

The UK chemicals and process supply chain for battery manufacture

An analysis of strengths and opportunities

A report prepared for the UK Advanced Propulsion Centre
Electrical Energy Storage Spoke

June 2018

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This report is the output of a project that combined automotive battery and chemicals industries in UK

This work represents a collaboration between the **automotive battery industry** and **chemicals industry**, working in the context of **UK Industrial Strategy**

- The work was sponsored and managed by the UK Advanced Propulsion Centre Electrical Energy Storage Spoke (WMG, University of Warwick)
- The work was closely supported by the UK Chemistry Growth Partnership and Innovate UK Knowledge Transfer Network
- The consultancy work and this report were executed by E4tech
- The Centre for Process Innovation provided input and review, especially on UK suppliers of relevant chemicals and processes
- 67 other organisations, listed in the appendix, took part in the interviews and workshop informing this work
- The work took place between March and May 2018, following a process described in the appendix



This work provides an initial assessment of the EV battery supply opportunity for the UK chemicals and process industry

There is an opportunity to grow a UK battery industry and related supply chain

- The 2017 UK Industrial Strategy identified four initial Grand Challenges to coalesce industrial activity upon high growth opportunities. Battery development and manufacture is one of these, delivered through the [Faraday Challenge](#).
- Battery pack manufacturing for electric vehicles (EVs) will logically take place close to the point of vehicle assembly since packs are hard to transport. This in turn implies that the battery cells which make up the packs will best be manufactured in (or close to) the UK. This could also mitigate the loss of vehicle engine production in the future.
- For cell production to occur in the UK, the supply chains of chemicals would need to be reconfigured, since most cell production and chemicals supply is currently in Asia. Whilst such inputs could be imported, to capture the most value, cell production and the related chemical and process equipment supply would need to come from UK suppliers.

The automotive battery and chemicals industries have not been well connected

- The emerging EV battery industry in UK would like to understand the potential for the UK chemicals and process industry to supply future requirements.
- Despite growth ambitions, the UK chemicals industry generally has limited information about the battery opportunity and requires clarity about specifications, timing and certainty of needs.

This work describes future battery chemicals and process needs, quantifies the supply opportunity, and provides an inventory and assessment of the potential supply chain in the UK

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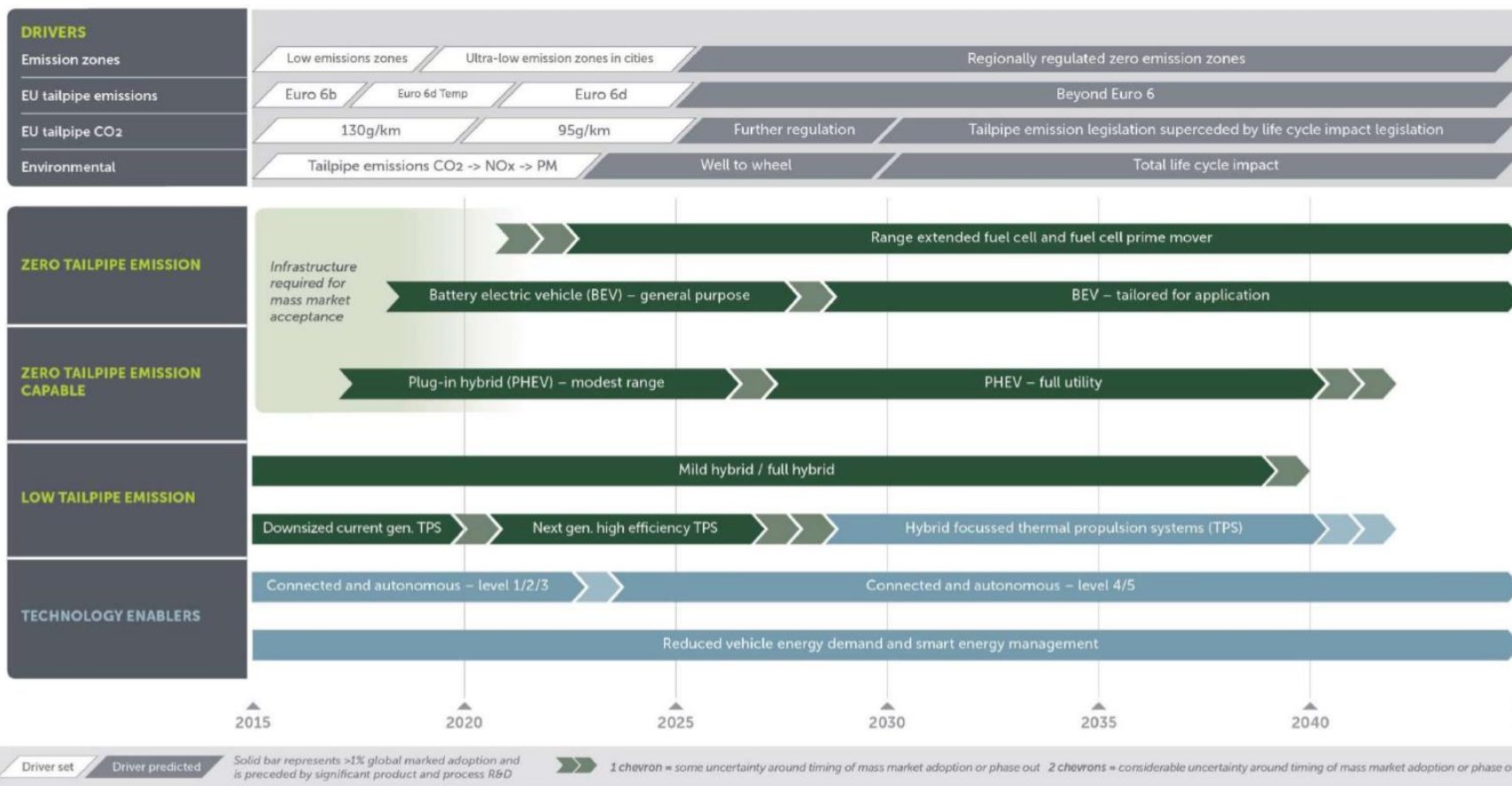
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Passenger cars are set to feature growing levels of electrification as regulatory and other drivers tighten

Passenger car propulsion roadmap (developed by consensus amongst industry and research experts)

