Q3 2022 Automotive industry demand forecast

December 2022

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Accelerating Progress

Q3 2022 – Automotive industry demand forecast

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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 Markit. Rho Motion and BloombergNEF (BNEF) have also guided the 2030 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.

Q3 2022 – Summary

Summary – Changes to projected demand by region

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	**Global demand update**	• The outlook for global automotive battery demand in 2030 remains above 2,900 GWh despite an uncertain economic and geopolitical outlook	page 8
	**European demand update**	• European vehicle production expected to reduce by 1 million vehicles in 2025 due to an uncertain economic outlook • A recovery for 2030 that gets BEV production back on track is uncertain due to an uncertain geopolitical situation and potential supply issues	page 10
	**UK demand update**	• UK 2025 BEV production share revised down to 25% - an uncertain economy is expected to drive buyers towards cheaper models and production is planned on that expectation • UK 2030 battery demand remains above 96 GWh as recovery is expected	page 20

Summary – Trends insight

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Silicon carbide opportunities for efficiency and cost	**Modelled potential for SiC components to increase BEV efficiency** **Model includes** • Silicon carbide (SiC) efficiency gains • Reducing vehicle weight by designing cooling, motors and cabling around SiC • Reduced battery mass Efficiency gains create opportunities for reduced cost and increased vehicle performance	pages 13-18
Silicon carbide market penetration	**Modelled SiC wafer demand and market penetration for LDV*** • SiC-based inverters are expected to dominate the market by 2030 • Europe will need between 600-800 thousand SiC wafers in 2030 • UK will need a supply of 80 thousand SiC wafers in 2030	pages 18

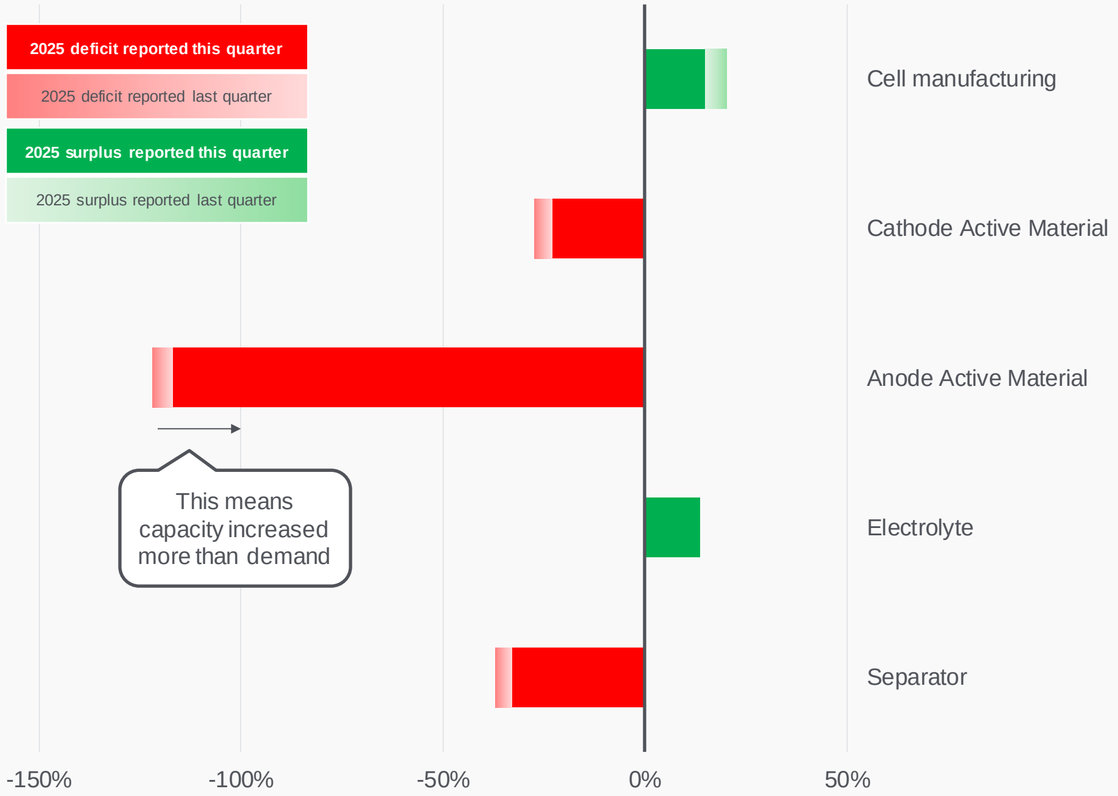
Source: APC analysis
*Notes: *LDV/Light Duty Vehicle segments only as defined by S&P Global Markit – see slide 16 for examples*

Summary – Supply chain activity

Q3 2022 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

2025 European[1] capacity vs demand balances



Status of regional capacity* v demand balance in 2025	Value** (%)	UK supply chain status
Decrease in capacity: Some projects delayed, likely to have reduced capacity in 2025	18%	Gigafactory plans to supply 90 GWh by 2030 mostly secured for UK vehicle production plants
Improving: Increased capacity at some projects plus reduced demand forecast	**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
Improving: Small supply increases expected and reduced demand	9%	Expected to be the next 'big thing' after CAM. Access to low-cost renewable energy is key to manufacturing competitiveness.
Improving: announced investments likely to be sufficient for capacity	8%	Value in today's liquid electrolyte is relatively low, but solid-state electrolytes are a key investment consideration
Improving: Supply stable, possible demand reduction	7%	Significant opportunities to localise in UK even though typically manufactured in Eastern Europe

Source: APC internal analysis, BNEF forecasts (Accessed: 08.11.2022)
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*

Q3 2022 – Demand update

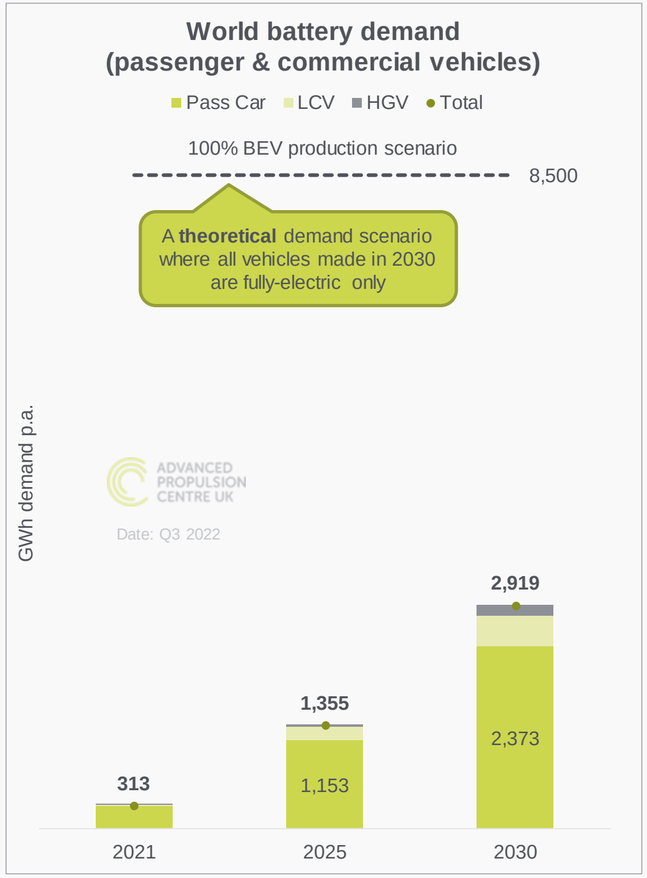
The following section includes battery demand from both Light Duty Vehicles (LDVs) and Heavy Goods Vehicles (HGVs)

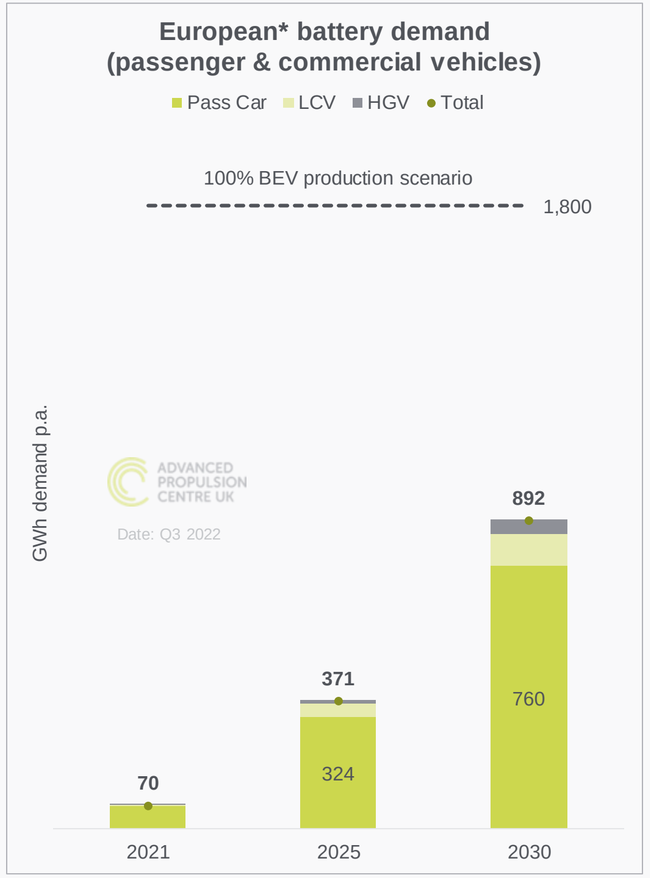
Battery demand forecast

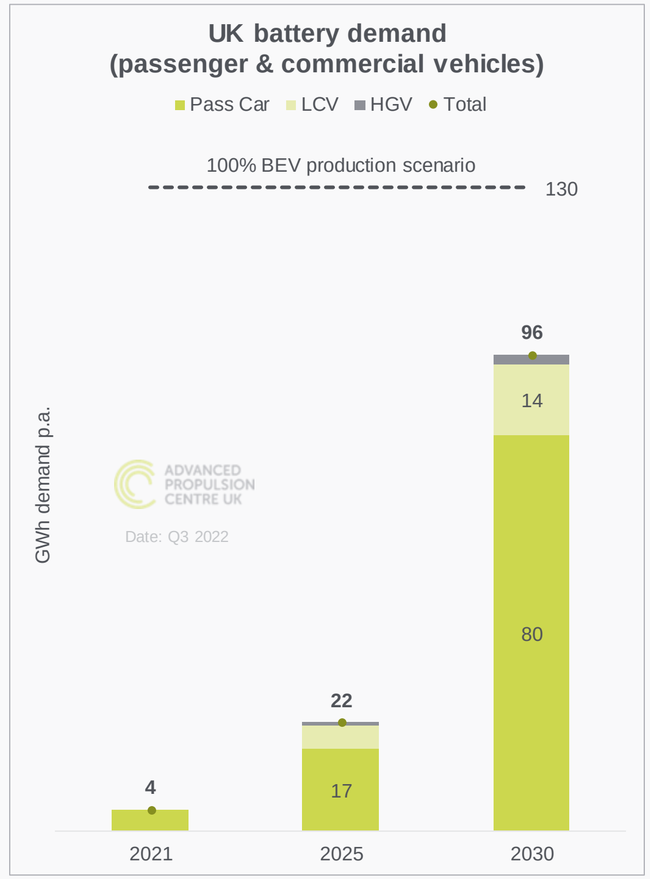
LDVs and HGVs

Q3 2022 notes

- World battery demand forecast to exceed 2,900 GWh by 2030, (more than double the forecast for 2025)
- 2025 European demand forecast down slightly compared to APC's Q2 2022 demand forecast due to economic uncertainty







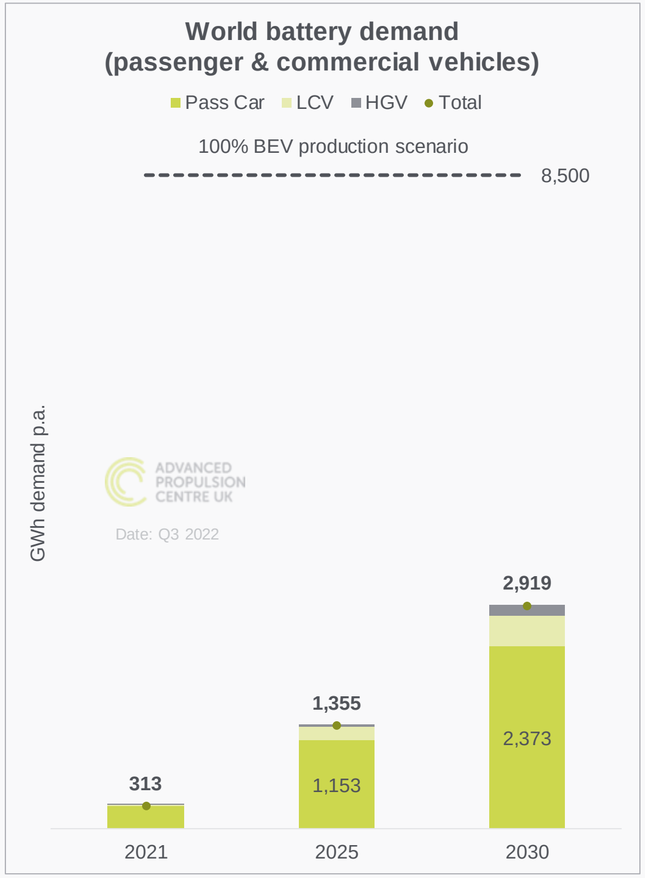
Source: APC Demand Databases using S&P Global AutoTechInsight (Nov, 2022), Rho Motion data (2022), BNEF (2022), LMC (2022)
*Note: LCV = Light Commercial Vehicles < 3.5t, buses not included. *European forecast includes non-EU countries such as Turkey*

