Beyond NaTECH Risk: Safety and Resilience in Hythane Transport Infrastructure

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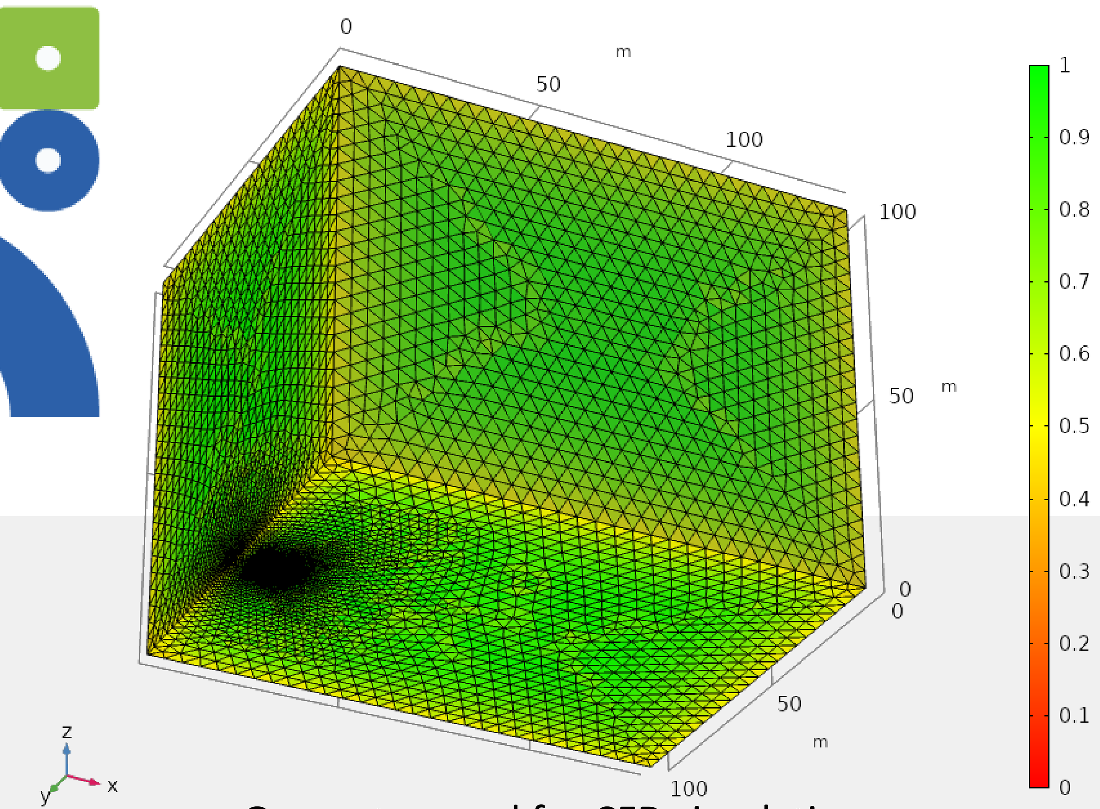
Spokes involved: TS2



Geometry used for CFD simulations

A technological accident initiated by a natural disaster is known as NaTECH (Natural hazard triggering technological disasters). Today, such events are a topic of great interest and concern due to the increase in the intensity of weather-related phenomena, caused mainly by climate change.