PRODUCT ROADMAP 2017: PASSENGER CAR

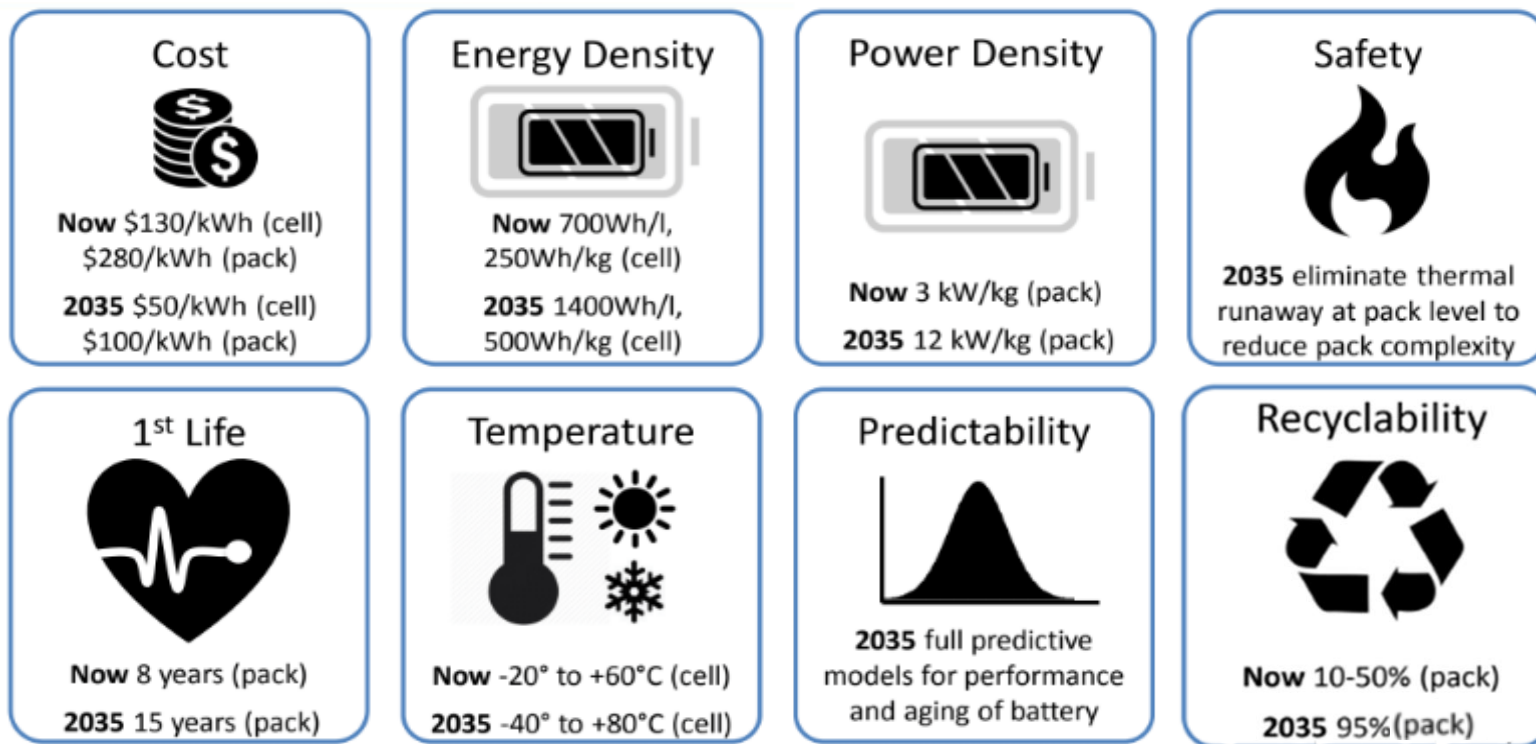
Roadmap developed by the Automotive Council and the Advanced Propulsion Centre



https://www.apcuk.co.uk/app/uploads/2018/02/PasCar_Full_Pack.pdf

Significant improvements in battery cost and performance will be required

Battery technology targets (developed by consensus amongst industry and research experts)



Source: WMG 2018

Battery technology will continue to develop, with important changes predicted in the 2025-2030 period

Battery technology roadmap (developed by consensus amongst industry and research experts)

TECHNOLOGY ROADMAP 2017: ELECTRICAL ENERGY STORAGE

Roadmap developed by the Automotive Council and the Advanced Propulsion Centre

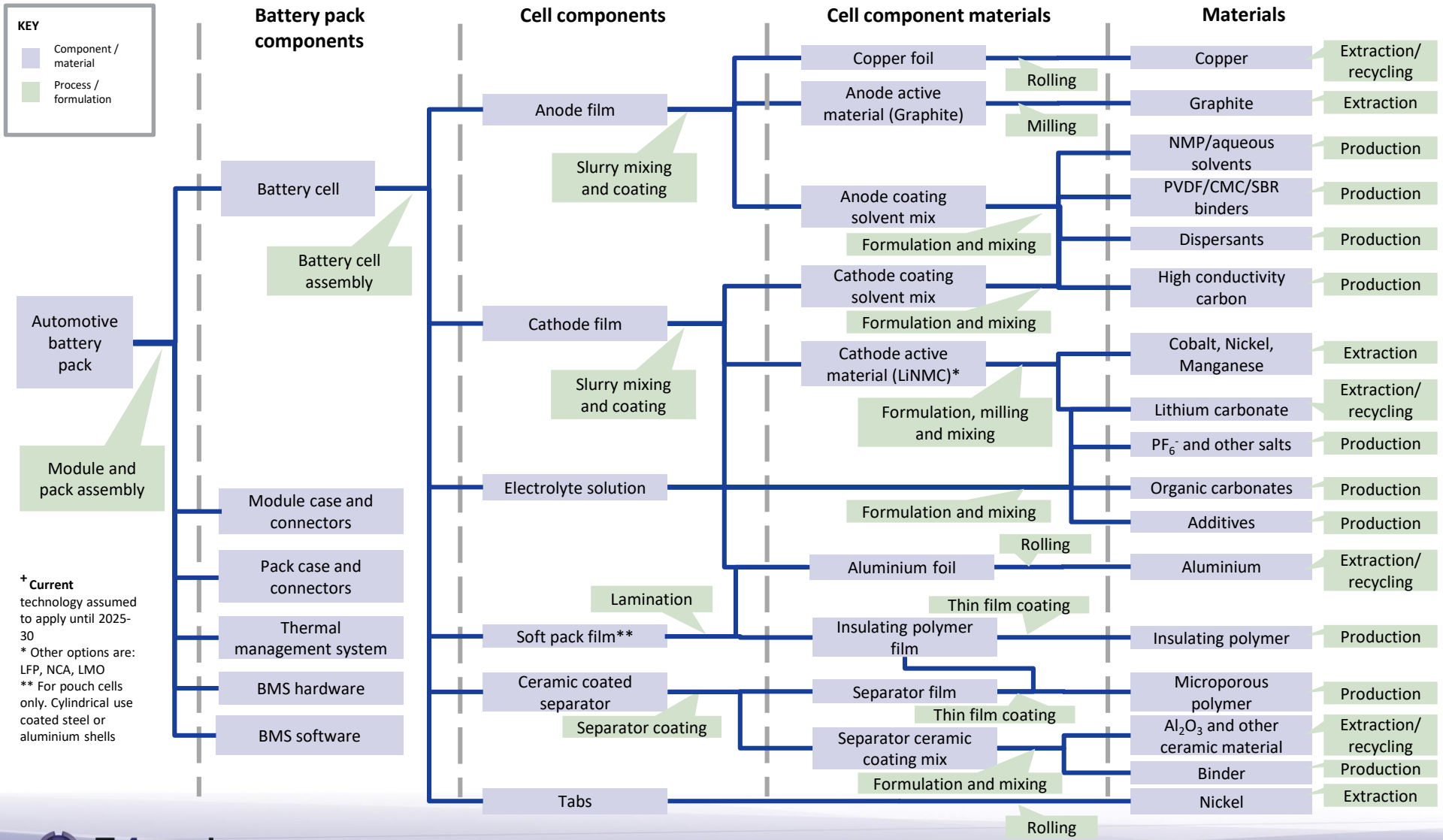


* All targets relate to battery packs.

