We are a small not-for-profit enterprise based in the West Midlands and provide a national service, principally as delivery partner for the Department for Business and Trade (DBT) and the Automotive Council in respect of late stage collaborative R&D and industrialisation grant funding. Specifically, we were engaged by DBT in 2020 to seek and develop industrialisation investment project proposals for electric vehicle batteries, motors, drives, power electronics and hydrogen fuel cells as delivery partner for the Automotive Transformation Fund.

We give consent for our responses to be made public.

Summary:

1. Through our insights and engagement with the established UK industry and overseas investors, we forecast that the UK has more than sufficient demand to support at least four or five gigafactories by 2030, and the need is urgent from 2025. The UK industry is very diverse with a significant number of small OEMs who will not attract dedicated gigafactory investors directly linked to their sole demand, so the UK needs not only established, large battery makers, but those prepared to co-develop and manufacture cells for the multiplicity of smaller UK off-takers.
2. Inhibitors to establishing capacity in the UK include smaller economically addressable market than if located in the EU because of logistics costs, risk-aversion in both private capital and government investment sentiments, perceived upstream raw and semi-processed materials supply chain risks and uncertainty of future economic environment, particularly energy costs vs competitor nations. Policy commitment, transparency and scale of support are often cited by investors as additional inhibitors. More recently, aggressive and streamlined subsidy programmes in the EU and North America have tilted investment in their favour. Global competition for critical upstream materials is growing rapidly, and with limited or early-stage UK mineral resources and current global reliance on China for intermediate processing, the UK needs strategic materials supply partners.
3. The market transition needed to deliver ZEV and urban clean air targets is distinct from the transition needed to sustain the significant economic and societal benefits of a vibrant auto industry transition given the balance of imports (90% of UK retails) and exports (~80% of UK vehicle production is exported).
4. Logistics costs and rule of origin requirements to support the UK's primary export market (EU27 states) drive a requirement for domestic battery manufacturing to remain competitive and to sustain industry investment and levels of high value employment.

5. Is there enough UK vehicle manufacturing demand in the UK to support gigafactories?

a) Yes, there is sufficient demand in the UK to support at least 4 or 5 gigafactories at viable scale by 2030 provided that economic conditions support competitive ongoing vehicle assembly operations and maintain some recovery of industry vehicle production output from the 2022 low out to 2030.

b) The Advanced Propulsion Centre (APC) forecasts automotive production demand of over 20 GWh in 2025 increasing to over 90 GWh in 2030. Faraday Battery Challenge (FBC) forecasts over 200 GWh demand for batteries including stationary energy storage demand of approximately 20 GWh. https://www.faraday.ac.uk/wp-content/uploads/2022/06/2040-Gigafactory-Report_2022_Final_spreads.pdf,

c) https://www.apcuk.co.uk/app/uploads/2023/01/Q3-2022-Quarterly-Automotive-Industry-Demand-Forecast-Report.pdf

d) Minimum economically viable scale for gigafactories is estimated to sit at >10 GWh (lower for specialist or high-performance cells). After that point, the capital investment cost per unit of capacity improves minimally, but conversion costs and finished cell ex-works costs continue to improve beyond that point, but only minimally beyond 30 GWh per annum operating scale. (Source: BNEF Bottom-up Battery Cost Model, Part 2- Cost Reduction Outlook, 2020 & Rho Motion Cost Model, 2021 for APC). However, higher economic viability thresholds for upstream materials manufacturing apply (e.g. Cathode Active Material-"CAM" and Active Anode Material-"AAM").

e) Currently, confirmed investment plans in the UK indicate an installed battery manufacturing capacity of only 15 GWh in 2025 and 28 GWh in 2030, this shows a disparity from forecasted APC demand vs installed capacity as early as 2025. The proposed Britishvolt project would have uplifted this installed capacity to 58 GWh in 2030, still leaving a significant shortfall in 2030 of around 40-60 GWh which would need to be imported (an estimated £3bn-£5bn of imports, dependent upon material prices).
f) To avoid this shortfall the UK needs substantially greater battery manufacturing capacity and upstream materials supply, including multiple new gigafactories and manufacturing plants for key high value inputs such as anode, cathode and electrolyte materials. As an example, the initial capacity of the new Envision AESC plant in Sunderland is 12 GWh with the possibility to increase to 35 GWh. This means that by 2030 the UK needs 3-5 more plants of this scale and by 2040 between 6-8 more to meet the forecast demand.
g) Automotive sector demand in the UK is very diverse. Cells need to be developed in parallel with vehicle programmes and must go through several cycles of technical evaluation and validation before vehicle OEMs commit to firm offtakes. The UK has several OEMs with large demand (in excess of 8-10 GWh pa) but also many more with sub 1 GWH to 5 GWh annual demand (e.g. luxury, sports, off-highway, motorsport, bus and HDV etc.) and in aggregate these customers generate a significant proportion of the total, yet each customer on their own is too small to justify establishing a dedicated gigafactory. Collaboration between smaller OEMs to align on a single supplier and cell type (to aggregate sufficient demand to attract a cell maker) is challenging for technical, timing alignment and competition reasons, therefore many smaller OEM customers are faced with limited choice or must wait for speculative investment in cell-making capacity.
h) It is likely that the UK could support several smaller-scale gigafactories or even Megawatt-scale (200-900 MWh annual output) for specialist, high performance cells for specialist use in addition to large-scale gigafactories.

