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REUSE & RECYCLING OF LITHIUM ION BATTERIES

Newcastle University

How much capacity do we need to recycle portable energy storage from Electric Cars?

Presented at the UK Energy Storage Conference (UKES) September 2019, Newcastle, UK

Oliver Heidrich (Newcastle University); Rajaeifar Mohammad (Newcastle University); Peter Wells (Cardiff University) and JP Skeete (Cardiff University);

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Civil Engineer from Newcastle (England, Germany)

My mission is that people appreciate the environmental and resource consequences of their actions (or indeed inaction).

I research Climate Change Mitigation and Adaptation Strategies and the impact they have on natural resources.

My vision is to make this world a better place.

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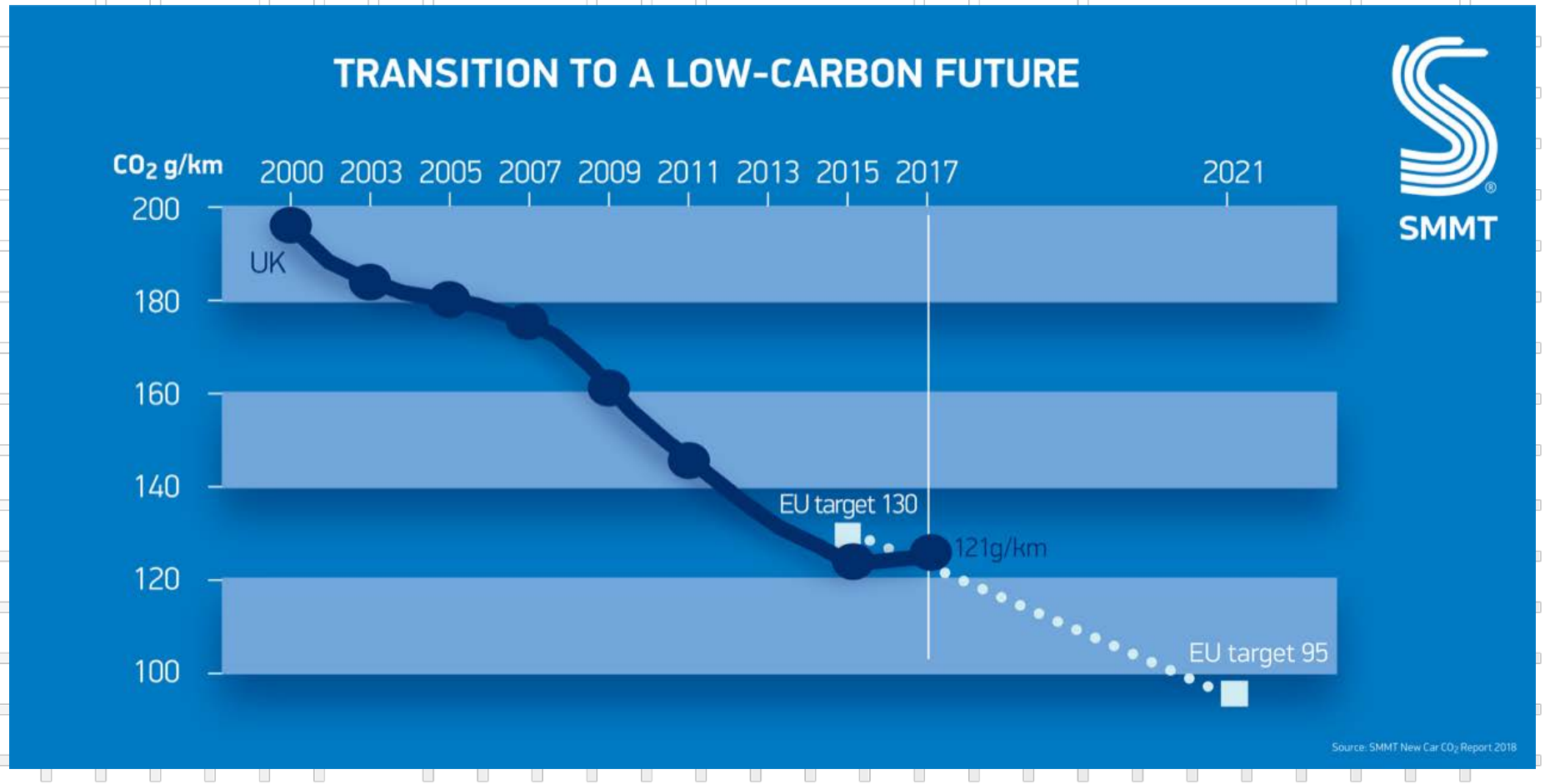
New car CO2 "bulge"