➤ 1 chevron = some uncertainty around timing of mass market adoption or phase out 2 chevrons = considerable uncertainty around timing of mass market adoption or phase out

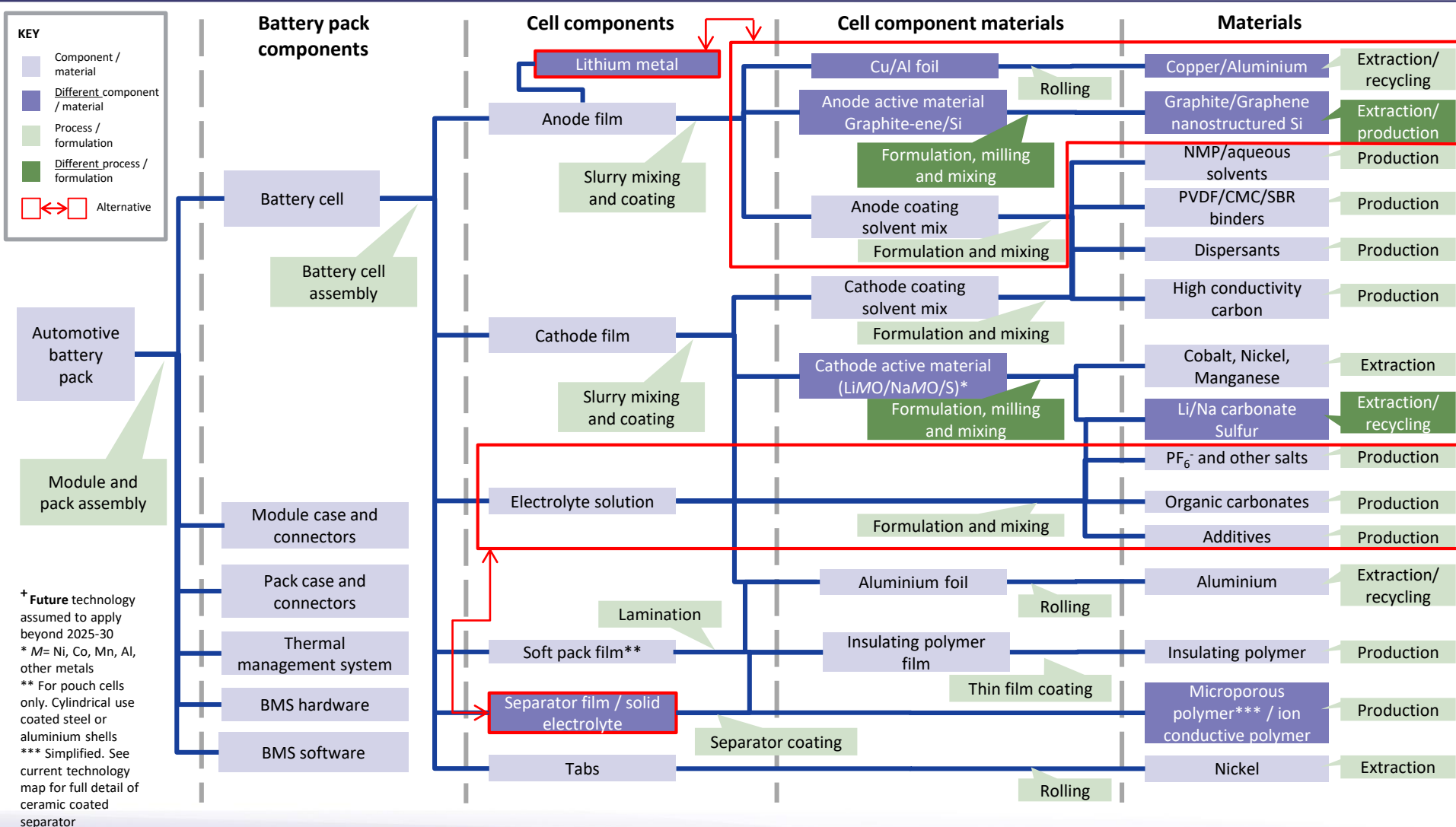
<https://www.apcuk.co.uk/app/uploads/2018/01/Electrical-Energy-Storage-2017.jpg>

The **current**⁺ EV battery technology supply chain (expected to be stable for at least 8 years) comprises many materials and processes



⁺ **Current** technology assumed to apply until 2025-30
^{*} Other options are: LFP, NCA, LMO
^{**} For pouch cells only. Cylindrical use coated steel or aluminium shells

The **future**⁺ EV battery technology supply chain could see some materials and processes replaced, once proven to be viable



⁺ Future technology assumed to apply beyond 2025-30
 * M= Ni, Co, Mn, Al, other metals
 ** For pouch cells only. Cylindrical use coated steel or aluminium shells
 *** Simplified. See current technology map for full detail of ceramic coated separator

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The current UK battery industry features only a few companies, just two of which manufacture in volume

Component	Battery technology	Material / Process	Firms	Capabilities
Battery pack / cell	Current / future	Battery cell manufacture and pack assembly	Nissan/AESC AMTE/AGM	Volume supply of automotive battery cell assembly and pack manufacturing. Small volume 'powder-to-power' cell manufacturing and supply of battery packs for niche applications
	Future		Faradion Oxis Energy ZapGo	Development and manufacturing / licencing of lithium sulfur, sodium ion and carbon ion cells in low volume

- Currently there is one large scale battery cell and pack manufacturer in the UK, which imports most cell components (including electrode and separator rolls) from Asia
- There is only one 'powder-to-power' cell manufacturer, with medium scale production facilities
- There are a number of firms developing new battery technologies and looking to either manufacture or license both inside and outside the UK
- There are parallel efforts to attract a major cell manufacturer to establish a plant in UK

UK battery manufacturers and technology developers do not rely on a UK supply chain but would welcome its development

- UK battery manufacturers find that sourcing process equipment from outside the UK is not a problem but sourcing materials, especially those used for conventional lithium ion batteries, poses supply security issues
- UK battery technology developers are currently sourcing their materials from outside the UK and are not facing particular challenges from a supply chain point of view, given the small scales and novel materials
- Technology developers are conducting collaborative R&D on next gen products with UK chemical companies
- *Note that the views of potential major battery company inward investors are not known with regard to which materials are must-have vs nice-to-have from UK sources*

Materials today can be manufactured anywhere and shipped around the world, however achieving substantial cost reductions means that in future local suppliers may become more attractive

Our business model does not rely on UK suppliers however we would welcome working with suitable ones as this would allow joint development work

UK firms have a role to play in supplying active materials for advanced chemistries. We find that smaller chemical companies are keen to get involved.

Battery companies believe that UK chemical and process companies have strong potential to supply the battery industry

- Conducting joint R&D with technology developers could be a way into the battery supply chain for UK chemical companies, provided they can supply battery-grade materials at scale
- Technology developers are already sourcing some lab and pilot scale process equipment from UK suppliers and think there is more potential

In current development projects we source ~50% of the materials from the UK. In future new chemistry cells we could source 100% of active materials from the UK, or ~70% of all cell materials

We qualify our suppliers through joint R&D work, so working with UK chemical companies on InnovateUK projects can lead to adding them to the list of our suppliers

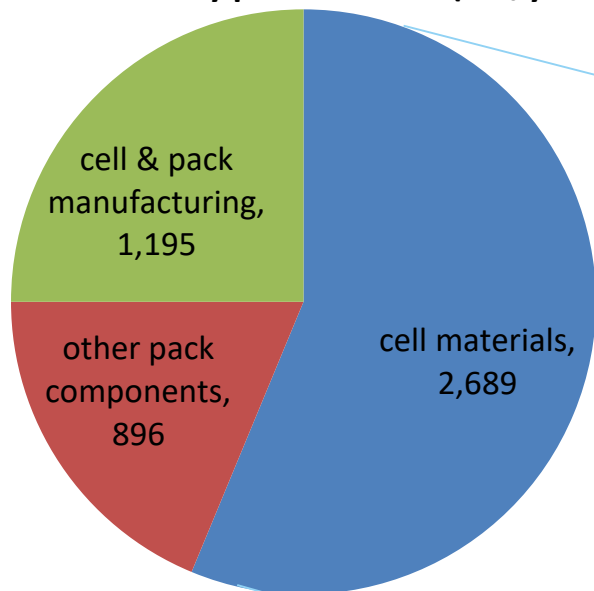
We believe the potential is there for UK process equipment manufacturers to supply the battery industry, however they would need to be educated on our requirements