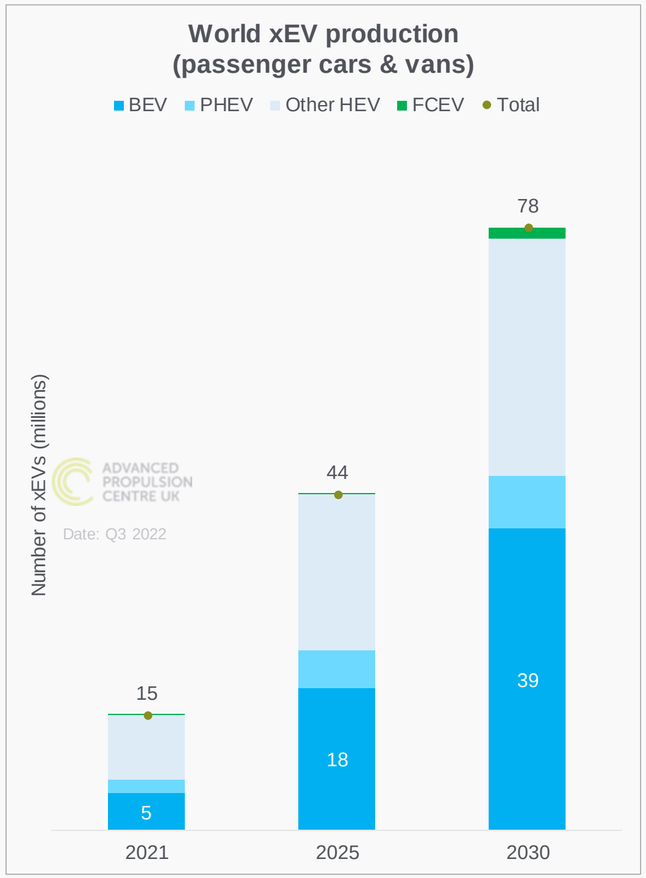
World xEV production

Passenger cars and vans

Q3 2022 notes

- World vehicle production would require more than 2,900 GWh of batteries, with 39 million battery-electric cars and vans produced globally by 2030





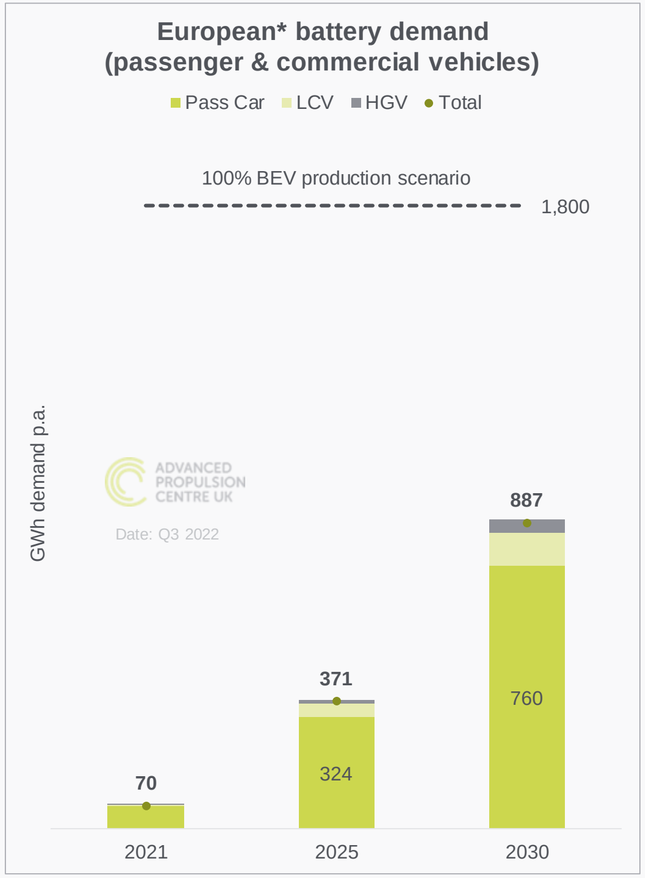
Source: APC Demand Databases using S&P Global AutoTechInsight (Nov, 2022), Rho Motion data (2022), BNEF forecasts (2022), LMC (2022)
Note: LCV = Light Commercial Vehicles < 3.5t, buses not included.

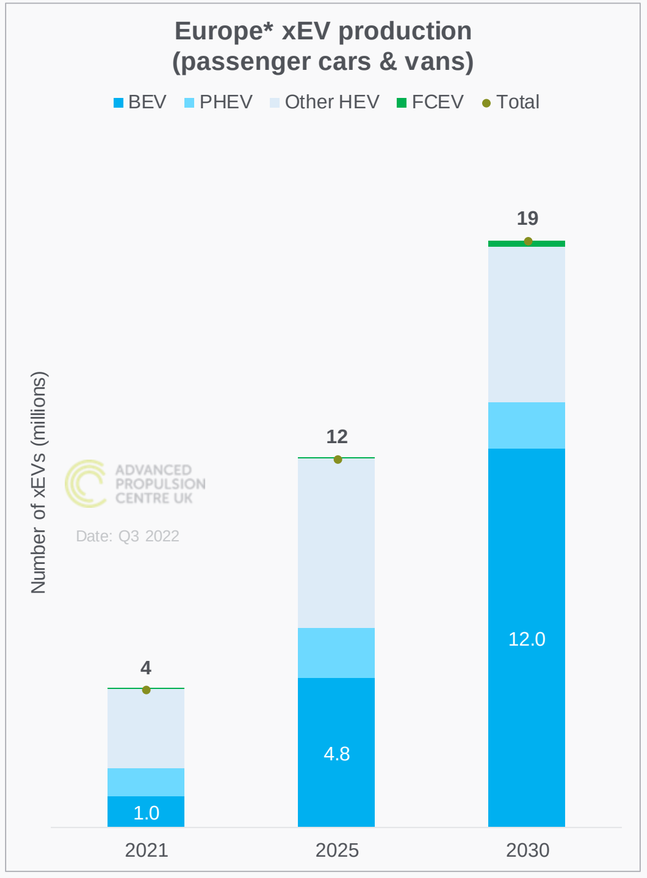
European xEV production

Passenger cars and vans

Q3 2022 notes

- Production forecast for 2025 reduced by 1 million vehicles compared to APC's Q2 2022 demand report. Recovery by 2030 expected.
- Forecast has greater uncertainty than previous reports due to geopolitical and supply chain uncertainties





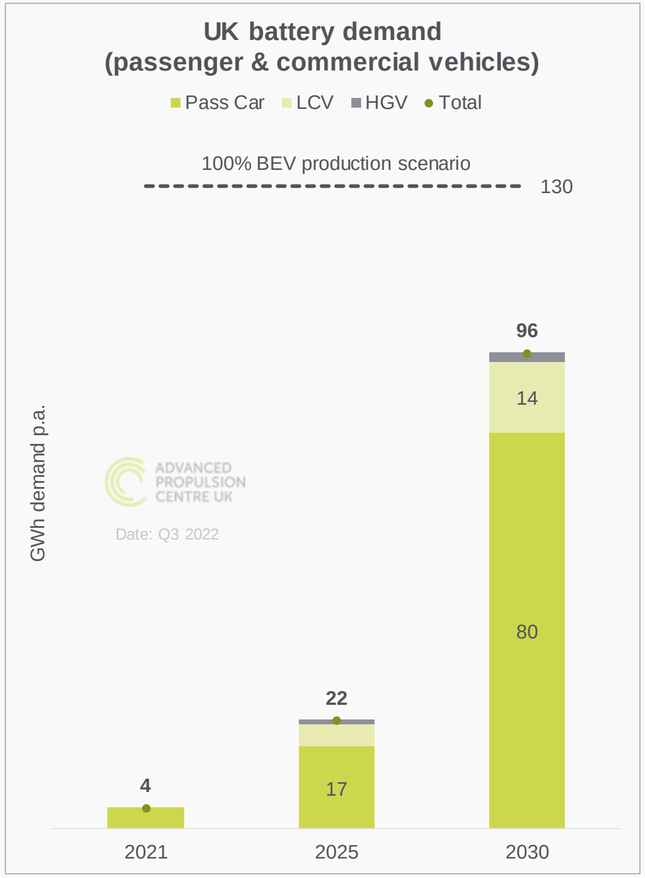
Source: APC Demand Databases using S&P Global AutoTechInsight (Nov, 2022), Rho Motion data (2022), BNEF (2022), LMC (2022)
*Note: LCV = Light Commercial Vehicles < 3.5t, buses not included. *European forecast includes non-EU countries such as Turkey*

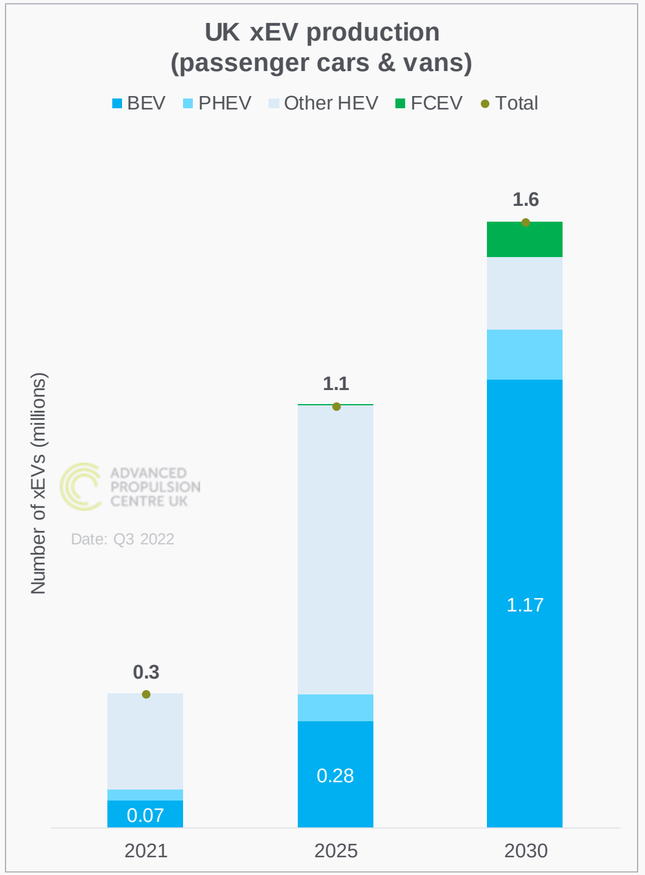
UK xEV production

Passenger cars and vans

Q3 2022 notes

- Economic uncertainty results in a reduced forecast for BEVs, compared to APC's Q2 2022 demand forecast, as buyers are expected to stick with cheaper options for longer
- Although BEV production is reduced overall production is increased with more PHEV and other HEV vehicles compared to APC's Q2 2022 demand forecast





Source: APC Demand Databases using S&P Global AutoTechInsight (Nov. 2022), BNEF forecasts (2022)
Note: LCV = Light Commercial Vehicles < 3.5t, buses not included.