6. Will the UK have sufficient battery production supplies by 2025 and 2030 respectively to meet the government phase-out plans for petrol and diesel vehicles?

i) It should be noted that the government's phase-out plans for petrol and diesel passenger cars and vans only apply to vehicles registered in the UK, yet only 10% of the UK's total new car registrations in 2021 were of UK-produced vehicles, and circa 78% of UK-manufactured vehicles were exported in 2022 to many global markets, including substantially to markets outside the European Union. Nonetheless, many UK manufacturers have committed to electrifying the majority or all of their products in the 2025-2035 period, supporting the strong demand growth indicated above in the APC forecast.
j) The market requirements should therefore be seen as distinct from those of the automotive manufacturing industry in the UK. Domestic UK cell manufacturing demand is created by other distribution markets in large part for certain vehicle manufacturers, yet for others, the UK is the predominant market. All OEMs have significant exposure to the EU market and by extension for vehicles sold into the EU/EEA markets they will need to comply with the upcoming EU Batteries Regulation, once adopted, (replacing the EU Batteries Directive 2020) and if import tariffs (into EU27 markets) are to be avoided on finished vehicles, the appropriate Rules of Origin stipulated in the UK-EU Trade & Cooperation Agreement (TCA) will need to be followed.
k) The UK retail market requirements – supporting the phase-out of petrol and diesel vehicles - *could* be satisfied through imports of finished electric vehicles for passenger car and light commercial vehicles on a purely numerical basis, but the HDV and specialist conversion (e.g. fire appliances, refuse wagons etc.) markets are less easily satisfied by imports due to cost of shipping and market-specific requirements. The UK market is also a strong market for domestically-produced premium and luxury vehicles and SUVs, and without domestic battery manufacturing to support UK OEMs, some market segments may not be satisfied with suitable imports, creating hold-off in replacement cycles in these segments, eroding the opportunity to transition these larger vehicle segments towards EV take-up in the near term. The industry, rather than the market, is the higher risk in the short to medium term.

l) The APC estimates that the UK will produce around 200,000 battery fully electric cars in 2025, accounting for 22% of total passenger car production and equivalent to 13 GWh of battery demand. In a scenario where the UK meets its 28% ZEV target for cars produced in 2025, UK manufacturers would produce 260,000 fully electric cars amounting to 17 GWh of battery demand.

m) The APC forecasts suggest that UK van production may be substantially ZEV by 2025/2026. This would add a further 3 – 4 GWh of battery demand in 2025 taking the total to over 20 GWh of battery demand. This would mean a UK battery production shortfall of at least 5 GWh considering the confirmed battery production plans in the UK are 15 GWh by 2025.

n) By 2030, APC forecasts that the UK will produce around 1,000,000 battery and fuel cell electric cars, accounting for 77% of total passenger car production and equivalent to 78 GWh of battery demand. In a scenario where the UK meets its 80% ZEV target for cars produced in 2030, the APC estimates at least 80 GWh of UK battery production would be required. By 2030, APC forecasts the demand for batteries in UK-produced zero-emission vans will reach 13 GWh, taking the total car and van battery demand figure to over 90 GWh.

o) As of today, confirmed plans in the UK provide a battery manufacturing capacity of only 28 GWh in 2030, if a like-for-like Britishvolt replacement were to be assumed, this would rise to 58 GWh in 2030 leaving a shortfall in 2030 of around 30 GWh (60GWh without a Britishvolt successor at similar scale) & which would need to be imported, or result in the industry shrinking.

p) The impact on balance of trade with >£6bn imported batteries in this scenario would be significant and would likely place UK OEMs at a significant competitive disadvantage based on logistics costs and working capital requirements for longer shipping routes.

q) https://www.faraday.ac.uk/wp-content/uploads/2022/06/2040-Gigafactory-Report_2022_Final_spreads.pdf, https://www.apcuk.co.uk/app/uploads/2023/01/Q3-2022-Quarterly-Automotive-Industry-Demand-Forecast-Report.pdf

