Clean Hydrogen Partnership

European Hydrogen Safety Panel (EHSP)
Clean Hydrogen JU Webinar "Computational Fluid Dynamics (CFD) for hydrogen safety analysis “, 07 December 2022

CFD for modelling of hydrogen releases and dispersion

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Air Liquide

EUROPEAN PARTNERSHIP

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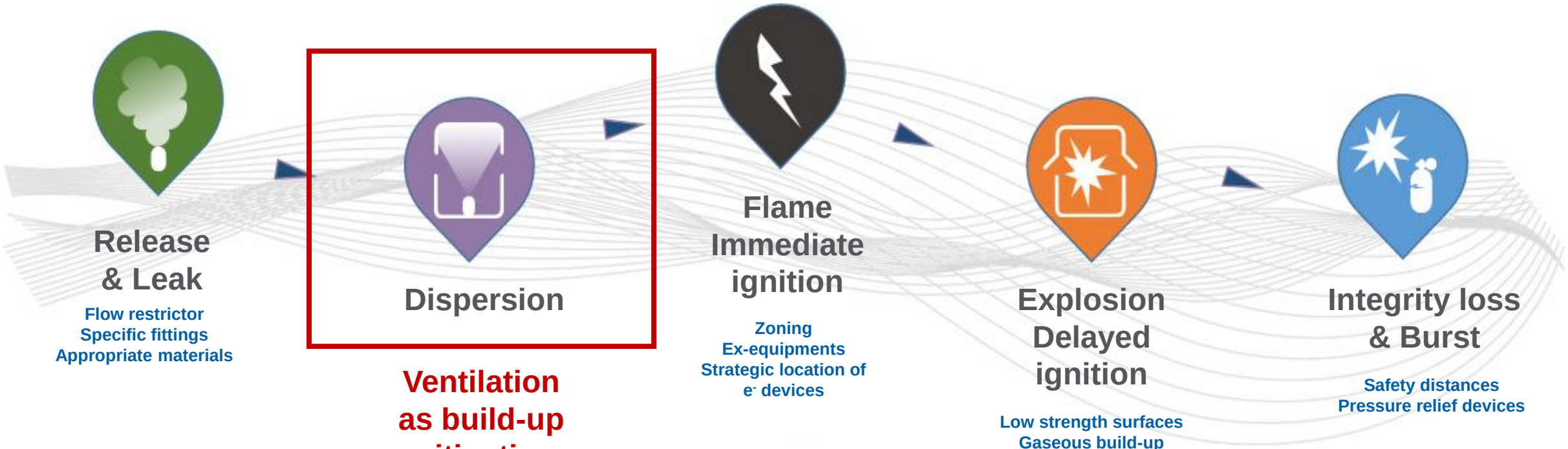
Accidental kindling chain

Manage hazards to provide safe applications



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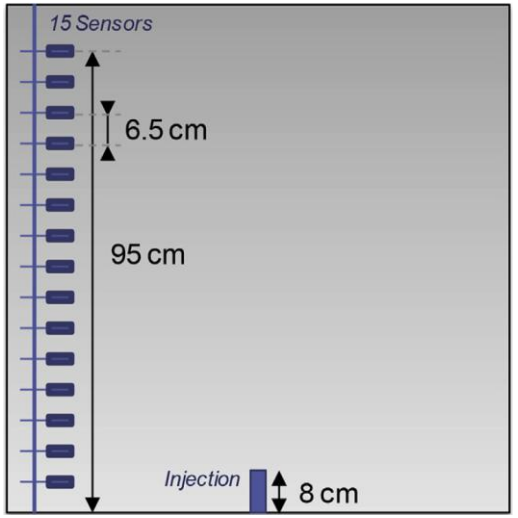
Natural ventilation

