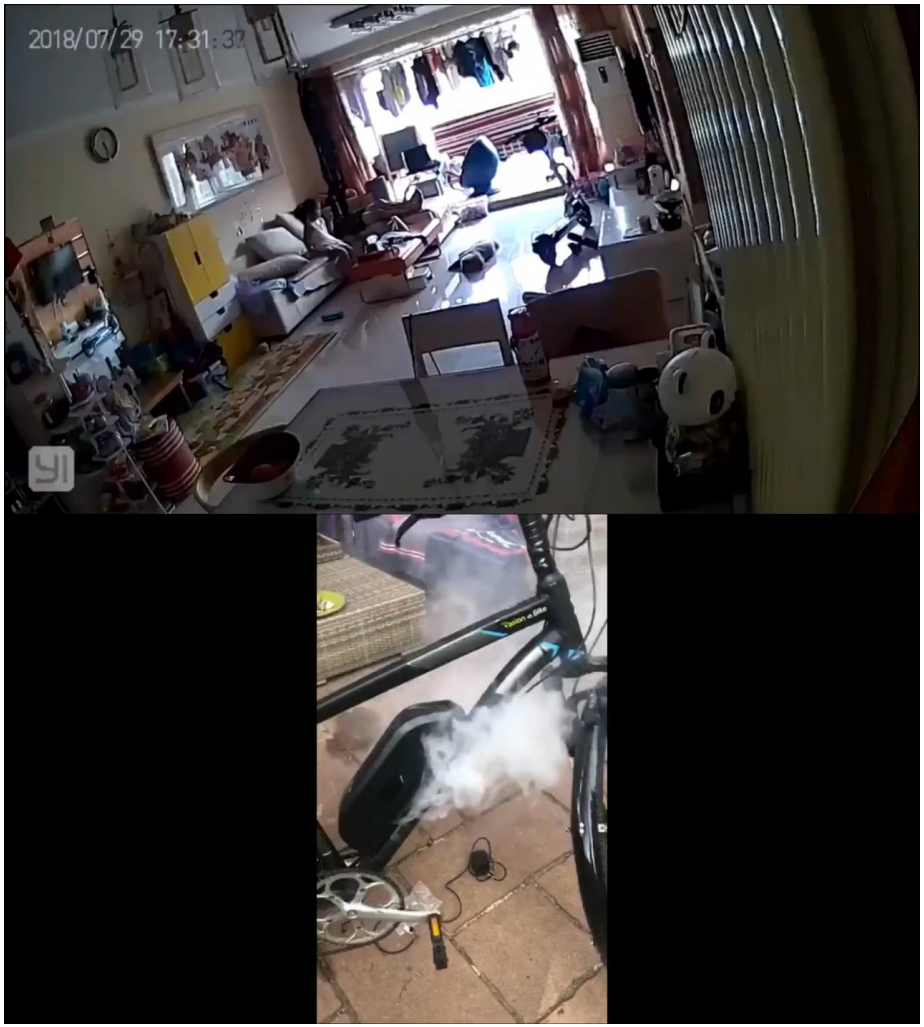
THE RESEARCH NEEDS FOR A FIRE SAFE SUSTAINABLE BUILT ENVIRONMENT

BATTERIES AND FIRE SAFETY

Dr. D. JOYEUX

REAL FIRES



SMALL BATTERIES AT HOME

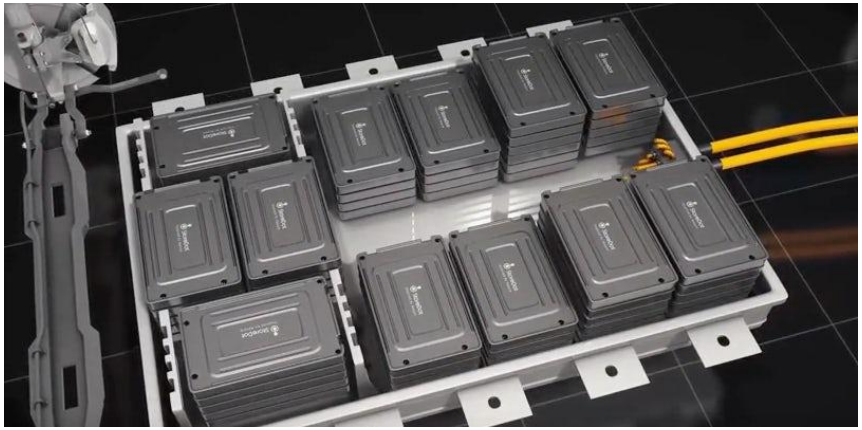
11,1V, 1Ah

3,7V 0,8Ah

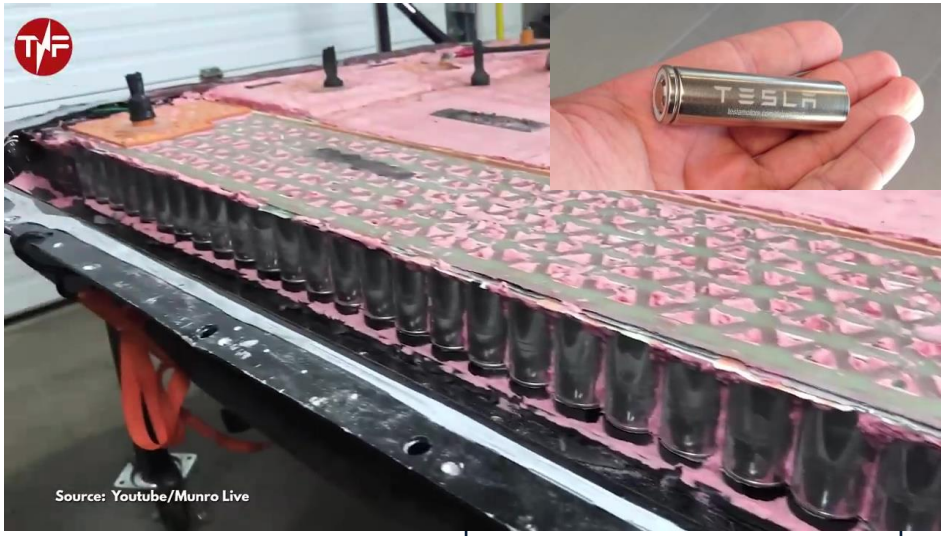
