



German Research Project SUVEREN

Safety of Urban Underground Transportation Areas considering New Energy Carriers: Objectives - Status – Results

ITA-COSUF Workshop on New Energy Carriers in Road Tunnels,
21.02.2019, Utrecht

Frank Leismann, STUVA e. V.



Motivation

Dynamic increase of New Energy carrier (NEC):



Source: shutterstock.com



Batteries



Pressurized Gas



Liquid Biofuels

Gap of

- **Knowledge**

Risk and impact of NEC

- **Regulation**

Existing, standards regarding design are based on conventional energy carriers only

BMBF Call 2016

German-French cooperation in the field „safety of future urban areas“



Project SUVEREN

Partner



GEFÖRDERT VOM



Bundesministerium
für Bildung
und Forschung

Project duration

August 2017 to July 2020

Associated Partner

-  INERIS
-  CETU
-  Station & Service
-  Feuerwehr München

Sub-Contractor

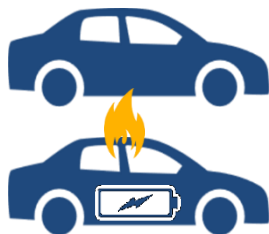
-  IFAB
-  INERIS
Développement



Overview SUVEREN approach



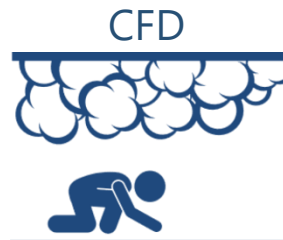
NEC Threats



Scenarios



**Case
studies**



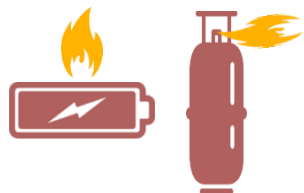
**Numerical
simulation**



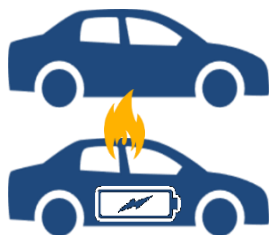
Measures



**Impact on
Safety**



NEC Threats



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Measures



**Impact on
Safety**



Risk assessment

- Release of toxic / suffocating gases
 - different propagation mechanisms (cold) which endanger the areas for evacuation
- NEC are high-energy fire sources, which likely lead to vehicle fires. Different fire development (in terms progression) result from
 - Thermal Runaway (Battery)
 - Jetflames (Gas)



Source: STUVA



Threats of Lithium-Ionen-Batteries

- Thermal runaway due to
 - Mechanical impact (accident)
 - Thermal impact (external initial fire)
 - Incorrect operation (defect BMS, charging, short circuit)
 - spontaneous (aging, production fault)
- changed fire load and / or changed fire development
 - Depending on design, battery capacity and state of charge (SOC)
- Battery fires are difficult to extinguish (encapsulated design, chemical properties)
- Release of critical amounts of toxic substances (e.g. hydrogen fluoride, heavy metals)
- gas emission of toxic gases before fire
- Threat to fire service
 - High voltage
 - Delayed re-ignition



Threats of pressurized gases



- Bursting pressure vessels
- Jet flame
- Flammable mixture (deflagration, explosion)
- Oxygen displacement
- Extreme cold temperature

H₂

- wide ignition range with low ignition energy
- high pressure vessels up to 700 bar
- high diffusion rate
- almost invisible flames, flame temperature 2.000° C

CNG

- Gas accumulation in the ceiling area

LNG

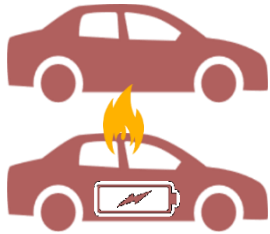
- Gas accumulation in the ceiling area
- Puddle (extreme cold)
- Poolfire
- BLEVE

