Q2 2023 Automotive industry demand forecast

September 2023

ADVANCED PROPULSION CENTRE UK

Accelerating Progress

Q2 2023 – Automotive industry demand forecast

This demand forecast covers

Markets	Global; European; UK
Vehicles	Light Duty Vehicles (LDVs) Heavy Goods Vehicles (HGVs) 
Materials	Lithium; Cathode Active Material (CAM); Battery foils; Electrolyte and Separator material

Our process

The data in these demand graphs is based on APC insight gathered from UK OEMs on xEV production; APC and Automotive Council PEMD traction specifications; and powertrain split forecasts from S&P Global IHS Markit. Rho Motion, BloombergNEF (BNEF) and Wood Mackenzie have also guided the demand forecast.

Quarterly updates

Any developments in the sector will change and influence these forecasts. APC will update these on a quarterly basis in line with the impacts of those announcements.

Q2 2023 – Summary

Summary – Changes to projected demand by region

Q2 2023 compared to Q1 2023

Global demand update	• World battery demand continues to grow as USA overtakes Germany as the second largest EV market.	page 8
European demand update	• The United States' Inflation Reduction Act has shifted investment momentum away from Europe. • BEV production plans potentially being held back by supply chain localisation challenges.	page 10
UK demand update	• JLR, Tata Agratas, and BMW Mini investment confirmed for UK. • Some reduction in LCV and PHEV demand balanced by increases in expected passenger car demand. • Increased demand from BEV passenger cars pushes 2030 demand up to 90 GWh. • Overall production reduced from 1.3 to 1.2 million – reductions in ICE-led and PHEV vehicles. • Meeting the current timeline for EU rules of origin expected to be a key challenge for UK-based BEV manufacturers.	page 21

Summary – Trends insight

Q2 2023

E-Motors demand	**E-Motors explainer** • Analysis of different motor technologies and our motors forecast. • Explainer of role of REE, why and how Tesla might be moving away from REE.	pages 13-21
Magnet materials and supply	**Potential magnet materials** • Analysis of different magnet materials, relative performance characteristics.	pages 15-19

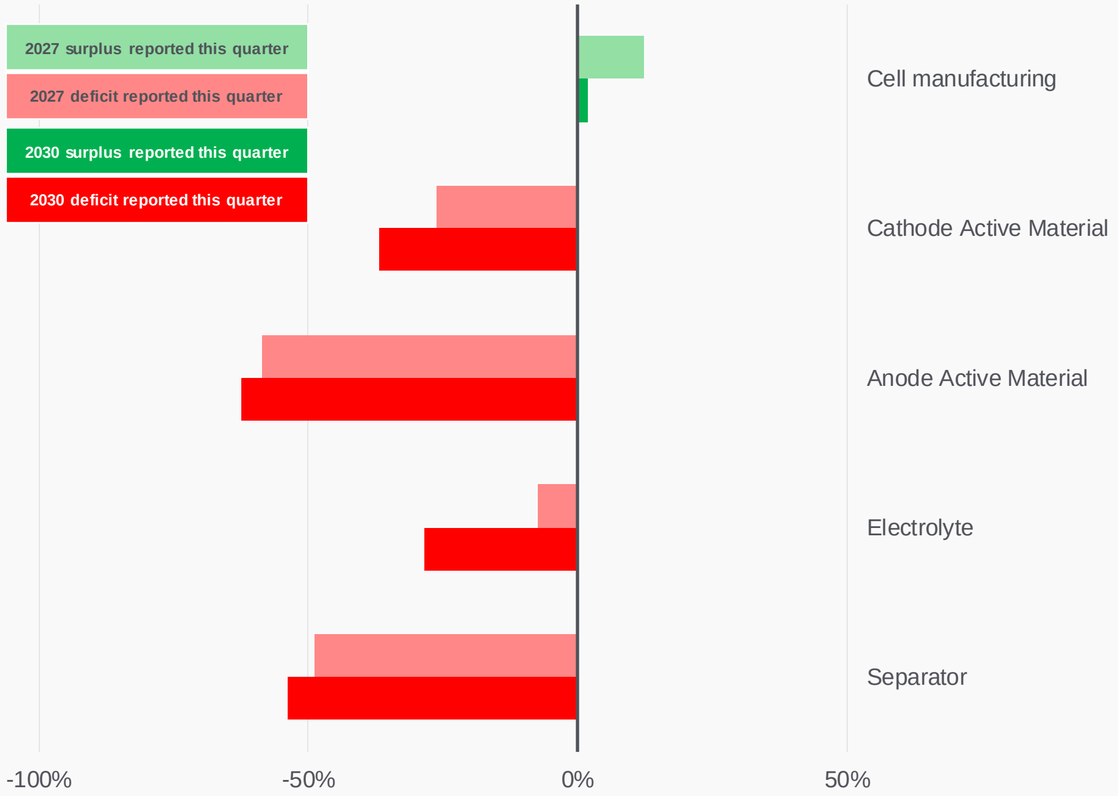
Source: APC analysis

Summary – Supply chain activity

Q2 2023 notes

- The graph refers to Europe's capability to supply battery cells and sub-components that arise from local vehicle production.
- It assumes Europe is a self-sustaining bloc with no imports or exports.
- USA has overtaken Germany as second largest EV market. Capacity demand and incentives are attracting investment to the USA market from Europe.

2027 and 2030 European[1] capacity vs demand balances



Status of regional capacity* v demand balance in 2030	Value** (%)	UK supply chain status
Announced capacity plans well in excess of demand however delays and potential cancellations are anticipated.	18%	Tata group commit to developing a gigafactory in the UK with up to 40 GWh capacity. There is further opportunity for investment with a supply gap remaining and demand expected to continue to grow beyond 2030.
Chinese supplier Huayou Cobalt announces plans to produce cathode material in Hungary – likely pCAM. This will be Huayou Cobalt's first European factory.	**46%**	Required to be made in the UK from 2027 for UK cells to qualify as local and to avoid EV tariffs in the EU.
No new major projects announced, significant under investment in localisation of graphite supply.	9%	Expected to be the next 'big thing' after CAM. Access to low-cost renewable energy is key to manufacturing competitiveness.
No new major projects announced, but future European electrolyte supply likely to near or match European demand as gigafactory plans clarified.	8%	Value in today's liquid electrolyte is relatively low, but semi-solid and solid-state electrolytes are a key investment consideration.
Separator materials remains a big growth opportunity for localisation in Europe.	7%	Significant opportunities to localise in UK even though typically manufactured in Eastern Europe.

Source: APC internal analysis of public announcements, BNEF forecasts (Accessed: 25.05.2023)
1) Europe region includes non-EU countries such as Turkey

*Risk-weighted capacity based on APC internal assessment of announced and under construction projects
**Value in terms of cost contribution to total cell cost based on an NMC811 cell

Q2 2023 – Demand update

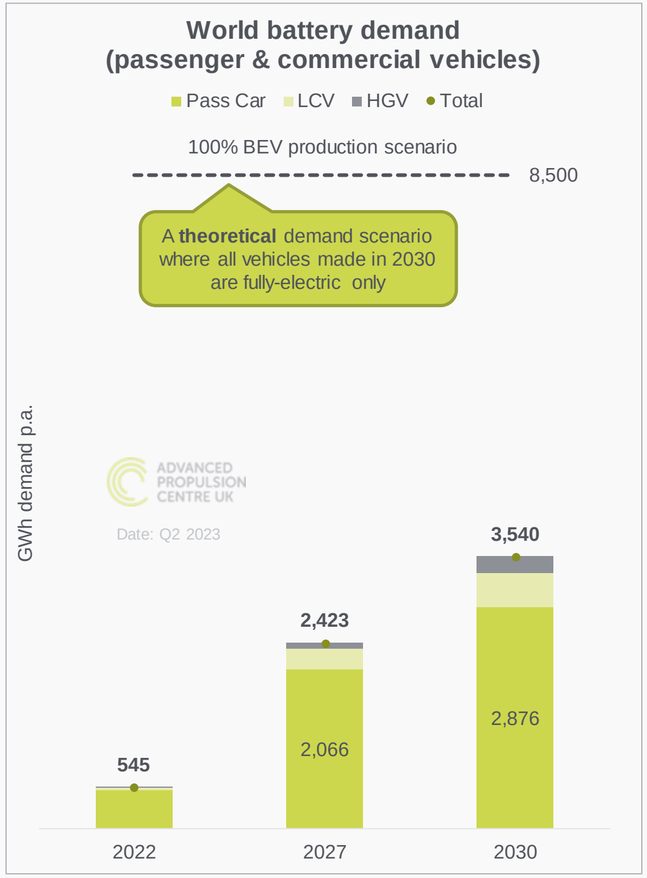
The following section includes battery demand from both Light Duty Vehicles (LDVs) and Heavy Goods Vehicles (HGVs)

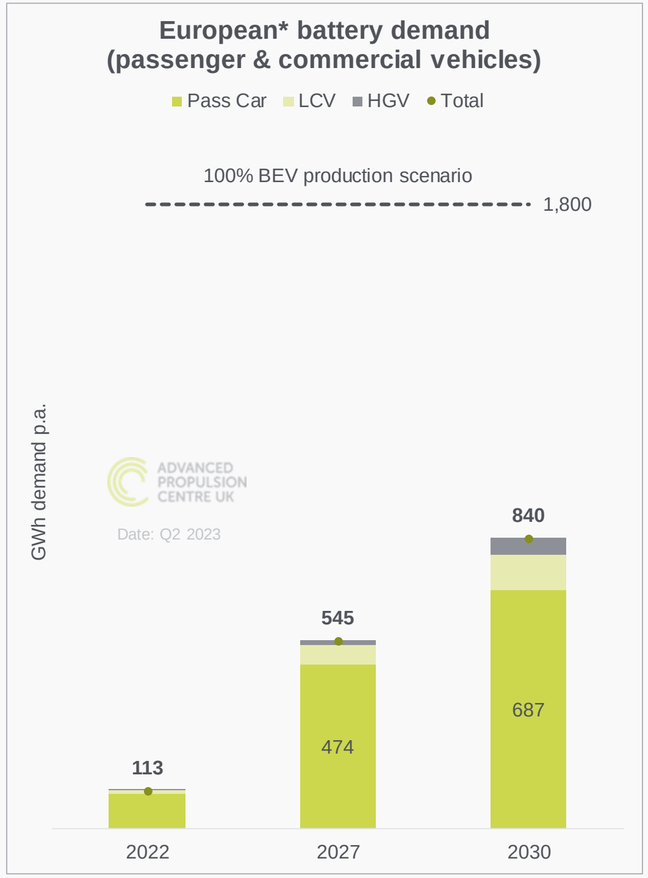
Battery demand forecast

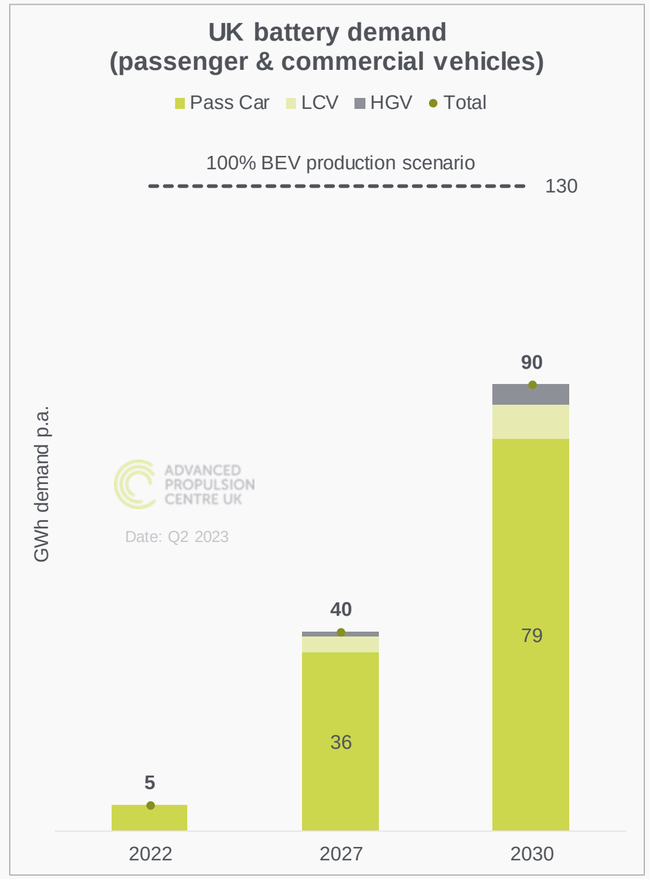
LDVs and HGVs

Q2 2023 notes

- Global battery demand remains strong with over 3,500 GWh demand by 2030.
- UK has seen some reduction of commercial vehicle demand but is buoyed by passenger car demand.