18650 2,5Ah, 3,7V

LARGE BATTERIES DESIGN IN TRANSPORTATION

Flash



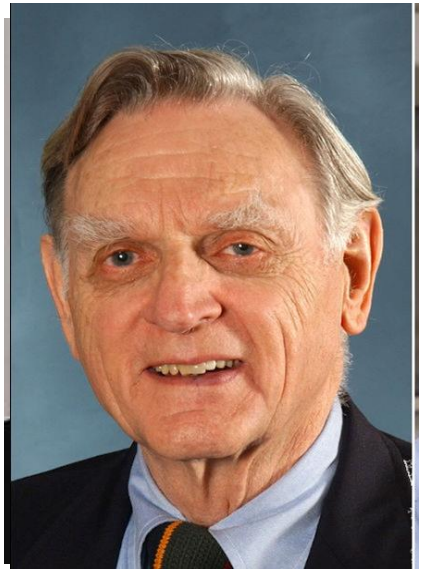
insulated



occasion

NOBEL AWARD

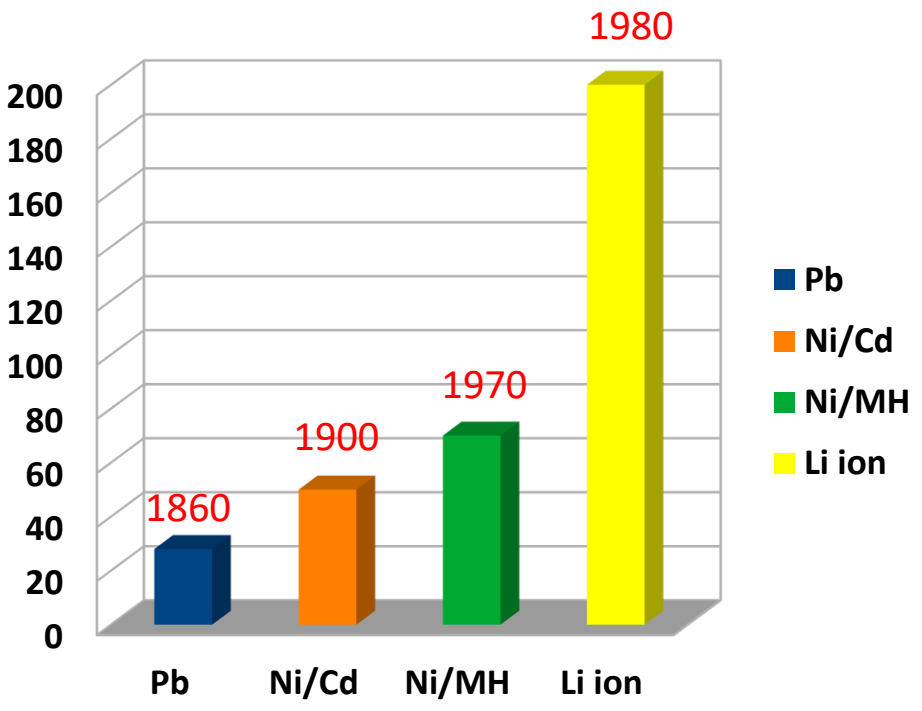
Stanley Withingam :
Composés d'insertion
Li / Li_xTiS_2 (1977)



