



Une méthode phénoménologique couplée à un code CFD pour l'évaluation des conséquences associées à l'incendie de véhicules

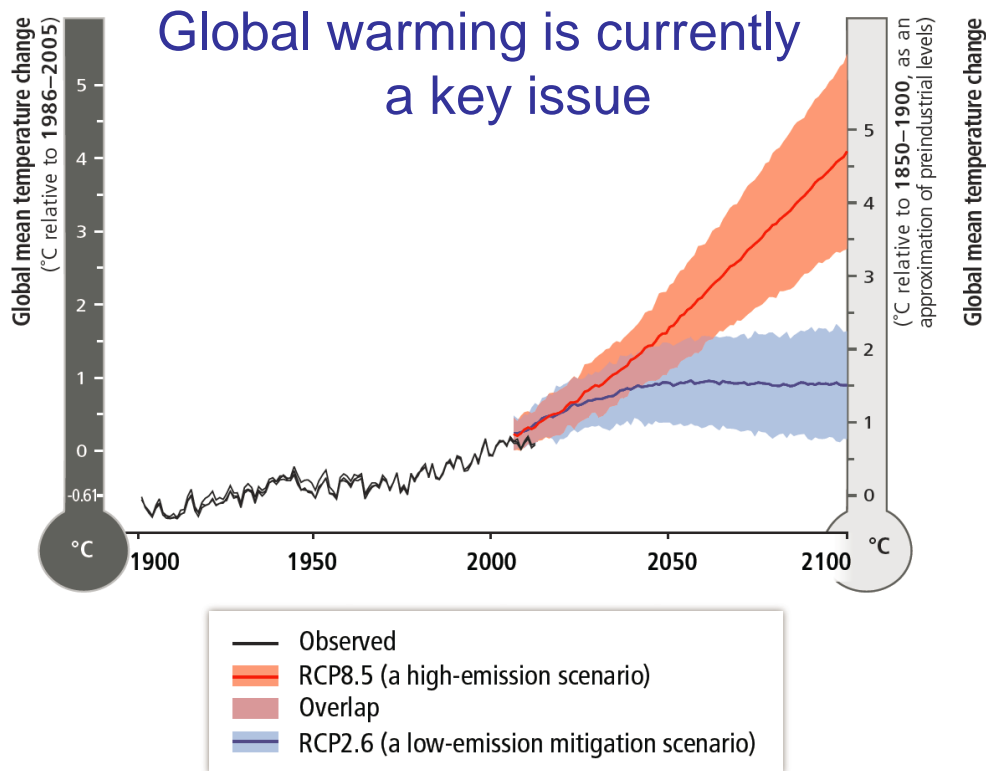
G. LEROY, B. TRUCHOT

GDR FEUX
BALMA

INERIS

maîtriser le risque |
pour un développement durable |

New Energy Carriers in the context of global warming



Transport is the most important contributor

A large panel of solutions for today and tomorrow



Hydrogen



Compressed Natural Gas (CNG) for Vehicles

Electrical cars (EV, HEV (Hybrid), PHEV (Plug-in Hybrid), FCV (Fuel Cell Vehicle))



