NEC in tunnels

A methodology for evaluating associated risks

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A range of solutions, a range of risks

Hydrogen (FCV)

Compressed Natural Gas (CNG) for Vehicles

Electrical cars (HEV, PHEV, EV, FCV)

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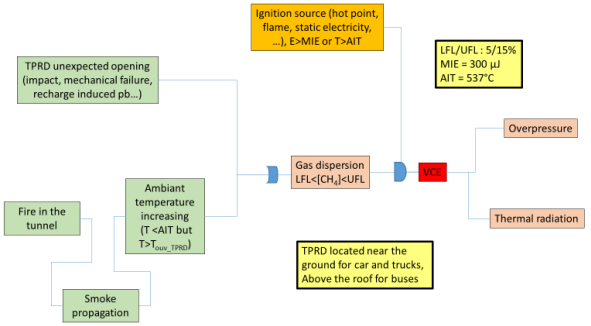
NEC as a primary risk, NEC as a secondary risk

NEC to be considered in two situations

- NEC vehicles can be a source
- NEC vehicles in the tunnel behind a fire and can induce additional consequences

Sequence is highlighted using bow-tie approach



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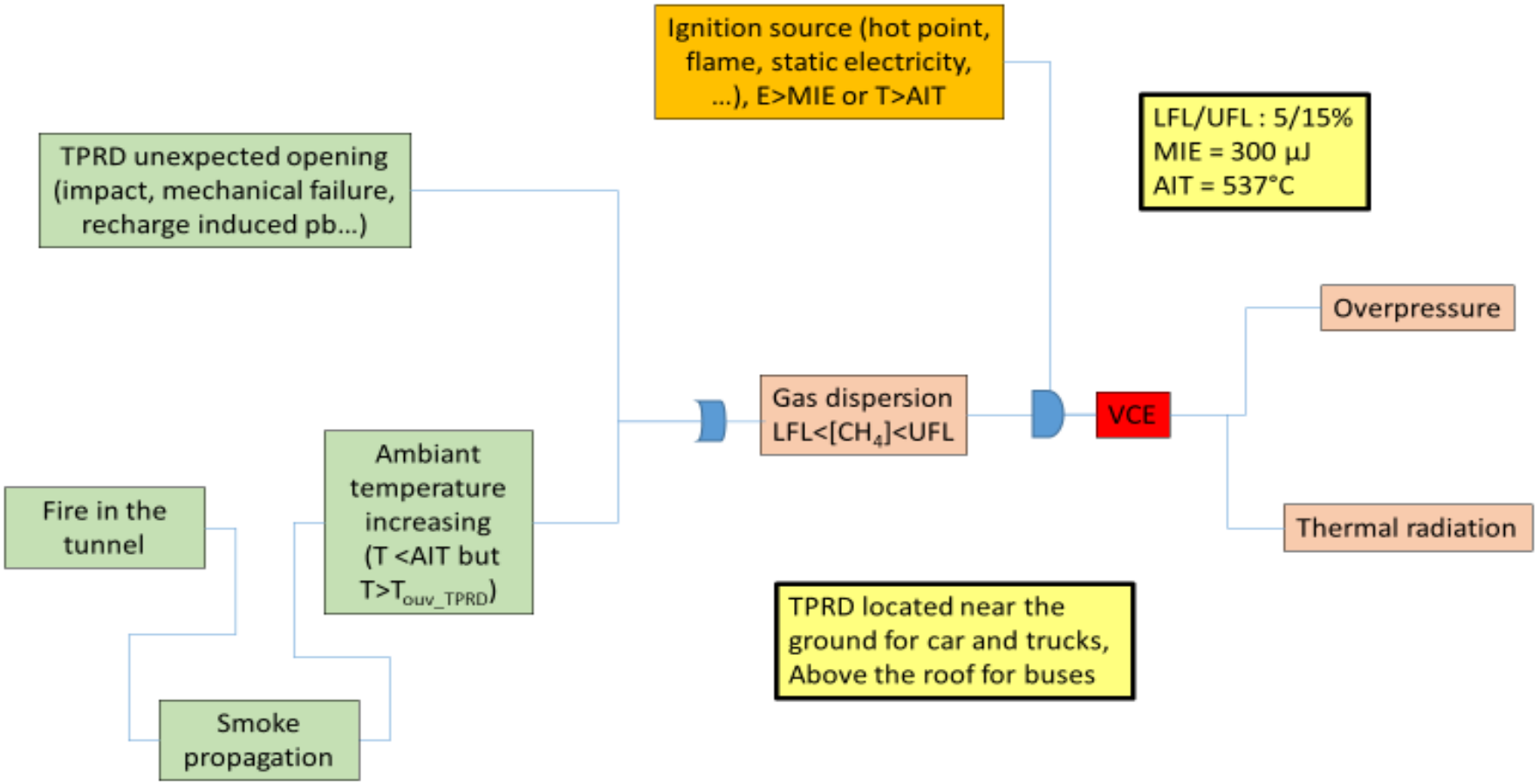