Can we achieve this- I don't think so
See Hill et al 2019- STEP CHANGE IS NEEDED

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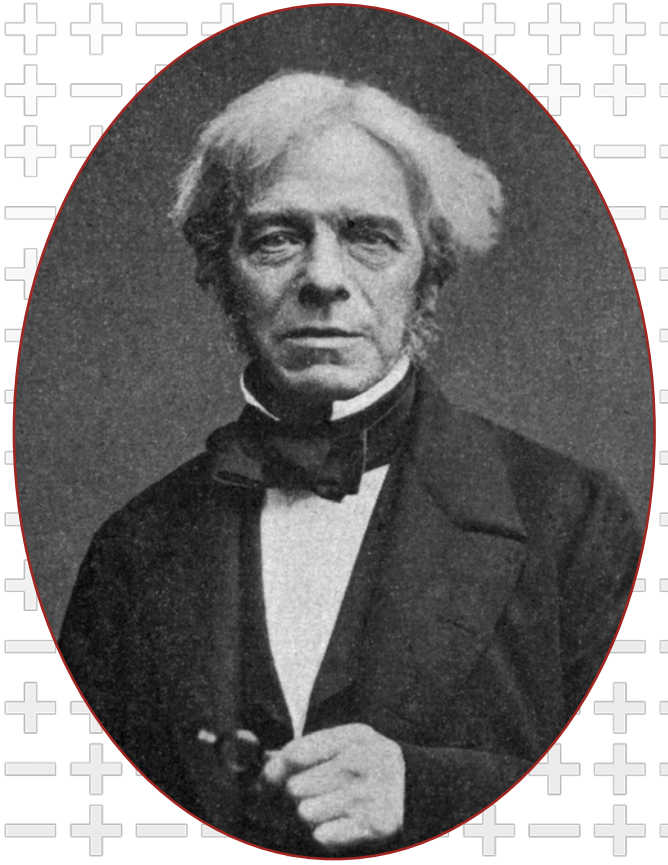
THE FARADAY MISSION

- Make the UK the go-to place and world leader for energy storage research and technology
- Lead the world in energy storage science and innovation
- Create jobs of the future-at many levels
- Provide policy advice to make best choices
- Secure a cleaner, greener future



Michael Faraday
Electrochemistry

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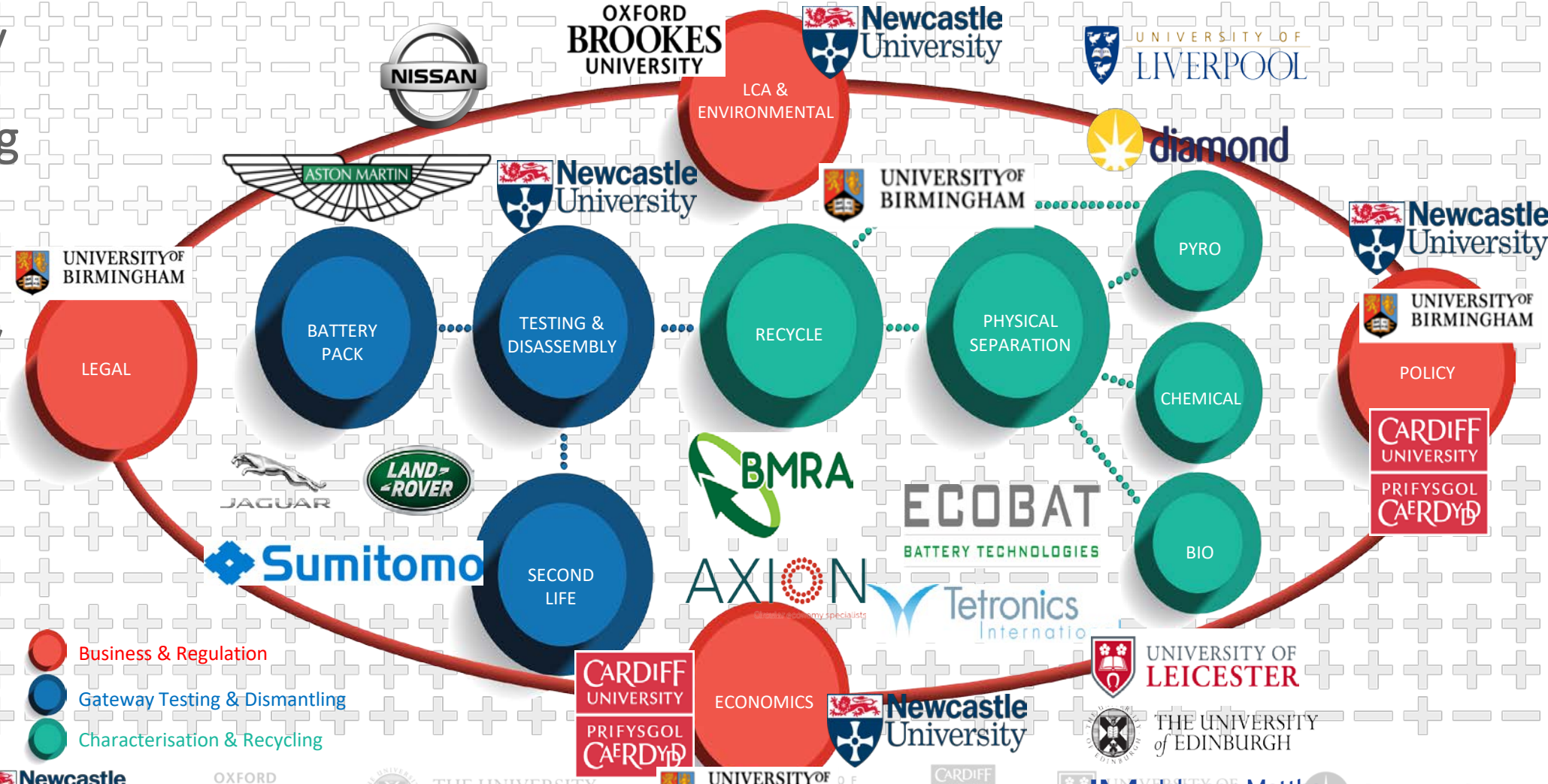
To facilitate a circular economy in lithium-ion batteries, tackling technical and socio-economic challenges in sensing, gateway testing, sorting, re-use and recycling