The volume and value of the UK EV battery supply chain opportunity can be estimated based on assumptions

- The UK manufactured 1.7m cars in 2016, around 80% of which were exported (SMMT 2017). Assuming that the manufacturing volume stays constant and that 50% of the vehicles manufactured in ~2030 are EVs, the UK would be manufacturing 850k EVs per year
- The volume and value of the battery supply chain for the 850k EVs is a function of battery price per kWh and average size of battery per EV
- EV battery price per kWh has been decreasing rapidly in recent years and the extent to which it will further decline by 2030 depends, *inter alia*, on progress in battery technology
- For the purpose of this assessment we assume that the current chemistry based on NMC cathodes and graphite anodes will still be used in 2030, however thanks to optimisation and volume manufacturing, the battery price at pack level will decrease to approximately \$150/kWh
- In the next two slides an estimate of the value and volume of the EV battery supply chain is provided, broken down by main component, based on the above assumptions
- This is purely indicative and only representative of the specific chemistry considered, because:
 - As chemistries evolve, so does the volume and value of each of the battery components
 - Even for the same chemistry, relative volumes will depend on cell size and design
- Note that manufacturing of batteries for vehicles other than cars and export of chemicals to non UK battery production plants offer significant upside to these estimates

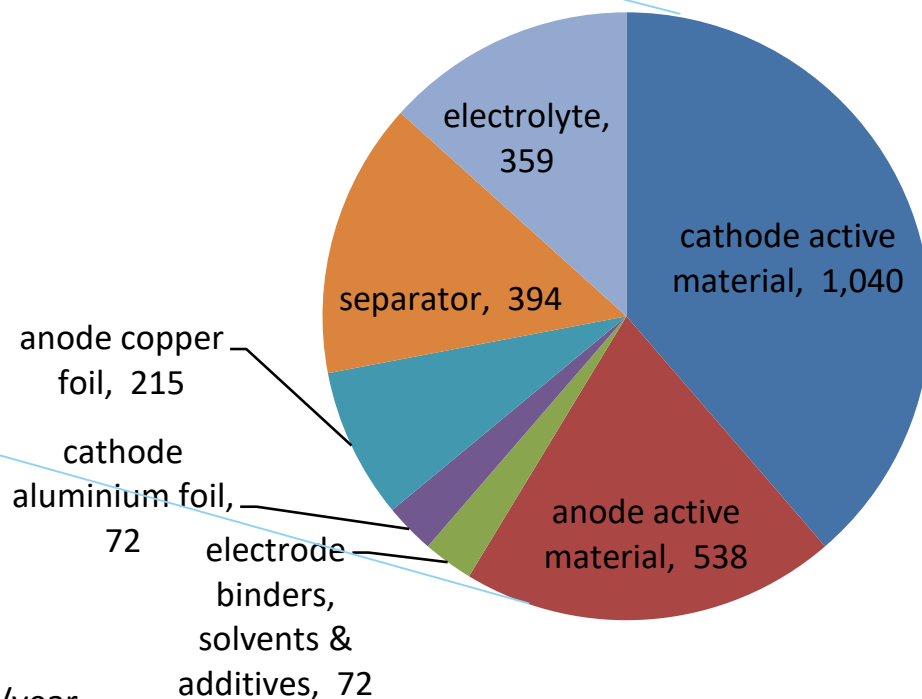
The supply of battery cell materials for UK car manufacturing could be worth £2.7bn per year, or £3,200 per car

Value of battery packs for cars (£m/year)



- Average value of cell materials per car: £3,200 (battery only, excluding vehicle)
- Typical value of chemicals in internal combustion engine cars is £800-1,000 (including vehicle)

Value of battery cell materials (£m/year)



Key assumptions:

- 850k EVs manufactured per year (~2030)
- 50 kWh average pack size (UK Automotive Council)
- Current Graphite/Nickel Manganese Cobalt chemistry
- 150 \$/kWh pack price
- Argonne National Lab BatPac model results for 100k packs/year

The corresponding volumes of each category of material would be substantial

Cell material	Annual UK value (£ million)	Annual UK volume
Cathode active material	1,040	69,000 t
Anode active material	538	48,000 t
Separator	394	263 million m ²
Electrolyte	359	27,000 t
Anode copper foil	215	18,000 t
Electrode binders, solvents and additives	72	10,000 t
Cathode aluminium foil	72	10,000 t

Key assumptions:

- 850k EVs manufactured per year (~2030)
- 50 kWh average pack size (UK Automotive Council)
- Current Graphite/Nickel Manganese Cobalt chemistry
- Bill of materials from NREL 2015 and ITRI 2015

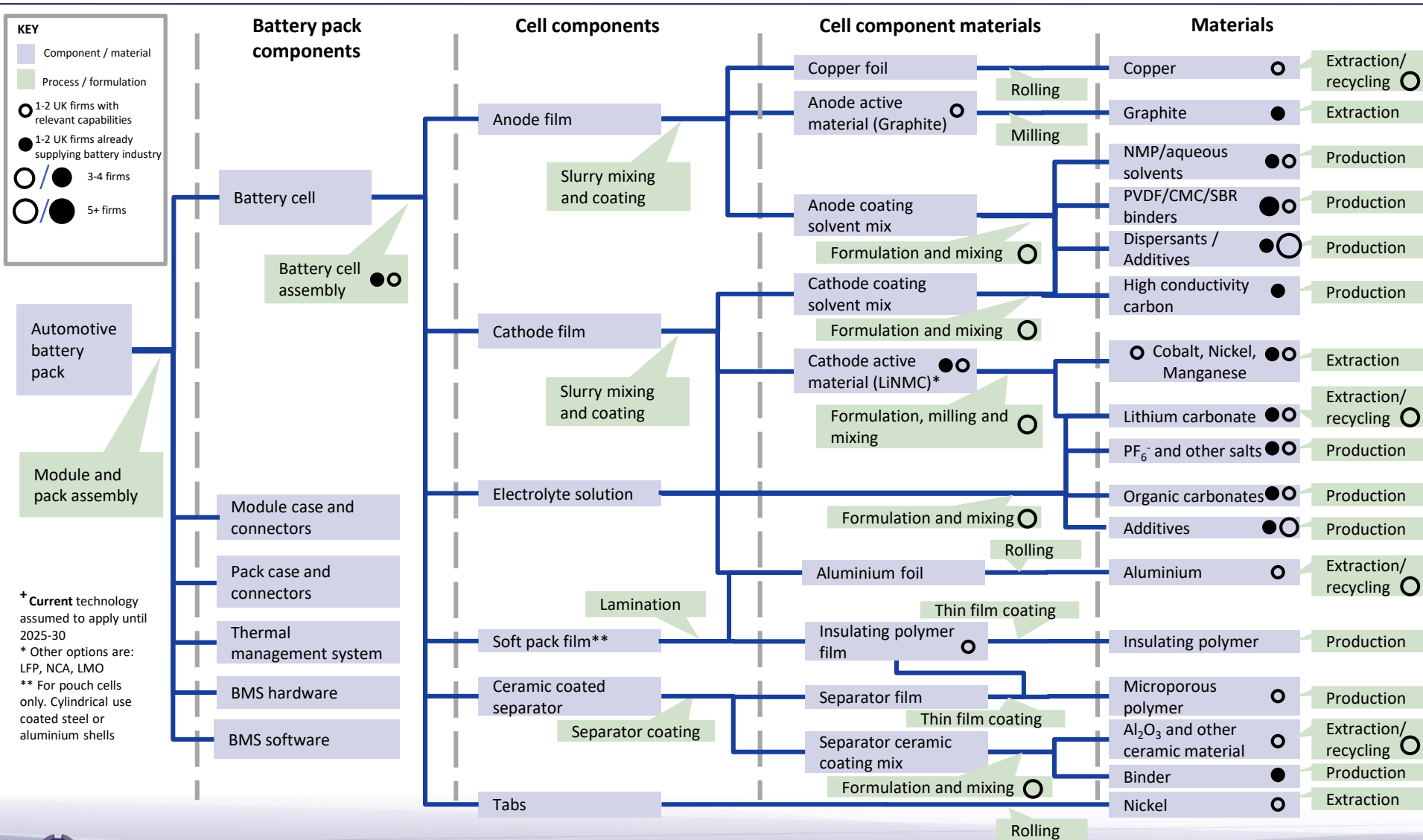
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The presence of UK chemical and process industry suppliers was mapped for current and future battery technologies