One main question

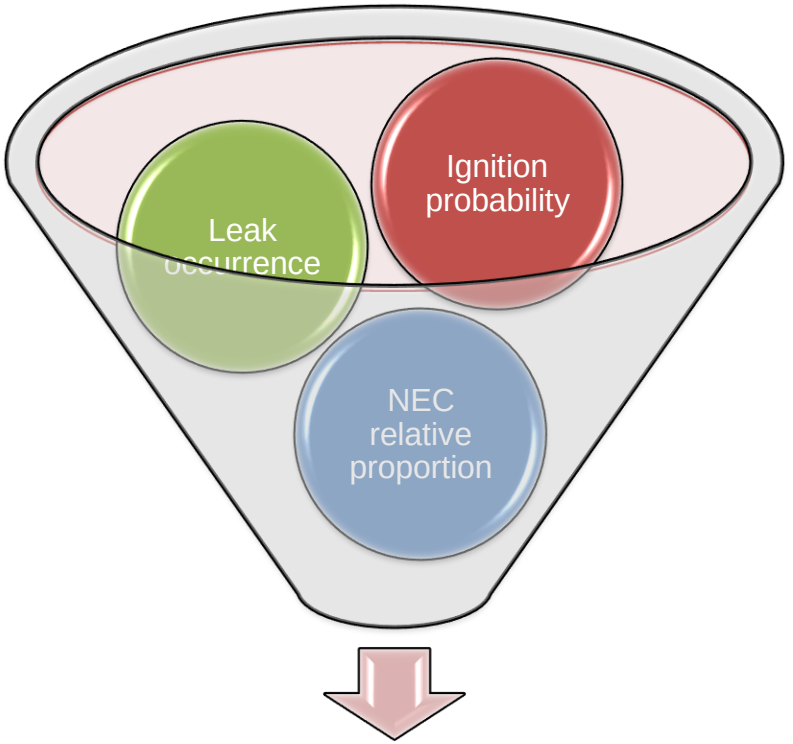
What are the additional risks for users induced by NEC in tunnels?

Probability of an event

No representative feedback

- Strong hypothesis required
- Evolving technologies

Computed occurrence rates to be compared with existing ones (eg: VCE)



$$\tau_{UVCE} = P_{non\_inf\_ouverture} \cdot \tau_{type\_veh} \cdot P_{inflammation\_nuage} \cdot \tau_{penetration} \cdot (\tau_{accident} \cdot P_{ouv_{sur_{choc}}} + \tau_{d\_remp})$$

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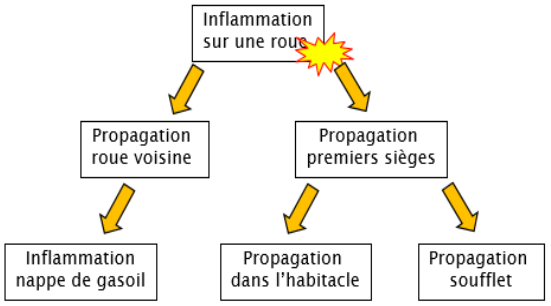
Consequence assessment: fire

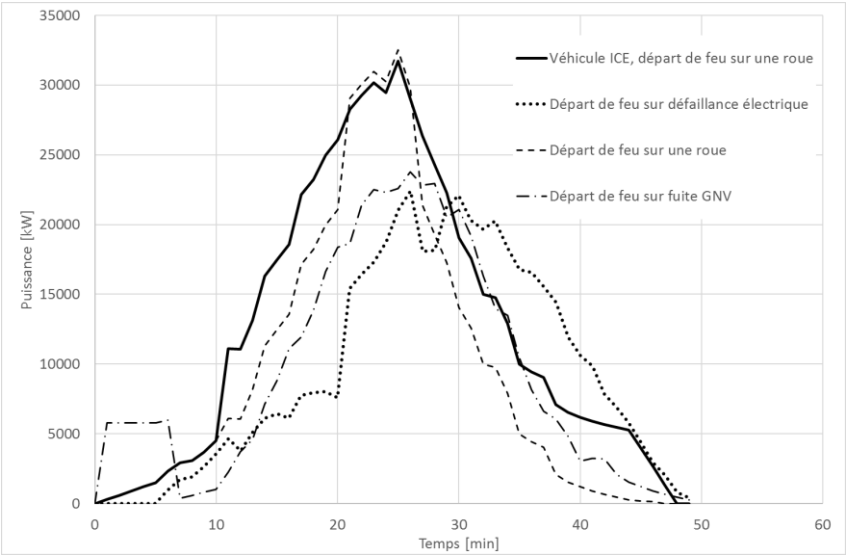
HRR to be computed considering NEC specific characteristics