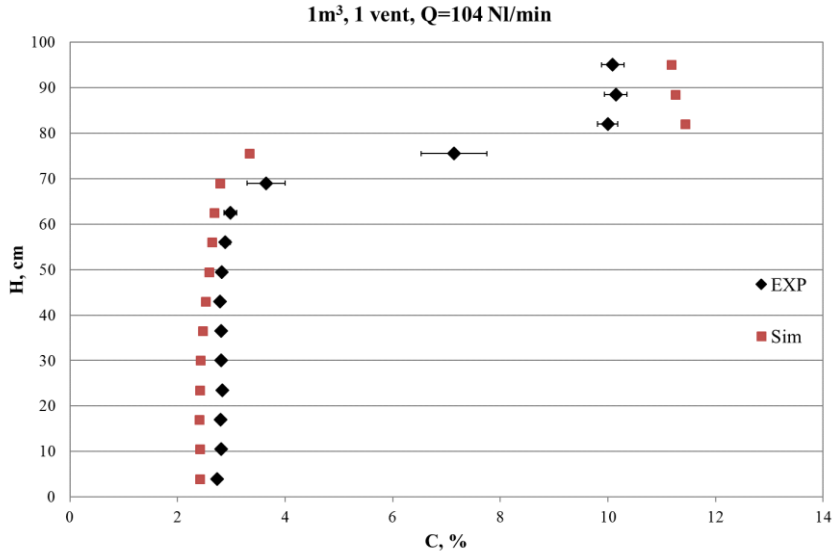
Simulation validation vs exp measurements for H2

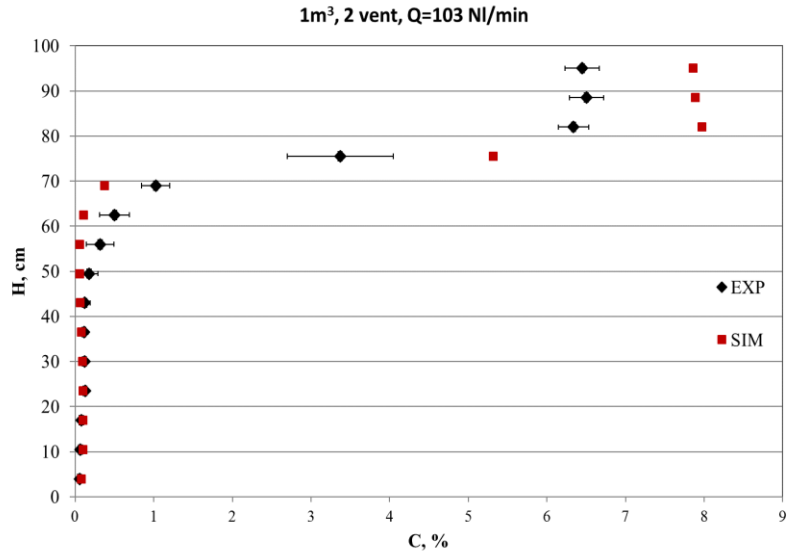
1m³ enclosure (release D= 27.2 mm, h=8cm)

- **1 opening** (h=180 mm, w=960 mm)
- **2 openings** (h=180 mm, w=960 mm)

➔ the computational time (k-ε model) is reasonable (~1 day to achieve a steady state)







➔ CFD results in good agreement with the exp measurements (exp error is of 3%)

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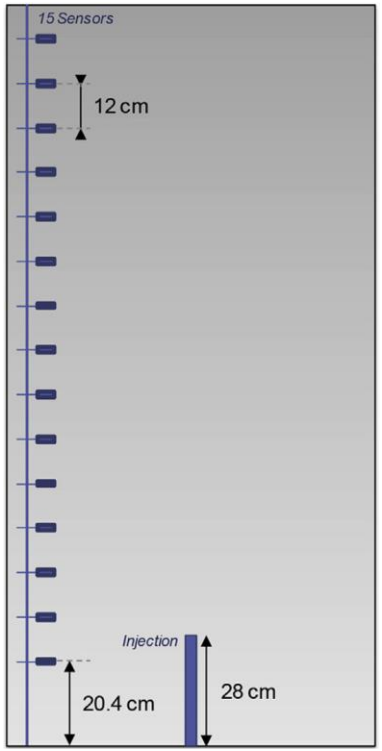
Natural ventilation