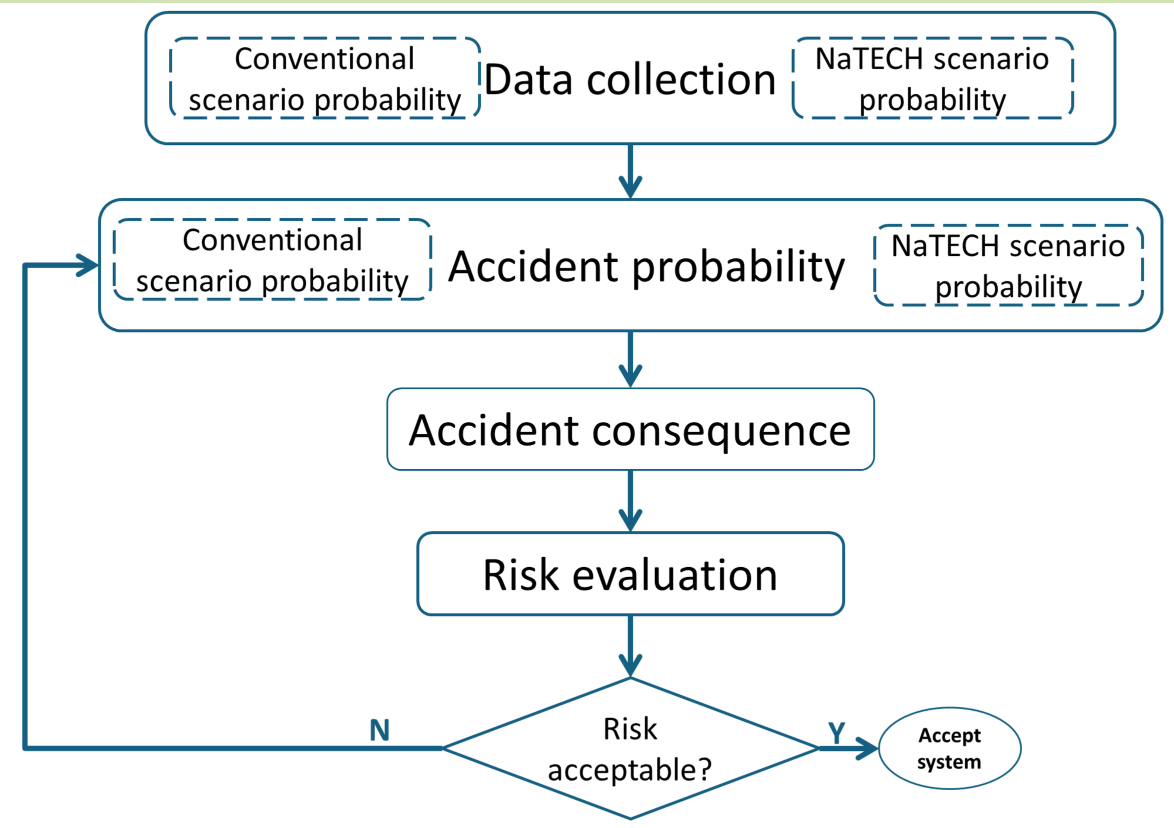
Hythane, a hydrogen-enriched methane mixture, could potentially reduce CO_2 emissions compared to methane and infrastructure costs compared to using hydrogen alone. However, its use in transport and distribution networks requires careful evaluation of safety and compatibility with existing infrastructures.

As a Proof of Concept, part of TS2-Multi Risk Resilience of Critical Infrastructures, a NaTECH risk analysis of Hythane transport infrastructure was carrier out to:

- → Perform a quantitative risk assessment of the NaTECH associated with the system of interest.
- → Evaluate the risk modification as the composition of the transported Hythane varies.

A quantitative risk analysis (QRA) of Hythane pipelines was performed as the CH_4 /H_2 ratio changes, using a specific framework for NaTech scenarios.

- → Earthquakes, floods, and lightning strikes were assessed as natural events and loss of containment (LOC) triggers.
- → Specific vulnerability models from the literature were used to assess the frequency of pipeline damage associated with natural events[1].
- → The event tree analysis (ETA) was developed to assess the frequency of occurrence of the consequences.
- → The consequences analysis was developed through both empirical models and CFD simulations:
  - Only empirical models were used for modelling consequences of jet fire.
  - To modelling the release and dispersion of the Hythane, computational fluid dynamics (CFD) simulations were carried out using a Reynolds Averaged Navier-Stokes (RANS) approach considering 1-minute release from a 5-cm diameter hole located at the top of the pipeline.