Positioning of the problems and opportunities

1. Recycling BEVs poses unique challenges and opportunities compared with conventional ICEs.

2. We predict the scrappage and recycling rates for Internal Combustion Engine (ICE) Cars and Electric Vehicles (EV) and their battery systems.

3. Terminal degradation Lithium Ion Battery (tLIBs) concept

4. Trading of raw materials, goods and ultimately waste is making use of a worldwide network of producers, manufactures and recyclers.

5. The restructuring of the End-of-Life Electric Vehicle (ELEV) recycling structure is likely to be a necessary condition to establish electro-mobility socio-technical system across the world

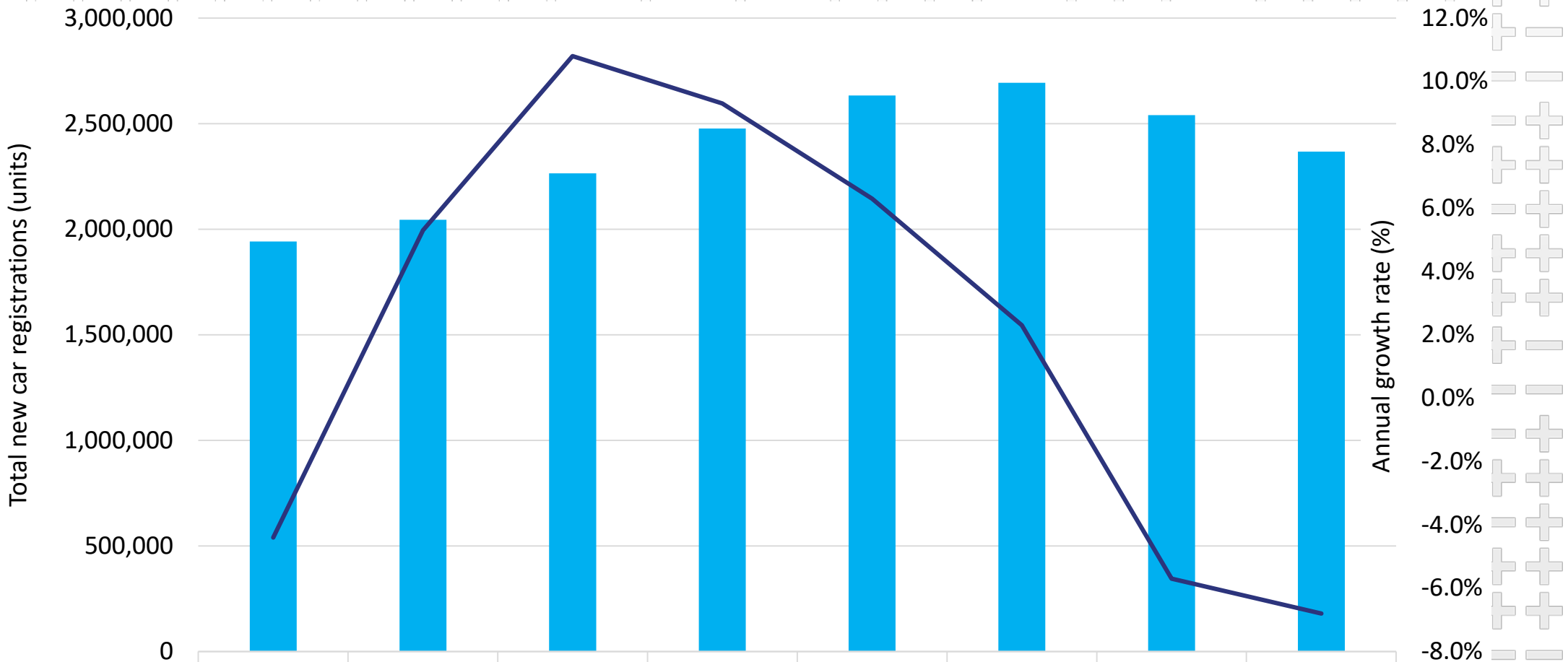
Cars become available for recycling through one of three basic routes:

1. Damaged (collision or other) and must be scrapped because it is beyond safe and / or economic repair.
2. Age and condition is such that that the cost of keeping the vehicle outweighs its value.
3. Car may be (illegally) abandoned resulting in collection by a Local Authority.

In the EU, 6 to 7 million cars are scrapped/a, with an additional 3 to 4 million classified as ‘Vehicles of unknown whereabouts’.

Forecast new car registrations in the UK from 2019 – 2025

Total new car registrations and annual growth (%) in the UK.



	2011	2012	2013	2014	2015	2016	2017	2018
Units	1,941,253	2,044,609	2,264,737	2,476,435	2,633,503	2,692,786	2,540,617	2,367,147
Growth	-4.4%	5.3%	10.8%	9.3%	6.3%	2.3%	-5.7%	-6.8%

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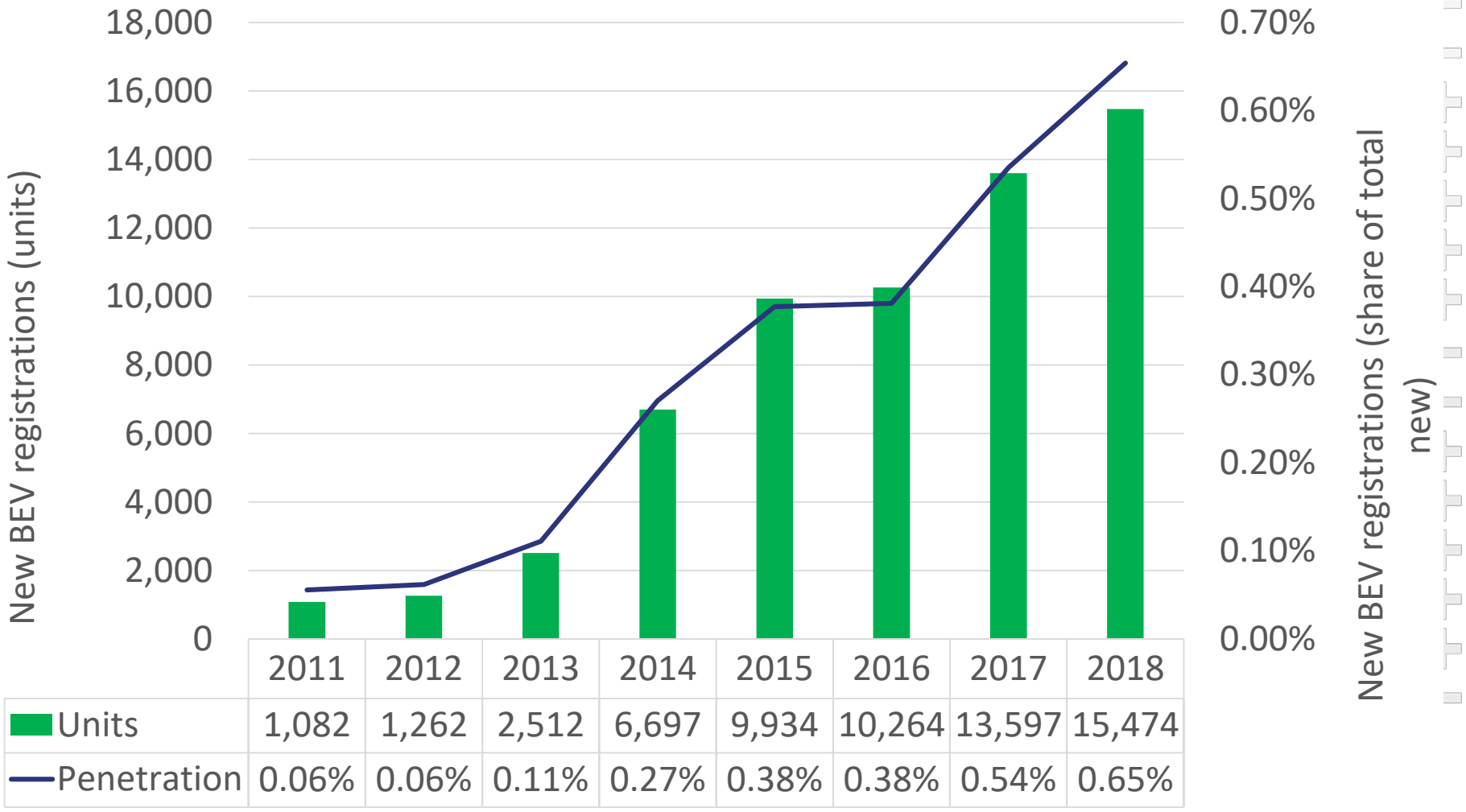
Forecast new car registrations in the UK from 2019 – 2025

New BEV registrations and share (%) of new car registrations by year in the UK.