Q3 2022 – Trends insight

Silicon Carbide (SiC) based power electronics can enable smaller battery pack sizes via powertrain efficiency gains

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Increase lithium supply

Investment incentives in sustainable Li extraction

Recycle Li from various sources

Decrease lithium demand

Manufacturing smaller & modular batteries

Moving from Li-ion to Sodium-ion batteries

Shifting production to other powertrains

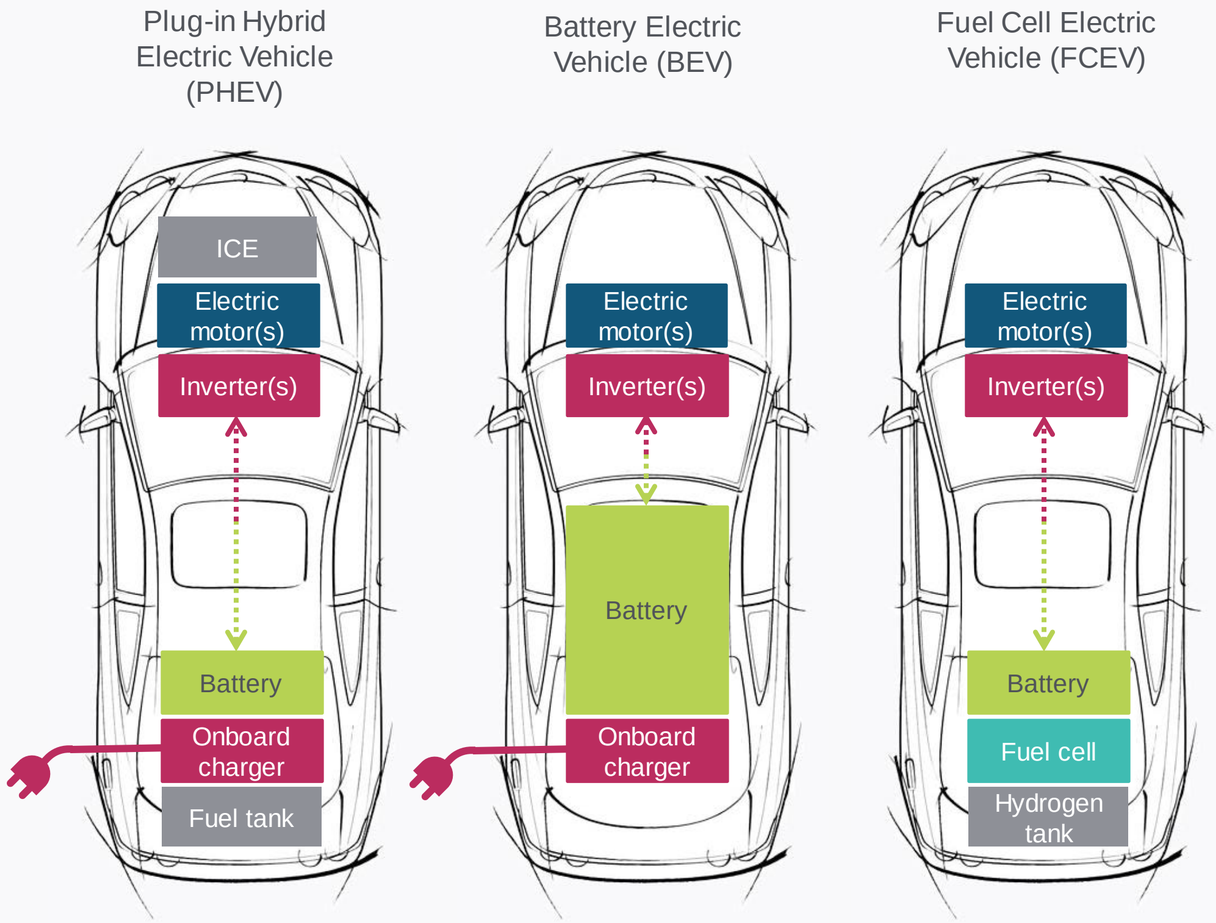
	Increase lithium supply		Decrease lithium demand		
Relative impact	**High**	**Low**	**High**	**Low**	**High**
Summary	Li shortage 40% better if all probable extraction projects come online by 2030	Significant supply from BEV end-of-life retirements likely to come later than 2030	APC baseline 2030 Li shortage 55% better than in 'Large Pack Size Scenario'	Na-ion in smaller BEVs that account for < 5% of battery electric cars and vans	Can enable a 40% improvement in Li market balance for cars and vans

In the previous demand report APC explored the relative impact for each of the five identified solutions to a potential lithium shortage in 2030

Manufacturing smaller batteries was identified as a key lever with a high relative impact

Source: APC analysis

From silicon (Si) to silicon carbide (SiC) – efficiency gains from power electronics to the powertrain



- The powertrain of a BEV, PHEV and FCEV includes a battery, inverters and electric motors
- The inverters include MOSFETs/IGBTs and diodes
- Inverters transform the DC power from the battery into three phase AC power for the motors
- Inverter technology based on SiC rather than Si provides an inherent efficiency gain and opportunities to optimise the powertrain
- Increased powertrain efficiency results in higher range or reduced battery pack size
- Reduced battery pack size is a win-win scenario as it reduces vehicle cost and reduces lithium demand

Source: APC analysis, US Department of Energy; Electrical and Electronics Technical Team Roadmap, October 2017 (adapted by Exawatt)

Benefits of silicon carbide (SiC) and assumptions used to model battery pack size reductions

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SiC can provide the following benefits to power electronics in EVs:

Efficiency	Cost	Safety
• Higher power-conversion efficiency relative to silicon-based power electronics • Reduced switching losses in SiC devices enables higher switching frequencies, which allows for reduction in the size of passive components and motor • More-efficient power conversion leads to reduced cooling requirement • SiC's high dielectric breakdown electric field strength allows for simple and efficient 800V conversion systems	• Reduced switching losses in SiC devices enables higher switching frequencies, which allows for reduction in the size of passive components and motor • More-efficient power conversion leads to reduced cooling requirement • Built-in body diode in a SiC MOSFET can eliminate the need for a separate anti-parallel diode • SiC's high dielectric breakdown electric field strength allows for simple and efficient 800V conversion systems	• Allows for operation at higher temperatures with reduced risk of thermal runaway

Taking advantage of these benefits involves changes to cooling, cabling and motor design. With that in mind, the efficiency assumptions are a look ahead to 2030 assuming design changes are adopted on that timescale.

Assumptions

Parameter	Value	Rationale
SiC power conversion efficiency	10%	Although figures vary from 5-15%, the lower end of the scale is likely to be simple material swaps rather than optimised systems.
Weight savings	~1-2%	Weight can be saved from the motors, cabling and cooling systems, a conservative estimate of 15kg has been used. Based on an assumption that a 10% decrease in vehicle weight is a 14% efficiency gain.
Battery size reduction	~3.5-5%	Using the gains to decrease the battery size creates a further weight saving dependent on initial battery size – that can give a further efficiency increase or be used to further reduce battery size. Based on an assumption that a 10% decrease in vehicle weight is a 14% efficiency gain.

Source: APC analysis, Exawatt, 'Fuel efficiency drives the auto industry to reduce vehicle weight' A. Robinson, A. Taub & G. Keoleian (2019)

Summary of silicon carbide (SiC) impact on BEV pack size and total cost

Q3 2022 notes

- Summary of modelled SiC opportunities for cost and pack size reduction by LDV segments assuming a 2030 timescale
- Forecast pack size increases could be mitigated by switching to SiC components
- Price assumptions are based on a 2030 forecast of $110/kWh, total cost includes cost of SiC inverters

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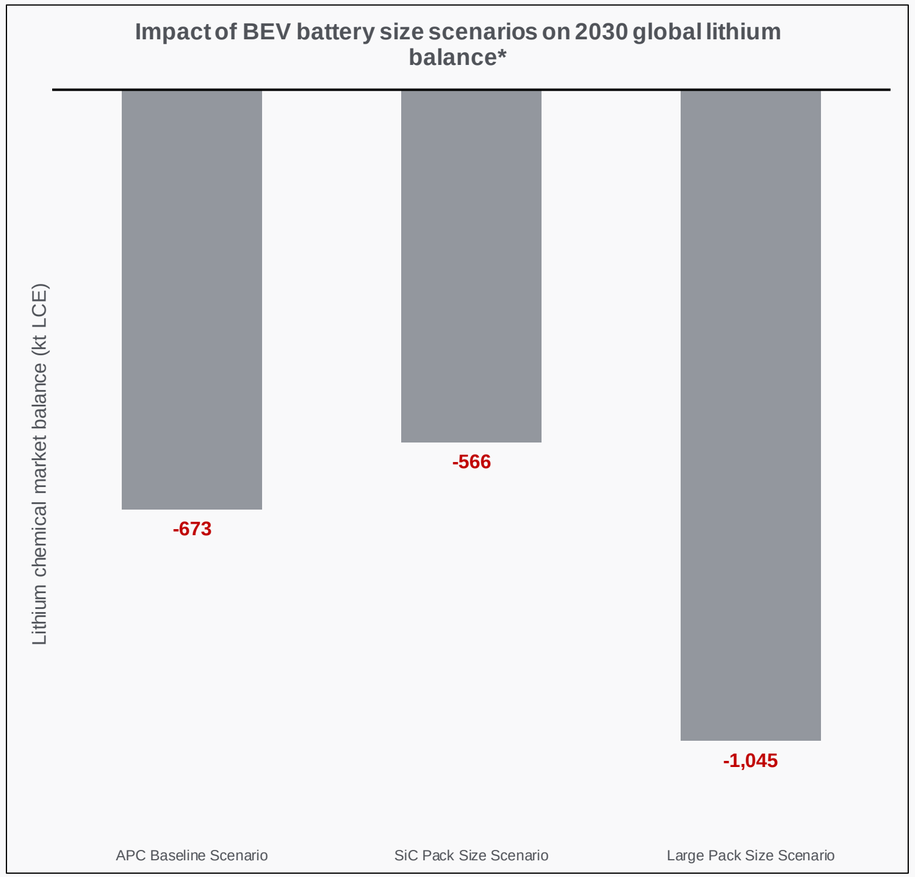
BEV LDV segment	% of 2030 global BEV production	Existing vehicle model examples	Baseline pack size (2030 forecast)	SiC reduced pack size (2030)	2030 total cost saving	Typical range with current pack size (miles)	SiC improved range with current pack size (miles)*
A	4%	 	40 kWh	**35 kWh**	£275	151	169
B	14%	 	50 kWh	**44 kWh**	£353	190	212
C	33%	 	60 kWh	**52 kWh**	£401	175	195
D	36%	 	110 kWh	**98 kWh**	£750	273	302
E	12%	 	80 kWh	**70 kWh**	£530	174	193
F / HVAN	2%	 	100 kWh	**89 kWh**	£671	227	252

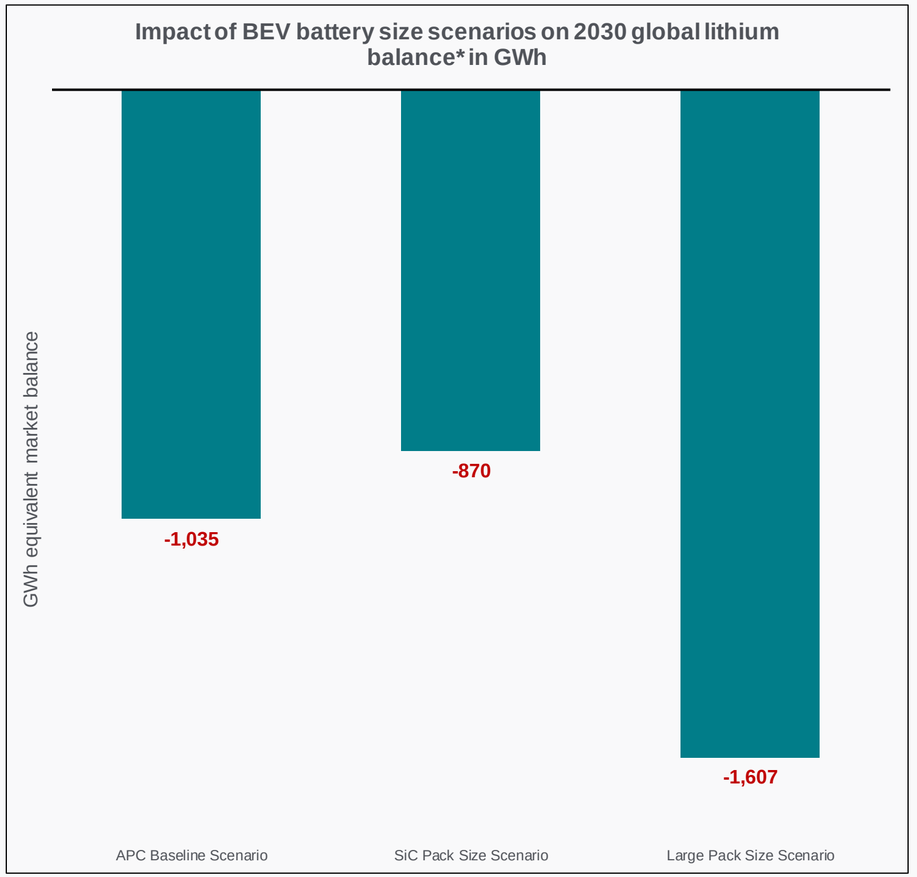
Source: APC analysis, Exawatt
**assuming no pack size reduction, based on 2022 pack sizes*

Lithium supply balance mitigation by silicon carbide (SiC) enabled battery size reduction