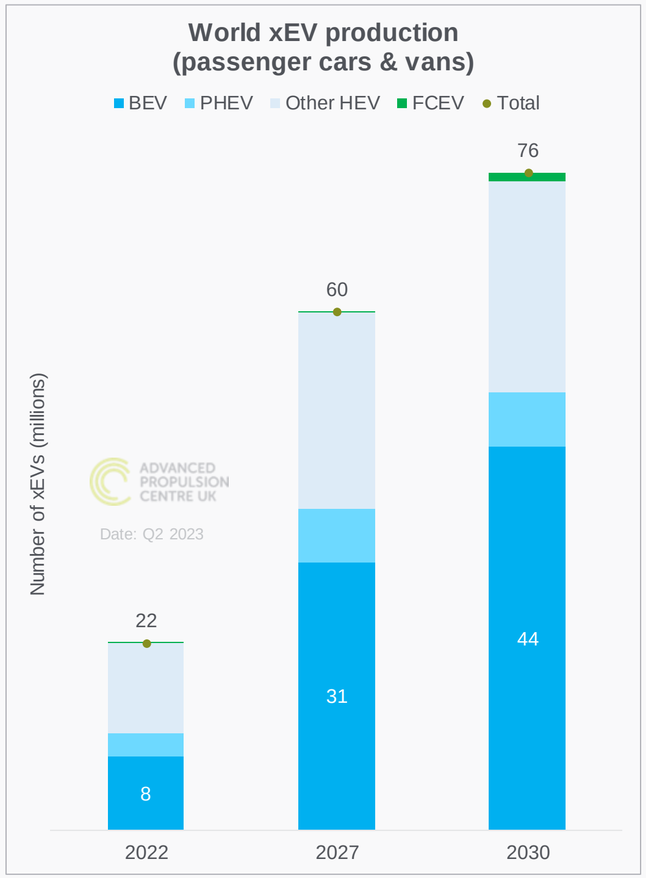
Source: APC Demand Databases using S&P Global AutoTechInsight (Jul 2023), Rho Motion data (Jul 2023), BNEF (Jul 2023), LMC (Jul 2023)
Note: LCV = Light Commercial Vehicles < 3.5t, buses not included. *European forecast includes non-EU countries such as Turkey

World xEV production

Passenger cars and vans

Q2 2023 notes

- World vehicle production would require 3,500 GWh of batteries, with 44 million battery-electric cars and vans produced globally by 2030.



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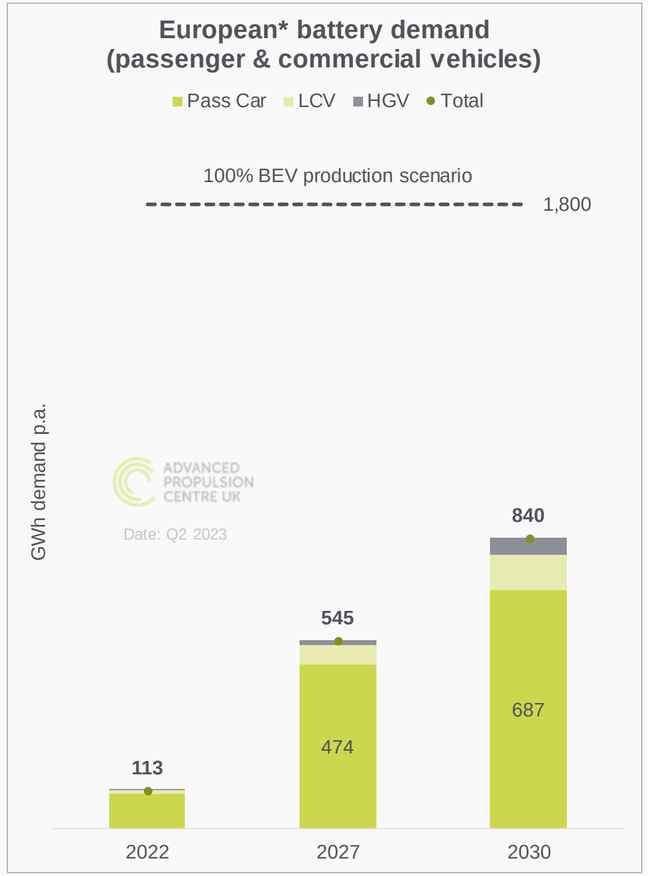
Note: LCV = Light Commercial Vehicles < 3.5t, buses not included.

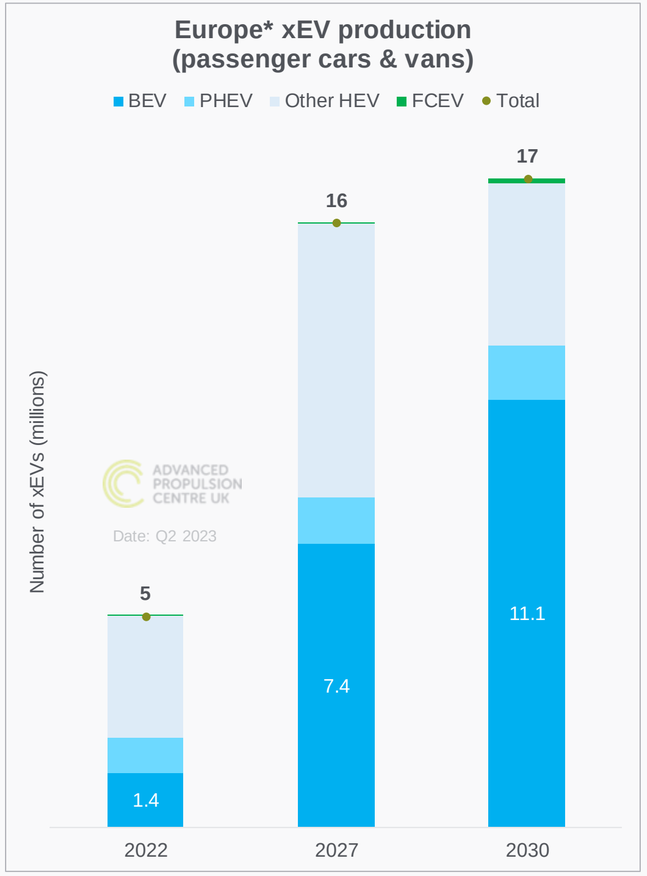
European xEV production

Passenger cars and vans

Q2 2023 notes

- 11 million fully-electric vehicles to be produced in Europe in 2030.
- UK reduction in PHEV and ICE production not reflected at European level.





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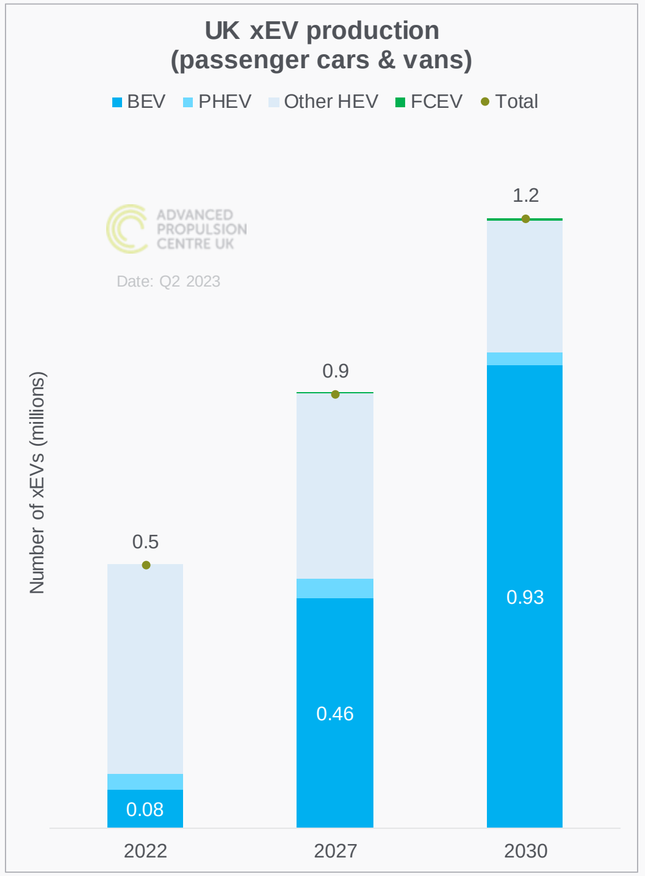
Note: LCV = Light Commercial Vehicles < 3.5t, buses not included. *European forecast includes non-EU countries such as Turkey

UK xEV production

Passenger cars and vans

Q2 2023 notes

- BEV production expected to be more than 40% of output in 2027 when new rules of origin come into force
- Reduction in PHEV and other hybrid production as OEM strategies shift to more ZEVs



Source: APC Demand Databases using S&P Global AutoTechInsight (Jul 2023), BNEF forecasts (2023)
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Q2 2023 – Trends insight

Changing trends in motor technology have an impact on material demand forecasts

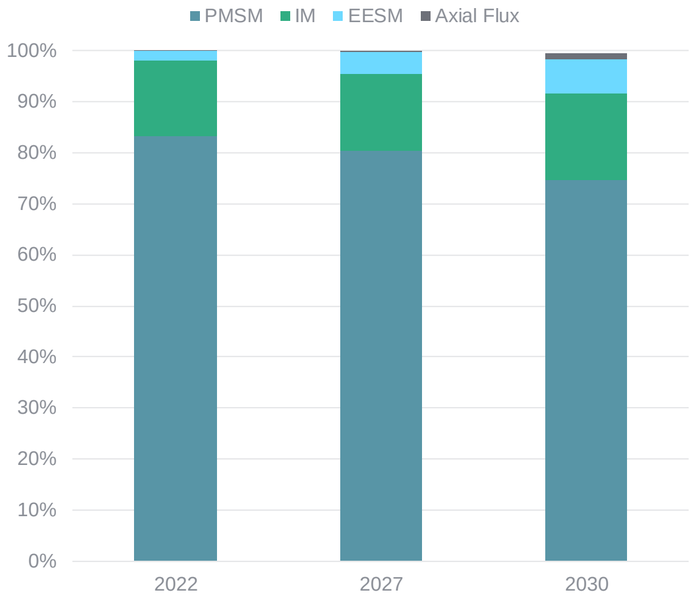
APC's quarterly demand forecasts have included motor materials demand based on unchanging motor type share (pages 31-32). This quarter we are changing our forecast to include a forecast of motor technology trends.

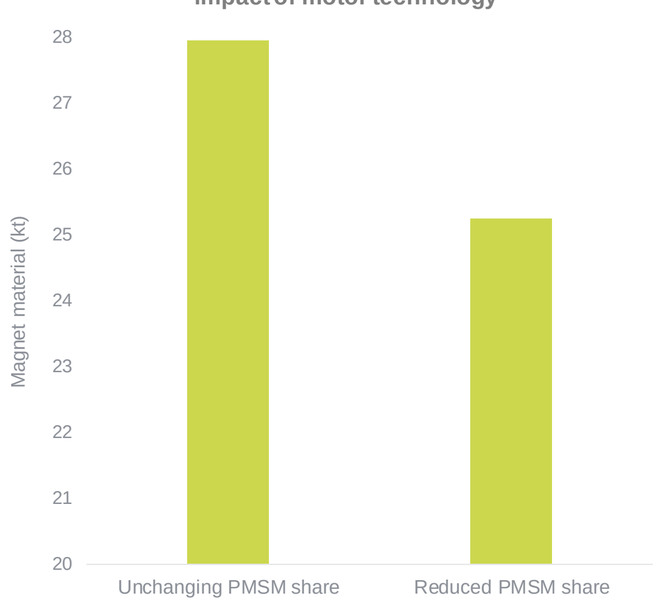
In this forecast the share of Permanent-Magnet Synchronous Motors (PMSM) is expected to reduce while Induction Motors (IM) and Electrically Excited Synchronous Motors (EESM) increases. This is in part driven by motor manufacturers developing motor technology that doesn't rely on rare earth materials.

