Fuel cells and hydrogen
Joint undertaking

HyIndoor
(Contract number 278534)

Sidonie RUBAN
Air Liquide, Paris-Saclay Research Center

New Energy World JU
fuel cells & hydrogen for sustainability

Programme Review Day 2012 – Brussels, 28&29 November 2012

Project overview

- Pre-normative research on safe indoor use of fuel cells and hydrogen systems
- 3 years
- 3.6 M€ budget – 1.5 M€ FCH contribution
- Partnership: Industry: FC and Gas companies, Testing laboratories, Research Institute, Leading actors in RCS development, innovation & project management consultancy

AIR LIQUIDE HYGEAR CCS GLOBAL European Commission cea

HEALTH & SAFETY LABORATORY KIT University of ULSTER LGi CONSULTING

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Project achievements

1 - Project goals, milestones

- Develop the **knowledge base** required to be able to predict H2 behavior indoor and consequences in case of early or late ignition

Experimental and modeling results
Jan 2013 => June 2014

- Define **improved criteria for allowing hydrogen and FCsystems indoors**

Recommendations for RCS – Sept 2014

- Issue a **safety guideline**
  - Sizing of enclosure openings or forced ventilation in function of H2 release parameters
  - Sizing of the vent area for deflagration mitigation in relation to the accumulated inventory and obstruction in the enclosure

Guideline published on
www.hyindoor.eu – August 2014

- **Disseminate the project outputs** through H2 safety community and industrials

Advanced Research Workshop
Sept 2013 – Bruxelles - TBC
Dissemination Workshop
Dec 2014 - TBD

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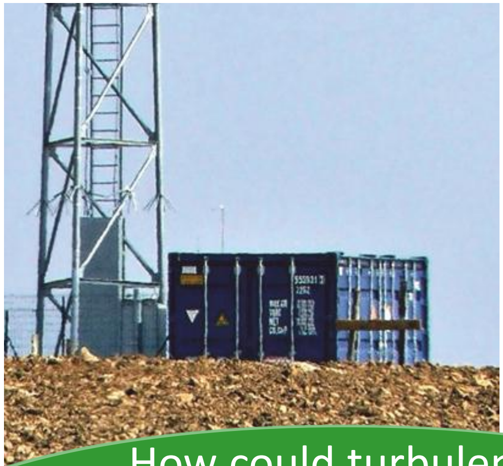
Project achievements
2 – Questions addressed

How to design openings to avoid wind effect?

What leak orientation will give the highest concentrations?

What leak diameter will give the highest concentrations?



What sensor technology should be used?

How could turbulence generated by ventilation or leaks affect the outcome of a deflagration?

Where should the vents be located?

Where should the sensors be located?

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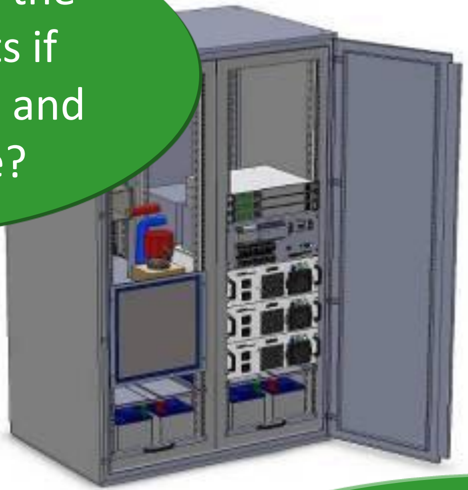
Project achievements
3 – Questions addressed

