

Understanding Battery Fire Safety: The Shape-Shifting Hazard

Prof Guillermo Rein

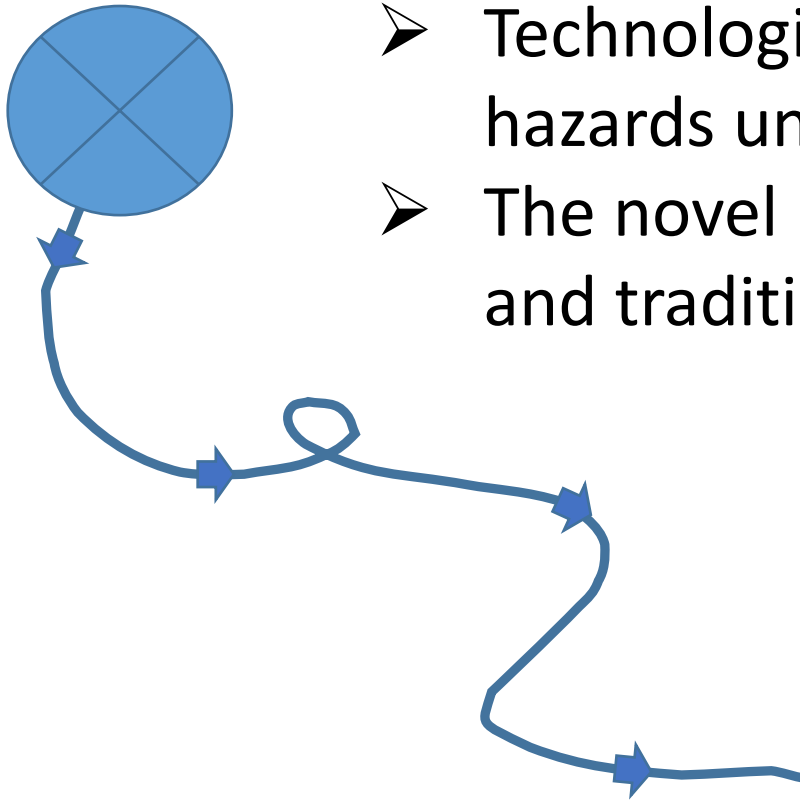
Department of Mechanical
Engineering

IMPERIAL



Blind Spots and Elephants

- Technologies **recently arrived** with fire hazards unknown to most.
- The novel hazard **escapes regulation** and traditional fire protection.



- Consequences are **not seen yet** in fire statistics.
- It could transition into the **elephant in the room**.





“I am very lucky this didn't happen at home”

Vancouver, BC, 2022

Vancouver sees 5-fold increase in fire deaths caused by exploding lithium-ion batteries

Fire department says tampering with, overcharging batteries is the issue

JANE SKRYPNEK / Jun. 13, 2022 4:33 p.m. / [NEWS](#)

VANCOUVER | News

Lithium ion batteries 'number one' cause of fire-related deaths in Vancouver, officials say

FIRE

Lithium ion batteries the leading cause of Vancouver fire fatalities, firefighters warn



