



Numerical modelling of hydrogen leakages in confined spaces for domestic applications

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Introduction

Why Hydrogen

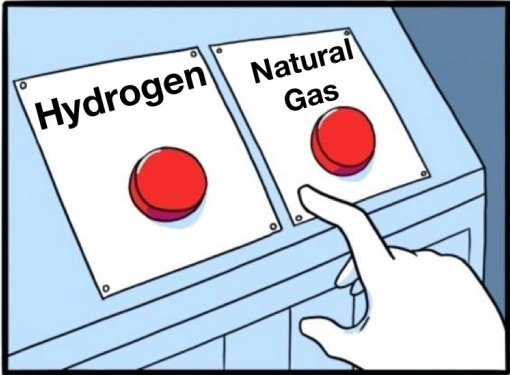


Policy paper
**Hydrogen net zero investment roadmap:
leading the way to net zero**
Updated 27 February 2024

**£69 million boost for hydrogen at
Cranfield**
Published 26 Mar 2024

UK’s largest investment in engineering and physical sciences training will enable Loughborough to build green hydrogen workforce of the future

13 March 2024



Property/Gas	Hydrogen	Natural Gas (Methane)
Energy Density	120 MJ/kg	50-55 MJ/kg
Combustion products	Water	Carbon dioxide
Global Warming Potential of combustion products	0.0005	1
Ignition Energy	0.019mJ	0.3mJ

UK shelves plan for country’s biggest hydrogen home heating trial
Decision deals blow to efforts to use the gas in move to net zero

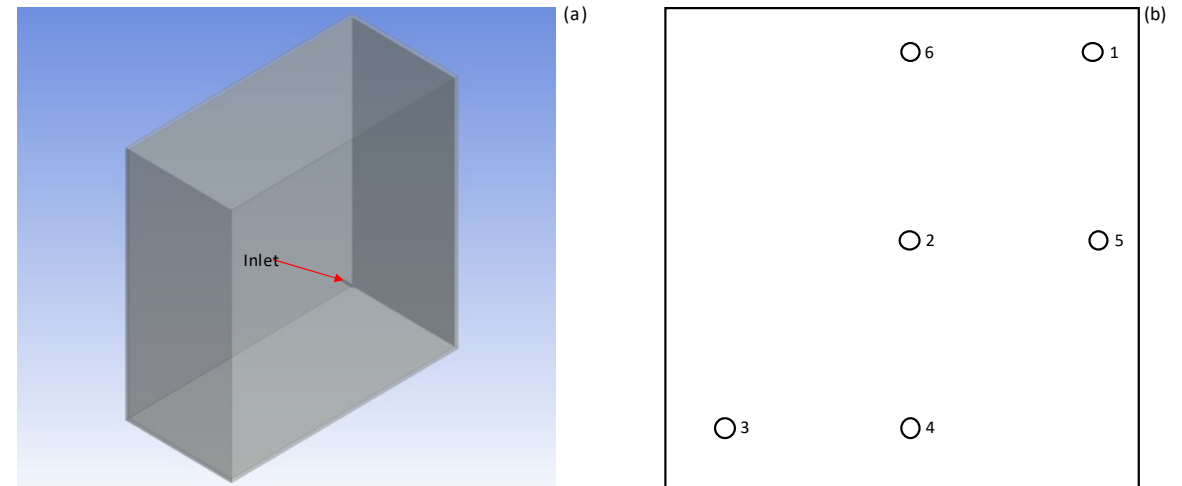
UK struggling to get hydrogen home heating trials off the ground

In another blow to the UK Government’s plans to decarbonise heating through the use of hydrogen, plans to trial a “hydrogen neighbourhood” in Scotland look set to be delayed until at least 2025.

