ESRA / Tekna webinar

Sikkerhetsutfordringer med fornybar energi

1. februar 2022

IFE Hynor
Hydrogen, sikkerhet og risiko

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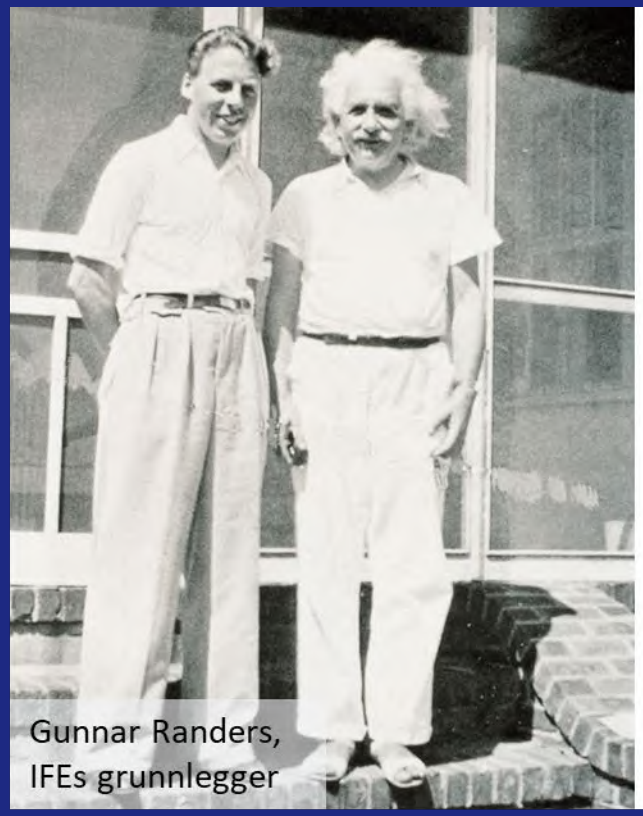
Forskningssjef IFE | Hydrogenteknologi
Senterleder FME MoZEES

Innhold

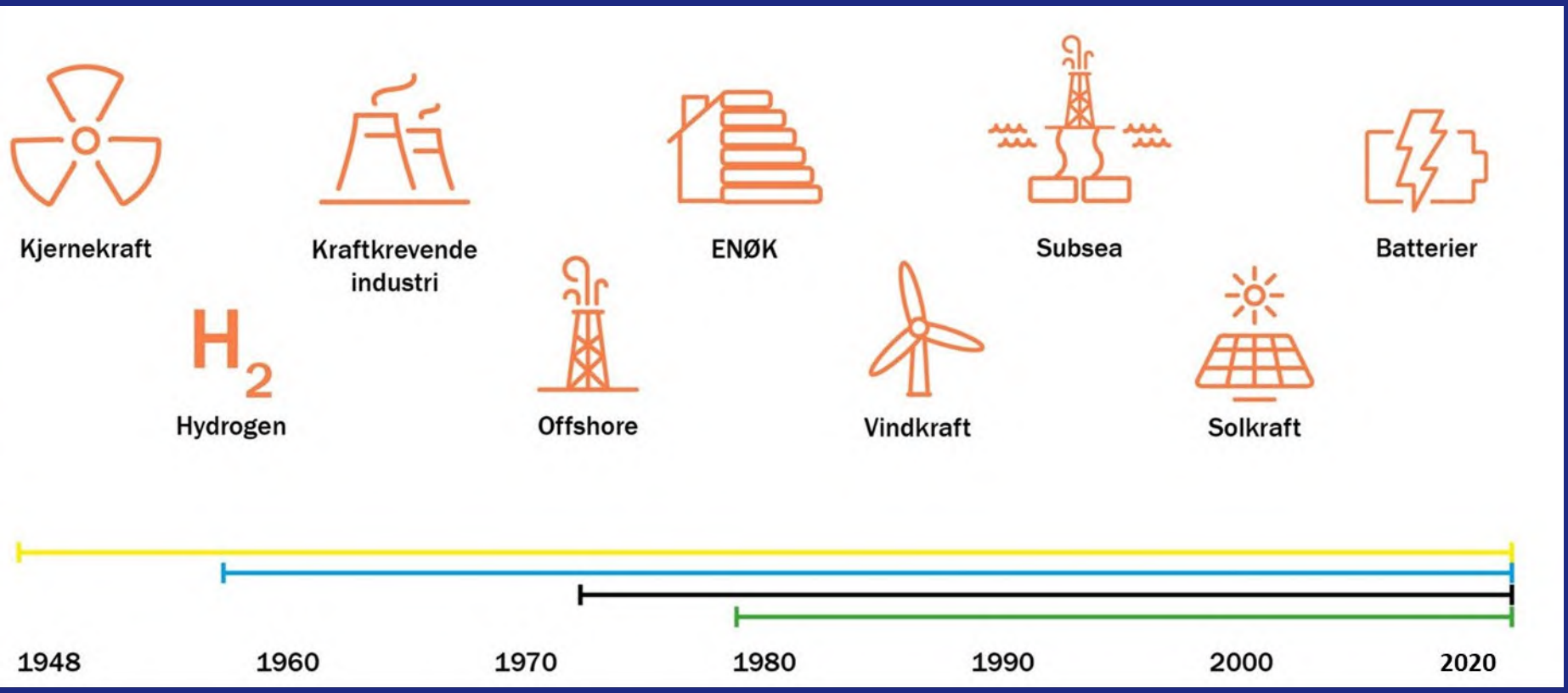
Institutt for energiteknikk er en forskningsstiftelse lokalisert på Kjeller og i Halden

Kjeller

IFE har i mer en 70 år bidratt til utviklingen av Norge som en energinasjon!



Gunnar Randers,
IFEs grunnlegger



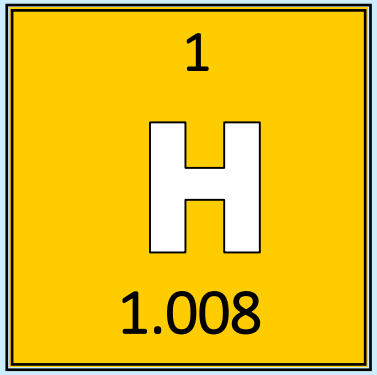
Hydrogen – fakta

- Hydrogen er en gass ved standard atmosfære
- 1 elektron + 1 proton

- Ikke-giftig (fargeløs, ingen lukt eller smak)
- **Brennbar** gass (usynlig flamme)
  - Stort antenningsområde (4-75% i luft)
  - Svært lav antenningsenergi (0.02 mJ)

- Lav volumetrisk tetthet (lettere enn luft)
- **Høy gravimetrisk tetthet** (3 × bensin)
- Kokepunkt: **-253˚C**