By [Simon Little](#) · Global News

Posted June 13, 2022 8:44 pm · Updated June 13, 2022 10:01 pm

Battery Fires in Electric Vehicles



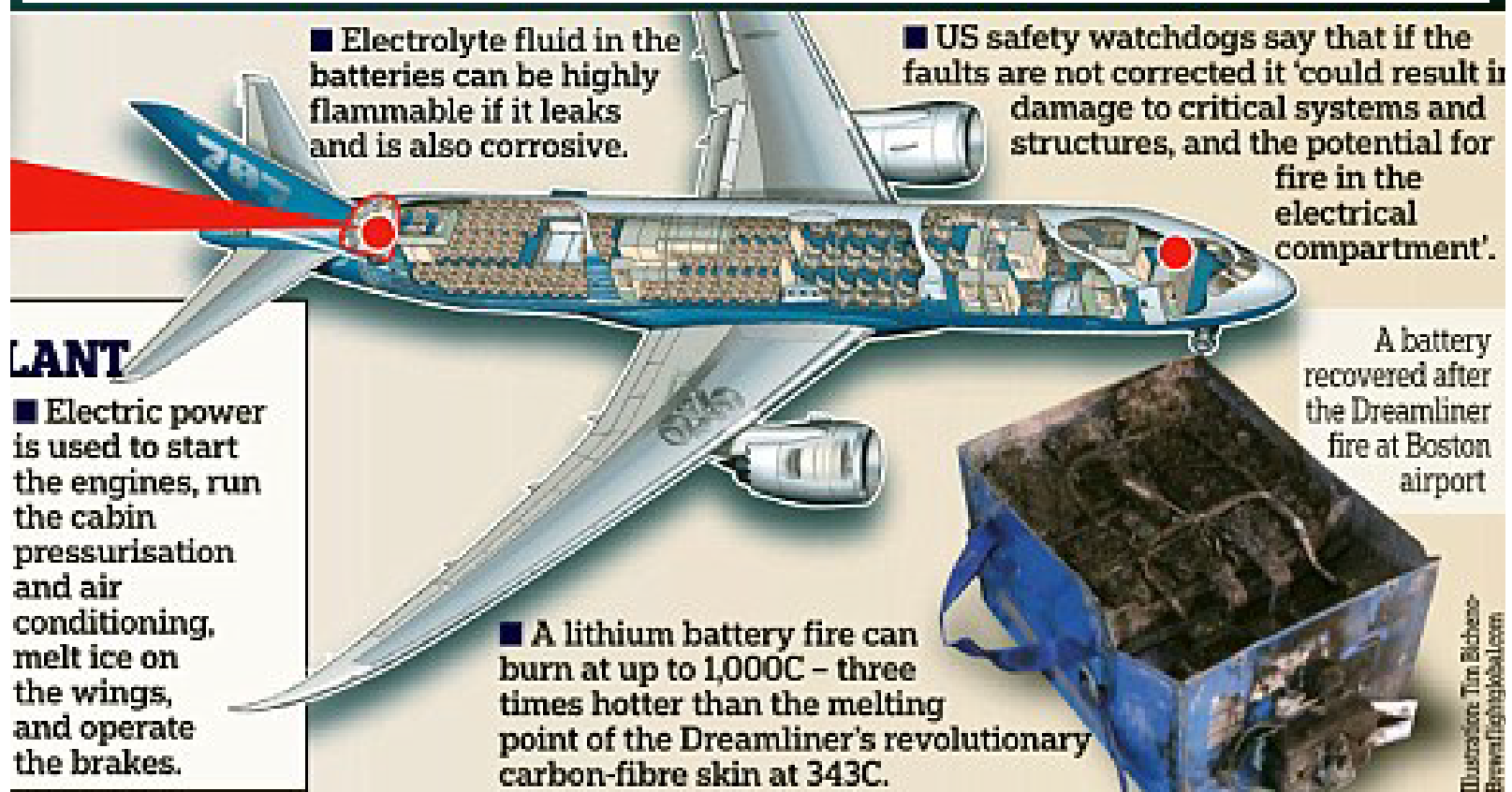
2019, Underground Park, China



As energy density grows

- Failure of Li-ion batteries ⇒ Flammable + Toxic + self-ignition

A Look At The Battery Issues That Grounded The Boeing 787 In 2013



Battery Fires during Storage and Transport

In warehouses, millions of cells can be lost in one single fire.

May, 2018.
Greece



May, 2017.
US



May, 2017.
UK



April,
2017. US

Xinhua/Laskaris
Tsoutsas 2018



Oct, 2015.
China

Batterybro

2015



Dec, 2013.
China



Sep, 2010.
Dubai



Nov, 2009. Canada

CBC News 2009






Feb,
2006. US

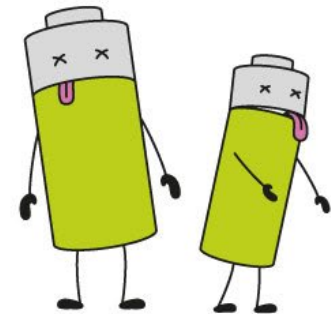
AIOnline



Battery Fires in Recycling Plants

Stop zombie batteries in their tracks

- 1 Never put batteries in normal rubbish or recycling bins 
- 2 Only recycle batteries using a proper battery recycling service  
- 3 Remove batteries from broken devices if you can and recycle both the battery and device separately 
- 4 If you can't remove the battery from a device, recycle both together using a small waste electrical recycling service 
- 5 Still unsure what to do? Visit www.takecharge.org.uk 



