Computer simulations help to visualize the behavior of hydrogen leakages

Introduction

Fictitious hydrogen leaks in the hydrogen house have been analyzed using computer simulations (CFD; Computational Fluid Dynamics). The risks of leaks and the operation of active and passive safety devices were examined. The results of the calculations have been used to provide insight into the consequences of a leak and to compare different situations. Computer simulations are a powerful tool to provide insight into (for example) the spread of leaks without having to carry out more expensive practical tests.

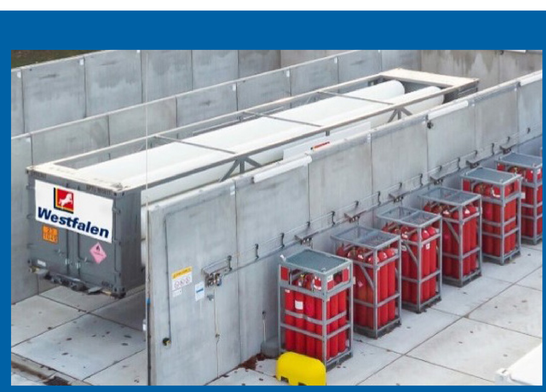
Objective

In the Netherlands, Kiwa and Alliander have collaborately build the Hydrogen Experience Center as a building block for their hydrogen strategy to serve several different purposes which include:

1. How to build a hydrogen system for the domestic market
2. Showcase for stakeholders how to heat a house with 100% hydrogen
3. Create an environment for field engineers and installation companies to learn about applications and conversions
4. Building block for the Lochem pilot project with the goal to heat 12 existing houses with hydrogen using the existing gas infrastructure

The risks associated with a leakage shall be thoroughly understood but cannot be tested in the Hydrogen Experience center without being exposed to that same potentially increased risk.

The use of CFD provides good insights in a range of influencing parameters to assess hydrogen leakages and safety measures when testing is not feasible.



The choice of leak size selection can be matched with situations in the field

The different leakages correspond with situations in the field:

Leakage class	Leak rate Natural gas (m³(n)/h)	Leak rate Hydrogen (m³(n)/h)
Negligible small leakage	0,005	0,015
33x larger than the leak tightness test of an inhouse installation	0,165	0,5
Large leakage *	10	29

** Normally stopped by the intervention of an excess flow valve*

Visualization is quite easy to understand for everyone

- Color coding helps to visualize the effects of gas concentrations, spreading and potential buildup
- Color coding corresponds with gas concentration percentage for odorisation and LEL levels
- This can be directly related to safety levels, potential risk or perceived risk

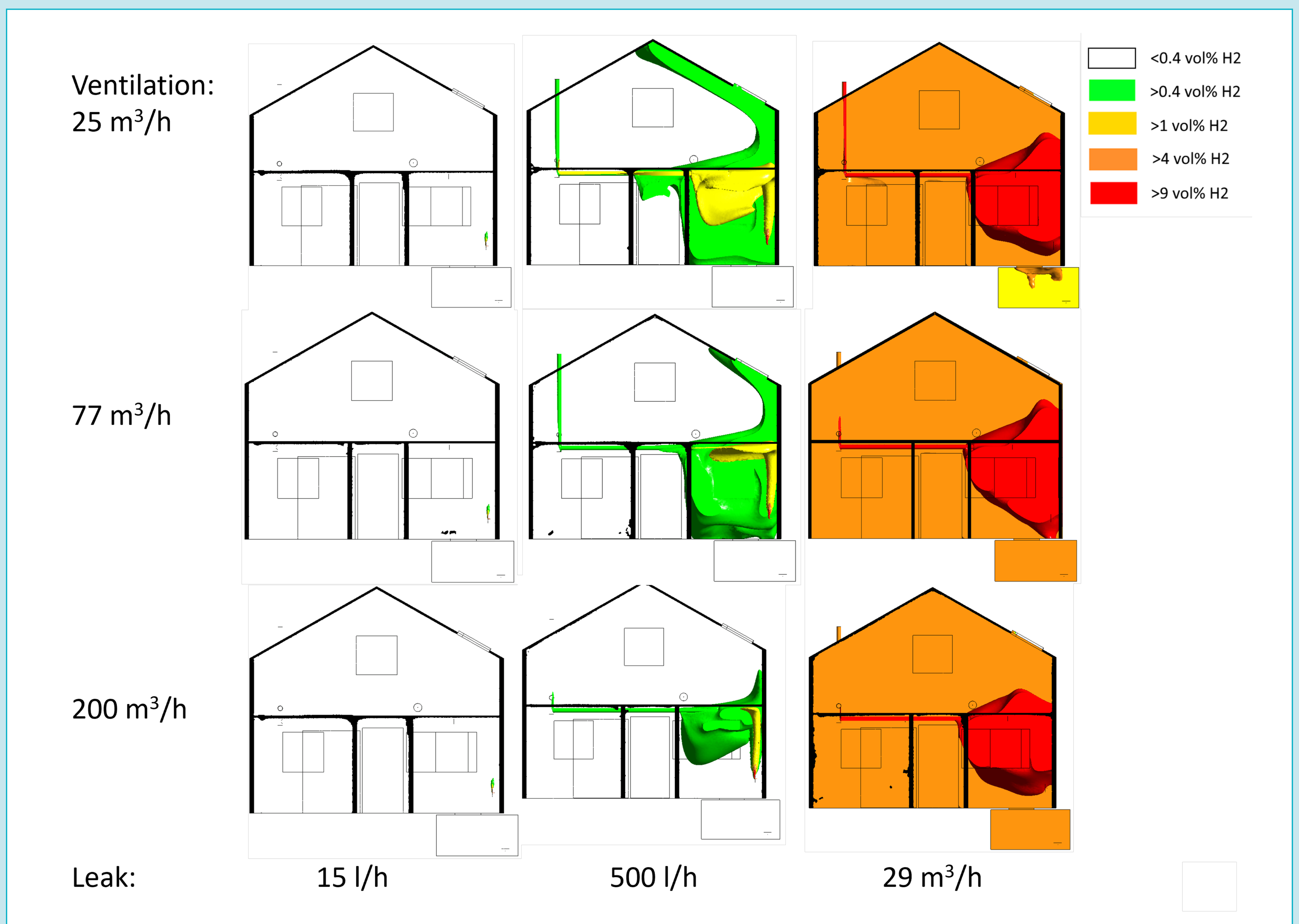
		Hydrogen	Natural gas
No alarm	White	<0,4 vol%	<0,6 vol%
10% LEL	Green	>0,4 vol%	>0,6 vol%
Odorization	Yellow	>1 vol%	>1 vol%
100% LEL	Orange	>4 vol%	>5,9 vol%
Flammable	Red	>9 vol%	>6,6 vol%