Biofuels



New technology: new potential hazards



Hydrogen

- Explosive gas
- Strongly pressurized tank



CNG

- Pressurized tank
- Flammable gas



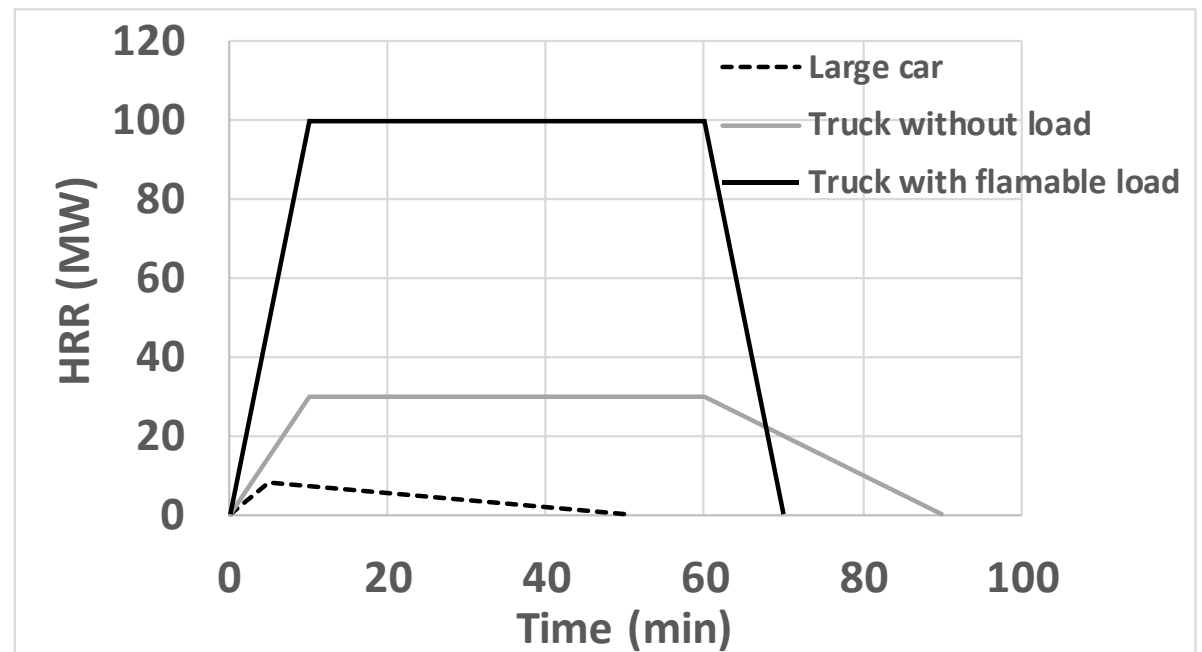
Electrical cars

- Fire self-ignition on charging and other strong conditions
- Toxic impact in case of fire

Major issue: Hazardous Goods Vehicles (HGV) transporting NEC products (hydrogen tank, **batteries**, CNG tank ...)

Based on a large series of experiments, standards were defined some decades ago and are currently used for safety design

Applicability of those standards compared to current real fire



Are the standards curves still valid for NEC?