The impact on the material demand is primarily a reduction in demand for magnet material.

Demand for Induction Motors (IM) and Electrically Excited Synchronous Motors (EESM) increases over the coming years.

Projected use of magnet material in motors is reduced in future forecasts.





Source: RhoMotion, Wood Mackezie, BloombergNEF, APC analysis. Image: Vitesco Technologies

Strengths, weaknesses and magnet use in motor technologies

	Permanent magnet motors are expected to continue to be the leading motor choice for the foreseeable future but currently rely on rare earth element (REE) magnets	Motors that do not contain magnets.	
	Permanent-Magnet Motors (including axial flux)	**Induction Motor**	**Electrically Excited Synchronous Motor**
Magnetisation	Permanent magnets, which typically include Neodymium (NdFeB), Samarium-Cobalt (SmCo).	Electromagnetic induction, laminated iron cores, squirrel cage or wound type.	Rotor is magnetised via external source of power.
Strengths	• A high efficiency, due to permanent magnets, instead of field windings. • Precise control for accurate speed and positioning, creating a smoother operation.	• Reliability and robustness, a simpler construction means minimal maintenance and increased lifespan. • Cost-effective due to simpler design, easier manufacturing process and no REE usage.	• More efficient at higher speeds and draws less reactive power, further increasing efficiency. • Cost-effective with no REE usage. • Adjustable power factor allowing optimisation to vehicle and drive characteristics.
Weaknesses	• High-cost, primarily due to permanent magnets created from rare earth elements (REE). • Can be sensitive to higher temperatures affecting performance. Additional cooling is necessary to regulate temperature.	• A lower power factor reduces overall efficiency but can be corrected with capacitors, leading to higher costs. • Limited range of speed control, restricted by the frequency of the power supply.	• EESM motors require sophisticated control algorithms and feedback mechanisms, increasing complexity. • Any variation in the power supply frequency/consistency can affect EESM motor performance.

Source: RhoMotion, APC analysis

What are the alternative magnet material choices?

Permanent magnets used in motors are typically made using Rare Earth Elements (REE). Contradictory to their name some REE are abundant but often not in concentrations to be able to extract on a commercial basis.

Two of the main REE currently used in permanent magnets, dysprosium and terbium, are much less abundant and economic reserves outside China containing these two elements are limited. China controls 90% of REE market.

There has been speculation that Tesla is contemplating switching to ferrite magnets following a Tesla press release in March 2023. Whilst these motors would be larger and heavier there are advantages in using ferrites due to the more abundant and cheaper raw materials used to make them (ferric iron and strontium carbonate) over REE. Over the past few years, Tesla have reduced the size of the permanent magnets in its PMSM motors which potentially enables a switch to larger magnets.

Magnet type	Advantages	Disadvantages	Availability
NdFeB (LREE)	Superior magnetic properties, low relative cost, easily processable.	Fragility and low resistance to higher temperatures can limit the usability for NdFeB. The process for manufacturing NdFeB magnets results in hazardous waste.	China Australia USA
Strontium/Barium ferrite $(SrFe_{12}O_{19})/(BaFe)$	Corrosion-resistant, relatively good temperature characteristics and an affordable purchase price.	Weaker than NdFeB – need a larger magnet or higher speed (Hitachi metals simulation).	Spain China Mexico
AlNiCo	Corrosion resistance and superior temperature characteristics.	They can both gain and lose magnetism easily, combined with poor resistance to interference.	China USA Europe
SmCo (LREE)	High heat resistance and resistance to corrosion.	Relatively expensive.	China Australia USA

LREE: Light Rare Earth Elements

What might drive OEMs to reduce reliance on REE?

Cost

Ferrite materials cost 80-90% less than materials used in neodymium-based magnets. Alongside a simpler manufacturing process ferrite magnets can be significantly cheaper on a per kg perspective.

However, ferrite magnets do not provide the same magnetic strength and therefore larger magnets are required. This leads to a larger and heavier motor which has implications in packaging and overall efficiency.

Motor design can mitigate some of the differences in magnets and investment in ferrite magnets could further close the performance gap.

In total this means it is not a simple case of using a larger, cheaper magnet and gaining the total material cost saving.

Supply chain security

China has a market share of over 85% for neodymium magnets, although new supply is coming online from Myanmar, USA, Australia and Canada.

Supply and pricing depends on relative prices of other rare earth elements mined with neodymium.

China has introduced restrictions on other rare earth elements and could extend those restrictions to include neodymium and related magnet materials and equipment.

The materials for ferrite magnets are more easily mined and processed globally and offer opportunity for alternative supply chains.

Environmental, social and corporate governance (ESG)

Hazardous waste is produced in the mining of neodymium. Neodymium is often found with radioactive elements adding an extra safety consideration.

While China dominates the supply chain, concerns over environmental standards in mining and refining remain.

Improving ESG (environmental, social, and corporate governance) factors is an important consideration for the automotive industry and makes a safer cleaner ferrite supply chain more attractive.

Can ferrite magnets achieve similar performance to REE-based magnets?

Research by Proterial shows that similar power can be achieved without significantly changing motor weight and size.

Examples of xEV traction motor designs

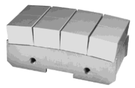
	Nd-Fe-B magnets used (Basis of comparison)	High-performance ferrite magnets used [1] (Equivalent motor performance)	High-performance ferrite magnets used [2] (Equivalent motor size and higher rotation speed)
Motor: 1/8 model • Nd-Fe-B magnets • High-performance ferrite magnets NMF -15G			
Max. output	110kW	110kW	105kW
Max. rotation speed	10,000 rpm	10,000 rpm	15,000 rpm
Thickness in axial direction	1(ref.)	1.4	1.0
Magnet B_r	1(ref.)	0.37	0.37
Magnet weight	1(ref.)	1.7	1.2
Motor weight	1(ref.)	1.3	1.0

Proposing High-Performance Ferrite Magnets for xEV Traction Motors | Proterial, Ltd.

What might drive OEMs to reduce reliance on REE?

The process of manufacturing ferrite magnets is not as costly, complicated, or polluting as producing rare earth permanent magnets (REPM). The production of ferrite magnets begins with calcining a finely powdered mixture of iron oxide (rust) and strontium (or barium) carbonate at a ratio of circa 9:1 to produce a metallic oxide material.

NdFeB magnets



Mine carbonatite extract REE ore via gravity and/or flotation.

“Crack” REE concentrate w/NaOH or H2SO4 to intermediate REE product.

Solvent extraction to separate out individual REE compounds.

Molten salt electrolysis of Nd(Pr) compounds with Fe & B ahead of strip casting.

Milling, mixing & pressing.

NdFeB sintering.

Machine to spec.

Plating to prevent corrosion.

Strontium (barium) ferrite magnets

Ferric iron source. Mine celestite (or barite) concentrate ore by gravity.

Convert ore to Sr(Ba) carbonate via soda/black ash process.

Calcine ferric iron with Sr (Ba) carbonate 9:1 (+/-minor La addition).

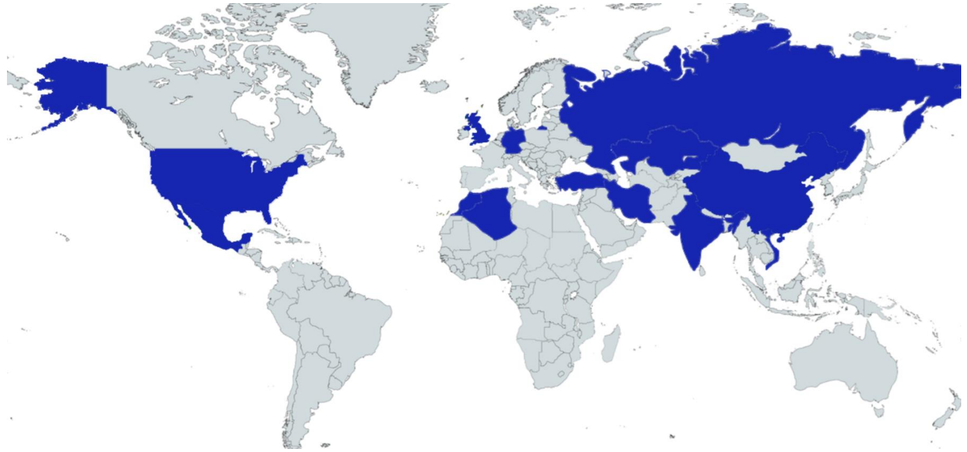
Wet milling and pressing followed by sintering.

Machine to spec. Plating not required as non-corrosive.

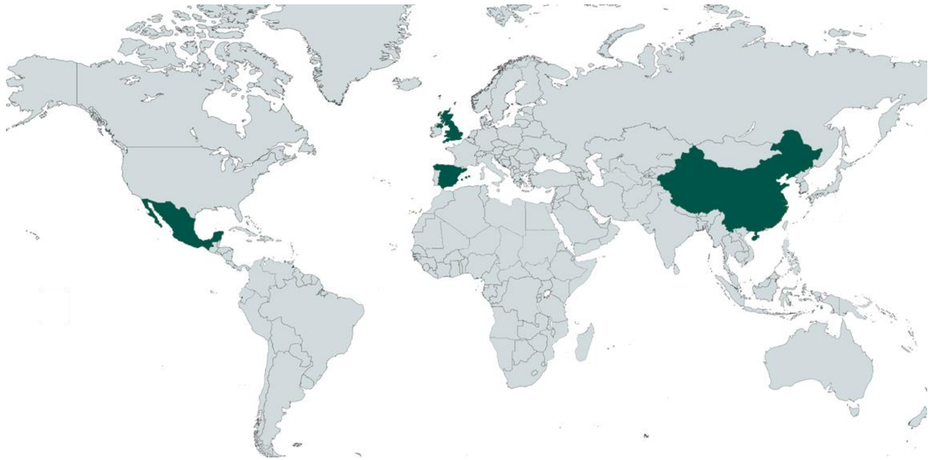
Ferrite magnets: Supply chains

- Alongside ferric iron, strontium and barium are two key materials that are used in the production of hard ferrite magnets.
- Barite was identified as a critical material by the EU in 2011. Strontium was added to the EU critical materials list in 2020, the economic importance of Strontium was upgraded in 2023.
- Celestite ($SrSO_4$) is the main ore for Strontium and Barite ($BaSO_4$) is the main ore for Barium.
- Spain is currently the world's largest Celestite miner, exporting predominantly to China. India and China are the largest Barite miners.
- The UK has deposits of both Barite and Celestite and has had historic activity in the mining of both, with Barite still being produced at a single UK site.

Barite



Celestite



Source: Edward Loye (Geolithical), NERC, UKCMIC, BGS

Automotive magnet material forecast

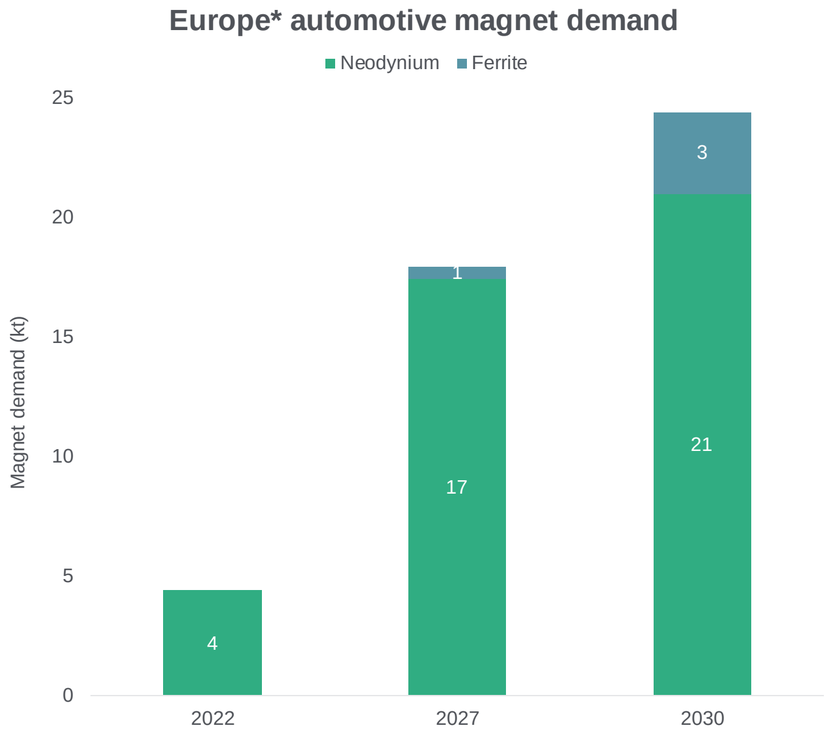
Wind turbines need similar magnet technology, doubling the demand for magnets in Europe and UK. Ferrite magnets are particularly well suited to off-shore wind power.