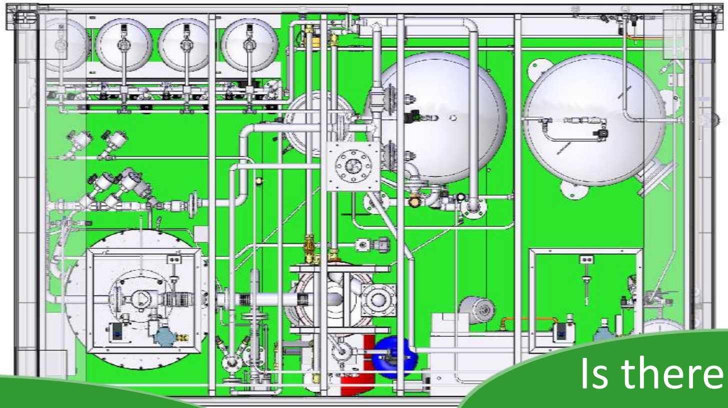
How large must the warehouse be to consider leaks as being outdoors?

Is there a risk of H2 accumulation under the ceiling?

What consequences could there be if a low concentration of H2 accumulates at the ceiling?

What would be the external effects if H2 accumulates and ignites inside?





Is there a risk of flame extinction and re-ignition?

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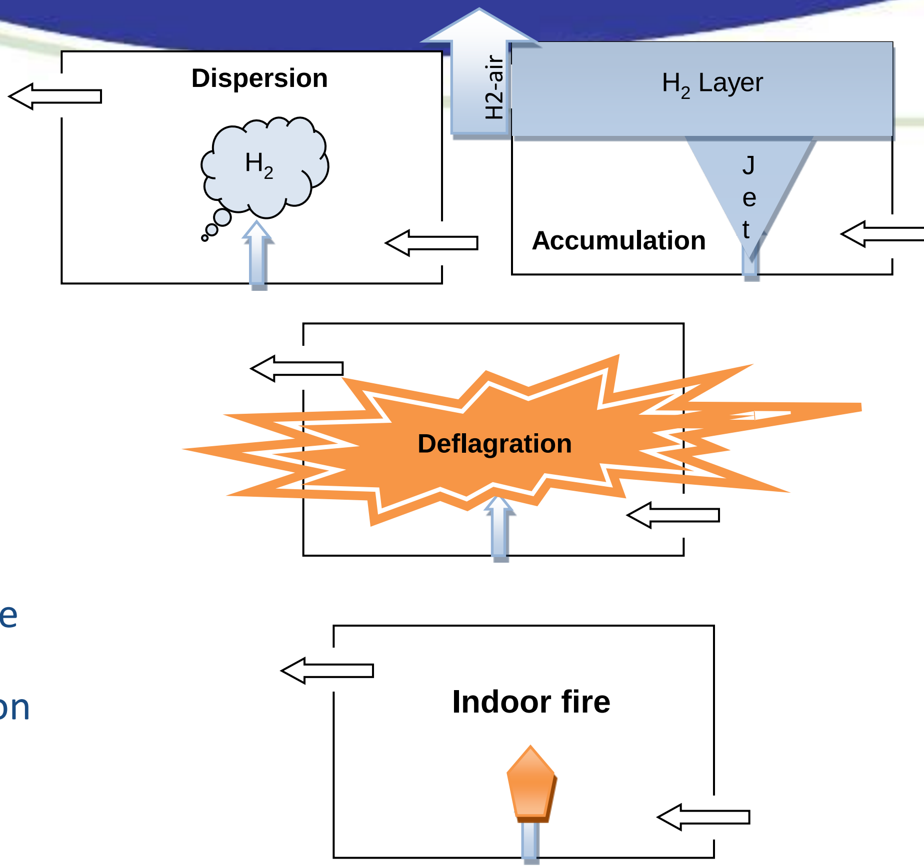
What is the acceptable configuration for obstacles?

