New energy carriers in underground infrastructures – unanswered questions and research needs

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on behalf of L-Surf partners

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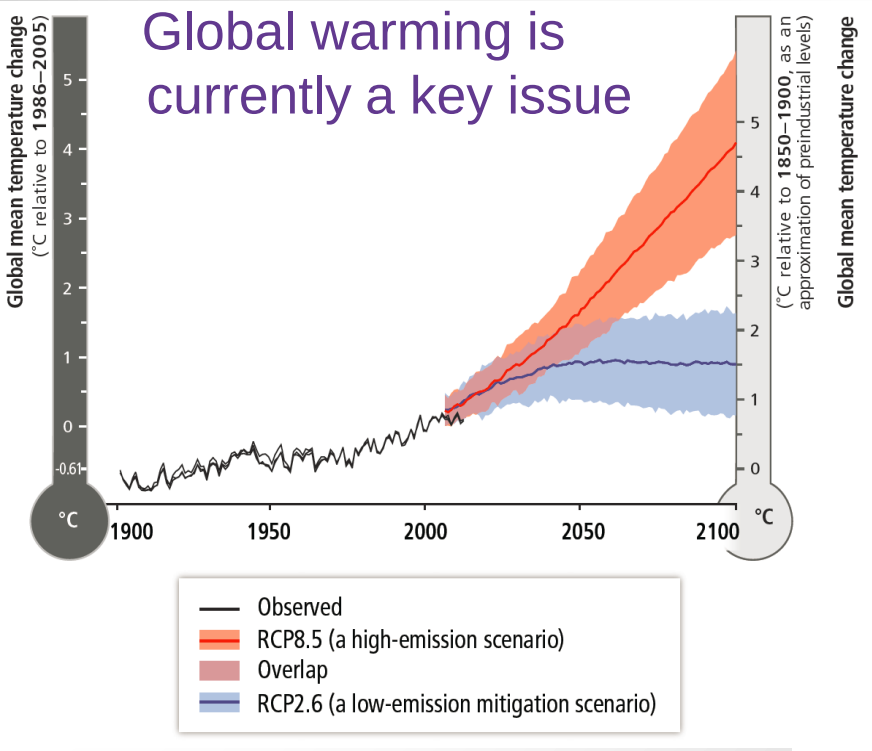
New Energy Carriers in the context of global warming



GIEC

CITEPA

Transport is the most important contributor

A large panel of solutions for today and tomorrow

Hydrogen

Compressed Natural Gas (CNG) for Vehicles

Electrical cars (HEV, PHEV, EV, FCV)

Biofuels

A major issue for the mass market development

- It is commonly admitted that cars can only explode in action films
- Around 20 years ago: LPG was launched as first innovative energy carrier for vehicles in France
  - cleaner & cheaper
  - Promised to great development (as in NL, B and I in the EU…)
- But, at the beginning, safety valve on LPG tank was forbidden … for safety reasons *and replace by thermal fuse*

➔ Let's imagine the impact on people and consequently on technological development of those technologies of a major accident

➔ It is our responsibility to be pro-active to prevent such a catastrophic emergency response endpoint

NEC in tunnels, state of the art from lit. survey

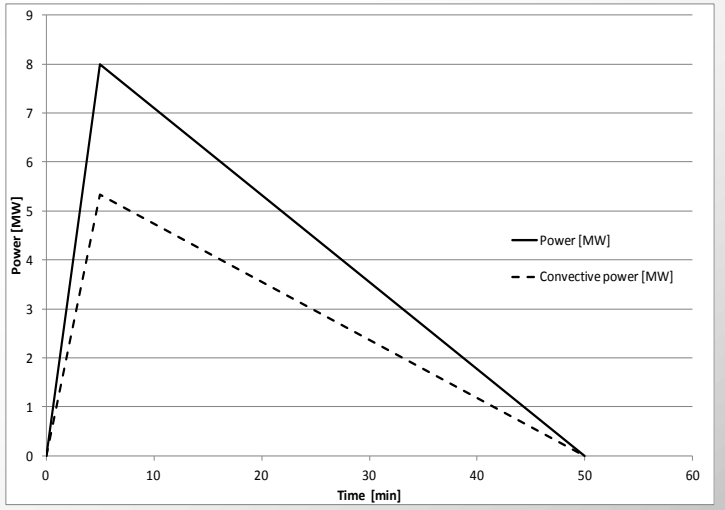
- Several papers focus on NEC … :
  - H_2 safety, including dedicated conference ICHS
  - Rechargeable Batteries
  - Biofuels, some addressing their fire behaviour