TAKE 
CHARGE
#takecharge

Major Battery Fires up to 2019

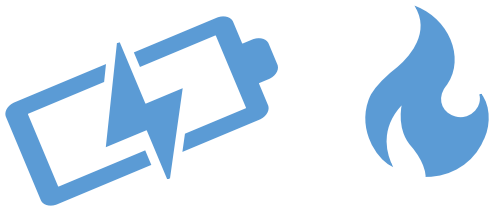
Lithium-ion battery fires that received large media coverage in the last two decades.

Sector	Company	Year	Incident description
Cell phone	Nokia	2003-07	Sudden failure in batteries of mobile phones.
	Kyocera Wireless	2004	
	Samsung	2016	
Notebook	Sony	2006	Sudden failure of batteries powering notebooks.
Electric Vehicle	Chevrolet	2011	Chevy Volt on fire weeks after crash test.
	Tesla	2013	Model S on fire after hitting debris.
		2013	Model S on fire after crash.
		2016-19	Model S suddenly on fire while parked.
	Jaguar	2018	i-Pace suddenly on fire while parked.
Aerospace	Boeing	2013	Sudden failure in auxiliary units of Dreamliner 787.
Hoverboard	Various	2015-17	Sudden failure in many hoverboard's batteries.
Marine	Corvus Energy	2019	Hybrid-battery ferry on fire due to coolant leaking.
Stationary energy storage systems	Various	2017-19	Battery fires in large grid-connected systems



Is Li-ion Battery an Innovation Blind Spot?

- I think so.
- Batteries can display a tendency to **ignite**, release gases, and burn with and without flames.



- Although statistically rare, **LIB fires pose hazards** which are significantly different to other fire hazards in terms of initiation route, rate of spread, duration, toxicity, and suppression.