Government fears legal backlash over early hydrogen heat decision

Aim and Objectives

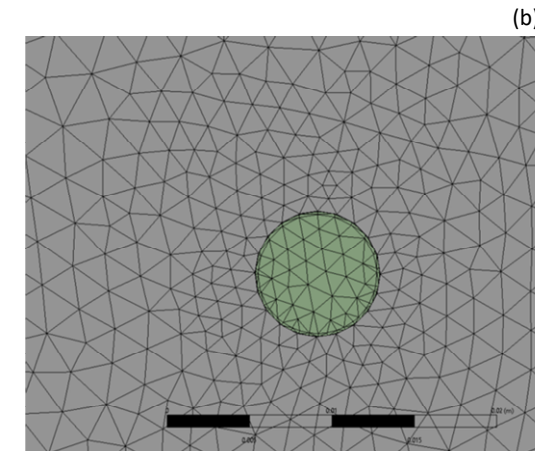
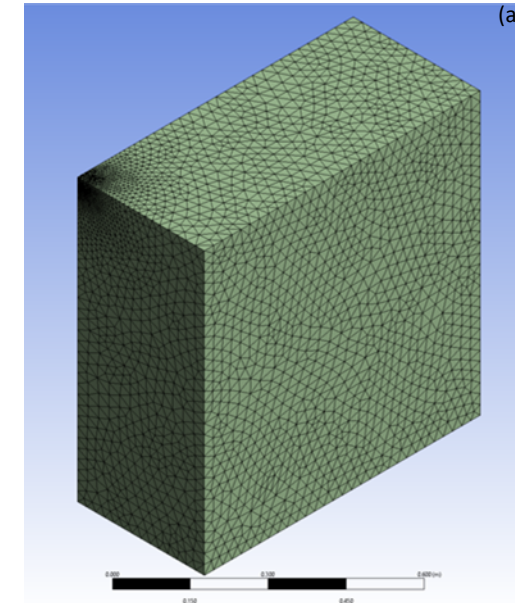
- Use numerical modelling to identify key differences between hydrogen and methane during leakage scenarios in small, confined spaces (i.e., a wall cupboard in a kitchen)
 - Comparison of gas leakage based on concentration
 - Influence of gas leak diameter (1.8mm – 7.2mm)
 - Influence of gas leak location within the space



Visualisation of cupboard geometry using (a) isometric view of the cupboard; and (b) Location of different gas inlets on the back face of the cupboard

Model Setup

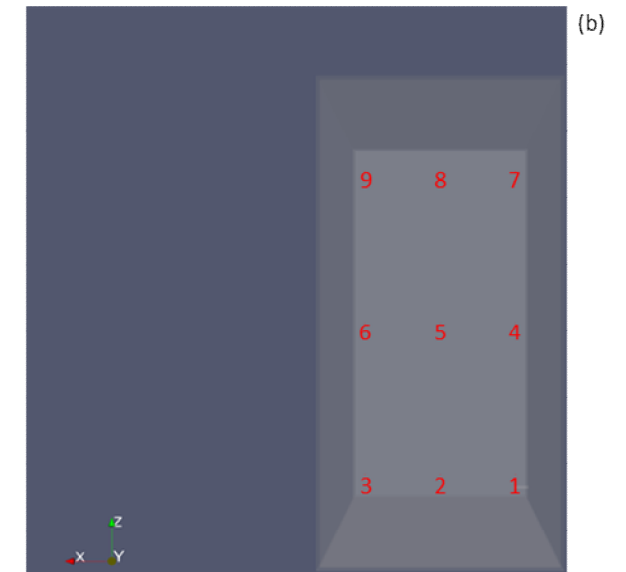
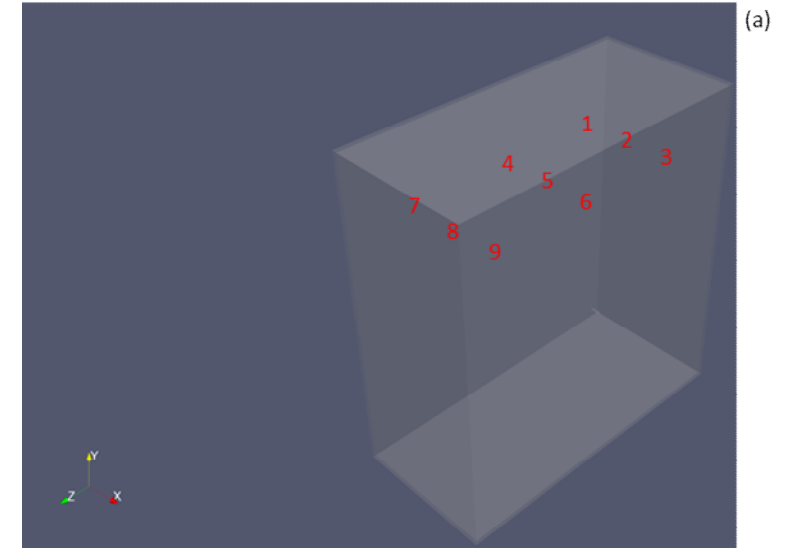
- k- ϵ equations used for simulating turbulent flow of gases
- First 10 minutes of leakage scenario considered
- Assumptions:
 - No venting in the cupboard
 - Gas mixtures (methane-air; hydrogen-air) do not react
 - No temperature change



Representative mesh for (a) Graded mesh for fluid domain to allow for visualisation of gas leak; and (b) Gas inlet (green).