John Goodenough (1979)
Li / $LiCoO_2$

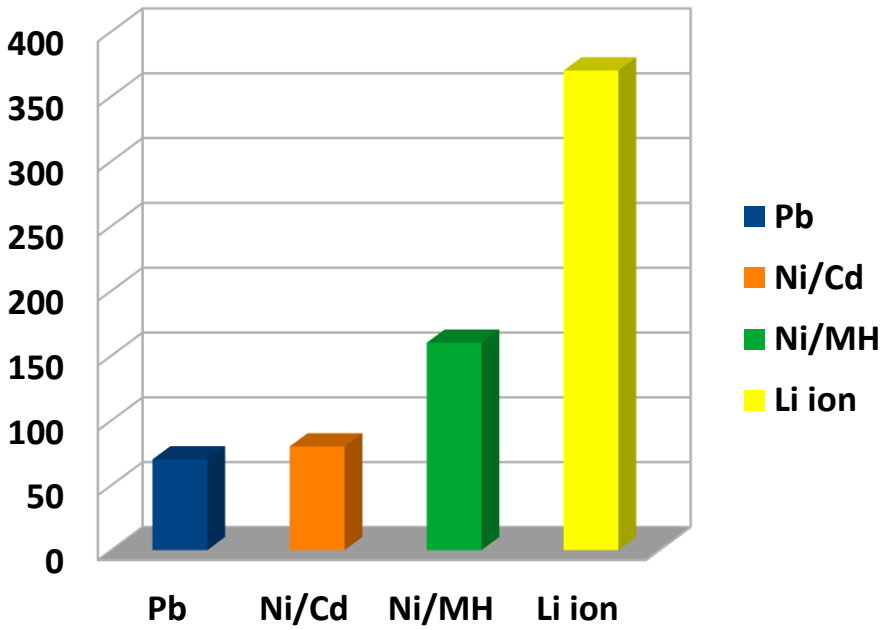
Akira Yoshino (1983) :
Li_xC / $LiCoO_2$