Q3 2022 notes

- The SiC enabled pack size reduction impacts the lithium demand balance
- In APC's Q2 2022 demand forecast reduced pack size impact on lithium demand was modelled and mitigation strategies were explored
- SiC allows a reduction of the lithium gap which reduces the strain on mitigation strategies



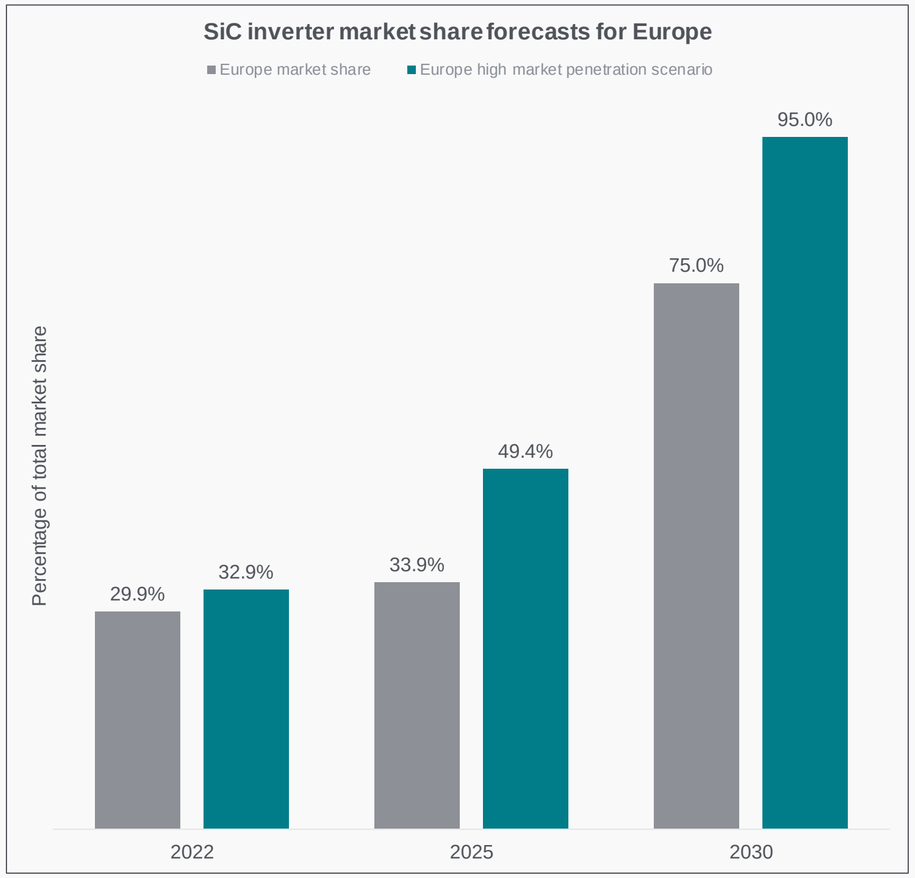


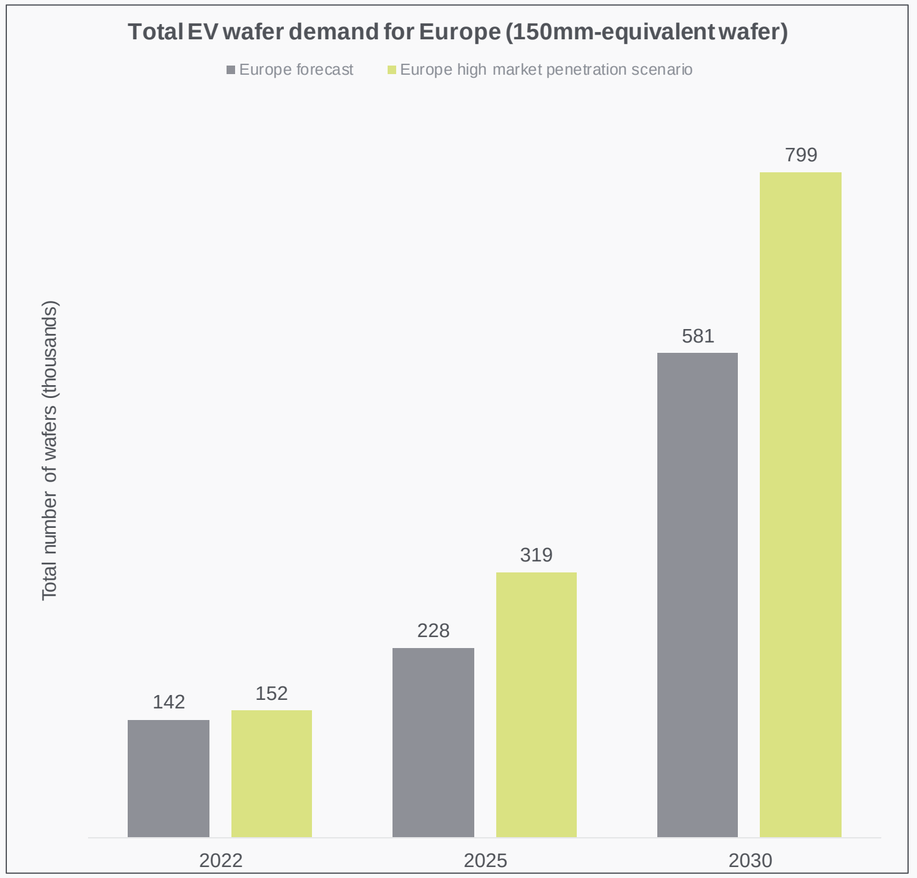
Source: APC analysis, Exawatt
*Assuming only 'Baseline Li Supply' including highly probable projects on top of existing operations and expansions

Potential European demand for silicon carbide (SiC)

Q3 2022 notes

- SiC adoption in inverters is expected to reach between 30-50% market penetration between now and 2025
- In a high penetration scenario, driven by cost savings, SiC could reach over 95% of the market by 2030
- The wafer demand presented is total demand for all wafer material based on 6” wafers
- The APC roadmaps show 8” and 12” being introduced in 2025 and 2030, respectively



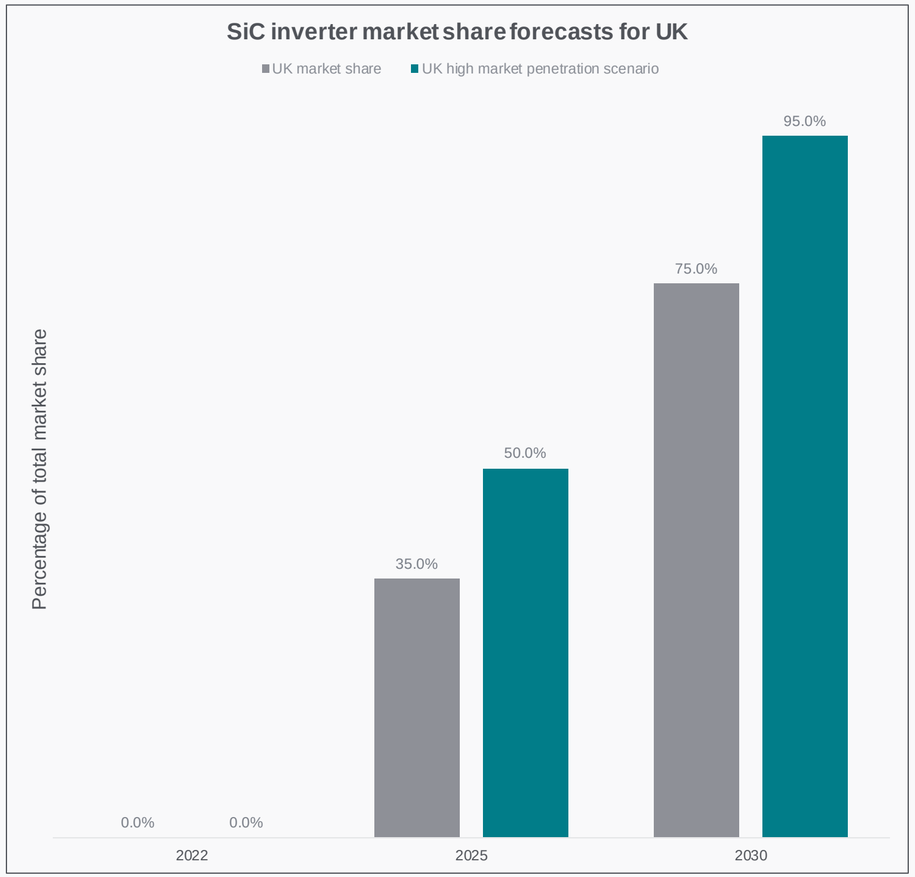


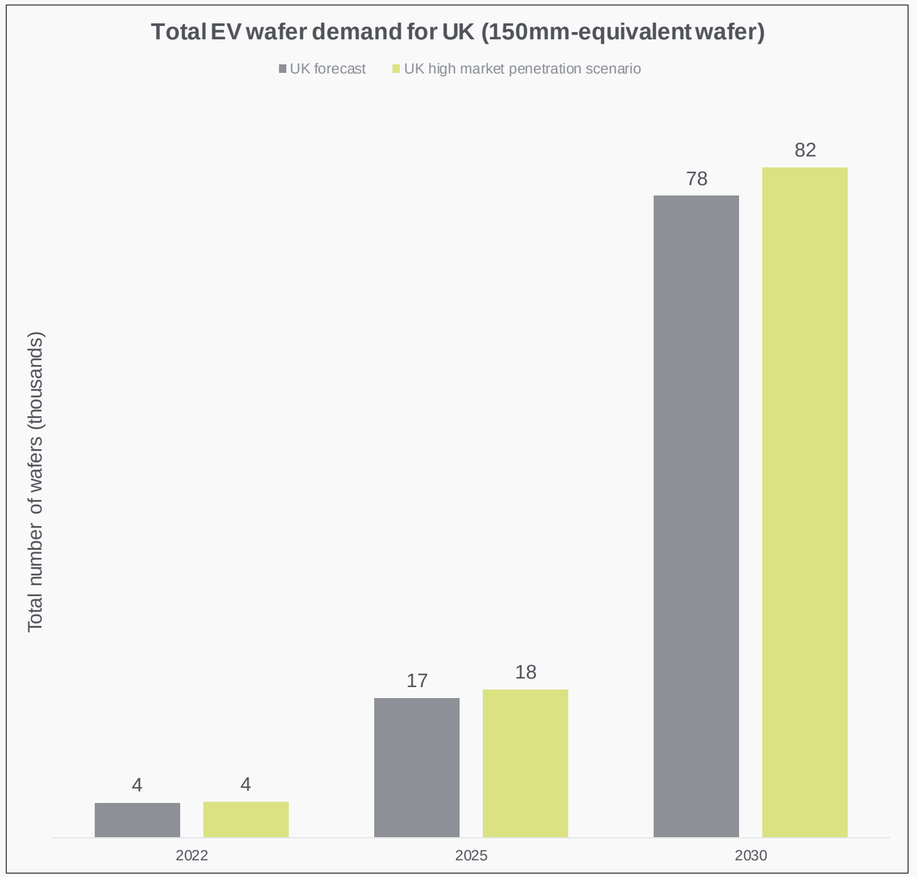
Source: APC Demand Databases using S&P Global AutoTechInsight Nov, 2022), Exawatt

Potential UK demand for silicon carbide (SiC)

Q3 2022 notes

- Current inverter production limited to Si in UK, however SiC based inverters starting to be delivered towards the end of 2022
- As with European demand SiC adoption in inverters is expected to reach between 30-50% market penetration between now and 2025 and between 75-95% by 2030
- The wafer demand presented is total demand for all wafer material based on 6” wafers
- The APC roadmaps show 8” and 12” being introduced in 2025 and 2030, respectively





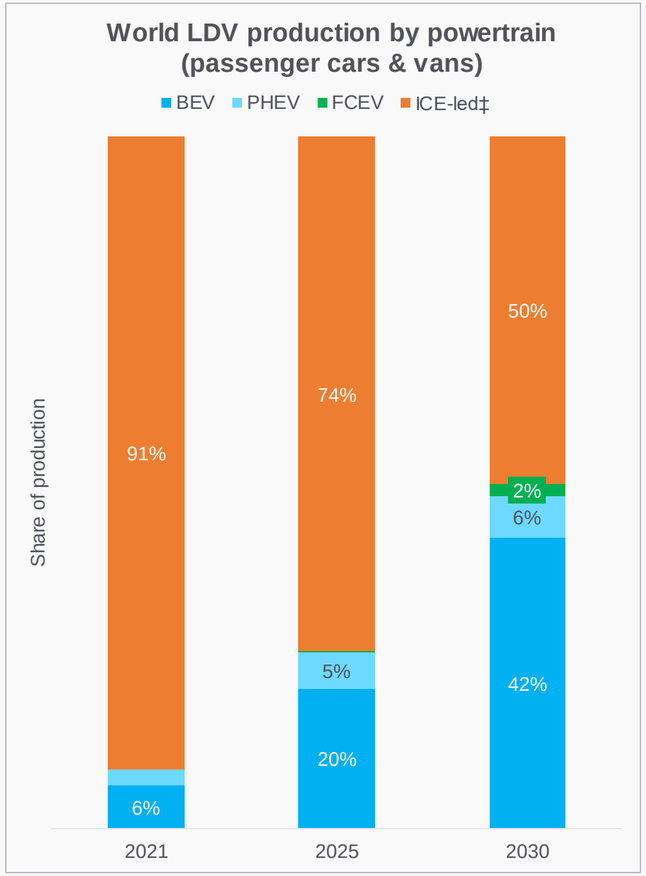
Source: APC Demand Databases using S&P Global AutoTechInsight Nov, 2022), Exawatt