LPG

- Gas accumulations in deeper areas
- BLEVE

DME

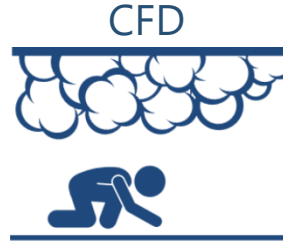
- Gas accumulations in deeper areas
- Puddle (extreme cold)
- Poolfire
- BLEVE



NEC Threats **Scenarios**



Case studies



Numerical simulation



Measures

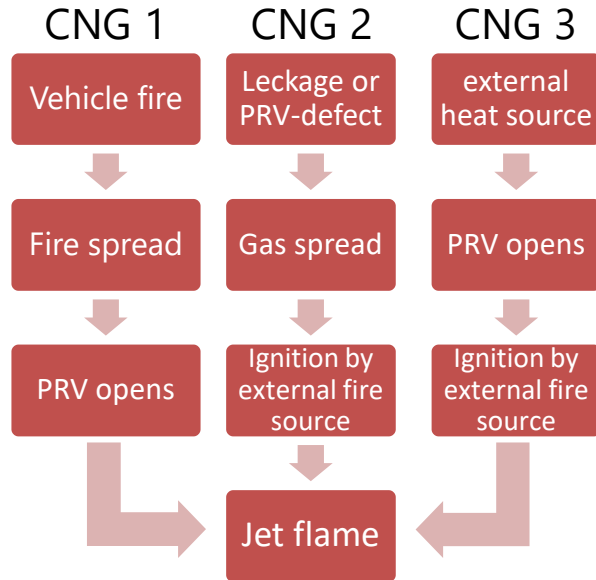


Impact on Safety

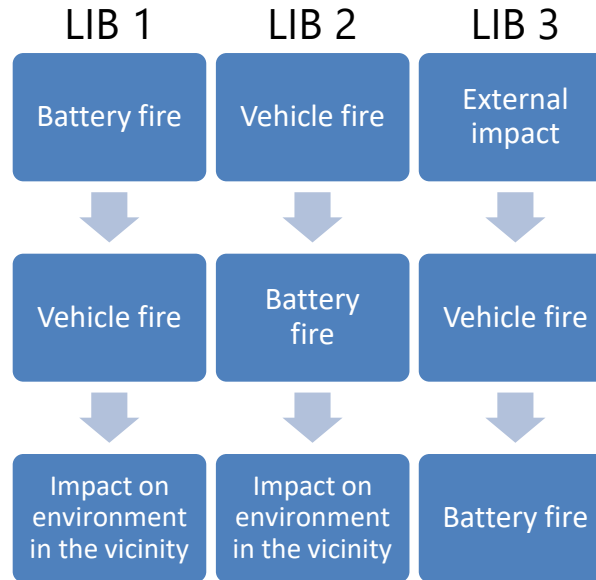


Scenarios

CNG-Scenario



LIB-Scenario



CNG Bus Fire (NL 2017)

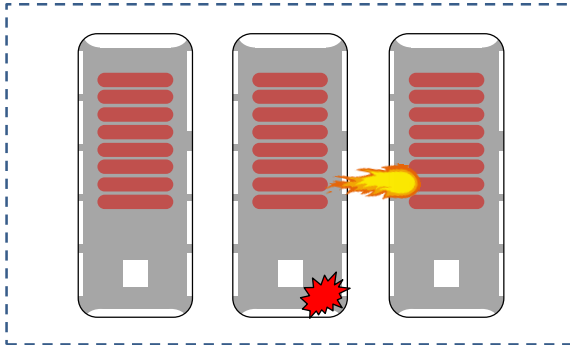


<https://youtu.be/VHf2o9oVY24>

Source: Bundesanstalt für Materialforschung und –prüfung (BAM)