- Reaksjon: $H_2 + ½\ O_2 = H_2O$



1 m^3 = 90 gram

@STP

IFE Hydrogen
Research Infrastructure

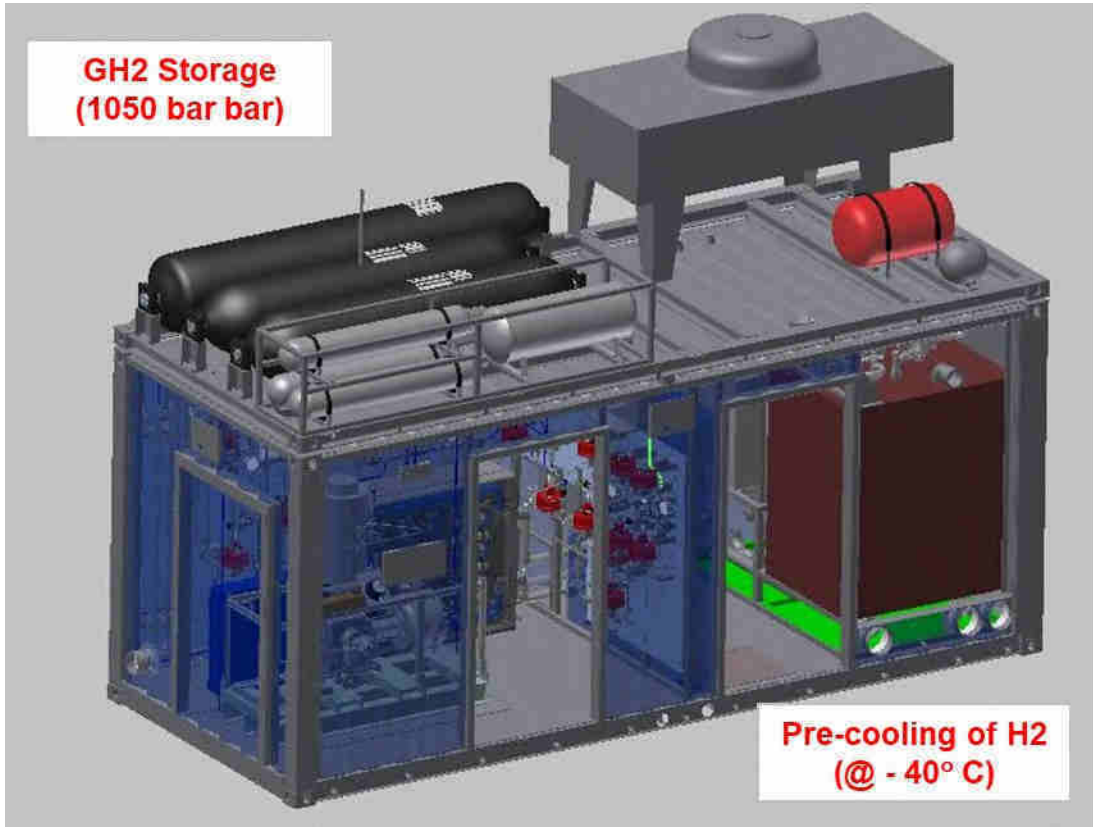
- IFE Hynor
  1. *Hydrogen Refueling Station (2011 – 2021)*
  2. *Solid oxide fuel cells (2014 – 2016)*
  3. Sorption Enhanced Reforming – ongoing
  4. PEM Fuel Cells & Batteries – ongoing
  5. PEM Water Electrolysis – ongoing
  6. *Liquid Hydrogen storage (2022 –)*

- Norwegian Fuel Cell and Hydrogen Centre*
  *open research infrastructure
  - PEM Fuel Cell System Laboratory
  - PEM Water Electrolysis System Laboratory

IFE Hynor
Hydrogen Technology Center

NORWEGIAN FUEL CELL AND HYDROGEN CENTRE
FUEL CELL & ELECTROLYSER SYSTEMS

Hynor Lillestrøm – H2-stasjon + H2-dispenser



Hynor Lillestrøm – H2-stasjon + H2-dispenser

Hynor Lillestrøm – H2-stasjon + H2-dispenser

Hynor Lillestrøm – Metallhydrid H2-kompressor

- Specifications
  - H2 flow rate: **ca. 1 kg/h** (10 Nm^3/h)
  - Heating temperature (oil): 160°C
  - Cooling temperature (water): 16°C
  - Inlet H2-pressure: **10 bar**
  - Outlet H2-pressure: **200 bar**