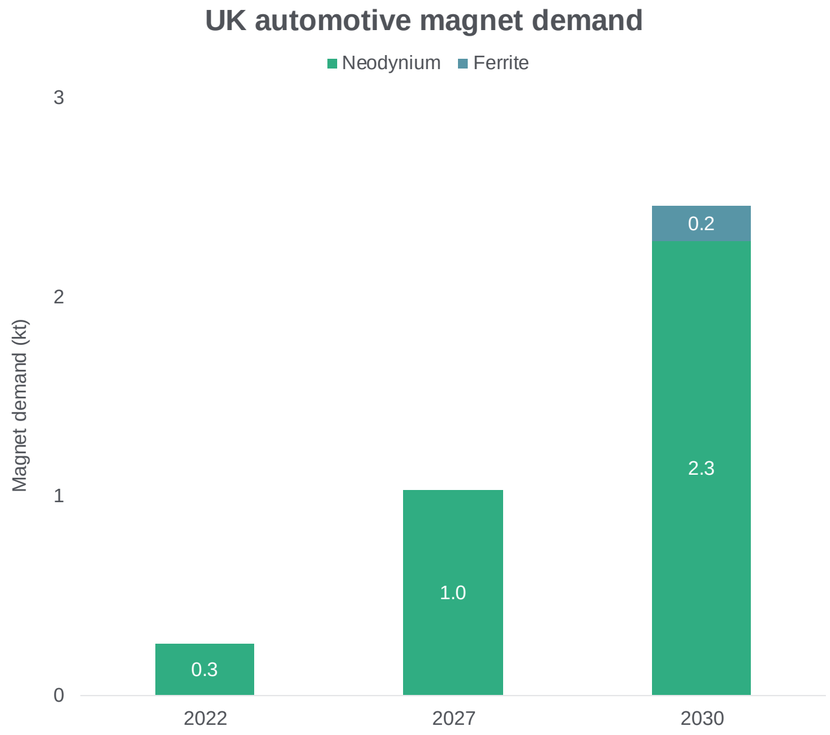
Assumptions:

100% segment A move to ferrite magnets where magnets are used.

20% segment B move to ferrite magnets where magnets are used.

20% vans move to ferrite magnets where magnets are used.





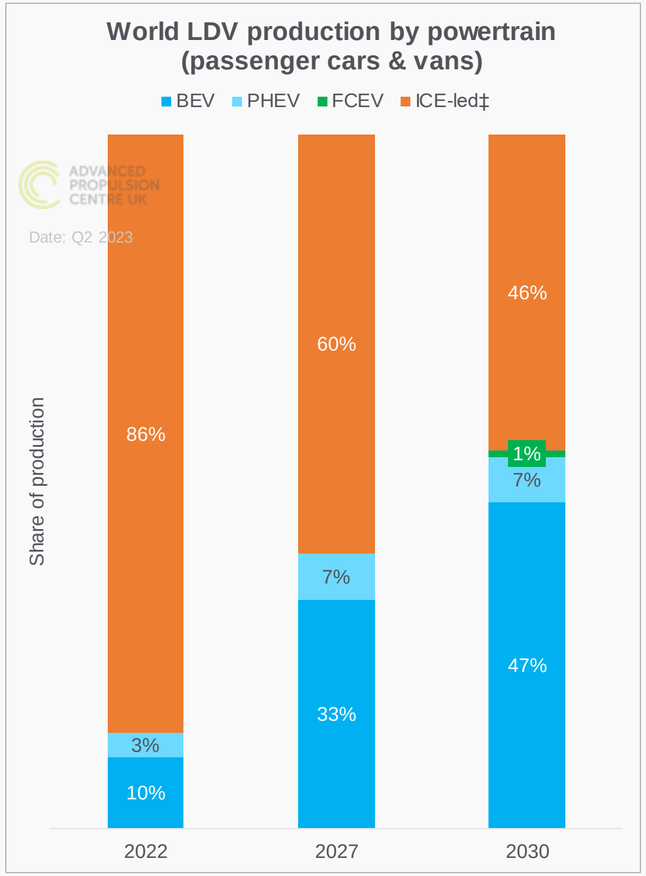
*European forecast includes non-EU countries such as Turkey. Magnet material refers to the mass of a finished magnet.

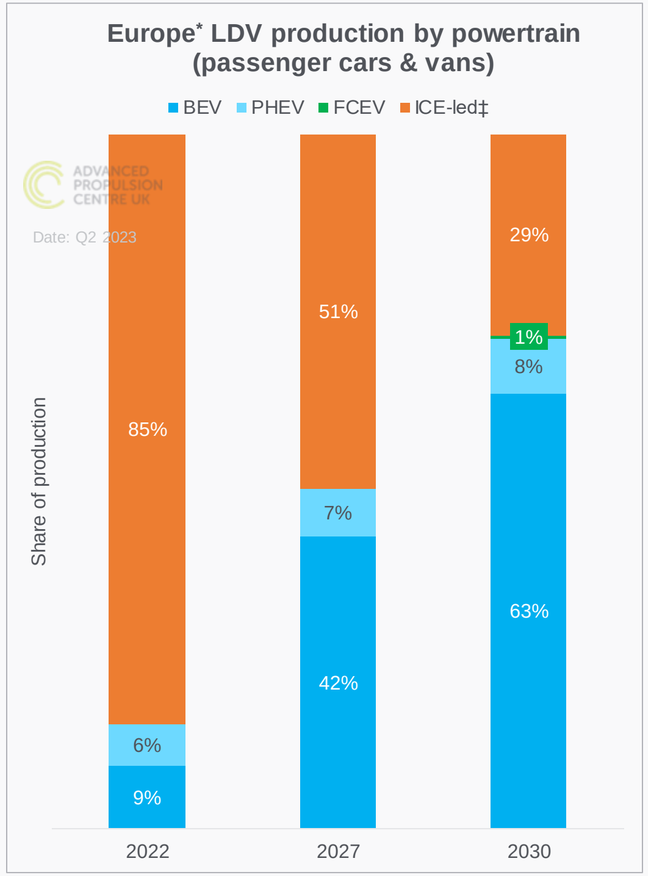
Q2 2023 – Electrified components data

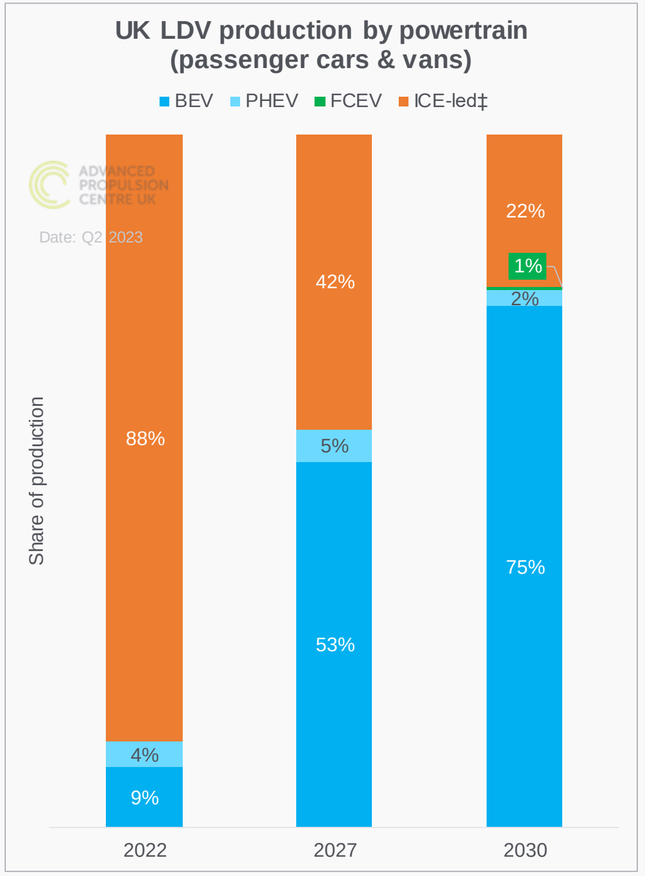
Forecasts for LDV production by powertrain

Q2 2023 notes

- Impact of Inflation Reduction Act continues to see global BEV shares creeping up
- For the first time the 2030 production share of BEVs is forecast to be higher than the global production share of ICE-led vehicles.
- PHEV production forecast reduced in favour of BEV in UK.





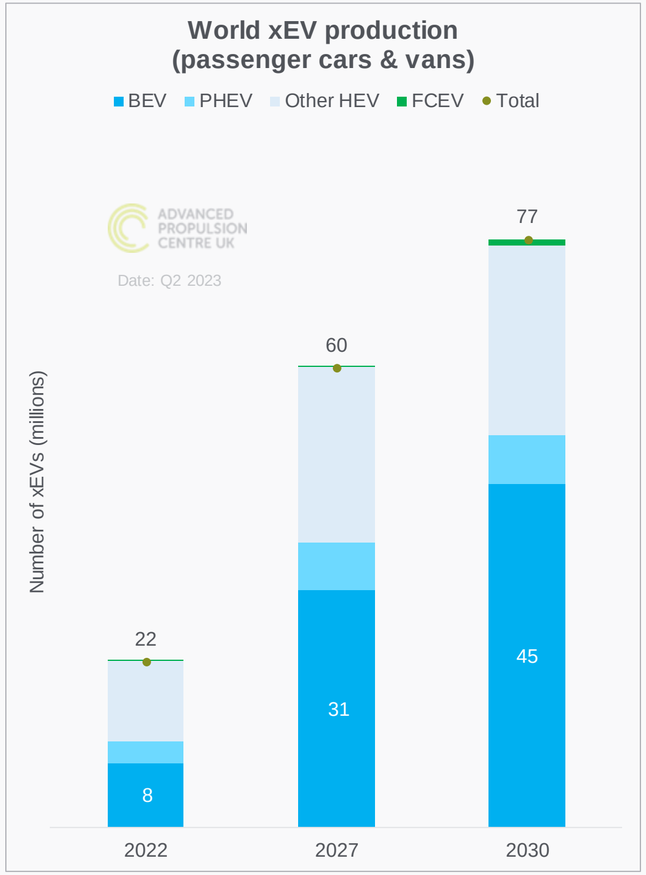


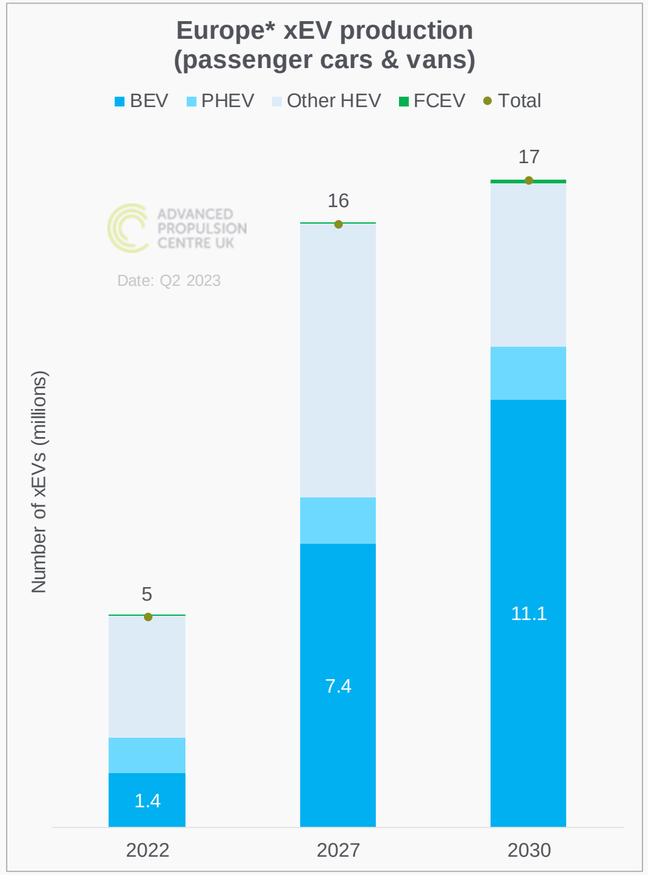
Source: APC Demand Databases using S&P Global AutoTechInsight (Jul 2023), BNEF forecasts (2023)
Note: Passenger cars & Light Commercial Vehicles < 3.5t only, *European forecast includes non-EU countries such as Turkey, ‡Includes non-plug-in HEVs & ICE

