

Supply Chain Opportunities for Automotive Batteries

Low Carbon Propulsion Solutions – the £24bn Opportunity
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There is no longer a “tipping point” for EVs – they are inevitable

Energy and Clean Growth Minister Chris Skidmore said (27 June 2019):

The UK kick-started the Industrial Revolution, which was responsible for economic growth across the globe but also for increasing emissions.

*Today we’re leading the world yet again in becoming the first major economy to pass new laws to **reduce emissions to net zero by 2050** while remaining committed to growing the economy - putting clean growth at the heart of our modern Industrial Strategy.*

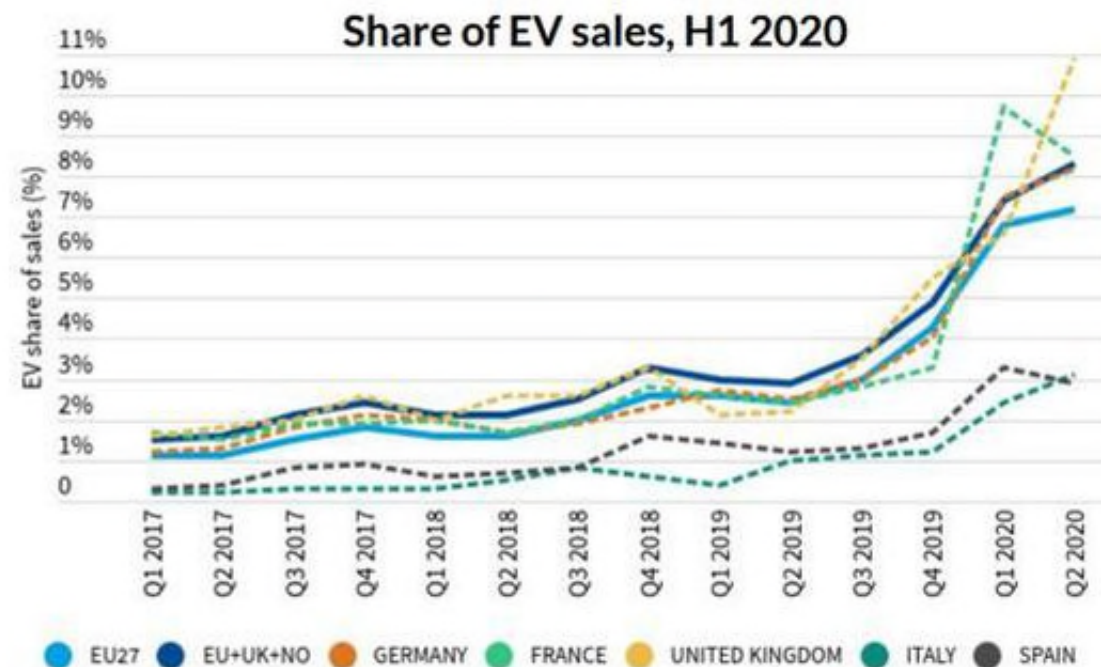


UK Prime Minister Boris Johnson announced (18 Nov 2020) 10 point plan for “Green Industrial Revolution”

*4. Electric vehicles: **Phasing out sales of new petrol and diesel cars and vans by 2030** to accelerate the transition to electric vehicles and investing in grants to help buy cars and charge point infrastructure.*

[PHEVS and BEVs will be allowed from 2030-2035, after which no internal combustion engines will be allowed]

EV models and sales are increasing significantly



Source: Transport & Environment analysis of ACEA Quarterly Alternative Fuel Vehicle Registrations