- The maps on the next slides illustrate where, if a UK battery industry existed, UK chemical and process companies could play
- Circles provide an indication of the number of UK firms with capabilities relevant to a particular material or process and whether they are already supplying the battery industry. They do not however indicate the size of the firm and the scale at which it supplies or could supply
- In most cases the capability is latent as few companies are currently supplying the battery industry or offering the exact same material/process that would be required. More detail on current vs latent capability and scale of manufacturing is provided later in the report
- A firm offering more than one material or process is represented on each one of the relevant boxes
- Firms that have materials that could potentially be used in combination with new battery concepts that are still to be developed or that are being developed but not disclosed are not represented
- **Note:** *E4tech's assessment is based on a review of 100+ chemical and process companies in the UK, and validated through interviews, a workshop and review by relevant stakeholders. However we are aware that the picture we provide is inevitably not entirely complete and accurate. Further input is encouraged and should be addressed to the APC Electrical Energy Storage Spoke at WMG: APC_EES@warwick.ac.uk*

Several UK companies have the potential to supply **current**⁺ EV battery technology

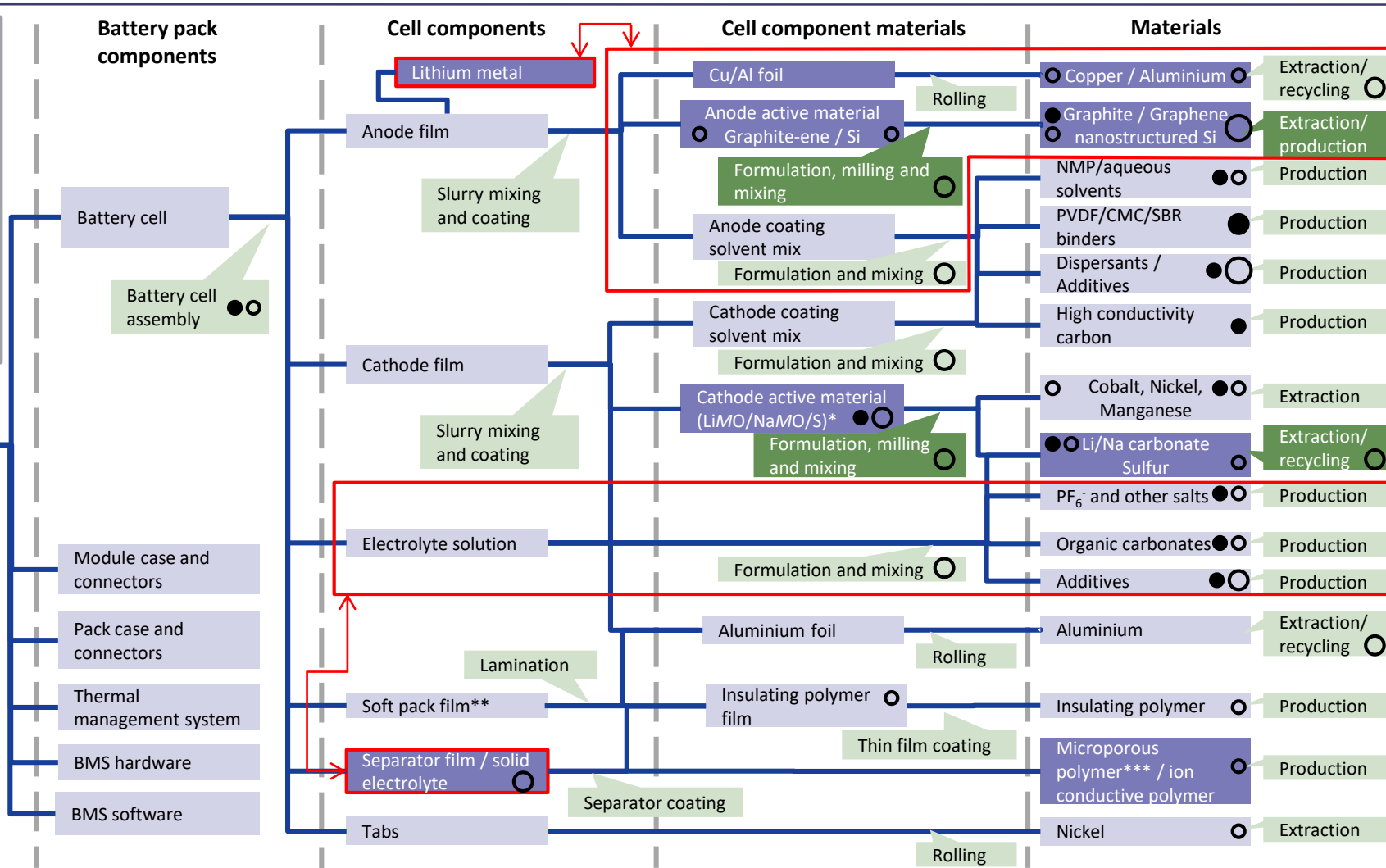


⁺ **Current** technology assumed to apply until 2025-30
 * Other options are: LFP, NCA, LMO
 ** For pouch cells only. Cylindrical use coated steel or aluminium shells

Several UK companies have the potential to supply future⁺ EV battery technology

KEY

- Component / material
- Different component / material
- Process / formulation
- Different process / formulation
- Alternative
- 1-2 UK firms with relevant capabilities
- 1-2 UK firms already supplying battery industry
- 3-4 firms
- 5+ firms



⁺ Future technology assumed to apply beyond 2025-30
 * M= Ni, Co, Mn, Al, other metals
 ** For pouch cells only. Cylindrical use coated steel or aluminium shells
 *** Simplified. See current technology map for full detail of ceramic coated separator

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Capabilities of UK chemical and process industry suppliers to supply the battery industry (1/6)

Component	Battery technology	Material / Process	Firms	Capabilities
Anode active materials	Current / future	Graphite	Phillips66 Talga Technologies Ltd	Volume supply of Pet-coke for synthetic graphite. Development of large reserves of natural graphite
	Future	Graphene	Applied Graphene Materials C-Tech Innovation DZP Technologies Ltd Graphion Talga Technologies Ltd Thomas Swan & Co Ltd William Blythe Ltd	Collaborative development with industrial partners, but also contract manufacturing of powders and dispersions
			Si nanoparticles / alloys	Nexeon PQ Corporation William Rowland Ltd
		New materials / electrode concepts	Epivalence Ltd Metalysis PV3 technologies	Collaborative development and supply of materials for new electrode concepts
		Anode additives	3M	

green = already supplying into the battery industry from the UK
blue = already supplying but not from the UK, though with strong UK presence
black = UK company with relevant capabilities, but not yet supplying