Data Collection and Post Processing

- Gas concentration measured based on mole fraction
- 9 probe locations towards the top of domain
- Arithmetic mean of all locations used to estimate gas concentration

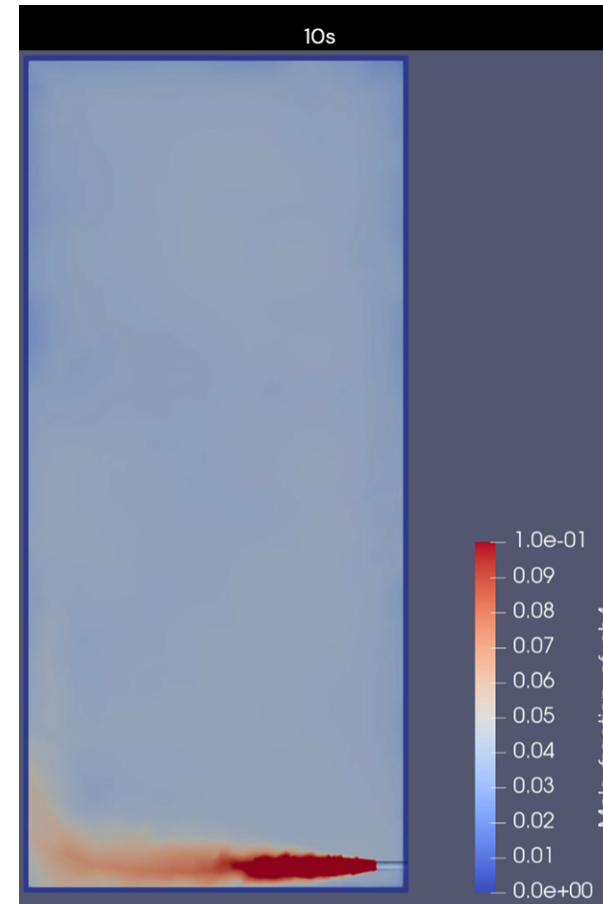


(a) Isometric view; and (b) Top View of the cupboard geometry to mark the locations of point probes (Labelled 1-9) for gas concentration measurement.

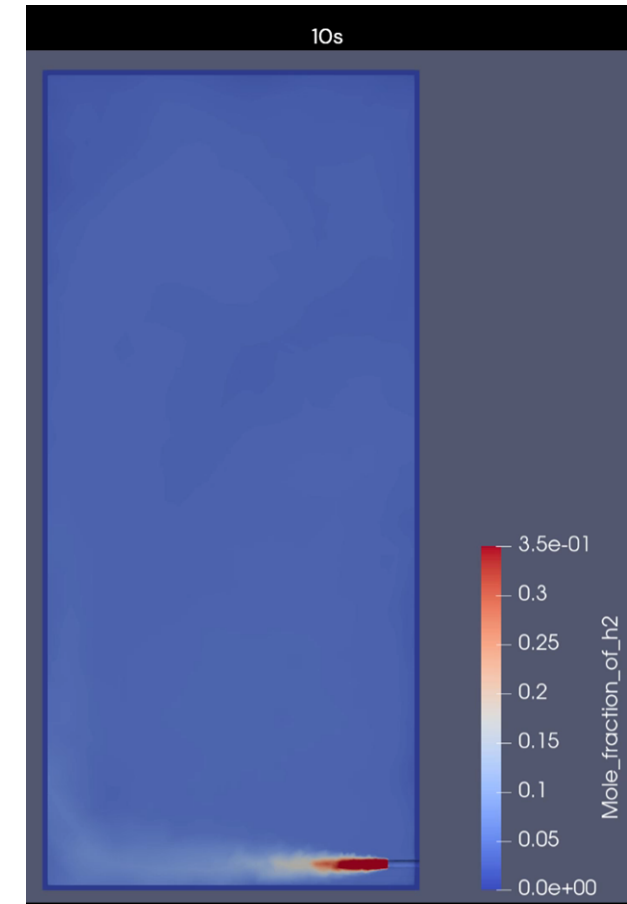
Results and Discussion

Observations about Gas Leakage

- Momentum driven flow of gases
- Stratification of gas observed as time progresses
- Hydrogen has higher concentration in air after 600s (10 minutes)