- Fire kinetic
- HRR peak value

Toxic emissions

- HF production rate for EV





Example: The predicted GNC bus HRR curve

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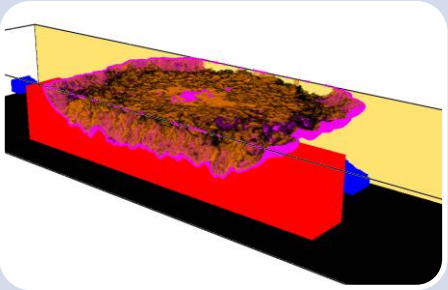
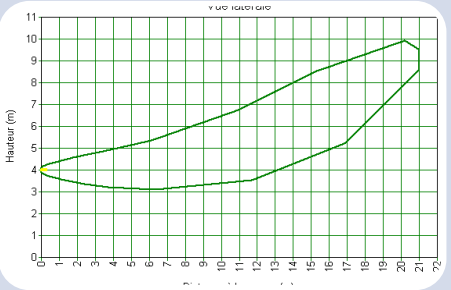
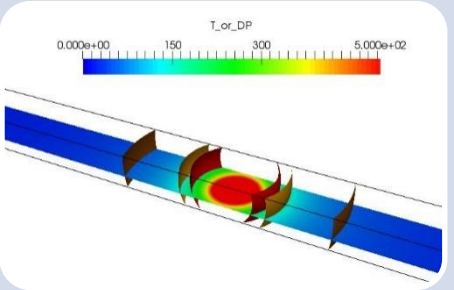
Consequence assessment: 3 new phenomena



Jet Fire
CFD to consider the jet fire and wall interaction



VCE
Dispersion model coupled with multi-energy to assess pressure consequences



Tank burst
3D wave propagation model to consider tunnel geometry

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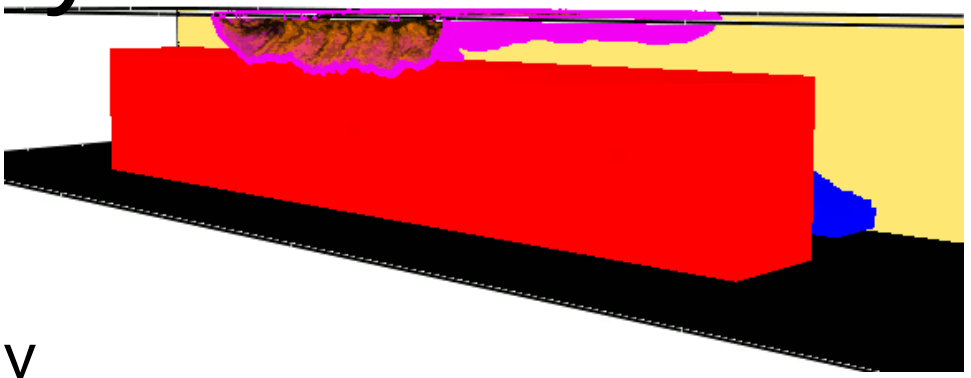
NEC as a primary risk



Consequences vary considerably

- Jet fire following collision on cars, buses or trucks
  - Cars or trucks : negligible increase of impact area compared to typical fire
  - Particular kinetic phenomena - vehicle passengers may be concerned
  - Bus passengers … natural gas radiation and hydrogen depending on the orientation of the release
- VCE on cars, buses or trucks
  - 50 m for lethal threshold, each side of the vehicle, for hydrogen vehicles
  - 25 m for lethal threshold, each side of the vehicle, for CNG vehicles
- Tank burst
  - CNG & Hydrogen: significant consequences due to the subsequent VCE
  - LNG : huge consequences due to the BLEVE