Project achievements
4 – Phenomena to be understood

DISPERSION
- Identify characteristic regimes of hydrogen dispersion
- Characterize and quantify the dynamics of the dispersion phenomena

DEFLAGRATION
- Hydrogen-air deflagrations including deflagrations of localised and stratified, turbulent and lean mixtures
- Inertial vent covers

FLAME
- Specific hazards for initial unsteady stage of fire development
- Self-extinction of enclosure fire and deflagration potential following extinction
- Under-ventilated and well-ventilated fires and associated thermal effects and hazards to life and property



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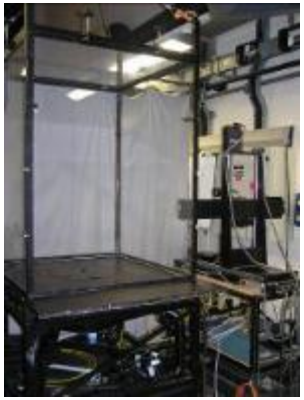
Project achievements
5 – Planned experiments (1/3)

- Test facility CEA:
  - Unignited releases: He concentration, flow through passive vents
  - Helium sensors:15 in the 1 m3 box and 27 in the 40 m3 garage set-up.
  - 3D velovity components PIV measures
  - Lasers
  - Cameras



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Project achievements
5 – Planned experiments (2/3)

- Test facility HSL:
  - Unignited releases (sub-sonic and choked) : measure concentration and temperature profiles and flow through passive vents
    - Up to 27 experiments
  - Vented deflagrations (well-mixed and stratified) : measure internal and external explosion pressures, video record of vented external explosion
    - Up to 18 experiments
  - Internal jet-fires (focussing on underventilated cases): measure oxygen concentration profiles and radiometer measurements, video record of flame
    - Up to 12 experiments

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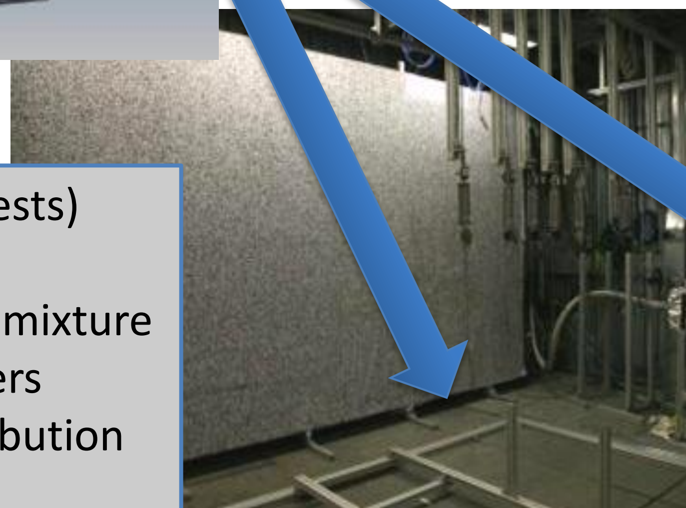
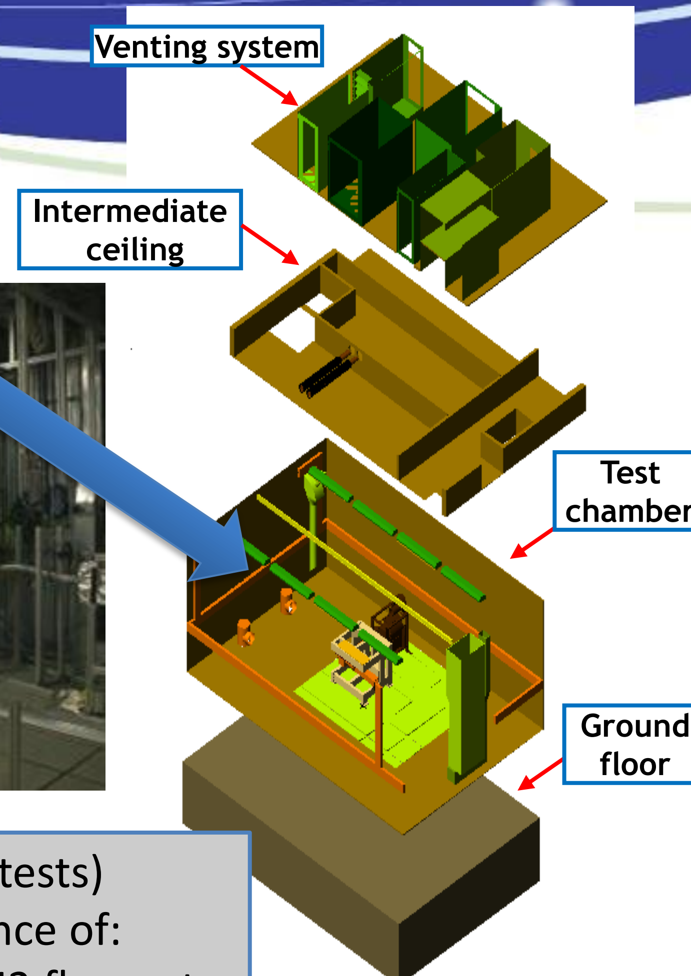
Project achievements
5 – Planned experiments (3/3)