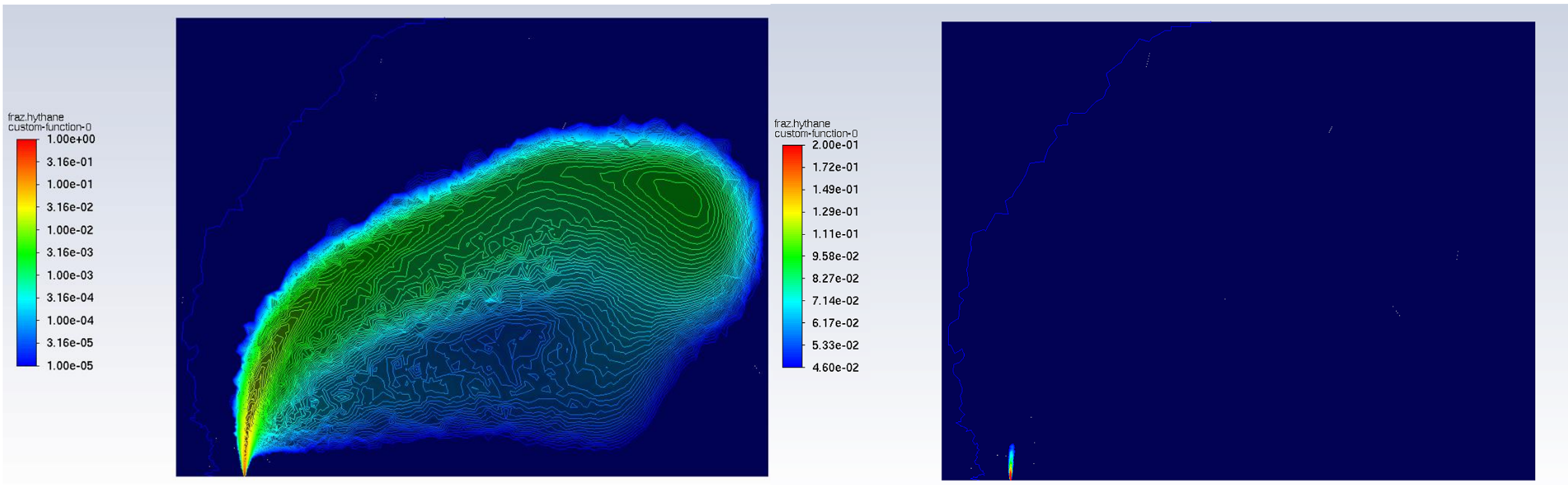
Framework of NaTECH risk analysis

	$R_{e.z.,100\% CH_4}$ [m]	$R_{e.z.,80\% CH_4-20\% H_2}$ [m]	$R_{e.z.,80\% CH_4-20\% H_2}$ [m]
Earthquake	40.2	42	43.5
Lightning strikes	9.4	9.9	10.3

Expansion of the effect zones when changing the mole fraction of H_2 in Hythane

Relevant results

- → For the flooding event, the probability analysis resulting in a zero value for the LOC frequency.
- → The effect of positive buoyancy is exhausted after approximately 75 metres in the wind direction.
- → The mass of flammable Hythane relative to the total mass released at t=60s is extremely limited.
- → In both seismic and lightning events, the expansion of the iso-risk zone increases when the mole fraction of hydrogen in the Hythane increases.



Hythane dispersion in the case of H_2 /CH_4 = 0.25 in terms of molar fraction (left) and in terms of molar fraction included in the flammable limits (right)

	f_{LOC}	$f_{Outcomes}$
Earthquake	$\psi \cdot 2.46 \cdot 10^{-4} \frac{events}{year}$	VCE→ $\psi \cdot 6.5 \cdot 10^{-5} \frac{events}{year}$ Jet Fire→ $\psi \cdot 8.67 \cdot 10^{-5} \frac{events}{year}$
Flood	0	0
Lightning strikes	$7.57 \cdot 10^{-2} \frac{events}{year}$	Jet Fire → $5.34 \cdot 10^{-2} \frac{events}{year}$

Occurrence frequencies of LOC after natural events and outcomes (related to a 1-minute release)

References [1] Cozzani V., Antonioni G., Landucci G. (2014). Quantitative assessment of domino and NaTech scenarios in complex industrial areas. *Journal of Loss Prevention in the Process Industries*, Volume 28, pages 10-22

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