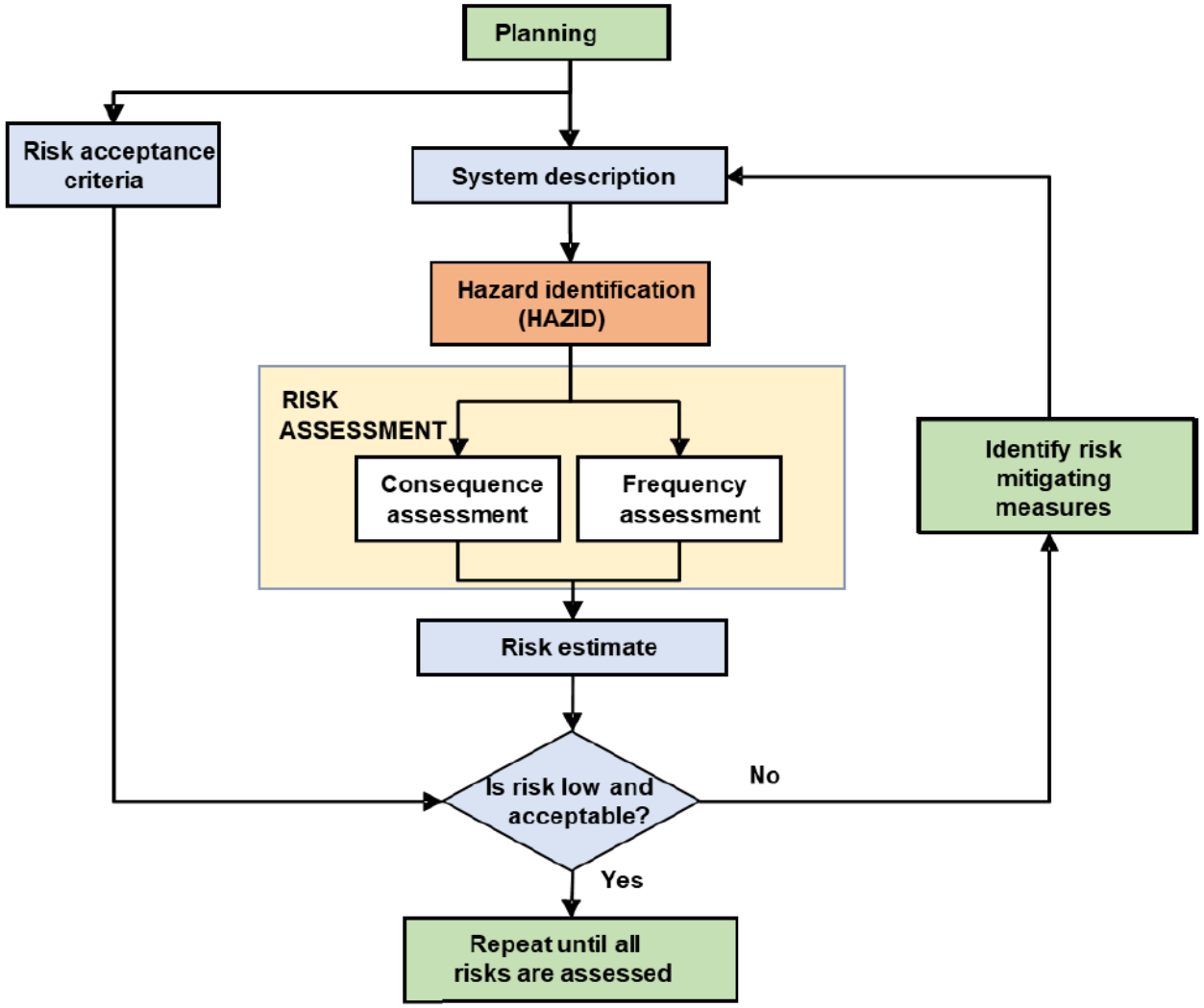
Hynor Lillestrøm – Lagring av gass

2014

IFE Hynor 2.0 – Testsenter for hydrogenteknologi

Januar 2022

IFE Hynor 2.0 – Risikoanalyse



Kilde: Olav Hansen, HyEX Safety

Risikoanalyse – H2-sikkerhet og modellering

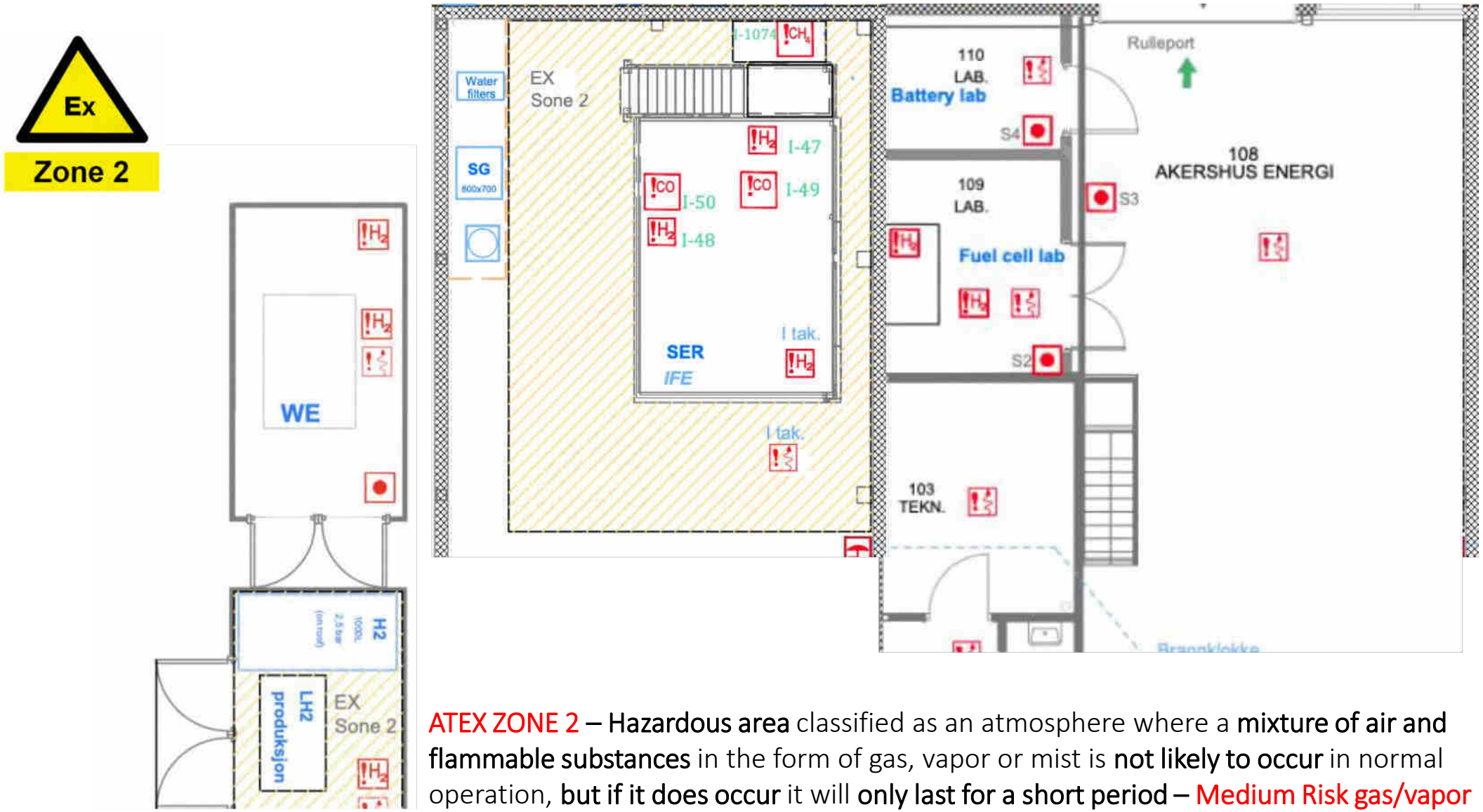
- Gas leakages (transient outflows)
- Ignition probability
- Dispersion distances and cloud volumes
- Fire radiation loads
- Blasts from vessel burst
- Deflagrations / detonation

Thresholds	Blast	Fire¤	Flash-fire
Threshold for injury/windows breaking	20-30 mbar	3 kW/m^2	
Threshold for possible irreversible effects	50-70 mbar	5 kW/m^2	
Lower threshold fatality risk (1%)	140 mbar	5-7 kW/m^2	0.5 LFL#
Some fatality risk (5%)	200 mbar	8 kW/m^2	LFL#
Severe fatality risk (~50%)	300-600 mbar	12.5 kW/m^2	LFL#
This study	400 mbar	25 kW/m^2	8% hydrogen