WHY LITHIUM

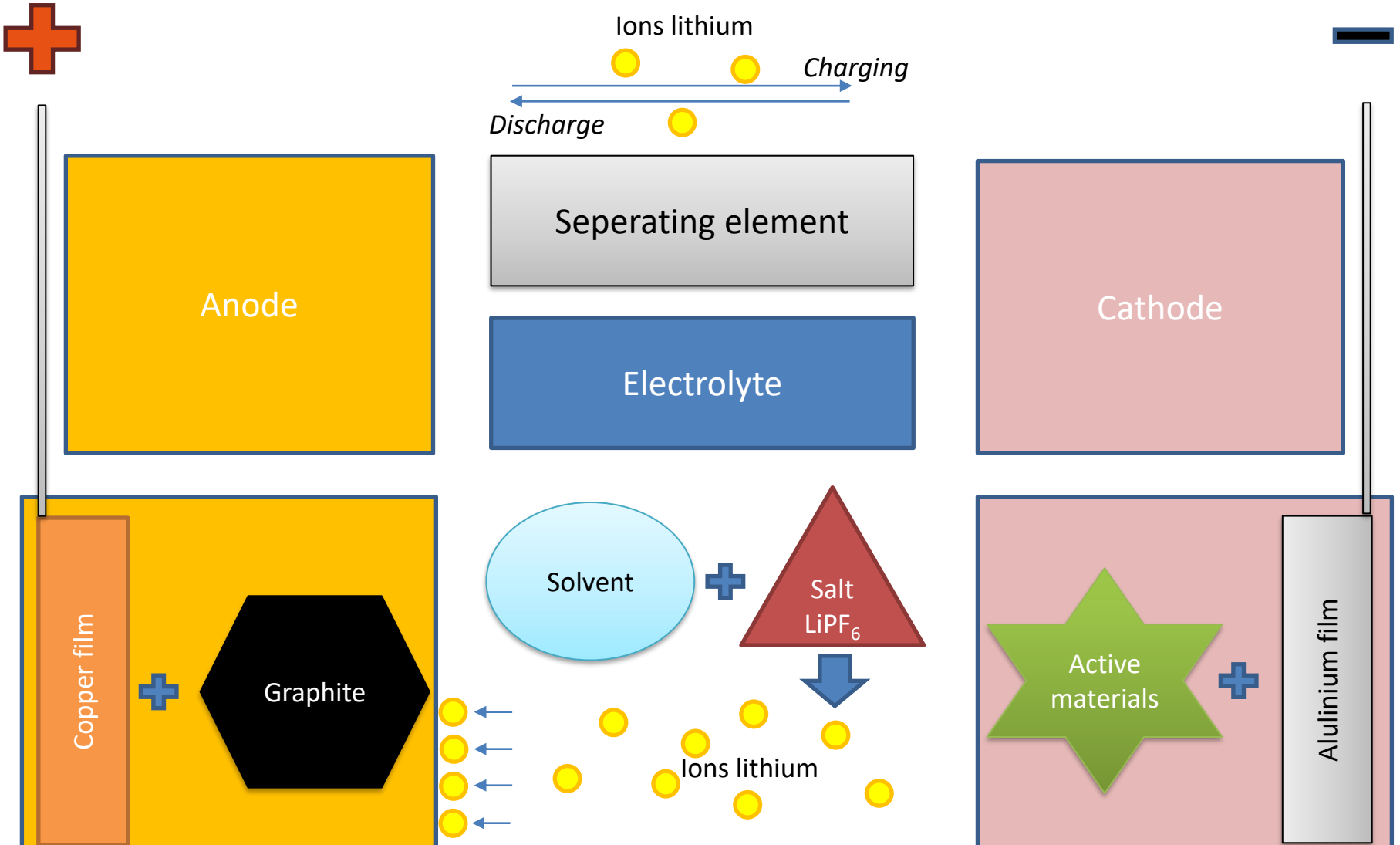


Release rate : W/kg

Energy : Wh/kg



HOW DOES IT FUNCTION ?