- Experimental tests can give some answers

INERIS facilities

Fire gallery

- 10 m² section
- 50 m long
- Fire up to 10 MW

Fire testing chambers

- 1 000 m³
- Fire up to 20 MW

Smoke treatment system

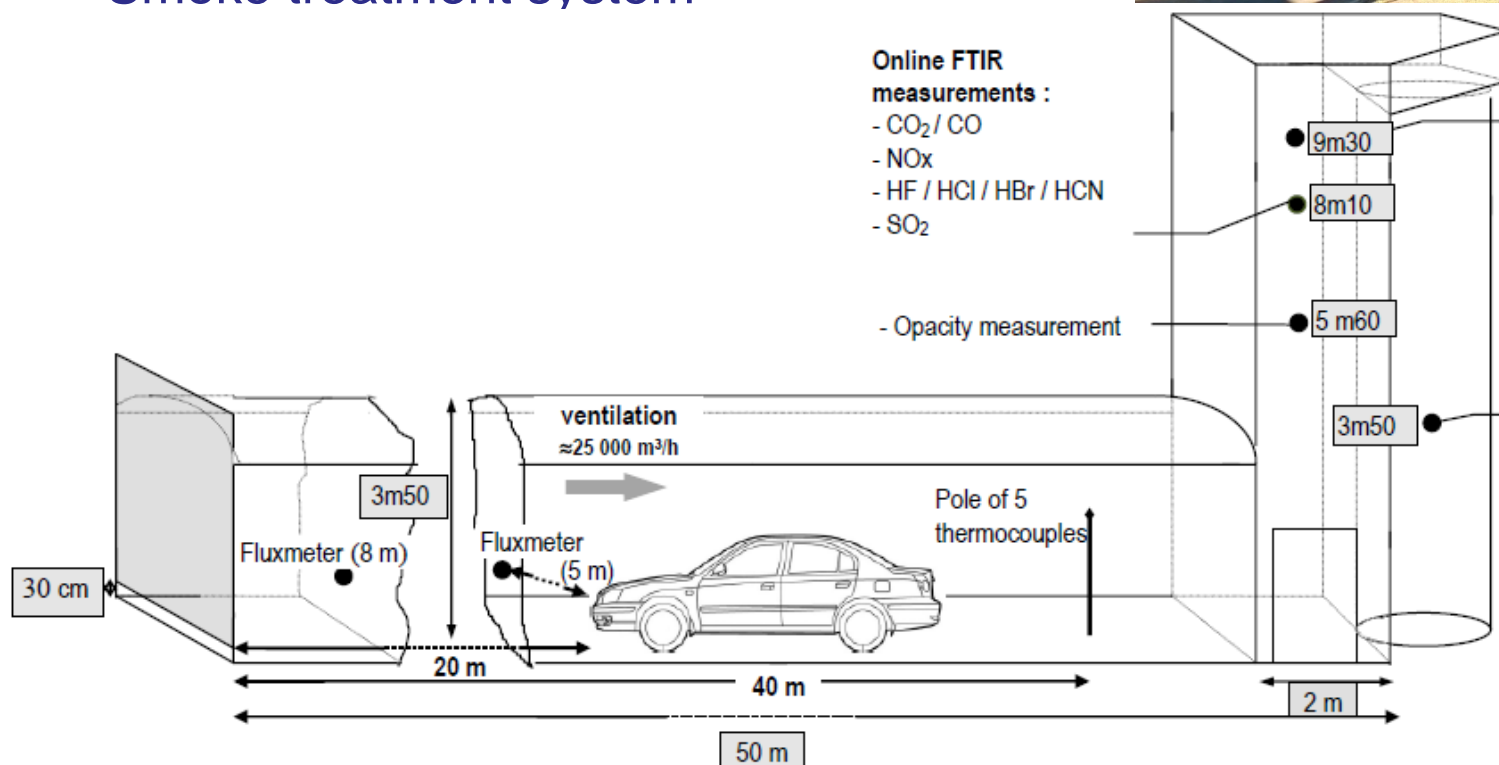


Online FTIR measurements :
- CO₂ / CO
- NO_x
- HF / HCl / HBr / HCN
- SO₂

- Opacity measurement

- THC
- smoke temperature

Online gas analysis
- O₂
- CO₂ / CO
- smoke temperature
- flow rate
- ambient pressure