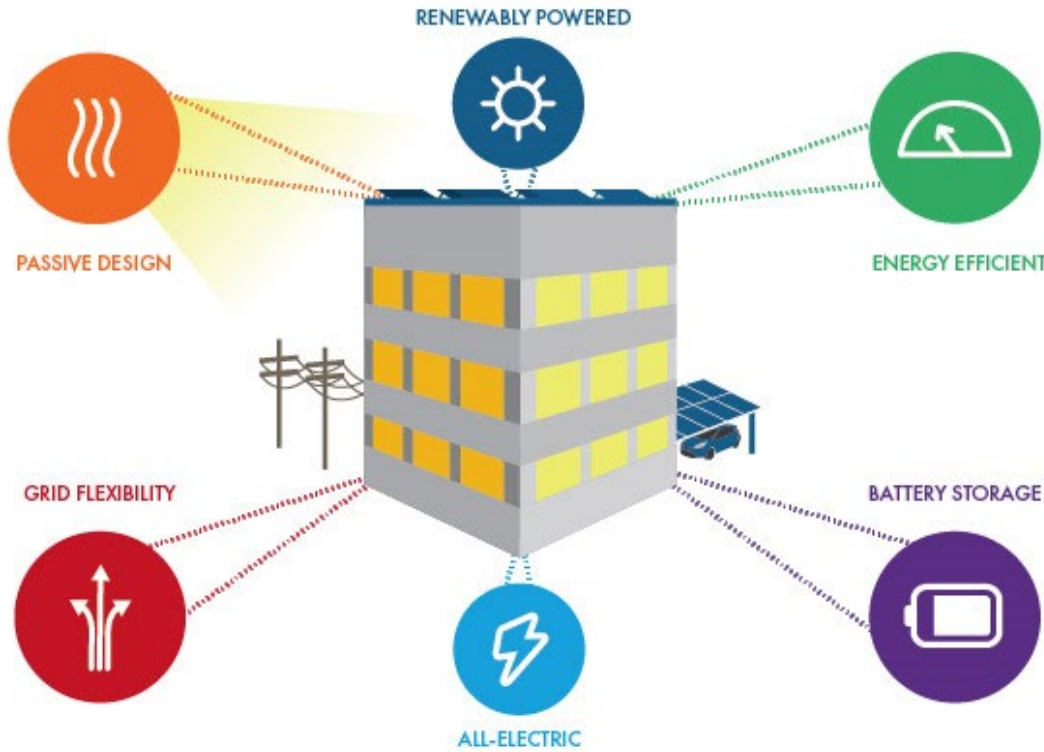
Fire Hazard is significantly different



- **Initiation route:** smoke detection is too slow.
- **Toxicity:** more lethal than smoke from any polymer.
- **Rate of spread:** Fire growth and jet fires can overwhelm protection.
- **Duration:** so long it led to the new term of *stranded energy*.
- **Suppression:** unknown best agent or delivery systems.

Net Zero & Battery Safety

Net zero: balance between production and removal of greenhouse gases



Survey to Fire Engineers

In 2016, I asked 100 fire engineers worldwide:

Which of these 16 Fire Protection Engineering systems are most affected by change?

Top systems were:

Li-ion fires is top 4 out of 16!

Design and architecture of new buildings

Timber buildings

Building facades

Batteries for energy storage

Tunnels and Underground

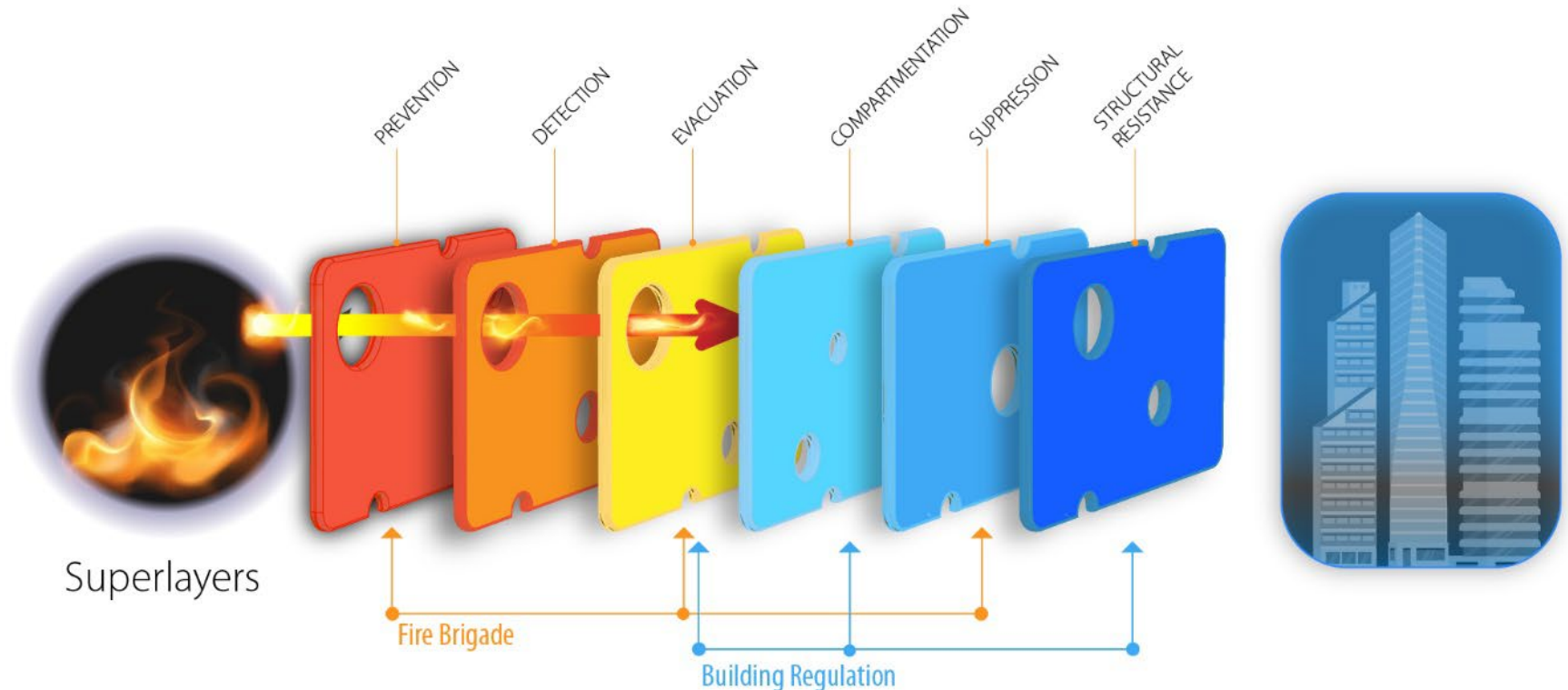
smart firefighting (including smart buildings and big data)