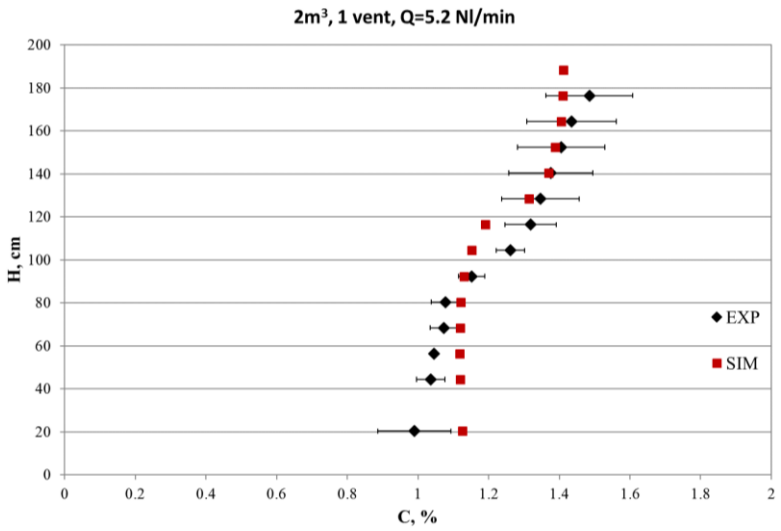
Simulation validation vs exp measurements for H2

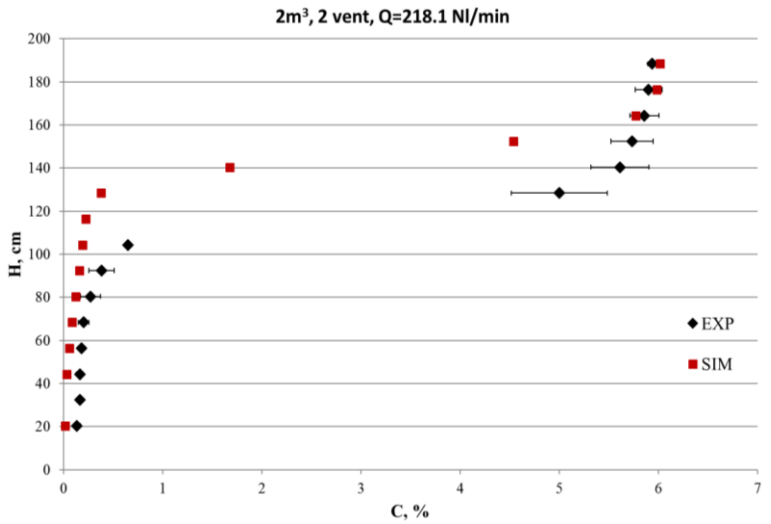
2m³ enclosure (release D= 27.2 mm, h=28cm)

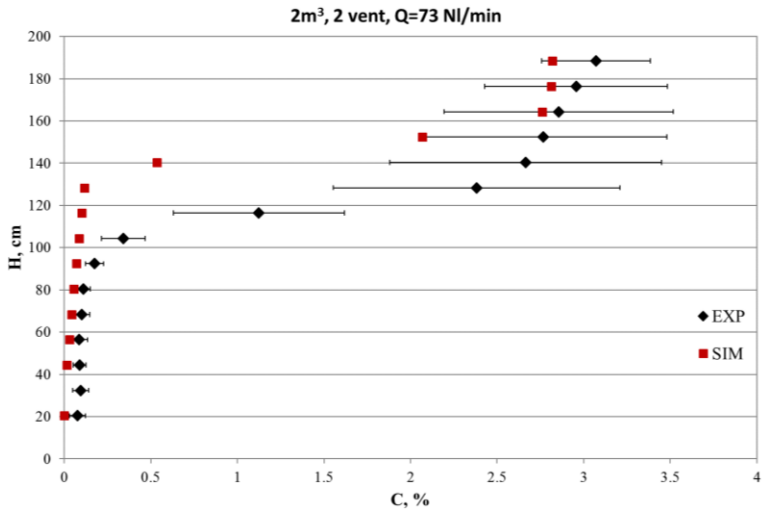
- **1 opening** (h=190 mm, w=900 mm)
- **2 openings** (h=190 mm, w=900 mm)

➔ the computational time (k-ε model) is reasonable (~1 day to achieve a steady state)









➔ CFD results in good agreement with the exp measurements (exp error is of 3%)

