Implications of New Energy Carriers on Road Tunnel Safety

Workshop organised by ITA-COSUF, PIARC and Knowledge Platform Tunnel Safety (KPT)

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Background

- Environmental concerns require decarbonisation of road traffic
- Reasons
  - Climate change
  - Local air quality problems
- Decarbonisation without reduction in transport activity means change of energy carrier
- Alternative and/or new energy carriers
  - Electricity
  - Syn fuels (H_2 or H_2 carriers)
  - Fuels with reduced CO2 emissions (LPG, CNG…)

Change in vehicle fleet

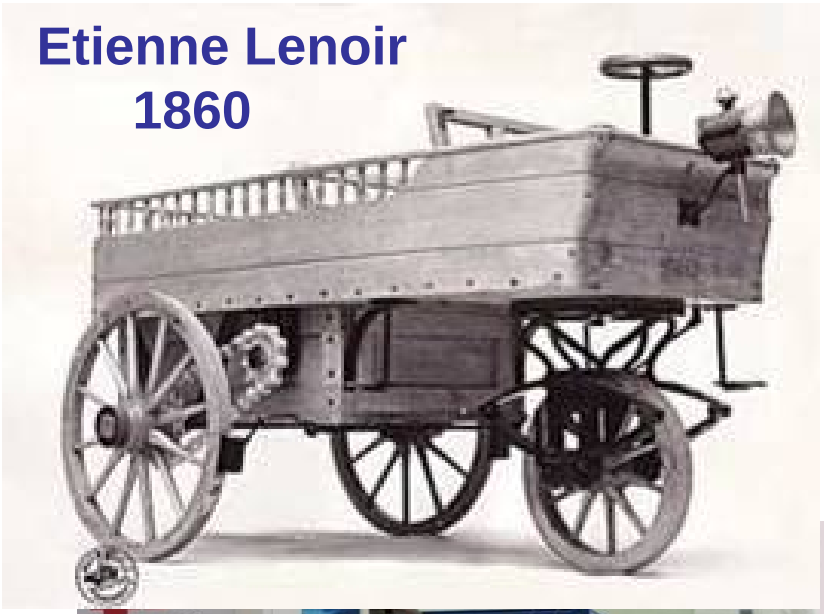
- Strong increase of BEVs in Europe
  - Nevertheless currently not more than 0,4% of all passenger cars and light duty commercial vehicles on road
  - Expected to increase to 10% in next decade(s)
  - In urban areas share is much higher
- Hybrid vehicles (IC + BEV) sales increase
- Fuel cell powered EV are still rare but an expected option for replacement of IC in medium/long distance runs (especially for transport)

Effects of alterative energy carriers on road tunnels

- Effects of incidents with ‘standard’ vehicles (well) known
- Little information available on effects of new energy carriers
- PIARC initiated the development of a “Technological Watch Paper” in the working cycle 2016 – 2019
  - Various activities on individual/national level (reports, journal and conference publications)
  - Lot of research activities concerning thermal runaway, fire risk etc. for batteries (cells) at OEM level (mostly unpublished)

New (?) energy carriers on roads (Gas/H2 vehicles)

Francois de Rivaz
1807



Multi-flex-fuel vehicle:
gasoline/CNG/H2 or
any mixture between CNG and H2
TU Graz 2010

New (?) energy carriers on roads, H2 Fuel Cell Vehicle

- TU Graz Prof. Kordesch 1970‘s

Electric motor drive	20kW
Weight	950kg
v_{max}	75km/h
Cruising range	300km
Fuel cell type	alkaline
Fuel cell manufacturer	Union Carbide
Power	3 x 2kW
Temperature	80°C
Fuel	pressurized H_2
Oxidant	air
Battery	7kWh/Pb

NEC carriers on roads, FCBEV

Risks - Battery Electric Vehicles

1) Risk due to electrical shortcuts because of damage of separator between anode and cathode of a cell
   - Result in a so-called thermal runaway (overheating) → evaporation of poisonous and flammable gases → fire
2) Mechanical damage of battery (cell) due to an incident → 1)
3) External fire reaches battery → 1)
4) Overheating due to recharging (no issue of a road tunnel)


Source: Heute online 15.8.18


Source: FF Landeck

Existing knowledge - Battery Electric Vehicles

PC battery fires:

- max. HRR more or less equivalent to conventional fuels
- Toxic gases different, most critical HF gases and aerosols (heavy metals)
- Gas releases from overheated batteries already prior to fire

Heavy duty vehicles incl. buses:

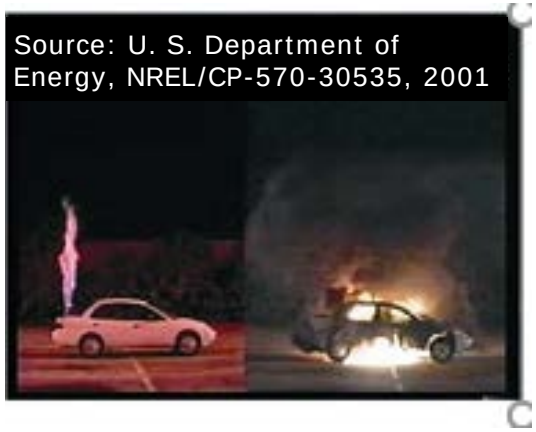
- No test data available

First responders to an incident:

- Normally next car driver, personnel from tunnel operator but not the well equipped fire brigade
- High risk because of HF as vented gases and HF deposition (acid) on the car body

Risks - Fuel cell vehicles

1) Risk due to fuel:
   a) Current storage technology 700 bar gaseous form
   b) Ignition limits of H_2 in air are within a wide range (4% to 76%)
   c) In case of overpressure due to external heat supply (fire) venting via pressure relief valve
   d) Vapour cloud explosion possible
   e) Flame has the characteristics of a jet
   f) Tank rupture unlikely



2) Risk due to battery:
   a) Same as for BEV
   b) Battery is smaller than in a BEV but much bigger than in a conventional car

Existing knowledge - FCEV

PC:

Tests only for H_2 fire from a blow-off event of a tank

Heavy duty vehicles incl. buses:

No test data available

Existing knowledge – LPG/CNG

PC:

Although already for a long time in the fleet, up to now no major incidents in tunnels reported

Uncontrolled release of gases is very critical

Heavy vehicles:

As above, but higher loads

Risks

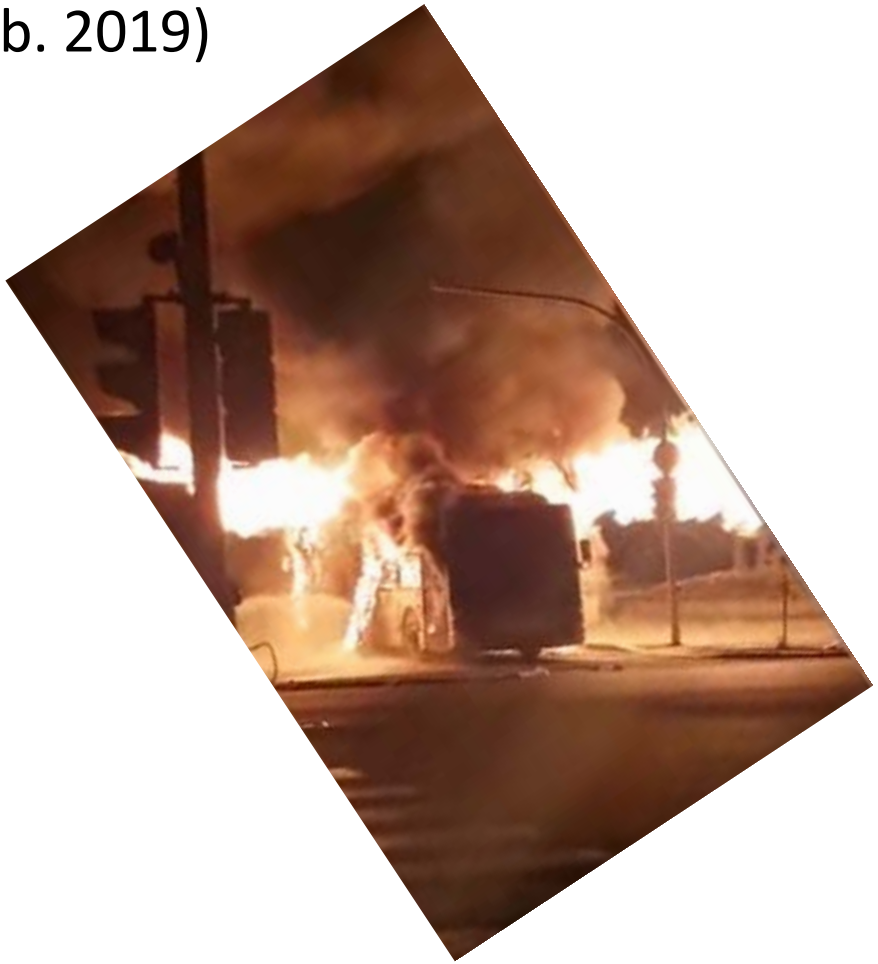
- BEV with large batteries (busses or transport of BEV)
- Fire of a transporter with conventional cars
  Arlberg Tunnel 14 km long, bidirectional traffic; Jan 29th 2019