1st step: Defining the source term by means of computational tool

- Based on experimental data
- HRR
- Toxic gas production

2nd step: Prediction of fire consequences

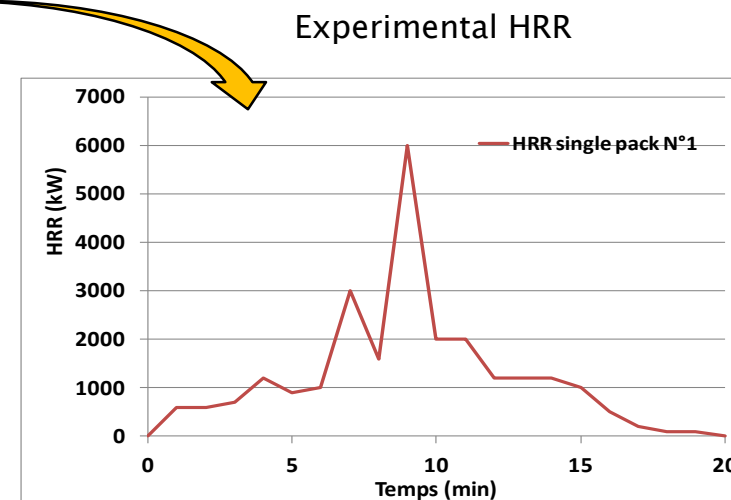
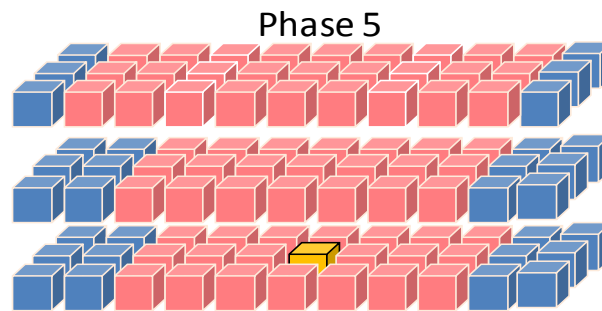
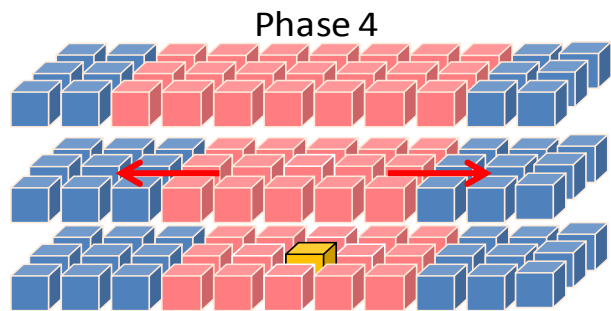
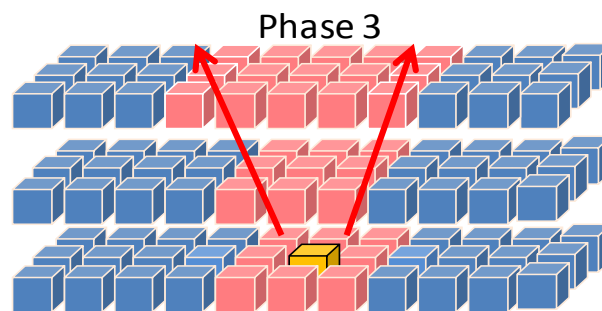
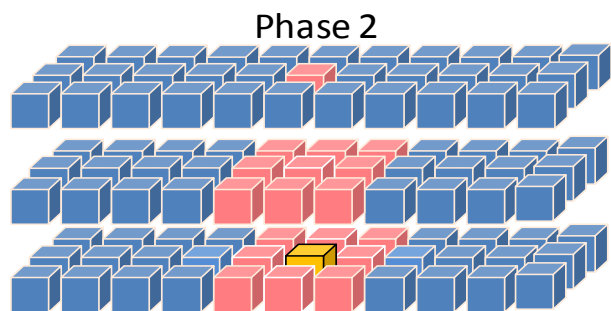
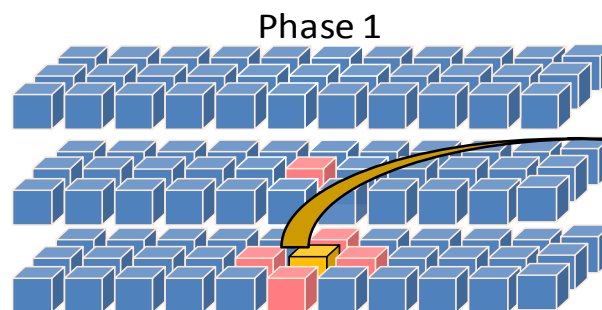
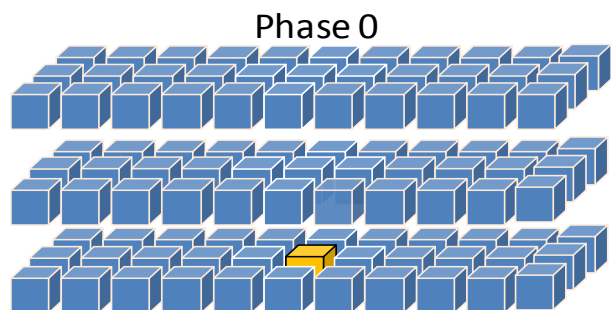
- Using CFD code
- Temperature fields: stratification process
- Toxic effects: relation between the emission factor and the mixture with the air flow generated by the ventilation system
 - Ensuring a safe evacuation

Application with batteries load:
comparing fire scenario using both
standard and modelled fire curves