	2011	2012	2013	2014	2015	2016	2017	2018
Units	1,082	1,262	2,512	6,697	9,934	10,264	13,597	15,474
Penetration	0.06%	0.06%	0.11%	0.27%	0.38%	0.38%	0.54%	0.65%

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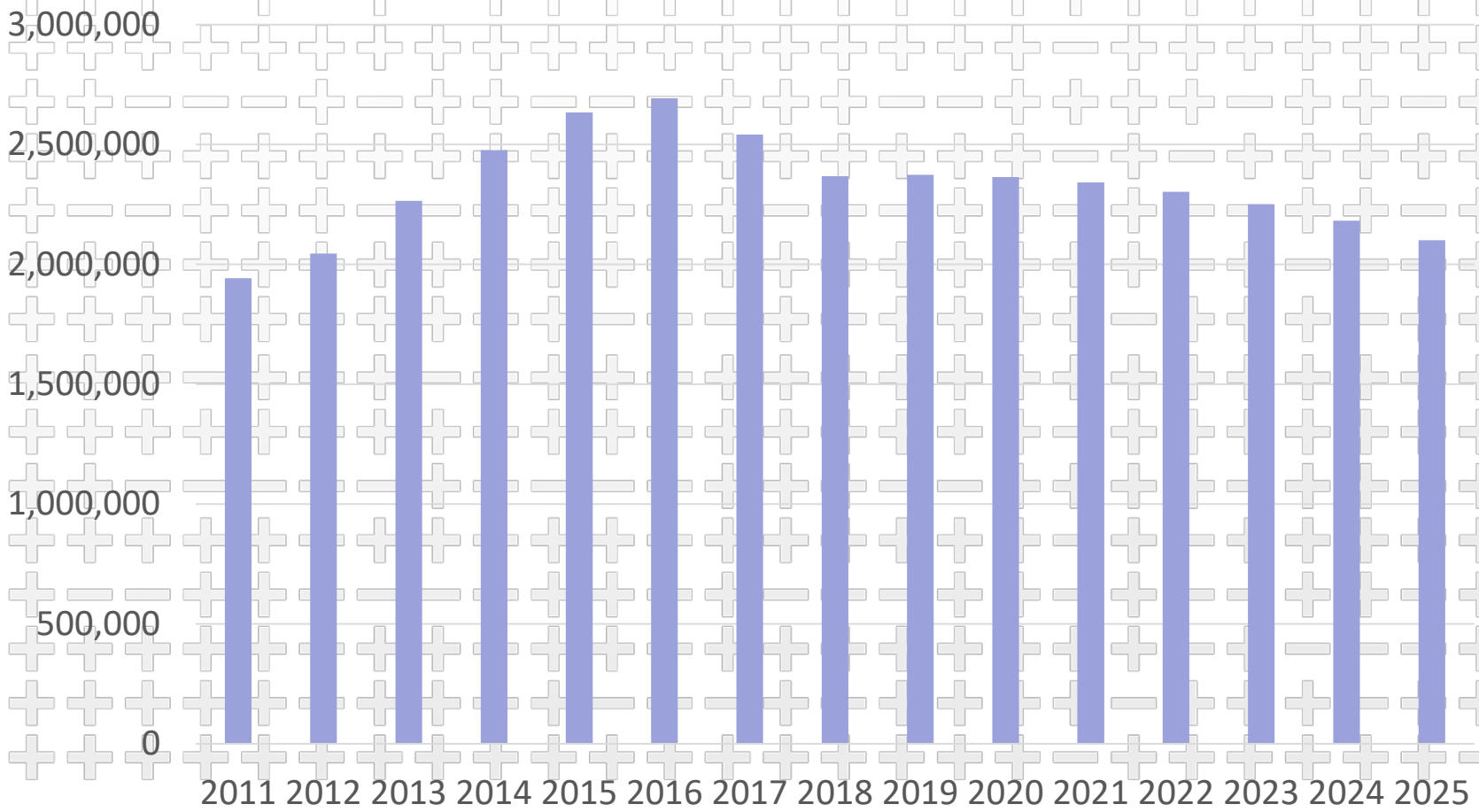
Forecast new car registrations in the UK from 2019 – 2025

Historical and forecast of new car registrations in the UK: 2011 – 2025. $(y_t = \beta_0 + \beta_1 t^2 + \beta_2 t)$