BATTERY = A SYSTEM

Dialogue with the car

Structure of the Battery

Communication

BMS

Electronique modules

Module cells

Module Cells

Interface For power delivery

Thermal Management

+

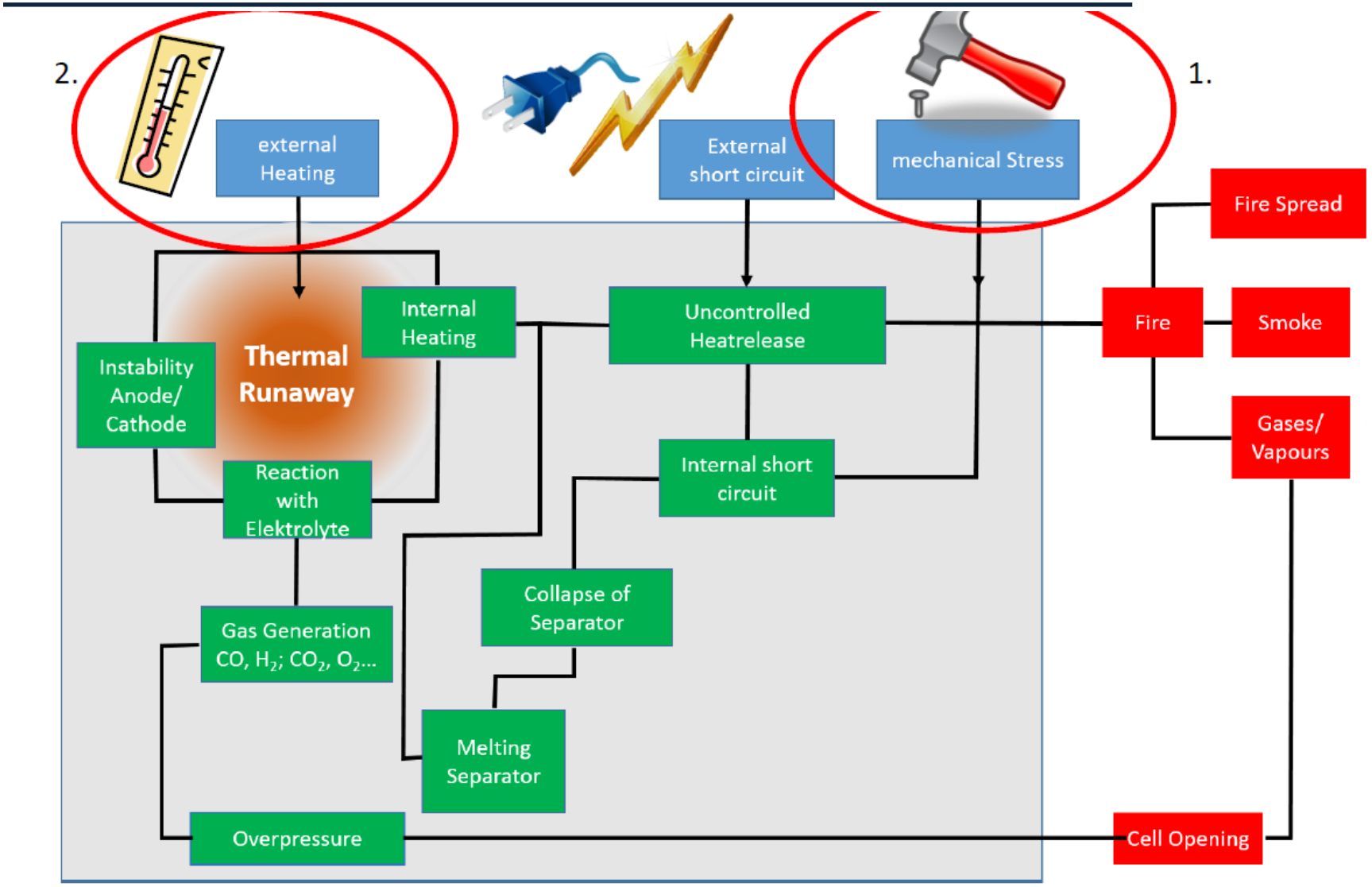
-

Efectis

WHERE ARE THEY

- Building:
  - Electromobility batteries to be charged
  - Electronic communication devices : PC, tablets, smartphones
  - Handyman tools
  - ..
- mobility:
  - Electromobility : EV, E-bikes
  - E-bus, E-trams
  - Sub-stations
- transportation:
  - E-trains,
  - E-navires
  - Tunnels
  - ..