7. Is UK-based battery production necessary to support the manufacture of electric vehicles in the UK?

r) Yes, it is pivotal. There is a clear correlation between global investments in cell manufacturing and vehicle assembly plant investment to manufacture EVs, and few locations where EV manufacture at scale is supported by imports in the long term, except where highly specialist, high-value cells are made. Here in the UK, Nissan's Sunderland vehicle production plant produces the Nissan Leaf within walking distance of where its batteries are produced by Envision AESC's gigafactory. Batteries are heavy, expensive and hazardous to ship across countries in large quantities especially as EV production ramps up to demand multiple GWh-worth of deliveries. Due to the high value, significant working capital is tied up in inventory in shipment (example: a UK vehicle plant producing 500,000 cars/year with a 100 kWh battery pack would have circa £1 bn of working capital tied up in inventory in shipment for batteries from Asia).

s) Long-distance shipping, even from Europe, exposes batteries to damage risk, especially when not contained in a vehicle system with an active 'Battery Management System' which monitors battery health and maintains reasonable temperatures (important for reducing cell degradation) despite ambient temperature changes in shipment.

t) Investment in a new electric vehicle assembly plant is potentially lower per unit of installed capacity than the battery manufacturing plant that supplies it. Significant alterations to vehicle assembly plants are necessary to support transition to EV manufacture; OEMs are likely to consider the relative economics of moving vehicle plants to centres of cell manufacturing rather than investing in cell manufacturing close to existing vehicle plants.

u) While the focus on localising battery production is a priority, the UK should not lose sight of the tightening material sourcing requirements outlined in the EU-UK Trade and Cooperation Agreement (TCA) Rules of Origin (ROO) for EVs. From January 2024, the ROO are clear that using UK or EU-made batteries alone will no longer qualify an EV for tariff-free trade with the EU. The Cathode Active Material (CAM) that is used in batteries should also be processed and sourced from the UK or EU for tariff-free trade of EVs, or at least 50% of the material

value in each battery cell has to be sourced from UK or EU production, which is very challenging to achieve without originating CAM.

v) Therefore, both battery production and CAM plants are necessary to support the manufacture of electric vehicles in the UK and remain competitive under the TCA ROO.

w) Rules of origin for other export destinations benefiting from current or potential future free trade arrangements with the UK may typically require compliance with 'value-add' rules (or limit the value of non-originating material, so called "MaxNOM" rules). Given the very high value of batteries, compliance with such rules without UK-originating batteries is unlikely unless, for example, trilateral cumulation rules could be agreed with the EU.

8. What are the risks to the UK automotive industry of not establishing sufficient battery manufacturing capacity in the UK?

x) Without UK battery manufacturing capacity, there is a significant risk that major investments in UK vehicle plants will fail to be attracted resulting in significant direct and indirect employment losses and the closure of several UK assembly plants and which are typically located in regions of relatively low GDP per capita, increasing the societal and economic impacts. The UK automotive sector has historically manufactured 1.0-1.6 million vehicles every year, would ultimately not be 'future-proofed' resulting in multiple plant closures and job losses across the regions.

9. What other domestic end uses for batteries would provide a market for UK battery production?

y) Stationary energy storage is a growing market and one in which the UK currently leads in Europe on installed and planned capacity. Stationary energy storage is critical to maximising the benefits of wind and solar energy projects both commercial and domestic. The UK also has significant off-highway and mining sector demand.

z) Rail, maritime and particularly aerospace can also benefit from investment in battery development that can be enabled by production at scale and the growth of this sector.

aa) The UK has a vibrant and growing electrified aerospace sector and together with demand from the e-motorsport sector will create significant demand for very high performance, high value specialist cells, including those potentially with different chemistries (for example lithium sulfur).

bb) The UK's sizeable defence sector is also developing electrified solutions, and again typically will take higher value, specialist cells, and this market is particularly sensitive to origin of technology and manufacture.

cc) The APC is not able to provide forecasts of demand in these sectors, but some automotive projects under consideration have spill-over benefits into these adjacent sectors. Automotive use can bring the scale that is needed to develop the supply chains and cost efficiencies that unlocks use of these technologies in other industrial and technology sectors.