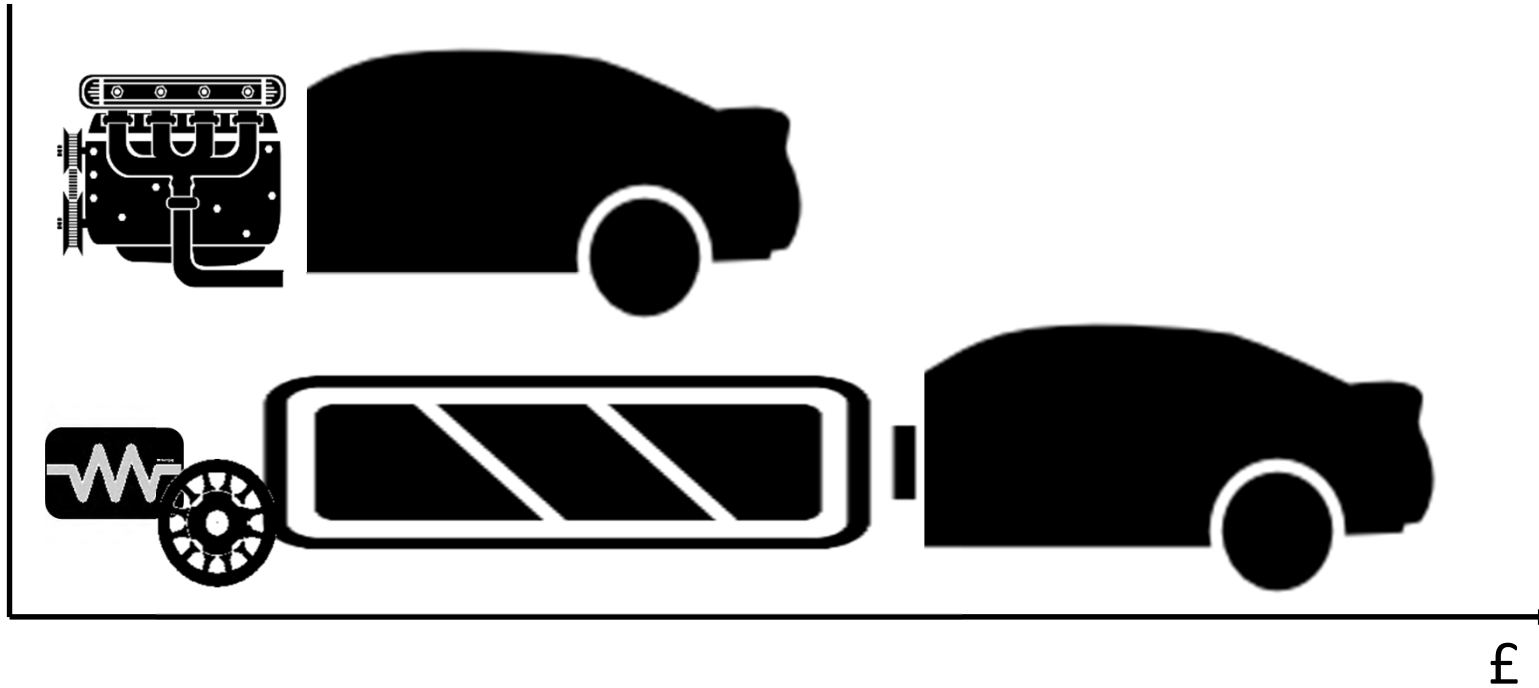
37% of November 2020 UK car sales had a traction motor and power electronics

**xEV % sales improved during COVID
And spiked at >30% in UK March 2020**

SMMT November sales data

	2020	2019	% change	Mkt share -20	Mkt share -19
Diesel	15,925	36,329	-56.2%	14.0%	23.2%
MHEV diesel	4,719	4,375	7.9%	4.1%	2.8%
Petrol	55,855	96,166	-41.9%	49.1%	61.4%
MHEV petrol	12,104	3,639	232.6%	10.6%	2.3%
BEV	10,345	4,652	122.4%	9.1%	3.0%
PHEV	7,717	4,362	76.9%	6.8%	2.8%
HEV	7,116	7,098	0.3%	6.3%	4.5%
TOTAL	113,781	156,621	-27.4%		