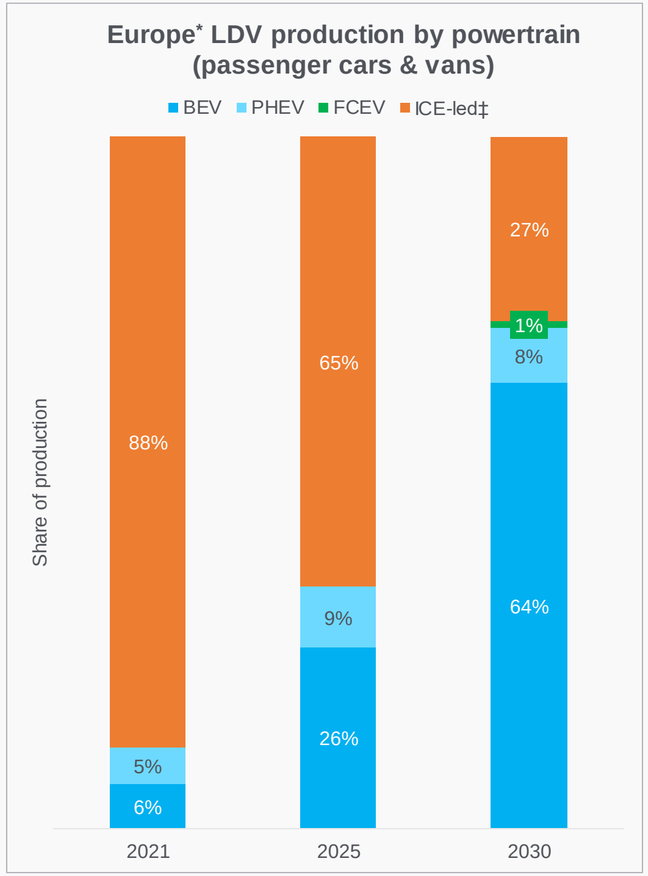
Q3 2022 – Electrified components data

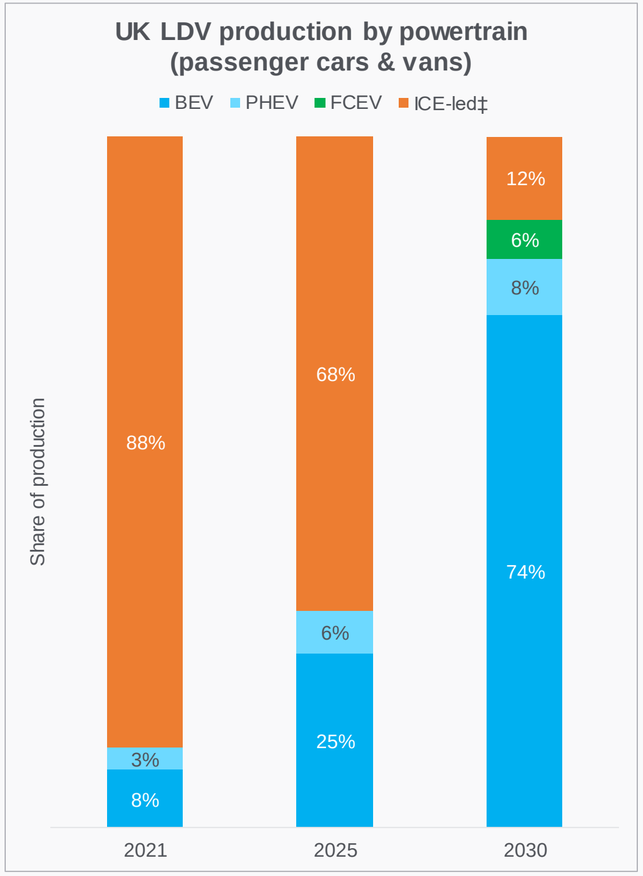
Forecasts for LDV production by powertrain

Q3 2022 notes

- Despite economic uncertainty the long-term outlook for BEVs is still positive
- Global BEV production forecast increased compared to APC's Q2 2022 demand forecast
- ICE-led powertrains still make up 50% of global production by 2030





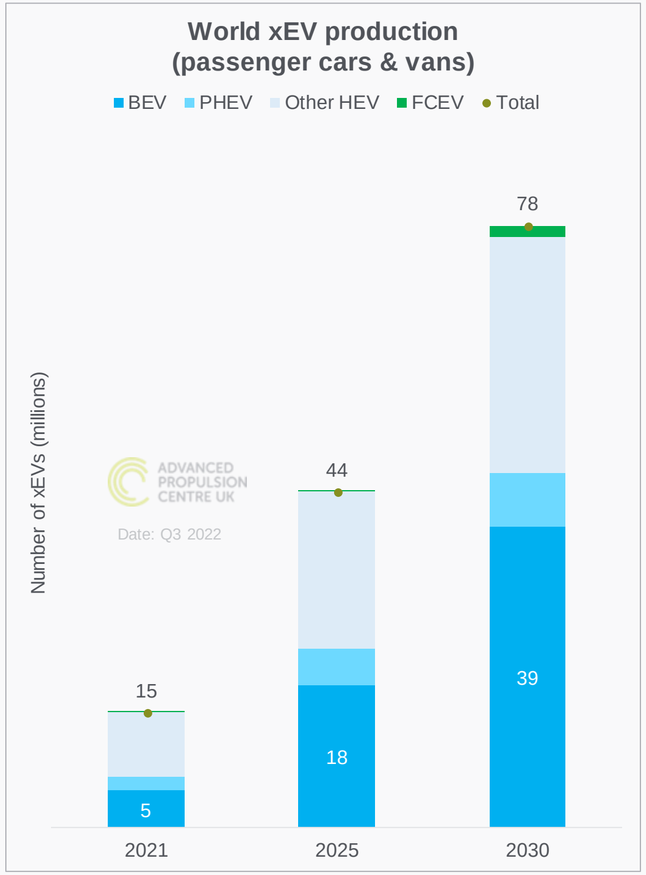


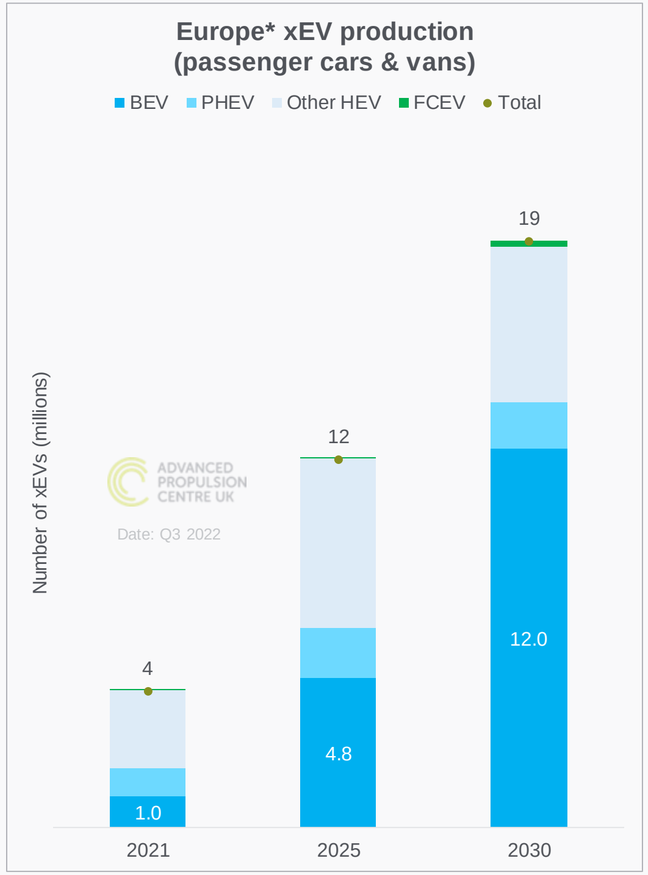
Source: APC Demand Databases using S&P Global AutoTechInsight (Nov, 2022), BNEF forecasts (2022)
*Note: Passenger cars & Light Commercial Vehicles < 3.5t only, *European forecast includes non-EU countries such as Turkey, ‡Includes non plug-in HEVs & ICE*

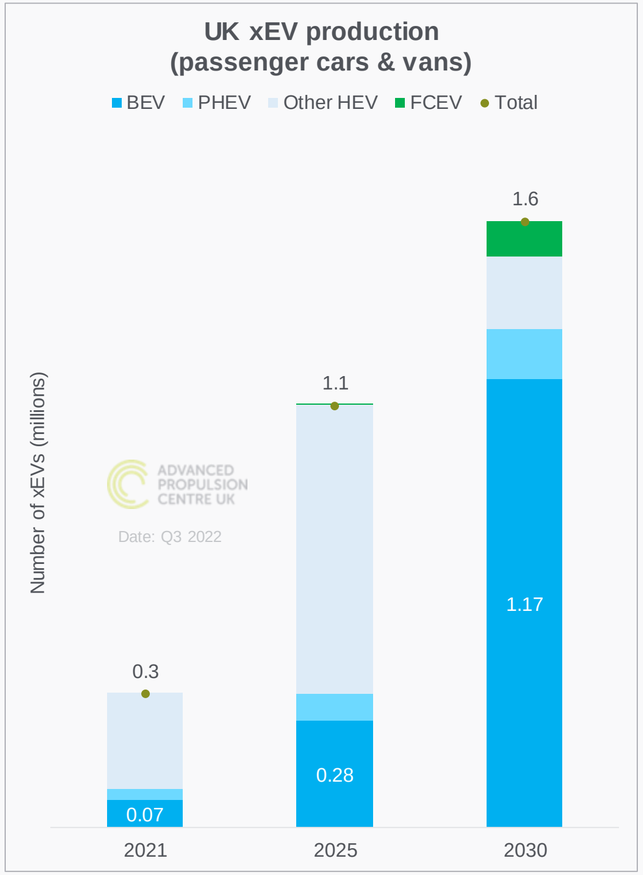
Forecasts for light duty xEV production

Q3 2022 notes

- European production expected to recover by 2030 to levels previously forecast in APC's Q2 2022 demand forecast
- UK production increased in 2025 compared to APC's Q2 2022 quarterly demand forecast, the vehicle mix is changed with more HEV and PHEV





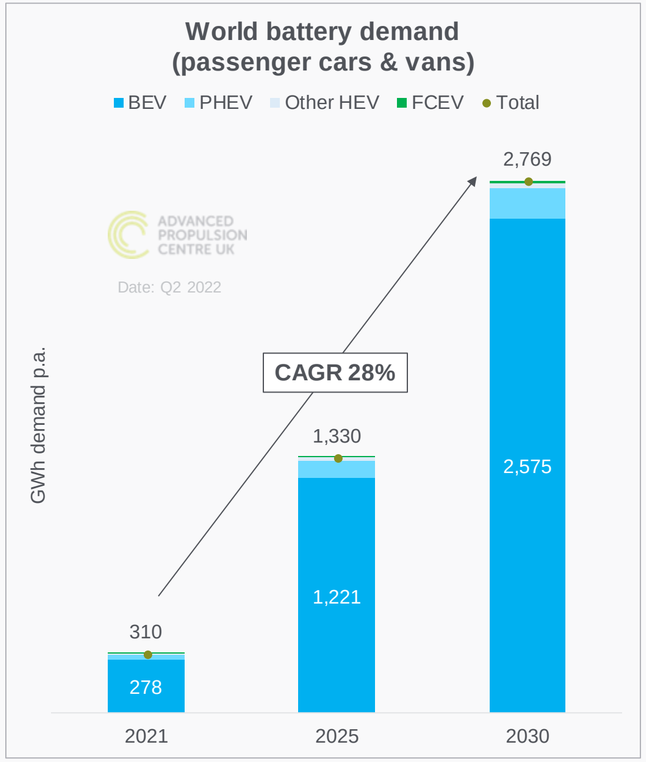


Source: APC Demand Databases using S&P Global AutoTechInsight (Nov, 2022), BNEF forecasts (2022)
*Note: Passenger cars & Light Commercial Vehicles < 3.5t only, *European forecast includes non-EU countries such as Turkey*