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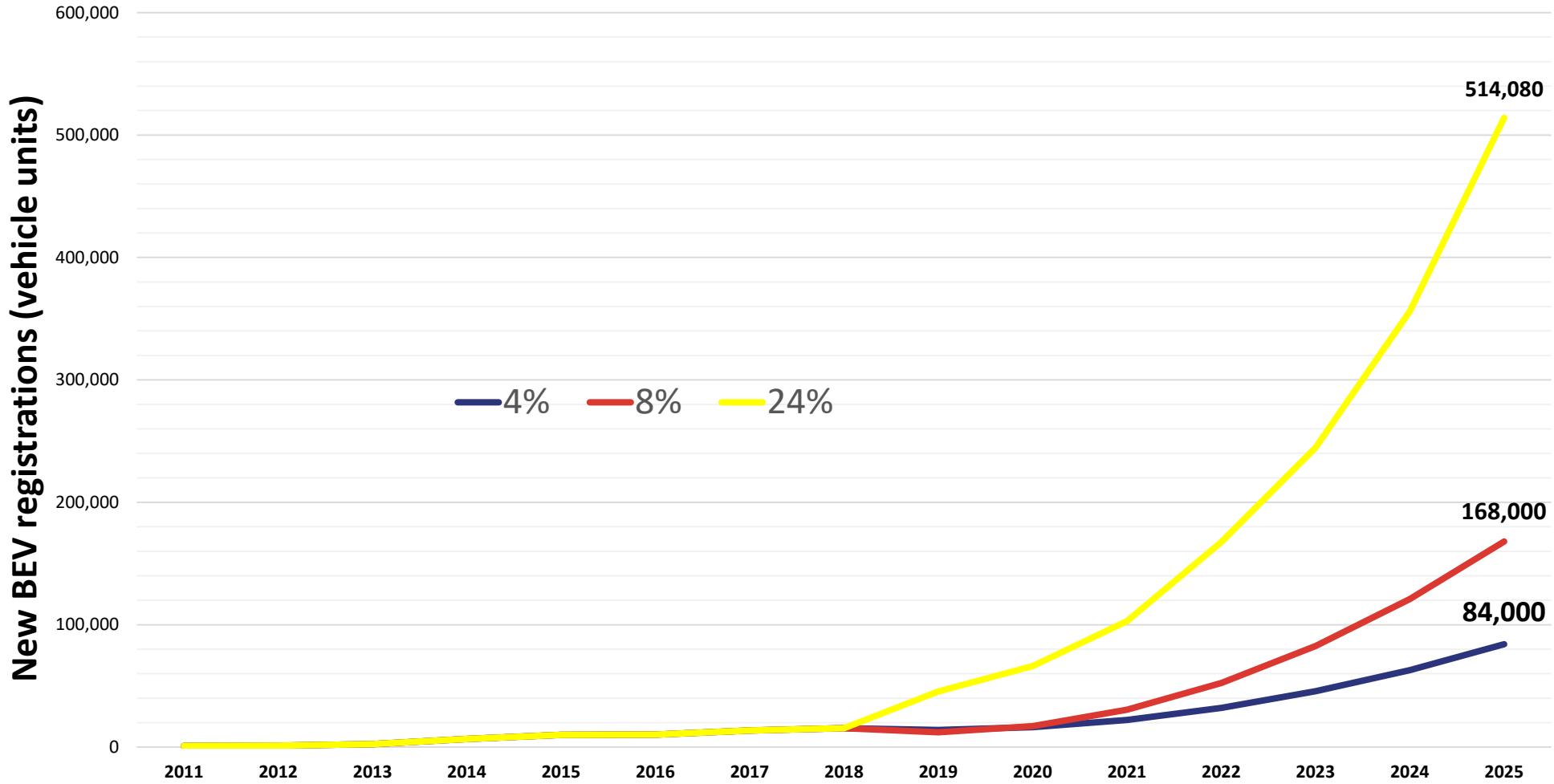
Forecast stockpile of tLIBs in the UK: 2011 – 2025

New BEV registrations in the UK up until 2025 based on penetration rates (share of total new registrations) of 4%, 8% and 24%.