Electrification is a major commercial opportunity for the UK

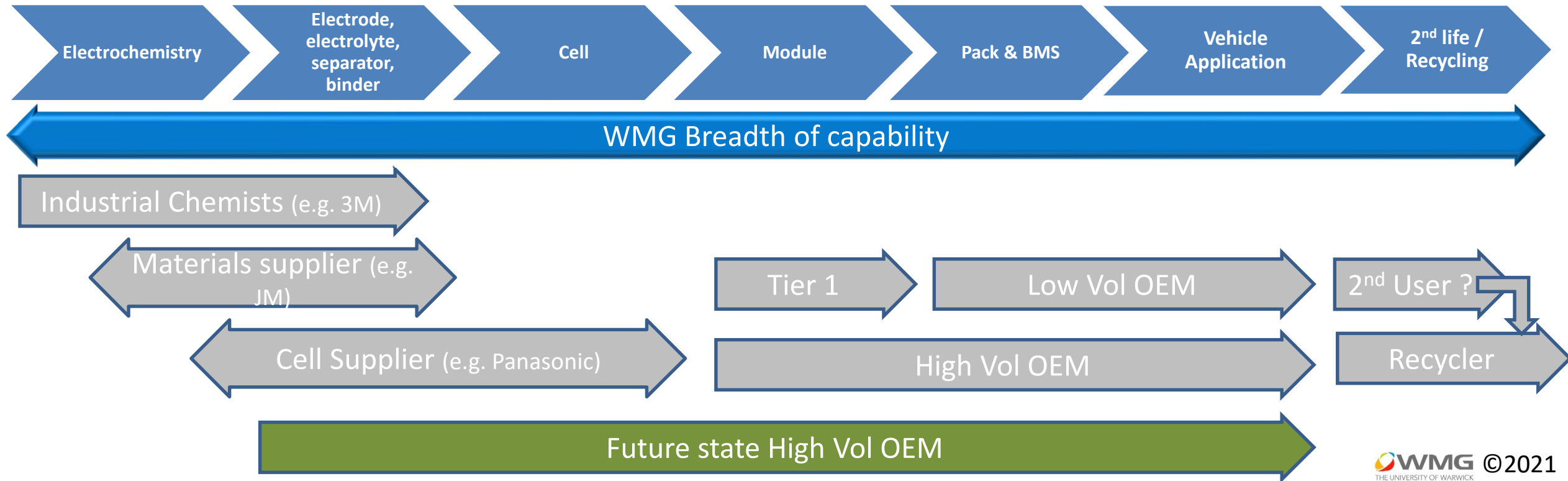


- ▶ One third of conventional vehicle cost is powertrain
- ▶ Motor and power electronics are similar in value to this
- ▶ Battery typically 5x that

Motors / drives	2030 UK (\$ billion)	2030 Global (\$ billion)
PHEV	0.2	9.6
BEV	0.8	24.4
Total	1.0	33.8