Capabilities of UK chemical and process industry suppliers to supply the battery industry (2/6)

Component	Battery technology	Material / Process	Firms	Capabilities
Cathode active materials	Current / future	Metal oxides	BASF Cornish Lithium ICoNiChem Widnes Ltd Johnson Matthey Oxkem Ltd William Blythe Ltd William Rowland Ltd	Volume supply of cathode mixed metal oxides from imported reserves based on current formulations. Exploring domestic reserves. Can develop and supply advanced formulations.
		Lithium salts	Cornish Lithium Green Lithium Leverton Lithium	Volume supply of lithium salts from imported reserves. Exploring domestic reserves
		Additives	Talga Technologies Ltd	Volume supply of conductive carbon
	Future	Advanced metal oxides	Johnson Matthey PV3 Technologies	Development and supply of advanced NMC and LNO cathodes

green = already supplying into the battery industry from the UK

blue = already supplying but not from the UK, though with strong UK presence

black = UK company with relevant capabilities, but not yet supplying

Capabilities of UK chemical and process industry suppliers to supply the battery industry (3/6)

Component	Battery technology	Material / Process	Firms	Capabilities
Electrode coating	Current / Future	Binders	3M Ashland Specialties Ltd Lubrizol Synthomer	Volume supply of PVDF, CMC and SBR binders. Development of binders for future chemistries
		Solvents / dispersants / additives	3M Ashland Specialties Ltd BYK Additives Circa Sustainable Chemicals Croda Eastman Fine Organics Ltd Lubrizol Thermo Fisher Scientific Thomas Swan & Co Ltd	Volume supply of NMP and water-based solvents and dispersants. In-house and collaborative development and supply, as well as contract manufacturing, of novel dispersants and additives for current and future battery chemistries
		Process equipment	Engie Fabricom Glacier Energy Services Labman Automation	Design and manufacturing of automated coating formulation and process systems
		Electrode printing	DZP Technologies Ltd Lubrizol	Development of thin-film printing technology for future electrodes

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black = UK company with relevant capabilities, but not yet supplying

Capabilities of UK chemical and process industry suppliers to supply the battery industry (4/6)

Component	Battery technology	Material / Process	Firms	Capabilities
Electrolyte	Current / future	Lithium salts	Leverton Lithium Green Lithium Cornish Lithium Oxkem Ltd Thermo Fischer Scientific	Volume supply of lithium salts from imported resources. Exploring domestic resources. Collaborative development and contract manufacturing of salts for new chemistries
		Organic Solvents	Mitsubishi Chemical Corp Fine Organics Ltd	Volume supply for electrolyte solvents for current chemistries. Contract manufacturing of formulations for future chemistries
		Electrolyte additives	3M Mitsubishi Chemical Corp Fine Organics Ltd Lubrizol Thermo Fischer Scientific	Volume supply of additives for current chemistries. Collaborative development and contract manufacturing for future chemistries

green = already supplying into the battery industry from the UK
 blue = already supplying but not from the UK, though with strong UK presence
 black = UK company with relevant capabilities, but not yet supplying

Capabilities of UK chemical and process industry suppliers to supply the battery industry (5/6)

Component	Battery technology	Material / Process	Firms	Capabilities
Separator	Current / Future	Binder for ceramic coating	3M Ashland Specialties Ltd	Volume supply of separators and of binder for ceramic coated separators
	Future	New separator materials / concepts	Unifrax Lauscha Fiberlean Technologies Lubrizol Dupont Teijin Films	Collaborative development and manufacturing of cellulose, ceramic, fiberglass and polymer based separators for future battery concepts
Current collectors	Current / Future	Copper	William Rowland Ltd Cornish Lithium	Supply of high purity copper from imported resources. Exploring domestic resources
		Aluminium	William Rowland Ltd	Supply of high purity aluminium
		Nickel	William Rowland Ltd ICoNiChem Widnes Ltd	Supply of high purity nickel

green = already supplying into the battery industry from the UK
blue = already supplying but not from the UK, though with strong UK presence
black = UK company with relevant capabilities, but not yet supplying

Capabilities of UK chemical and process industry suppliers to supply the battery industry (6/6)

Component	Battery technology	Material / Process	Firms	Capabilities
Packaging	Current / future	Laminated metal soft packaging film	Dupont Teijin Films	Supply of insulating polymer film that can be laminated on to aluminium foil
Battery cell	Current / future	Manufacturing automation equipment	Engie Fabricom Fives Cinetic Corp Glacier Energy Services	Design and manufacturing of industrial machines, process equipment and electronics
	Current / future	Recycled materials / recycling processes	Aurelius Technologies Axion Biffa Waste Services	Development of EV battery recycling processes and supply of recovered materials

green = already supplying into the battery industry from the UK
 blue = already supplying but not from the UK, though with strong UK presence
 black = UK company with relevant capabilities, but not yet supplying

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There is a high level of interest amongst UK chemical and process companies in the EV battery market

- The companies interviewed are all looking at the EV battery market with interest
- A few are already supplying or have supplied the battery industry internationally
- Several are currently working with battery manufacturers / technology developers in the UK through the Faraday Challenge
- Others are either planning to engage with battery manufacturers or considering conducting R&D activities

We are interested in understanding the landscape of new battery chemistry R&D and who in the supply chain to talk to

We are particularly interested in collaborative R&D projects, such as those funded by InnovateUK

We would like to meet potential partners, discuss the challenges ahead and look into possible economies of scope

However there is a need to better understand the requirements of the battery industry

- All companies interviewed believe that they have relevant capabilities
- But a few don't have a good understanding of how exactly these may fit with current and future battery technologies
- Some companies are learning through collaborative R&D programmes with battery manufacturers / technology developers
- Some companies have broad capabilities and/or can supply chemicals on a contract basis
- Others would need to substantially invest in R&D and production facilities

We still don't have a good understanding of what we could supply and how EV battery chemistry will evolve over the next 10-20 years

Participating in the Faraday Challenge is helping us better understand the requirements of the battery industry

We can manufacture on a contract basis but the customer would have to pay for any R&D work required

More confidence in the market is required for most companies to be prepared to invest

- Companies are unclear on exactly what products the battery industry will require, on what scale and when
- Auto sector confidence in direction of battery development not matched by the chemical industry, which perceives risks
- This is a potentially big barrier to investing in products that are dedicated to the battery market. Closer engagement needed between auto and chemicals
- Given the uncertainties, chemicals companies are looking at low risk strategies to enter the battery supply chain. These include adapting existing products, developing new products that can have multiple applications, or conducting R&D activities co-funded by public grants

We would need good information on future battery technologies and markets so that we could develop the right products at the right time

We could develop new products but will prioritise finding uses for our existing products so we'll conduct collaborative R&D with battery developers on this basis

We would prefer to develop products that can be sold to other industries as well

Time is needed to develop new products, scale them up and build the necessary manufacturing capacity

- Only a few UK companies are already supplying the battery industry at scale
- Those who are not will need time, once the business case is made, to develop new products and the necessary production capacity
- Typical time to market for new products in the chemical industry is in the order of 2 years
- Some have multi-purpose production plants that they can use for medium production volumes
- Others though only have pilot production facilities

We would need to launch a development project with stage gates that would last a year or more. This is typically done with the customer

We could replicate existing materials in a year. We could scale up new materials in around three years, but it would take at least four years for these materials to be used in commercial batteries

We cannot currently supply at scale. We could rent facilities for medium-scale production but anything beyond that would be difficult to arrange

The UK chemical industry perceives established suppliers to the current battery industry as hard to compete with