Vysus Group

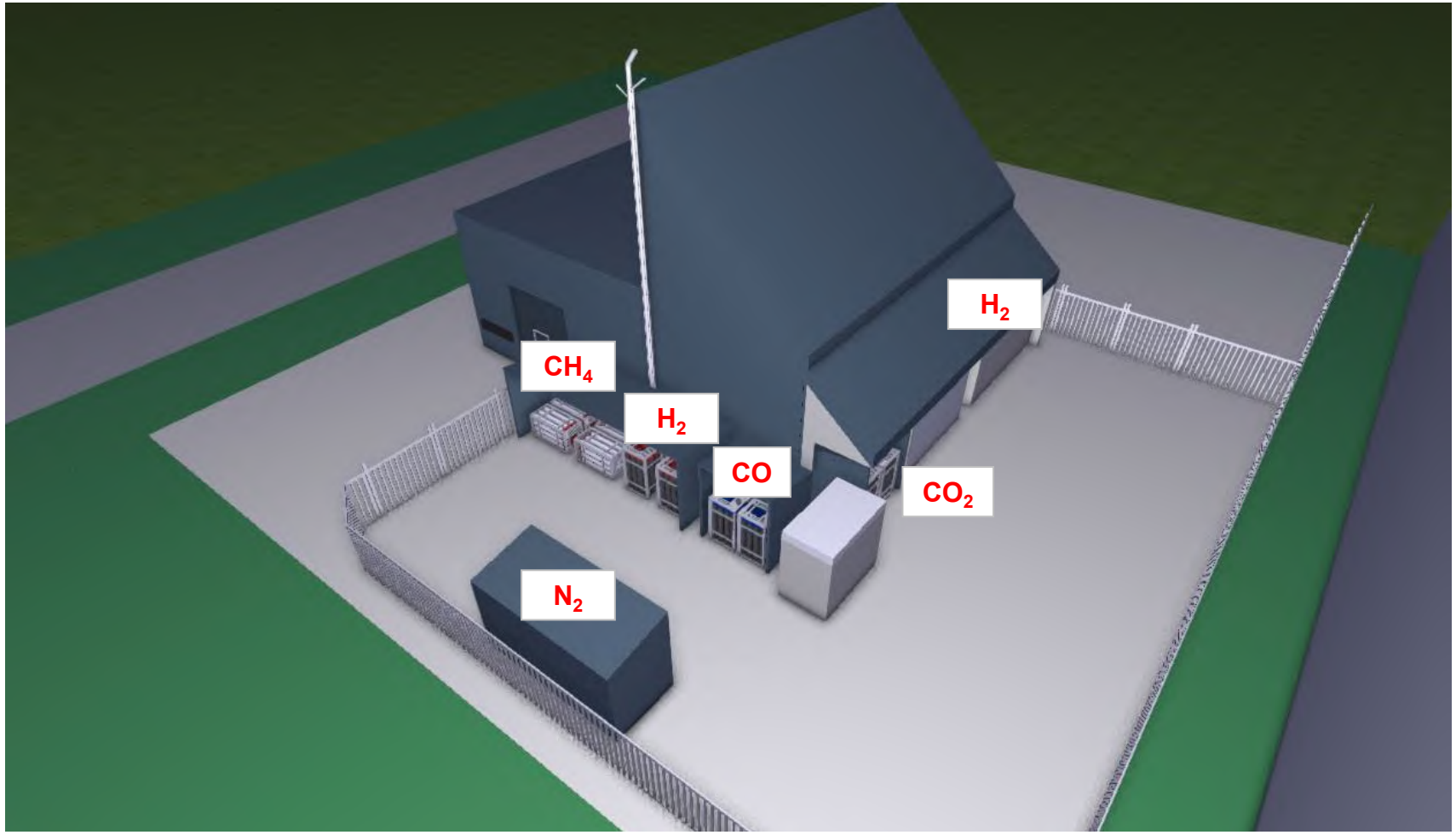
HYEX SAFETY

Risikoanalyse – EX soner



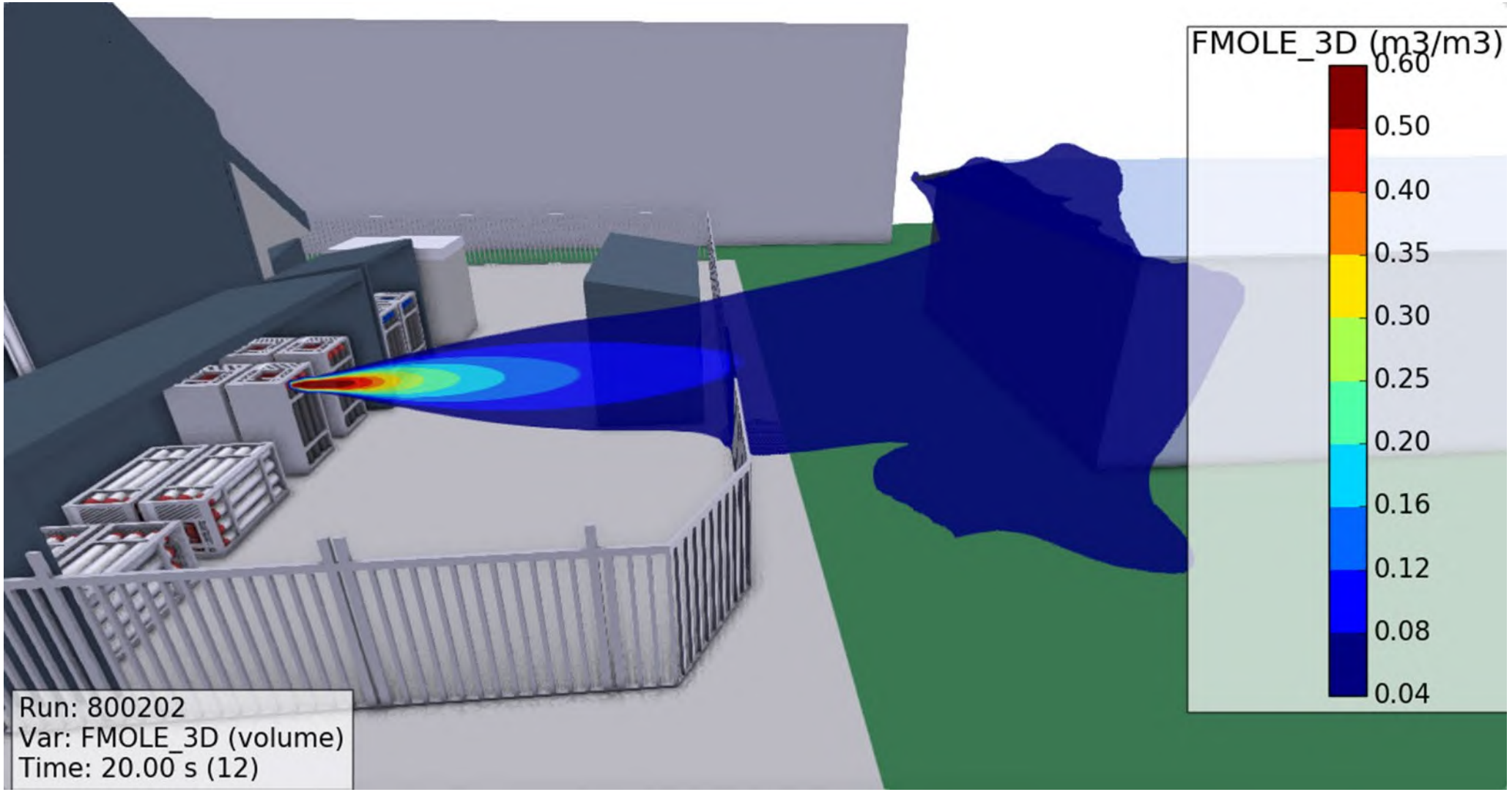
ATEX ZONE 2 – **Hazardous area** classified as an atmosphere where a **mixture of air and flammable substances** in the form of gas, vapor or mist is **not likely to occur** in normal operation, **but if it does occur** it will **only last for a short period** – Medium Risk gas/vapor