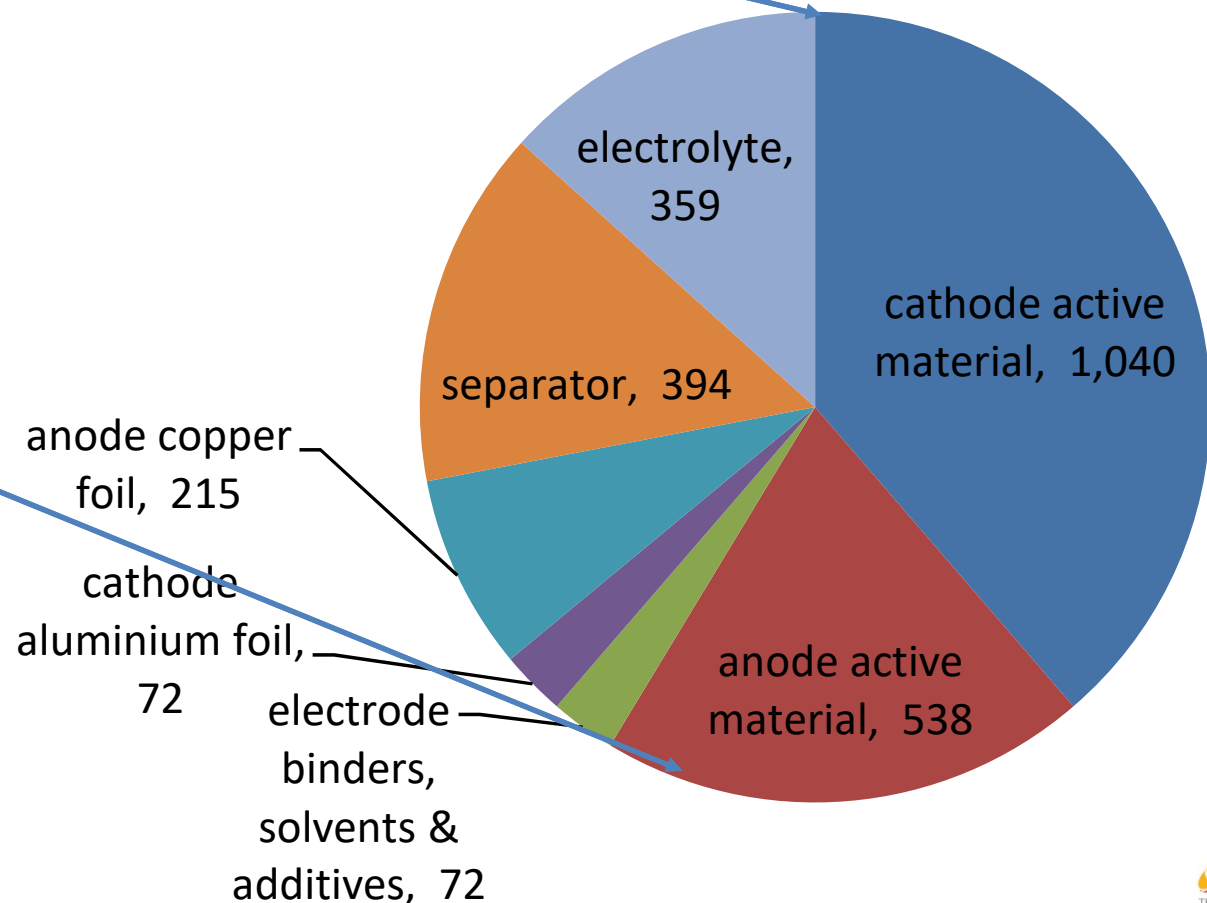
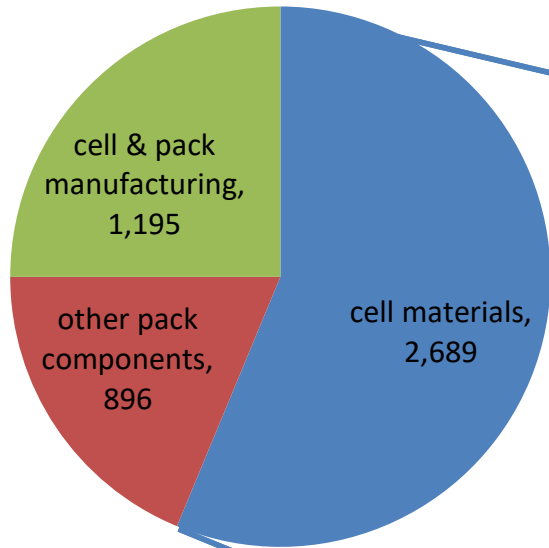
Batteries	2030 UK (\$ billion)	2030 Global (\$ billion)
PHEV	0.6	18
BEV	4.9	144
Total	5.5	162

Automotive Industry Supply Chain for Batteries



Supply of Battery Cell Materials for UK Car Manufacturing

- 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)



Key assumptions:

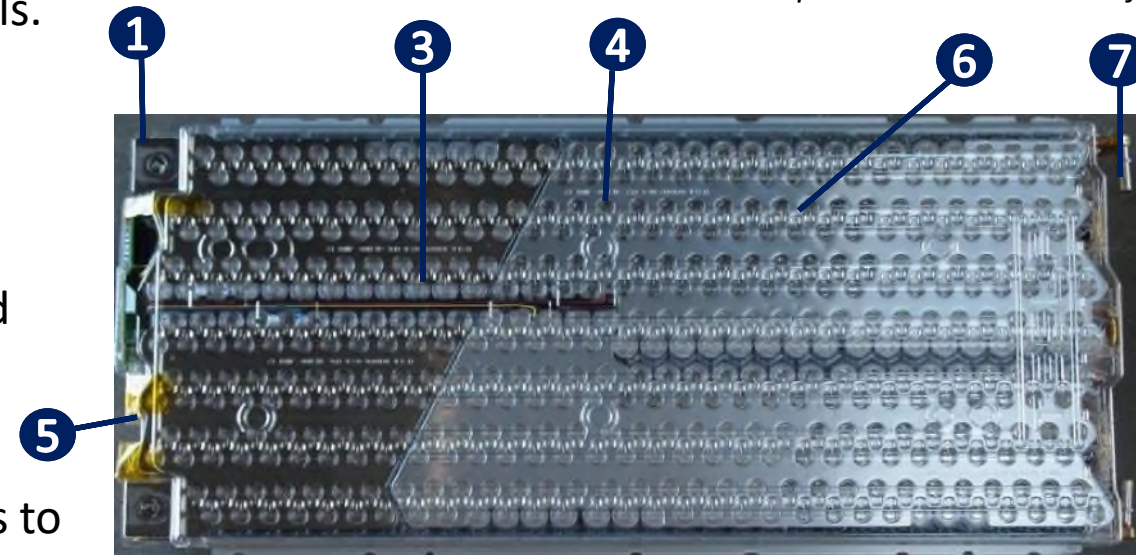
850k EVs manufactured per year (~2030)
50 kWh average pack size
Current Graphite/Nickel Manganese Cobalt chemistry
150 \$/kWh pack price

Automotive Battery: Module Components

1. **Casing:** Metal casing provides mechanical support to the cells and holds them under slight compression for best performance.
2. **Clamping Frame:** Steel clamping frames secure the modules to the battery case.
3. **Temperature Sensors:** Sensors in the modules monitor the cell temperatures to allow the battery management system to control cooling and power delivery within safe limits.
4. **Cells:** Each module in a pack contains the same number of cells. The number of cells varies by format and usage requirements.
5. **Terminals:** Two terminals on the module allow it to be electrically connected to other modules via the bus bars.
6. **Tab Interconnects:** each cell has two tabs – one positive and one negative. These are welded together in series then connected to the terminals.
7. **Cooling Channels:** Liquid coolant runs between rows of cells to withdraw heat and avoid thermal runaway. Other packs, such as Nissan Leaf, instead use air cooling.