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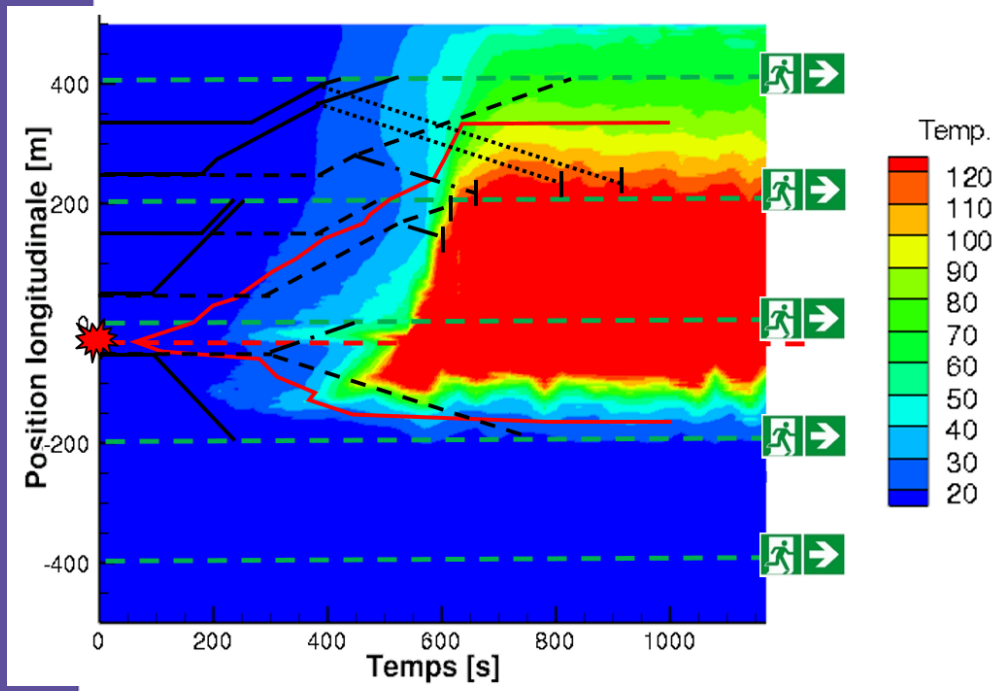
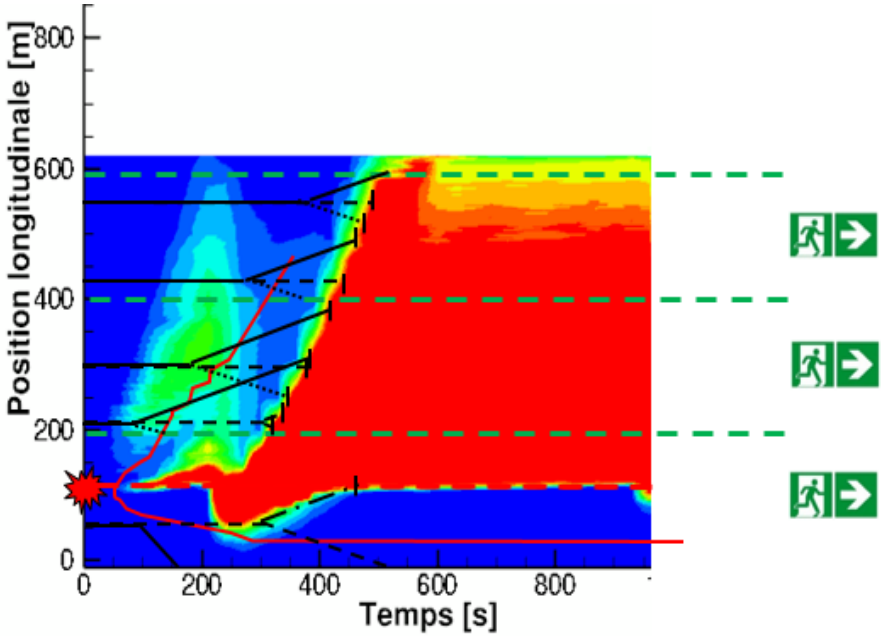
NEC as a secondary risk

100 MW fire in a congested tunnel



➔ Up to 50+15 additional deaths

200 MW fire in a congested tunnel



➔ No additional deaths

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Results in a nutshell and perspectives

- NEC in tunnels lead to new risks, mainly
  - For the NEC vehicle itself, the VCE case following a leak without fire on the NEC vehicle
    - up to 15 to 30 people exposed to lethal effect, bus passengers to be added
    - occurrence rate between $1{,}56 \times 10^{-3}$ (NEC : 2%) and 7.82×10^{-2} for 10^8ttveh.km (NEC : 100%)
  - In case of a distant fire in the tunnel with a NEC bus in the queue
    - Up to 65 to 80 people exposed to lethal effect, including the 50 bus passengers
    - a maximum occurrence rate about 2.0×10^{-4} / 10^8ttveh.km
- Communication to manufacturers and stakeholders so they consider this specific risk in the development process
- Evolution in terms of risk acceptability

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Thank you for your attention

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