… but very few relevant to tunnel safety:

- Some words in the *Handbook of tunnel fire safety* (Carvel et al, eds. 2010) regarding H_2
- Some papers on explosion or gas dispersion for security aspects
- Some workshops, the last one held in Marseille before the ISTSS

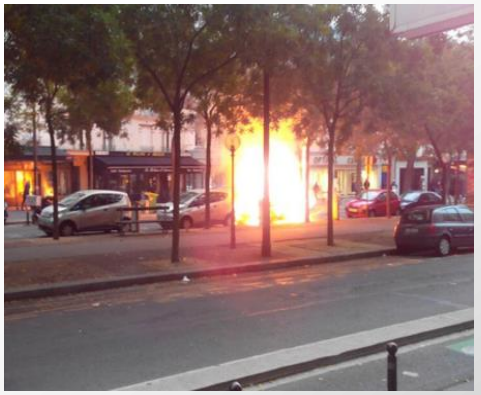
➔ Ensuring safety is critical for NEC sustainable development

The major insight: Are ref. standards still valid?



- Tunnel safety by design relies on pertinent fire scenarios
  - Small fire, most probable case
    - NEC impact on a car fire?
  - Fire design curves:
    - HGV fire: hazardous goods or not ?
  - Will fire keep the safety related sizing phenomenon?
- Every following consequence to be accounted for
  - Thermal effect: relation between fire power and ventilation velocity
  - Toxic impact: relation between the emission factor and the mixture with the air flow generated by the ventilation system
  - Visibility: function of the quantity of soot generated by the fire and the dilution by the air flow and smoke management systems potentially operating
  - Overpressure in case of explosion

Impact of NEC on car fire development



➔ The fire kinetics : the first minutes after ignition

are crucial for evacuation in tunnels !

➔ The maximum power that can be reached

- ➔ impact of battery on the fire power ?
- ➔ jet fire on CNG or H_2 can generate propagation to several vehicles with a rapid increase of the HRR

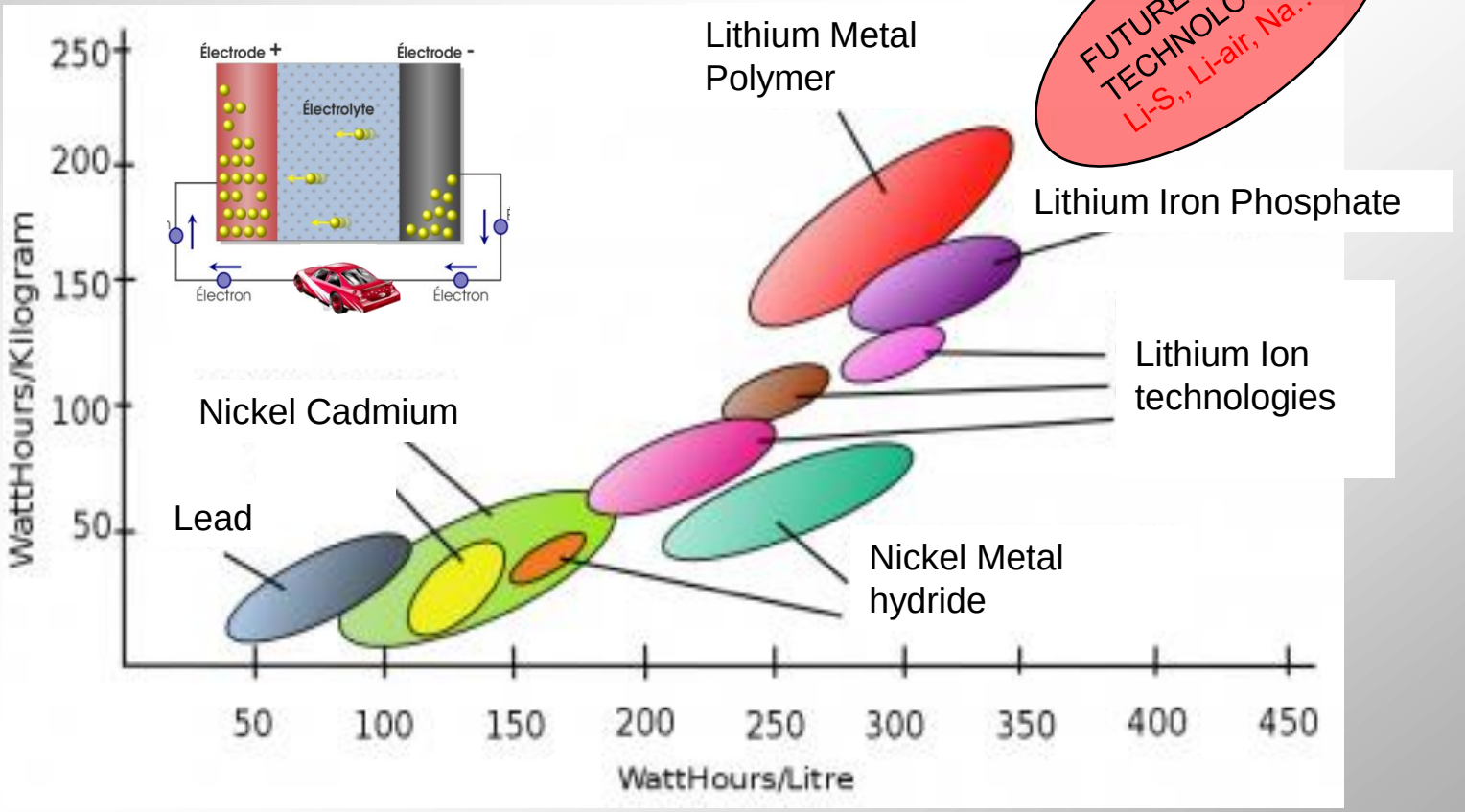
➔ The possibility of additional consequences:

- ➔ Explosion of compressed gas: CNG or H2
- ➔ Jet fires

➔ What could be consequences on the firemen action ?

- ➔ Is water still able to fight such fires (electro mobility) whatever EV types ?
- ➔ Explosion as a result of water use on battery fire (Li-M) ?

Batteries and global vehicle HRR



CNG / H2 and fire development

- CNG and H_2 are commonly stored in high pressure tank
- Safety systems are used for preventing tank burst

  ➔ in case of fire, gas is rejected through this safety valve or thermal fuse

  ➔ generation of a jet fire, what could happen in tunnels ?

  ➔ propagation to vehicles in the surrounding with a rapid increase of the HRR

Impact of NEC on design fires for FSE of tunnels: freight consideration

SP Fire tests

- 200 or 300 MW for gasoline tanker fire
  - New energy mass transport through tunnels
    - Bio-fuels: large proportion of ethanol
      - ➔ Behavior of large scale ethanol pool fire (SP)
    - Batteries: fire propagation in case of fire on battery loading
      - ➔Impact on kinetics
      - ➔Likelihood of fire start (spontaneous ignition) in normal or abuse conditions ?

Hydrogen, CNG: are new phenomena expected?

Is an explosion possible?

CNG

- Technical data required for tanks
  - operational pressure: 200 bar
  - test pressure: 300 bar
  - burst pressure: 470 bar
- Prevention of burst
  - Safety pressure discharge valve
  - Thermal fuse that melt around 100°C
  - Development of specific materials that generate diffuse release

➔ Still opened questions: Can a tank burst event be systematically avoided?

➔ Safety measures to be designed in accordance with safety in tunnels

Required research topics regarding batteries

- 2 main topics
  1. Probability of fire start regarding the failure modes of batteries
     - Detailed risk analysis
  2. Standard fires of reference in FSE:
     - Can we accept revising our standard for fire design (cars and HGV)?
     - Is a new standard required for the battery fire development with imposed fire tests?

➔ Consideration of the concept of moving technology: staying aware of technological development

Required research topics regarding biofuels

- Research regarding the specific behavior of large Ethanol/EXX pool fires (UN3475)
  - Modification of fire properties, mainly for HGV
  - Structure resistance curve can be inadequate
  - News fuels compatible (or not) with existing fuel mix (gasoline or diesel fuels meeting EU fuel Standards)
    - Alternative fires to kerosene ?