↓ List continues with 10 more systems related to fire protection

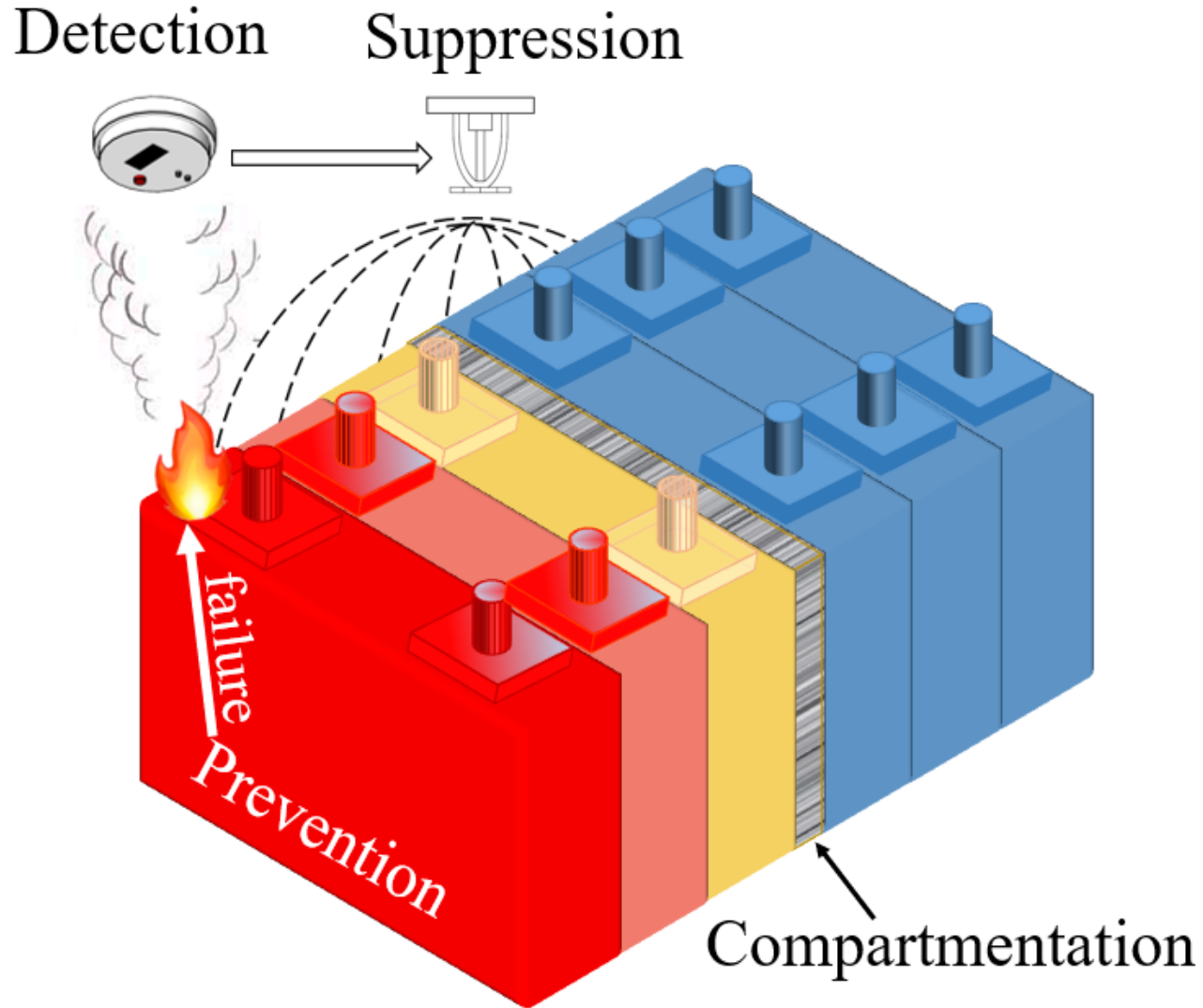
Layers of Fire Protection

To make the world safer from