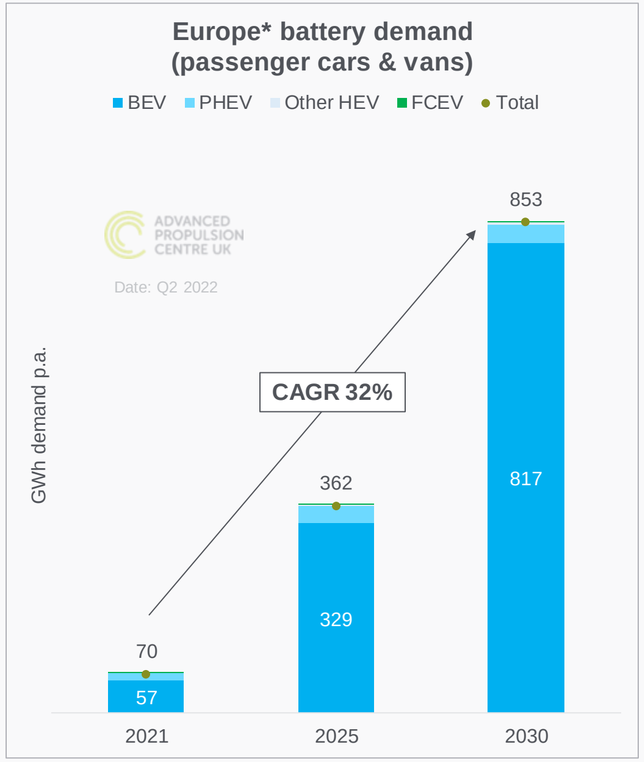
World battery demand for LDVs

Q3 2022 notes

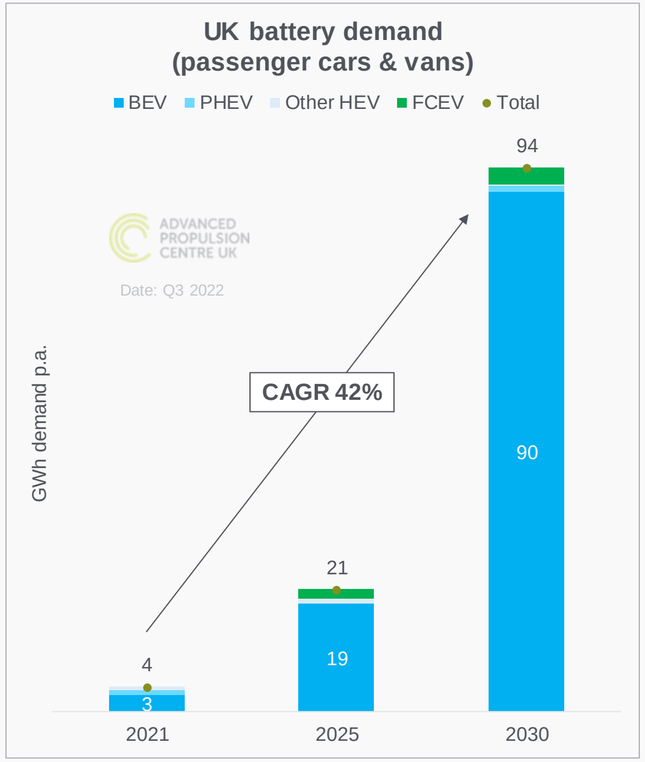
- World battery demand for LDVs to exceed 1,000 GWh by 2025 and close to 2,800 GWh by 2030
- Despite a dip in 2025 CAGR remains at 32% for Europe and 42% for UK



- World battery demand for light duty xEVs is forecast to exceed **2,700 GWh by 2030**
- Relative to APC's Q2 2022 demand forecast, 2030 demand remains largely unchanged



- Relative to APC's Q2 2022 demand forecast, we have seen a 4 GWh reduction in demand for 2025
- Relative to APC's Q2 2022 demand forecast, there is potential for a 7 GWh uplift in 2030 despite economic uncertainty in the short term



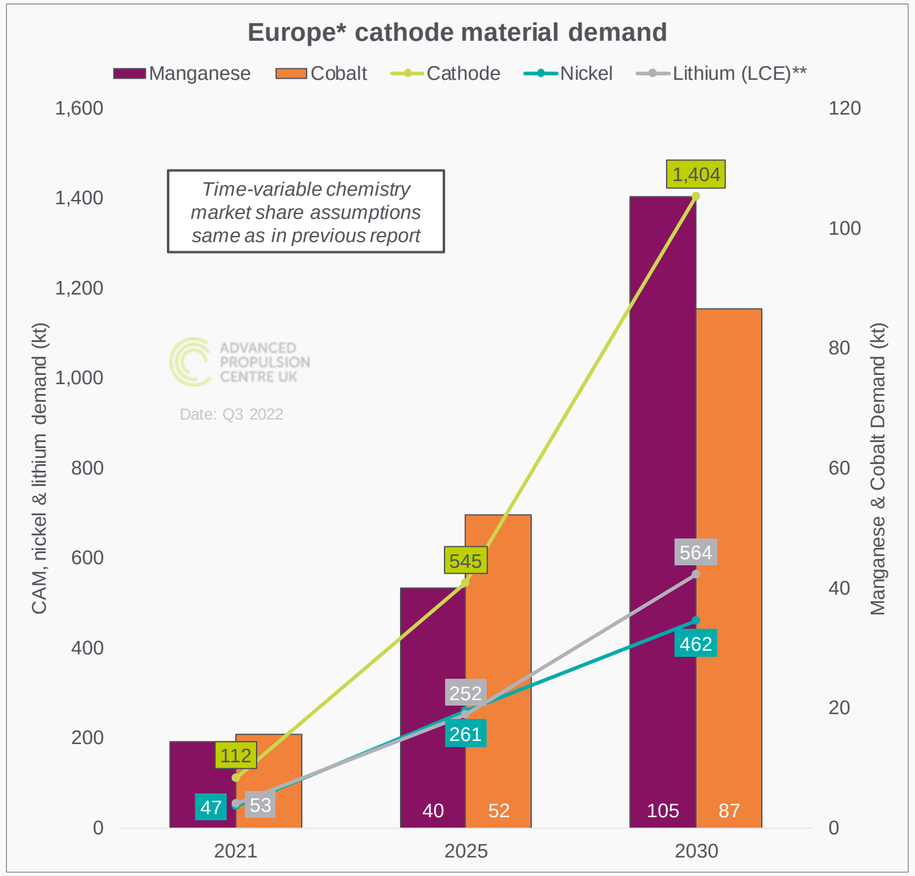
- UK battery demand forecast to account for 11% of European battery demand in 2030
- Relative to APC's Q2 2022 demand forecast, demand reduced 5 GWh in 2025 and 2 GWh in 2030

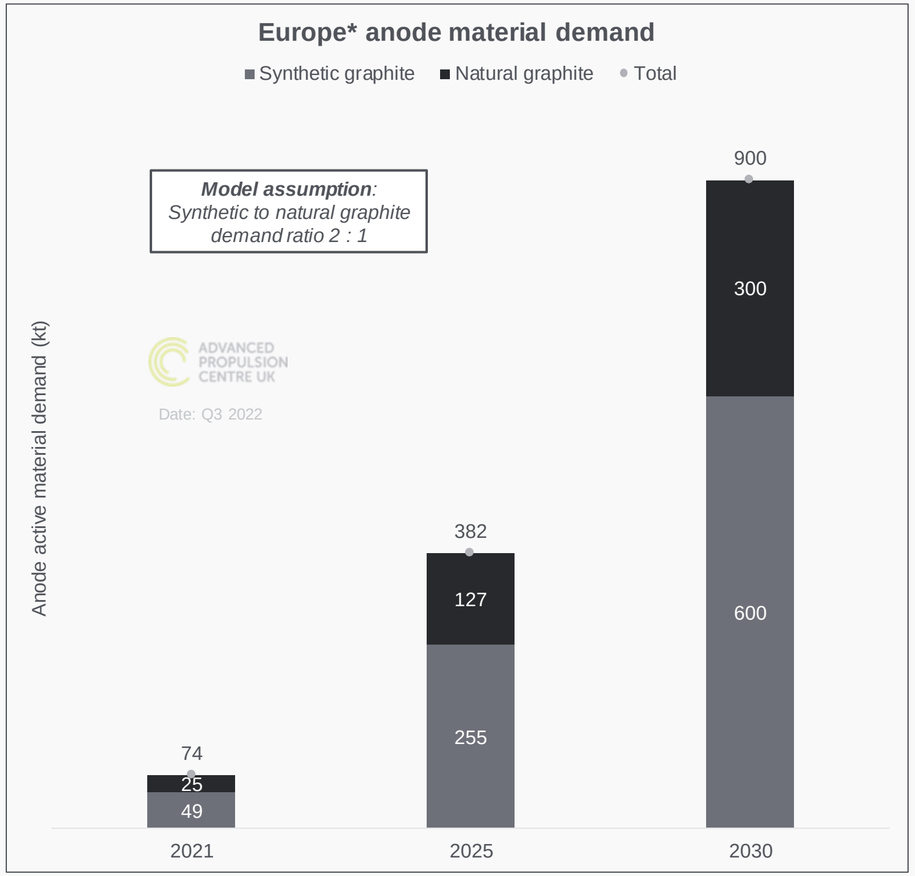
Source: APC Demand Databases using S&P Global AutoTechInsight (Nov, 2022), BNEF forecasts (2022)
*Note: Passenger cars & Light Commercial Vehicles < 3.5t only, *European forecast includes non-EU countries such as Turkey*

European Cathode Active Material (CAM) demand

Q3 2022 notes

- Despite the reduction in forecast production numbers the demand for cathode and anode material demand in 2025 is still forecast at 5x 2021 levels