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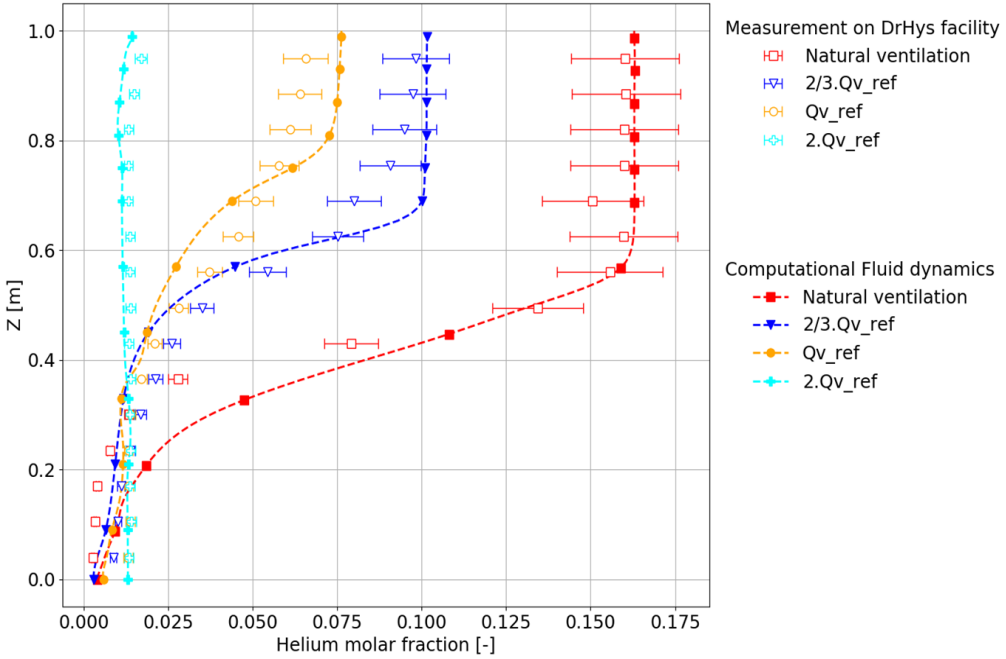
Forced/Mechanical ventilation

Simulation validation vs exp measurements for He

1m³ enclosure (release D=4-18 mm, h=8cm)

- opening
  - Ventilation: circular (D=16 cm)
  - Bottom free: rectangular (h=15 cm, w=30cm)
- Ventilation: 0-300 m³/h

➔ the computational time (k-ε and k-omega models) is reasonable (several days to achieve a steady state)



Good agreement for He concentration between measurements and CFD results

- In terms of concentration
- In terms of distribution behavior

⇒ *Additional numerical calculations were performed to better understand transition behaviour*

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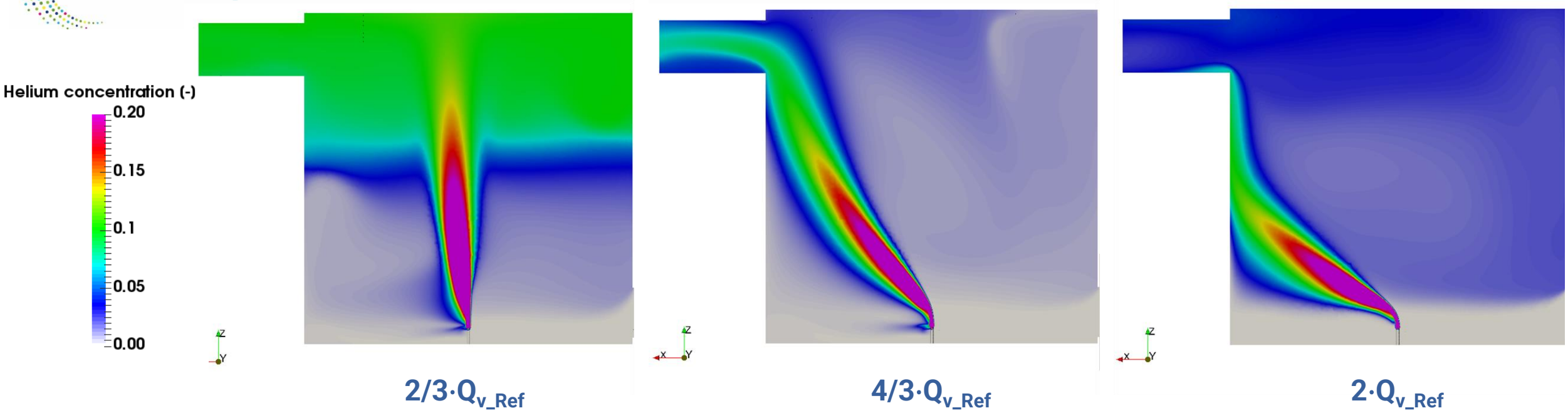
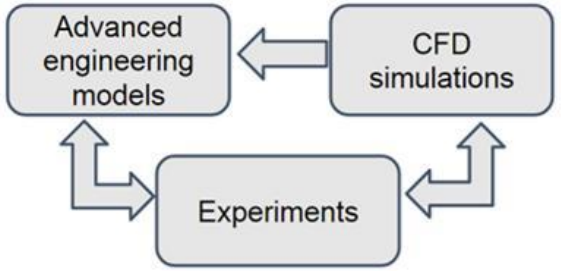
Numerical focus on ventilation impact on He jet