Test facility KIT:





EXPLOSION test (150 tests)
to assess influence of:
- Vent size and lean H2 mixture
- H2 homogeneous layers
- Non uniform H2 distribution
- Pressure release
- Number of vents
- Vent cover inertia
- Obstruction

FLAME test (50 tests)
to assess influence of:
- Vent size and H2 flow-rate
- Number of vents

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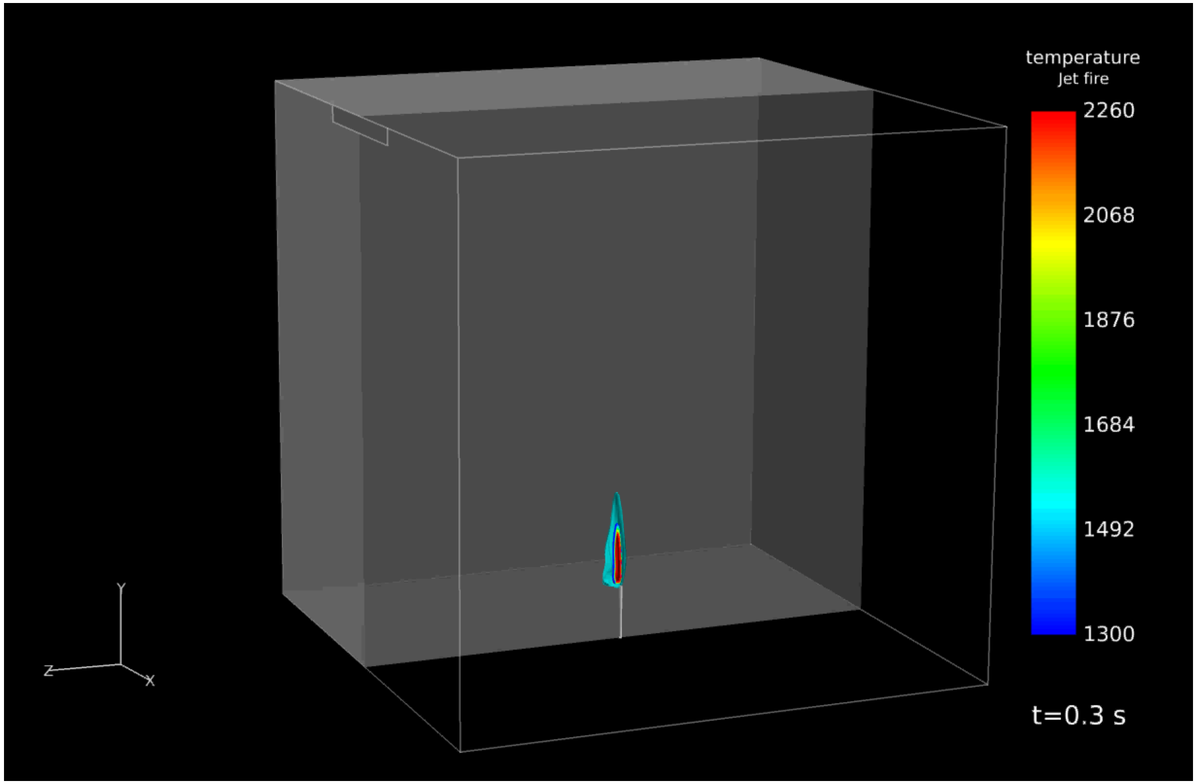
7 – Flame modeling indoor (UU)