FLACS-modell for lagring av gass utendørs



FLACS (FLame ACceleration Simulator) – A commercial Computational Fluid Dynamics (**CFD**) software used for **explosion modeling** and **atmospheric dispersion modeling** within the field of **industrial safety** and **risk assessment** (www.gexcon.com)

H2-gass lekkasje (4 mm) ut mot bakgård → 133 g/s



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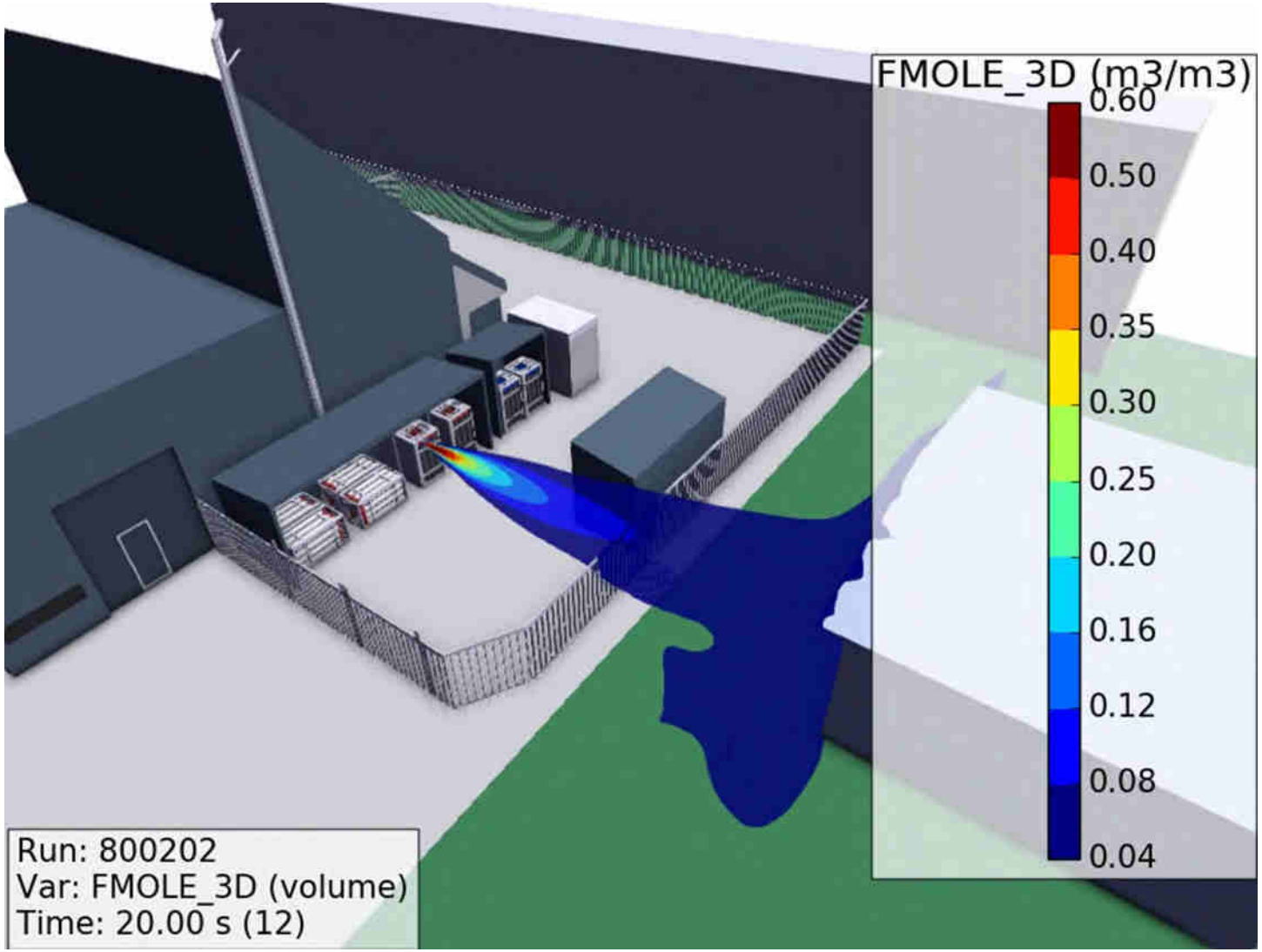
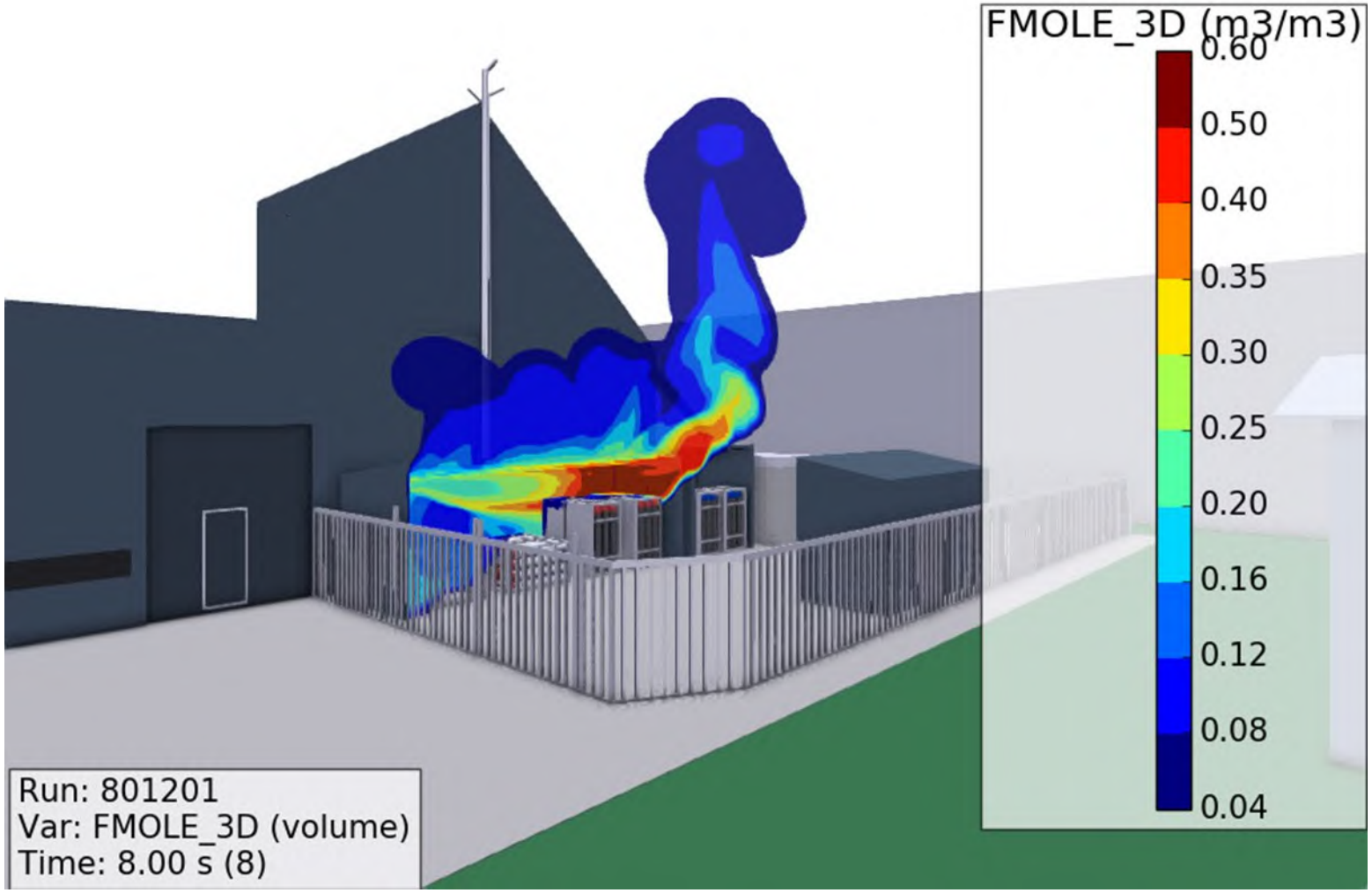