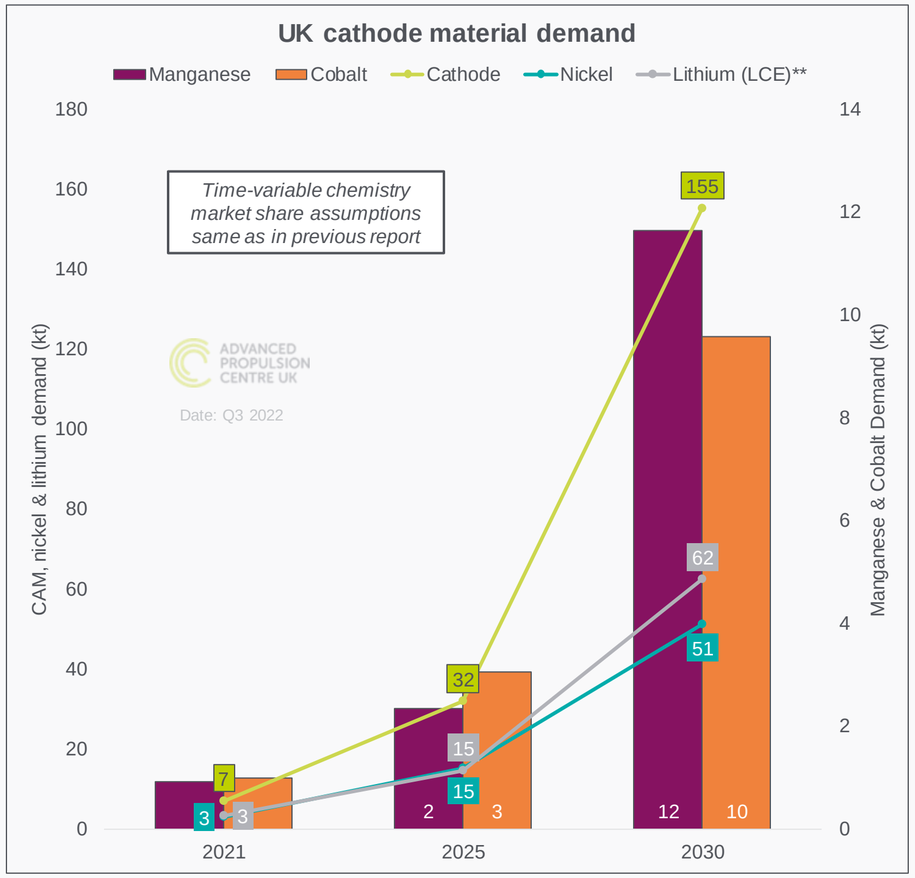


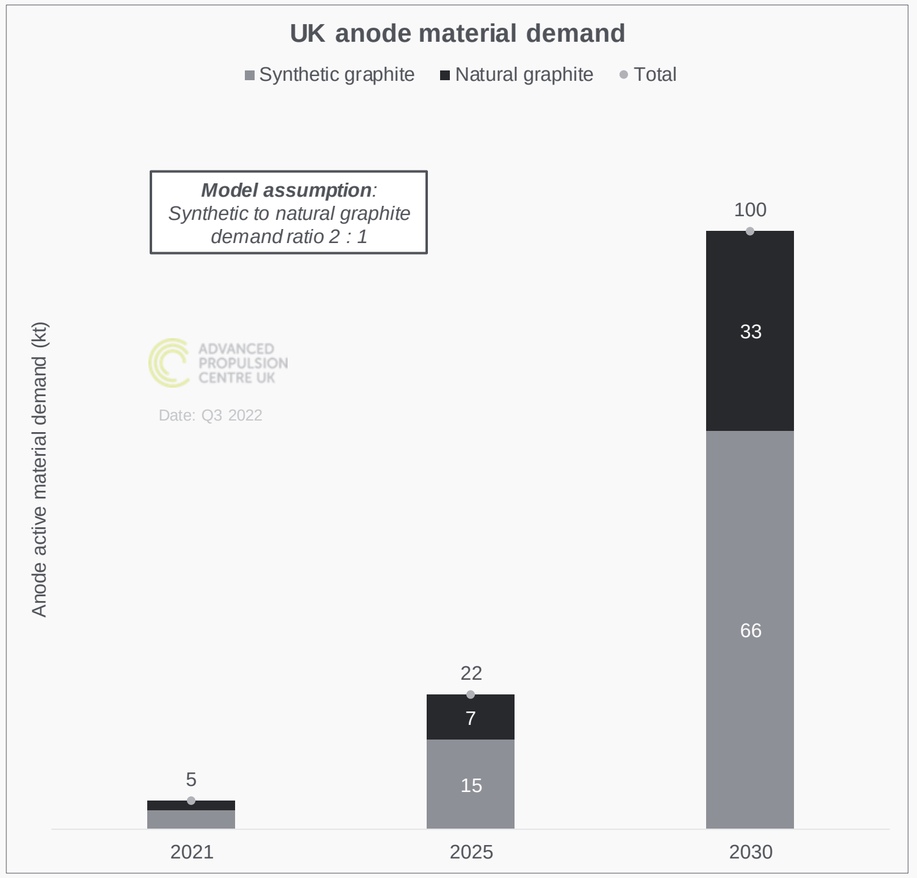
Source: APC Demand Databases using S&P Global AutoTechInsight (Nov, 2022), Rho Motion data (2022), BNEF forecasts (2022)
*Note: Passenger cars & Light Commercial Vehicles < 3.5t only, *European forecast includes non-EU countries such as Turkey, **Contained Li metal would be 5.3x lower*

UK Cathode Active Material (CAM) demand

Q3 2022 notes

- Demand revised down slightly due to economic uncertainty
- There is still a big opportunity to localise (at least) 3 CAM plants in the UK



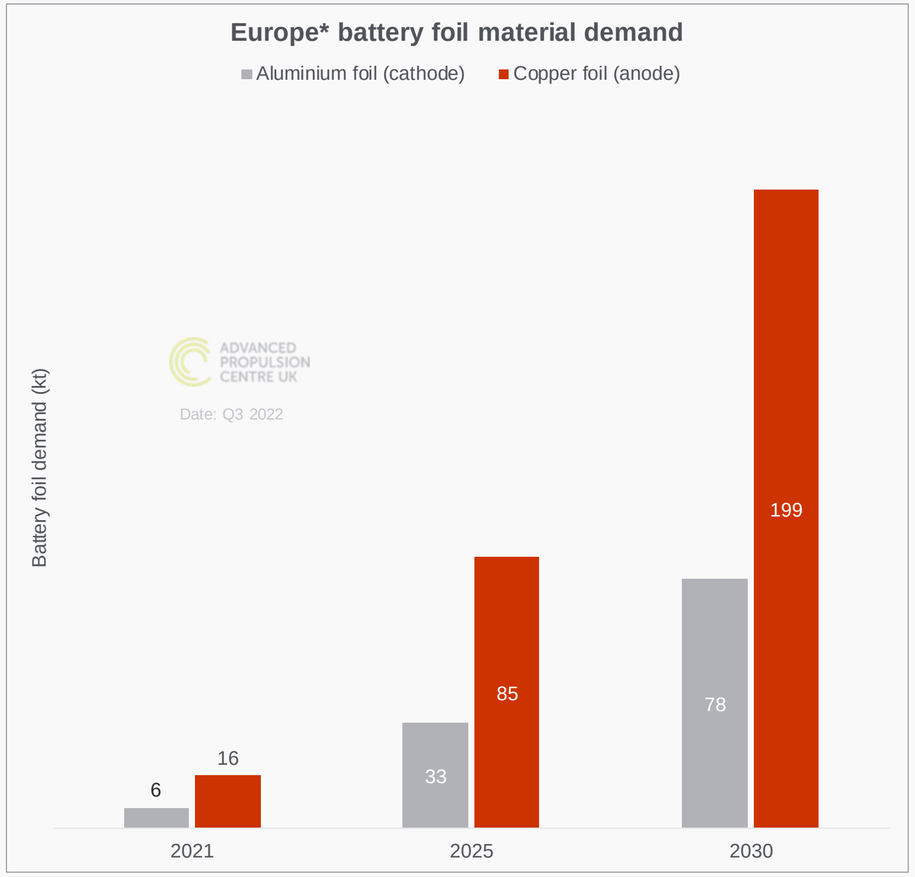


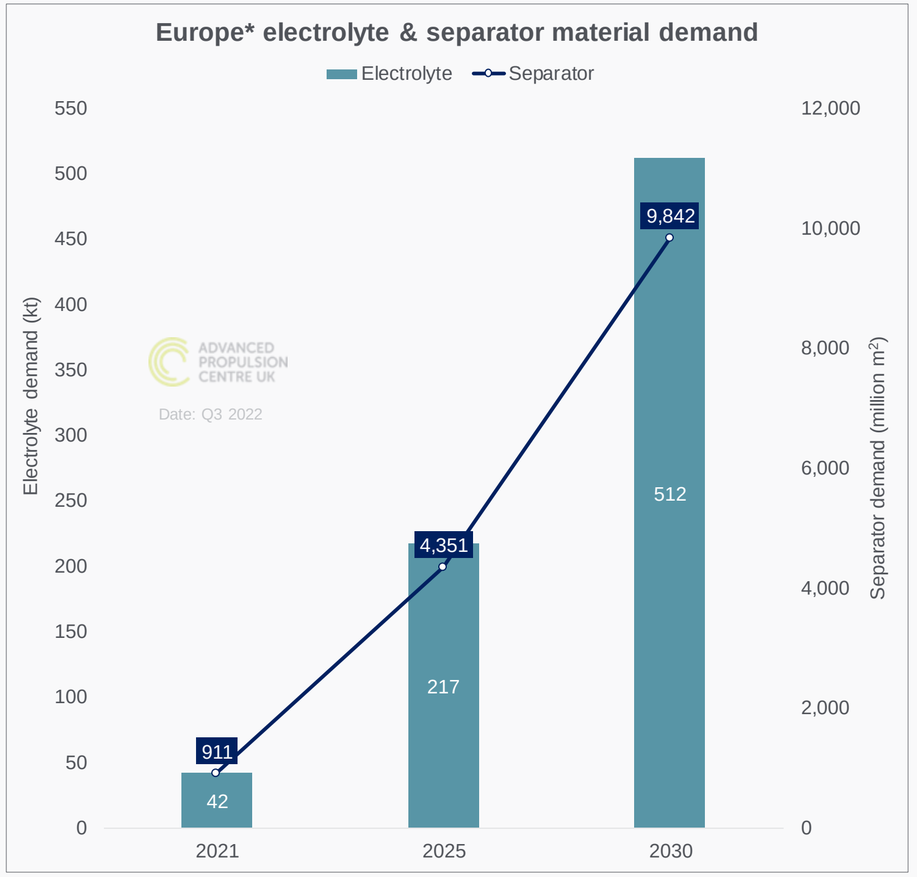
Source: APC Demand Databases using S&P Global AutoTechInsight (Nov, 2022), Rho Motion data (2022)
*Note: Passenger cars & Light Commercial Vehicles < 3.5t only, **Contained Li metal would be 5.3x lower*

European demand for battery foils, electrolyte and separator material

Q3 2022 notes

- The expected demand reduction puts European demand just below 120kt battery foil material by 2025
- A delay in demand provides an opportunity for localisation to catch up



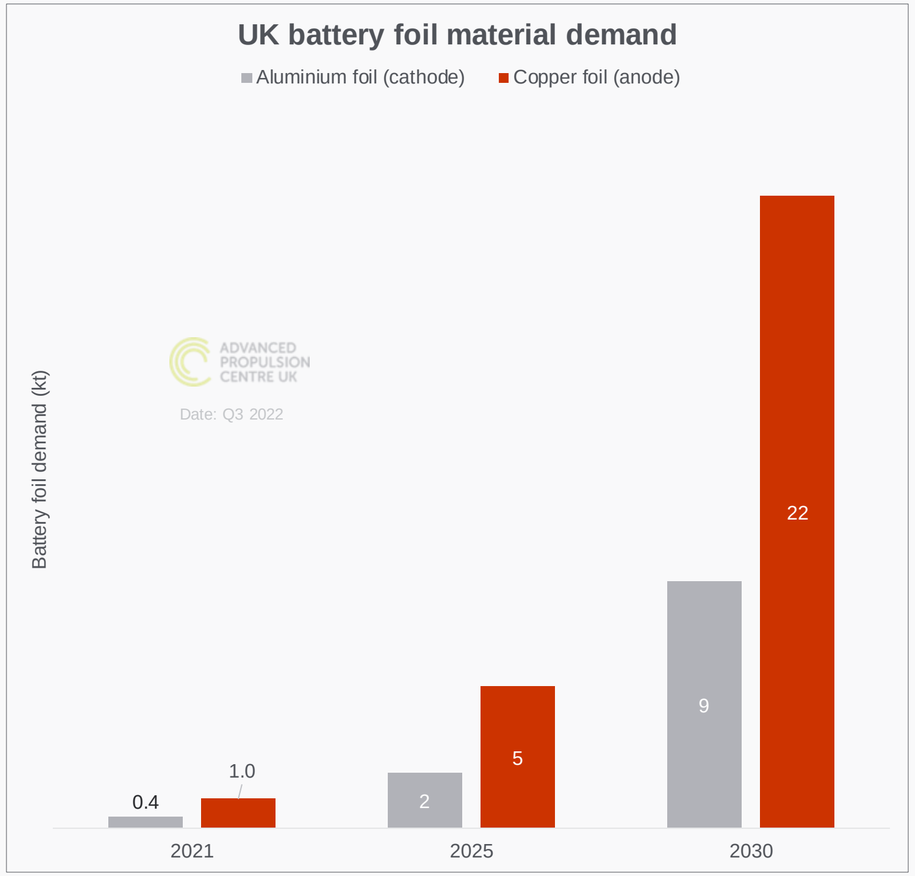


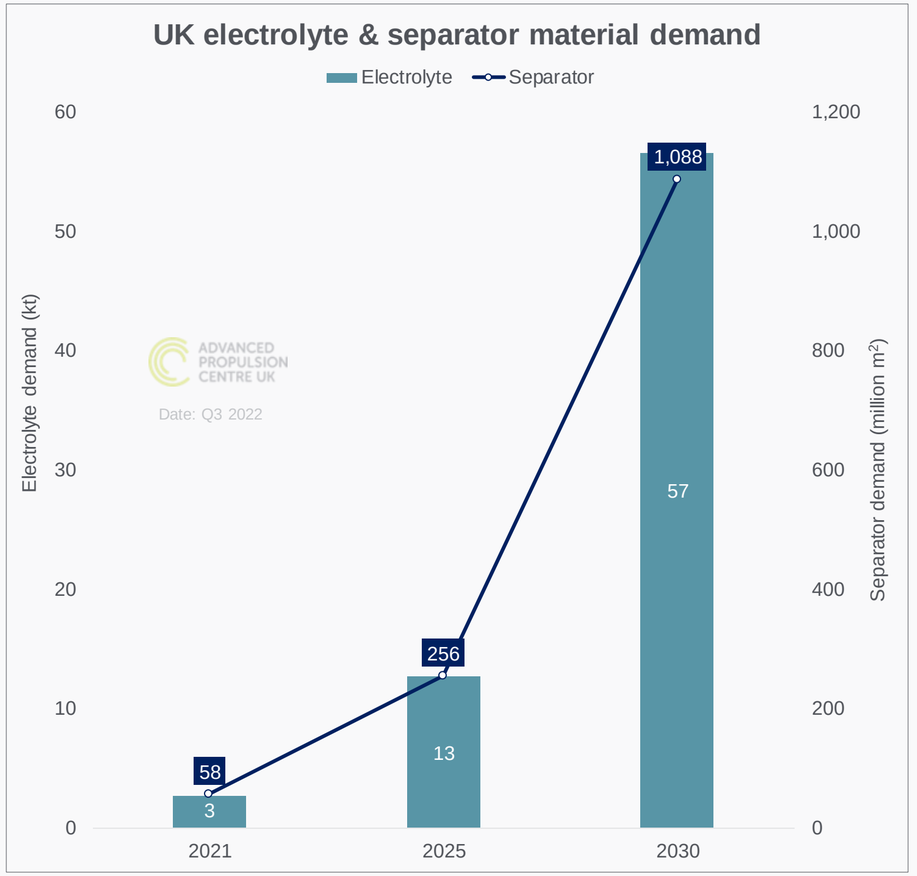
Source: APC Demand Databases using S&P Global AutoTechInsight (Nov, 2022), Rho Motion data (2022), BNEF forecasts (2022)
*Note: Passenger cars & Light Commercial Vehicles < 3.5t only, *European forecast includes non-EU countries such as Turkey*