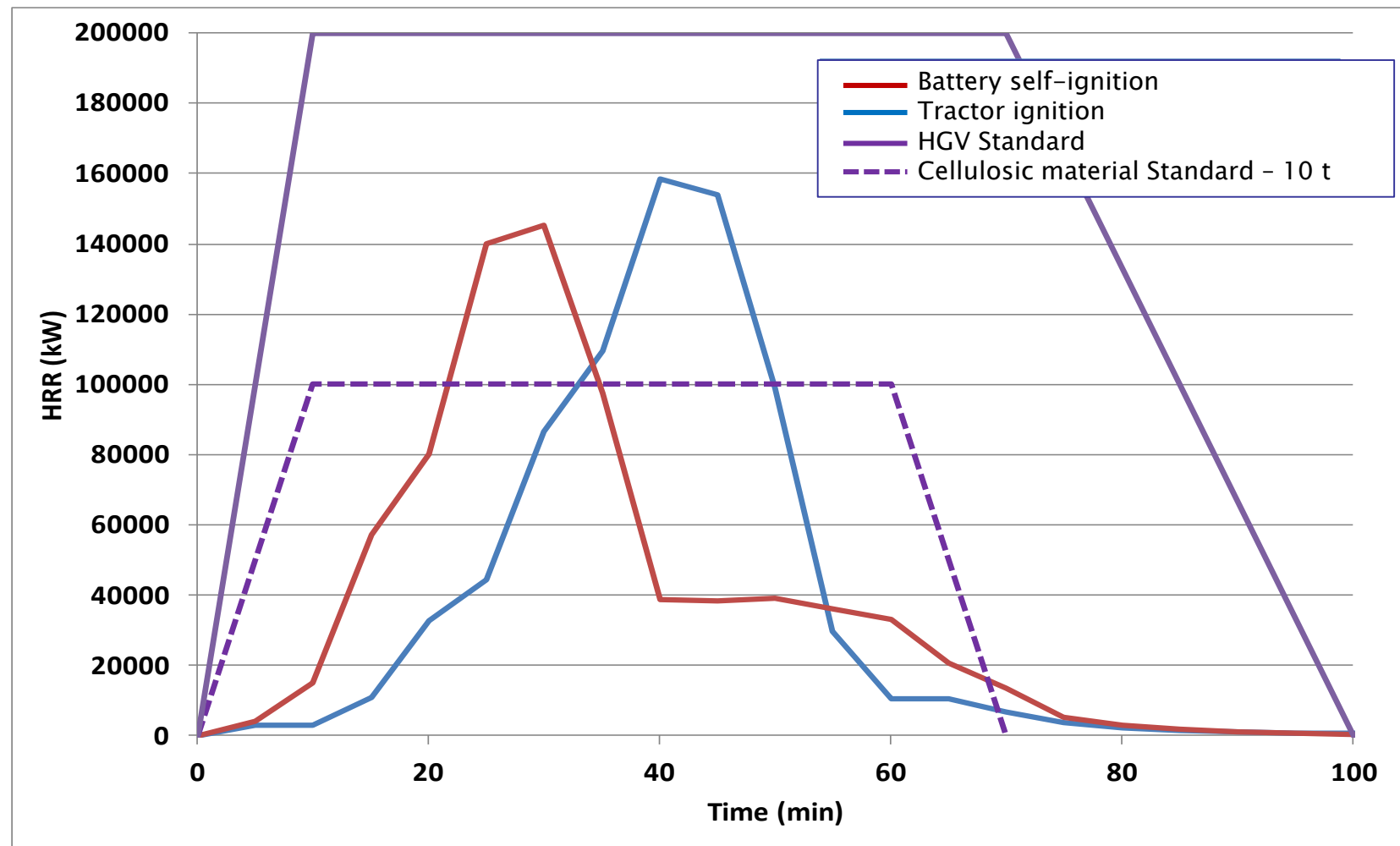
1st step: computation tool

Fire propagation simulation in truck load



Li-Ion Batteries pack used in EV

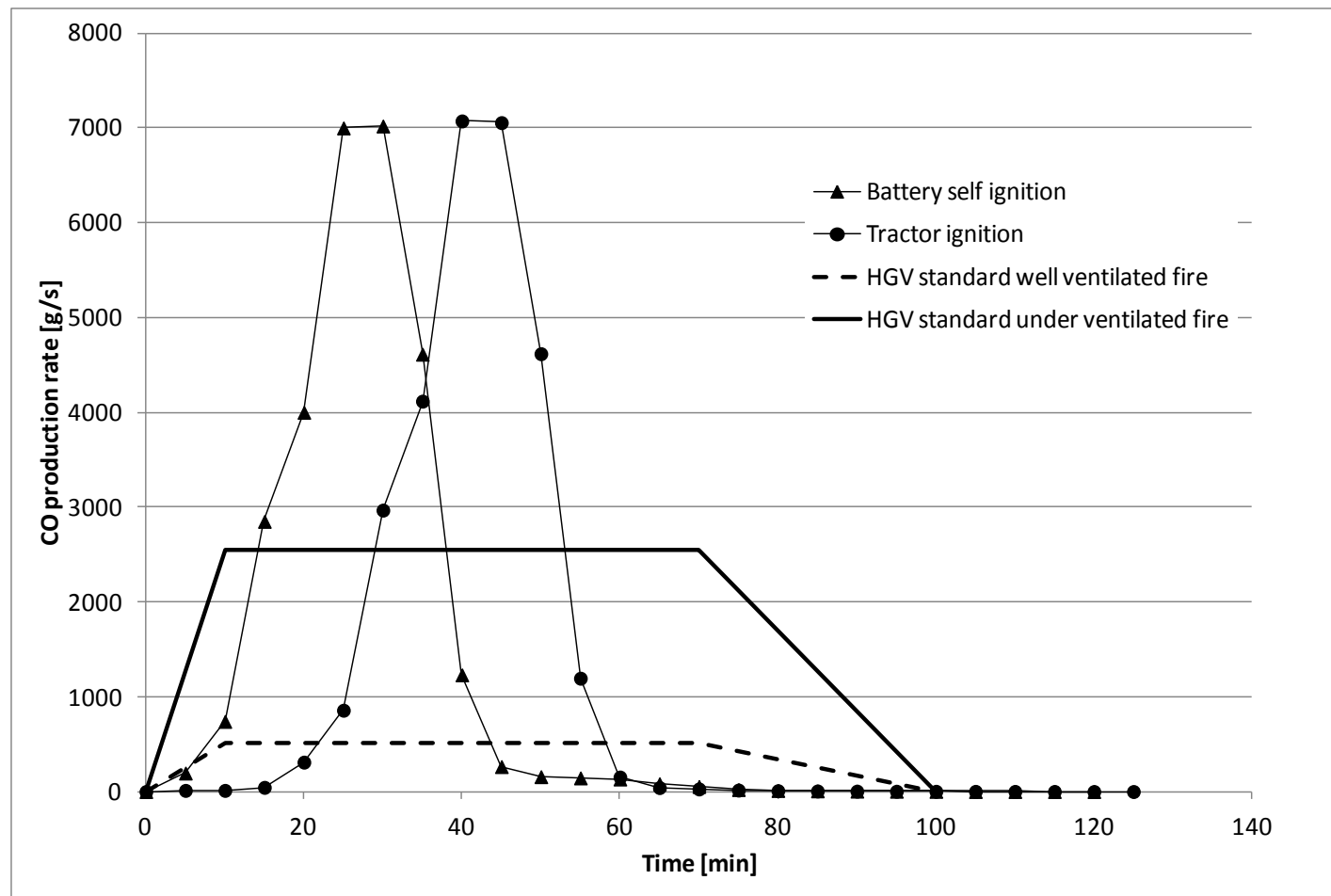
1st step: HRR curves



Batteries load has a high propensity to burn

However Hazardous Goods Vehicle standard curve is conservative

1st step: Toxic production rate curves



For batteries load, the equivalent rate of CO can reach 50 (g/s)/MW

This tool provides appropriate input for considering risks induced in tunnels by transportation of battery packs

2nd step: Evaluation of consequences in case of fire in tunnel: CFD approach

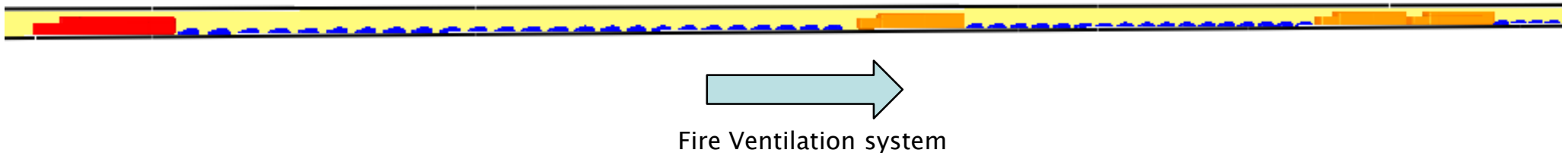
Fire Dynamic Simulator (FDS)