H2-gass lekkasje (4 mm) inn mot vegg – *«Worst-Case-Scenario»*



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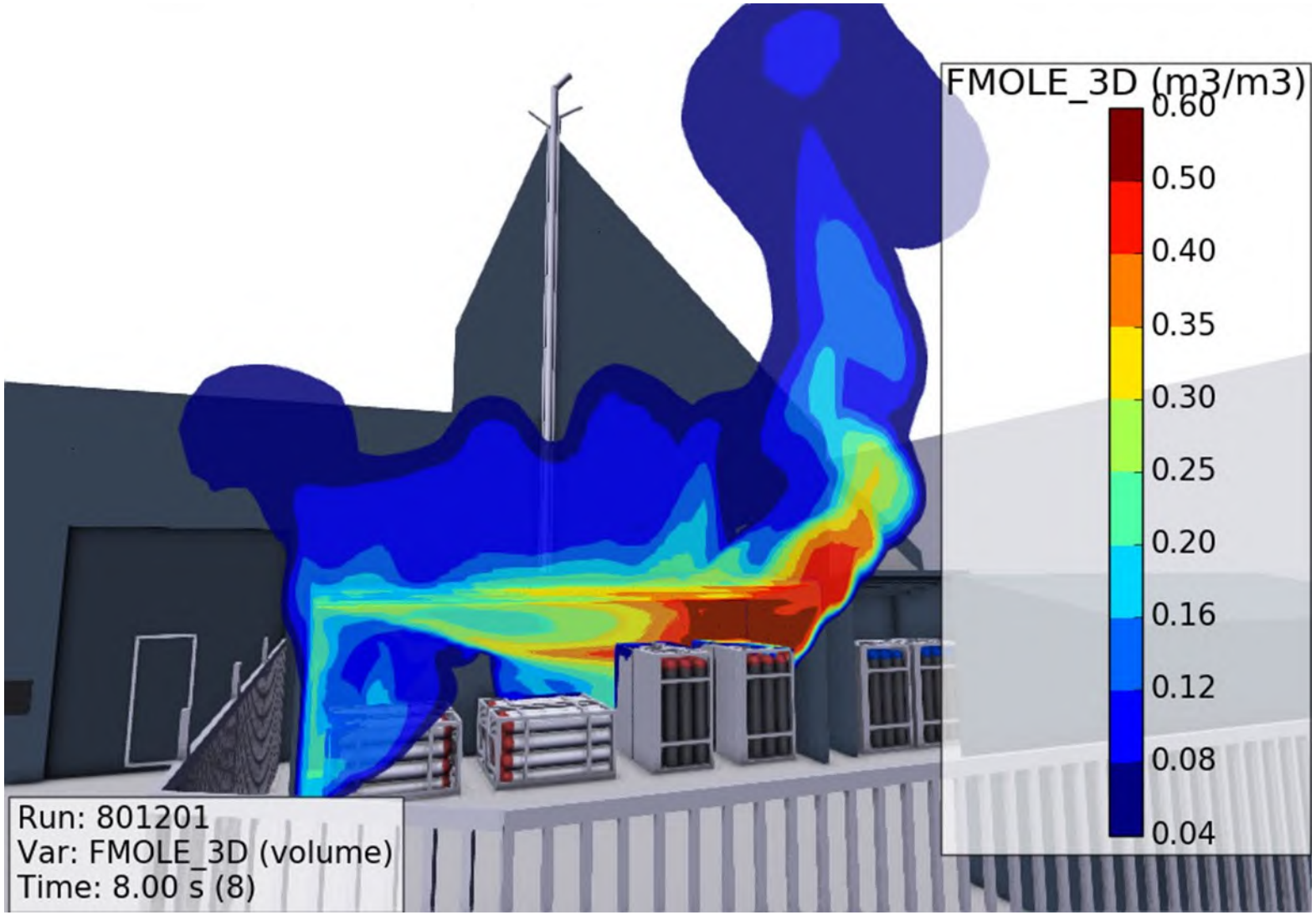