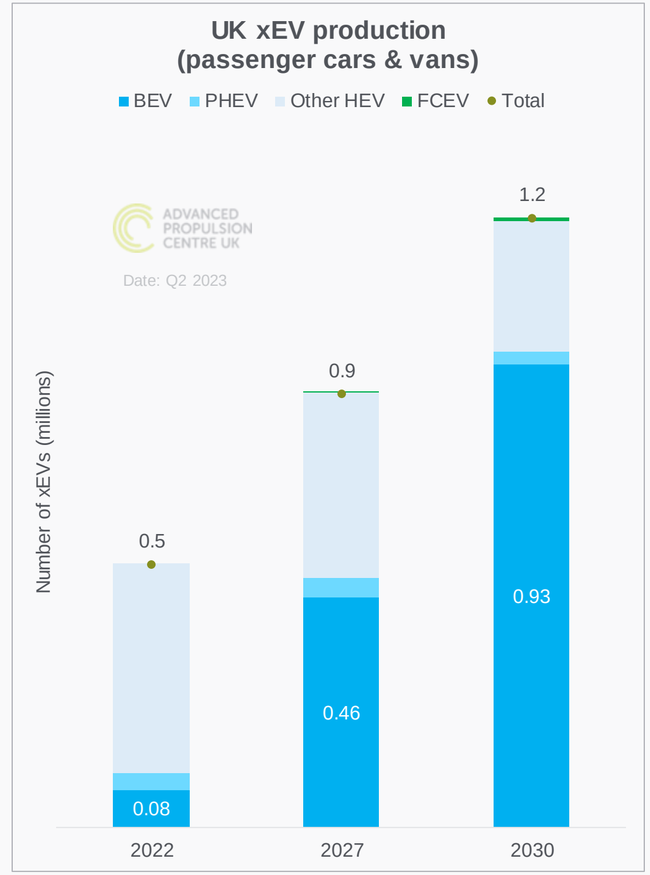
Forecasts for light duty xEV production

Q2 2023 notes

- UK PHEV production forecast reduced in favour of more BEVs.
- Europe is expected to produce 11 million BEVs by the end of the decade.
- Global EV production creeping up with an extra 1 million added since last quarter.





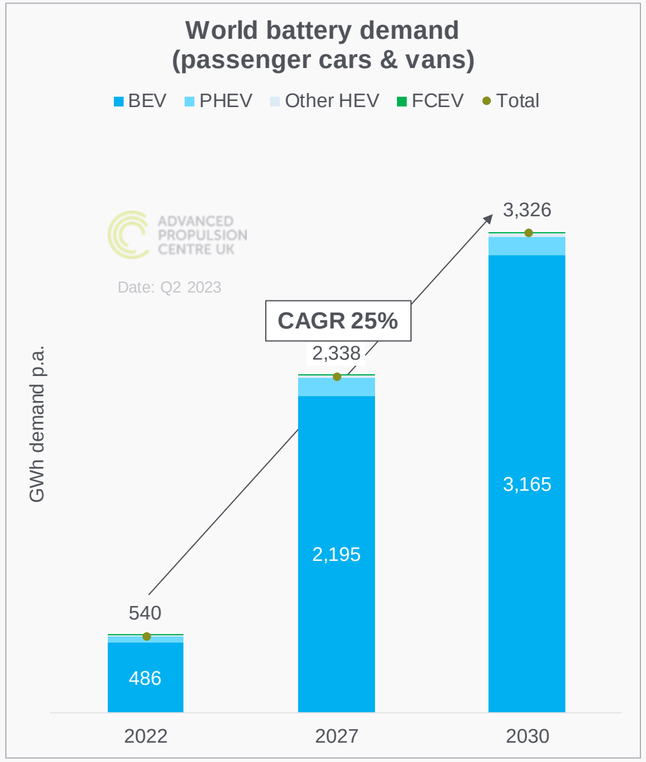


Source: APC Demand Databases using S&P Global AutoTechInsight (Jul 2023), BNEF forecasts (2023)
Note: Passenger cars & Light Commercial Vehicles < 3.5t only, *European forecast includes non-EU countries such as Turkey

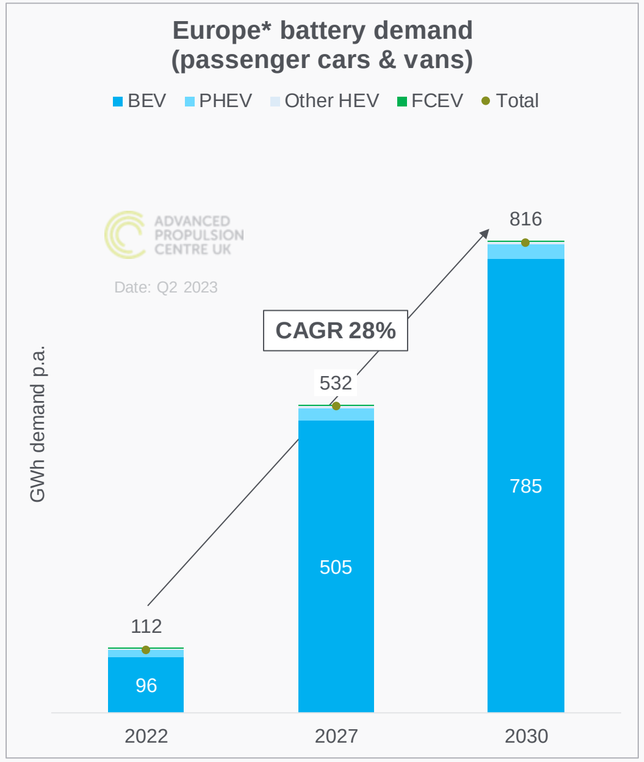
World battery demand for LDVs

Q2 2023 notes

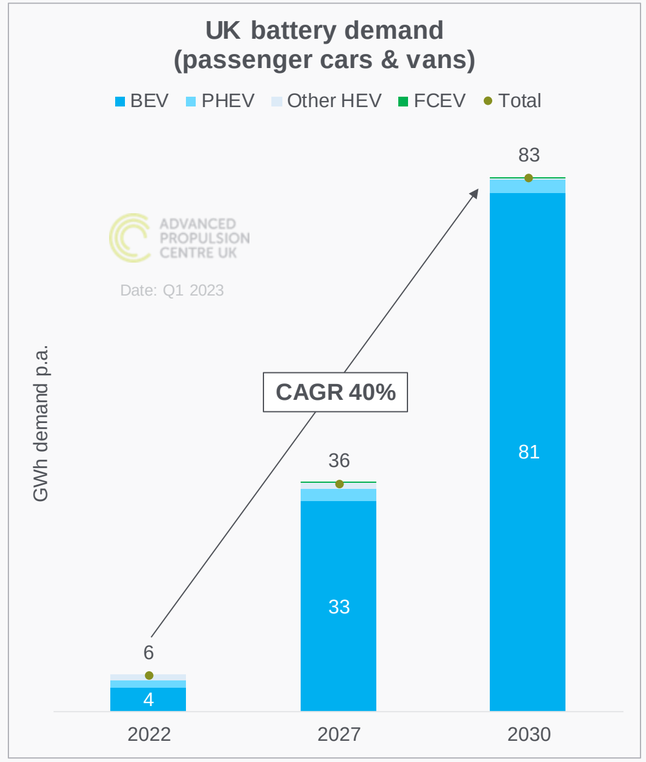
- World and European battery demand remain similar to APC's Q1 demand forecast with a small increase in European demand forecast.
- UK demand sees an increase over the APC's Q1 demand forecast in line with an expected increase in BEV production.



- Relative to APC's Q1 2023 demand forecast demand remains very similar with a small increase



- European battery demand to account for 24% of global battery demand by 2030
- Relative to APC's Q1 2023 demand forecast the forecast remains relatively unchanged



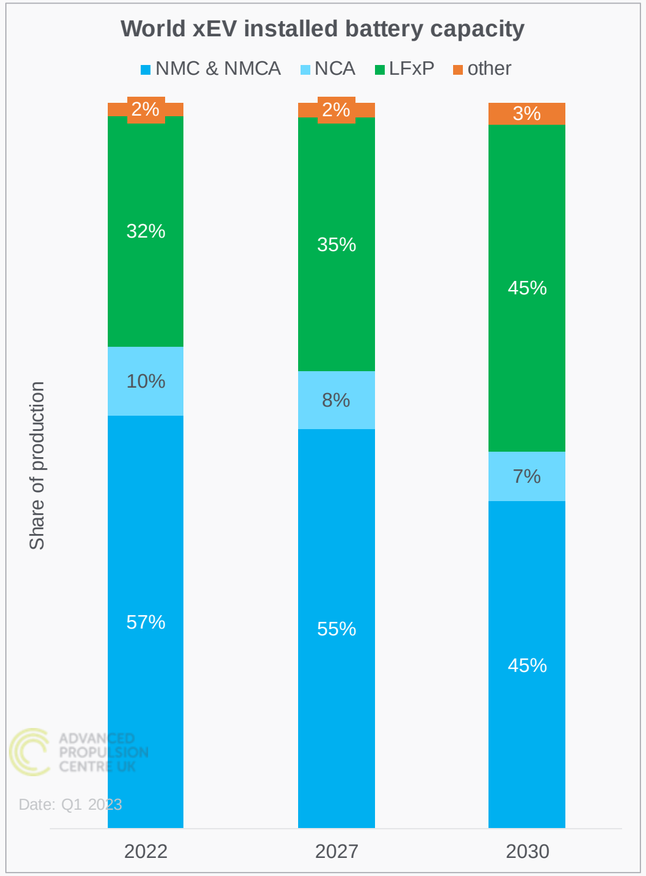
- UK battery demand forecast to account for 10% of European battery demand in 2030
- Relative to APC's Q1 2023 demand forecast, BEV demand increased in line with expected increase in BEV production.

