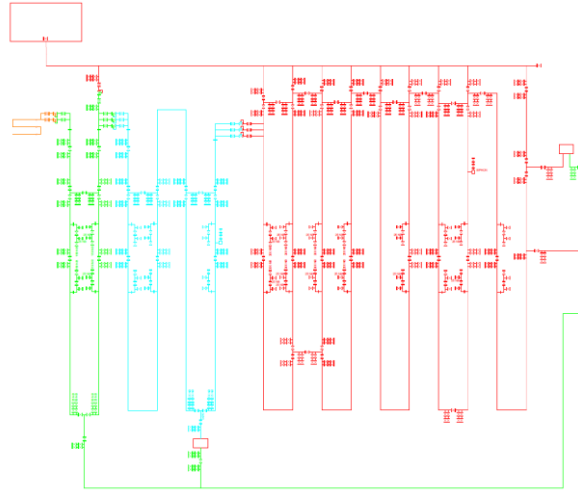


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H21 Phase 2: Microgrid

- HP, IP, MP, LP
- Various diameters
- Flow Assurance
- Operational Assurance
- Prove conversion



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HyNTS Future Grid (ISP only)

HyNTS Transmission Test Rig Vision

This ambitious programme puts our stakeholder's needs at the heart of the Hydrogen challenge. Providing an innovative testing facility that allows the design, testing and demonstration of Hydrogen within the NTS in order to facilitate Live Hydrogen Transportation on the NTS and achieve Net Zero 2050 targets to decarbonise the UK.

Phase 1 NTS Mini Rig

Using decommissioned NTS assets to build a complete NTS Mini Rig that allows the testing of Entry and Exit Points, Filters, Valves, Meters and Pre-Heaters with 10%, 20% and 100% Hydrogen in Methane Mixes.

Duration
April 2021 – 2023

Funding
NIC 2020 Bid

Phase 2a Deblending

Trialing separation technologies such as Cryogenics and Membrane to demonstrate the capabilities to transport a Hydrogen / Methane mix and separate these at offtakes to provide a flexible gas supply.

Duration
2022 – 2024

Funding
BEIS Funding Competition

Phase 2b Compression

Assessing the impact on compressors of transporting and processing Hydrogen and testing the capability and impact of driving the compressors using Hydrogen as the fuel source.

Duration
2022 – 2024

Funding
BEIS Funding Competition

Phase 3 3rd Party Test

Opening up the Test Rig facility for a wider range of Third Party Testing, operating a number of innovation projects that allow manufacturers to trial new technologies and assess the impact of Hydrogen on their assets.

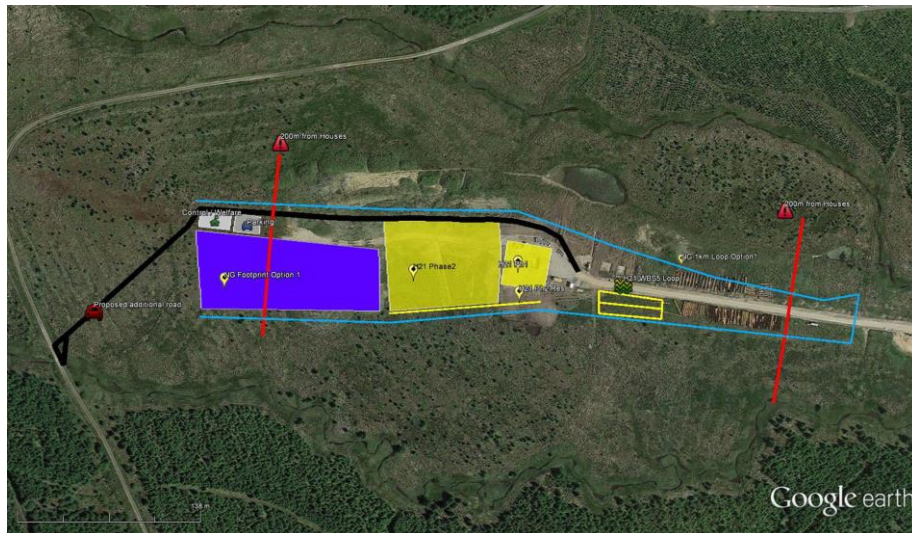
Duration
2023 Onwards

Funding
Various Innovation Funds

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Potential Future Position



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LH2@SCALE

- Looking for partners to join a Joint Industry Project
- Experimentation, modelling, validation and potential tool creation
- Investigate liquid hydrogen phenomena at more representative scales than have been considered before:
 - Outflow, pressure drop, two-phase behaviour
 - Pooling, dispersion, accumulation, ventilation
 - Fire, explosion, BLEVE
 - Effects on materials
 - Other H₂ based fuels?
- Currently canvassing for scope and partners



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Thanks for your attention!

Questions?



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Baker Hughes	Valentina Bisio
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BP	Bart Baillievier Andre Bec Richard Cousins Armin Ghadak David Heavens Franklin Salazar Tony Tate
Chevron	Aliya Batyrova Ganesh Mohan Sreeraj Nair
Chiyoda Corporation	Michiyo Kato
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TechnipFMC	Anousone Champassith Jerome Hocquet Victor Tomsa
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TGE Gas Engineering	Stephen Mclachlan Jessica Scheidt Samantha Walter Xuesong Zheng
Thornton Tomasetti	Tim Ashworth Peter Johnson Saffron Wyse
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