fire, protect people, their property, and the environment.

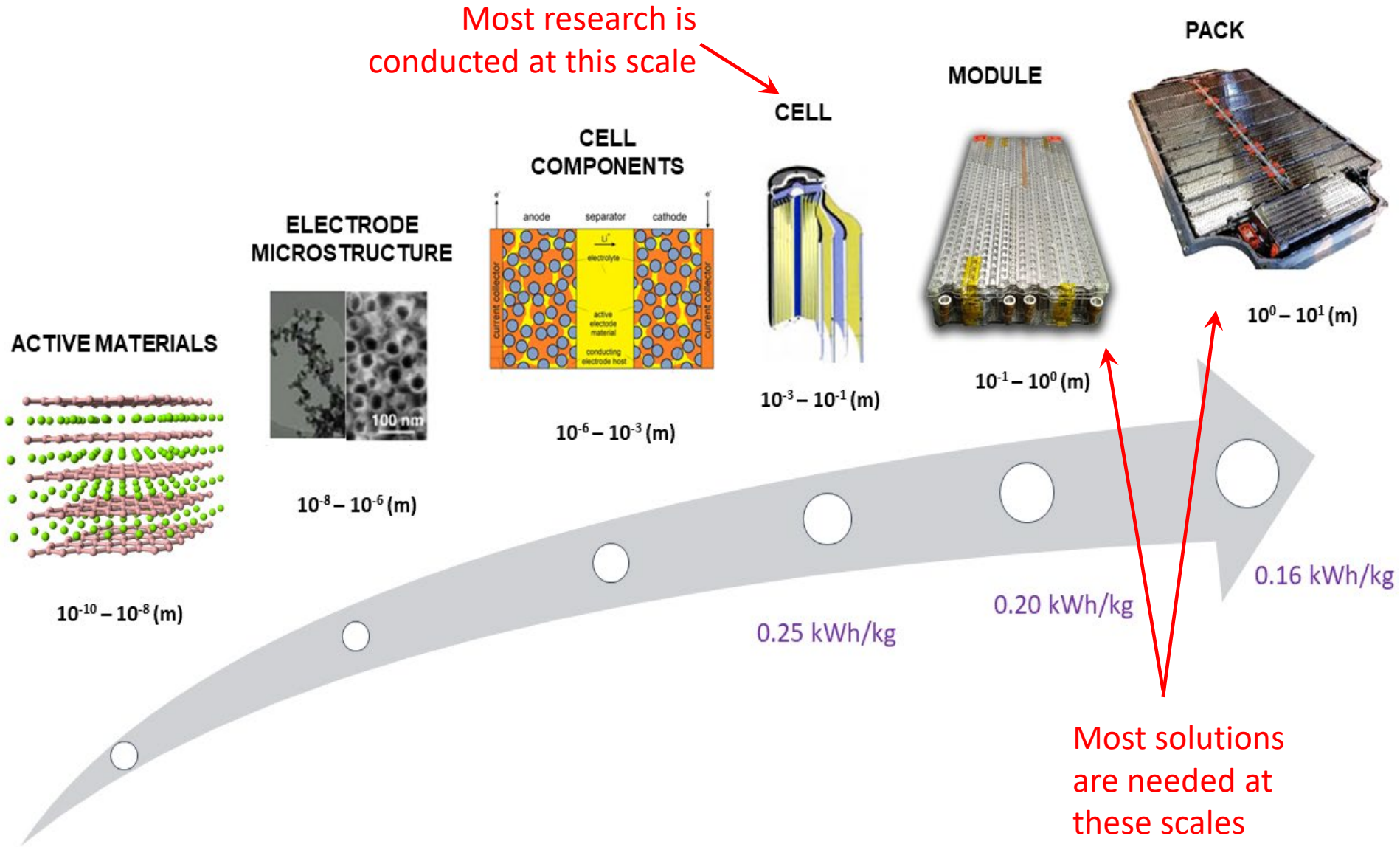
Each layer may have imperfections, so multiple layers improves safety