- The general perception is that displacing established suppliers who already work with large battery manufacturers (mostly in Asia) is difficult
- The auto industry's desire for shorter supply chains is not (yet) felt by most UK chemical suppliers
- Established suppliers benefit from having amortised their production plants and from technological learning
- Some think that playing catch up on current technology is not the right strategy therefore
- Many indicated building close partnerships with developers of new battery technology as their preferred strategy, allowing them time to grow and gain competitive advantage over suppliers to current battery technology manufacturers

Emulating the suppliers to Asian cell manufacturers in the UK would be hard and we would risk being 'just in time to be too late'

We see becoming suppliers to large battery manufacturers in Asia as very difficult and instead look to team up with UK cell developers for collaborative R&D

We can provide the most value to developers of new battery technology if we become involved in their R&D programmes early on (TRL 2-4). This would also allow us enough time to scale up production

Government's role in addressing the perceived risks with battery chemicals and processes is viewed as very important

- Certainty in the UK battery market is essential to enable investment in chemical production plants
- In addition to support to EV adoption and battery manufacturing, perceived risk in the development of the chemicals and process supply chain also needs to be addressed
- Any support provided would need to last long enough for the supply chain to reach critical mass

To scale up we need investment, which can only be attracted if the market opportunity is clear enough

Government support on materials is needed because this is not addressed by the BIC. Lack of support so far may be due to the perception that this is low value added

We need a long term support programme, not one that only lasts 2-4 years

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There is a large supply chain opportunity for the chemicals industry, but barriers remain

EV batteries are a large potential **opportunity**:

- UK auto industry already innovative in vehicles, modules and packs
- Faraday Challenge actively working to develop cell manufacturing in the UK
- Large scale chemical supply opportunity with strong growth fundamentals
- Chemicals supply from nearer sources than Asia is highly desirable for auto battery producers
- Some UK players are already supplying into the global EV battery industry

Important **barriers** need to be overcome, however:

- Timing and scale of ramp-up unclear to many chemicals suppliers
- Battery chemistries are evolving so specific chemical and process needs are dynamic
- Supply for current battery chemistries is dominated by strong players outside UK so UK suppliers are not yet confident to compete

Overall, the UK chemicals and process industry has a good presence in several higher value areas, plus other opportunities

Presence* of relevant UK suppliers	Stronger	<ul style="list-style-type: none"> - Electrode binders, solvents and additives - Lithium salts and electrolyte additives 	<ul style="list-style-type: none"> - Anode active materials for both current and future technologies: graphite, graphene, silicon - Future cathode formulations - Future solid electrolytes
	Weaker	<ul style="list-style-type: none"> - Mixing and coating equipment for electrodes and separators 	<ul style="list-style-type: none"> - Current cathode materials - Electrode films, electrolyte solvents and separators
		Lower	Higher

Value of chemicals and processes in EV batteries

* NB the depth of capability is not analysed here; this would be required to draw full strategic conclusions about UK competitive advantage and areas to focus on

Recommendations: Maintain momentum by building confidence for the chemicals sector and deepening analysis to support this

Build confidence for the UK chemical and process supply industries:

- Continue to build relationships between chemical and auto sectors and link to Faraday Challenge to keep focus
- Include substantial engagement of chemical and process industry in second phase of Faraday Challenge (years 5-10)
- Engage chemicals sector in UK Battery Industrialisation Centre scale-up activities

Deepen analysis to ensure that opportunities are clearly understood⁺:

- Understand how important the UK presence or absence of a supply capability is – which are crucial for a battery company to grow in UK, which are nice-to-have?
- Understand the UK's potential competitive advantage in each supply area versus competitors. Should the UK specialise? What are the implications for attracting a cell manufacturer to UK?
- Assess specific UK supply opportunities for individual companies (e.g. through collaborative research and development) – to prove technical capability and business case

⁺ A list of potential ways to extend this work is included in the appendix

Next steps: this report will guide development of the UK battery and chemicals industries through continued dialogue

Strategic development of the battery industry and chemicals supply chain in UK:

- This work will be used to inform further development of the Faraday Challenge and ongoing efforts to establish EV battery manufacturing in the UK
- Continued strategic engagement is invited through:
 - APC Electrical Energy Storage Spoke at WMG (University of Warwick): Prof David Greenwood, Advanced Propulsion Systems d.greenwood@warwick.ac.uk
 - Chemistry Growth Partnership: Richard J Carter, BASF plc. leading the CGP Supply Chain Group richard.carter@basf.com

Practical support for stronger interaction between battery and chemicals industries:

- Part of this report can form the basis of a supplier directory if updated. To provide comments or corrections please email the APC Electrical Energy Storage Spoke at WMG: APC_EES@warwick.ac.uk

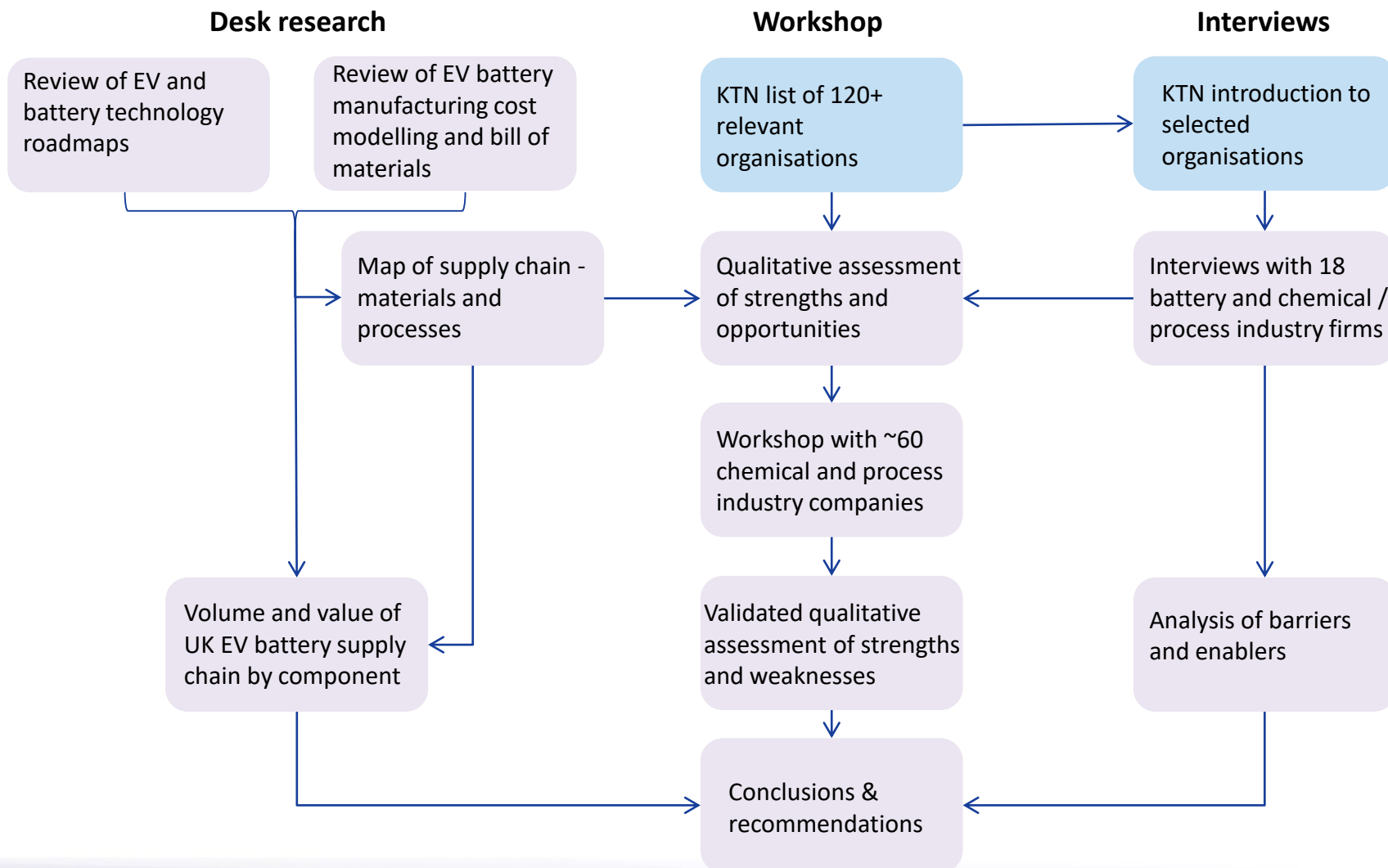
We would like to thank the following organisations for interview and/or workshop participation during this study