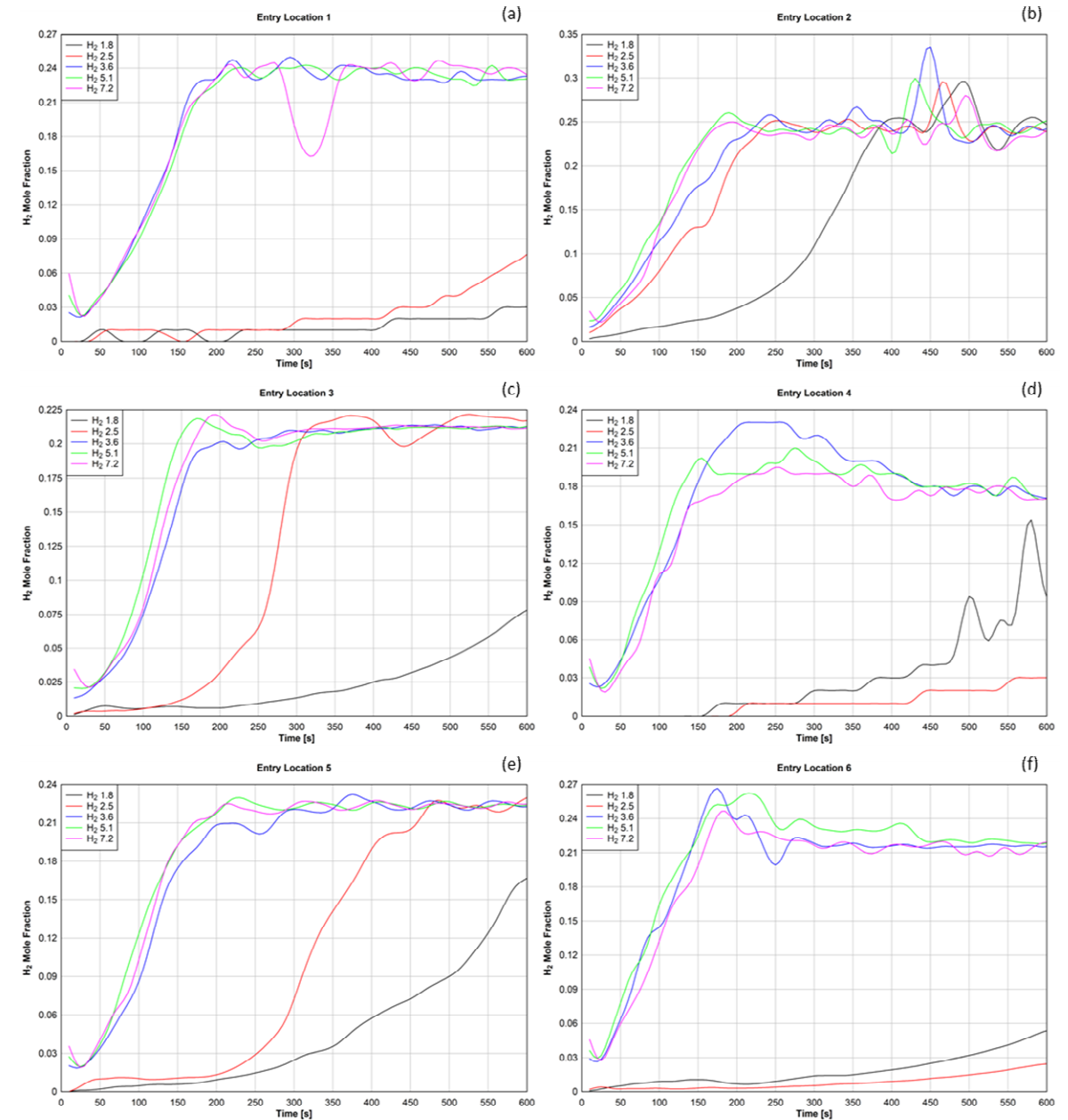
Methane Leak



Hydrogen Leak

Gas Leaks - Hydrogen

- Maximum concentration between 20-30% in air
- Maximum concentration reached between 150-350s
- The leak location influenced the maximum concentration measured in the domain
- Gas leaks from non-corner locations reached maximum concentration 45s faster than corner leak locations