Project objectives: CFD validation, engineering models development

Pre-test simulations of KIT experiments on 1 g/s, flame in a 1 m³ enclosure with 1 vent:

- flame extinction starts at 25 s and O2 concentration is 0 after 30 s
- Outside thermal effects through vent at max 2 meters from the enclosure
- **Yet thorough validation against experiments is needed!**



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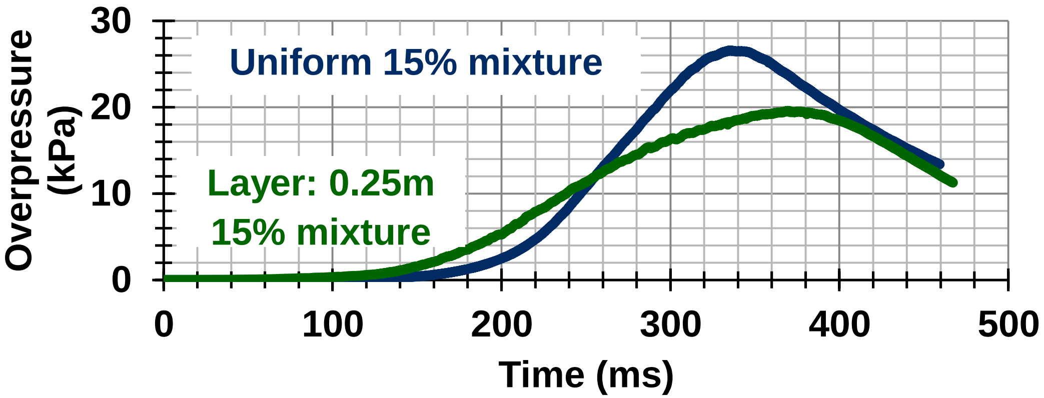
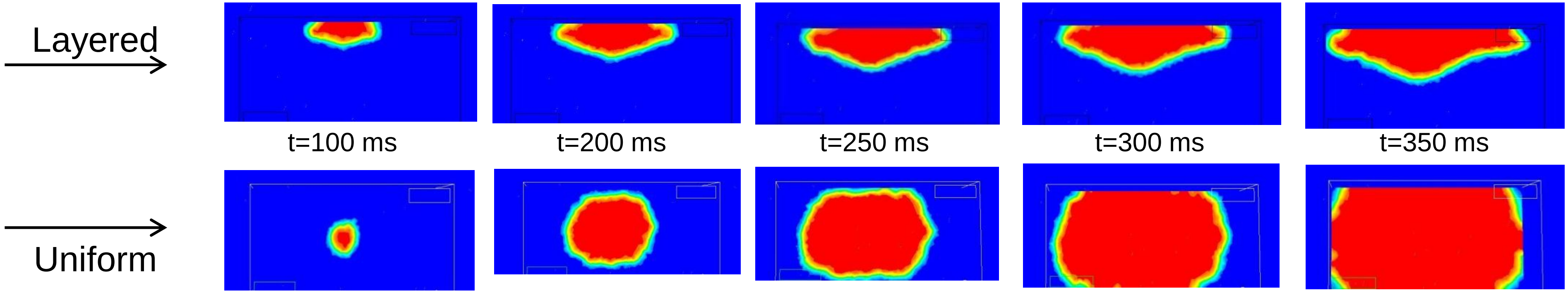
Project achievements
8 – Deflagration modelling (UU)