$2/3 \cdot Q_{v\_Ref}$ $4/3 \cdot Q_{v\_Ref}$ $2 \cdot Q_{v\_Ref}$

According to ventilation, the jet seems directly oriented in the outlet flow, induced by the ventilation, without mixing with the other parts of the enclosure…

In this configuration can not be computed by 1-D distribution and hard to be measured measurements



⇒ More investigations are in progress in order to better define this behaviour (e.g. other Q_v, other Q_r…)

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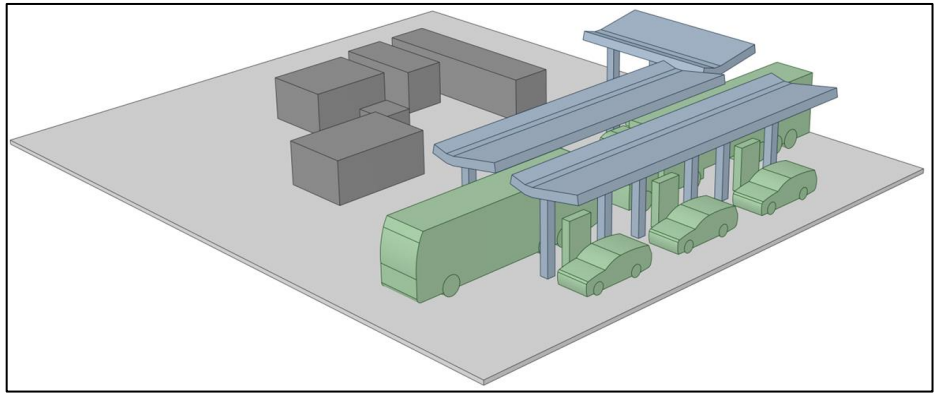
Application to Risk Assessement

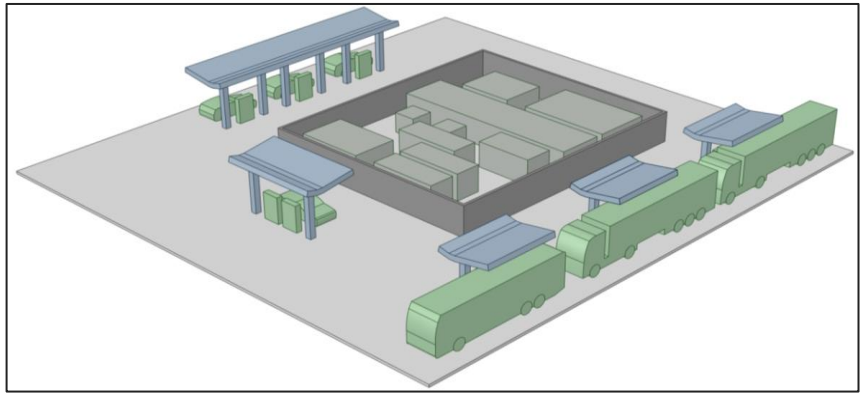
The objectives of the **MultHYfuel** project is to **defining commonly applicable, effective, and evidence-based guidelines** to facilitate the construction of HRS in multi-fuel refuelling stations, thanks to