Location of the leakage plays an important role in the spreading of the gas

The location of the gas leak is important when it comes to leak detection. When detection by users is not likely to take place via odorization, additional safety measures can be considered.

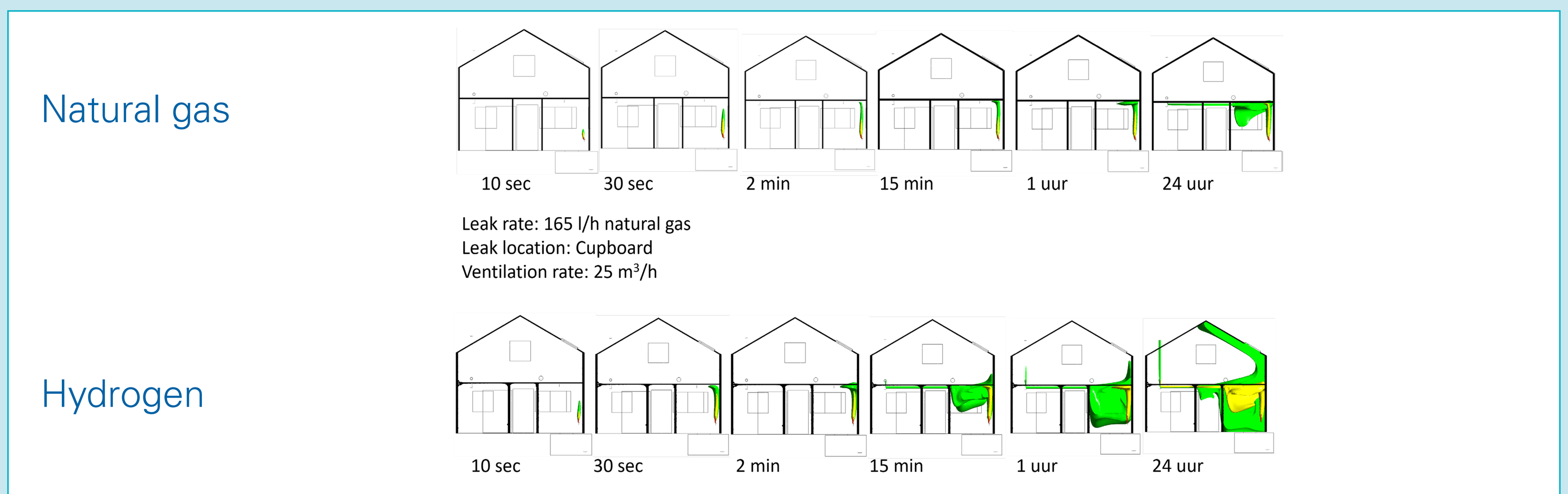
Active ventilation can help to decrease the effects of a gas leak

- Ventilation cannot always eliminate the effects of a gas leak
- With active ventilation, the level of gas concentration can be partially managed
- Large leaks cannot be removed by using active ventilation in houses



Hydrogen and natural gas spreading shows same levels on short time frames

- Comparison between simulations with natural gas and hydrogen shows the same type of behavior on short timelines
- Short time frames are comparable for medium leakages for hydrogen and natural gas
- An active ventilation rate of 25 m³/(n)/h isused the assessment of hydrogen and natural gas



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References

[1] Bryan Verveld, Ruben Verschoof, „CFD simulaties waterstofgas demowoning," Demcon | Multiphysics, 2022.

[2] Mark Crowter, Georgina Orr, James Thomas, Guy Stephens, Iain Summerfield, „Energy Storage Component Research & Feasibility Study Scheme HyHouse," KIWA Gastec. 2015.

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