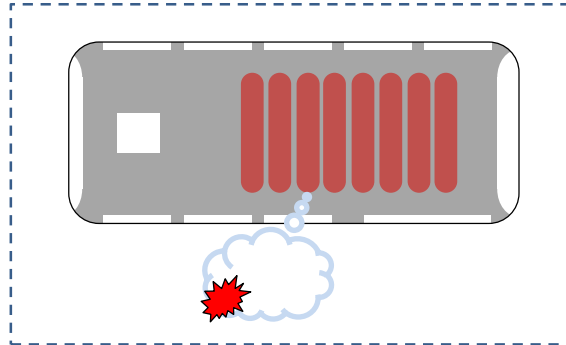


Examples design-scenarios - Gas



CNG Scenario I

- Buses parked close to each other (Depot)
- 3 CNG buses
- Fire spread from motor compartment of middle bus



CNG Scenario II

- Busdepot
- Single CNG-Bus
- Gas leakage due to defect PRV
- Ignition by external source

Source: Bundesanstalt für Materialforschung und –prüfung (BAM)

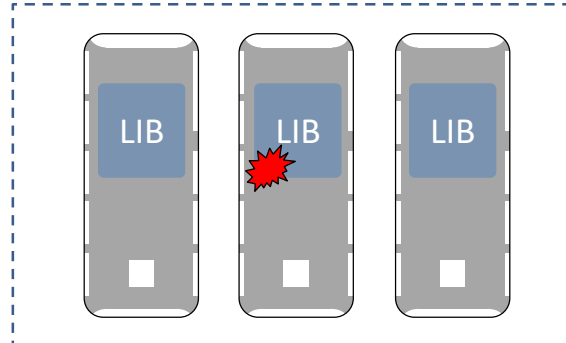


Examples design-scenarios - Battery



LIB Scenario I

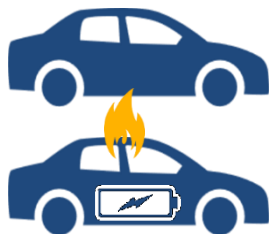
- Underground carpark
- 6 vehicles, thereof 2 electrical
- Thermal runaway induces fire



LIB Scenario II

- Busdepot
- 3 electro-Buses
- Thermal runaway induces fire on the middle bus

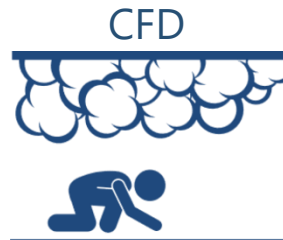
Source: Bundesanstalt für Materialforschung und –prüfung (BAM)



NEC Threats **Scenarios**



**Case
studies**



**Numerical
simulation**



Measures



**Impact on
Safety**



NEC in underground urban transportation areas

- Flowing traffic
 - Traffic tunnel (road)
 - Access tunnel (traffic area)
- Stationary traffic
 - Parking garages
 - Delivery zones
 - Vehicle depots
- Stations and hubs



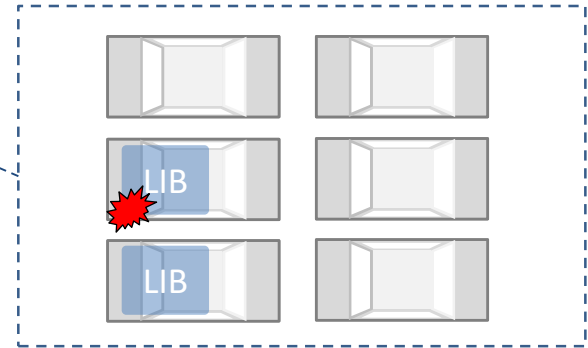
Source: Shutterstock.com, stock.adobe.com



Case study parking garage



Scenario „modules“



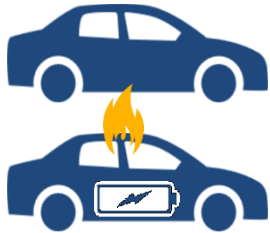
Quelle: <https://www.berlin.de/tourismus/fotos/sehenswuerdigkeiten-fotos/1355918-1355138.gallery.html?page=1>

Set up for numerical simulation

Source: Bundesanstalt für Materialforschung und –prüfung (BAM)



