BVRLA

Fleets in Charge

DEEP DIVE

Battery Health: Supercharge your knowledge

Chancery Lane, London
16 May 2023

bvrla.co.uk/fleetsincharge

In partnership with AutoTrader

Competition Law Do's and Don'ts

DO NOT

- Discuss individual company prices, price changes, terms of sale and profit margins.
- Discuss information as to future plans of individual companies, production, distribution or marketing plans, including proposed new territories or customers.
- Discuss matters relating to individual suppliers or customers or any commercially sensitive information.

BE WARY

YOU MUST SEEK ADVICE IF:

- You receive information from another competitor, or are asked to provide information, that you believe is confidential or commercially sensitive.

ALWAYS:

- Ensure a detailed agenda is circulated in advance and are followed closely and minutes of the meeting are recorded and kept.
- Begin the meeting with the reminder that the attendees should not discuss commercially sensitive information under any circumstances.
- Be prepared to halt a meeting if conversations cross into potentially unlawful territory.

NO PROBLEM

- Discussion on any matter relating to the aims and objectives of the committee – for example issues of law and policy affecting the industry.
- Discussing BVRLA policies, lobbying tactics & strategies, and other BVRLA activities.
- Discussing information about industry activities obtained from third parties or other media sources provided the availability of the information has not been arranged with a competitor.
- Discussion with other trade bodies or organisations which will be of general benefit to the industry.

Agenda

10:00	**Welcome**	Toby Poston, BVRLA
10:05	**Keynote: Battery Chemistry**	Dr Billy Wu
10:35	**Panel: Battery Degradation**	Chair: Marc Palmer, Autotrader Panellists: Scott Raffan, Geotab; Dr Matt Stock, Innovate UK and Gavin White, About: Energy
11:20	**Tea/Coffee Break**	
11:35	**Department for Transport**	Adam Dack
12:05	**EV Consumer Landscape**	Marc Palmer, Autotrader
12:25	**Panel: Battery Health Certificates**	Chair: Catherine Bowen, BVRLA Panellists: Thomas Mulon, MOBA; Tobias Huelsing, Bosch; Patrick Cresswell, ClearWatt; James Wallace, Elysia Battery Intelligence from WAE and Alex Johns, Altelium
11:30	**Closing Comments**	Toby Poston, BVRLA

Imperial College
London

The life and death of lithium-ion batteries
How long do they last?

Dr. Billy Wu
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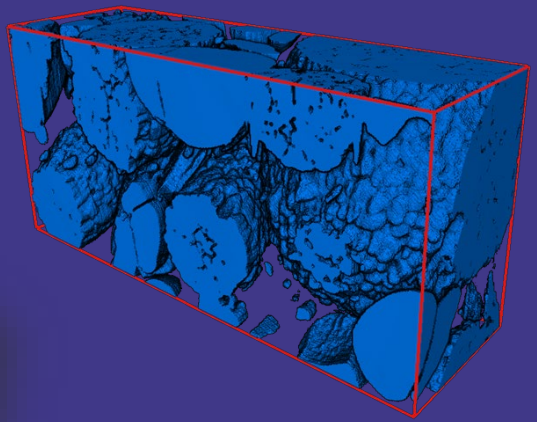
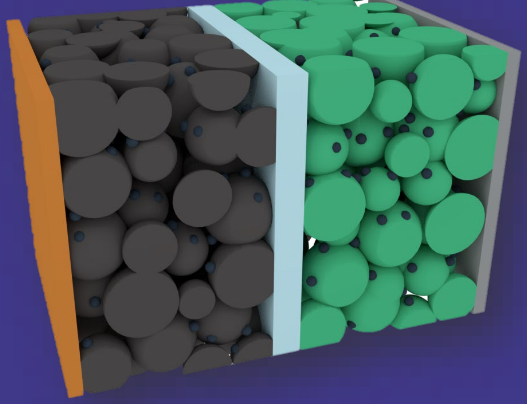
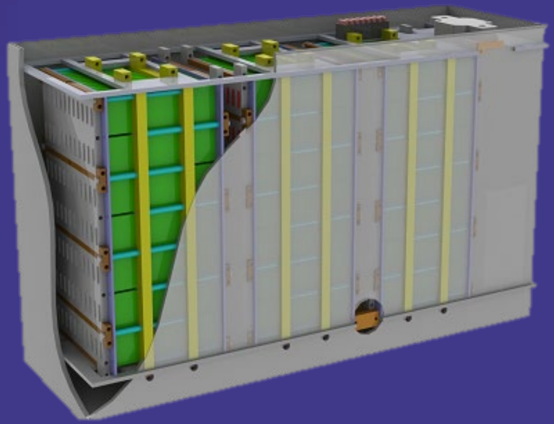
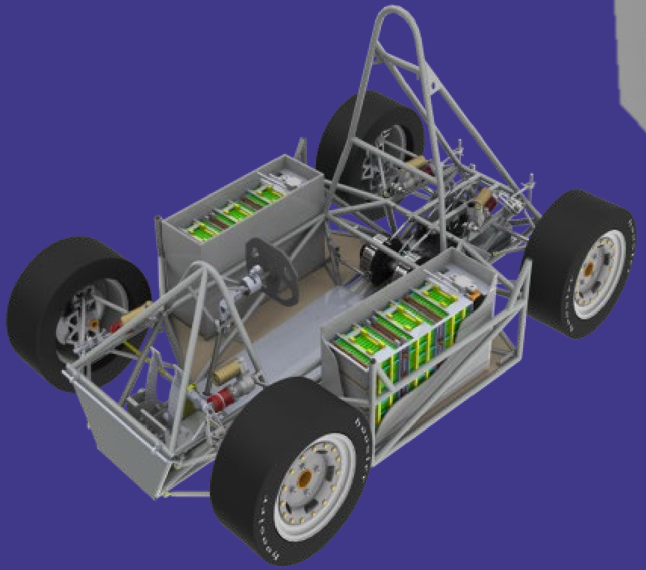
Twitter - @ICBillyWu









Dyson School of
Design Engineering

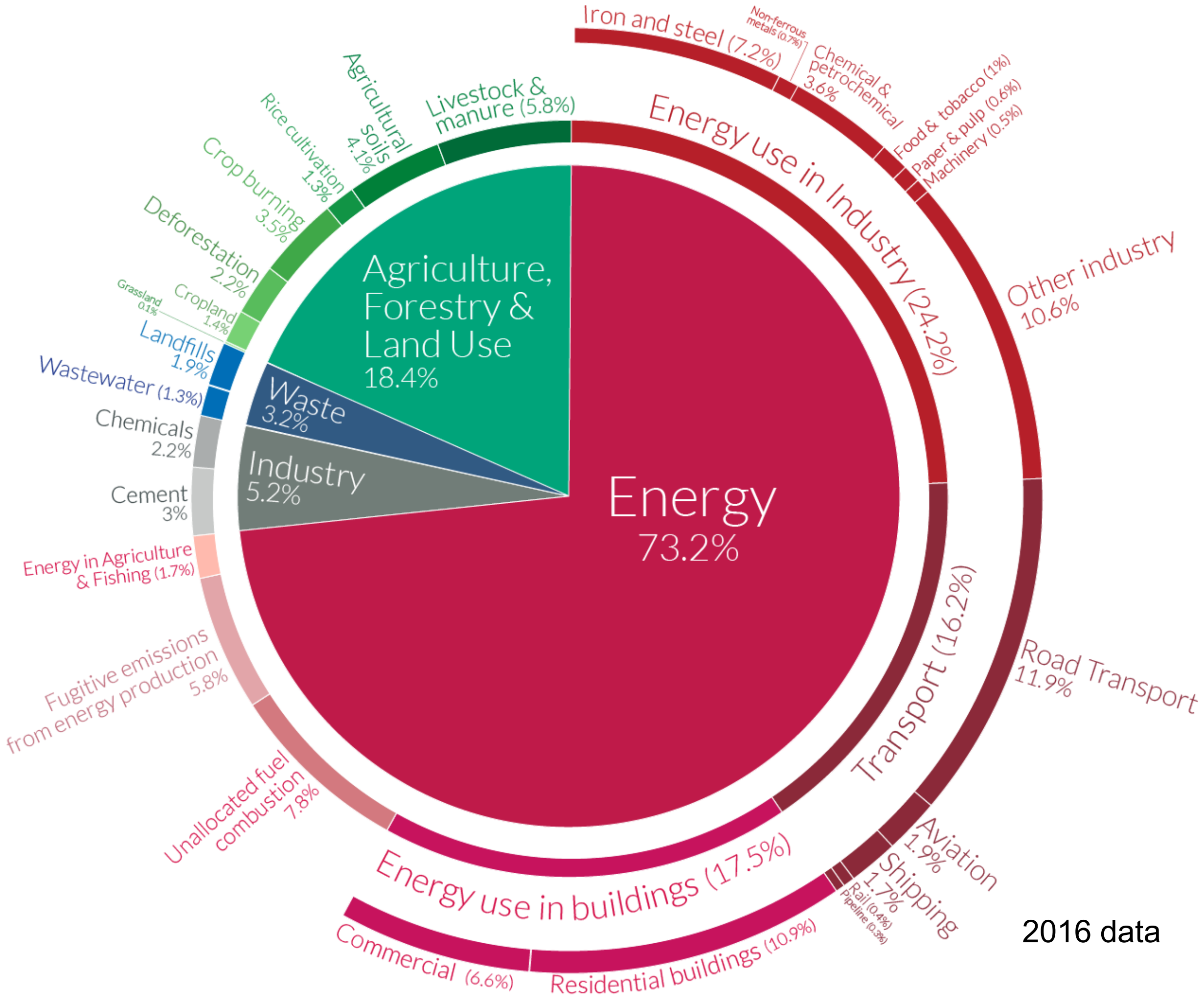
“THE STONE AGE CAME TO AN END, NOT BECAUSE WE HAD A LACK OF STONES, AND THE OIL AGE WILL COME TO AN END NOT BECAUSE WE HAVE A LACK OF OIL.”

FORMER SAUDI OIL MINISTER, SHEIK AHMED ZAKI YAMANI

Source: The Telegraph, June 25, 2000

Inevitable transition to electric vehicles

Global greenhouse gas emissions by sector (~50 billion tonnes CO_2eq.)

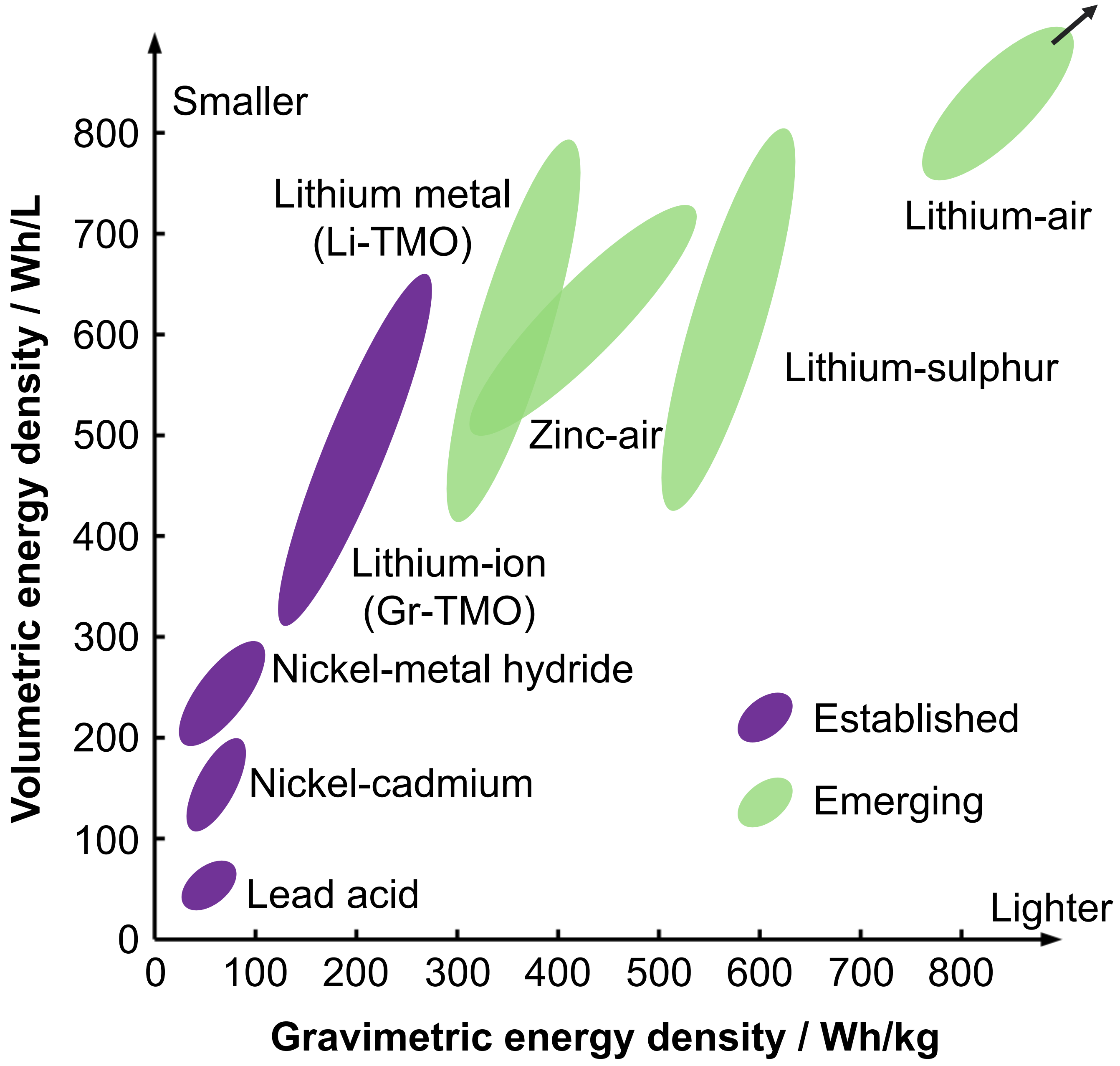


2016 data

https://www.bbc.co.uk/news/science-environment-51366123
https://www.bbc.co.uk/news/world-europe-40518293
https://ourworldindata.org/emissions-by-sector

Battery technologies

- Petrol ~9,500 Wh/L and ~12,800 Wh/kg
  - Engine efficiency ~25%
  - ~2,400 Wh/L and ~3,200 Wh/kg
- Lots of different chemistries which are defined by their cathode/anode materials
  - Lead acid
  - Nickel-cadmium
  - Nickel-metal hydride
  - Lithium-ion
    - Graphite-Transition Metal Oxide
  - Lithium metal
    - Lithium-Transition Metal Oxide
  - Lithium-sulphur
  - Metal-air

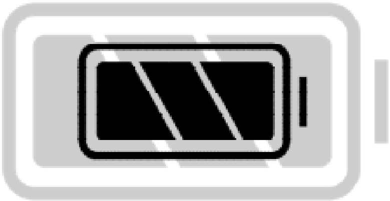


Significant improvements needed

Cost

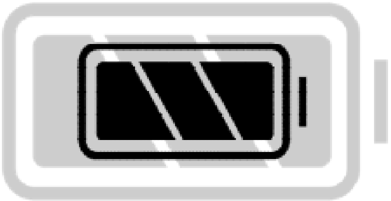
Now 130$/kWh (cell)
280$/kWh (pack)
Future 50$/kWh (cell)
100$/kWh (pack)

Energy density



Now 700 Wh/L
250 Wh/kg (cell)
Future 1400 Wh/L
500 Wh/kg (cell)

Power density

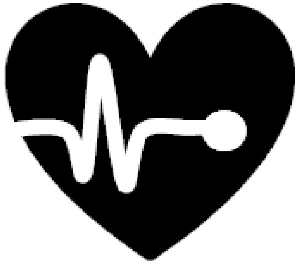


Now 3 kW/kg (pack)
Future 12 kW/kg (pack)

Safety

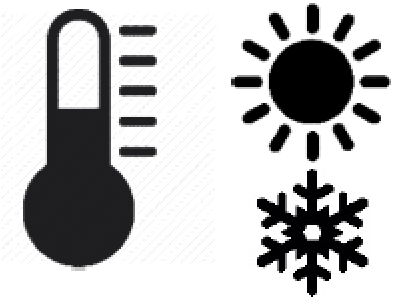
Future eliminate thermal runaway at pack level to reduce pack complexity

1st life



Now 8 years (pack)
Future 15 years (pack)

Temperature



Now -20° to +60°C (cell)
Future -40° to +80°C (cell)

Predictability

Future full predictive models for performance and aging of battery

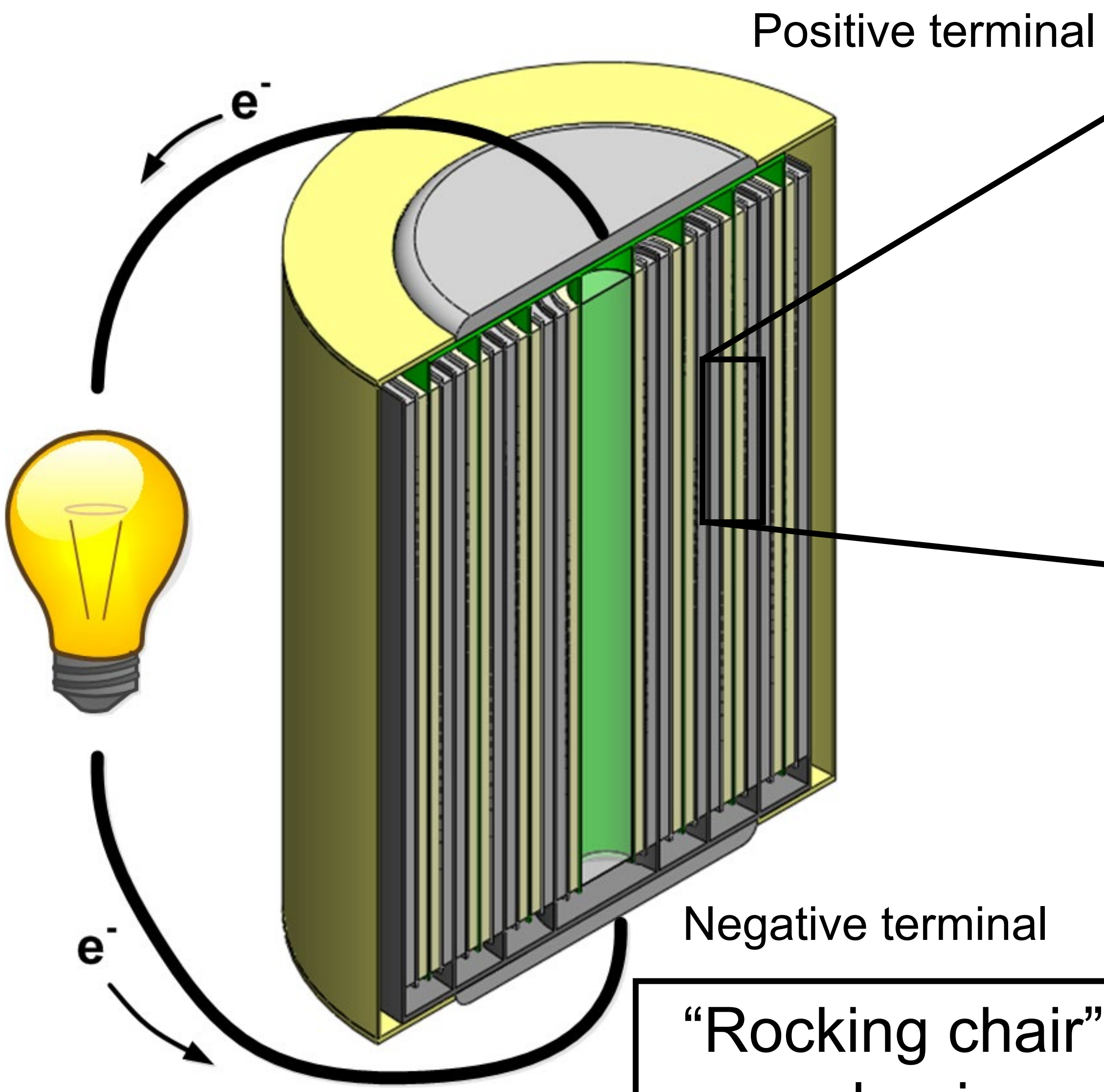
Recyclability

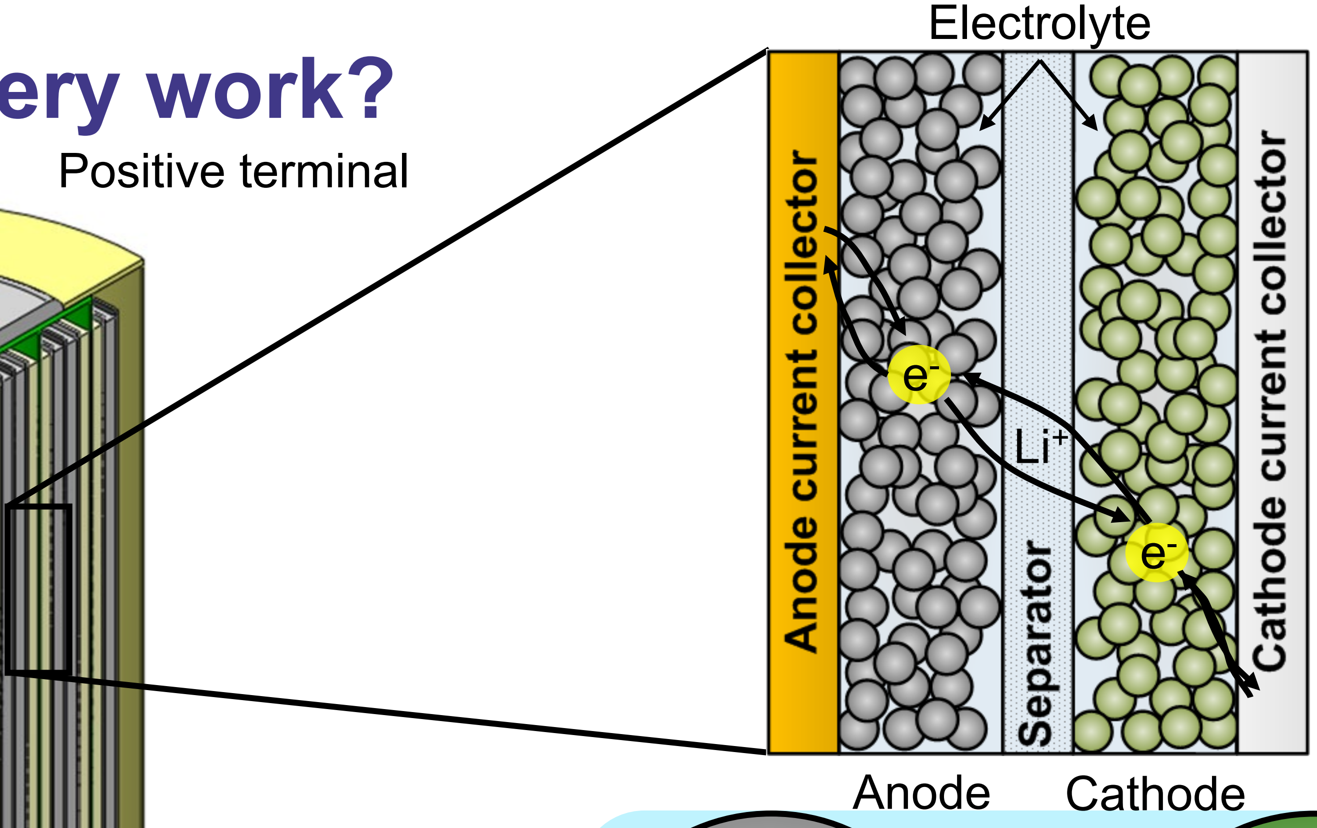
Now 10-50% (pack)
Future 95% (pack)

Faraday Institution targets

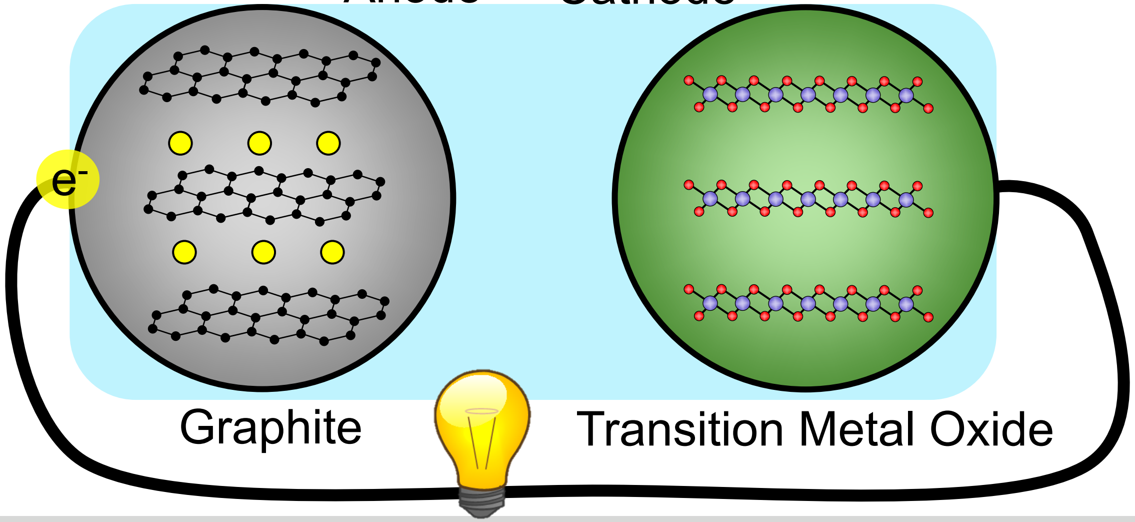
Adapted from content from Professor Dave Greenwood at Warwick Manufacturing Group

How does a battery work?





“Rocking chair” mechanism



Do we have good chemistry?

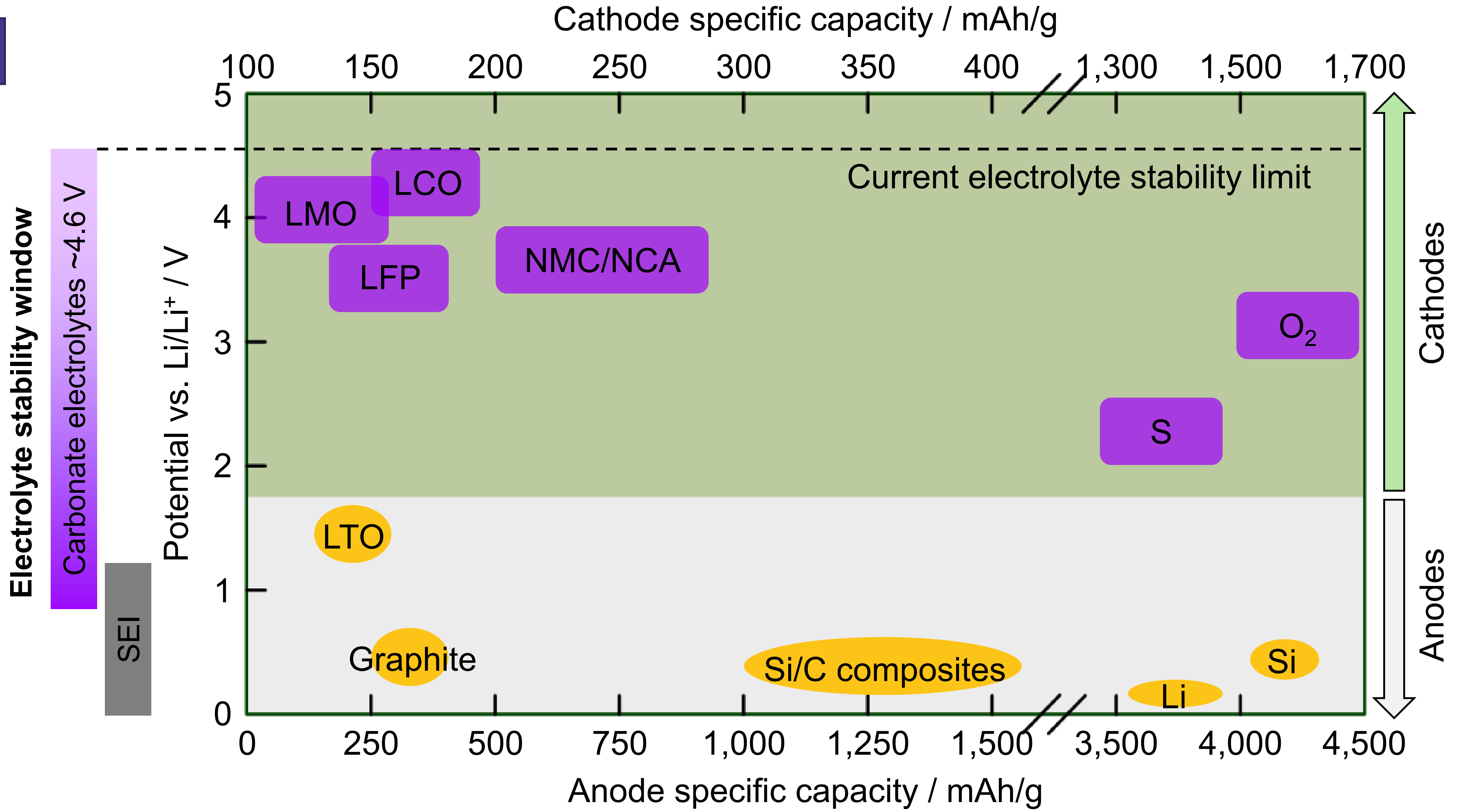
Design objective

Anode
High capacity and low voltage

Cathode
High capacity and high voltage

Electrolyte
Large stability window

All
Cheap, mass produced, non-flammable

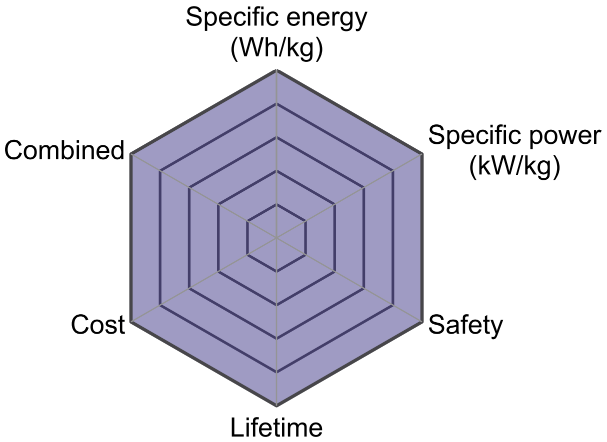


Adapted from content from Dr. Monica Marinescu from Imperial College London
LMO – Lithium manganese oxide; LFP – Lithium iron phosphate; LCO – Lithium cobalt oxide; NMC – Lithium nickel manganese cobalt oxide; NCA – Lithium nickel cobalt aluminium oxide; LTO – Lithium titanate; S – Sulphur; Si – Silicon; Li – Lithium; SEI – Solid electrolyte interphase

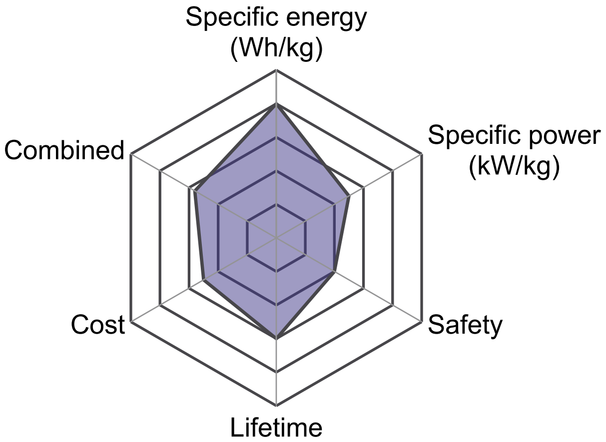
Do we have good chemistry?