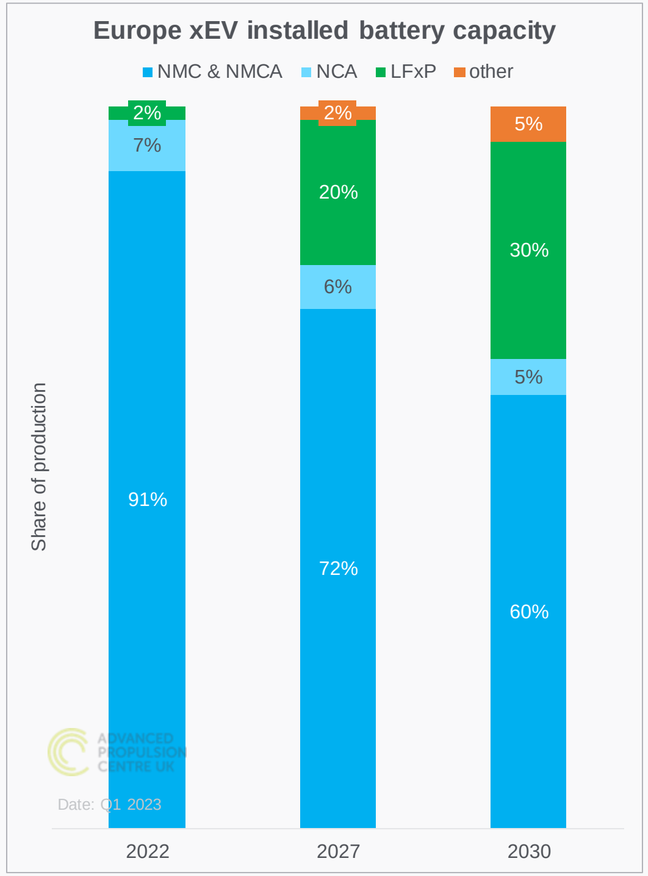
Source: APC Demand Databases using S&P Global AutoTechInsight (Jul 2023), BNEF forecasts (2023)
Note: Passenger cars & Light Commercial Vehicles < 3.5t only, *European forecast includes non-EU countries such as Turkey

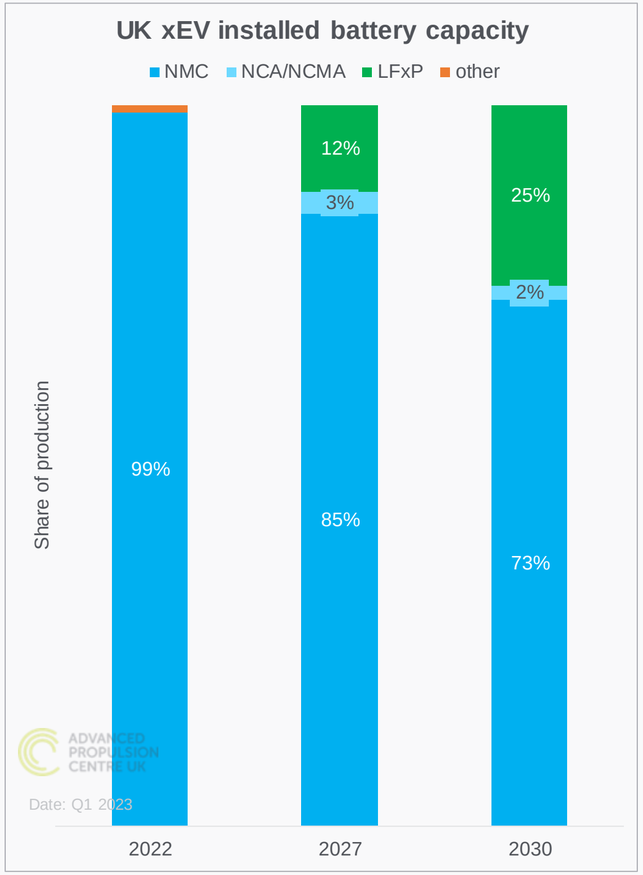
Forecasts for automotive battery production by chemistry

Q2 2023 notes

- Unchanged automotive battery chemistry production forecast relative to Q1 2023.
- Globally growth of LFxP pushes NMC share to below 50% by end of this decade.
- In Europe and UK NMC continues to dominate for this decade.







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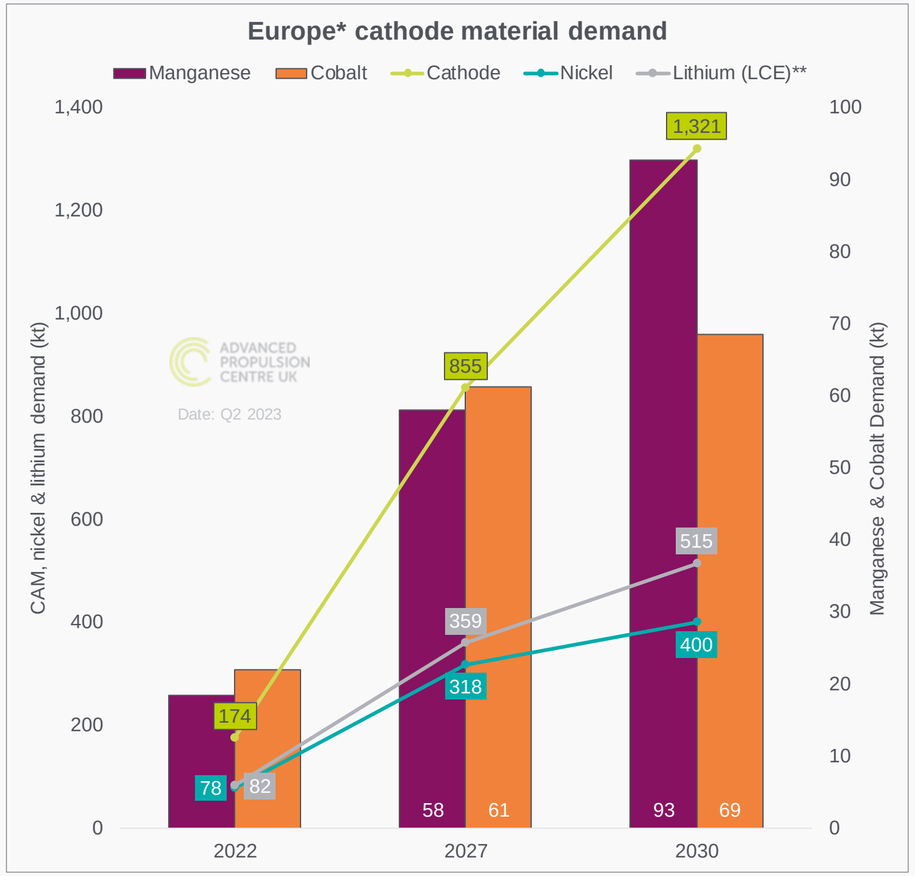
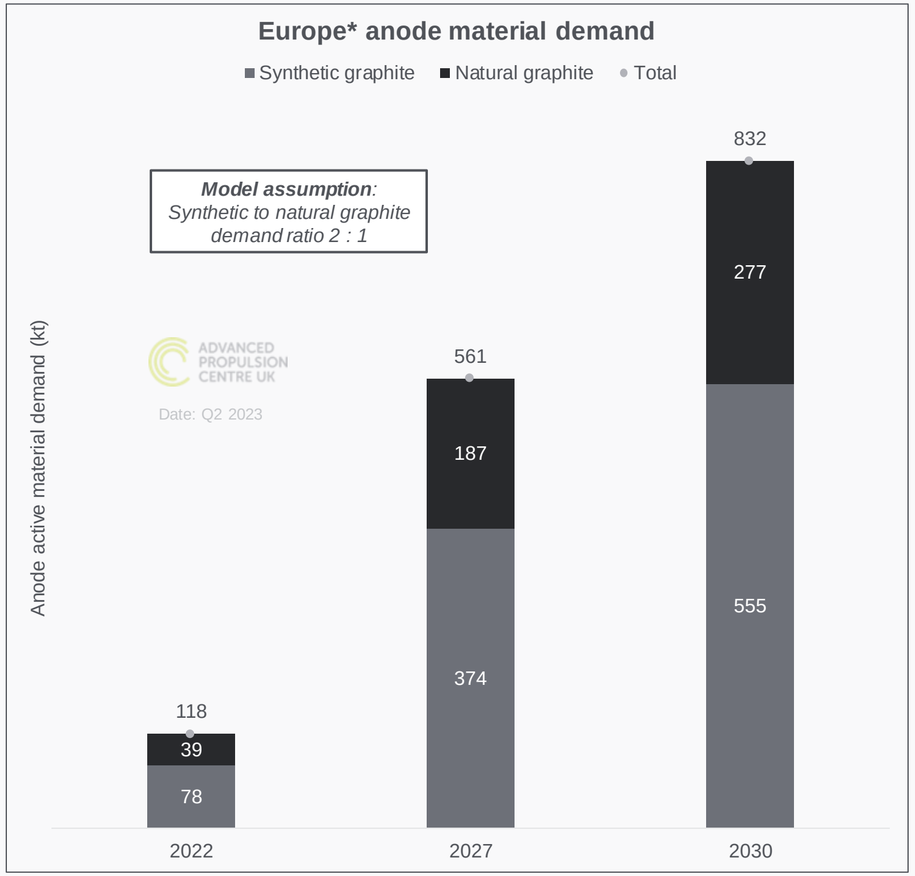
European Cathode Active Material (CAM) demand

Q2 2023 notes

- European demand for Cathode Active Material (CAM) rises to above 1,300kt driving an increasing deficit in European supply despite investment.
- Some potential investment expected in Europe now moving to Canada and USA where large incentives are available.



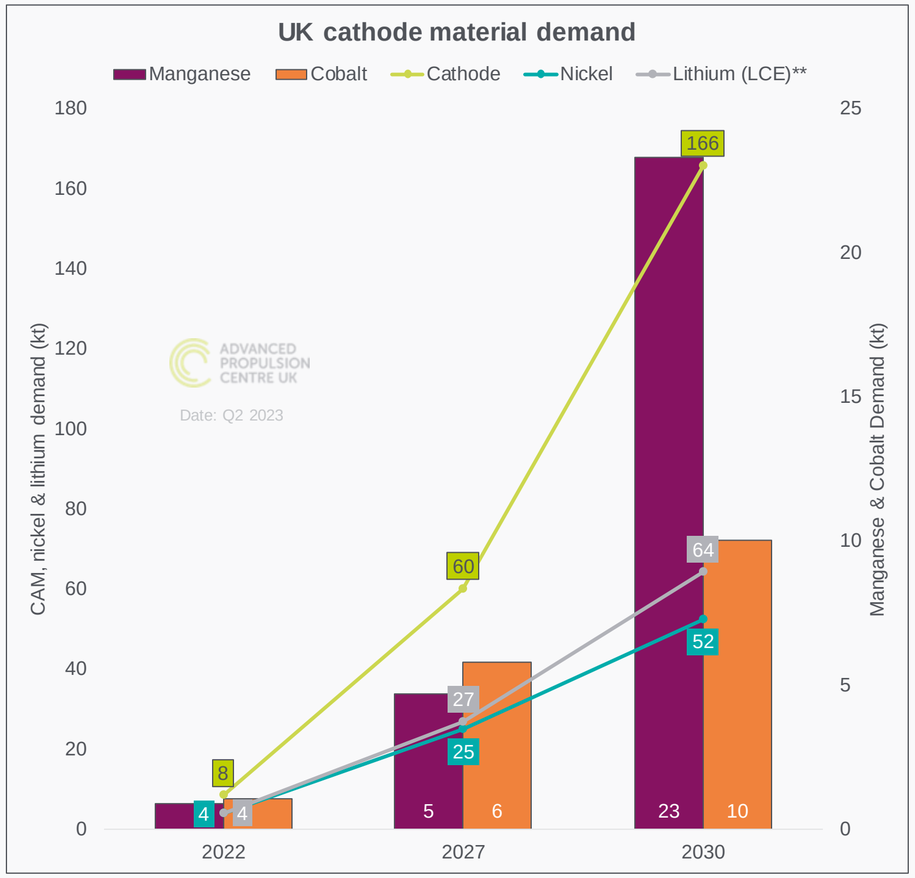


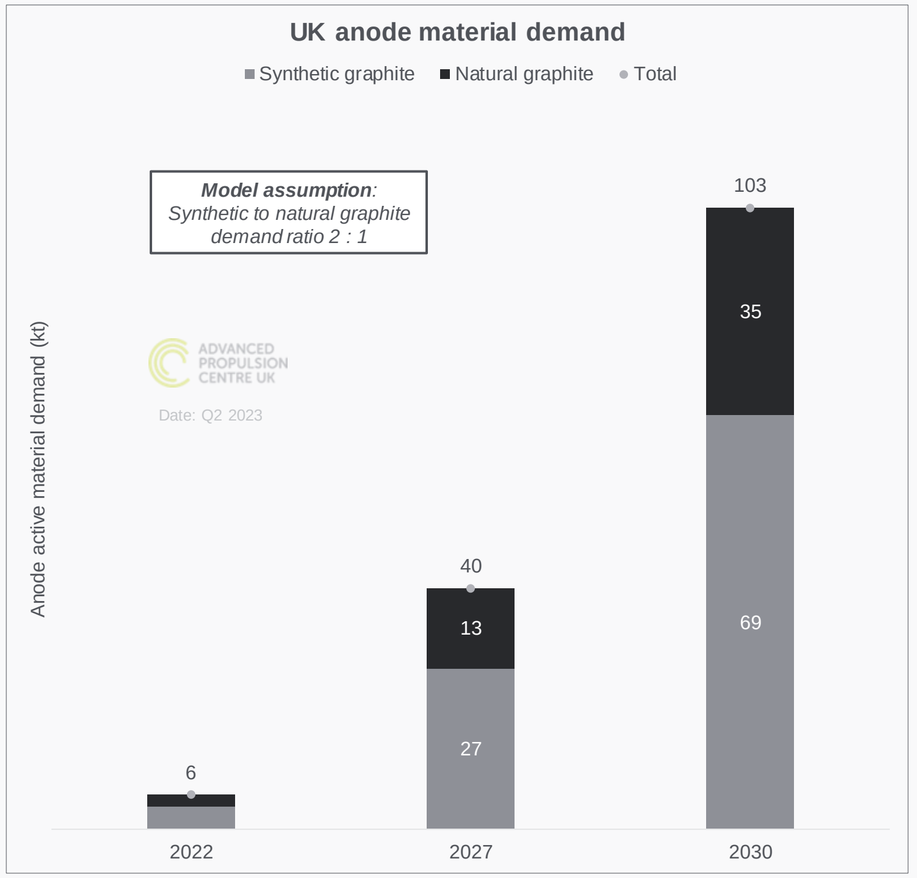
Source: APC Demand Databases using S&P Global AutoTechInsight (Jul 2023), Rho Motion data (2023), BNEF forecasts (2023)
Note: Passenger cars & Light Commercial Vehicles < 3.5t only, *European forecast includes non-EU countries such as Turkey, **Contained Li metal would be 5.3x lower

UK Cathode Active Material (CAM) demand

Q2 2023 notes

- Small increases to battery material demand seen in both 2027 and 2030.