Thanks



Scales in Li-ion Battery Systems



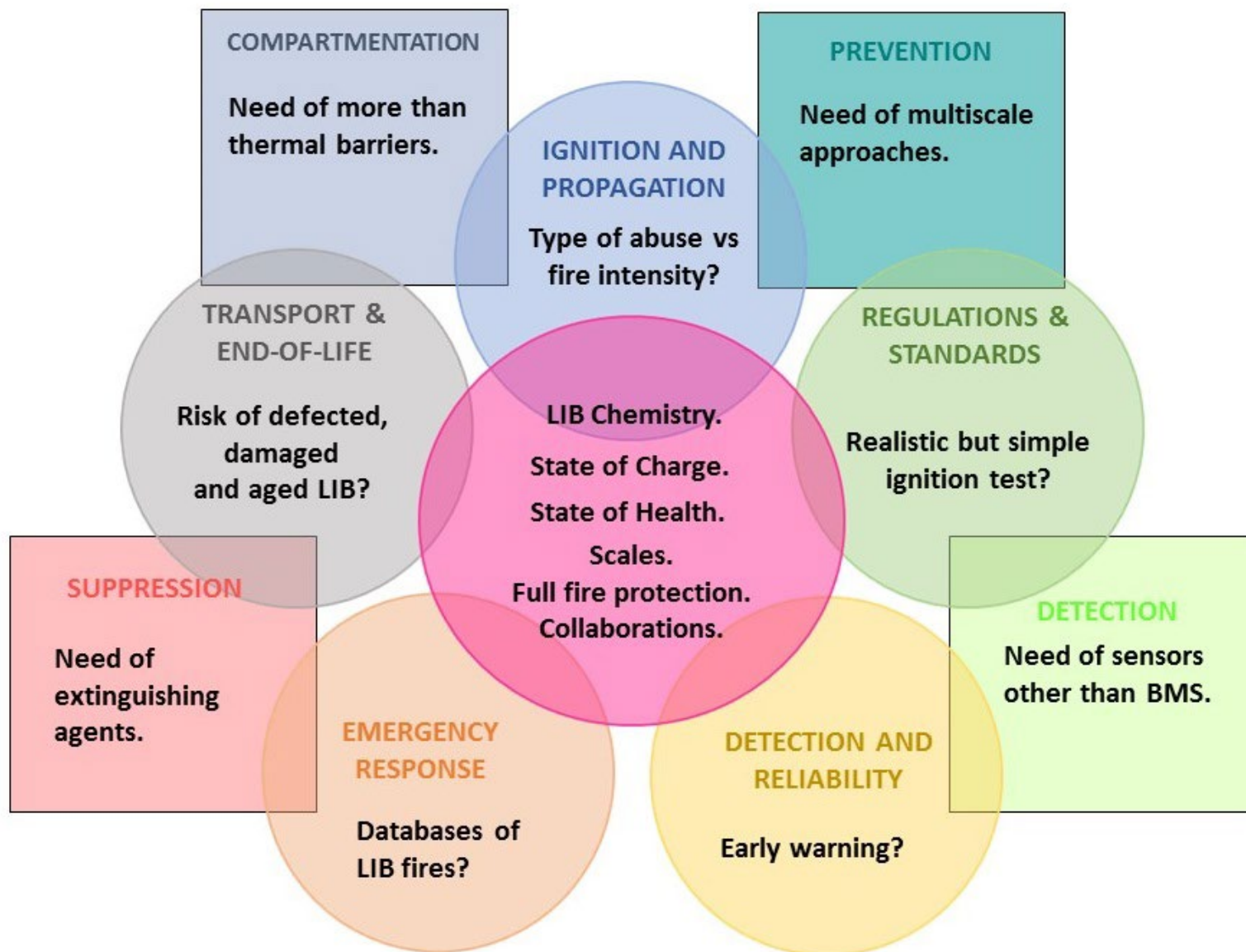
Key Protection Technologies

Venting



Protection layers	Key technologies
Prevention	Cathode & anode modification, electrolyte additive , shut down, coated separator, thermistors, vents , battery management system.
Compartmentation	Barriers, battery management system, sealed container .
Detection	Anomalies in Voltage, temperature or deformation. Presence of heat, smoke, or off-gassing.
Suppression	Smothering, cooling, chemical, isolating, flooding .

Industry vs. Research



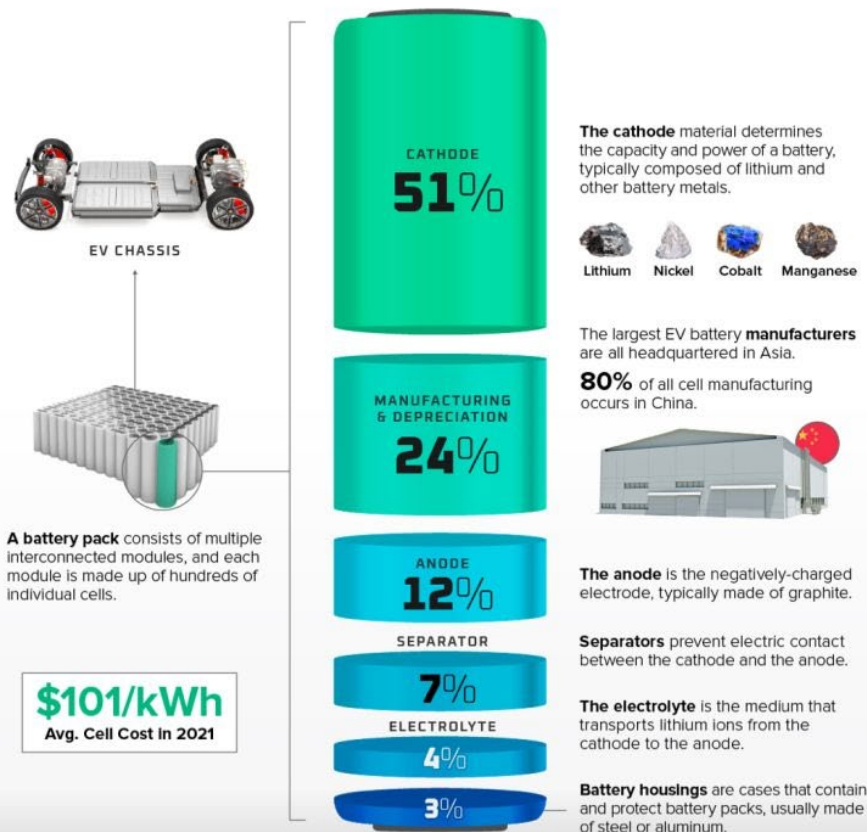
Why are batteries not safer?

E

Breaking Down the Cost of an EV BATTERY CELL

The average cost of lithium-ion batteries has declined by 89% since 2010.

What makes up the cost of lithium-ion cells?



Percentages may not add to 100 due to rounding.
Source: BloombergNEF

- Safer batteries require improvements to the housing, electrolyte and separator.
- These are the least expensive components so manufacturer might not perceive them as competitive gain?
- **Make safety part of the market** (state regulations and global industry standards).

Concluding Remarks



- A shape-shifting blind spot.
- Statistically rare but **batteries pose fire hazards**. Even spontaneous ignition is possible.
- Research has focuses on prevention of ignition & propagation at cell scale. More is needed on **detection & suppression**, and at **module & pack scales**.
- Understanding \Rightarrow safety \Rightarrow better batteries.
- Safety be introduced in the market via **global industry standards** and state regulation.