Nickel = Capacity
Cobalt = Rate capability (power), stability
Manganese = Safety, cost

The perfect cathode

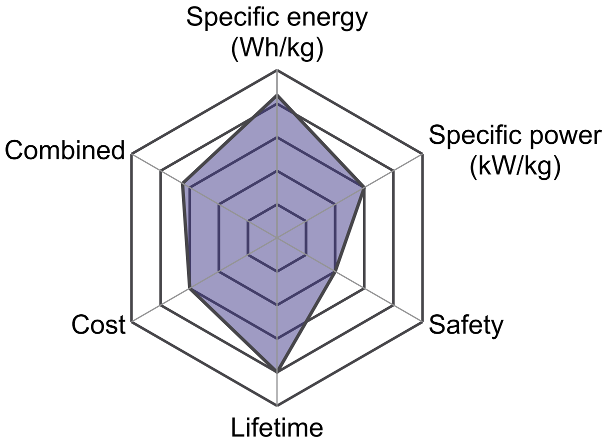


NMC

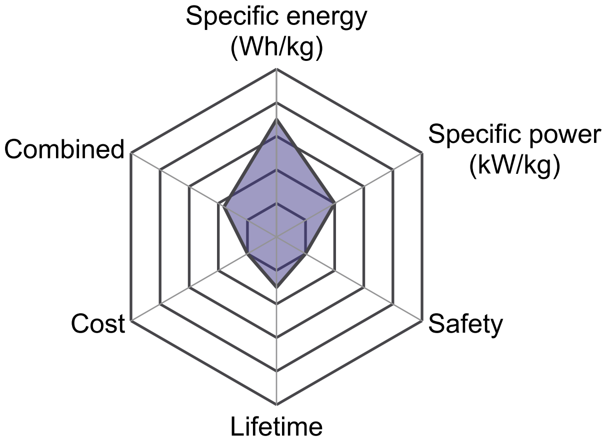


Increasing nickel content trend continues

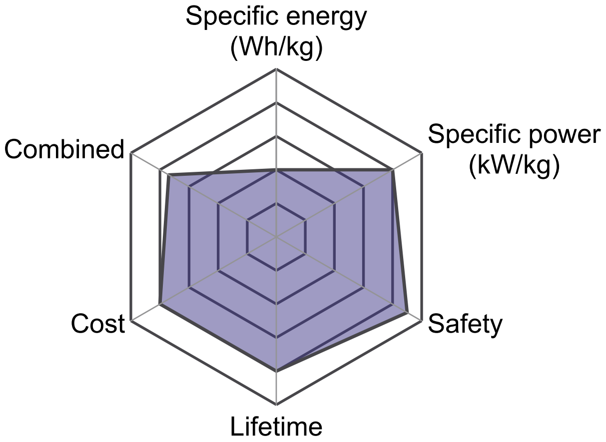
NCA



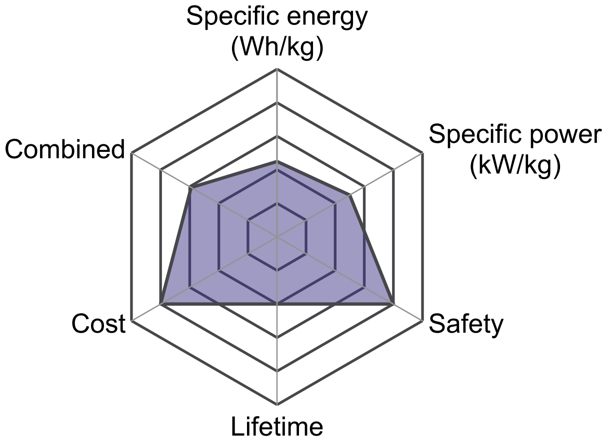
LCO



LFP



LMO



*Not to scale

LMO – Lithium manganese oxide; LFP – Lithium iron phosphate; LCO – Lithium cobalt oxide; NMC – Lithium nickel manganese cobalt oxide; NCA – Lithium nickel cobalt aluminium oxide

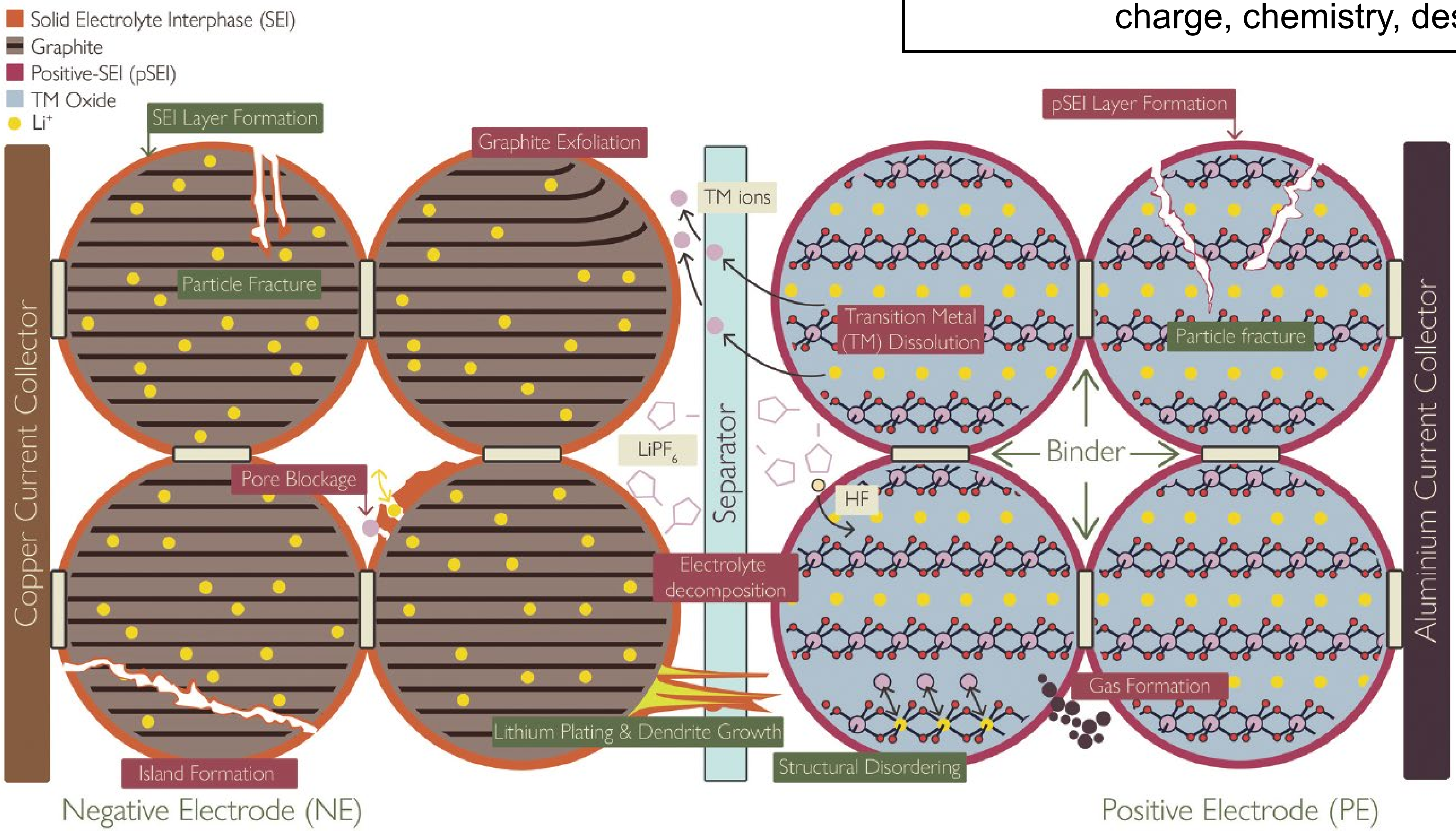
Not a 1 size fits all solution

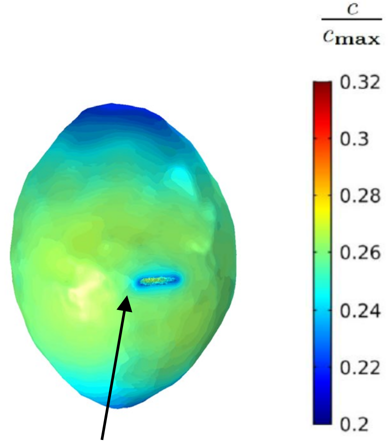
Tesla battery day 2020

Dyson School of Design Engineering

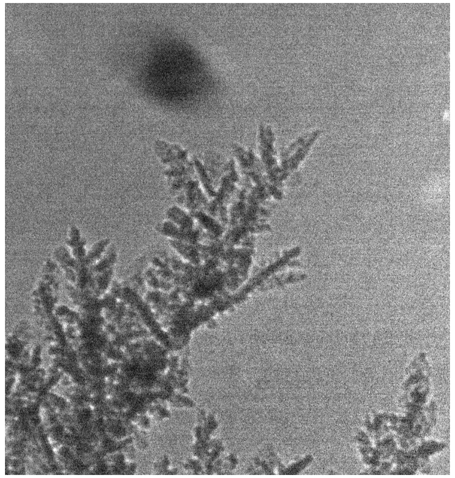
Degradation mechanisms

Degradation in batteries is complex and depends on a range of factors: temperature, current, state-of-charge, chemistry, design etc





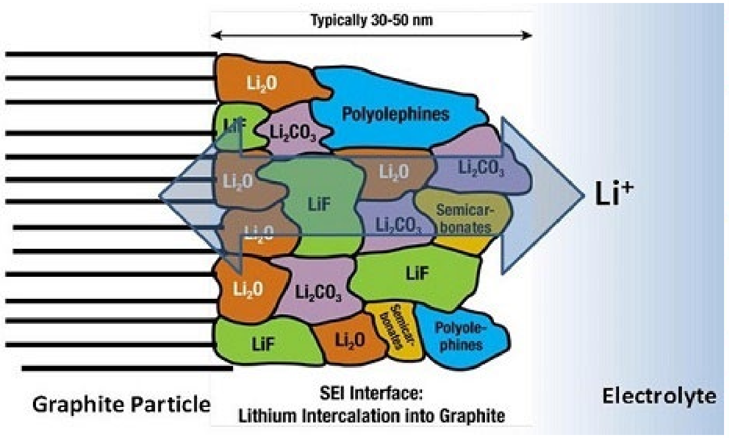
Particle cracking



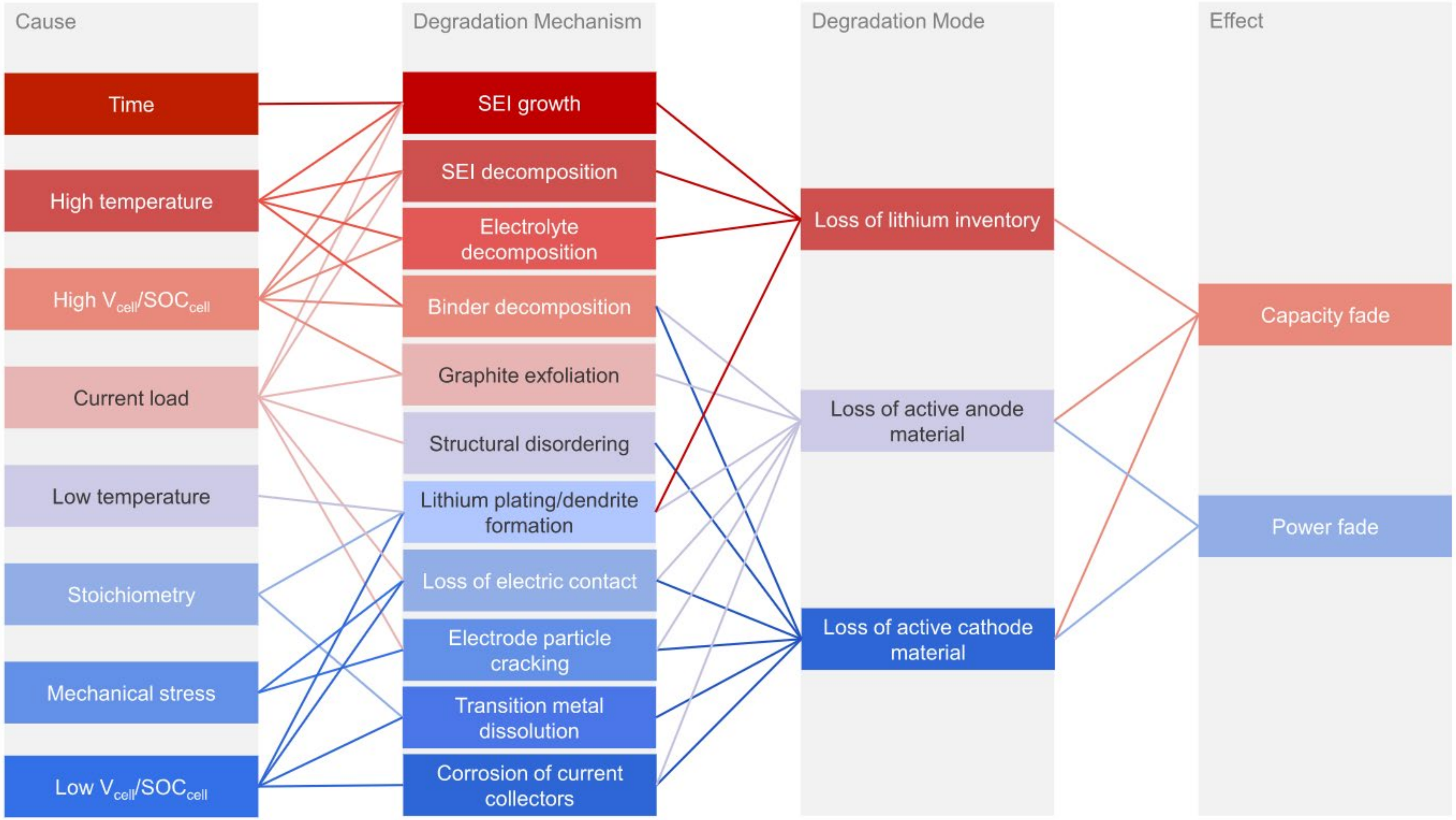
Lithium ion battery degradation: What you need to know. Edge et al. Physical Chemistry Chemical Physics. 2021, 23, 8200-8221

Degradation modes in lithium-ion batteries

SEI layer=Passivation layer



Lithium dendrites=Short circuiting



Battery degradation is path dependent; A+B=C but B+A≠C

Degradation diagnostics for lithium ion cells. Birkl, C. et al. Journal of Power Sources. 2017. 341, 373-386

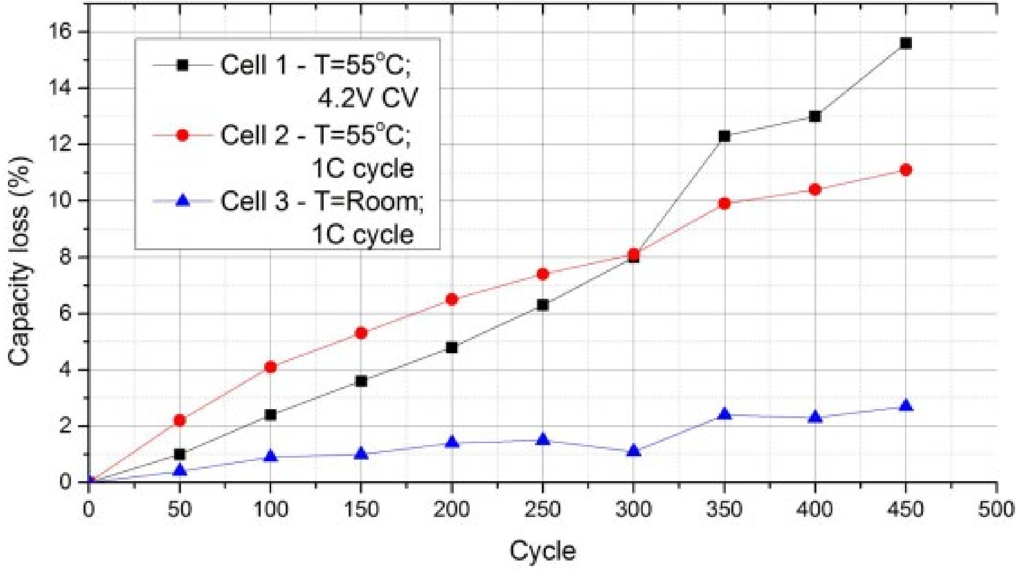
How do we define state-of-health?

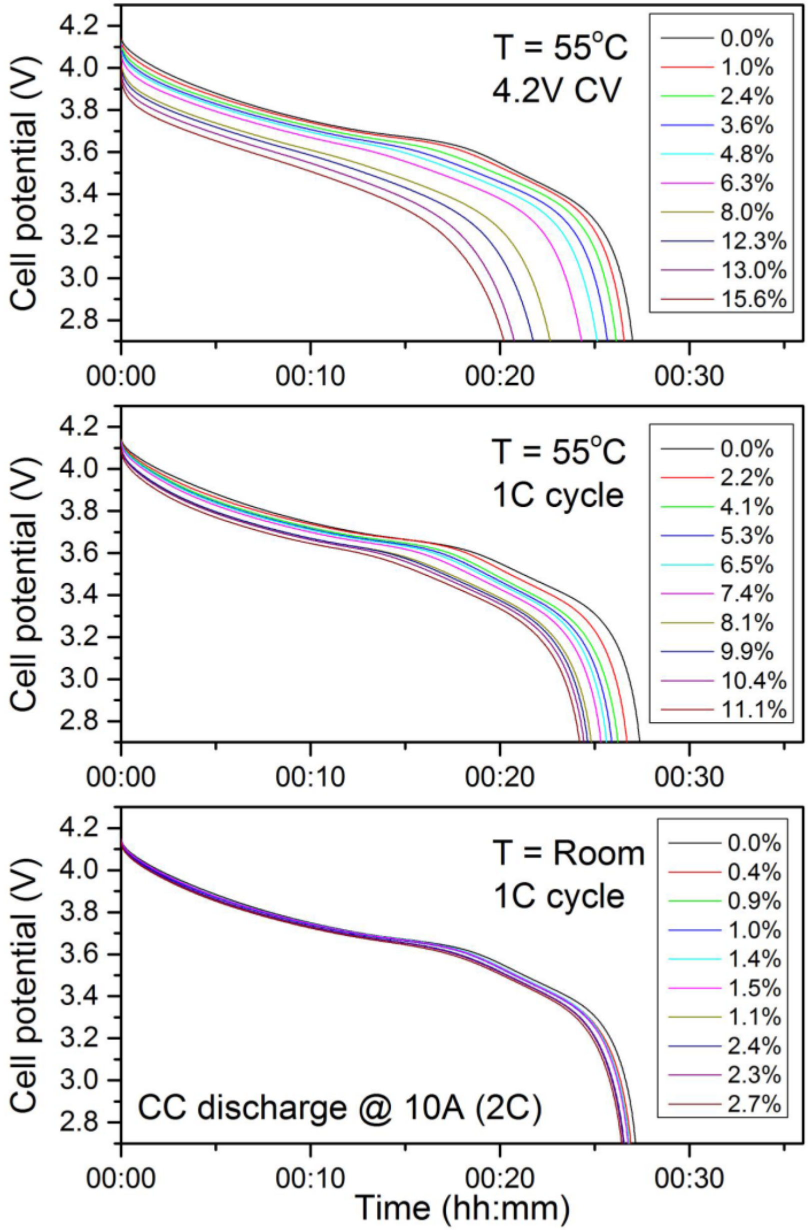
$$SOH_{Capacity} = \frac{Current\ capacity\ (Ah)}{Initial\ capacity\ (Ah)}$$

Reduced range

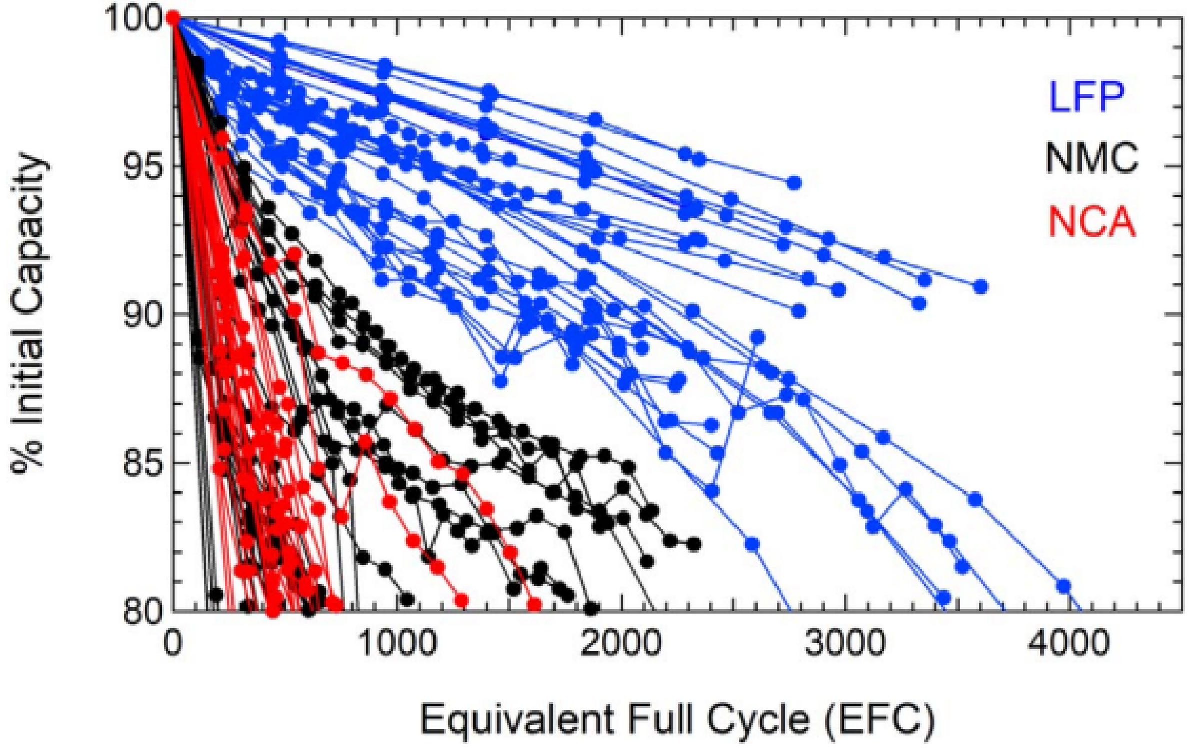
$$SOH_{Resistance} = \frac{Current\ resistance\ (\Omega)}{Initial\ resistance\ (\Omega)}$$

Reduced acceleration

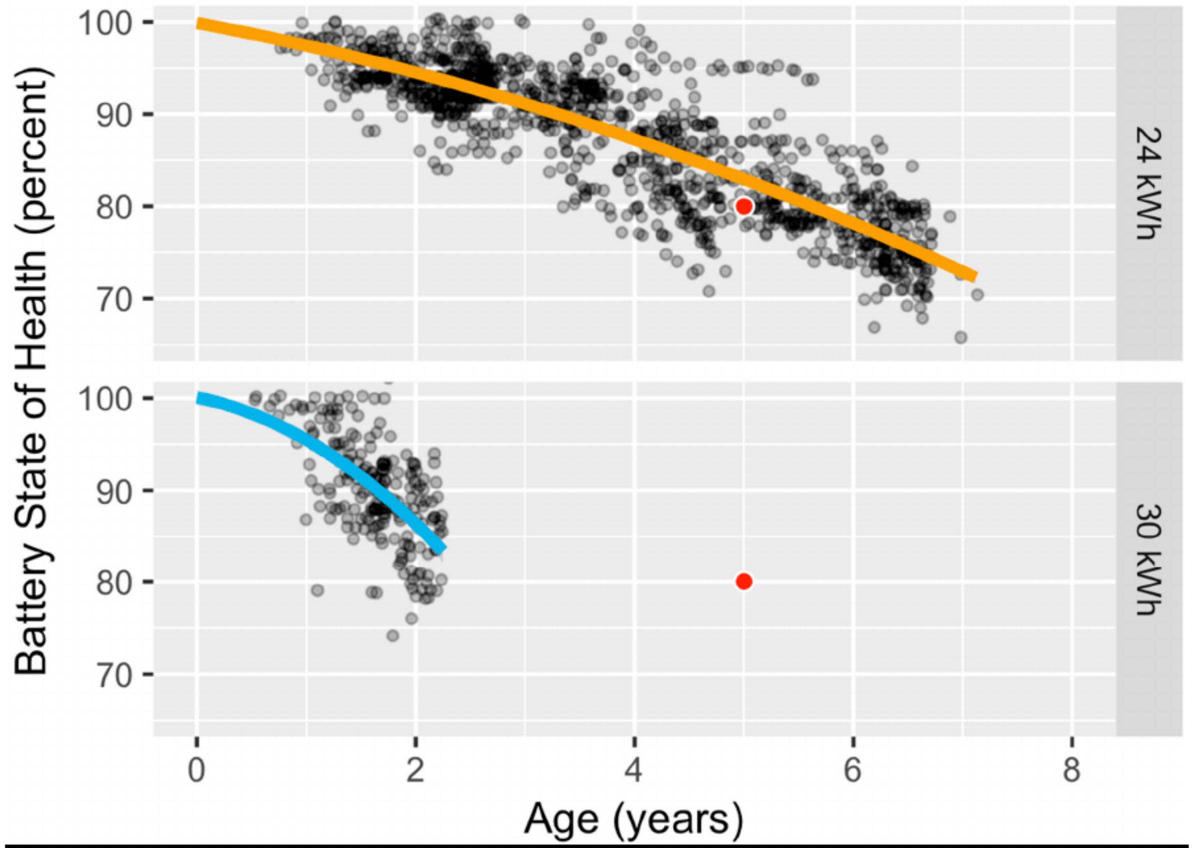




So how long do batteries last?