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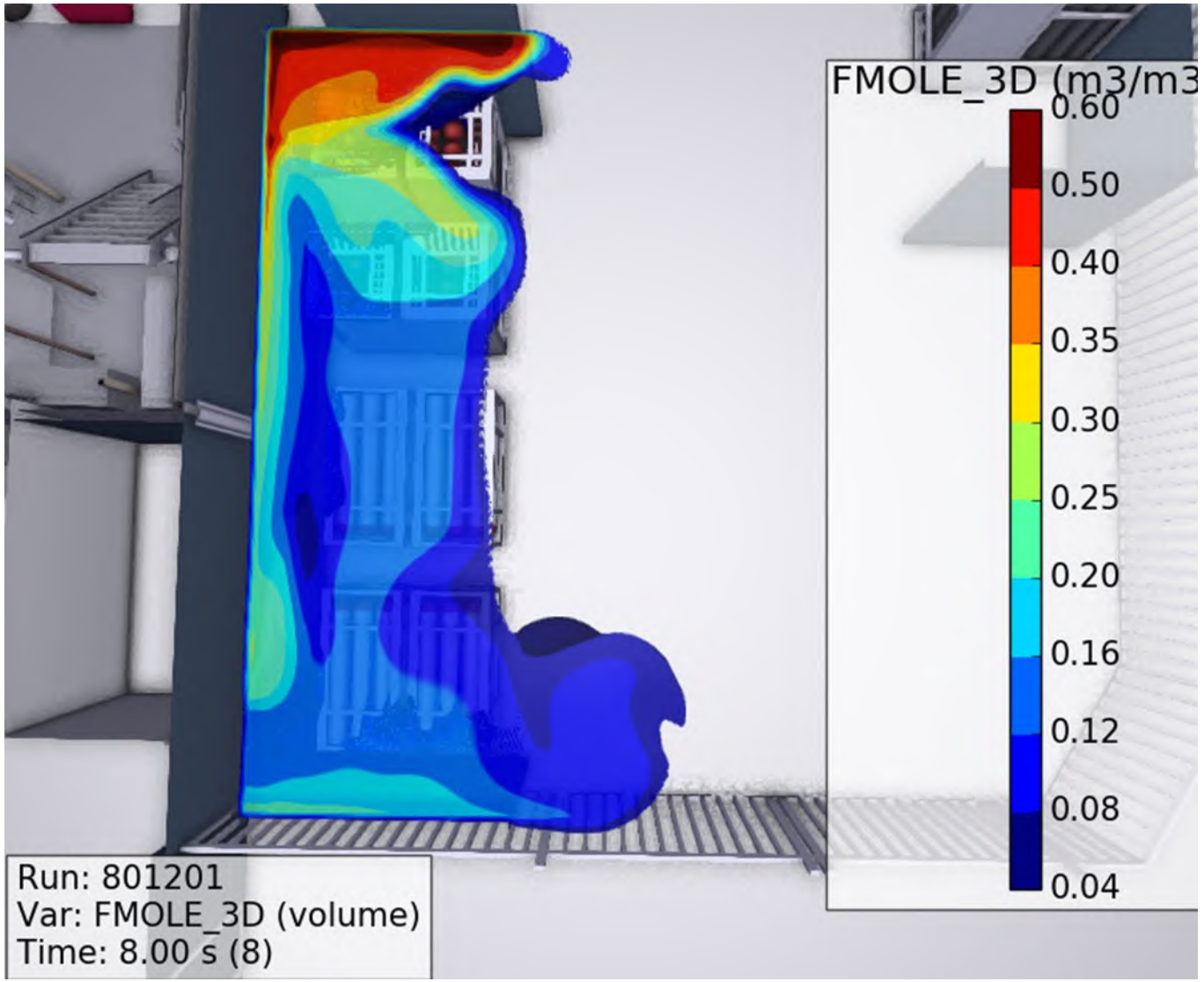
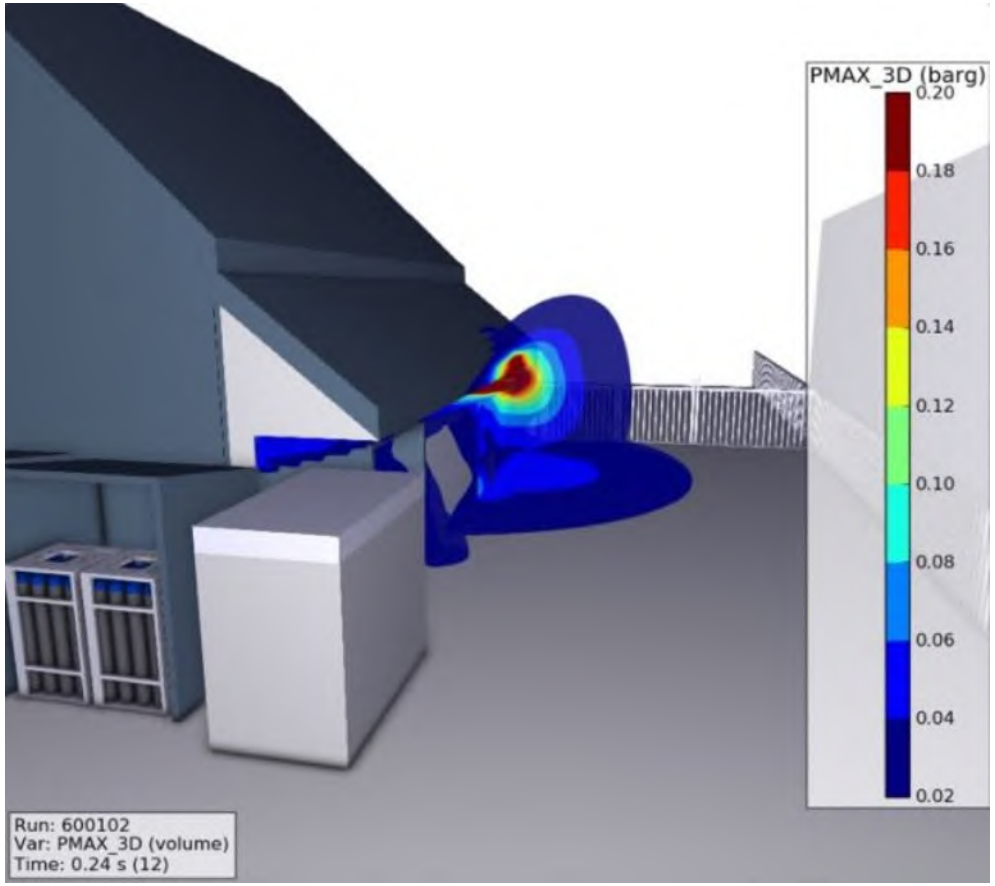
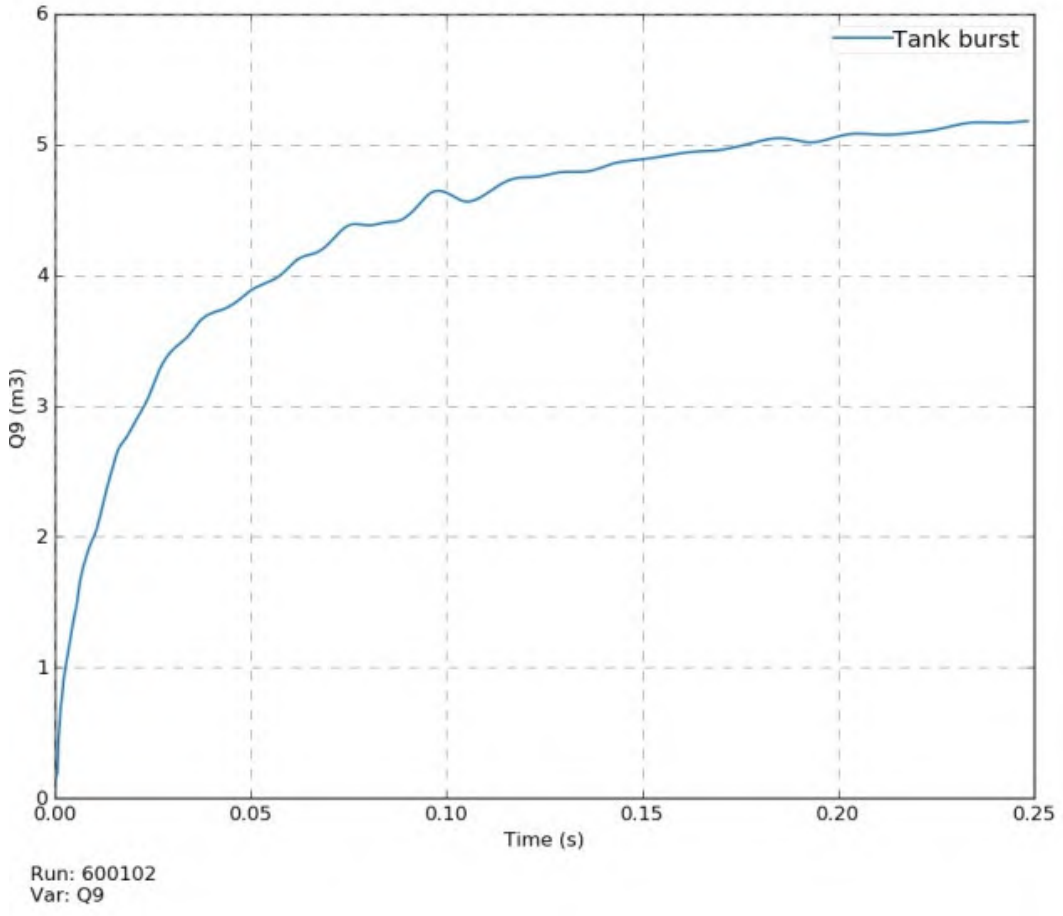