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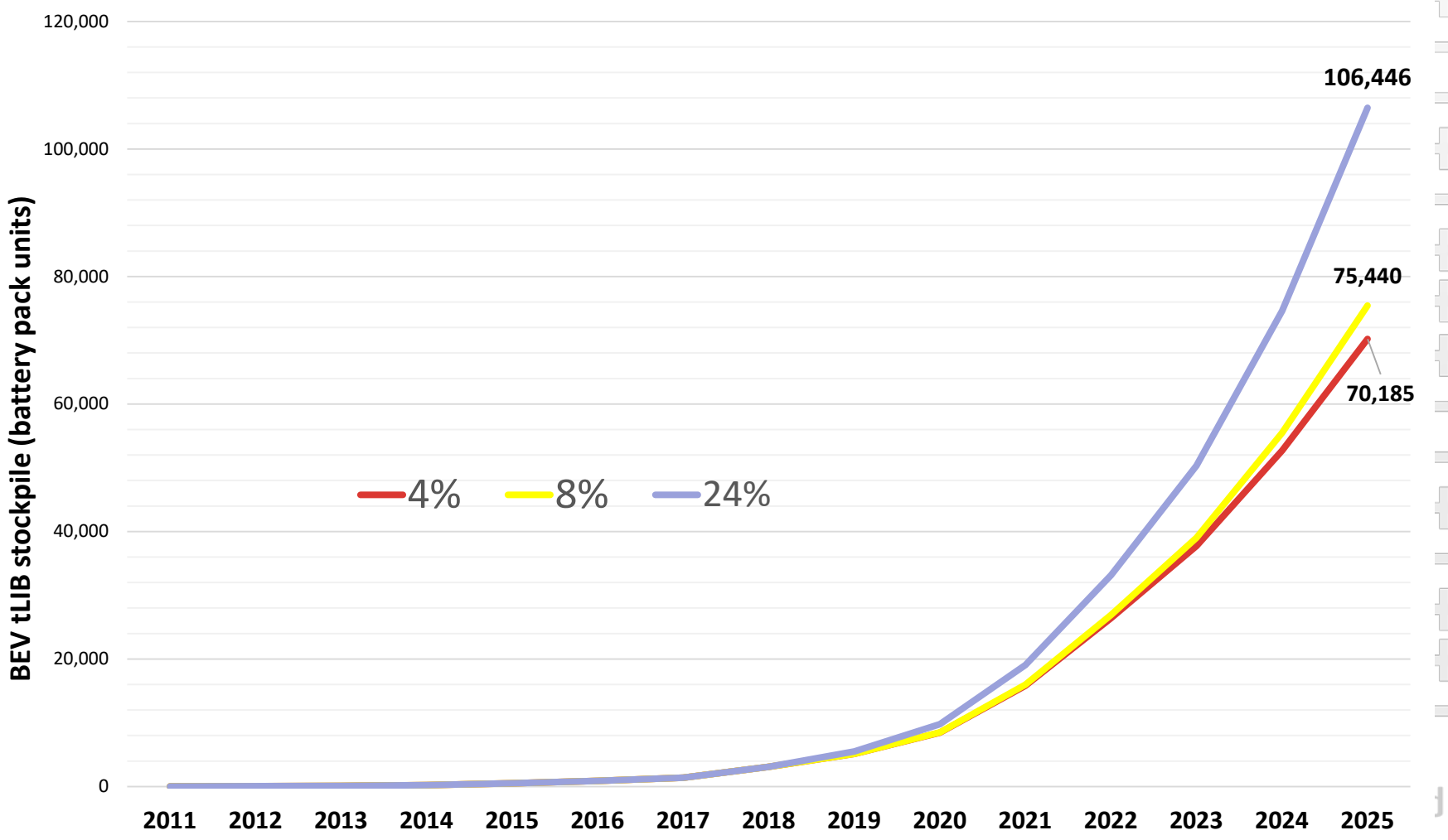
Forecast of stockpile of tLIBs (2011 – 2025)

Accumulated stockpile of terminally degrading lithium-ion battery packs (tLIBs) from BEVs



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UK Macro issues

- Geopolitics (Brexit, DRC)
- Impact of other emerging technologies (autonomous vehicles, blockchain)
- Lock-in to Lithium-ion?
- The “CO2 bulge”

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Future of sector depends upon what happens to the stockpile:

1. How are tLIBs currently being processed UK ELV sector?
2. How can recyclers in the UK grow capacity in line with the supply of BEV battery packs?
3. Who is / should be liable for the costs of treatment and disposal of tLIBs at end of life?
4. What if the ELV sector collapses before sufficient volumes are generated?
5. Is the current ELV regulatory environment suitable for BEV recycling (e.g. transportation of tLIBs)?
6. What will happen when other social and technological trends are factored into the analysis?- Global Issues

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Global issues- thresholds of scale that potentiate new battery life cycle management opportunities

1. Can stationary energy storage market can grow fast enough to absorb “second life” batteries.

2. How can we avoid stranded assets

3. Can battery chemistries evolve rapidly enough to displace Li+ from the throne.

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Thank you for your attention

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THERE IS MORE- SO MUCH MORE

Please

TALK to ME or WRITE to Me

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Refernces

Ciez, R.E. and Whitacre, J. (2019) 'Examining different recycling processes for lithium-ion batteries', Nature Sustainability, 2(2), p. 148.