Lifetime of cells cycled under lab conditions

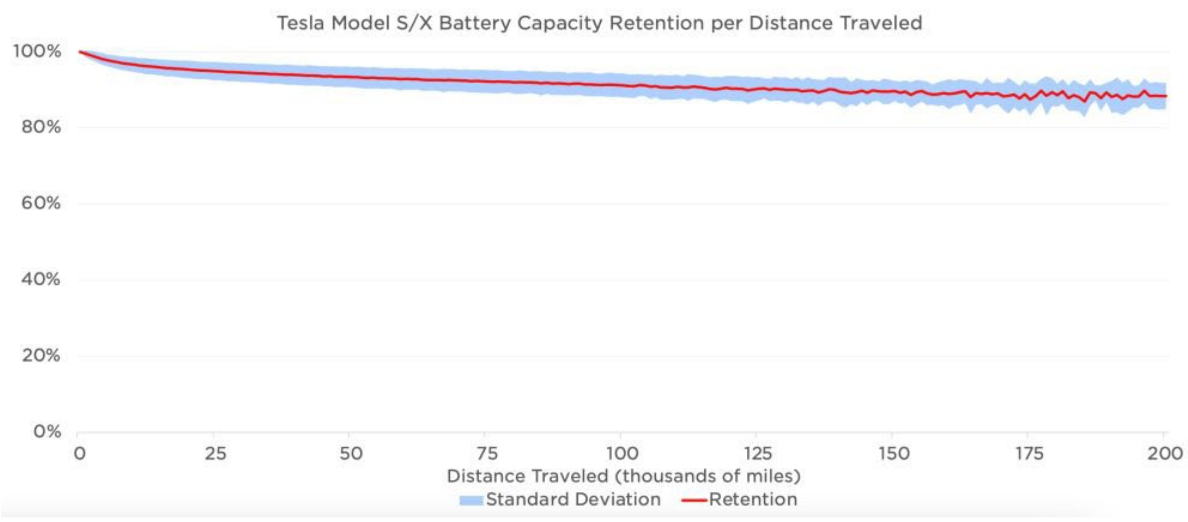


Nissan leaf manufactured between 2011-2017

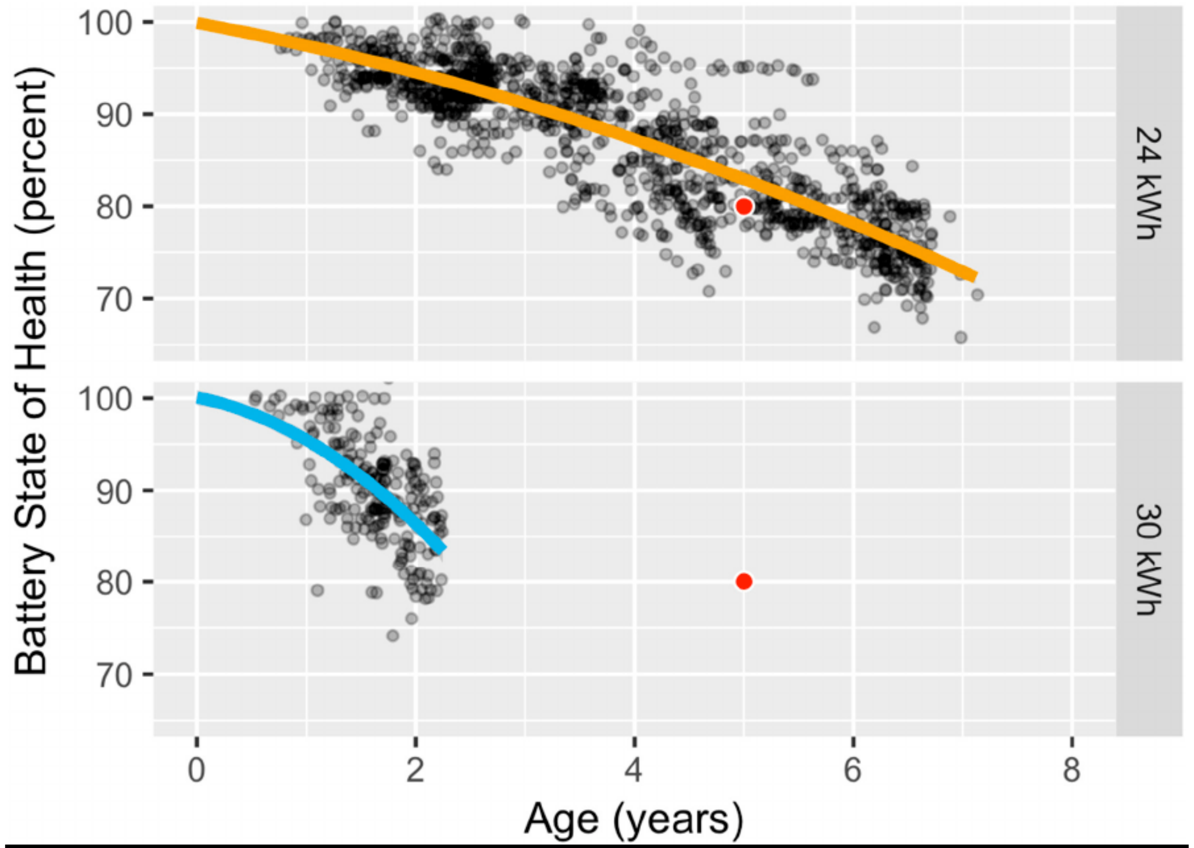
Degradation of Commercial Lithium-Ion Cells as a Function of Chemistry and Cycling Conditions. Preger et al. Journal of the Electrochemical Society. 2020
https://electrek.co/2021/08/12/tesla-claims-battery-packs-lose-only-capacity-200000-miles/
Accelerated Reported Battery Capacity Loss in 30 kWh Variants of the Nissan Leaf. Myall et al. 2018

So how long do batteries last?

It depends!



Tesla model S/X



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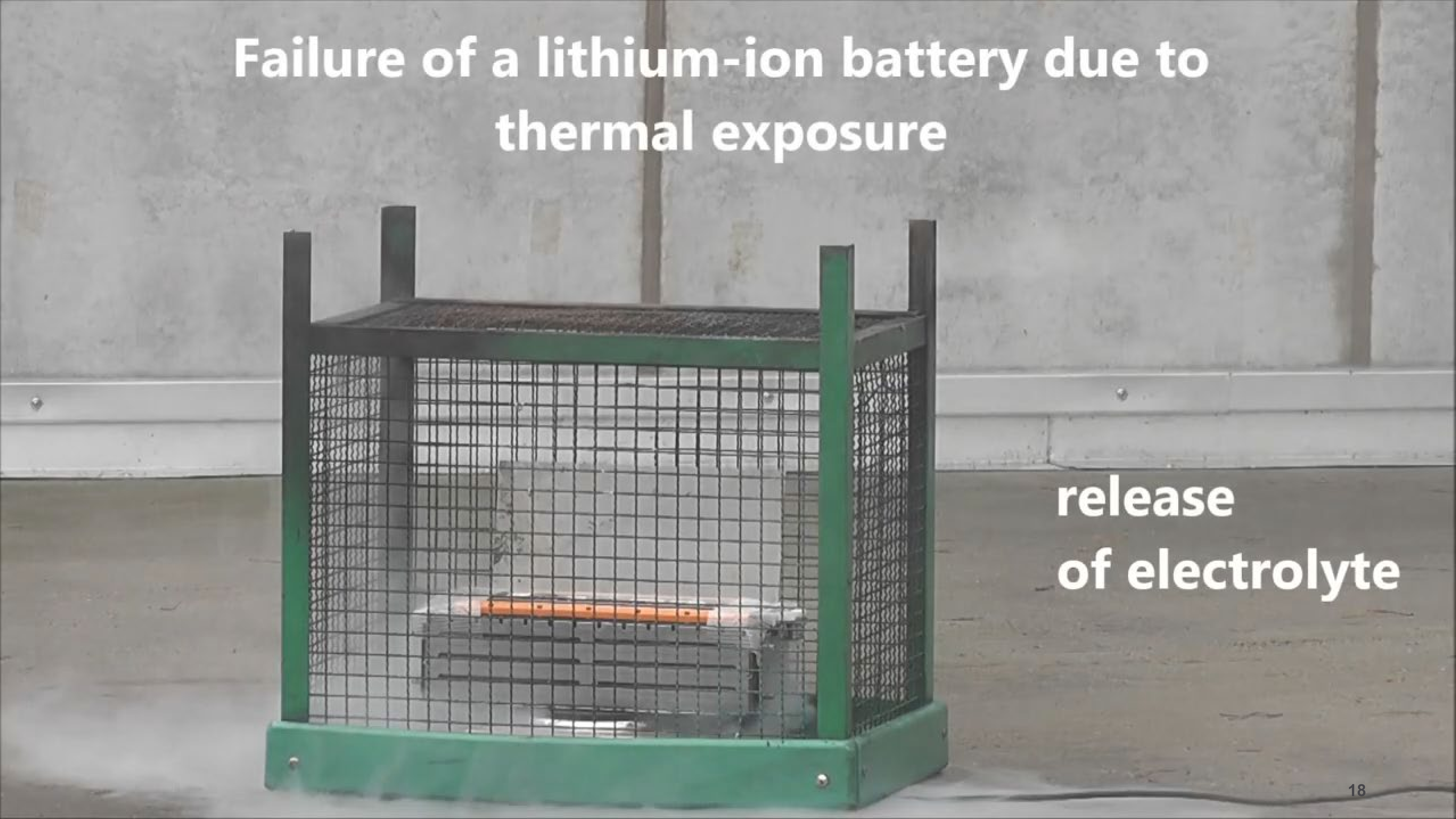
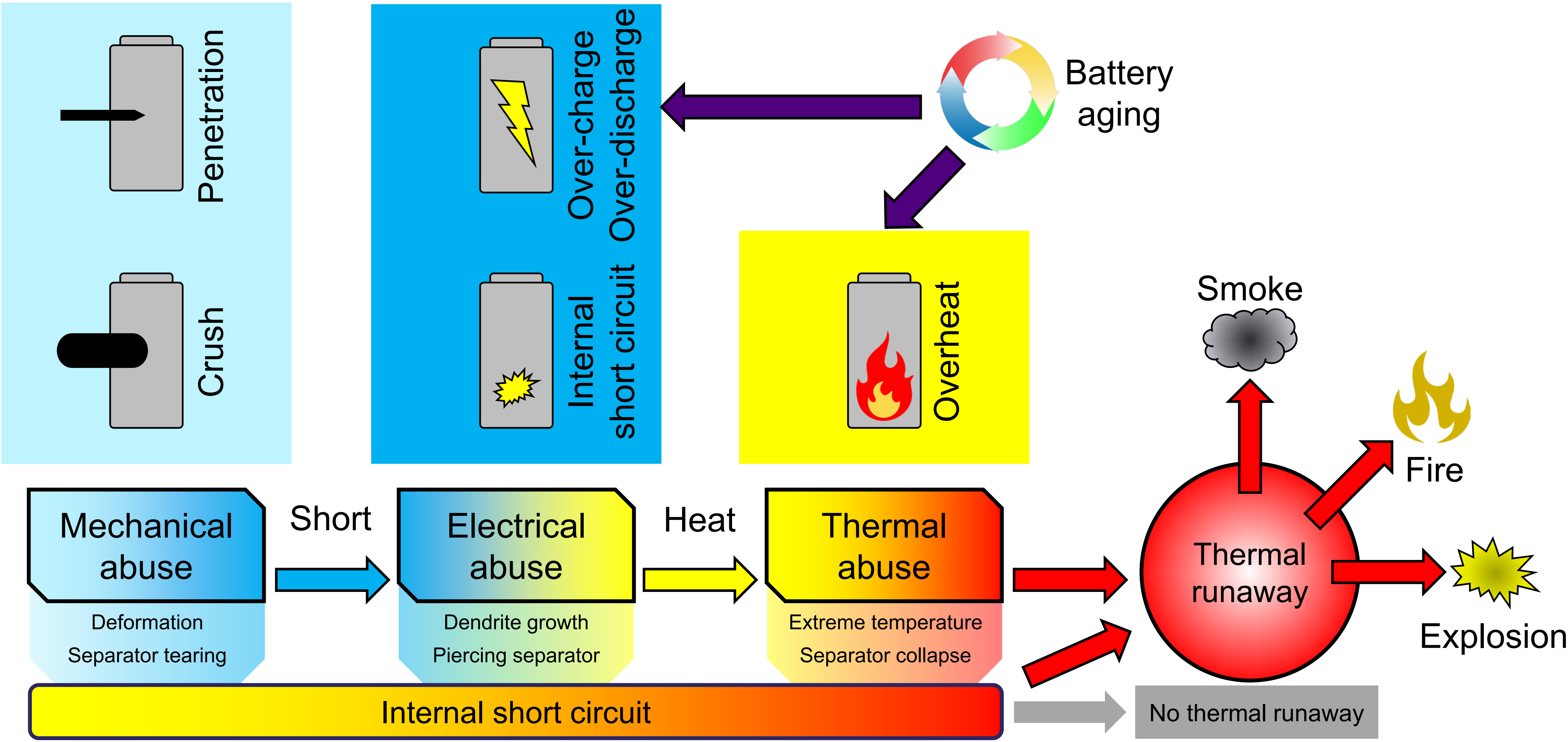
Accelerated Reported Battery Capacity Loss in 30 kWh Variants of the Nissan Leaf. Myall et al. 2018

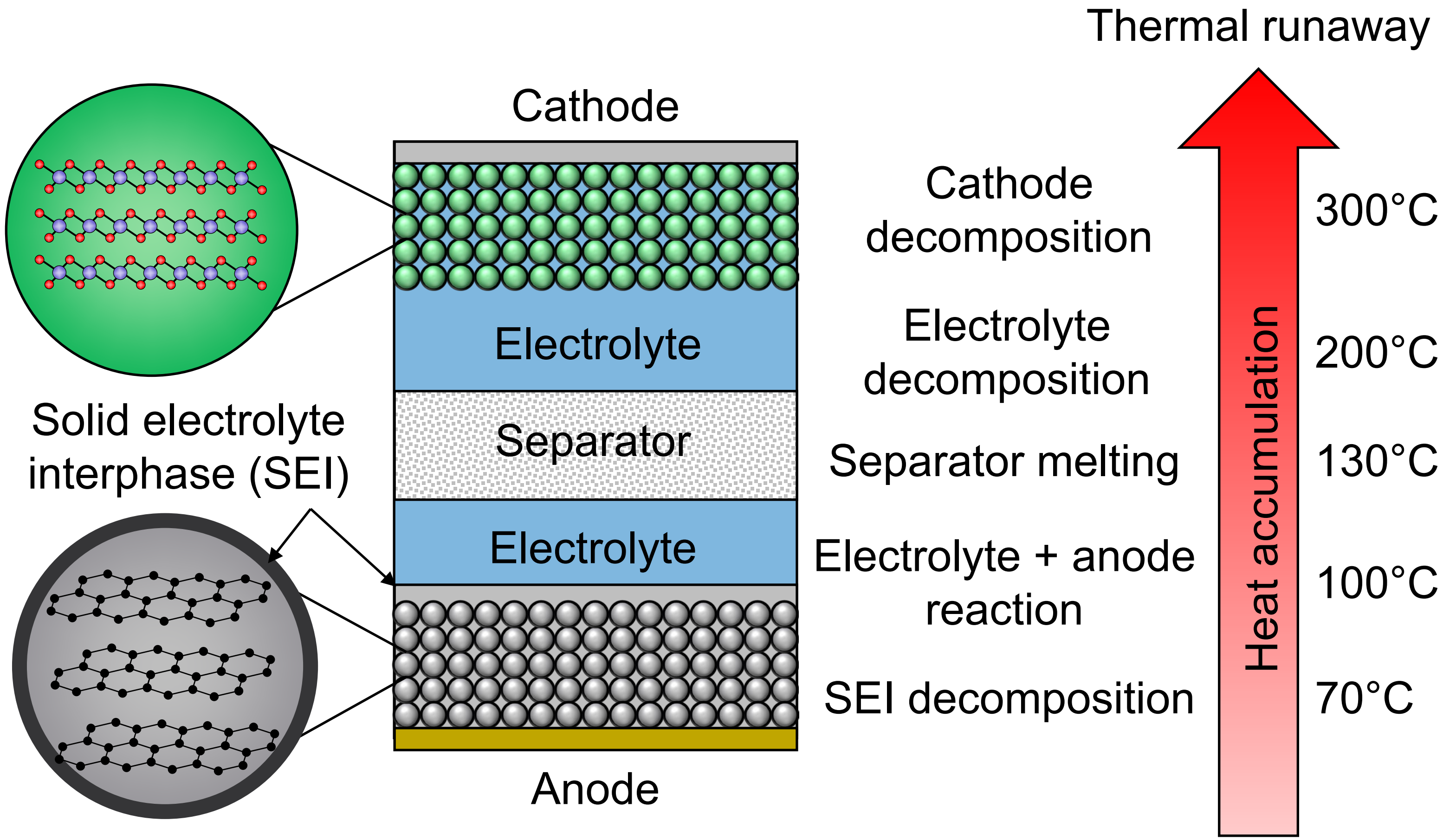

Failure of a lithium-ion battery due to thermal exposure
release
of electrolyte

Types of battery abuse



Adapted from Thermal runaway mechanism of lithium ion battery for electric vehicles: A review. X. Feng et al. Energy Storage Materials 10 (2018) 246–267
A review of battery fires in electric vehicles. Sun et al. Fire Technology. 2020, 56, 1361-1410

What happens when lithium-ion batteries go wrong?

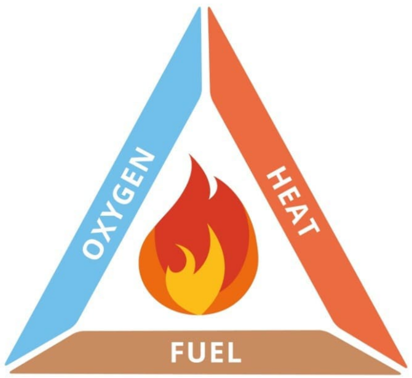


Oxygen release

Hydrofluoric acid release

Internal short circuit

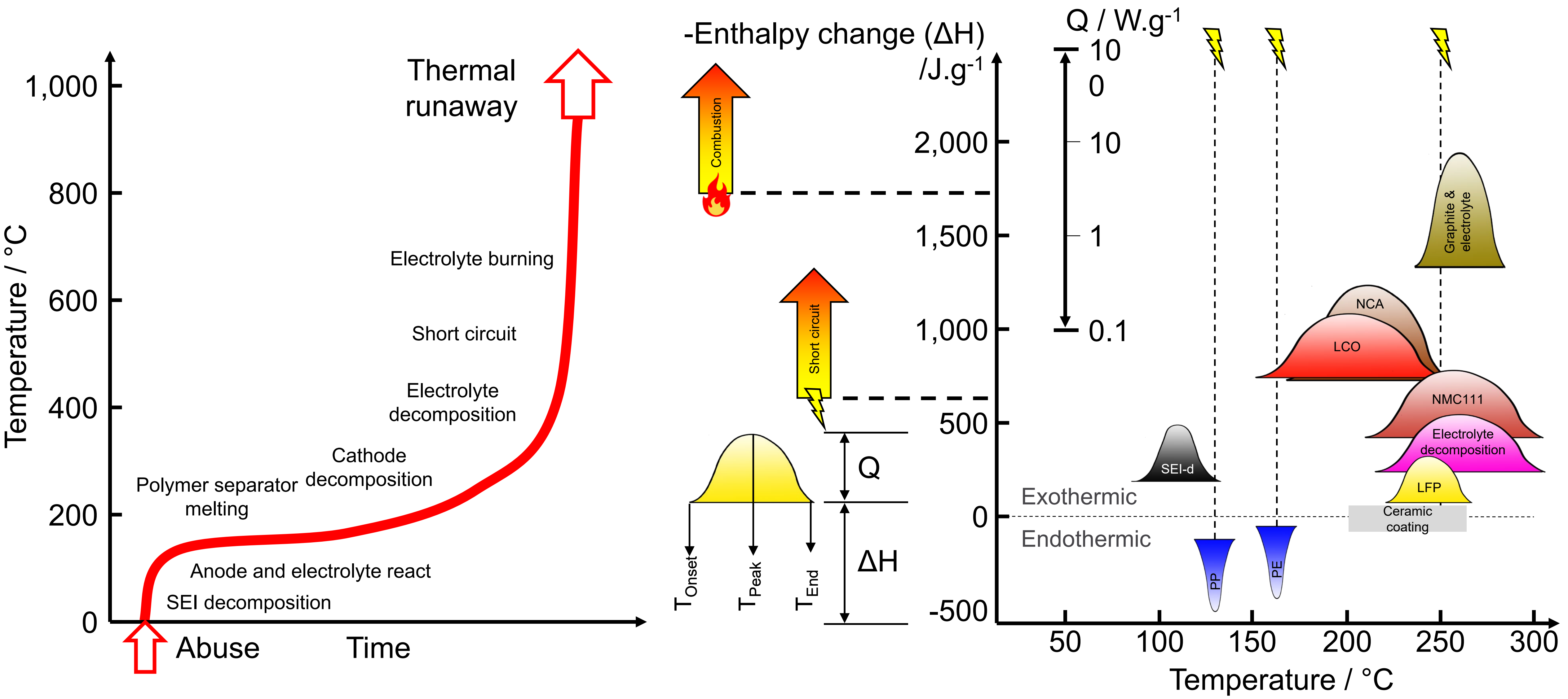
Heat production



Common battery electrolyte components = Salt + solvent
Salt = Lithium Hexaflurorophosphate ($LiPF_6$)
Solvent = Ethylene Carbonate (EC), Dimethyl Carbonate (DMC)

Adapted from Progress of enhancing the safety of lithium ion battery from the electrolyte aspect. Wang et al. Nano Energy 2018; 55 :93–114 .
https://www.evaluationengineering.com/applications/product-safety/article/13007366/fire-protection-engineers-address-liion-safety
https://www.highspeedtraining.co.uk/hub/fire-triangle-tetrahedron-combustion/

Energy release during thermal runaway

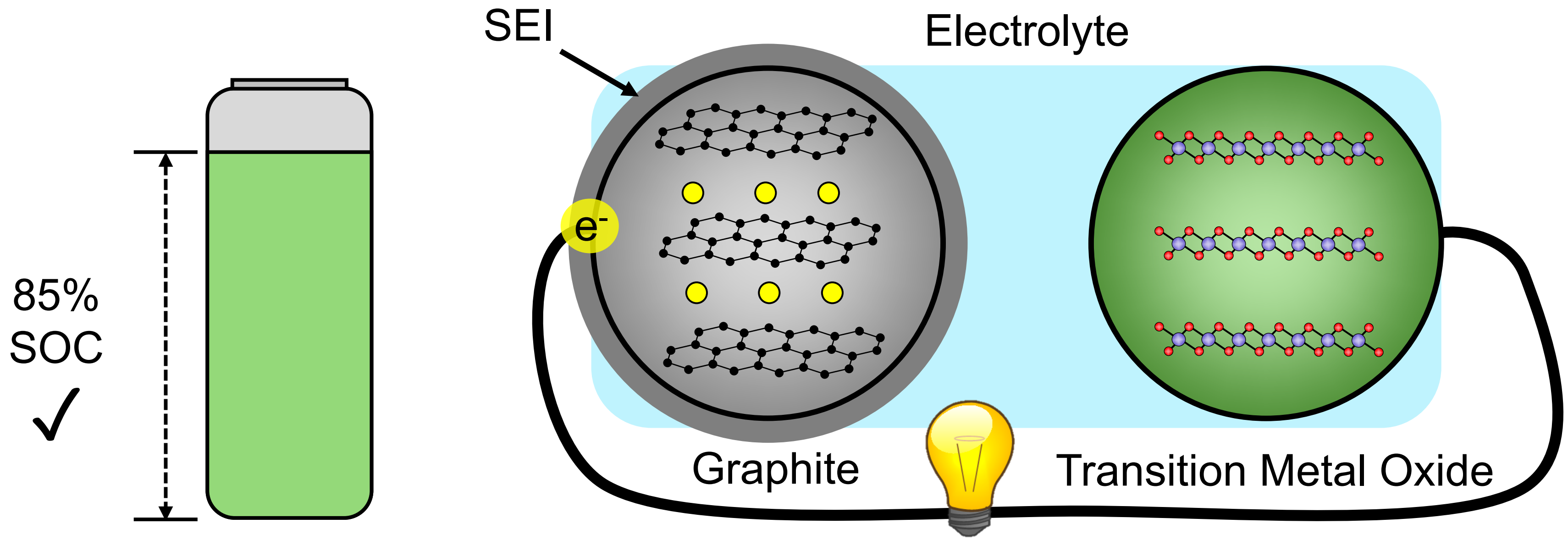


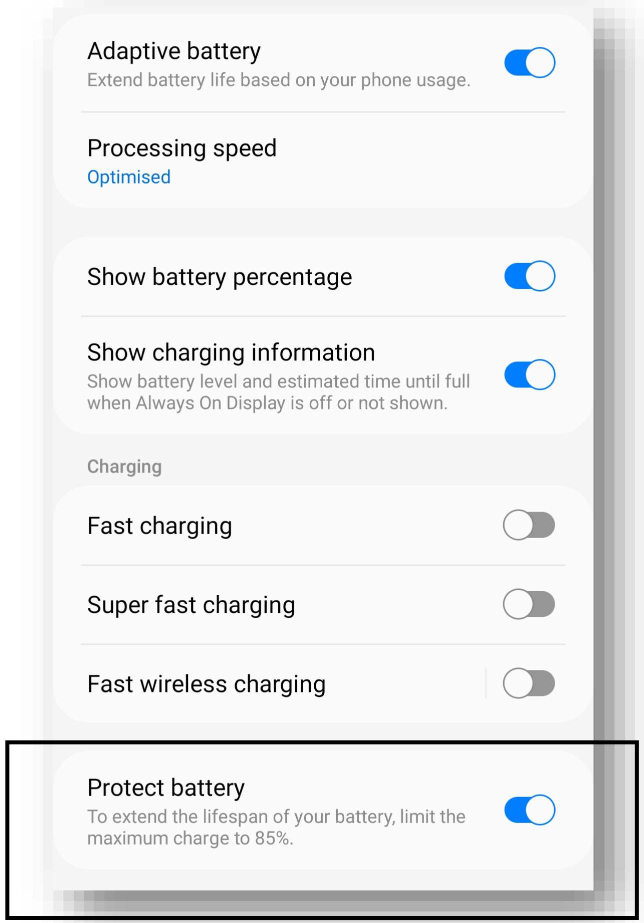
Adapted from Thermal runaway mechanism of lithium ion battery for electric vehicles: A review. X. Feng et al. Energy Storage Materials 10 (2018) 246–267
Q = Maximum heat generation | ΔH = The enthalpy or the total energy released during reaction | SEI-d = Solid electrolyte interphase decomposition | SEI regen = SEI decomposition and regeneration | PP = Polypropylene | PE = Polyethylene | LTO = Lithium titanate oxide | LFP = Lithium iron phosphate | LCO = Lithium cobalt oxide | NCA = Nickel cobalt aluminium oxide | NMC = Nickel Manganese Cobalt Oxide

Reduce time at high state-of-charge

Keeping the battery fully charged can accelerate degradation

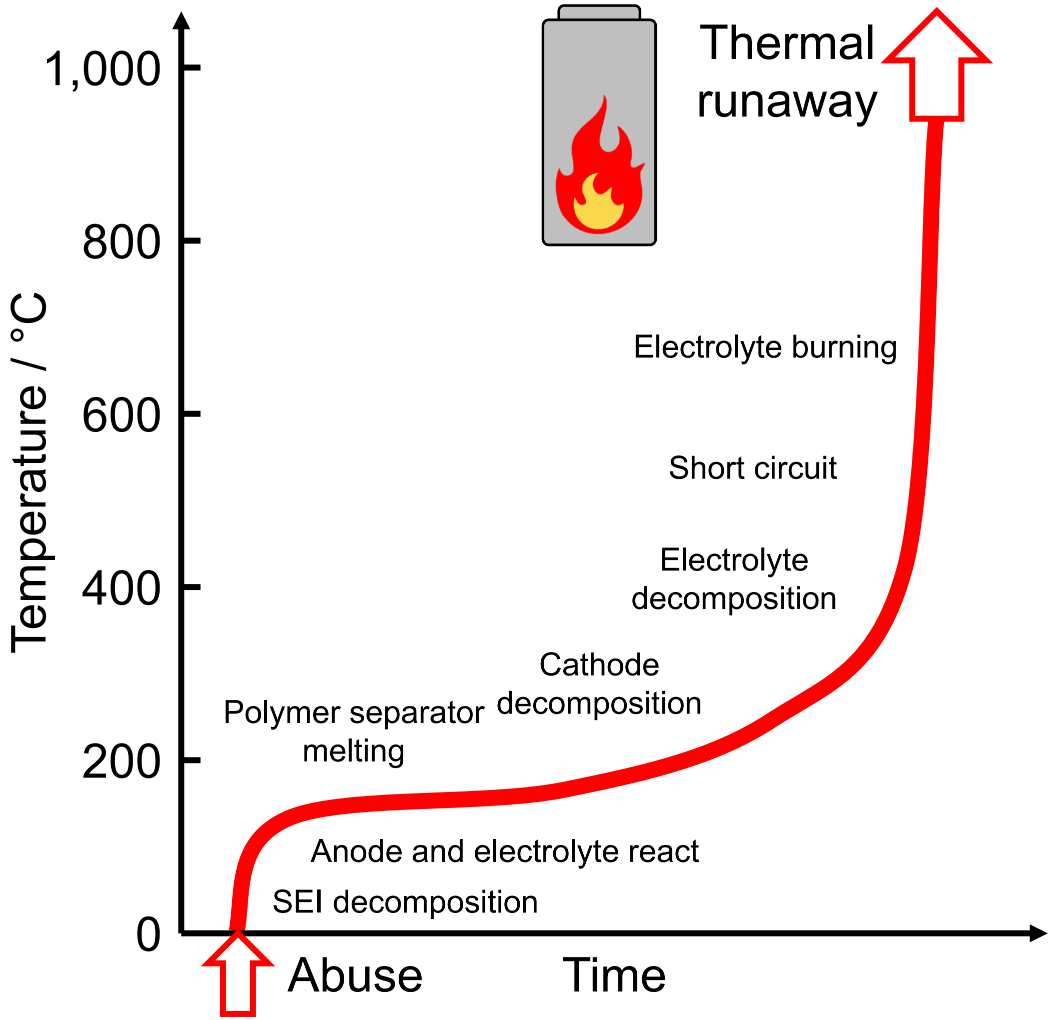
- ~85% state-of-charge is the optimum between energy and lifetime
- High state-of-charge accelerates the growth of the solid-electrolyte interphase (SEI) layer
  - Consumes lithium-ions = lower capacity
  - Thicker layer = high resistance/lower power