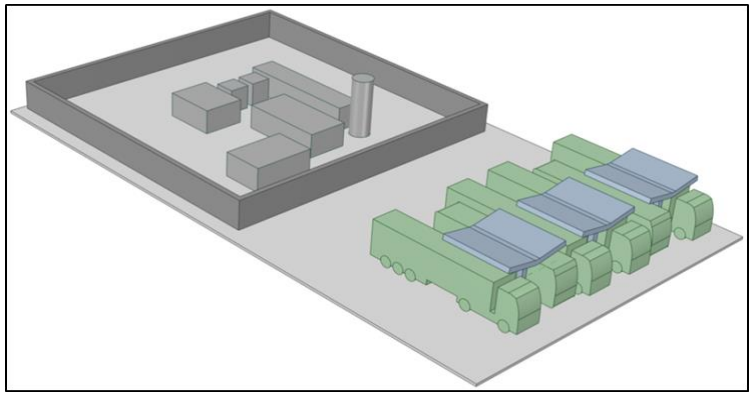
- Identification of relevant gaps
- Practical, theoretical and experimental data;
- Active and continuous engagement with key stakeholders;
- Successfully disseminate the project's results

Methodology: **Experimental** and **numerical approaches** are used for the risk assessment

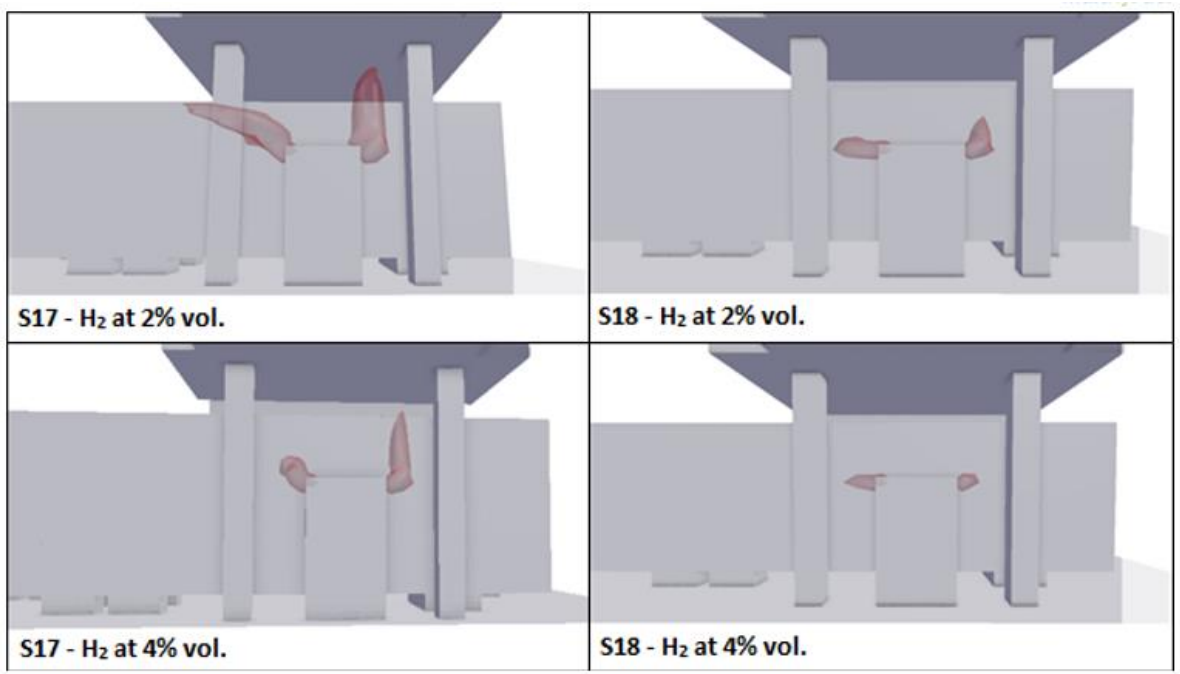
- 0D/1D correlations for the build-up dispersion
- 3D CFD, to capture the full stratification, impact of obstacles and forced ventilation