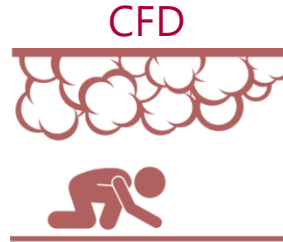
NEC Threats



Scenarios



Case studies



Numerical simulation



Measures

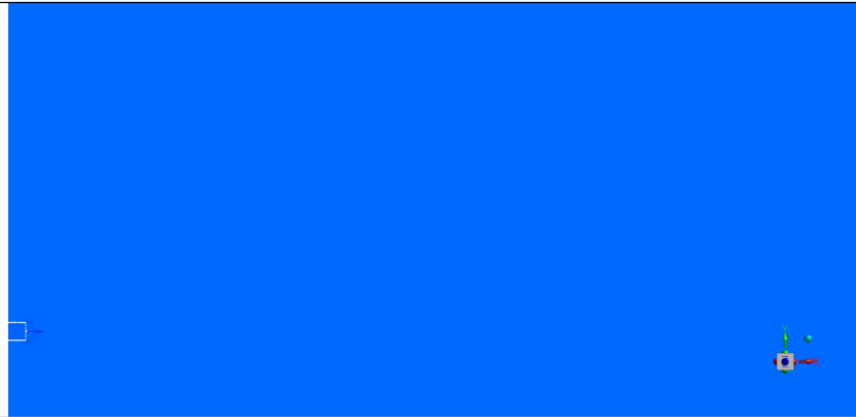


Impact on Safety



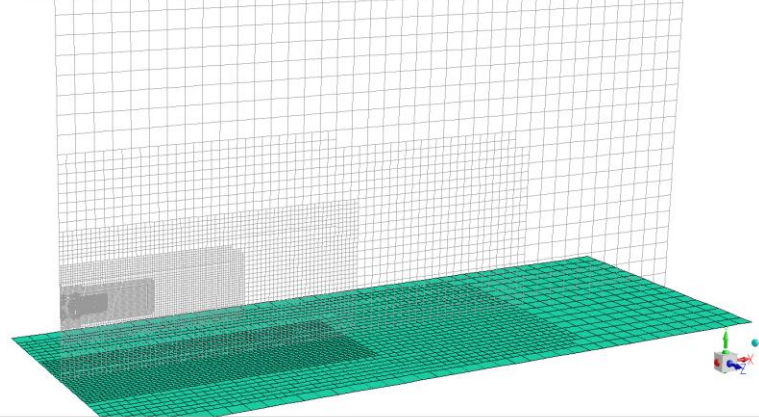
CFD-Modelling of Jetflame

Temperature



Contours of Static Temperature (k) (Time=2.5000e-04)

Flamme surface

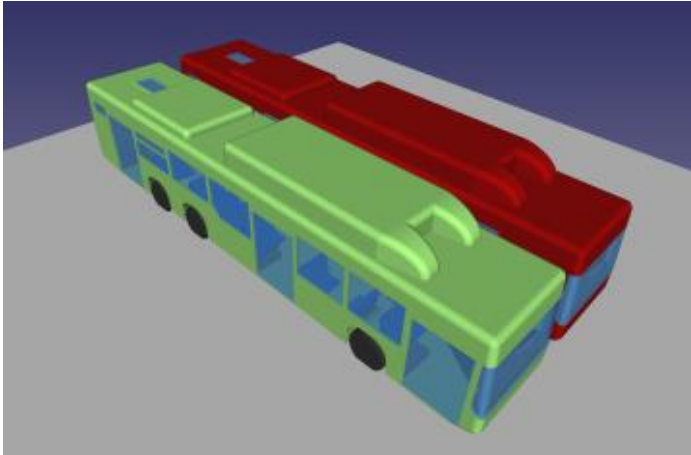


Contours of Static Temperature (k) (Time=3.5000e-03)