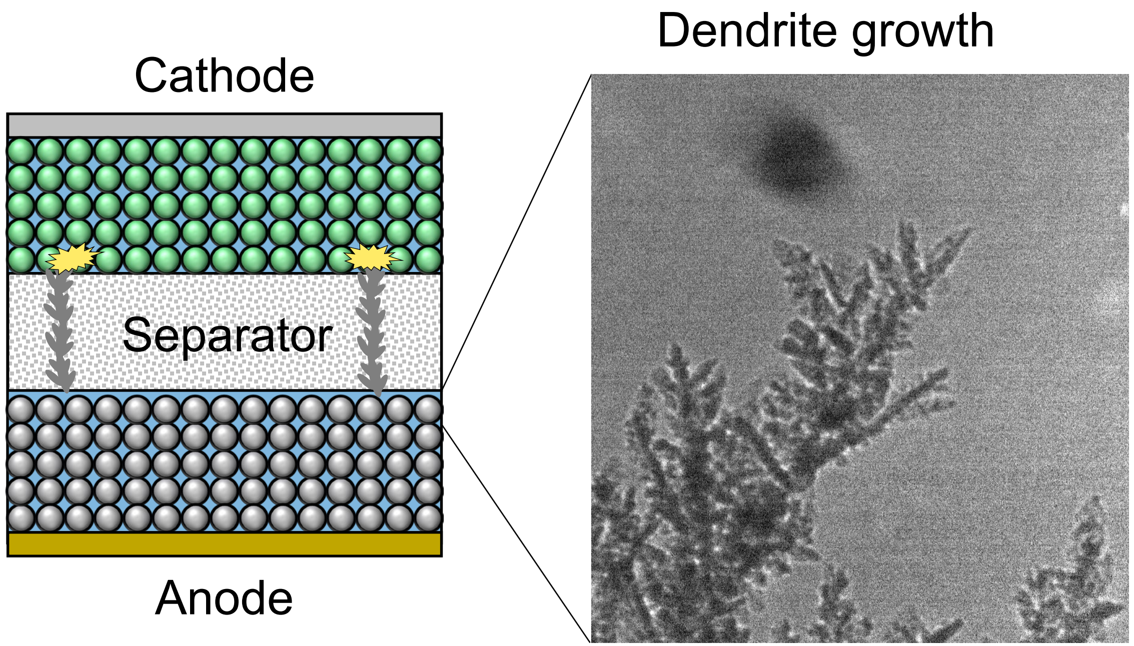
Don’t let the battery get too hot

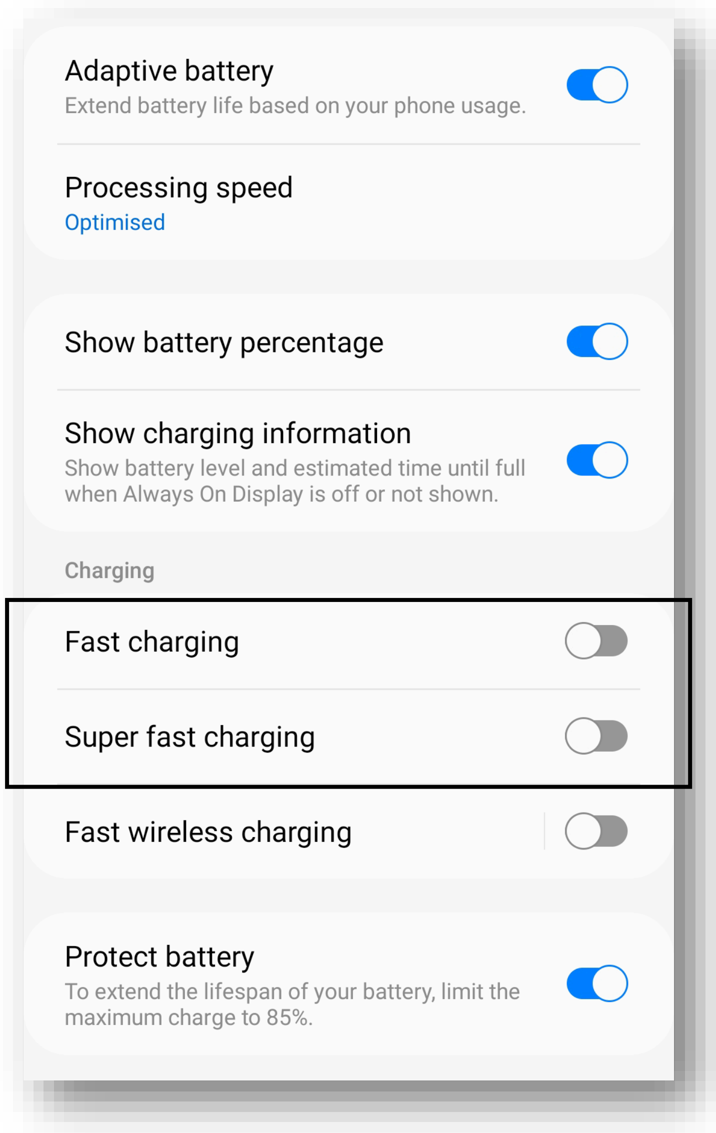
- At >70 °C the battery can enter into thermal runaway
- Warm conditions accelerate the growth of the SEI
  - Decreases capacity and power
- Avoid putting batteries in hot locations



Use slow charging

- Fast charging generally degrades your battery
  - Worse at low temperatures
- Fast charging can cause lithium dendrite formation
  - Leads to capacity fade
  - Potentially can cause an internal short-circuit and fire



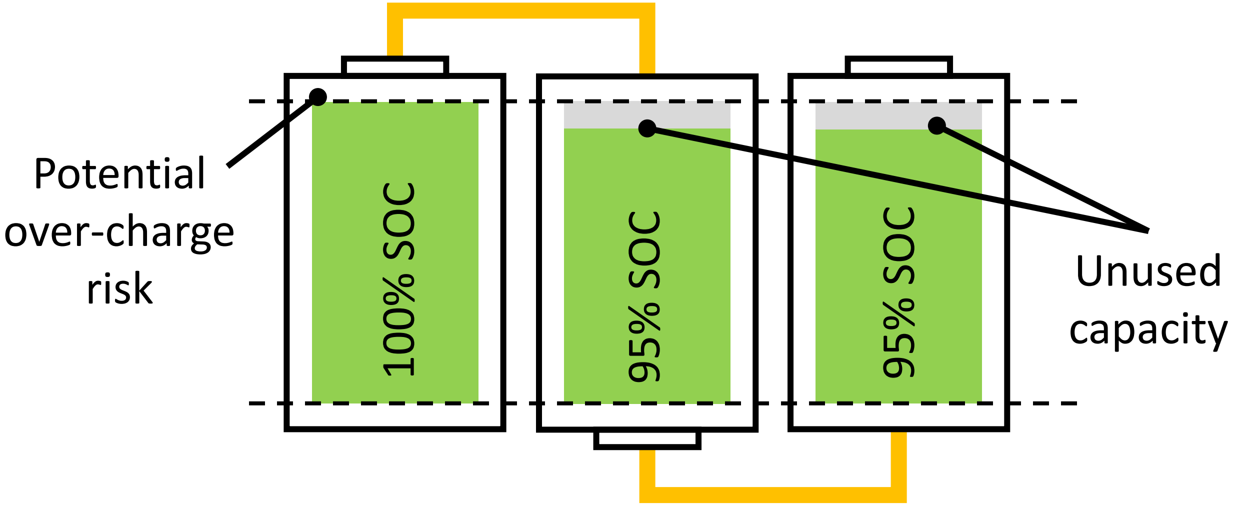


Operando Visualization and Multi-scale Tomography Studies of Dendrite Formation and Dissolution in Zinc Batteries. Yufit et al. Joule. 2018.
*Note that the radiograph of the dendrite growth is for a zinc dendrite but this would be similar for a lithium dendrite

Avoid over-charge and over-discharge

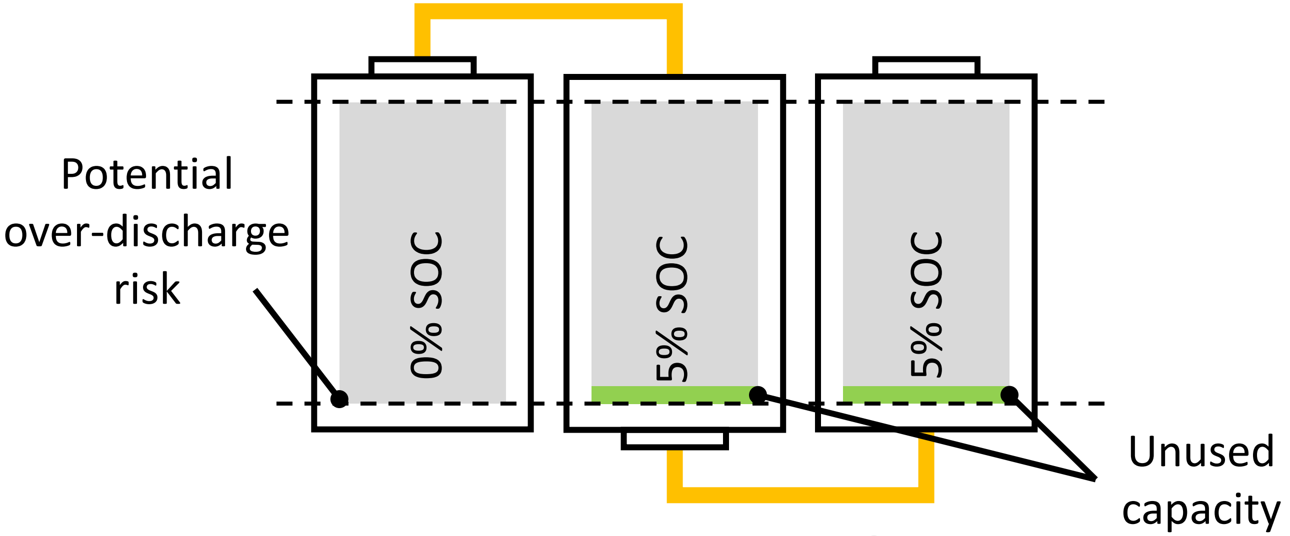
Over-charge

- Most lithium-ion batteries have a maximum voltage of 4.2 V
  - Lithium iron phosphate batteries generally are fully charged at 3.6 V
- Overcharging can decompose the electrolyte
  - Causes bulging of the cell
- Issue in battery packs with cells in series



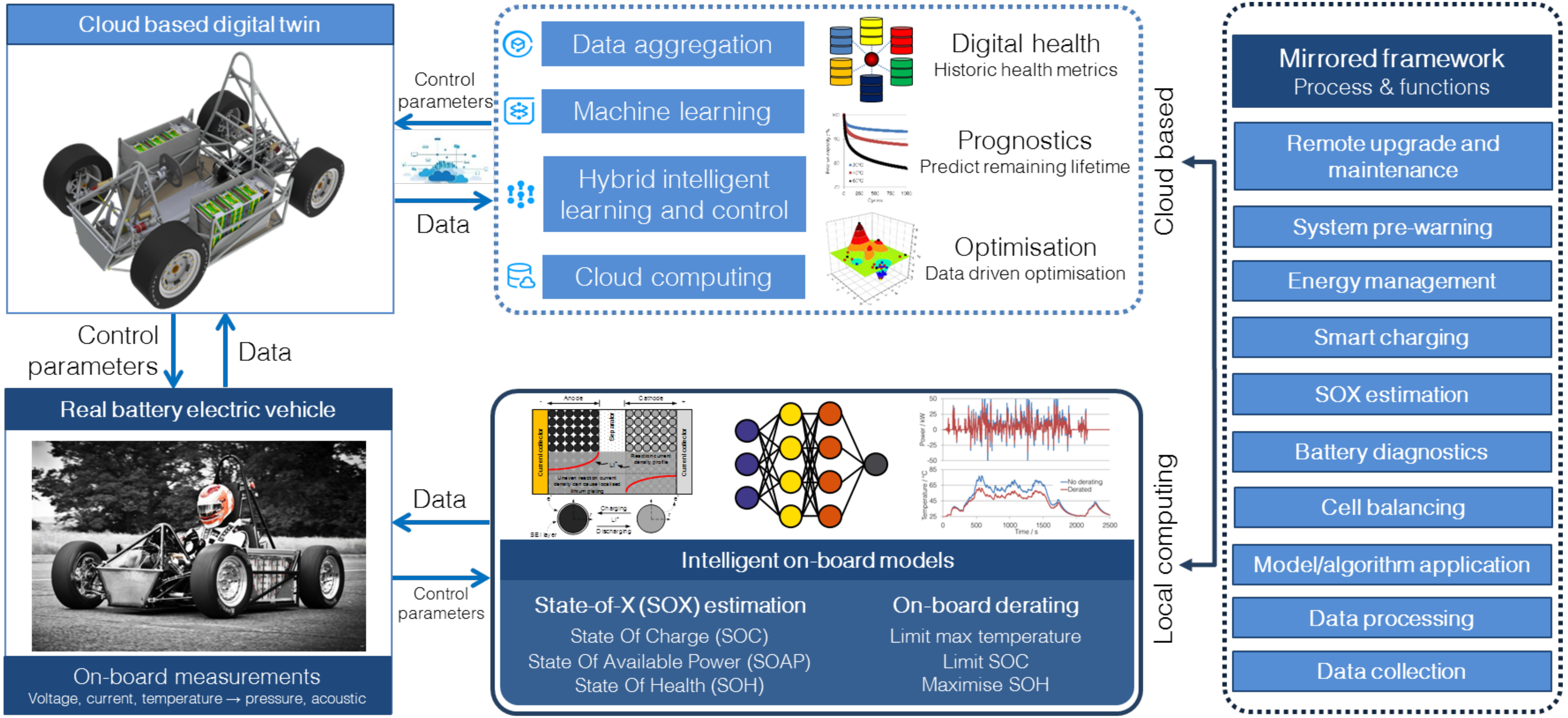
Over-discharge

- Overdischarging the battery (~<2.7 V) can dissolve the copper current collector
- On next recharge, the copper can form copper dendrites and short circuits
- Problem in battery packs



Battery digital twins

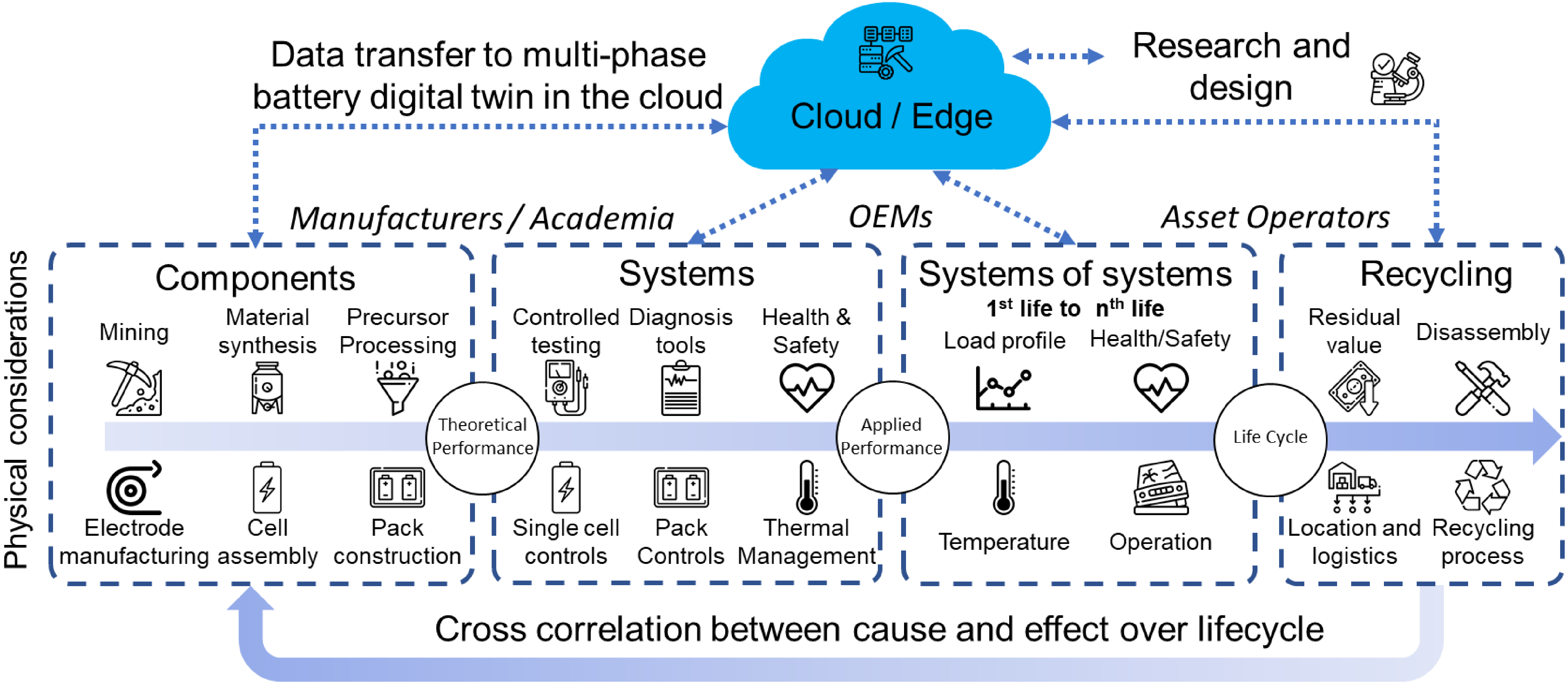
Battery digital twins fuse real-time data with physically relevant models towards making asset specific decisions



Battery digital twins: Perspectives on the fusion of models, data and artificial intelligence for smart battery management systems. Wu et al. Energy & AI. 2020. 10016

A holistic approach

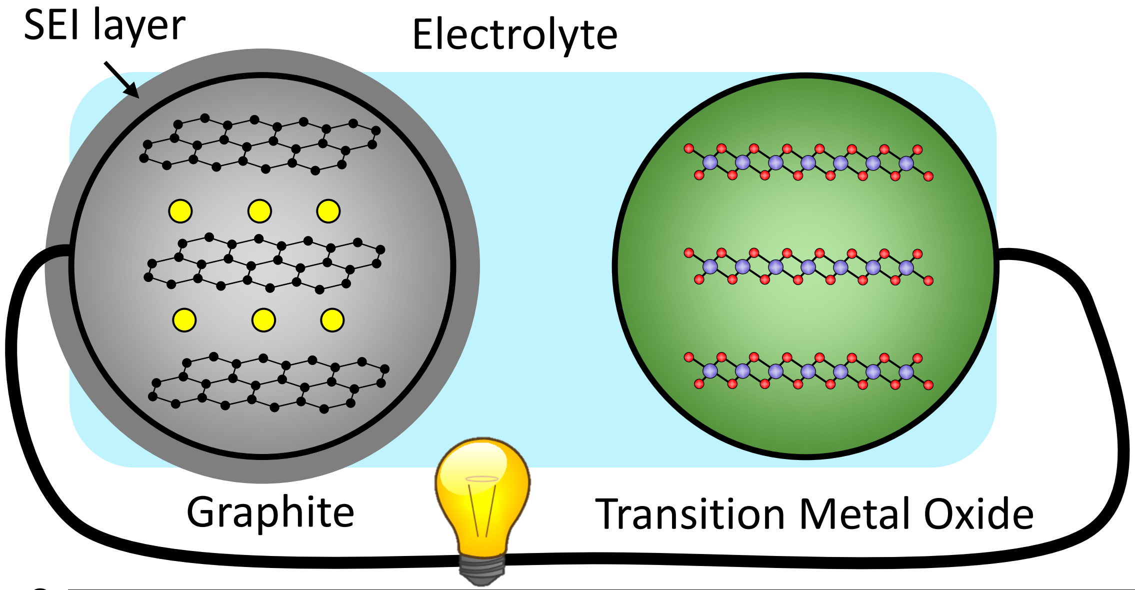
Battery digital twins can be a key enabler for battery passports

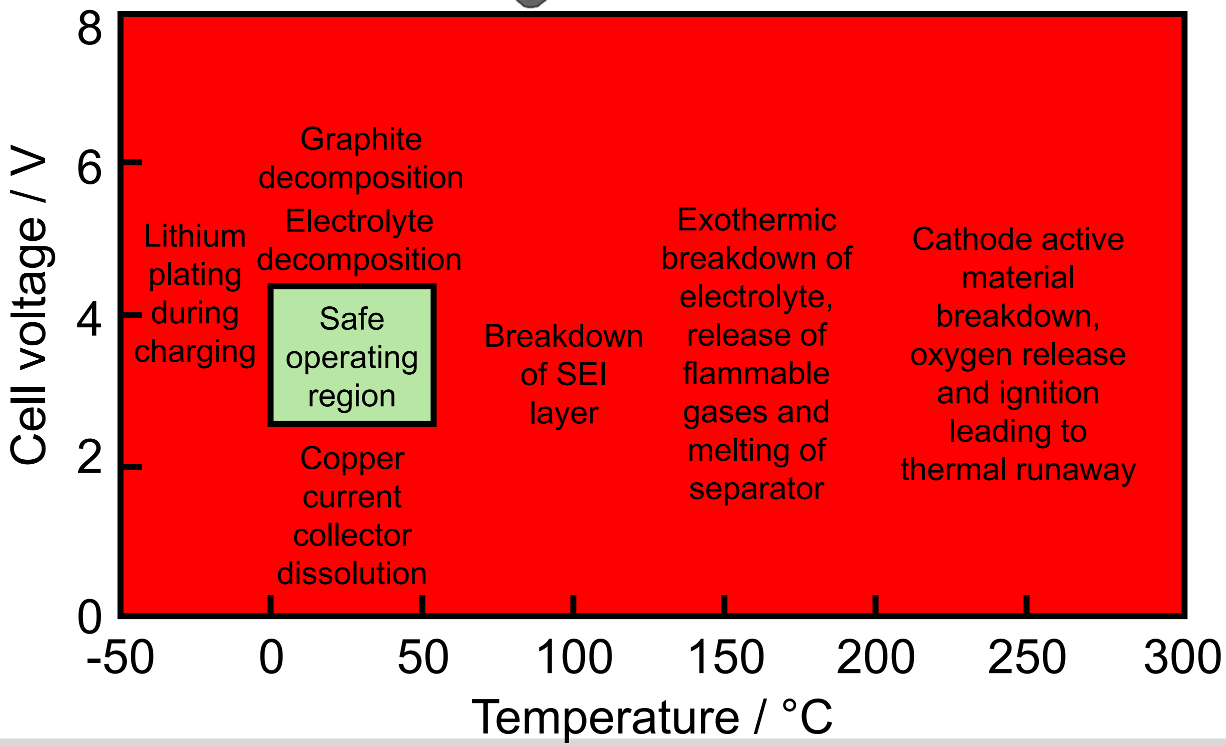


Enabling robust battery digital twins at the industrial scale. Dubarry et al. Joule. 2023

Conclusions

- Electrification of transport is inevitable
- Different flavours of batteries
  - NMC/NCA = High performance, LFP = Low cost
- Many complex and coupled degradation modes
  - SEI layer growth @ High temperatures
  - Lithium plating @ Low temperature fast charging
  - Particle cracking @ High currents
- Thermal runaway of batteries can be caused by mechanical, electrical and thermal abuse
  - Likelihood of failure increases with battery age
- Some batteries safer than others
- Lifetime can be extended with careful use
- Battery digital twins can be an enabler





Thank you for listening

billy.wu@imperial.ac.uk | Twitter - @ICBillyWu

Dyson School of Design Engineering

Panel: Battery Degradation

Marc Palmer
Autotrader

Scott Raffan
Geotab

Dr Matt Stock
Innovate UK

Gavin White
About: Energy

BVRLA Battery Health: Supercharge your knowledge

Scott Raffan - Solutions Engineering, Geotab

16th May 2023

GEOTAB

Global Footprint

- 2177 employees worldwide
- >45% of employees are STEM
- 42K+ customers in 165 countries
- More than 700 partner ecosystem
- $410M USD revenue (2021)
- 3.3M+ subs globally
- 60% of subs with fleets size 500+

Our mission: driving to innovation

Global Market Leader

Center of the connected fleet industries providing best in class data for any vehicle and ecosystem to enable customers.

Driving Innovation

Open platform enables innovation and fuels creativity enabling growth with. Empowering change. Never satisfied.

Data Centric

Focused on data integrity used to solve different challenges for customers. Make better, real time decisions to deliver business impact.

Sustainability

Helping organizations and communities drive to sustainable practices. Living it in our corporate environment. Committed to climate pledge. Leader in electrification with 236 models supported.

Enabling Communities

Positively impacting where we live from safety, sustainability and productivity;
it's beyond just vehicles.
Everyone is a stakeholder.

Why Geotab for EV?

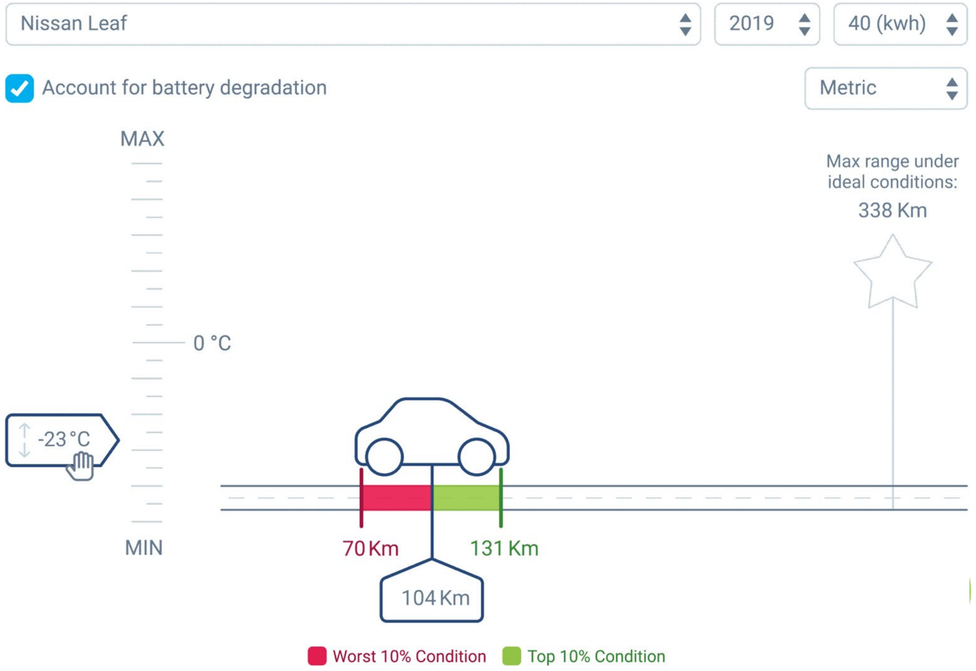
World's largest EV performance dataset in the world

Trusted EV authority with unique benchmarking tools for EV performance

When adding EVs to your fleet, Geotab helps you understand key performance metrics for battery degradation and range implications. Our tools are built based on real-world EV trip data from over 6,000 EVs and represent 1.8 million days of data.

Gain an understanding of:

- Do EV batteries wear out like other standard technology?
- Does how I use and charge my vehicle affect its battery life?
- How does temperature affect my vehicle's range?



[View our EV battery degradation tool](#)

[View our EV temperature range tool](#)

We wanted to know:

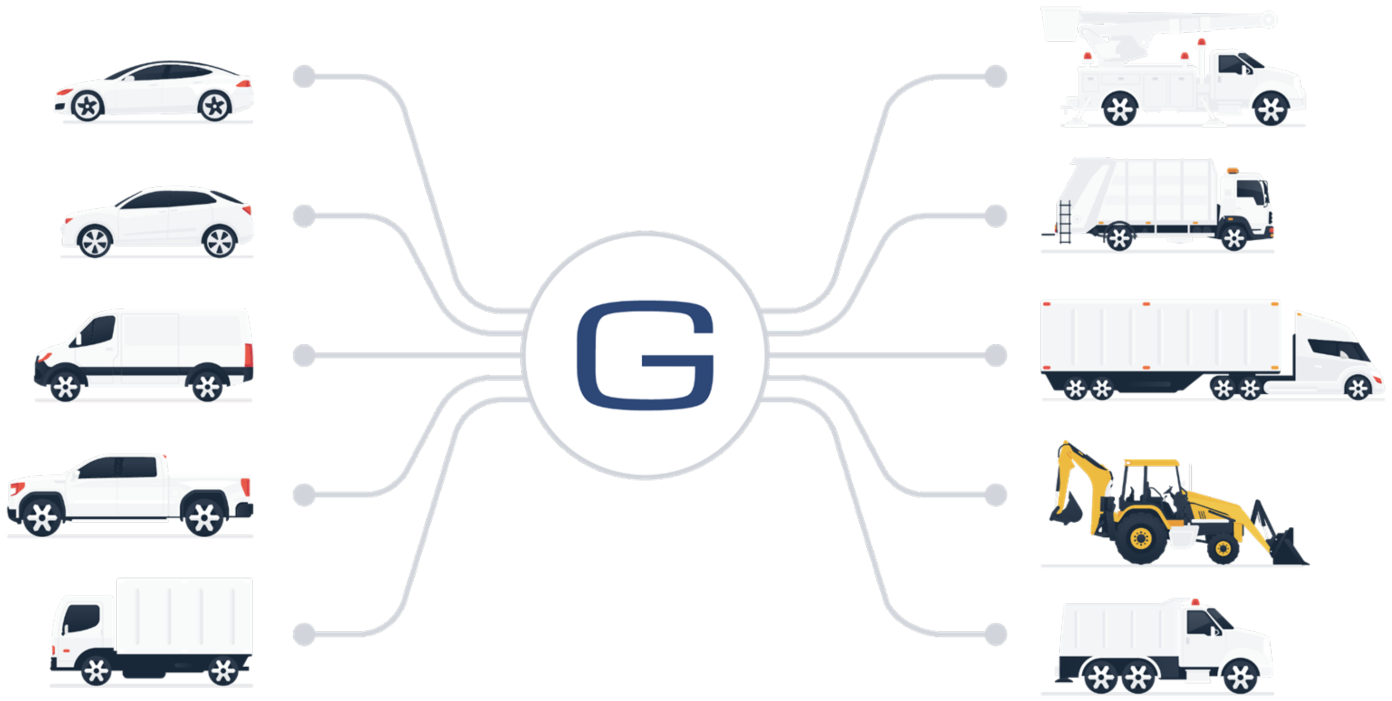
How have EV batteries fared in the real world?

- Should EV drivers be concerned?
- Is it different across different MMYs?
- What external factors impact degradation rates? Is there any correlation with:
  - Usage
  - Hot/Cold climates
  - Charging type - L1, L2, DCFC
- What can an EV operator do to limit degradation?