Required research topic regarding H_2 and CNG

- Manufacturing tanks “safe by design”
  - Preventing burst phenomena
  - Preventing non burning leaks of gas

➔Design of efficient and reliable safety systems

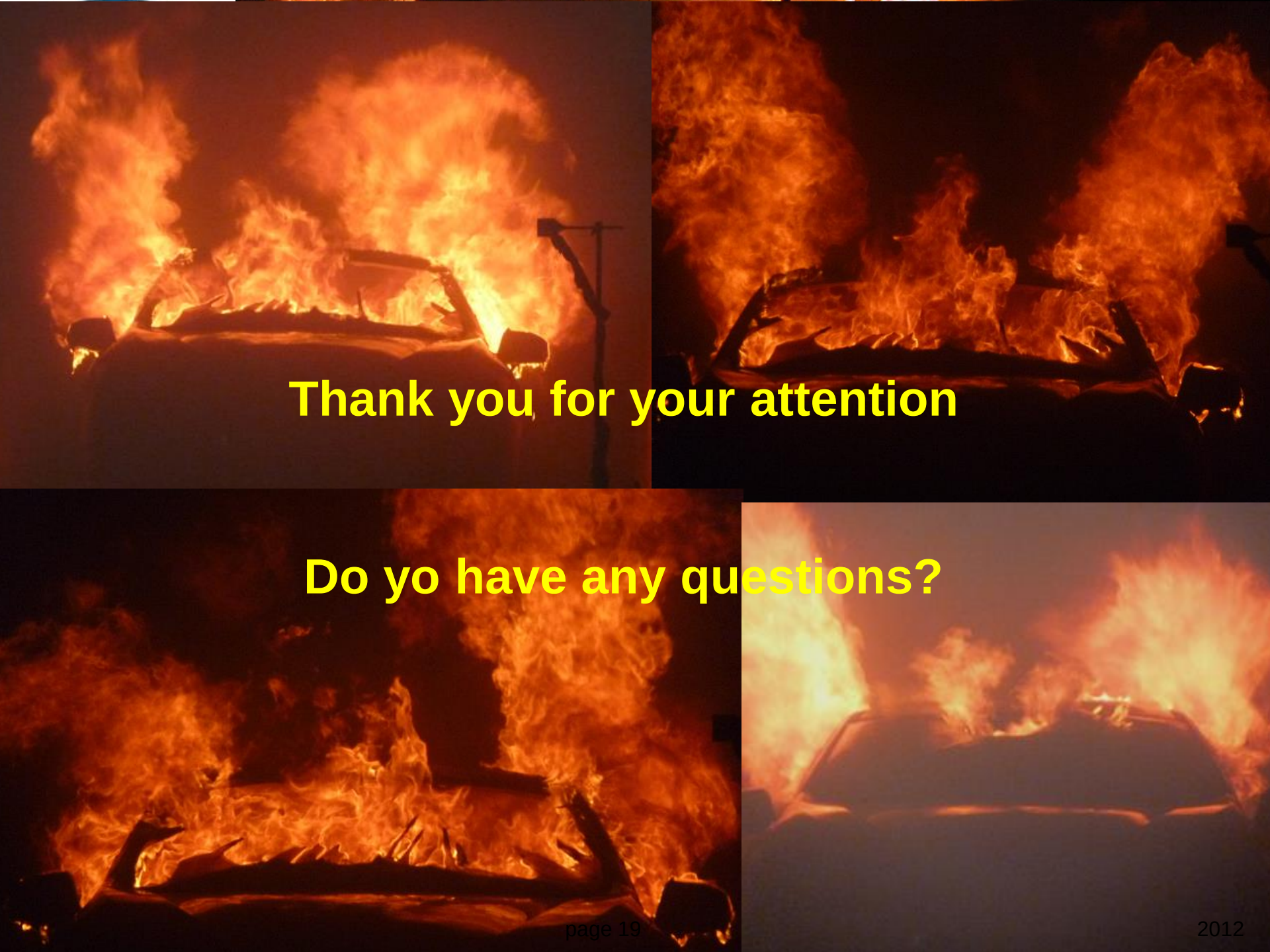
➔Due consideration of the impact of tunnel confinement into the design process

Conclusions

Today, research is needed for ensuring NEC to be used in underground infrastructures

- It is not acceptable that NEC to be forbidden
- New atypical scenarios and probability evolution must be accounted for
- Possibility of introducing NEC in specific tunnels (A86, channel tunnel, …)
- Check whether regulation is in accordance with NEC development

L-Surf, an active consortium for such research actions, with suitable experimental and numerical facilities



Thank you for your attention

Do yo have any questions?