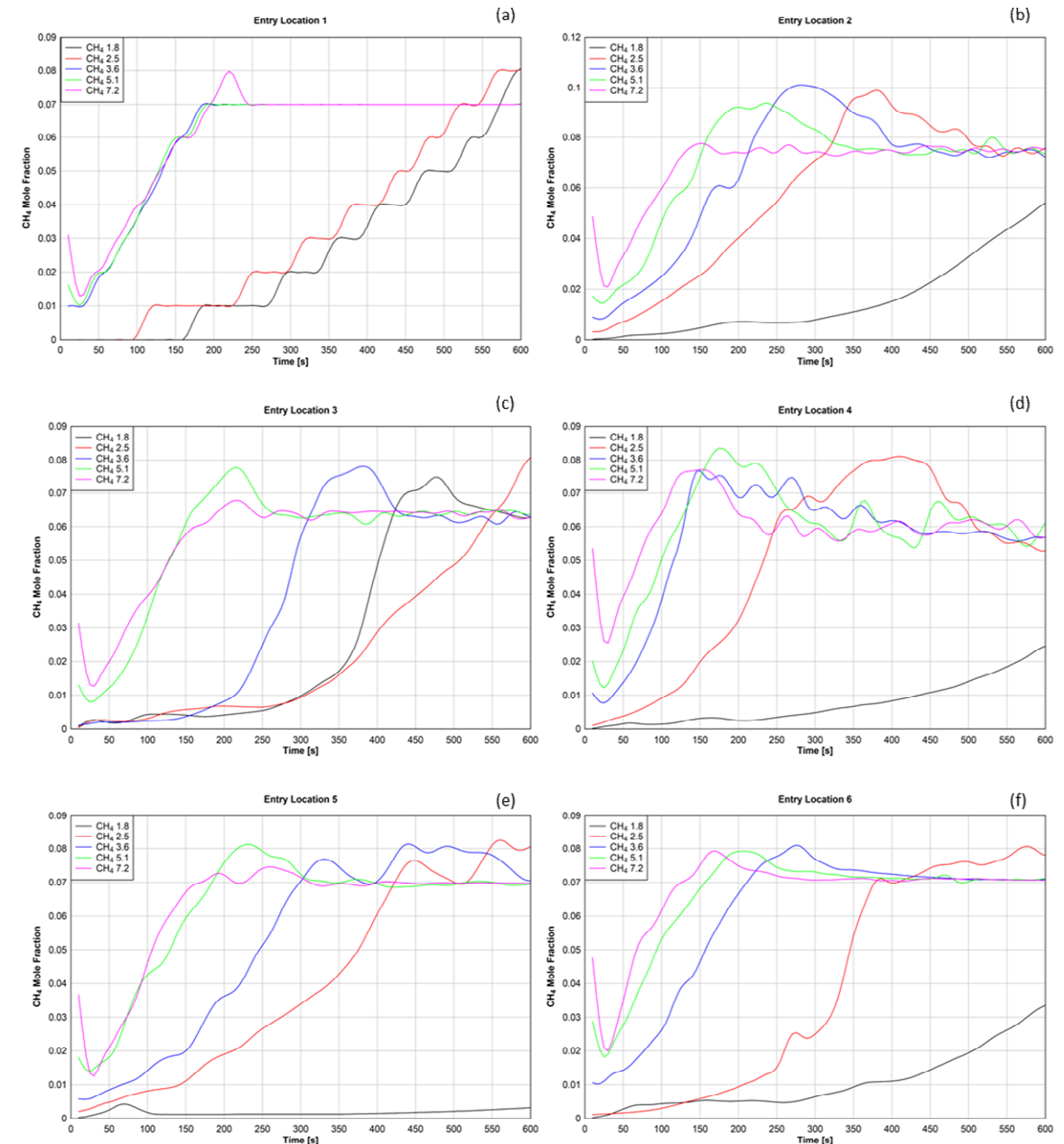
Change in hydrogen concentration in a cupboard for different leak diameters (1.8mm; 2.5mm; 3.6mm; 5.1mm and 7.2mm) at (a) entry location 1; (b) entry location 2; (c) entry location 3; (d) entry location 4; (e) entry location 5; (f) entry location 6



Results and Discussion

Gas Leaks - Methane

- Maximum concentration between 6-7.3% in air
- Maximum concentration reached in approximately 235s
- Under severe conditions (7.2mm leak diameter), maximum concentration was achieved up to 45s slower than hydrogen cases.
- Leak location influenced the maximum concentration for each case



Change in methane concentration in a cupboard for different leak diameters (1.8mm; 2.5mm; 3.6mm; 5.1mm and 7.2mm) at (a) entry location 1; (b) entry location 2; (c) entry location 3; (d) entry location 4; (e) entry location 5; (f) entry location 6



Conclusions

Key Findings

- Both Hydrogen and Methane tend to stratify during the leak process
- In most cases, both gases were within flammability limits at the end of 600s
- Inverse correlation between leak diameter and time take to reach maximum concentration
- For both cases, the leak location influences the way and rate at which gas occupies the space



Key Findings

The Way Forward

- Hydrogen as a fuel can be used with appropriate safety and detection processes in place
- Develop a deeper understanding of the ignition consequences of hydrogen in a domestic setting
- Improve awareness around hydrogen consumption to improve technology uptake





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