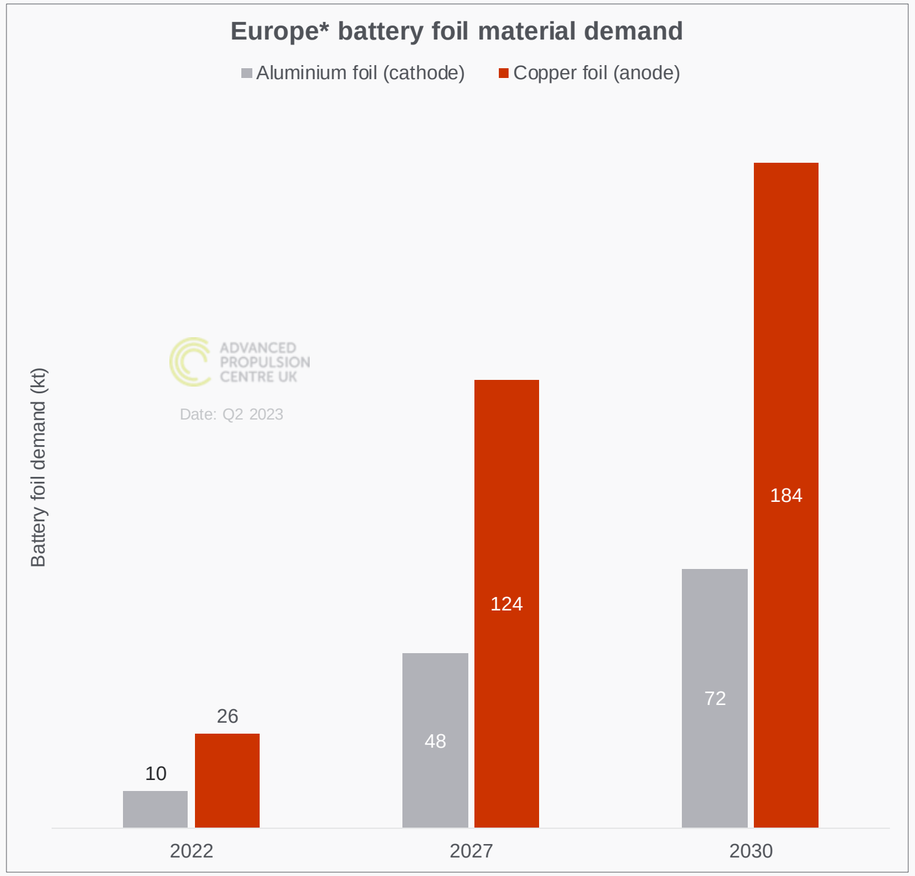


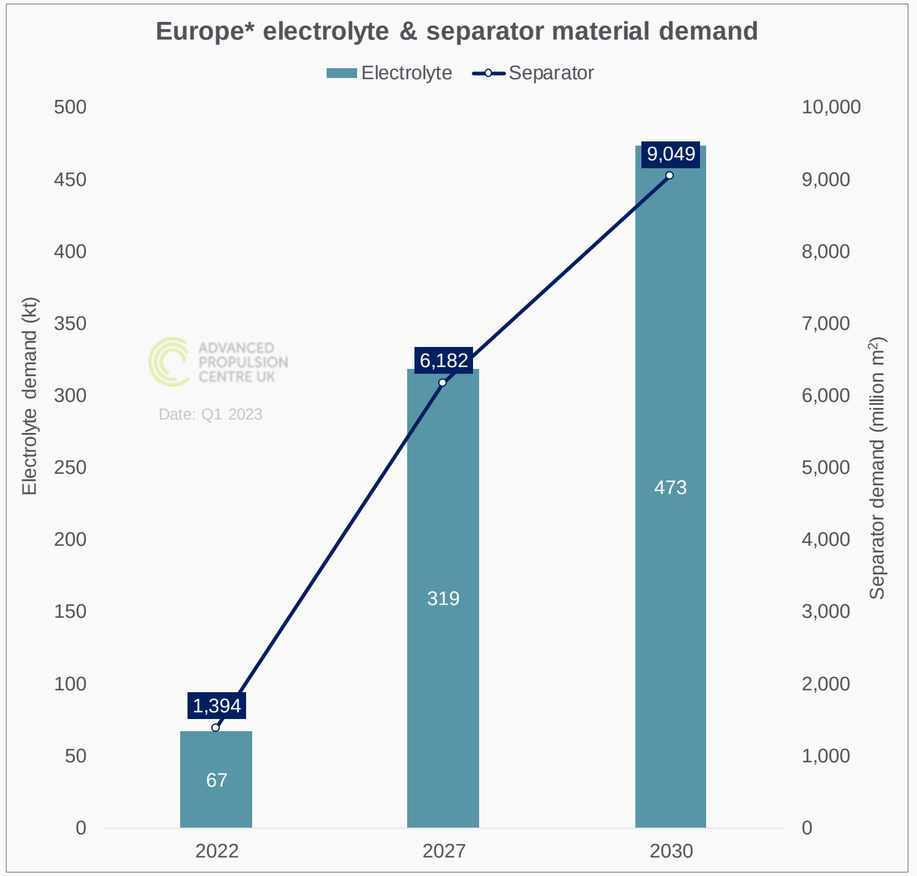
Source: APC Demand Databases using S&P Global AutoTechInsight (Jul 2023), Rho Motion data (2023)
Note: Passenger cars & Light Commercial Vehicles < 3.5t only, **Contained Li metal would be 5.3x lower

European demand for battery foils, electrolyte and separator material

Q2 2023 notes

- Currently separators and electrolyte are an area of under-investment in Europe. This could impact Europe's ability to produce locally made cells.





Source: APC Demand Databases using S&P Global AutoTechInsight (Jul 2023), Rho Motion data (2023), BNEF forecasts (2023)
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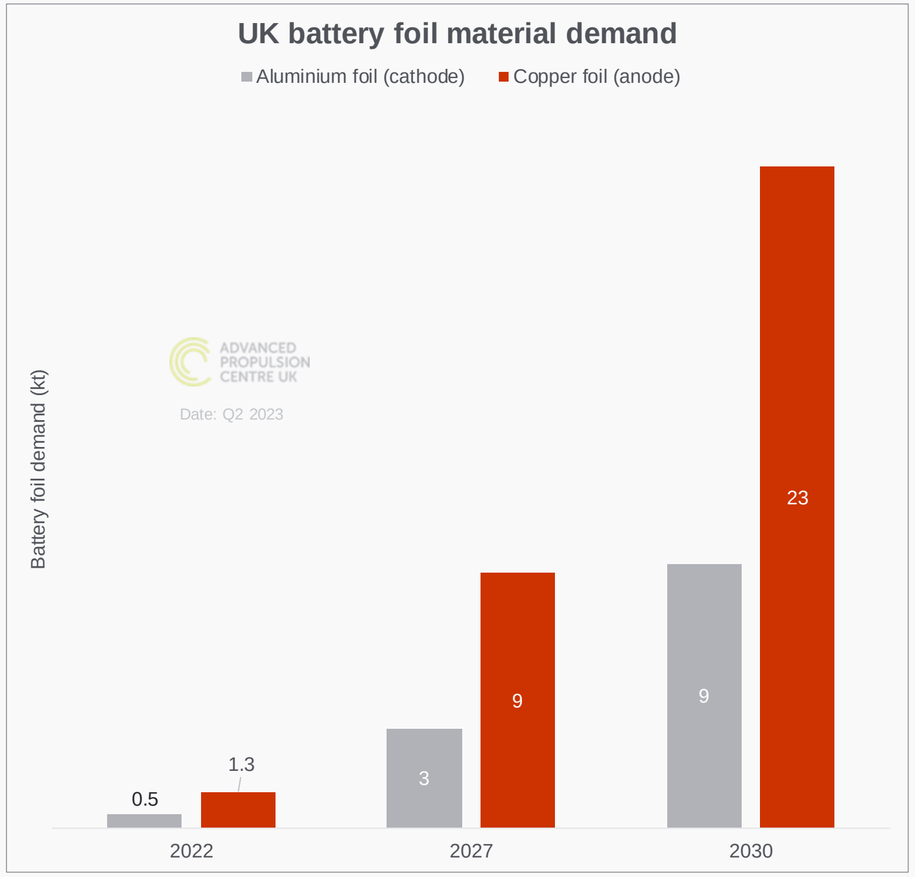
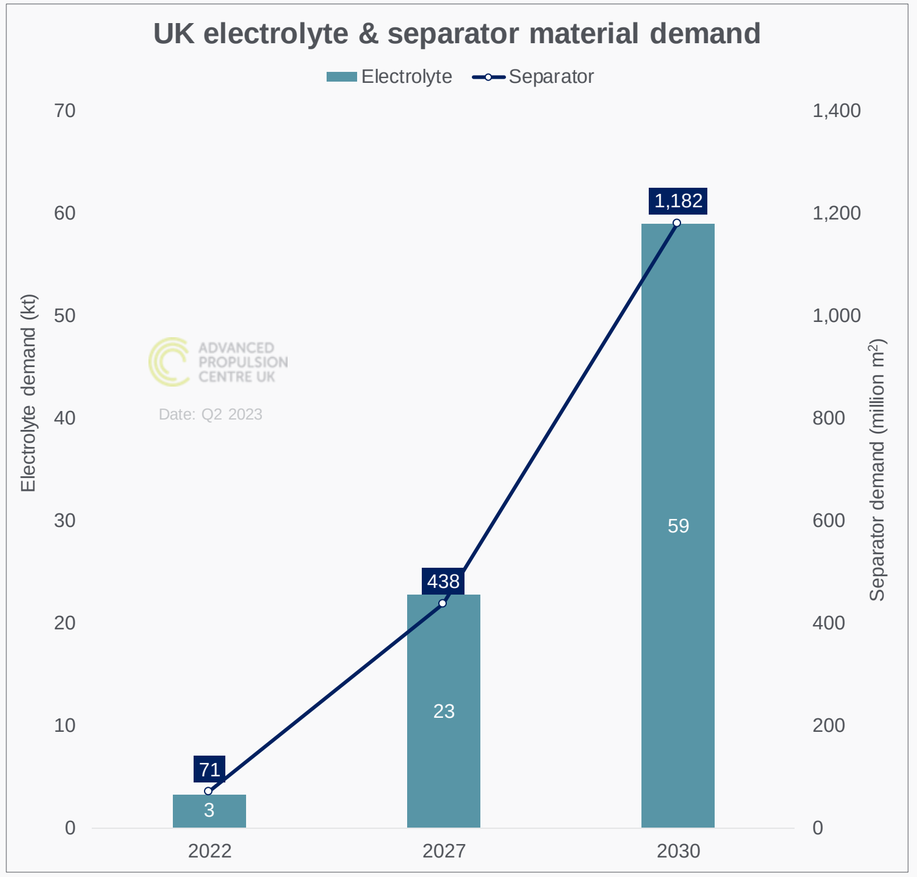