FFFS (water mist based) supported fire fighting perfectly


Source: https://vorarlberg.orf.at/news/stories/2961499/

Risks

CNG bus on fire (Rome, Feb. 2019)



https://www.youtube.com/watch?v=FROKUUjNegs&feature=youtu.be

Consequences - General

- Vehicles with alternative fuels pose a “different” risk to the tunnel and the rescue forces
- Vehicles with fuels stored under pressure (LPG, CNG, H2…) produce jet flames in case of a fire
- Venting gases of batteries pose a high risk to tunnel users due to their toxicity and as a possible fire source
- Any release of LPG in a tunnel cause a remarkable risk in an explosion at other locations than the incident

Consequences – Tunnel infrastructure

- Currently no sensors for vent gases in tunnels
- Forced ventilation might be required as soon as an incident (also without fire) is detected
  - H2 has a very broad ignition range in air. I.e. even small releases of H2 might be critical
  - High ventilation rates (proposed air speed > 10 m/s) would help, but are counterproductive for escape possibilities and would require unrealistic high ventilation power
- Sizing of water-based firefighting systems ?
- Sizing of waste water treatments systems ?

Consequences – Rescue forces

- Recognition of such vehicles in case of an incident is almost impossible
- Current approach to fight fires with lots of water might not be sufficient in case of BEVs → water supply, drainage system
- Cooling down of vehicles in waterfilled containers not possible
- Danger due to
  - Explosive mixtures
  - High voltage

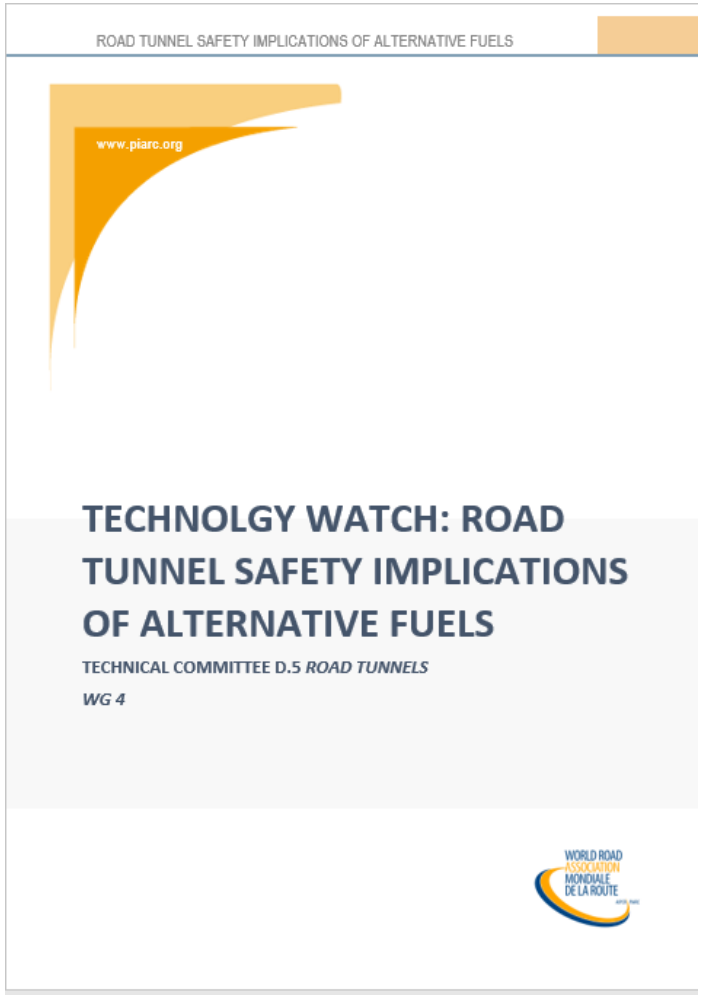
Identification of vehicles with “other” fuels ?

Crash at Herzogberg Tunnel, A; 2013
© Feuerwehr Mooskirchen

Consequences – Risk analysis

- Current state of the art considers HC fires with traditional toxic gases like CO, HCN, HCl
- Other toxics not considered yet
  - in gas form: HF, PH3
  - heavy metals in form of aerosols: Co, Mn, Li
- Also accidents without fire must be considered (release of vent gases)

PIARC activities



Draft report:
Active work for next cycle proposed

Cooperation with ITA-COSUF group:
Would be more than fruitful