Heidrich, O., Hill, G.A., Neaimeh, M., Huebner, Y., Blythe, P.T. and Dawson, R.J. (2017) 'How do cities support electric vehicles and what difference does it make?', Technological Forecasting and Social Change, 123(Supplement C), pp. 17-23.

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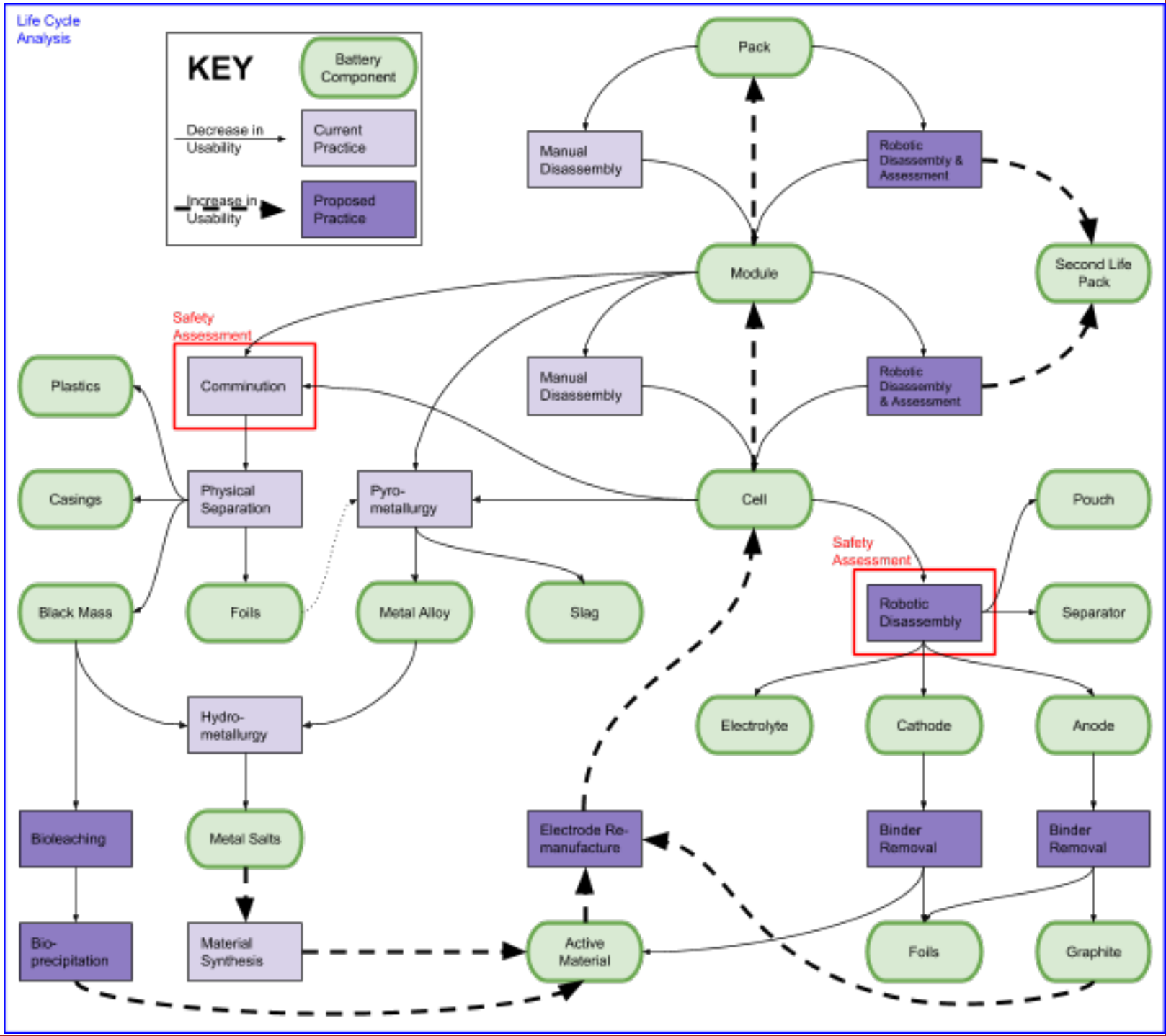
Olivetti, E.A., Ceder, G., Gaustad, G.G. and Fu, X. (2017) 'Lithium-Ion Battery Supply Chain Considerations: Analysis of Potential Bottlenecks in Critical Metals', Joule, 1(2), pp. 229-243.

Flow chart representing potential routes for the circular economy of lithium-ion cells, detailing second life applications, reuse, physical recovery, chemical recovery and biorecovery .



Valuable raw materials-but what and how much?

1. Over the last decade a great interest has been emerged in Evs,

2. Average BEV range has increased, battery durability has improved, and costs per kWh of charge capacity has fallen.

3. Cell, cooling system, BMS and packaging.

4. However, less consideration has been given to the technical and economic implications of recycling BEVs, particularly in terms of their core battery packs.