3M United Kingdom Plc	Cornish Lithium Ltd	Fives Cinetic Corp	Mitsubishi Chemical Corporation	The Natural History Museum
AA Battery Recycling Ltd	Croda	Green Chemistry Centre of Excellence, University of York	NEPIC	The University of Manchester
AGM Batteries Ltd	C-Tech Innovation Ltd	ICoNiChem Widnes Ltd.	Nexeon	Thermo Fisher Scientific
Applied Graphene Materials	Deep Science Ventures	IEE Consultancy	Nissan	Thomas Swan & Co. Ltd.
Ashland Specialties UK Ltd	Department for International Trade	Ilika Technologies Ltd.	Oxis Energy	University of Edinburgh
Aurelius Technologies	Deregallera Ltd.	Johnson Matthey	Phillips66	University of Kent
AVL Powertrain UK Ltd	DuPont Teijin Films	JULABO UK Ltd	Powerstar	University of Nottingham
BEIS	Durham University	Labman Automation	PQ Corporation	University of Warwick
Beta Technology Ltd	DZP Technologies Ltd.	Leverton Lithium	PV3 Technologies	William Blythe Ltd
Biffa Waste Services	Energy Technology Partnership	Lubrizol Advanced Materials	QinetiQ	William Rowland Ltd
Bitrez	Engie Fabricom	Lubrizol Ltd	RTC North / Enterprise Europe Network	ZapGo Ltd
Brunel University London	Epivalence limited	M&I Materials	ScotCHEM	
BYK Additives Ltd	Faradion Ltd	METALYSIS	Talga Technologies	
Circa Sustainable Chemicals Ltd	Fine Organics Ltd	Metiscube	Teesside University	

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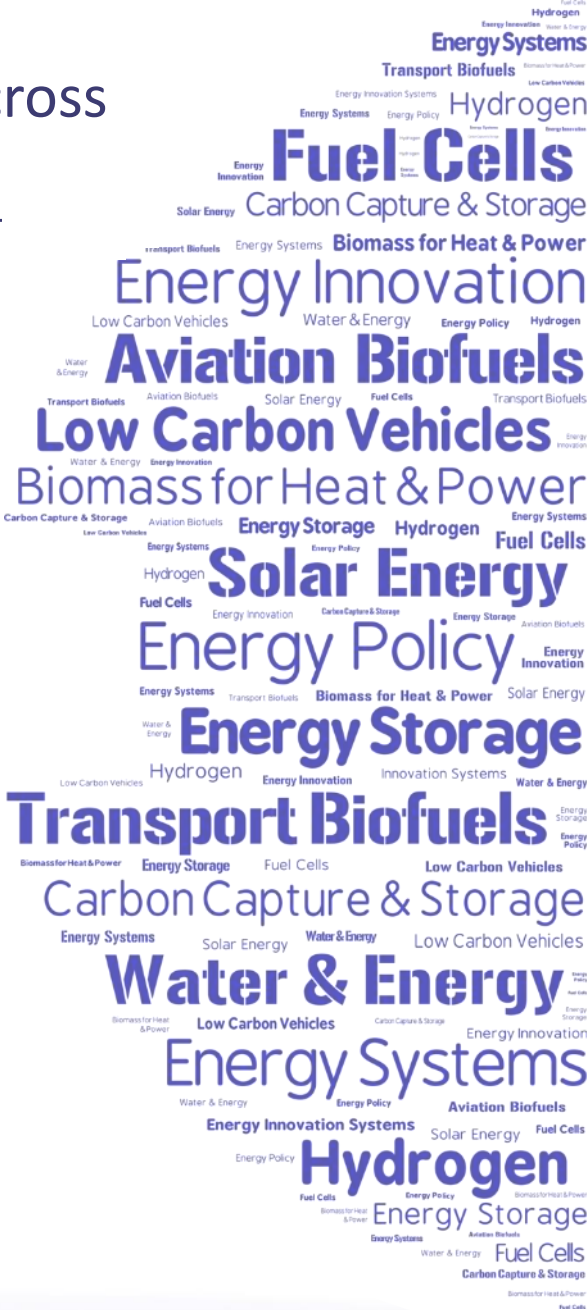
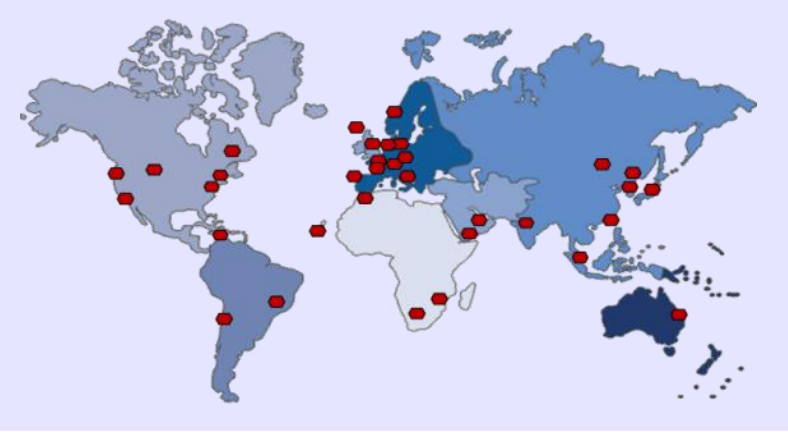
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The project was informed by desk work, 18 interviews and a well-attended workshop



E4tech is a strategic consultancy firm working across strategy, energy and sustainability

- International consulting firm, offices in UK and Switzerland
- Focus on sustainable energy, transport, chemicals
- Established 1997, always independent
- Deep expertise in technology, business and strategy, market assessment, techno-economic modelling, policy support...
- A spectrum of clients from start-ups to global corporations. E.g....



This work could be deepened and extended in several ways

Strategic topics:

- How important is the presence or absence of a supply capability – which are crucial for a UK battery company to grow in UK, which are nice-to-have?
- What is the UK's potential competitive advantage in each supply area versus competitors? Should the UK specialise? What are the implications for attracting a cell manufacturer to UK?
- What is needed to reduce uncertainty for the chemicals and process industry?
- What level of collaboration across the supply chain is appropriate?
- What ongoing mechanisms are needed to ensure close collaboration between the battery and chemicals industries (R&D funding, forums, roadmaps etc)?

Specific analyses:

- Quantify additional opportunities for export of chemicals and supply to non passenger car applications
- Identify potential production capacities and ramp-up times by supplier / material
- Quantify process equipment opportunities
- Quantify value in terms of margins not sales
- Include the role of facilitators by mapping R&D and technology providers
- Develop employment and other economic multipliers that are specific to the EV battery supply chain
- Monitor the development of the supply chain and the changing perception of chemical and process firms as the education process progresses
- Section 4 of this report could be developed into a full supplier directory