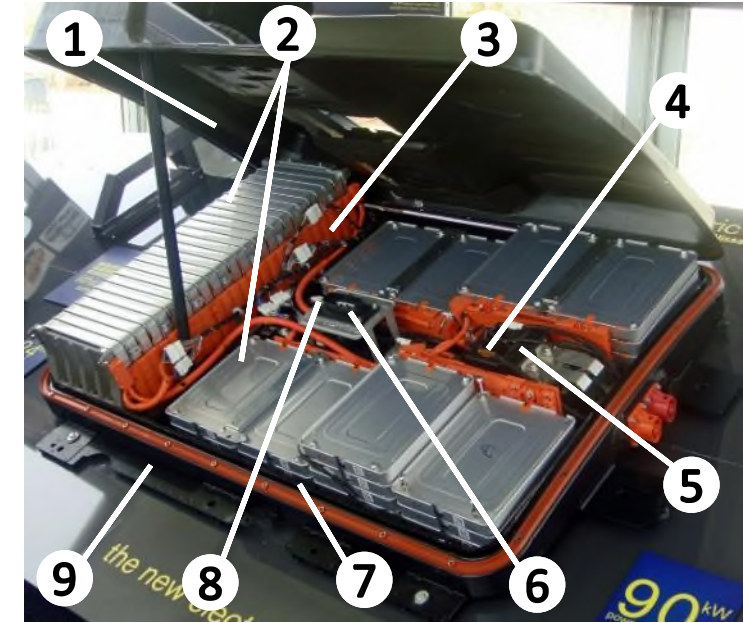
Sample module: Nissan Leaf



Sample module: Tesla Model S

Automotive Battery: Pack Components

1. **Upper case:** Provides fire protection and watertight casing for the battery components and protects it from dirt ingress. Also shields service personnel from high voltage components.
2. **Battery modules:** A 'module' is formed by connecting multiple 'cells', supporting those cells in a structural frame and then attaching terminals. Modules are designed according to cell format and vehicle requirements.
3. **Bus Bars:** Electrically connect the battery modules together, and connect the modules to the contactors.
4. **Contactors:** Electrically isolate the battery pack from the vehicle. Closed upon completion of safety tests and opened in the event of a crash or battery fault.
5. **Fusing:** Fuses protect expensive components from damage due to power surges and faults.
6. **Disconnect:** Used to electrically isolate the battery from the vehicle during servicing or maintenance.
7. **Cooling:** Modules require cooling. Packs may be cooled using air, water or vehicle air conditioning fluid.
8. **Battery Management System (BMS):** The BMS ensures the cells remain within their safe operating temperatures and voltages. It measures the remaining charge in the battery and reports on state of health. It also ensures the battery is correctly connected and isolated before closing the contactors.
9. **Lower case:** Structural casing supports the mass of the battery pack and protects it from damage.



Sample pack: Nissan Leaf

Battery recycling essential for environmental & economic sustainability

1. Pre-treatment



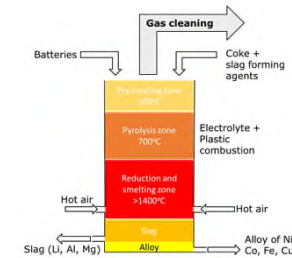
2. Processing + electrolyte treatment



3. Material separation



4. Material Recovery



Discharging

Dismantling

Pyrolysis

Freezing

Controlled atm' shredding

Inert shredding

Wet shredding

Pyrometallurgical

Magnetic separation

Dry separation

Wet separation

Screening

Solvent extraction

Alloy leaching

Cathode leaching

Precipitation

Tariff free UK/EU trade requirements for electrified vehicles

	2021-2023	2024-2026	2027 onwards	Comments
Vehicle (cars, buses, coaches, light duty and heavy duty vehicles)	60% max NOM	55% max NOM	45% max NOM <u>and</u> EV and PHEV batteries must originate in territory	Will create pressure to localise vehicle parts to UK/EU from Asia – especially where low cost batteries used (e.g. LFP)
Battery Pack	70% max NOM <u>or</u> “assembly of pack from non-originating cells or modules”	40% max NOM <u>or</u> CTH with cathode material made in territory	30% max NOM <u>or</u> CTH with cathode material made in territory	Assembly of packs in UK/EU required to count as local. 2027 requirements likely not possible without cathode manufacture in UK/EU
Cells and Modules	70% max NOM	50% max NOM <u>or</u> CTH with cathode material made in territory	35% max NOM <u>or</u> CTH with cathode material made in territory	2024 just about possible with UK/EU cell assembly and imported cathode if <u>everything</u> else UK/EU*. 2027 will need cathode from UK/EU.
Comments	Ok for current UK EV manufacturing methods and supply chains.	Could just get to 40%/50% NOM without cathode manufacture, but almost <u>every other</u> part must be UK/EU*. Coating in UK/EU required.	Can't do this without cathode material manufacture in UK/EU ?. Battery pack (except HEV) must be UK/EU.	*possible but very difficult

Terms and their application

NOM – Non-Originating Material

- ▶ Input materials imported from outside UK/EU

RVC – Regional Value Content

- ▶ Value added in UK/EU
- ▶ $RVC + NOM = 100\%$

CTH – Change in Tariff Heading

- ▶ Components made in-territory from imported materials becomes considered local as a result of processing materials with different tariff headings into those covered by this agreement
- ▶ E.g. purchasing anode active materials and processing into coated anodes means the anode is considered “local”
- ▶ BUT – cathode materials are specifically excluded from CTH – meaning they must be made in-territory from (imported) raw materials in order to secure a CTH

Bilateral / Diagonal provisions

- ▶ UK and EU have full “bilateral cumulation” (i.e. components originating in UK or EU can both count towards RVC)
- ▶ Third countries are counted as NOM by both - “diagonal cumulation” is not allowed
- ▶ Agreement is silent on whether this may be extended to countries with whom both EU and UK have FTAs.