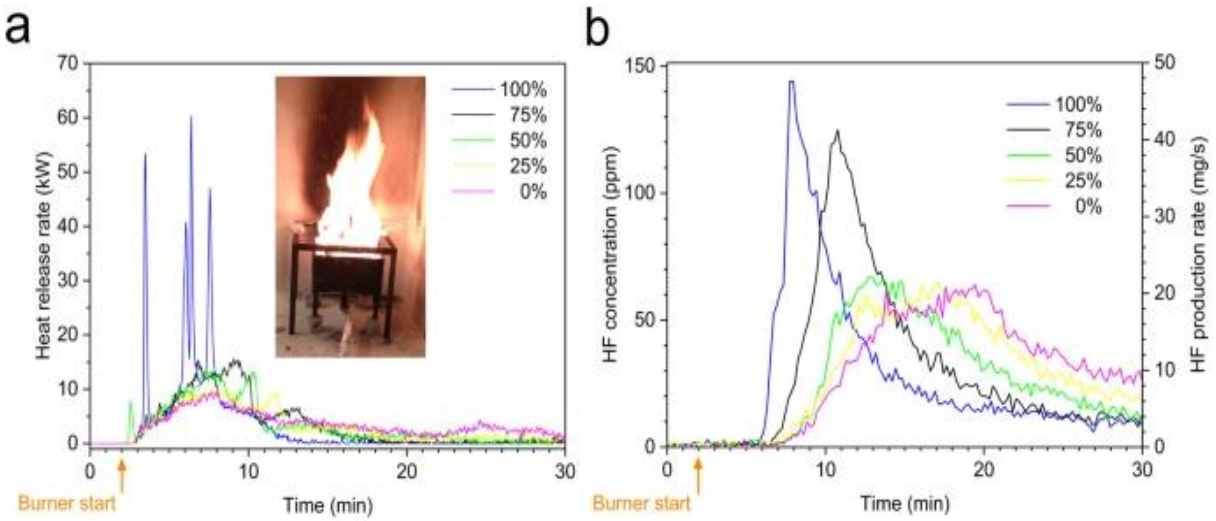
RUNAWAY OF LITHIUM BATTERY



SMALL BATTERIES FIRE TESTS

- Heat release rates (kW, total enery (kJ), HF release (mg/s/g), mass loss (g) …

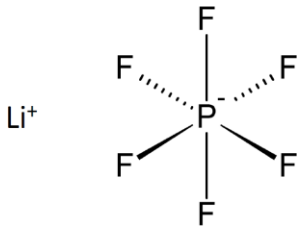
Test	Weight loss (g, %)	Max HRR (kW)	THR (kJ)	Hydrogen fluoride					
				Amounts from FTIR (g)	Amounts from filter (g)	Total amounts (g)	Amounts from gas washing bottles (g)	Total yields (mg/g)	Total yields (mg/Wh)
A	145 g 19.7 %	29	2766	1.2	1.0	2.2	N/A	15	24
B	155 g 21.0 %	19	2502	0.7	0.4	1.1	N/A	7	12
C	406 g 24.6%	31	6605	6.3	1.3	7.6	N/A	19	58
D	419 g 19.1%	53	6893	4.8	1.6	6.4	11.2	15-27	46-81



ELECTROLYTE

Lithiumhexafluorophosphate

$LiPF_6$



- Mainly $LiPF_6$
- Low temperature reaction 107 °C
- Large gaz producer POF_3 and HF

$$LiPF_6 \xrightarrow{380\ K} LiF + PF_5 \quad \text{(under exclusion of water)}$$