UK demand for battery foils, electrolyte and separator material

Q3 2022 notes

- UK demand for battery foils, electrolyte and separator material revised down slightly as the vehicle mix is revised due to economic factors



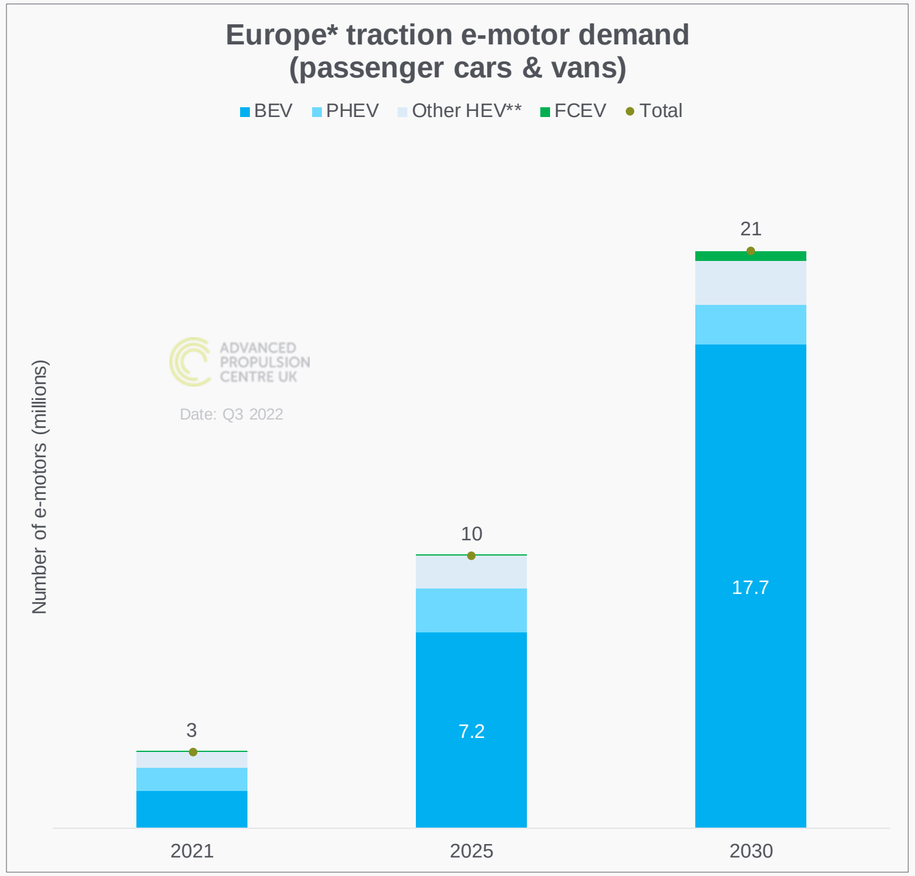


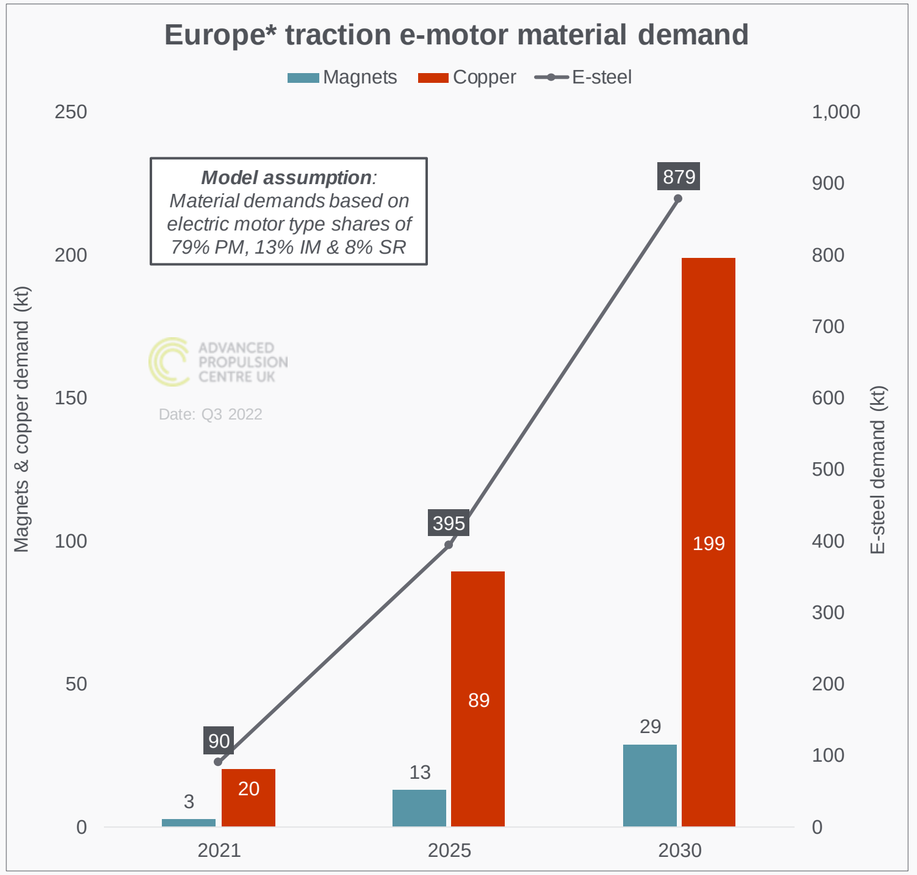
Source: APC Demand Databases using S&P Global AutoTechInsight (Nov, 2022), Rho Motion data (2022)
Note: Passenger cars & Light Commercial Vehicles < 3.5t only

European demand for traction electric motors

Q3 2022 notes

- The Europe traction motor demand remains largely unchanged despite expected demand reduction – a scenario created by the differing numbers of motors used in models expected in the coming years



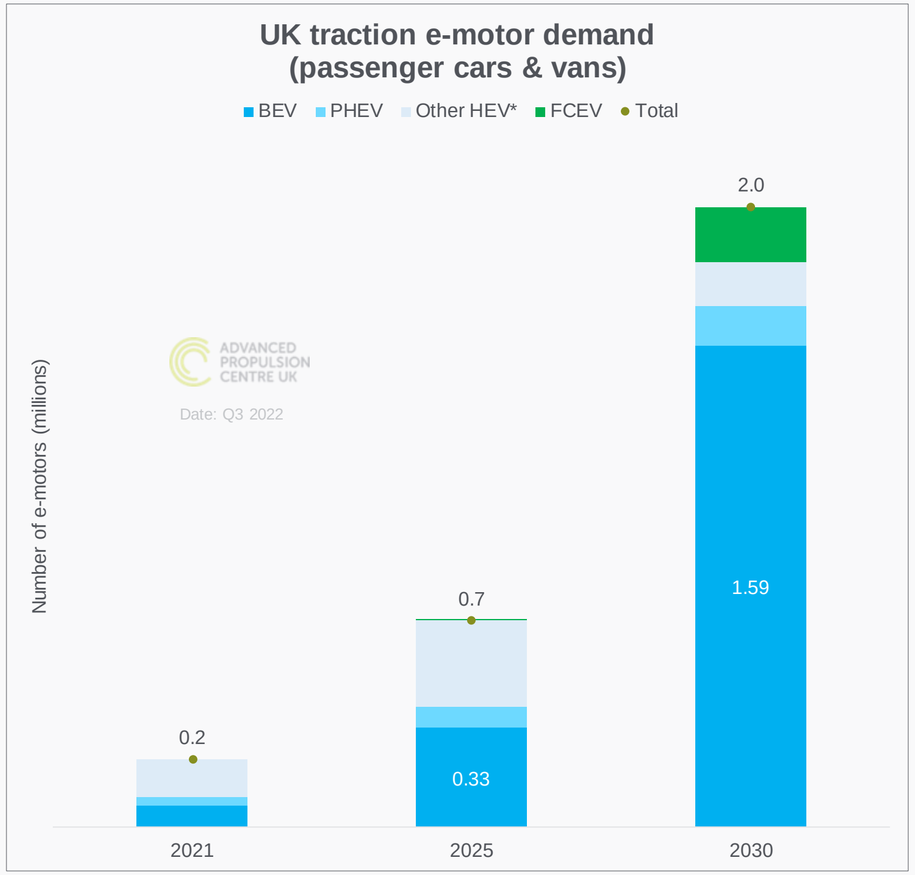


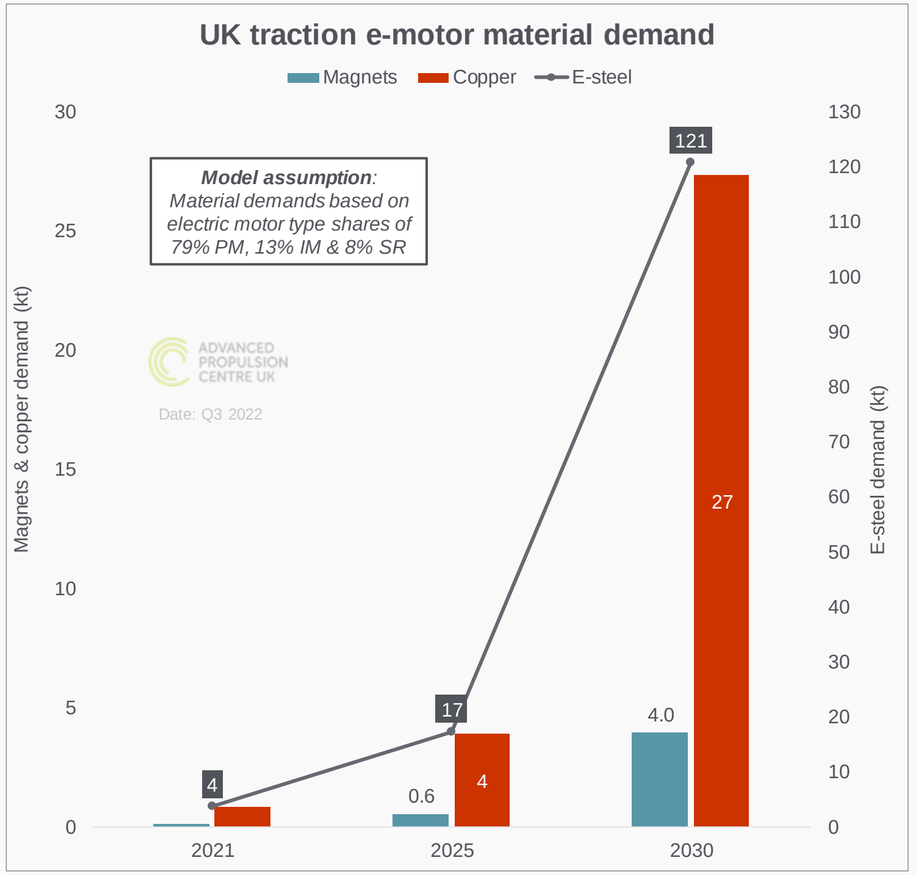
Source: APC Demand Databases using S&P Global AutoTechInsight (Nov, 2022)
*Note: Passenger cars & Light Commercial Vehicles < 3.5t only, *European forecast includes non-EU countries such as Turkey, **Excluding mild hybrid electric motors*

UK demand for traction electric motors

Q3 2022 notes

- Despite economic uncertainty the UK demand for traction electric motors is still expected to reach 2 million units by 2030
- There remains an opportunity to transition the UK's ICE manufacturing plants





Source: APC Demand Databases using internal insights and S&P Global AutoTechInsight (Nov, 2022)
*Note: Passenger cars & Light Commercial Vehicles < 3.5t only, *Excluding mild hybrid electric motors*

This Q3 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

December 2022