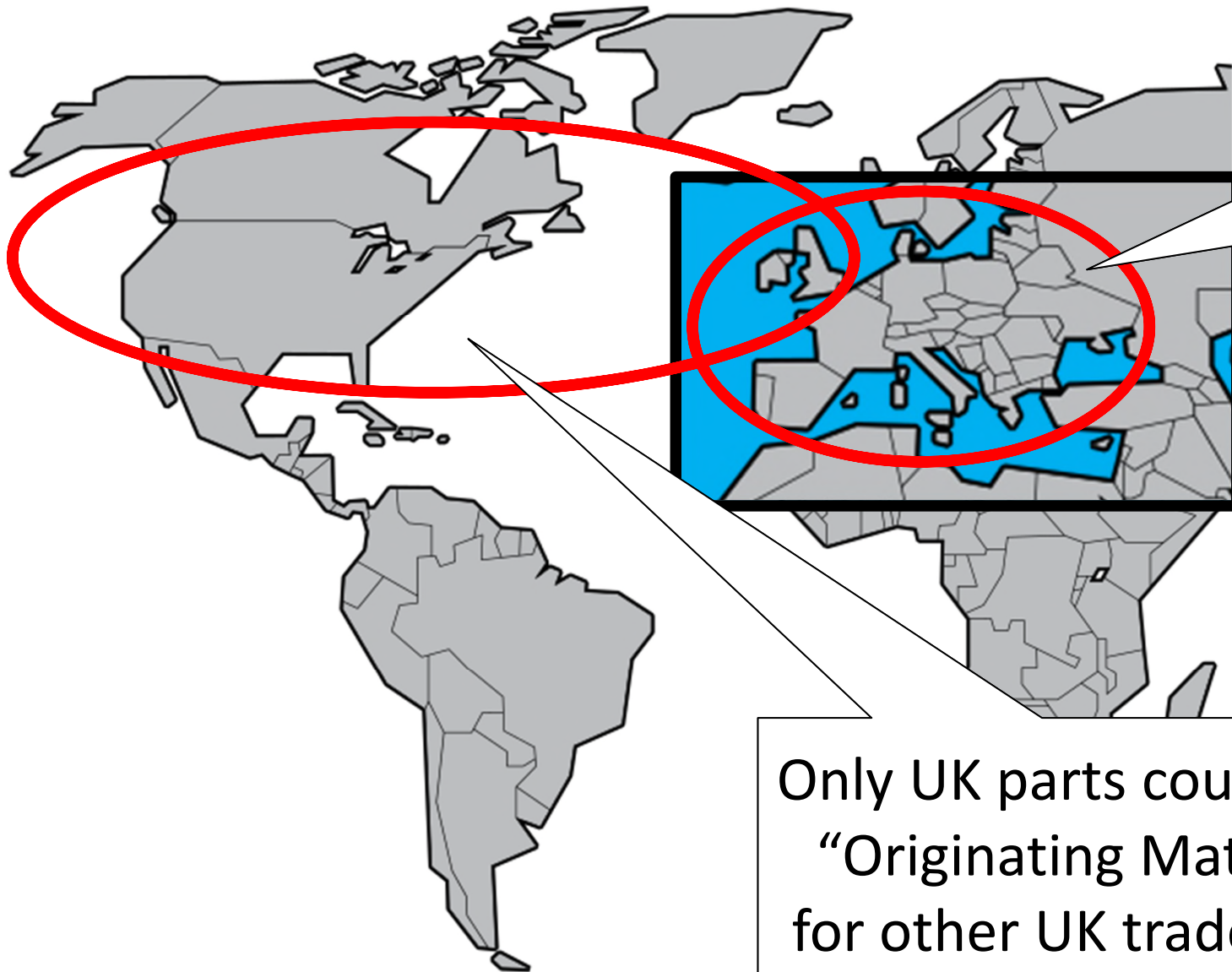
ICE vehicles

- ▶ Requirement is for 45% max NOM from 2021.
- ▶ Most UK OEMs at or close to this.