Pre-test simulations of HSL experiments on combustion of layered lean H2-air mixtures:

- Faster initial combustion due to wider flame area in a layer
- Slowing down later due to flame area decrease under ceiling
- Lower peak pressure due to smaller combustible H2 mass

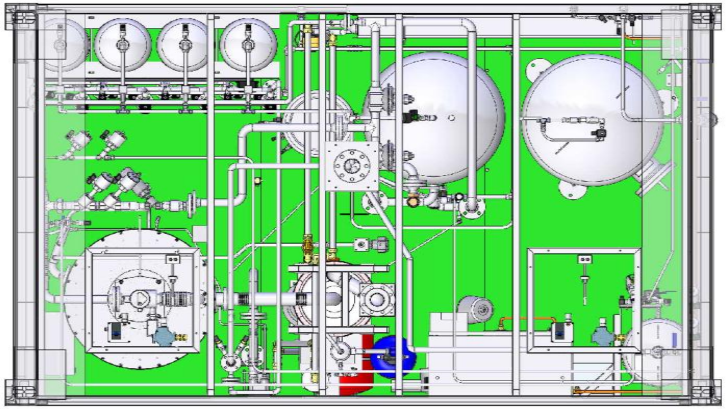




Project achievements

8 – How progress will be measured

- Sizing of openings and vents of typical early application using available knowledge
  - Will be redone at the end of the project, based on new research knowledge to measure improvement on hazards and associated risks assessment capability
- Publications, dissemination events



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Alignment to MAIP
1 – prenormative research on safety

- Generic knowledge will be issued and will address the following objectives
  - Early markets
    - " In order to pave the way for a widespread acceptance of fuel cells in early applications pre-normative research will aim to **develop methodologies and procedures** for **safe indoor use of fuel cells** [...] and compatibility with electrical and building codes."
  - Cross cutting issues
    - "Developing European and international standards that provide the technical requirements to achieve safety and build confidence as well as **guiding authorities and other stakeholders** in their application."
  - Transport & Refuelling Infrastructure
    - " Pre-normative research will complement the RTD in this application area. In particular [...] safety of hydrogen **[material handling] vehicles especially in confined spaces**."

Cross-cutting issues
1 – RCS

- Translation of scientific results into international norms. Possible influence on:

Document #	Description	Active	Published
ISO/TR 15916	Basic considerations for the safety of hydrogen systems	√ Ed 2	
ISO/DIS 20100	Gaseous hydrogen — Fuelling stations (supersedes ISO/TS 20100)	√ Ed 1	
IEC/NP 62282-4-101	Fuel cell technologies – Part 4-101: Fuel cell systems for forklift applications – Safety	√ Ed 1	
IECCDV 62282-5-1	Fuel cell technologies - Part 5-1: Portable fuel cell power systems – Safety	√ Ed 2	
IEC 62282-3-100 :2012	Fuel cell technologies - Part 3-100: Stationary fuel cell power systems – Safety (Revision of IEC 62282-3-1)		√ Ed 1
IEC 62282-3-300:2012	Fuel cell technologies - Part 3-3: Stationary fuel cell power systems – Installation		√ Ed 1
IEC 60079-10-1	Explosive atmospheres – Part 10-1: Clarification of areas – Explosive gas atmospheres	√ Ed 1	√ Ed 2

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Enhancing cooperation and future perspectives
1 – Needs and opportunities for the future

- Sharing through IA Hysafe
  - Sharing of knowledge gaps priorities with the research community outside the project
- International activities through IEA HIA Task 31
  - Sharing results through IEA HIA task 31 meetings
- Opportunities to share knowledge gaps priorities, experimental data results, and model evaluation with the following projects:
  - Work of Sandia National Lab on NFPA 2 improvement

Thank you for your attention

sidonie.ruban@airliquide.com