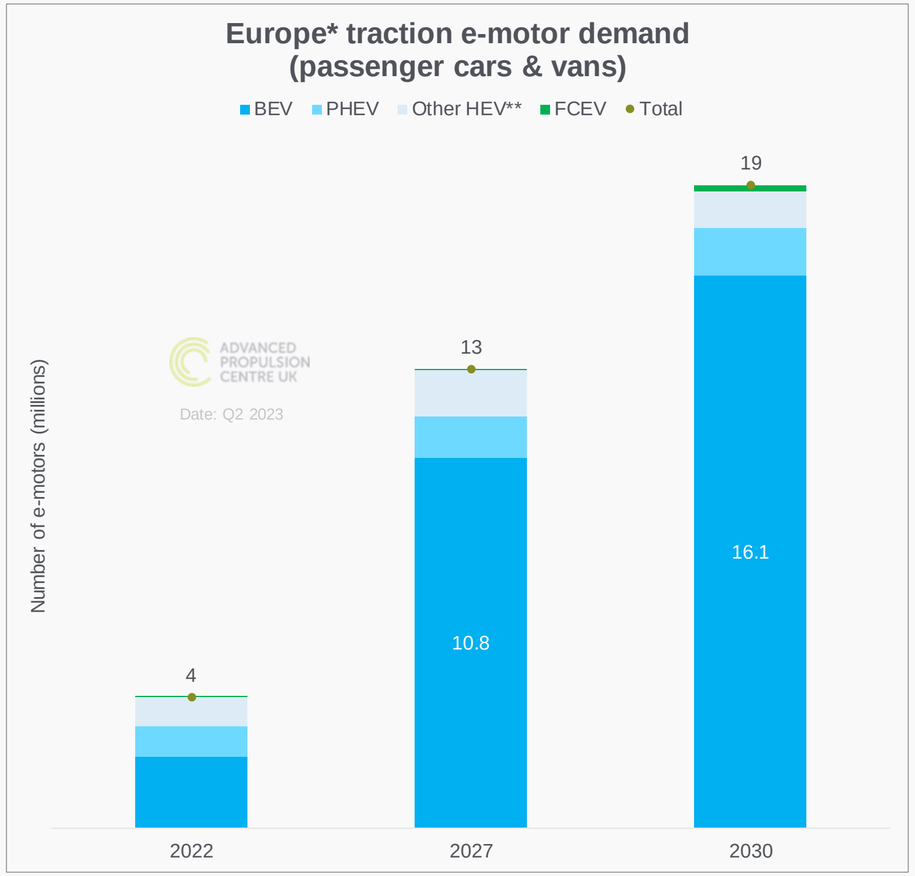


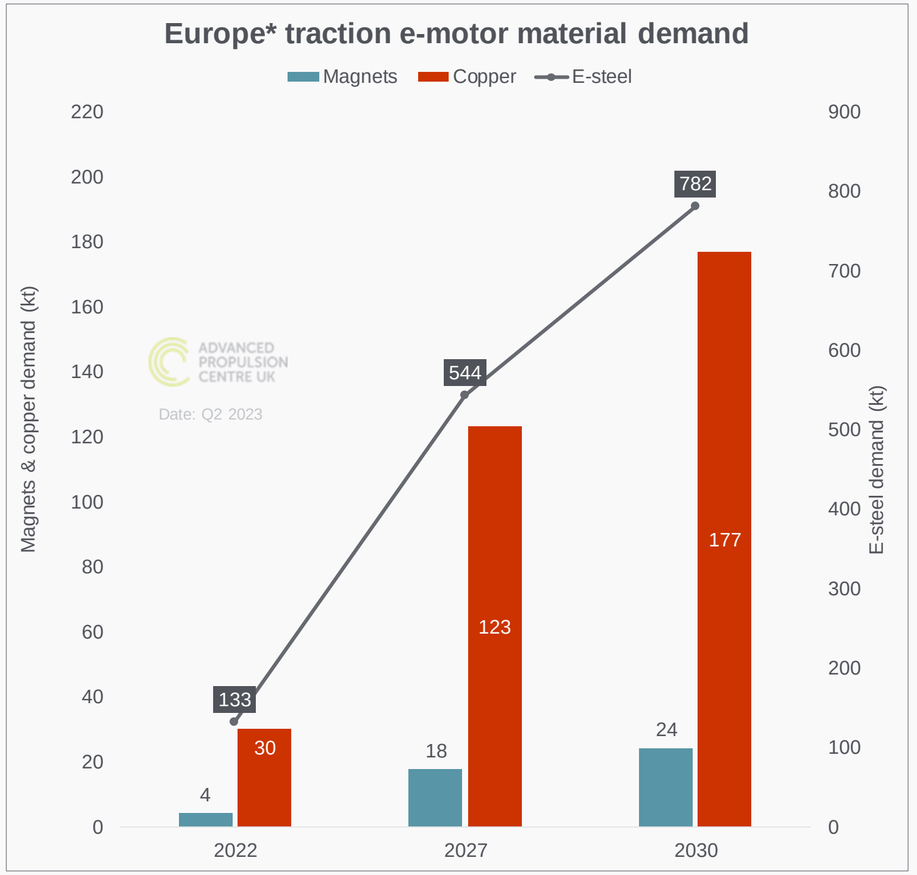
Source: APC Demand Databases using S&P Global AutoTechInsight (Jul 2023), Rho Motion data (2023)
Note: Passenger cars & Light Commercial Vehicles < 3.5t only

European demand for traction electric motors

Q2 2023 notes

- Expect small shift away from permanent magnet motors towards end of decade – reducing magnet demand compared to Q1 forecast.
- Updated demand modelling with dynamic changes to motor design.



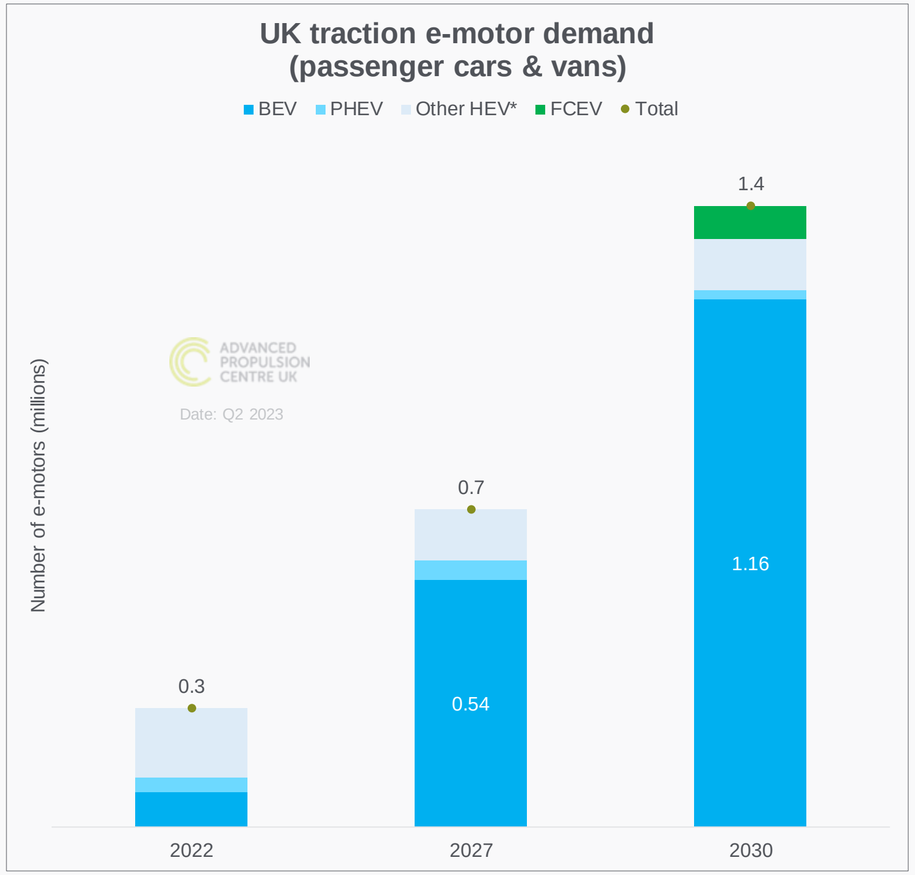


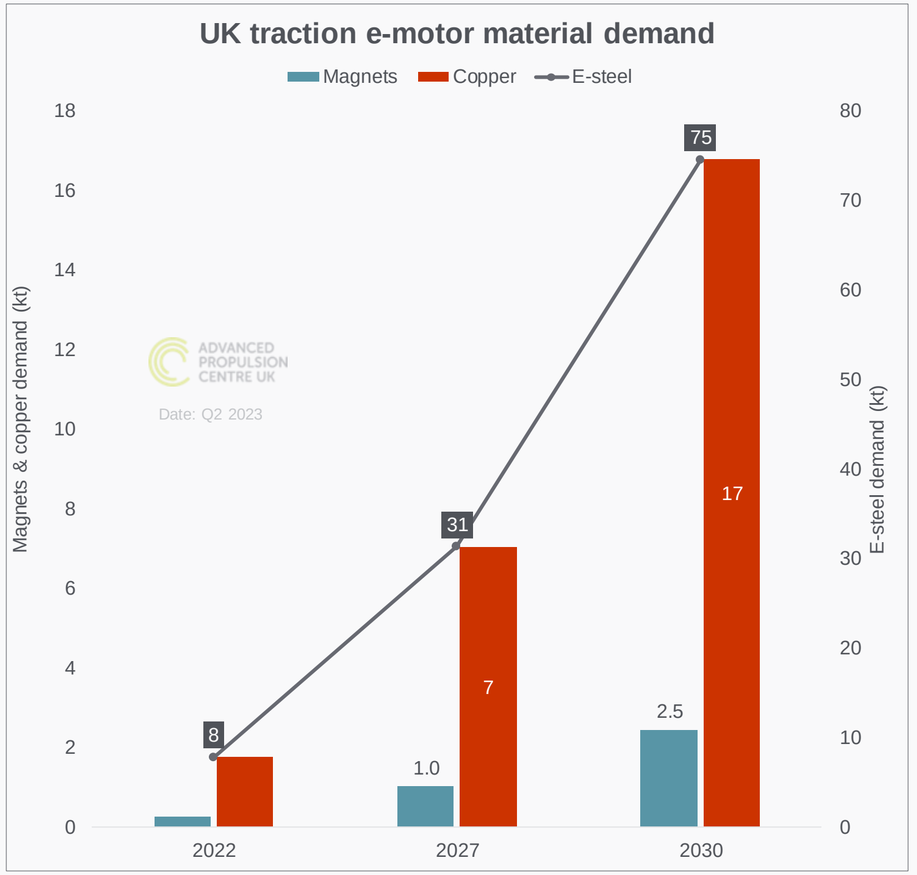
Source: APC Demand Databases using S&P Global AutoTechInsight (Jul 2023)
Note: Passenger cars & Light Commercial Vehicles < 3.5t only, *European forecast includes non-EU countries such as Turkey, **Excluding mild hybrid electric motors

UK demand for traction electric motors

Q2 2023 notes

- UK to require 1.4 million high-power traction e-motors in 2030. UK strength in manufacture of motors can be leveraged to supply both UK and export.
- Updated demand modelling with dynamic changes to motor design.





Source: APC Demand Databases using internal insights and S&P Global AutoTechInsight (Jul 2023)
Note: Passenger cars & Light Commercial Vehicles < 3.5t only, *Excluding mild hybrid electric motors

This Q2 Automotive demand forecast is provided by the Technology Trends team at the APC

If you have any questions or would like more detail on any of the graphs or data email: info@apcuk.co.uk

September 2023