The Results

Over 3 million trips analysed, with over 6000 EVs. Full analysis to be published soon

- Average degradation was observed to now be ***lower*** than initial studies
    - Sub 2% per year
- High use and charge cycles are not the main factor of degradation
- Charge management is key
    - Avoid DCFC in hot scenarios
    - Minimise time that batteries at sat with 100% SOC
- Adopt a “right size” approach to selecting your EV
    - Give a buffer on required range and actual range



Let’s stay connected

@geota
b

GEOTAB

Sharing insights about battery degradation and how battery development/innovation will change this

16th May 2023

UK Research
and Innovation

Battery degradation

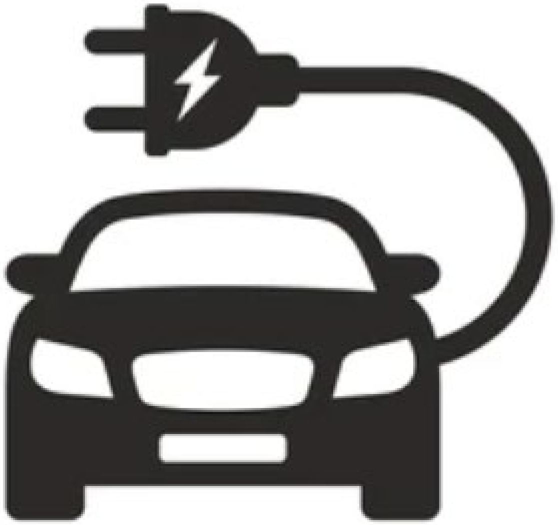
Problem:

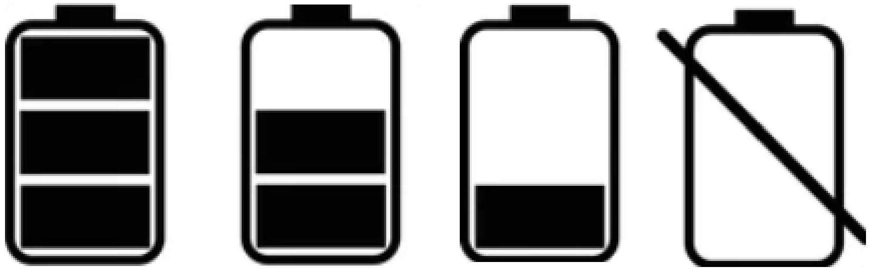
Loss of active lithium, and increased internal resistance

Factors:

1. Temperature
2. Depth of discharge
3. Charging rates
4. Battery cell design
5. Age

How can innovation in battery technology help?





Innovations in battery technology

Cell

Module

Pack

Vehicle

Innovations in battery technology

Cell

Module

Pack

Vehicle

- Materials
- Electrolytes
- Mechanical optimisation
- Manufacturing methods

Innovations in battery technology

Cell

- Materials
- Electrolytes
- Mechanical optimisation
- Manufacturing methods

Module

- Module design
- Thermal management
- Cell connections
- Monitoring and control

Pack

Vehicle

Innovations in battery technology

Cell

- Materials
- Electrolytes
- Mechanical optimisation
- Manufacturing methods

Module

- Module design
- Thermal management
- Cell connections
- Monitoring and control

Pack

- Pack integration
- Thermal management
- Structural design
- Monitoring and control

Vehicle

Innovations in battery technology

Cell	Module	Pack	Vehicle
			
• Materials • Electrolytes • Mechanical optimisation • Manufacturing methods	• Module design • Thermal management • Cell connections • Monitoring and control	• Pack integration • Thermal management • Structural design • Monitoring and control	• Vehicle-to-grid • Charging methods • Energy management

What is the Faraday Battery Challenge?

- £541 million programme
- Running from 2017 to 2025
- Part of the UKRI Challenge Fund
- Delivered by Innovate UK

UK Research and Innovation

Faraday Battery Challenge

The Faraday Institution	Innovate UK	UK Battery Industrialisation Centre
Discover	**Develop**	**Deploy**

Continuous research into battery requirements and technology trends

Equality, diversity & inclusion and skills programmes

Building ecosystem in partnership with Innovate UK KTN

What is the Faraday Battery Challenge?

THE FARADAY INSTITUTION

Discover

www.ukri.org/publications/faraday-battery-challenge-funded-projects/

What is the Faraday Battery Challenge?

Innovate UK

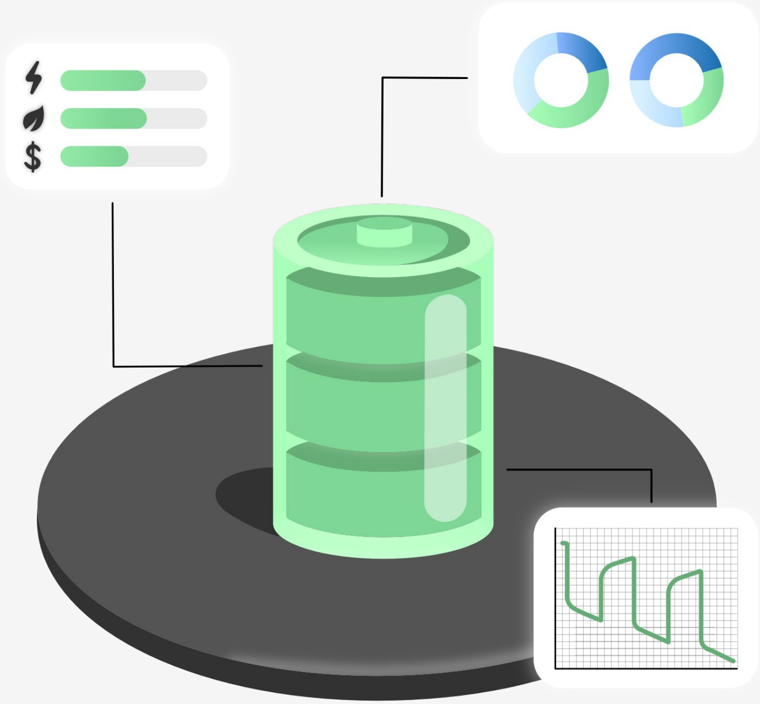
Develop

www.ukri.org/publications/faraday-battery-challenge-funded-projects/

Thank you

matt.stock@iuk.ukri.org
faradaybatterychallenge@iuk.ukri.org

UK Research
and Innovation



ABOUT:ENERGY

Accelerating Electrification

Imperial College London | The Faraday Institution | Royal Academy of Engineering | ktn | Advanced Propulsion Centre UK | Plug and Play | Creative Destruction Lab | UKRI Innovate UK Edge | University of Birmingham

How to help your batteries

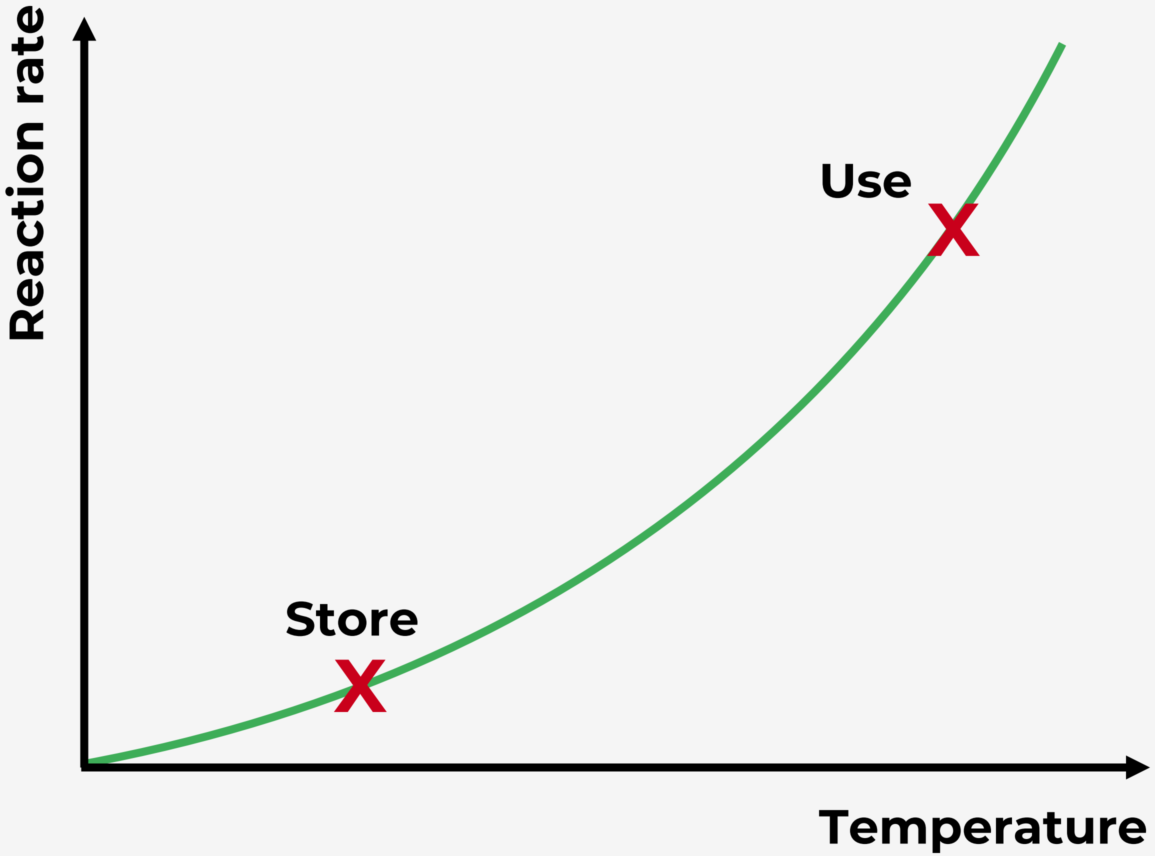
Store cold, use hot

Charge slow

Store half-full

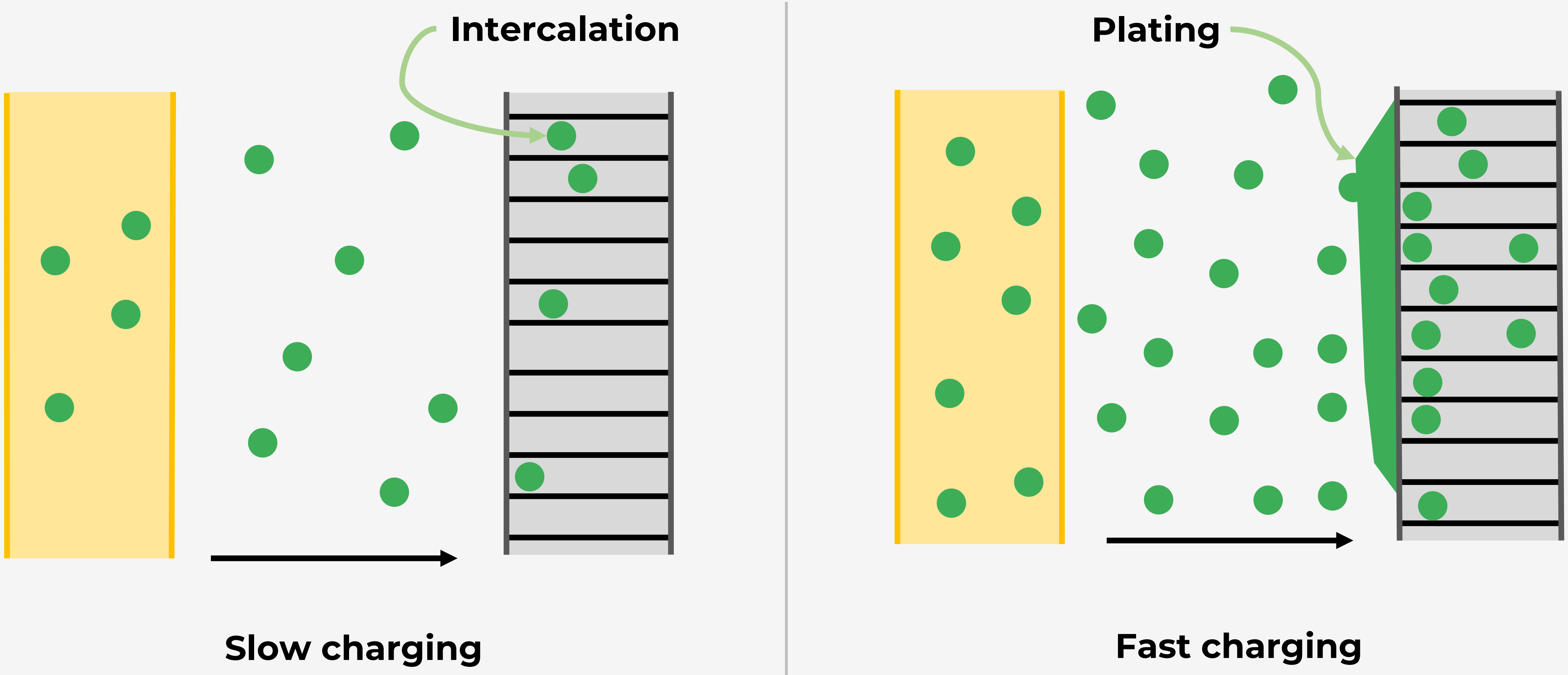
ABOUT:ENERGY

Store cold, use hot



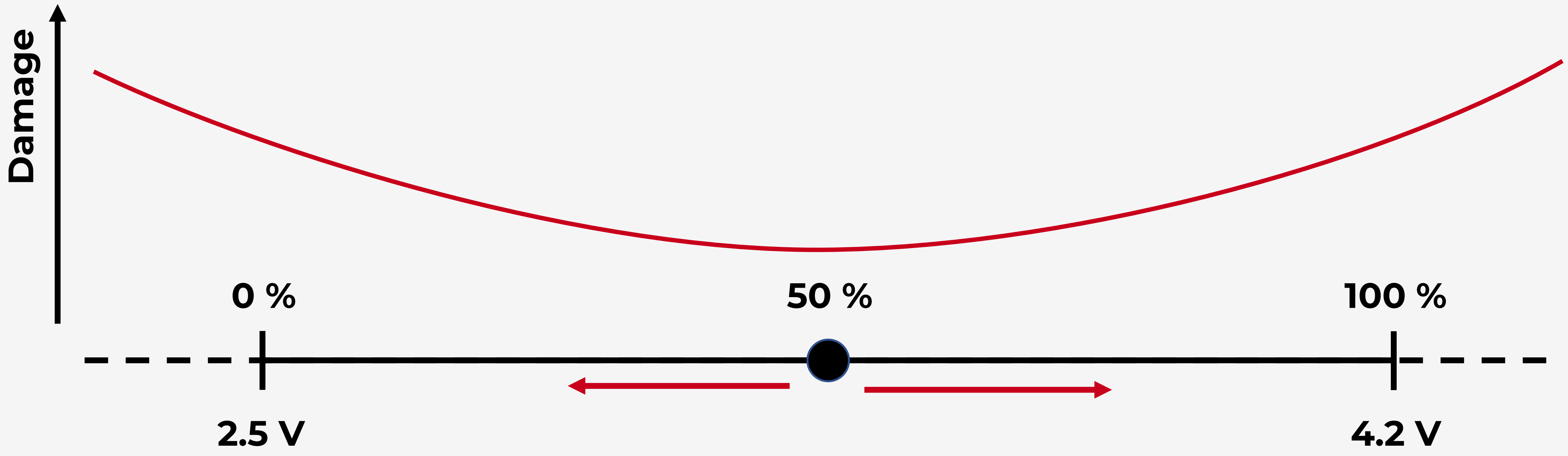
ABOUT:ENERGY

Charge slow

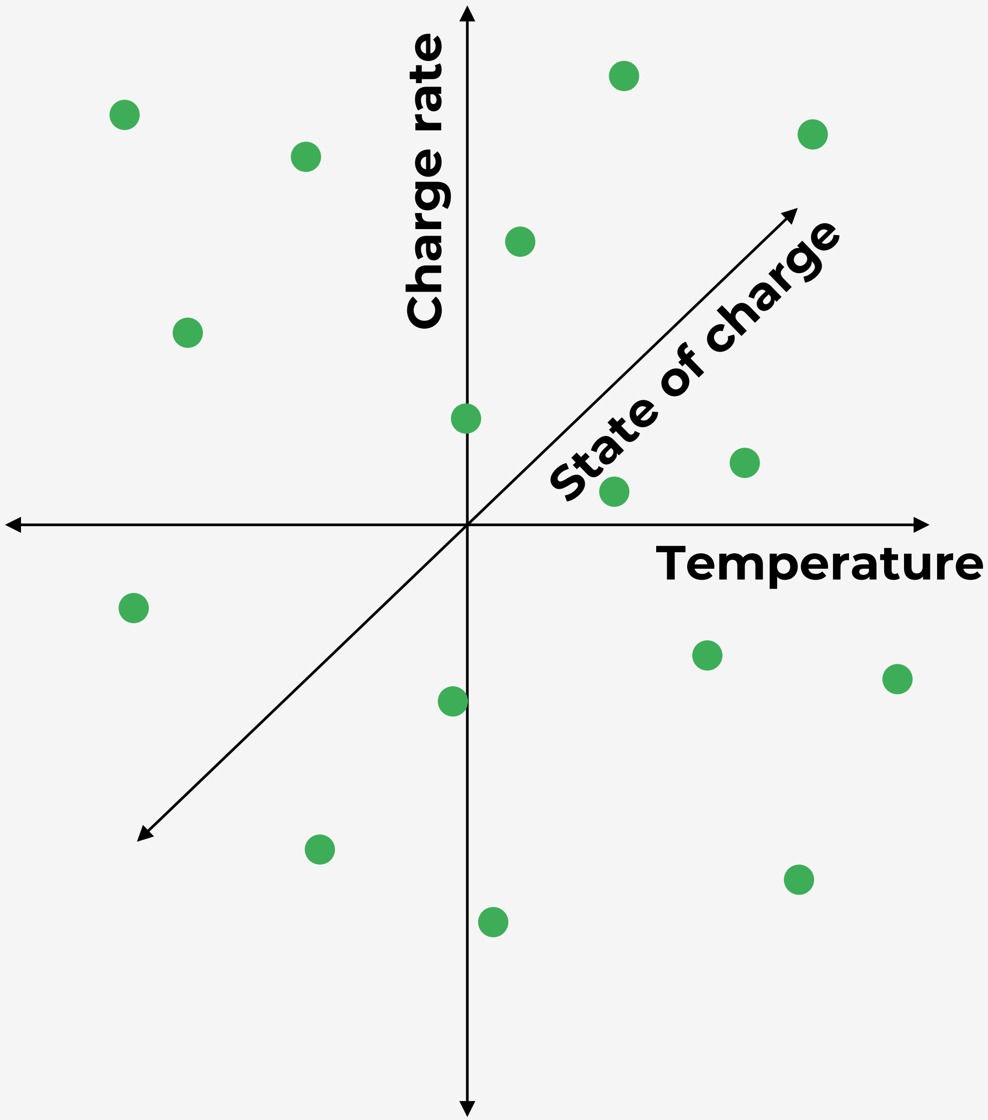


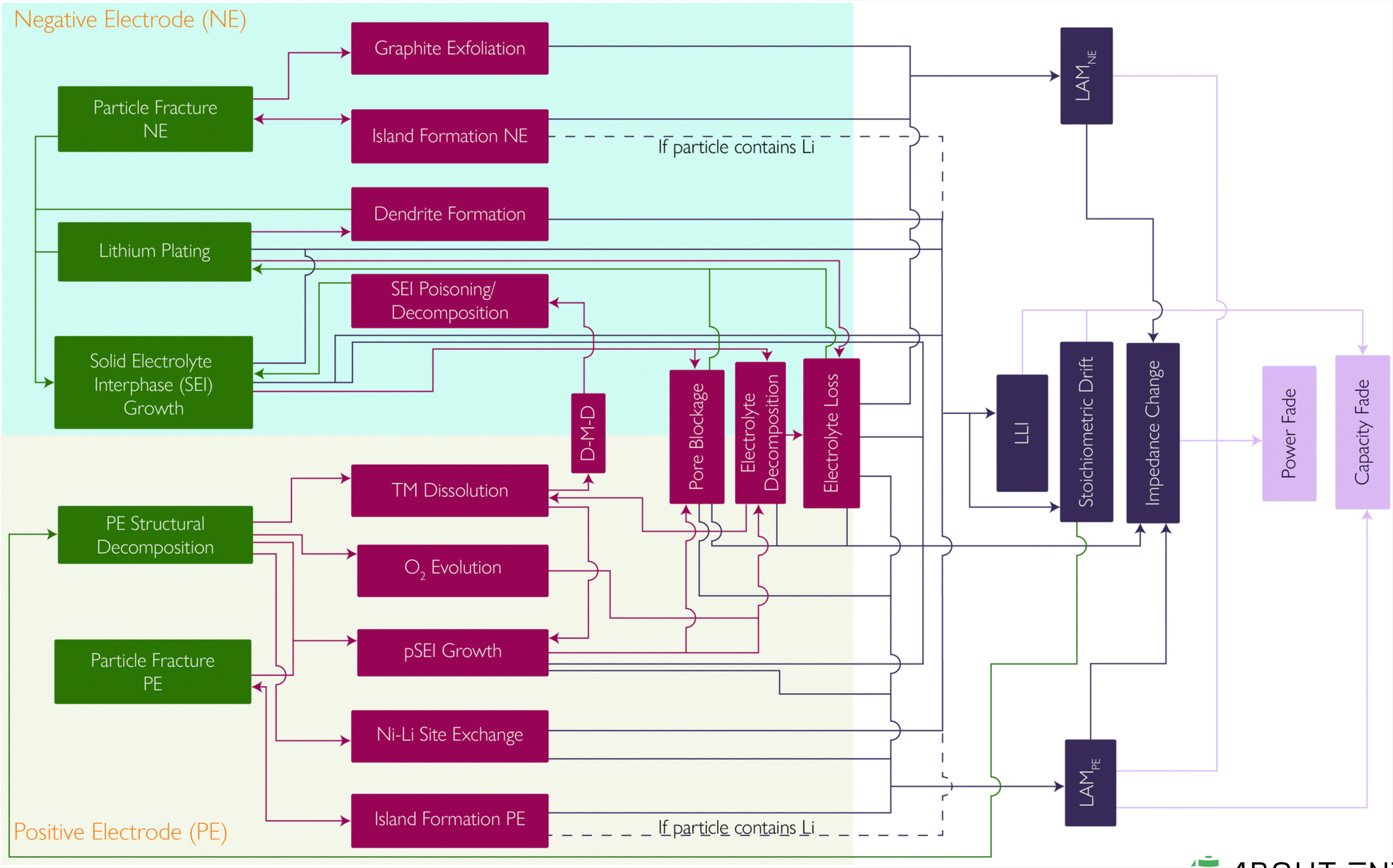
ABOUT:ENERGY

Store half-full



Degradation gets complex





Source: J. Edge *et al.* (2021) "Lithium ion battery degradation: what you need to know"

How we help

Thermal control

Cell cycling protocols

Teardown

Modelling

VOLTT

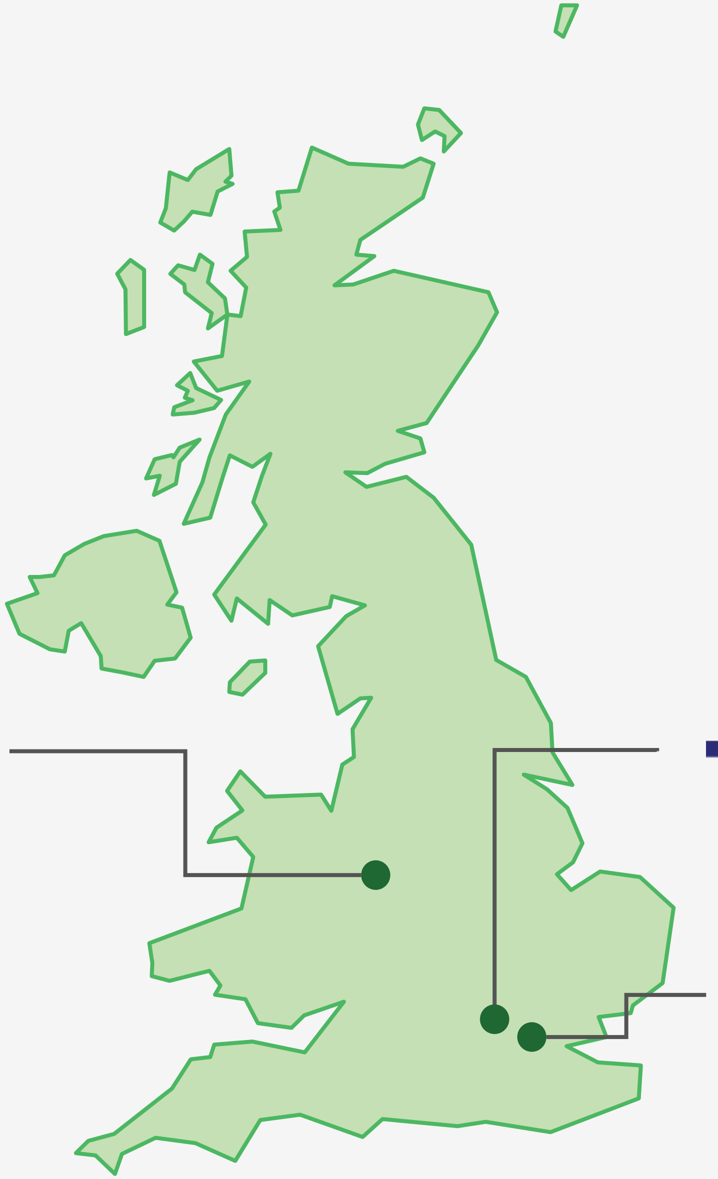
Industry-leading models

- Electrical
- Thermal
- Electrochemical
- Degradation

Large database

500+ Commercially available cells

Who are we?