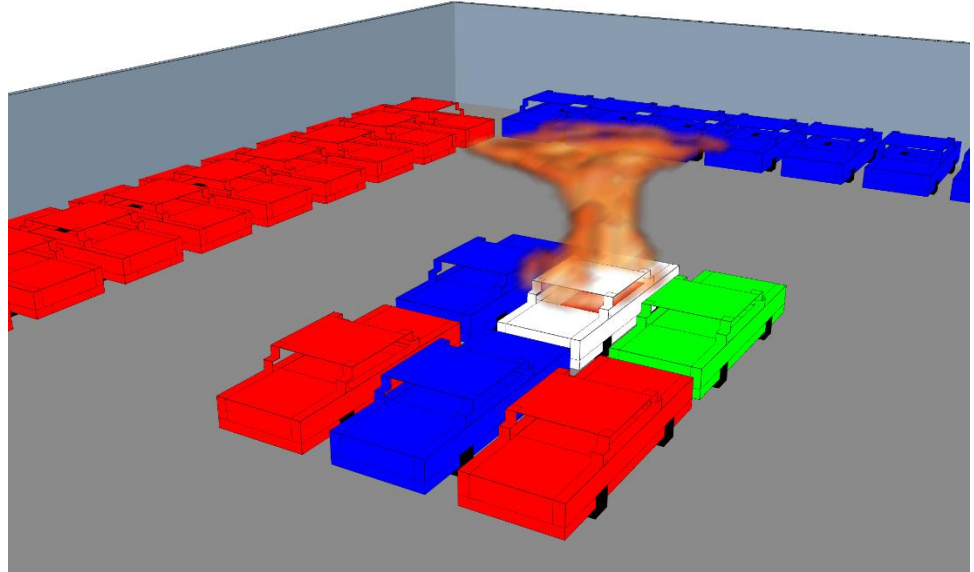
Source: Bundesanstalt für Materialforschung und -prüfung (BAM)



CFD-Simulation



Source: Bundesanstalt für Materialforschung und -prüfung (BAM)



Source: FOGTEC



Evacuation simulation

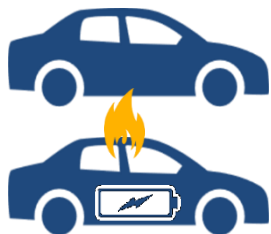
- Determine the impact of NEC (based on results of CFD-calculation)
- Quantify the difference between conventional and NEC
- Develop recommendations for calculation and rescue concepts