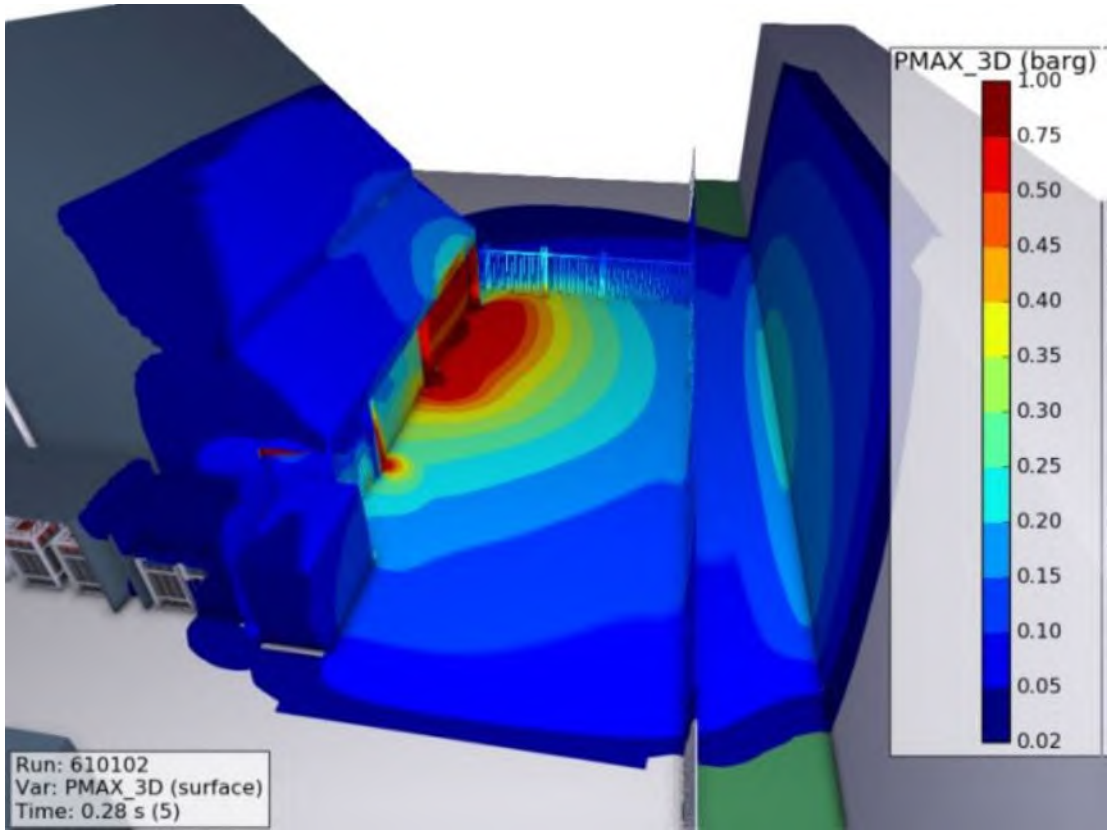
Brudd på H2-tank på LH2-anlegg → umiddelbart H2-utslipp

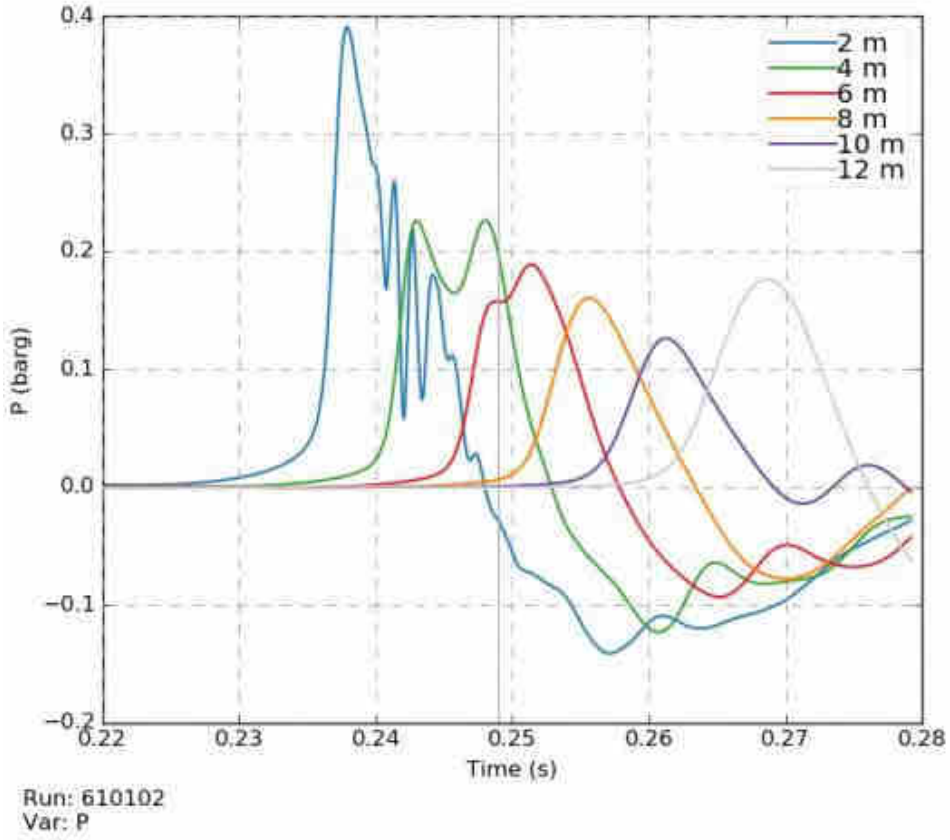




Eksplosjon med **ca. 125 g H_2** (60% av 200 g) → **Lav risiko for personell i nærheten**

Lekkasje fra LH2-anlegg (container) → forsinket H2-utslipp





400 mbar ved 2 m fra LH2-container → Lavt trykk på nabobygg, lav risiko for personell i nærheten