Tunnel considered: 10 m width and 5.5 m height, a total length of 500 m

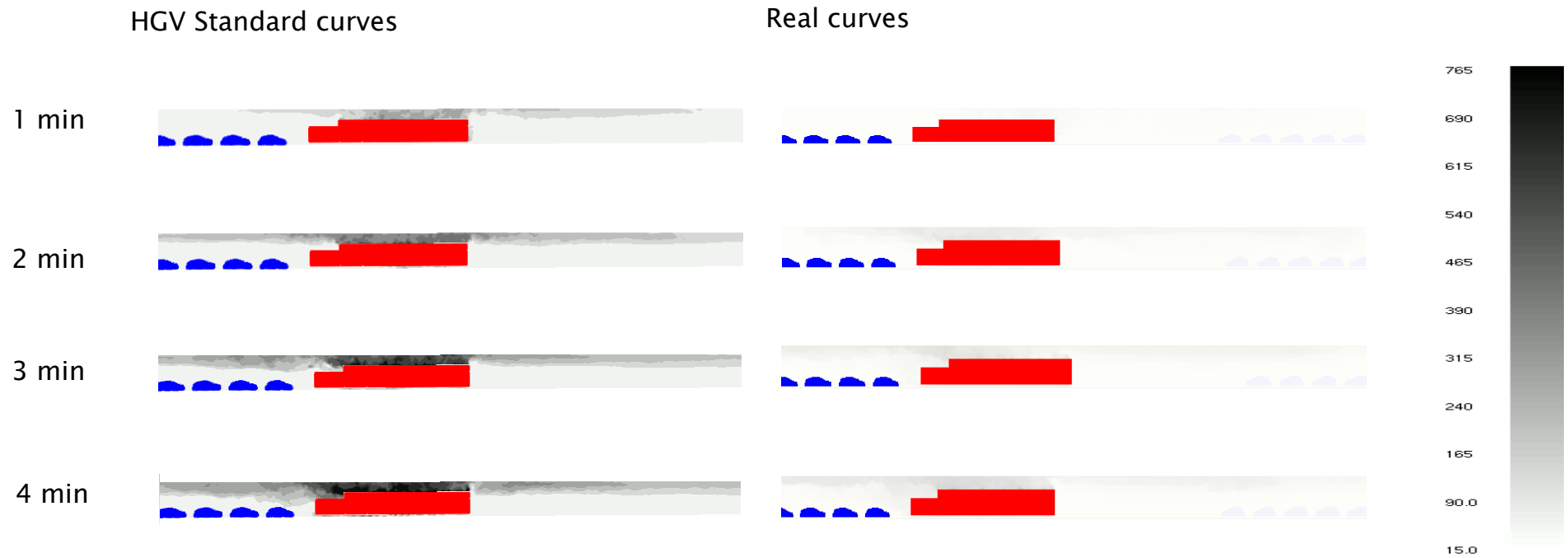
Characteristic cells size: 0.2 m

Congested distribution

Fire ventilation system of 1 m/s



Results: Temperature distribution



Lower stratification effect on the real case because of a slower fire development

CO mass fraction as equivalent toxic after 4 min

HGV Standard curves



Real curves



$\times 10^{-3}$

5.00

4.50

4.00

3.50

3.00

2.50

2.00

1.50

1.00

0.50

0.00

While the fire development is slower using the real curve, the toxicity near the ground increases more rapidly

- Stratification phenomenon

HGV standard is less conservative

While CFD models are nowadays commonly used for fire safety,
Term source is one of the key issues

Applicability of Generic fire curves

An innovative methodology has been developed for evaluating fire
consequences from vehicle

- Based on experimental data
- Prediction of fire source term (HRR and toxic gases release rate)
- Simulation of smoke dispersion

An example on batteries load truck shows that generic fire curves
are less conservative in terms of toxicity than real curves due to
the stratification effect

While the development of NEC is still a continuing process, it
should be required, in the future years, to propose an evolution
of the commonly used standard curves.



THANK YOU !!