Source: STUVA



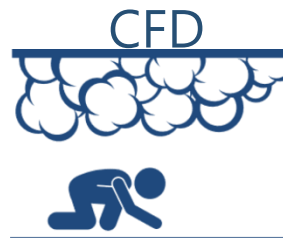
NEC Threats



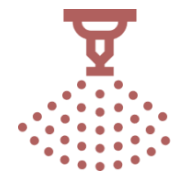
Scenarios



Case studies



Numerical simulation



Measures



Impact on Safety



Development of measures to mitigate the impact

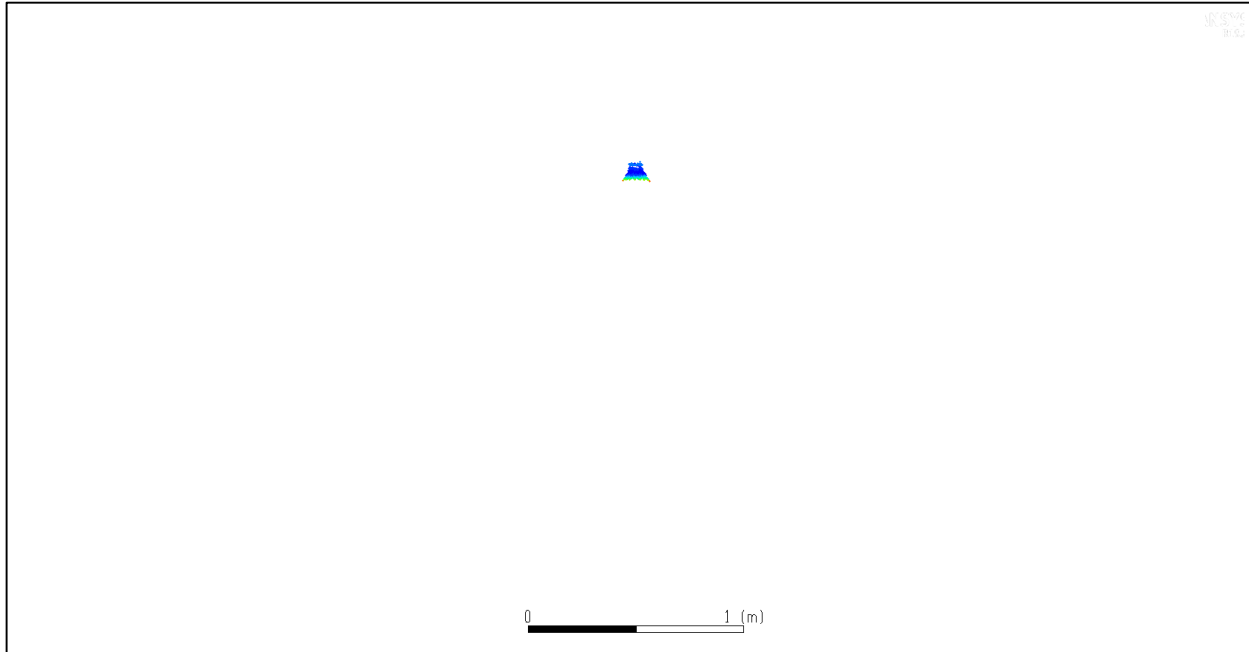
- Identification of appropriate detection sensors and threshold values
- Development and proof of active measures for the reduction of the effects of NEC induced events



Source: IFAB



CFD modeling of watermist



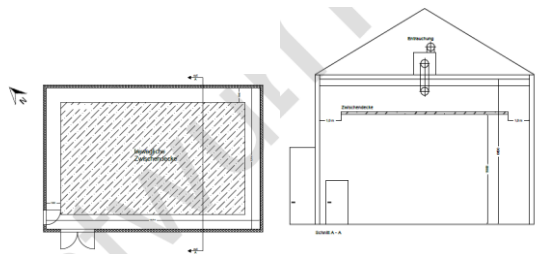
Source: Bundesanstalt für Materialforschung und –prüfung (BAM)



Large scale fire tests for calibration and validation of CFD

Test Location

DLR - Fire Test Hall (Traun, Germany)



Source: IFAB

Real scale fire tests are scheduled
25.03.2019 – 12.04.2019

Fire load

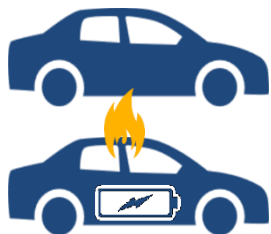
- Full size Lithium-Ion Batteries
30 kWh / 40 kWh
- CNG Jet flame
- Substitute fire load

Mock up

- Separate fire load
- Car

Measures

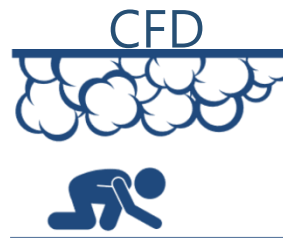
- Active fire fighting
- Testing of Sensors



NEC Threats Scenarios



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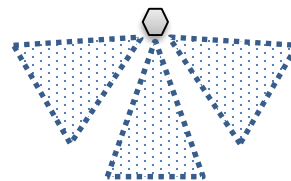
Project results

Safety concepts for underground urban areas:

- Engineering methods to calculate and to assess the risk and impact of NEC (*performance based design*)
- Recommendations for appropriate design and equipment of new and existing underground infrastructures (*best practice*)

Technologies for mitigation:

- Evaluation and validation of sensors and active measures



- SUVEREN-Guideline (Leitfaden) providing concrete support
- Training programmes for designer and operators
- Results will be used as input for standards and regulations





Thank you very much for your attention

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