UNIVERSITY OF BIRMINGHAM

THE FARADAY INSTITUTION

Imperial College London


Decrease CO_2
Platform for innovation
Reduce raw materials
Optimise battery packs
Our mission
Increase uptake
Increase lifetime
Reduce costs
Reduce waste
ABOUT:ENERGY

Takeaways

Store cold, use hot

Charge slow

Store half-full

ABOUT:ENERGY

Panel: Battery Degradation

Marc Palmer
Autotrader

Scott Raffan
Geotab

Dr Matt Stock
Innovate UK

Gavin White
About: Energy

BVRLA

Department for Transport

DfT battery health regulations update

Adam Dack

Senior Engineer, Vehicle Environmental Standards

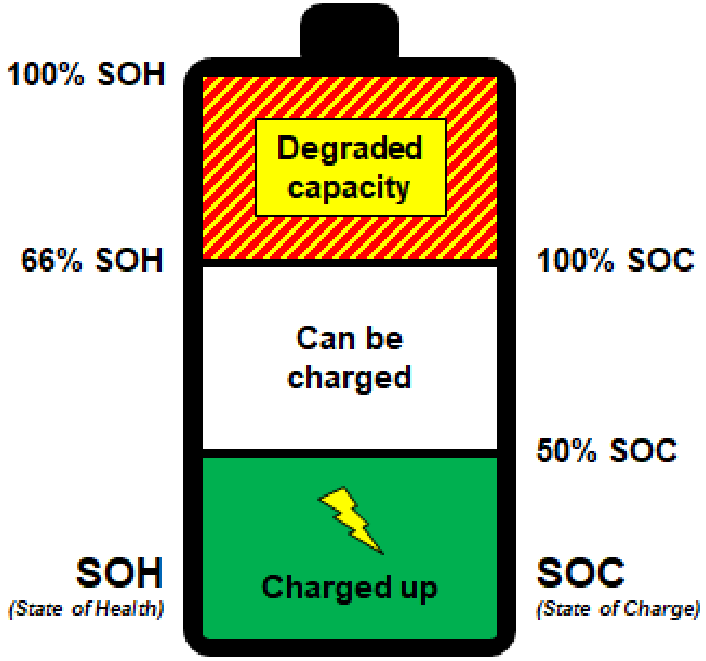
16 May 2023

Overview

- **Global Technical Regulation No. 22**
  - — Introduction to UNECE
  - — Background
  - — Approach
  - — Global views on implementation
  - — Future work

- **Research update: existing EVs**
  - — Scope and objectives
  - — Initial insights

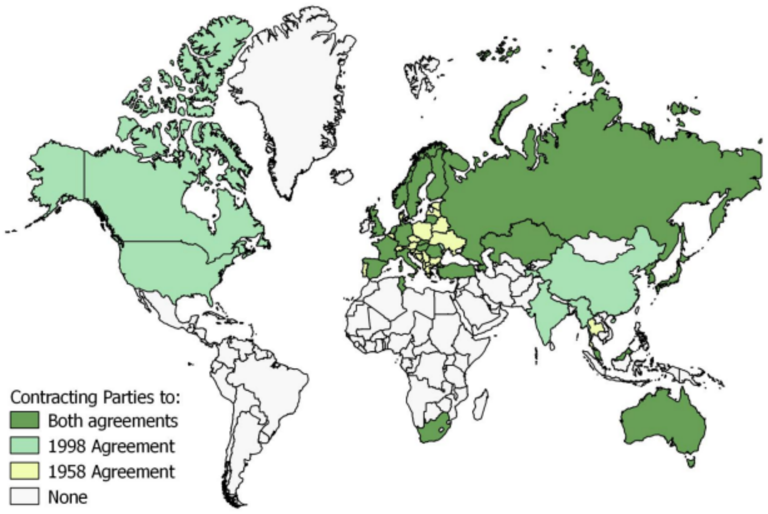
- **Summary**



Global Technical Regulation No. 22

GTR22: Introduction to UNECE

- The United Nations Economic Commission for Europe (UNECE) established to promote **economic cooperation** and **integration**
- ~80% of UK vehicle regulations are developed via the UNECE's **World Forum for Harmonisation of Vehicle Regulations**
- **Global Technical Regulations** (GTRs) provide a regulatory framework, typically containing harmonised **test procedures** and **requirements**
- UN Regulations are similar to GTRs, but also include administrative procedures for **type approval** and **mutual recognition**



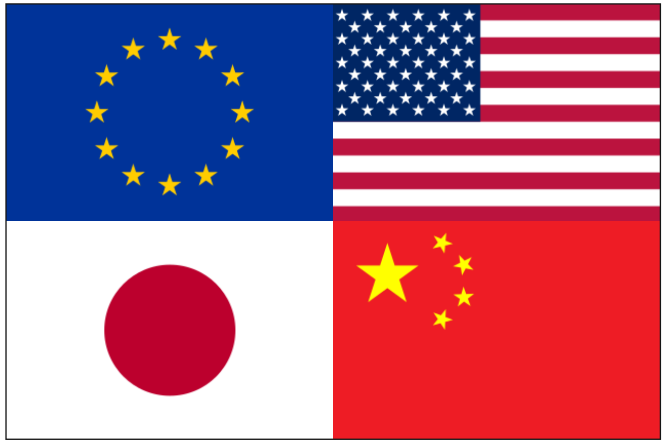
Images: UNECE

GTR22: Background

- UN GTR No. 22 on *In-vehicle Battery Durability for Electrified Vehicles* published in 2022 (openly available online), with key input from DfT

- **Aim:** Develop a battery durability standard for new BEVs/PHEVs to ensure that inferior products do not enter the market

- Secondary benefits could include:
  — Improved consumer confidence in **performance over time**
  — Improved confidence once vehicles reach **second-hand market**



GTR22: Approach

Part A

- Mandates installation of state of health (SOH) monitors and **accessible display** to consumer

- Requires the SOH monitors to meet an **accuracy** requirement

- Validate accuracy of SOH monitors over time/mileage through **in-service testing** against regulatory test cycle (WLTP)

Part B

- Adopt a minimum performance requirement (MPR) for battery durability:
  - Min. 80% capacity remaining **after 5 years** or 100,000 km (62,000 mi)
  - Min. **70% capacity** remaining **after 8 years** or 160,000 km (100,000 mi)

- Validate MPR is met by assessing SOH values on vehicles in service (e.g., via MOT or over-the-air telematics)

- Use a statistical process to determine pass/failure for a vehicle model

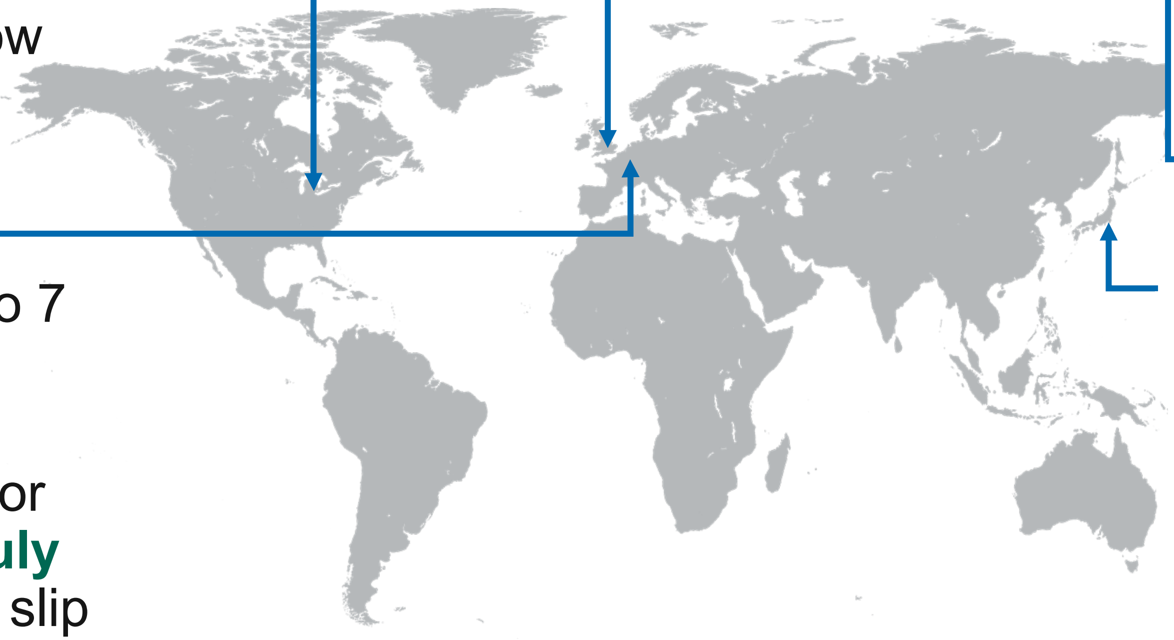
GTR22: Global views on implementation

USA/Canada

- EPA included GTR in their next emissions package, starting in **2027**
- Canada likely to follow USA timeline

European Union

- GTR included in Euro 7 package
- Euro 7 proposed to become mandatory for new vehicles from **July 2025**, but date could slip



UK (GB)

- Considering options for implementation
- Currently conducting analysis on benefits of UK implementation

Japan

- SOH monitors to be required from **October 2024**
- Implementation dates of other aspects of GTR to be confirmed

GTR22: Future work

- Conducting analysis on the benefits of implementing GTR22 in the UK, while continuing other work through the UNECE

- Currently only **passenger cars** and **light commercial vehicles** (LCVs) are in scope of the GTR

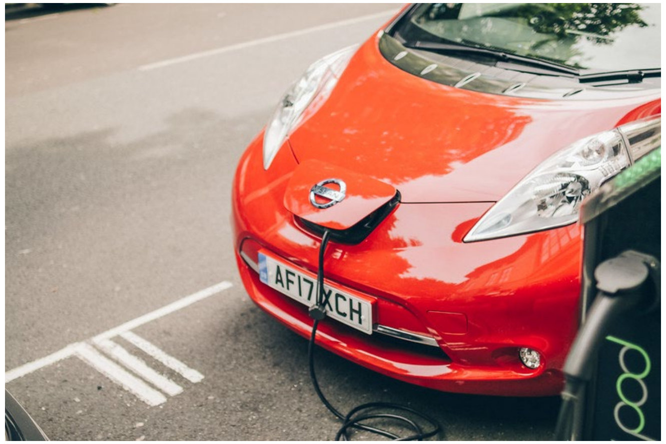
- MPRs are still to be agreed for LCVs, with manufacturers citing their **varied duty cycles and use cases**

- Work ongoing to develop a separate GTR for **electric heavy-duty vehicles**, expected to be published in late 2024

Research update: existing EVs

Research update: Scope and objectives

- What can be done for **existing EVs**?
- DfT researching **accessibility** and **comparability** of on-board battery health information for a wide range of used EVs
- **30 used EVs**, including BEVs and PHEVs, cars and vans, model years 2017 through 2021
- Probe vehicles for any **on-board information**, e.g., via dashboard, OBD tools, CAN bus
- Perform **GTR22 battery health test** and compare against on-board information



Research update: Initial insights

- Early results suggest **very limited accessibility**, often requiring specialist equipment and/or tools

- Comparability also looks to be a challenge; different battery management systems will estimate battery health in different ways

- Challenges with accessibility and comparability demonstrate a need for **standardisation** (e.g., as provided by GTR22)

- **Analysis is ongoing**, further results to follow later this year

Summary

- If GTR22 is introduced in the UK, battery health information will be **accessible** and **comparable** across vehicle models and manufacturers

- However, effect on second-hand market not likely to be seen for several years

- DfT is researching provision of battery health information in **existing EVs**, but accessibility and comparability are key challenges

- Battery health certificates may offer some utility, but **exercise caution** when comparing results from different vehicle models and manufacturers

slido

Audience Q&A Session

ⓘ Start presenting to display the audience questions on this slide.

Latest on The Road to 2030

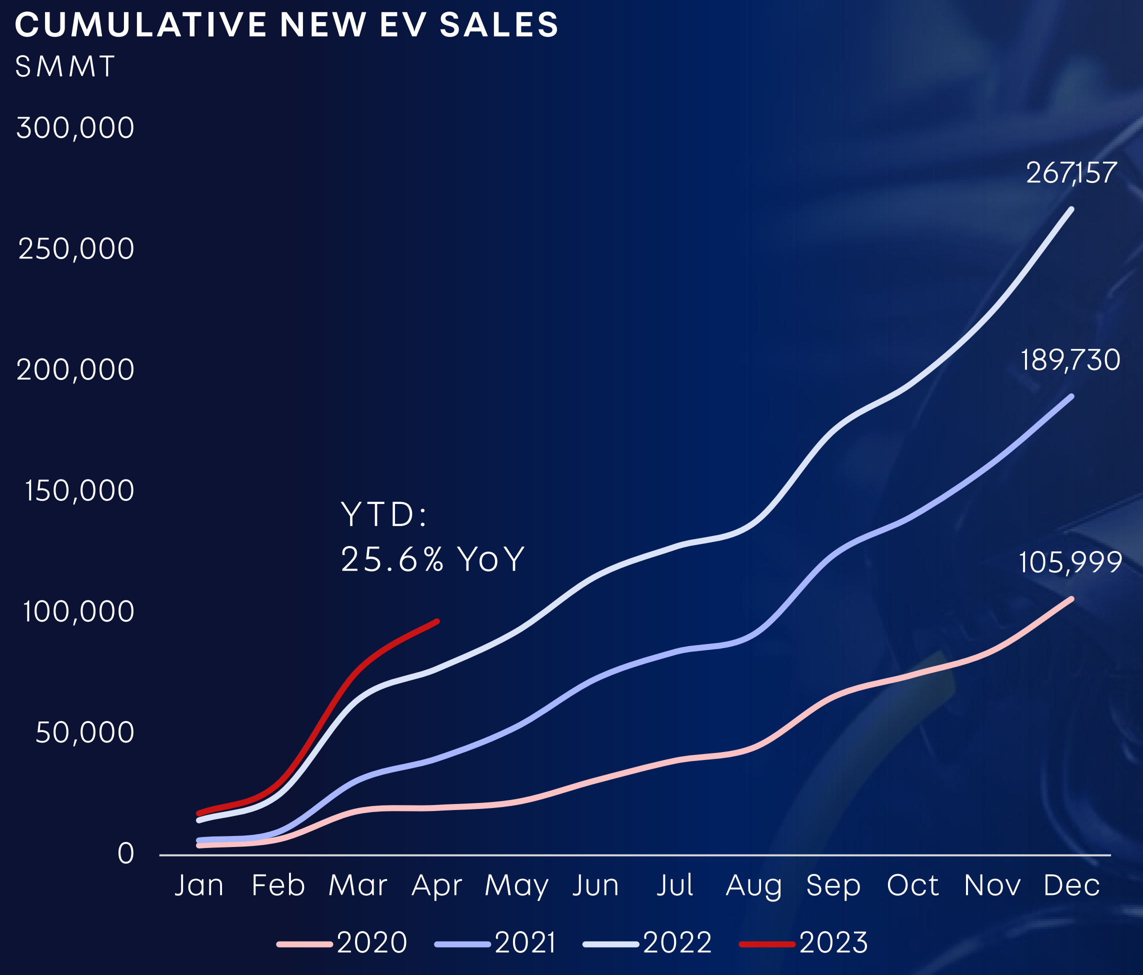
MARC PALMER, AUTO TRADER

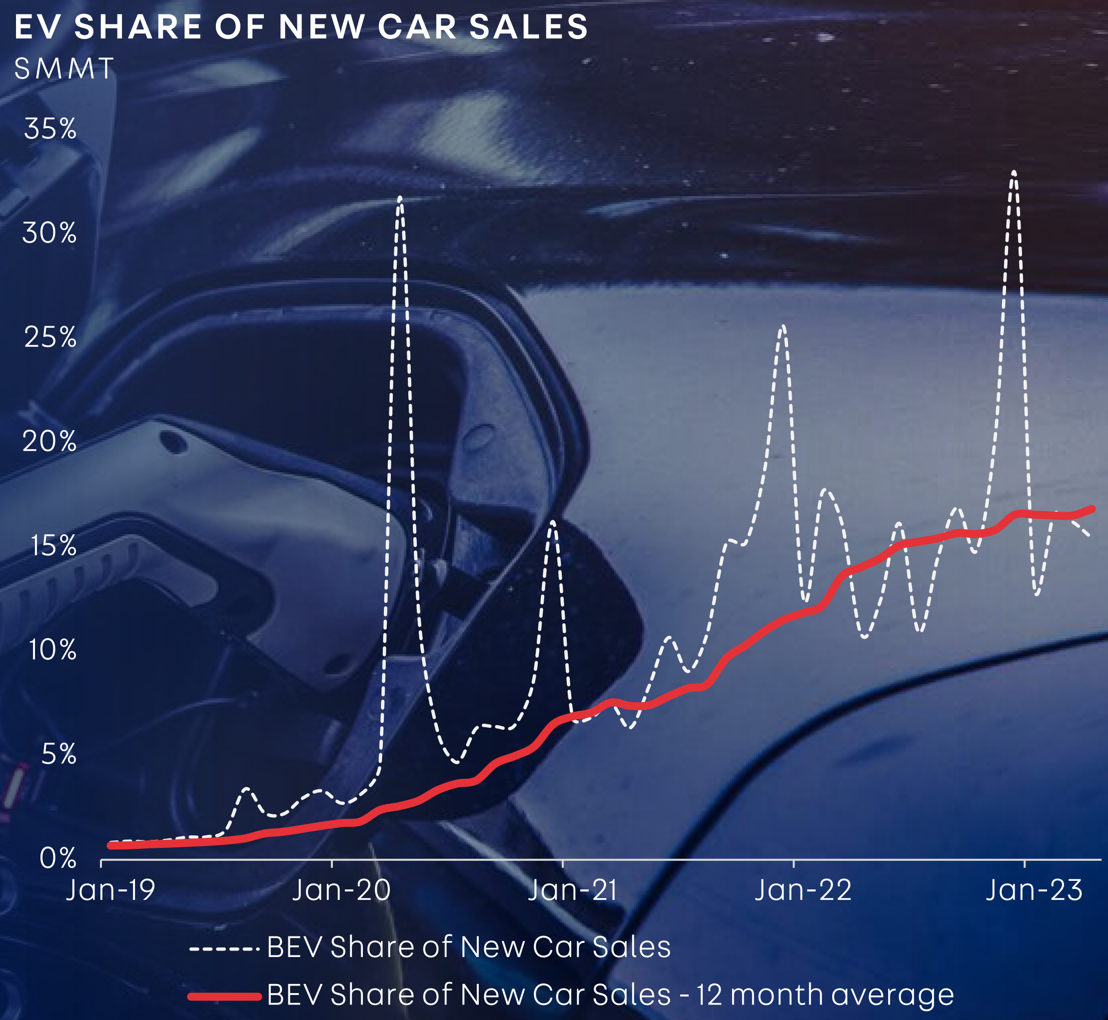
BVRLA, MAY 2023

AutoTrader

01 The new EV market

Fleet continues to drive new EV sales with retail more limited - electric's market share has flattened recently





AutoTrader

Consideration for new EVs on Auto Trader is improving but remains subdued.

Only 9% of new car leads are on EVs (down 11ppts year-on-year)

EV SHARE OF NEW CAR MARKET ON AUTO TRADER

AutoTrader

Source: Auto Trader internal data

There are now 76 new electric models available to buy in the UK. Choice is limited compared to ICE models, but the gap is closing

76

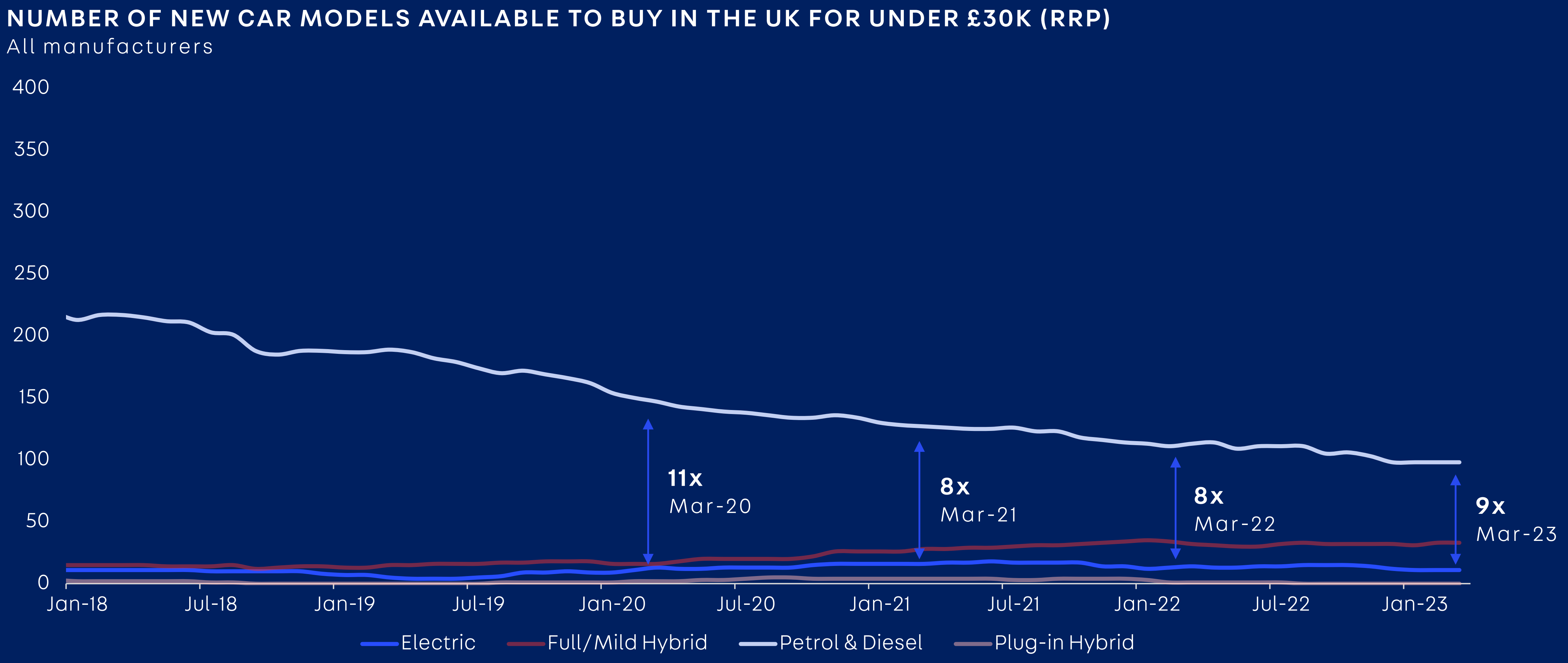
Different electric car models available

4x

More ICE models - was 11x 3 years ago

AutoTrader

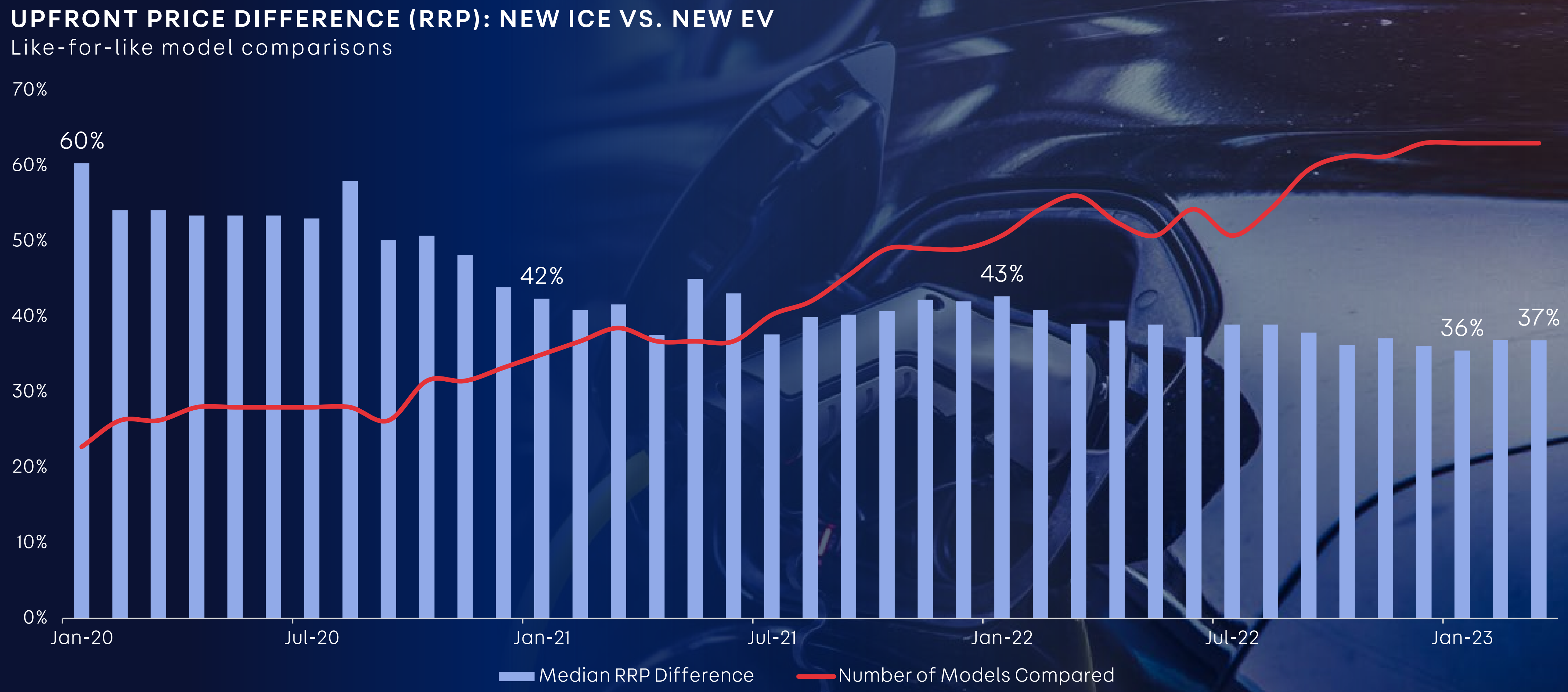
Not enough affordable new EVs with 9x more new ICE cars for under £30k vs electric - the gap isn't closing quickly



AutoTrader

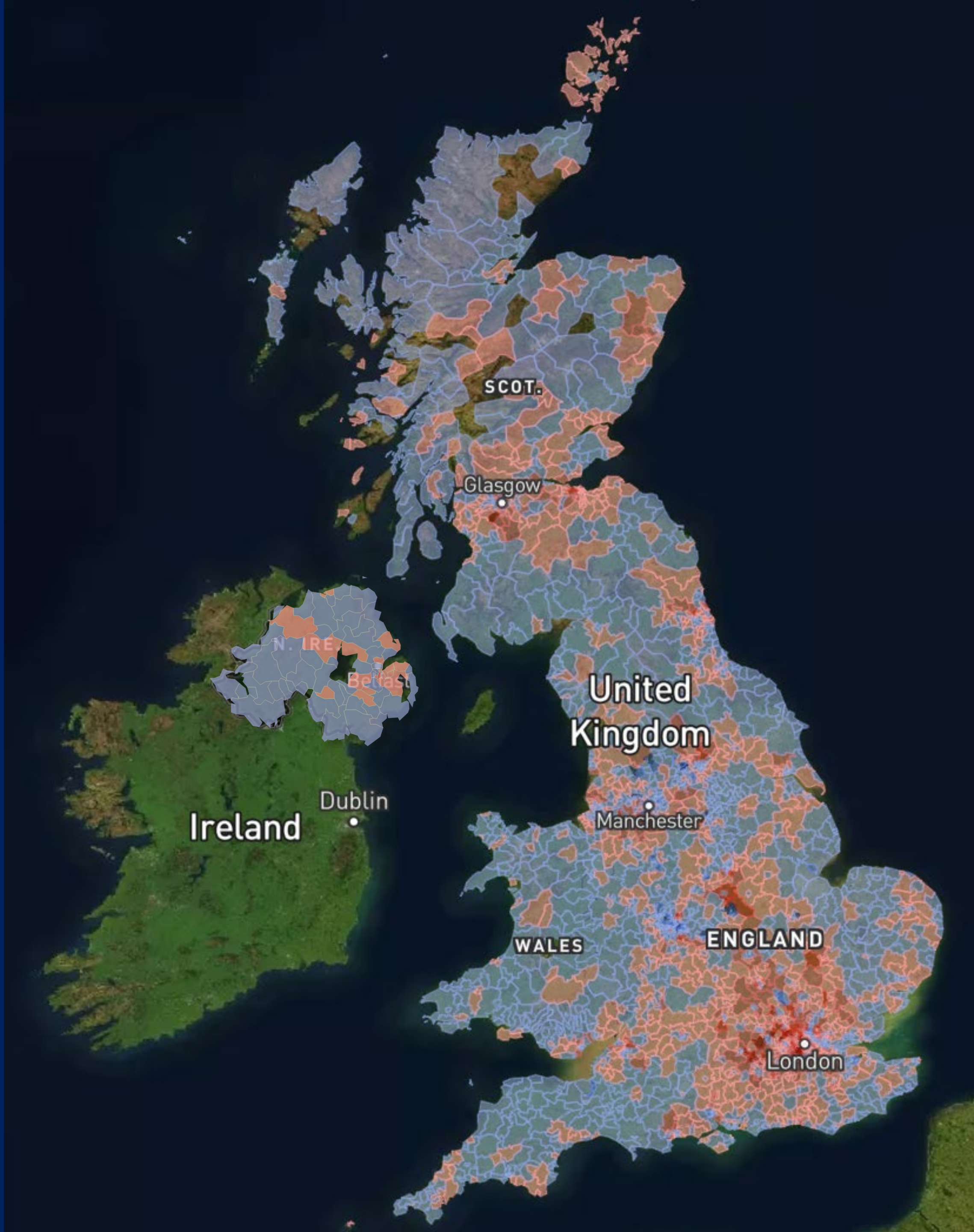
Source: Auto Trader internal data

Like-for-like, new EVs are still around 37% more expensive than ICE



AutoTrader

Demand for EVs is still spread across the UK's affluent areas.



AutoTrader

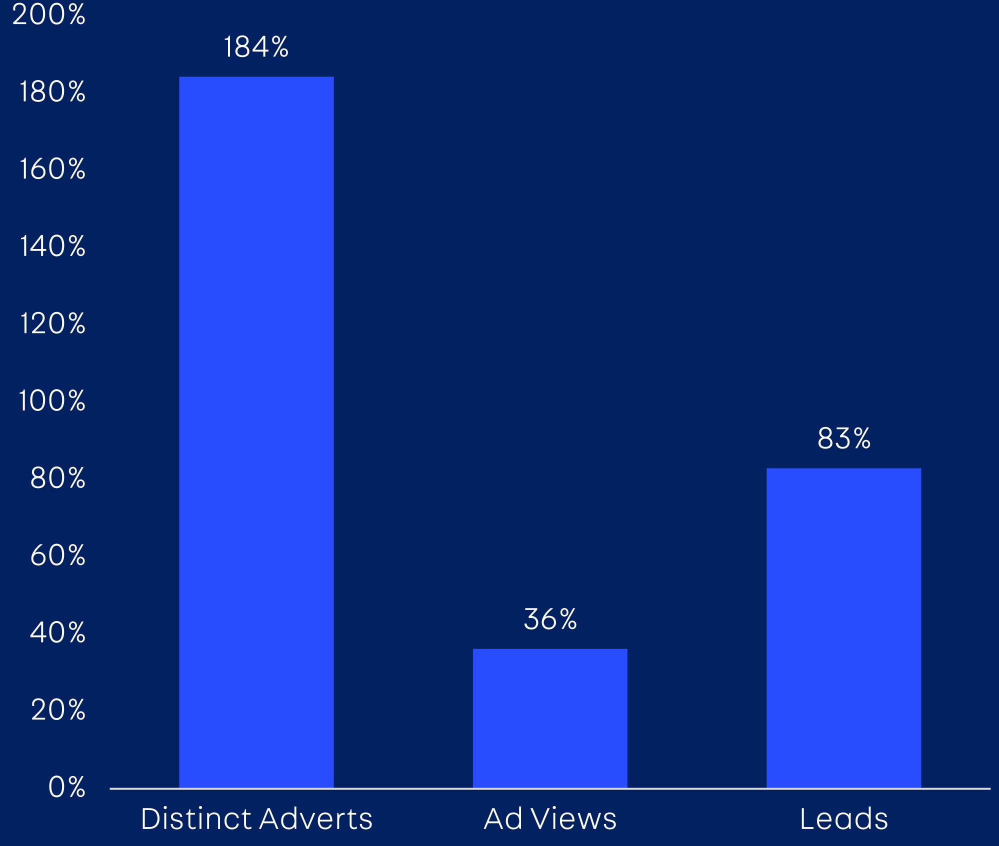
- Retail demand is subdued, with share of leads taken by EVs halved YoY
- Choice is increasing, but hasn't yet reached more affordable levels
- Retail demand is still located in affluent areas, with little sign of mainstream interest

02 The used EV market

AutoTrader

Demand for used EVs is ahead YoY, but outpaced by supply, with daily average volumes up by c.10k

USED EV ACTIVITY: YEAR-ON-YEAR
April-2023

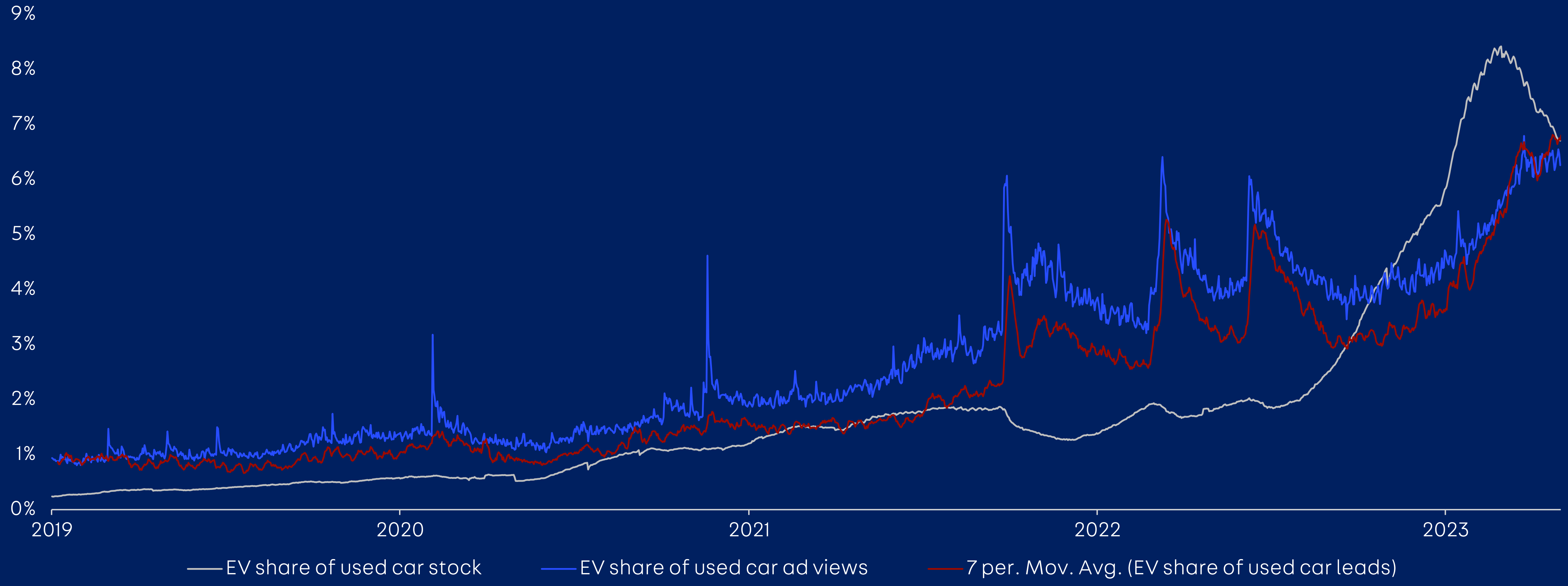


NUMBER OF UNIQUE USED EV ADVERTS
Advertised on Auto Trader.