Motorcycles and carriages for disabled persons

- ▶ Requirement is for CTH or 50% max NOM from 2021.
- ▶ Applies ICE and EV

UK trade agreements with RoW will consider EU parts as NOM



UK / EU trade deal treats parts from UK and/or EU as “originating material”

For UK OEMs – whether to source in UK or EU will be influenced by global sales volumes

Only UK parts counted as “Originating Material” for other UK trade deals

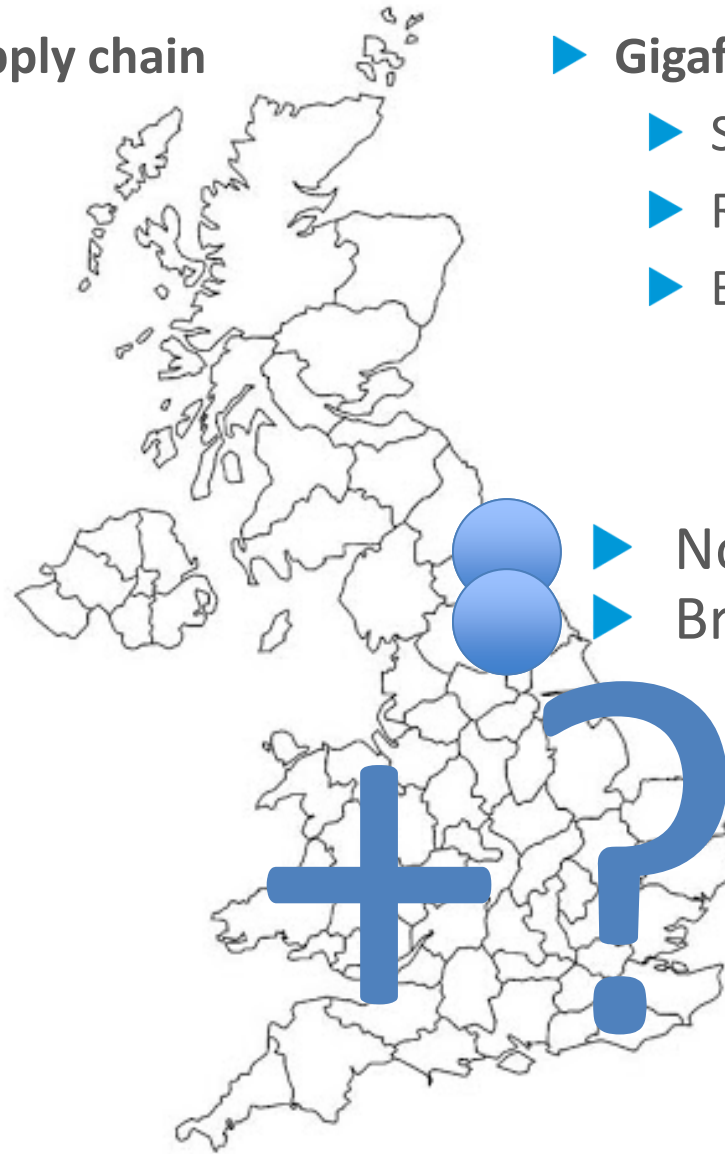
UK Gigafactory – the keystone in the supply chain

▶ Gigafactory unlocks upstream supply chain

- ▶ Buyer for materials
- ▶ Justifies plant investment
- ▶ Links to UK R&D capability

▶ Gigafactory unlocks downstream supply chain

- ▶ Security of supply in sellers' market
- ▶ Rules of origin for export
- ▶ Bespoke product once volumes justify it



▶ Now - AESC – 2-4GWh/yr

▶ BritishVolt announced Blyth 30GWh/yr

Thank You

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