$$PF_5 + H_2O \rightarrow \boxed{POF_3} + \boxed{\textbf{2 HF}}$$

$$LiPF_6 + H_2O \rightarrow LiF + \boxed{POF_3} + \boxed{\textbf{2 HF}}$$

$$POF_3 + 3\,H_2O \rightarrow H_3PO_4 + \boxed{\textbf{3 HF}}$$

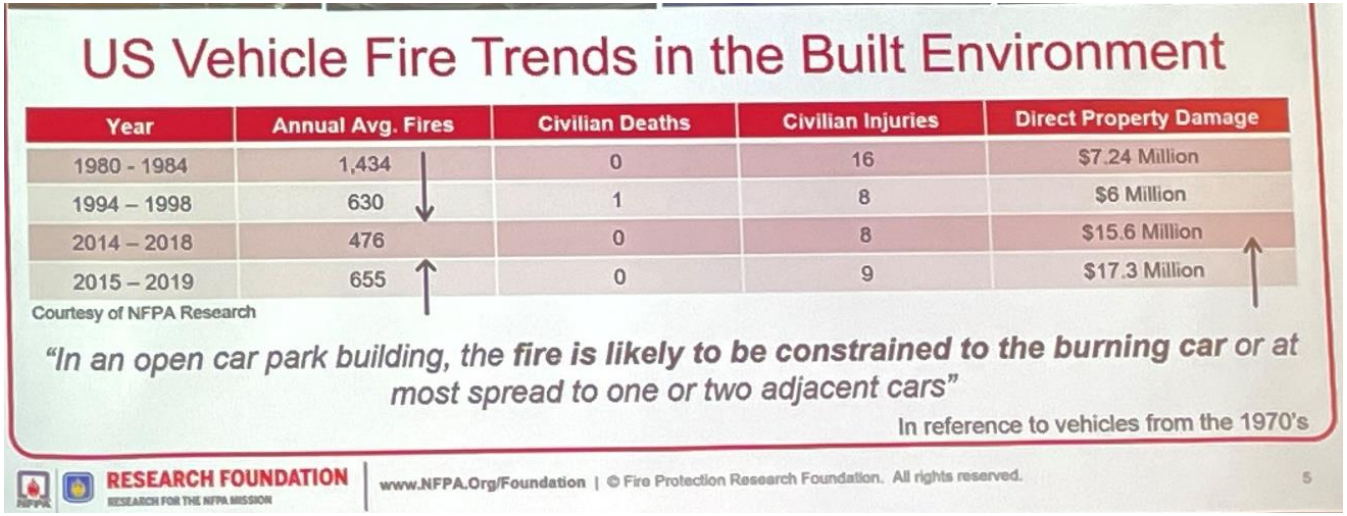
TOXICITY OF HYDROGEN FLUORIDE

- Irritating Gaz with high consequences on Health
- Serious damage especially on respiratory tract.
- Realease of Hydrogen Fluroride strongly corrosive with water.
- Fluorine Ion can penetrate on water and in other tissues generating poisoning modifying calcium, potassium level in blood
- Hydrogen Fluroride can produce pains later
- Few ppm of fluorohydride acid strongly irritating.
- HF(g) can be perceived at 0.04 ppm

Ref : Toxic Gases From Fire In Electric Vehicles Ref , WILLSTRAND, 2020
Ref: ATSDR - Agency for Toxic Substances and Disease Registry, "Medical Management Guidelines for Hydrogen Fluoride,"
Ref : U.S. National Library of Medicine, National Center for Biotechnology Information, "Hydrofluoric acid"

FIVE CONFERENCE : STATISTICS FROM NFPA

- Alarming statistics from US and Norway
- No intervention scheme
- Identification of many chemical species released in extinguishing waters, with large ecotox



US Vehicle Fire Trends in the Built Environment

Year	Annual Avg. Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage
1980 - 1984	1,434	0	16	$7.24 Million
1994 – 1998	630	1	8	$6 Million
2014 – 2018	476	0	8	$15.6 Million
2015 – 2019	655	0	9	$17.3 Million

Courtesy of NFPA Research

*"In an open car park building, the **fire is likely to be constrained to the burning car** or at most spread to one or two adjacent cars"*

In reference to vehicles from the 1970's

RESEARCH FOUNDATION
RESEARCH FOR THE NFPA MISSION

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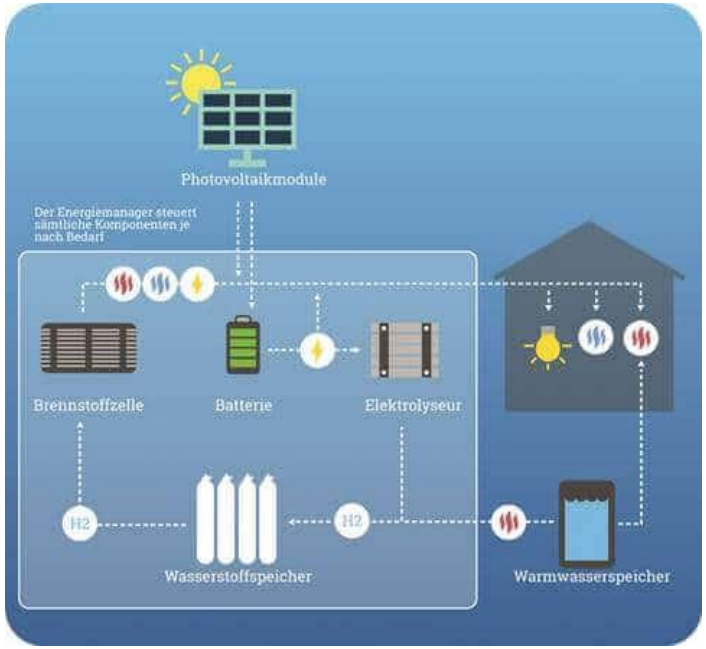
INCREASE OF FIRE RISKS

- Size of batteries
- Quality of the batteries
- Number of batteries
- Insulation of batteries
- Aging of batteries
- Aging of the BMS
- Re-use of batteries
- Exposition of battery to fires
- Storage of batteries

AND NEW TECHNOLOGIES (ESS)



44 kWh
2 days of home consumption
1.6 x 1.2 x 0.4 m^3

NEED OF EU-RESEARCH

- Statistics
  - Number of fires
  - Type of fires
- Phenomenon
  - Ignition
  - Runaway
  - Propagation
  - effluents
- Software : BMS - information management
- Automatic extinction - detection
- Firefighters intervention

NEED OF EU-LEGISLATION

- BMS record information : how to use them for anticipation?
- Reuse of batteries : how to control their quality?
- Storage of battery in house : How to protect to high kinetics ? how to protect to fire propagation?

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