Source: Auto Trader internal data

Supply and demand dynamics have improved in recent weeks - demand has risen as prices fall

EV SHARE OF USED CAR MARKET ON AUTO TRADER
0-5 years old.



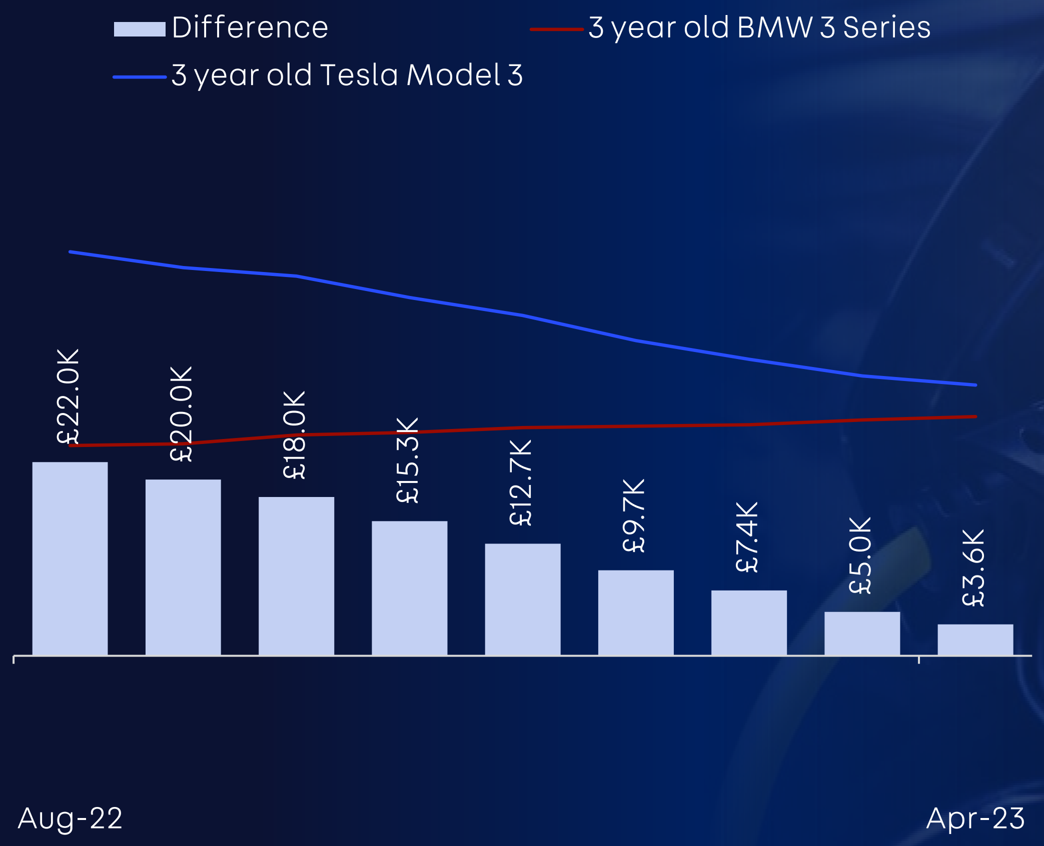
AutoTrader

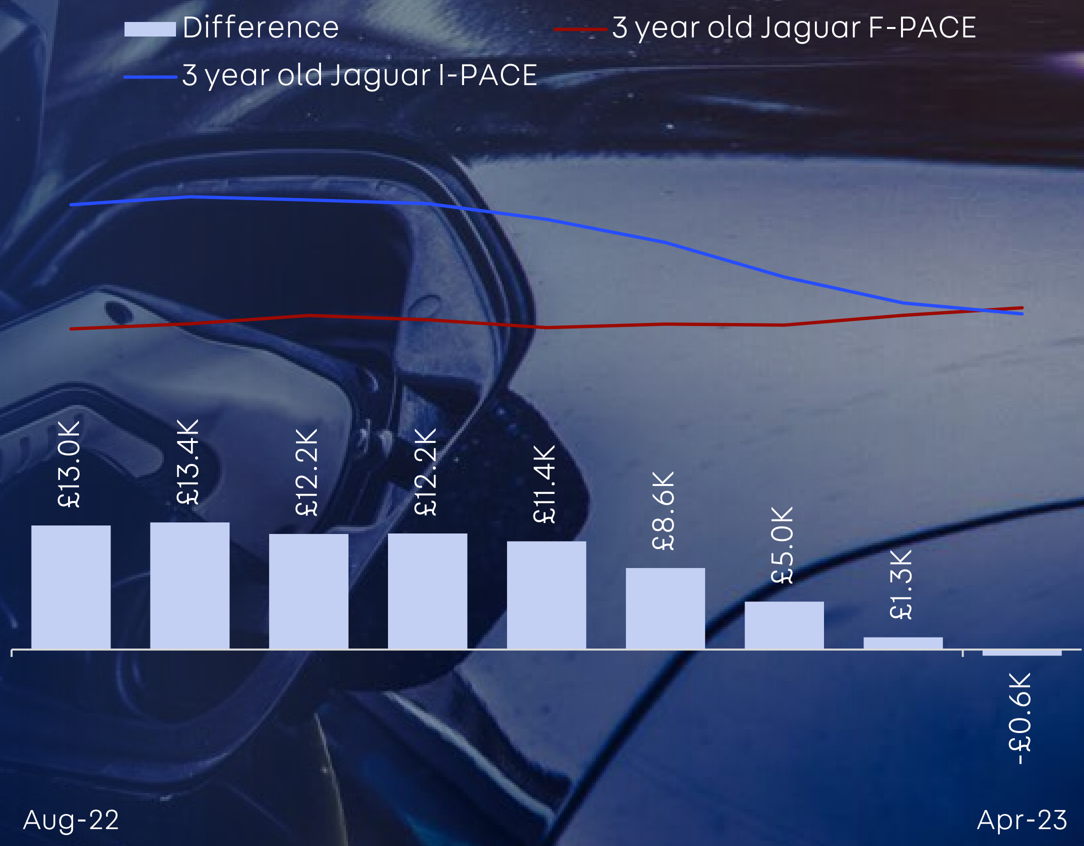
Source: Auto Trader internal data

The price gap has closed considerably - some electric models are now being cheaper than their ICE equivalents after three years

EV VS. ICE ADVERTISED PRICES AFTER THREE YEARS

Average prices

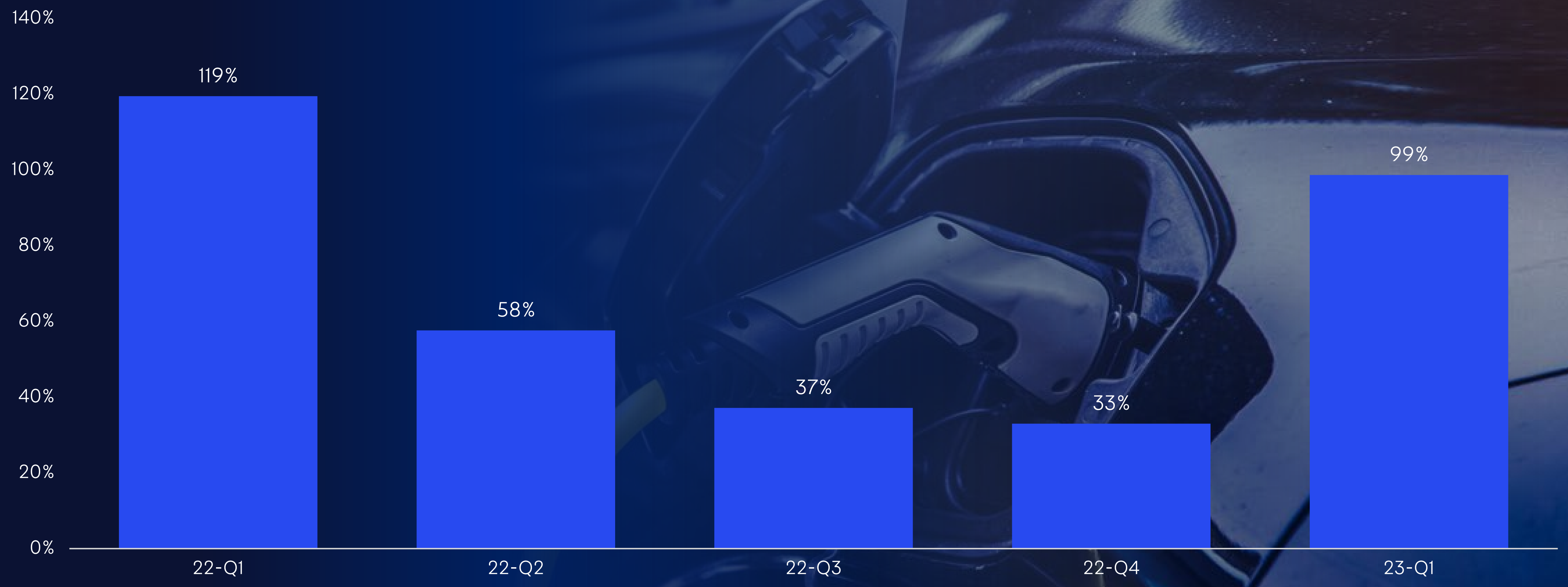




AutoTrader

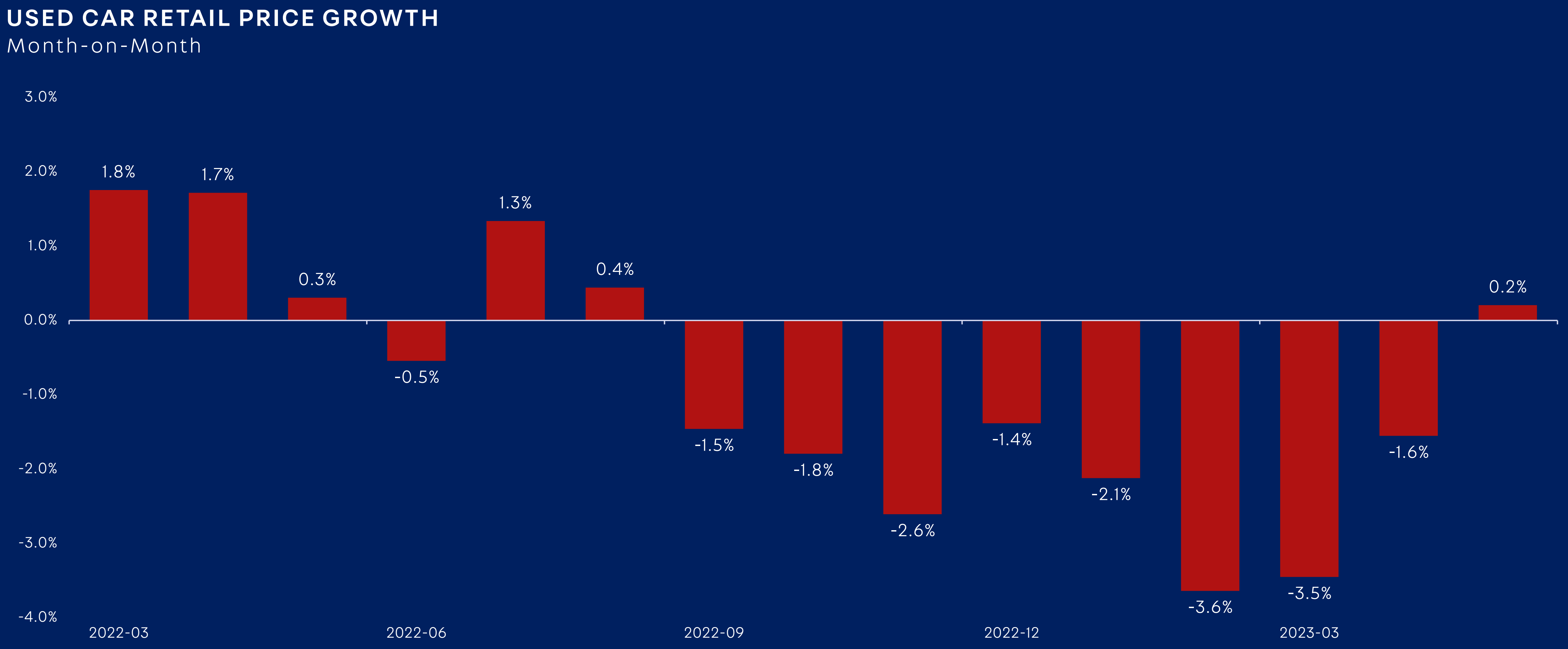
Leading to more sales in Q1 with volumes doubling YoY - 2.3% used sales are now electric

USED ELECTRIC CAR SALES: PROXY YOY
Based on the cars removed from Auto Trader



AutoTrader

Month-on-month used EV prices fell for eight consecutive months – but latest data shows a slight recovery



AutoTrader

Source: Auto Trader internal data

Future RVs on electric vehicles were very strong before supply ramped-up, but have dropped recently in response to the market

FUTURE RETAIL RESIDUAL VALUES BY FUEL TYPE: 3 YEARS, 30K MILES

1st day of each month snapshot

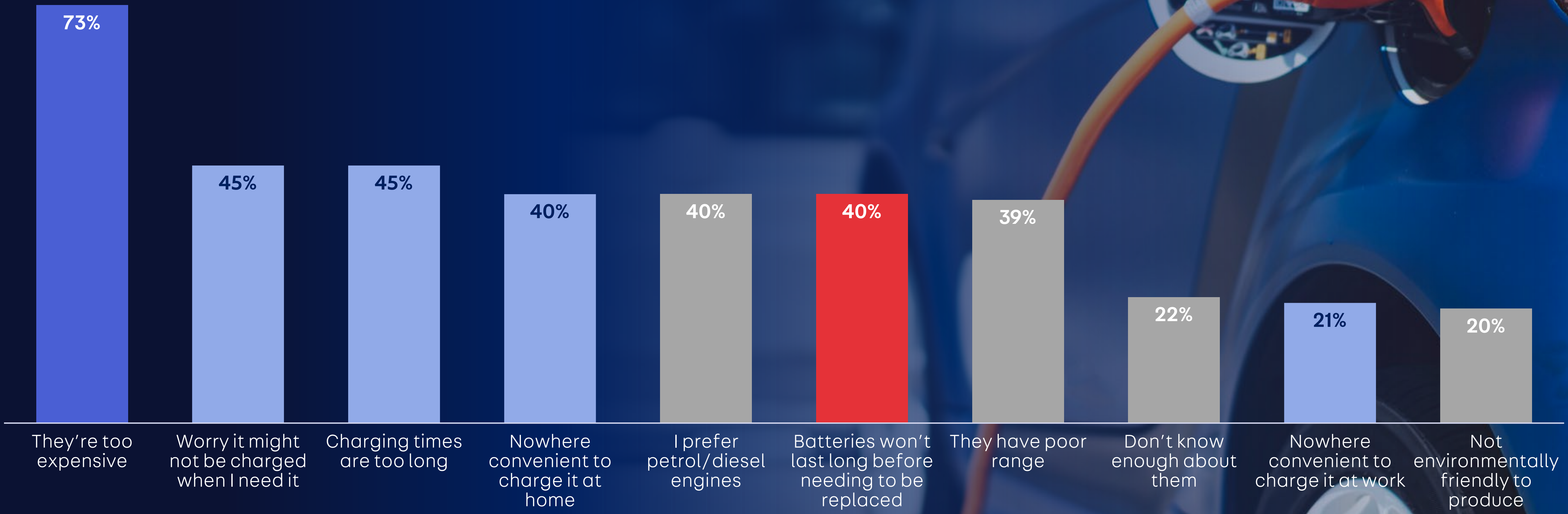
AutoTrader

- Used EV demand is up and leads have grown by 83% YoY – positive signs
- Supply is +184% - this is impacting speed of sale, with electric the slowest-selling fuel type
- Prices have fallen 18% YoY, leading to a significant drop in the upfront price gap to ICE
- Signs that this phase of maturation is impacting future values

03 Barriers to adoption

Reasons to reject are numerous - 3 in 4 say cost puts them off, 40-45% cite charging concerns and 40% worry about batteries

REASONS TO NOT CONSIDER AN ELECTRIC CAR
Multiple answers

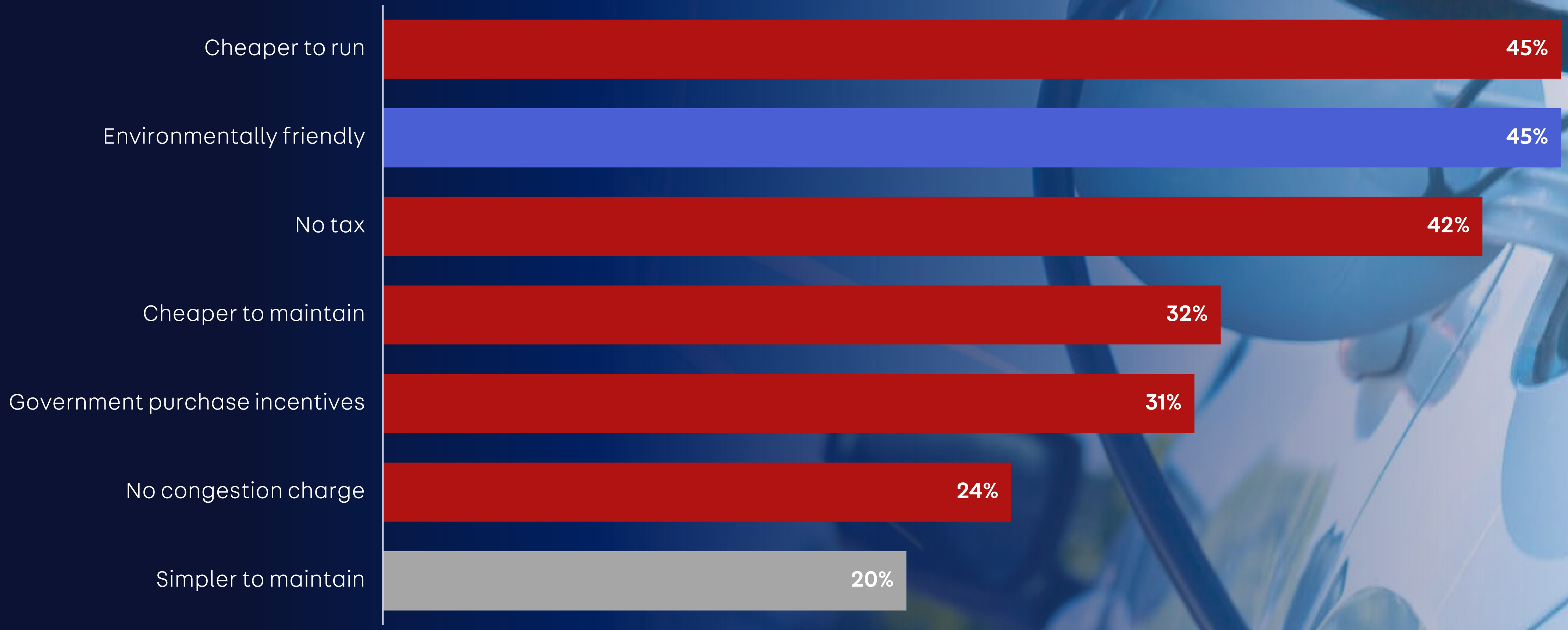


AutoTrader

Source: Auto Trader study May-23, n=1,080

The big thing to get rejectors to consider in future is cost

REASONS TO CONSIDER AN ELECTRIC CAR IN FUTURE
Multiple answers

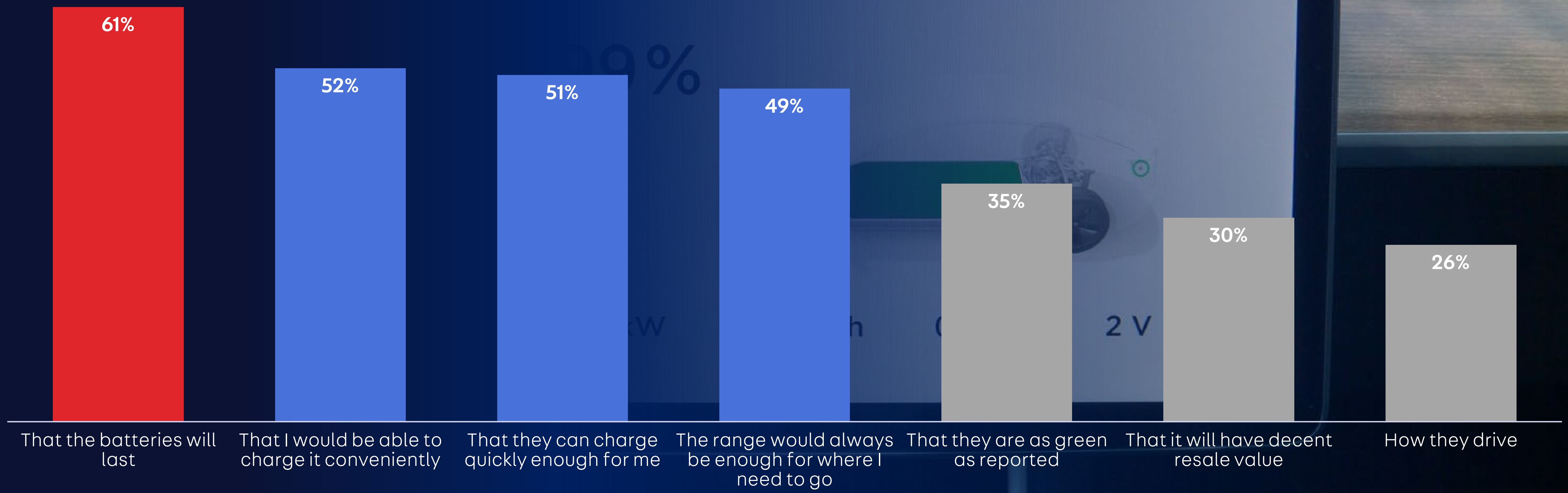


AutoTrader

Source: Auto Trader study May-23, n=1,080

And the information they need is battery reassurance and charging

WHAT INFO THEY NEED TO CONSIDER AN ELECTRIC CAR
Multiple answers



Source: Auto Trader study May-23, n=1,080

AutoTrader

- Cost of buying and running is a reason to reject for three quarters
- Cheaper running costs and incentives to buy are the main reasons to consider in future
- Battery health is the top information need, with charging info next

AutoTrader

Panel: Battery Health Certificates

Catherine Bowen
BVRLA

Thomas Mulon
MOBA

Tobias Huelsing
Bosch

Patrick Cresswell
ClearWatt

James Wallace
WAE

Alex Johns
Altelium

moba

What is the difference between these two vehicles ?

Renault Zoé Life R90

£13,500 - 12,000 miles - 2017

Published on May 10th 2023 at 13:33

Renault Zoé Life R90

£13,500 - 12,000 miles - 2017

Published on May 10th 2023 at 13:33

The battery State of Health!

Renault Zoé Life R90

£13,500 - 12,000 miles - 2017

Published on May 10th 2023 at 13:33

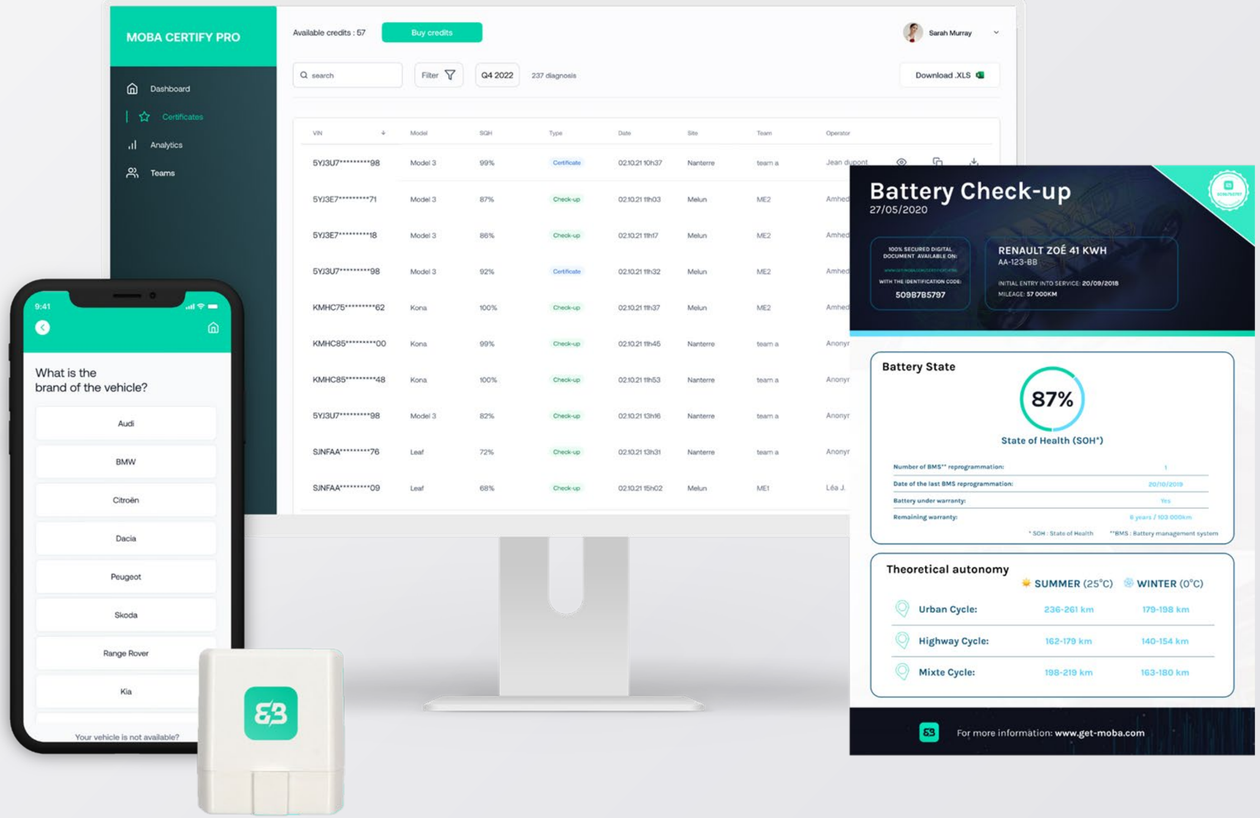
Renault Zoé Life R90

£13,500 - 12,000 miles - 2017

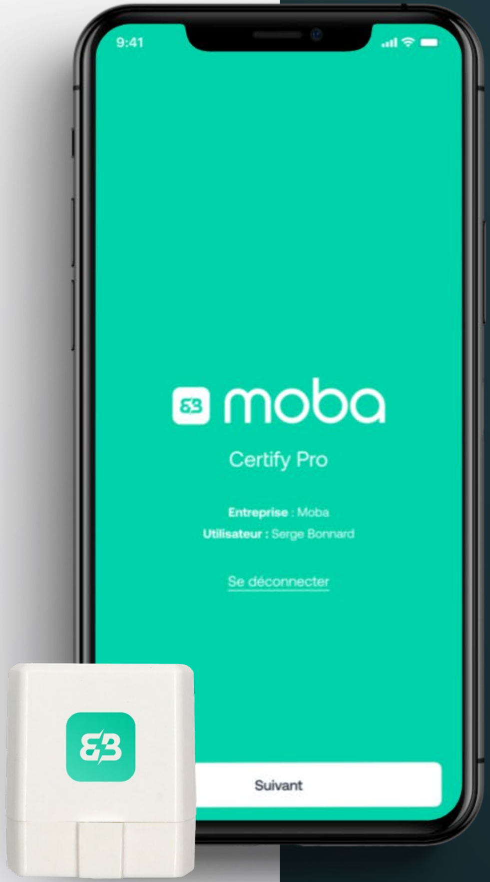
Published on May 10th 2023 at 13:33

Our solution : Moba Certify Pro

The first trusted third party that certifies the battery State of Health of EVs



The simplest tool on the market to certify EV's batteries



- Easy & Fast to use
- Intuitive
- Without training
- Multi-brands
- +90% of BEV market covered