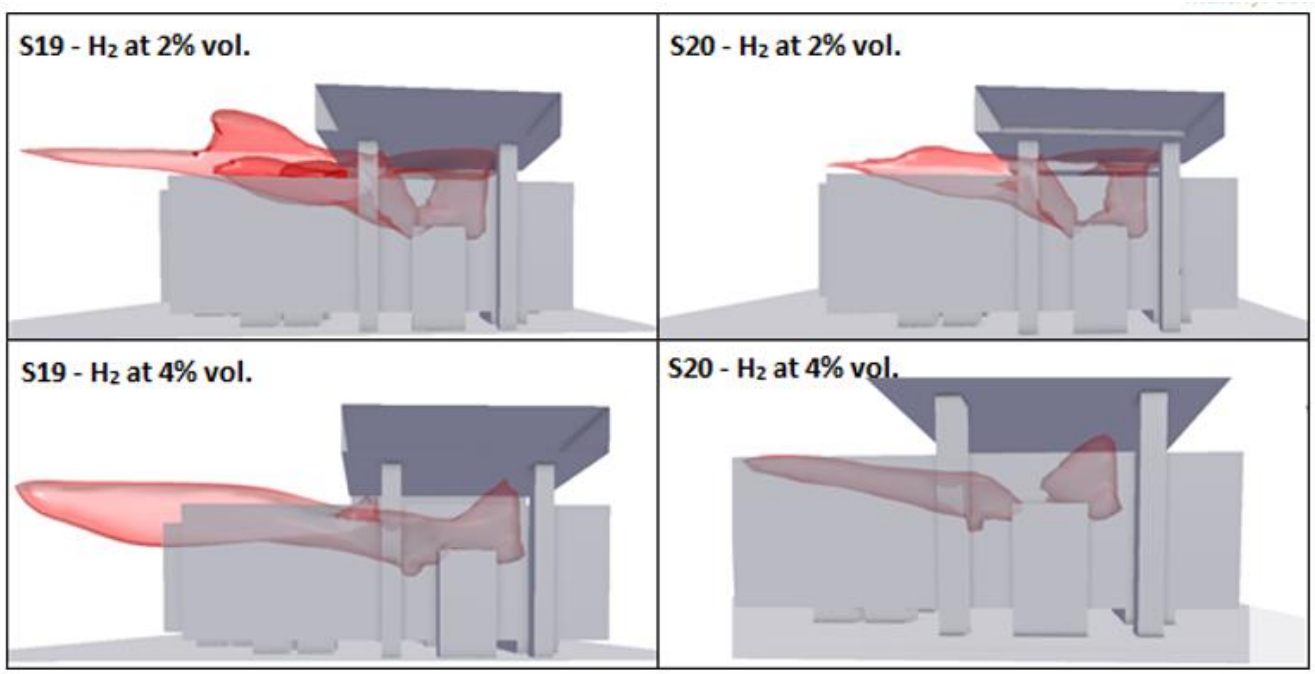




Results



flow rate of 1.5 g/s, wind F1.5 and D5



flow rate of 14.8 g/s, wind F1.5 and D5

CFD results demonstrates that the wind condition as well as the ambient geometry has a strong impact on the results, hence for the realistic scenario, where the associated safety distance must be precisely evaluated a CFD approach can be used to reduce the conservative 1D results

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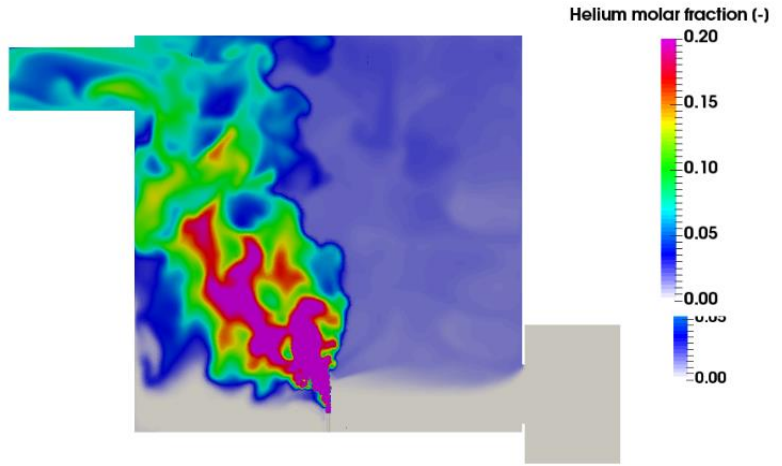
Conclusion & Recommendations

Conclusion for CFD

- Appropriate CFD approach can be used for modeling of natural, mechanical ventilations
- Good agreement were shown between CFD & experiments
- CFD approach can be used to
  - develop & validate simple models
  - preparer experiments
  - perform detailed/refined risk assessment



Recommendations for CFD

- Special attention should be paid to
  - the turbulence model
  - the mesh
  - CPU time/accuracy trade-off
- Validate CFD against experimental results in similar conditions

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Keep in touch/Thank you

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For further information
https://www.clean-hydrogen.europa.eu/

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