Our clients references

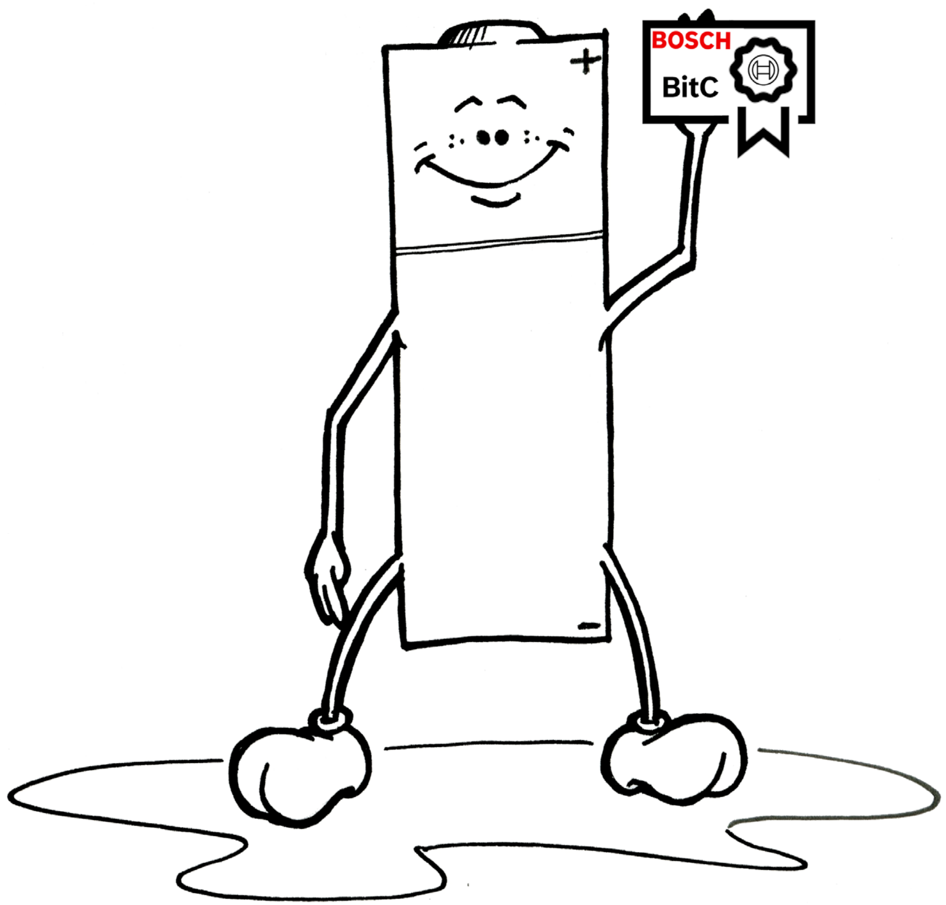
TOYOTA

Emil Frey

Aramisauto.com

and more than 100 other companies in Europe…

Bosch Battery in the Cloud



BOSCH

Battery in the Cloud
Usage Certificate

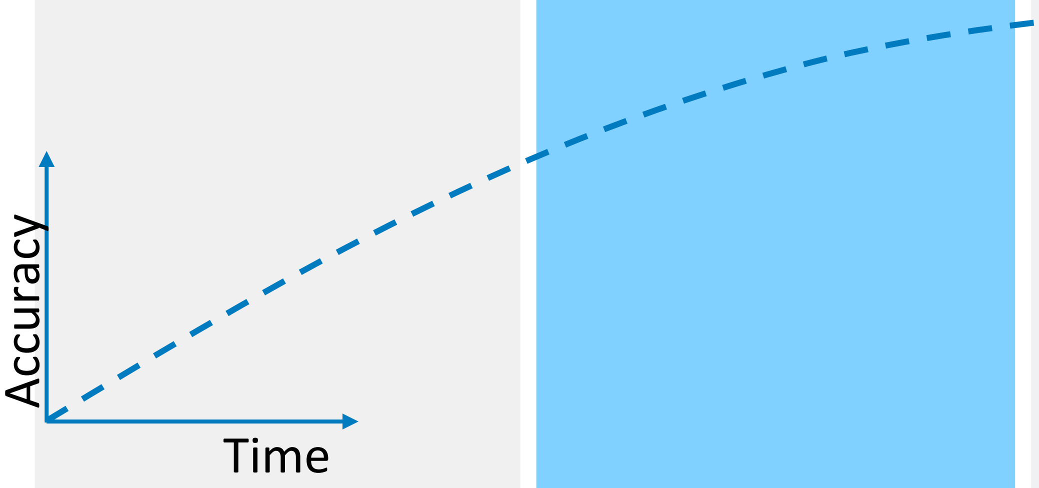
One Shot

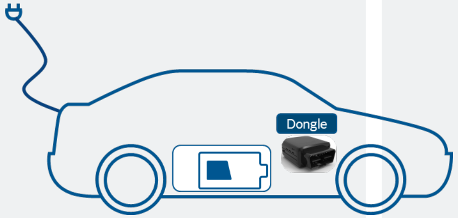
Quick certificate

Snapshot Analysis

Permanent Evaluation

Lifetime Monitoring





VDE verified

Battery in the cloud process to the Usage certificate

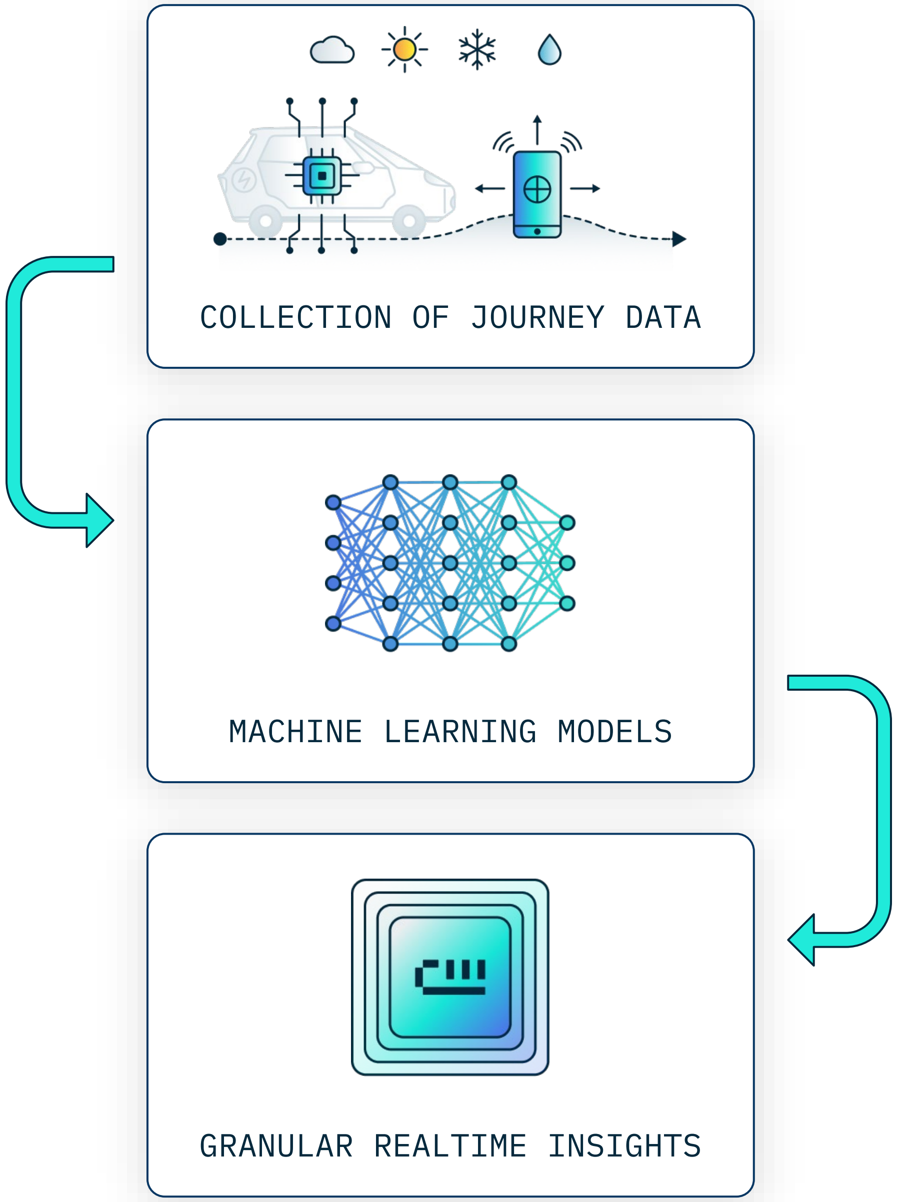
BOSCH

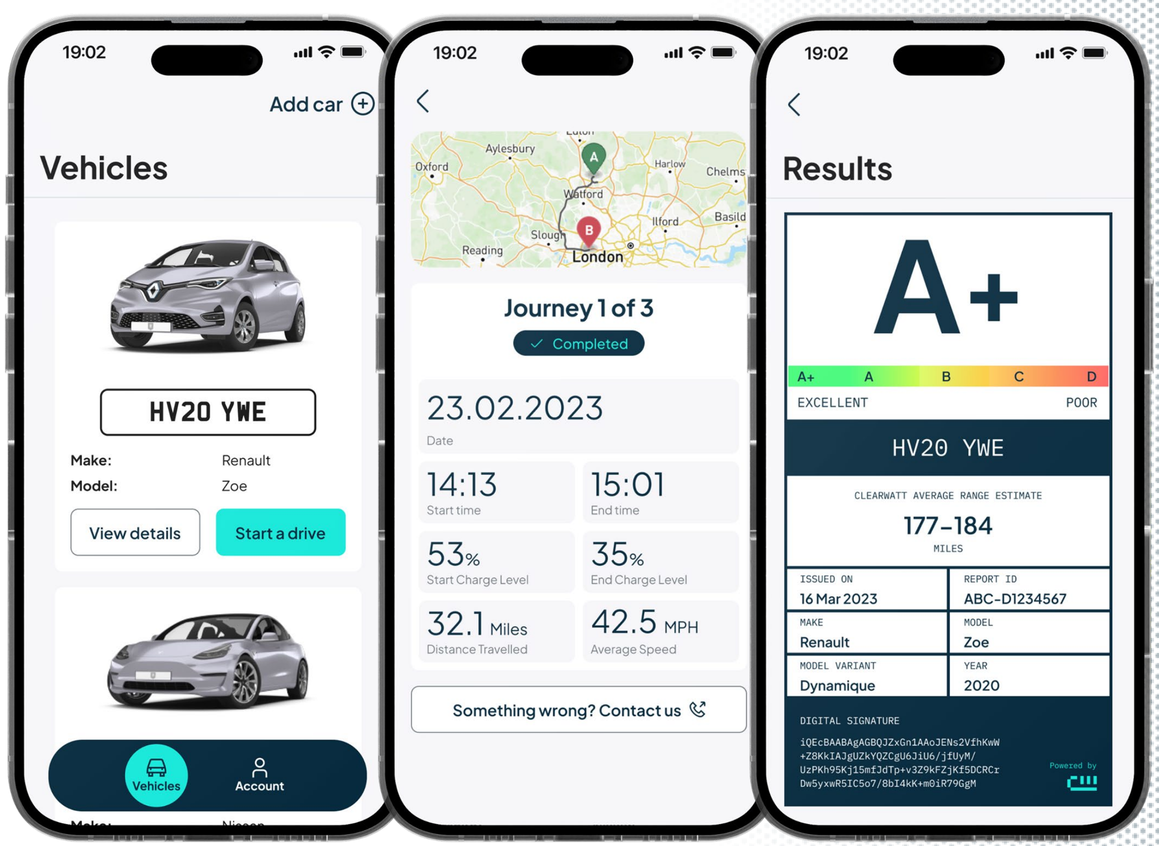
ClearWatt

Patrick Cresswell
Managing Director

www.clearwatt.co.uk

ClearWatt





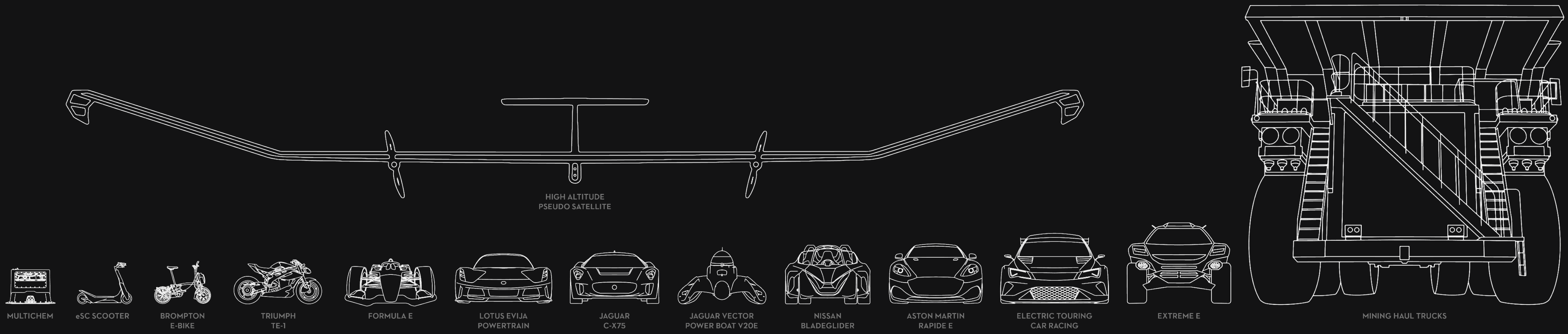
www.clearwatt.co.uk

elysia BATTERY INTELLIGENCE from WAE

Early Prediction of Battery Remaining Useful Life Using Hardware Agnostic Software

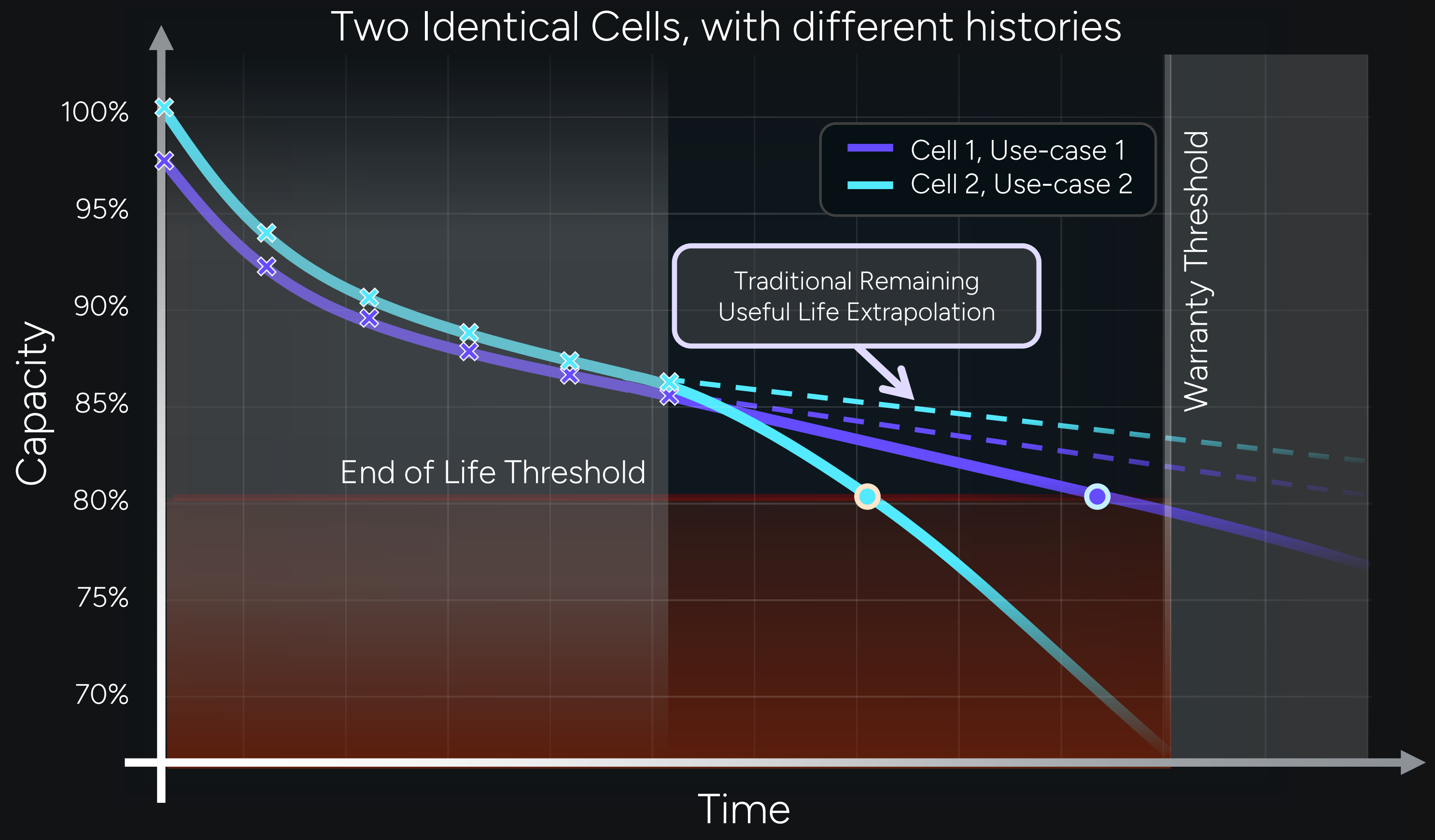
James Wallace – Product Lead

10 years of real-world electrification experience, rapidly innovating across industries, environments and technology paradigms



Battery Lifetime potential is path dependent...

Two cells cycled to the same capacity may have very different prognoses, depending on **how** they got to this point (the use-case), even if they are treated equally from this point forward.



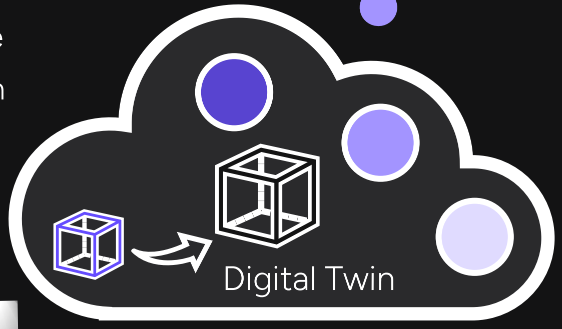
2. Degradation Insights
Remaining Useful Life

Knee-point prediction

Usage Sensitivity Insights

3. Performance Simulations
Preventative Maintenance

Safety Insights



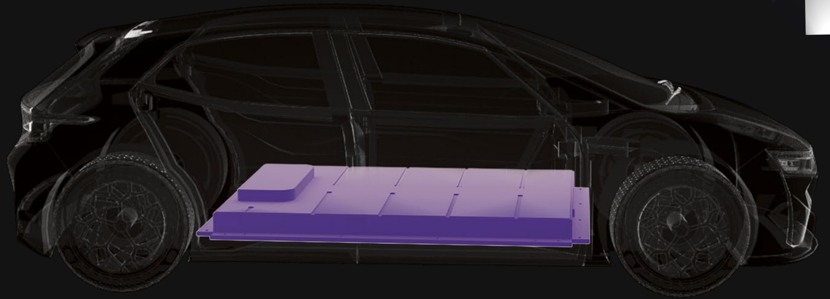
1. Targeted Telematics
Event-triggered data

5. Bespoke BMS Calibration
Asset-specific parameter optimisation according to individual risks & opportunities

4. Diagnostics & Prognostics
Real-world performance KPIs

Usage Sensitivity Insights

Integration into Fleet Management Tools



elysia BATTERY INTELLIGENCE from WAE

James Wallace
Product Lead – Battery Intelligence
james.wallace@wae.com

Alex Johns

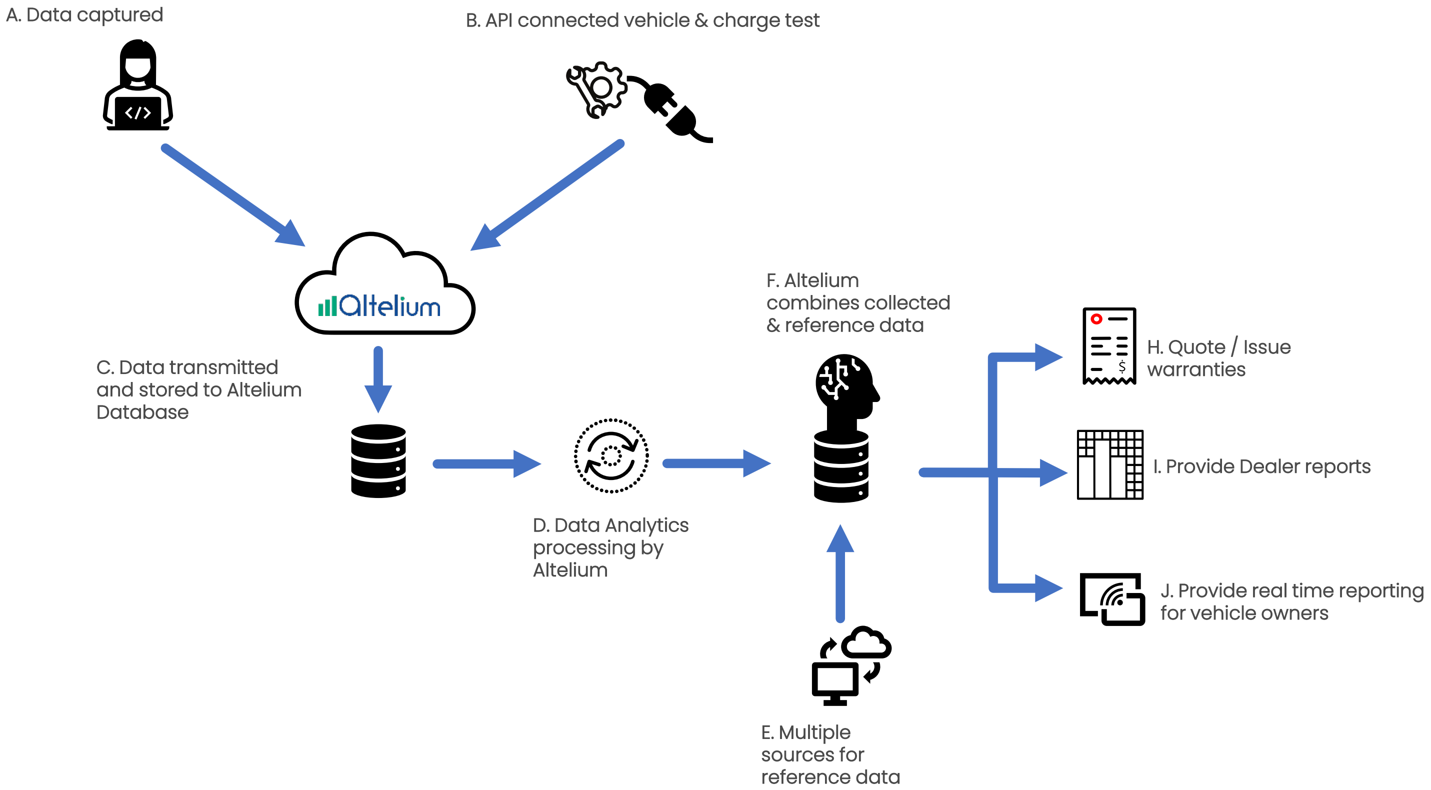
Business Development Manager

The Value of Battery Health Certificates – The Altelium Practical Approach

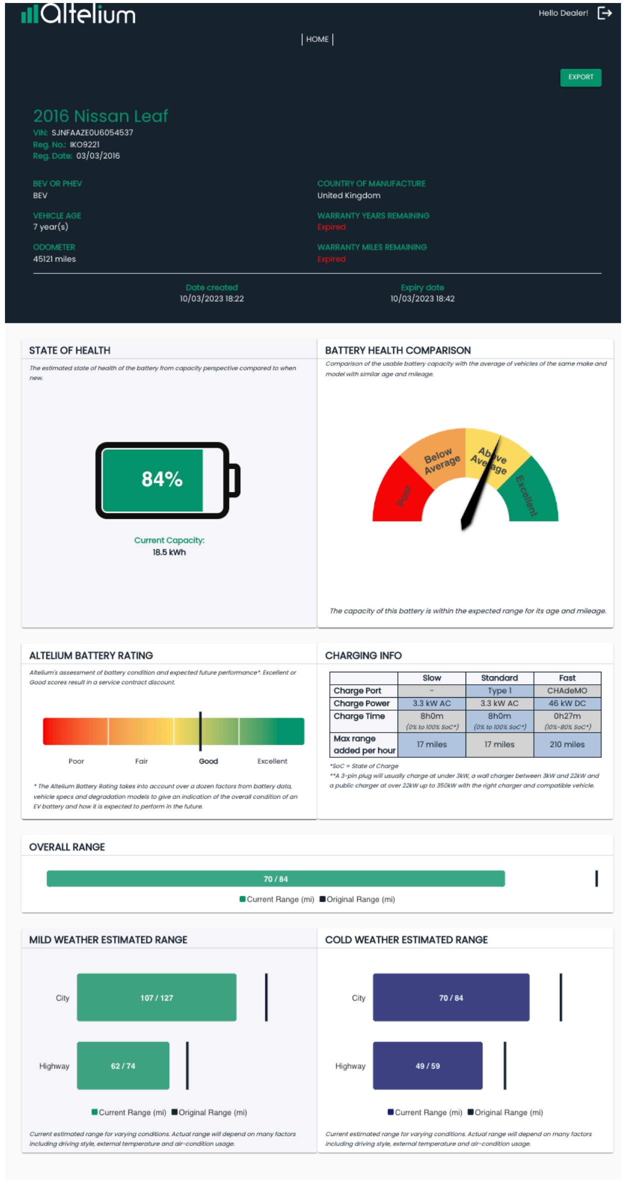
Methodology

Technology Overview

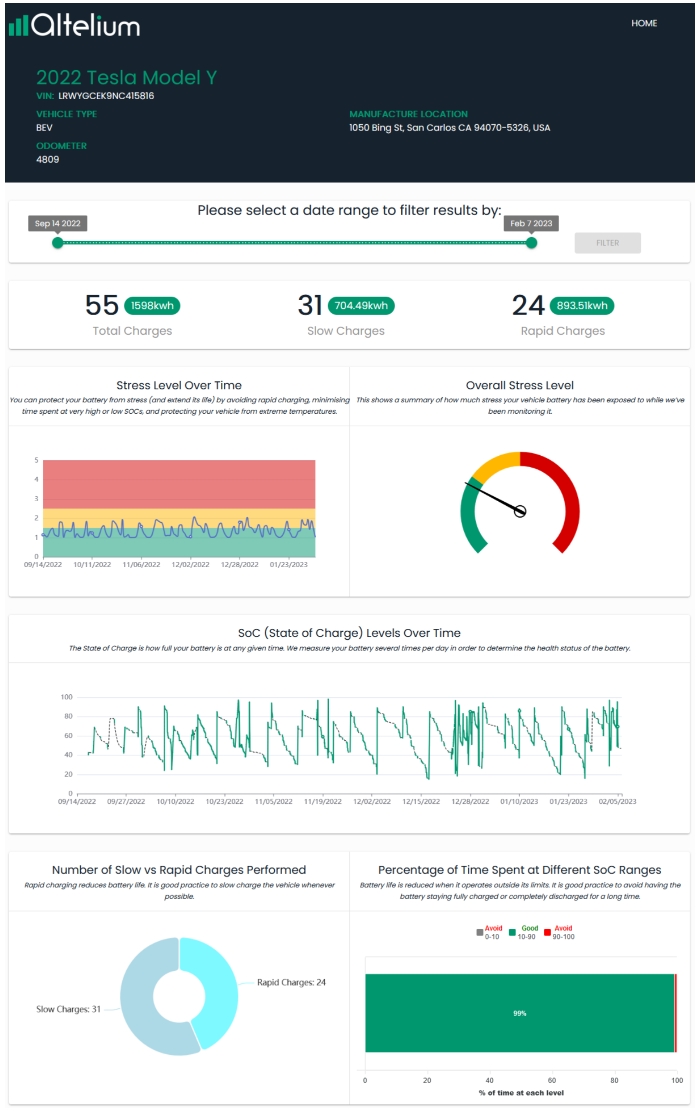
Our end-to-end tech platform enables the analysis of individual EV batteries on dealer forecourts, the provision of dealer reports and real-time reporting to vehicle owners.



Dealer Report



EV Insights



We provide Dealer Extended Warranties, Dealer Reports and EV Insights

Altelium provides EV Warranty solutions across the EV ecosystem for OEMs, Dealers, Leasing Companies, Fleets and Battery Cell OEMs. Our solutions include customer centric Dealer Reports and EV Insights for EV Drivers.

EV OEM + Extended Warranty

Product: Battery data-driven OEM and Extended warranty

Coverages: Electrical and Mechanical Breakdown and Performance Breakdown
(battery degradation risk)

Client: EV OEM / Dealer / fleet / leasing company

Benefits:
- Balance sheets protection
- Reduced buyer finance costs
- Increased buyer confidence
- Increased battery residual value

EV Dealer Report + EV Insights

EV Dealer Report
Benefit:
- Purchasing and pricing accuracy
- Ability to assess EV batteries
  - SoH and battery quality

EV Insights for EV Owners as part of extended warranty
Benefit:
- Battery health reports
- Tips to prolong battery life
- Rewards program → Behavioural management

Panel: Battery Health Certificates

Catherine Bowen
BVRLA

Thomas Mulon
MOBA

Tobias Huelsing
Bosch

Patrick Cresswell
ClearWatt

James Wallace
WAE

Alex Johns
Altelium

Final Thoughts

- Chair summary
- Thank you to Autotrader for supporting today's event
- Thank you to our speakers and you for participating in today's event
- **Feedback & Suggestions**: please spend a few minutes to complete the feedback survey when you receive the email