10. Does the UK have a sufficient supply of critical materials to support vehicle battery production?

dd) Not currently, and for some materials, supply chain options are very limited. Establishing partnerships with key minerals-rich nations will be vital to sustain supply in the medium-long term.

ee) Materials critical to battery production include: lithium, nickel, cobalt, graphite and increasingly, copper, and are so classified as a result of supply-demand imbalances being forecast as global demand grows, and particularly where UK or European regional intermediate processing is under-invested, or forecast to become so.

ff) The predominant use of lithium, for example has rapidly, from 2015, become lithium ion batteries for vehicles and energy storage. Nickel, becoming a key input metal into high performance cell cathode materials is also forecast to be used predominantly in batteries

before 2040 vs current dominant uses in stainless steels and plating/medical instrument manufacture.

gg) An example of the increasing supply-demand imbalance is lithium, where prices for the key traded refined input material lithium carbonate (price indices quote “lithium carbonate equivalent” or “LCE") have risen more than seven-fold since 2021, and similarly nickel currently trading at twice its average price in 2020.

hh) More than three quarters of global battery-grade lithium carbonate is currently refined in China, and whilst the UK has modest brine and hard rock deposits of lithium, exploitation of these assets and subsequent refining is yet at an early stage and is a current focus area for support from the Automotive Transformation Fund.

ii) Whilst a large nickel refinery operates in Wales, input feedstock is imported and it does not currently produce battery grade materials. Upstream raw materials supply, including of semi-refined ores and concentrates is a key location-determinant for investors in battery materials processing plants. Security and resilience of supply together with energy costs are key factors.

jj) The UK’s Critical Minerals Strategy launched in 2022 is key to ensuring secure and sufficient supply of critical minerals. It is unlikely the UK can be self-sufficient for materials required for battery manufacturing, therefore strong relationships with partner nations are needed. (https://ukcmic.org/, https://www.gov.uk/government/publications/uk-critical-mineral-strategy/resilience-for-the-future-the-uks-critical-minerals-strategy)

kk) There is an opportunity for the UK to meet some of the demand for lithium by localised extraction and processing, as well as by resourcing recycled materials. However, building resilience within the supply chain through these methods is unlikely to become significant until at least 2040 and the supply would still need to be supplemented with imported raw material. Significant opportunity exists to capitalise on the UK’s chemicals sector expertise and chemicals parks to build lithium refining capacity based on feedstock concentrates from partner nations, and in doing so, secure resilient and cost-effective supply for UK battery manufacturing.

ll) The UK will need to maintain a supply of nickel, manganese and cobalt in order to manufacture batteries in the UK, as none of these critical materials are found within the UK (or able to be economically extracted). The use of cobalt in CAM variants is reducing and may be eliminated in some formulations but demand is still rising globally as battery production is rising faster than the evolution of cobalt-free CAM.

mm) Currently the UK does not import these raw materials as there is no cathode active material (CAM) production in the UK. Lithium is currently imported for use in electrolyte production.

nn) In addition to the CAM the UK would need to import anode active material (AAM) i.e. graphite and silicon to ensure a secure supply of these feedstocks.

oo) Meeting the upcoming EU Batteries Regulation with minimum recycled inputs content (specifically battery metals) will require establishment of a ‘circular materials economy’ in the UK to avoid the unnecessary export of battery recyclate (shredded batteries- ‘black mass’) to be processed and metals recovered into new CAM materials.

pp) The materials supply chain for batteries predominately flows through China and the processing and production of these materials will tend to have higher embedded carbon emissions based on current energy mix in China being heavily reliant of fossil fuels. In addition, the dominance of China in this critical materials supply chain is driving global policy interventions to support reduction in reliance on China. For example, the USA is now investing heavily in developing its own cathode and anode manufacturing along with a domestic and partnership-based supply chain to reduce its risk and reliance on China, and a major feature of the Biden Administration Inflation Reduction Act is to drive domestic processing of key critical materials and in some cases this is distorting investment flows with potentially damaging consequences to supply security outside North America.

qq) Recent HMG trade discussions with Indonesia in respect of nickel supply, for example, have been welcomed by the industry.

11. How ready are UK vehicle producers for the EU-UK Trade and Cooperation Agreement (TCA) rules of origin (ROO) phasing in from 2024?

rr) Today, UK vehicle producers of ICE-powered vehicles are in very large part, compliant, and will probably continue to be compliant based in the UK's strong ICE output, and the bilateral cumulation rule set out in the EU-UK TCA.

ss) For electric vehicles, the position is less certain from 2024, and particularly at risk from 2027 as the originating value thresholds rise at a vehicle level, in combination with the requirement for originating batteries. The likelihood of batteries qualifying as originating at this point is largely determined by sourcing of regionally produced Cathode Active Material (CAM), which is forecast to be under-invested in the region by 2025 (i.e. installed regional capacity lower than demand) ref: APC Q3/2022 Quarterly Demand Update: https://www.apcuk.co.uk/app/uploads/2023/01/Q3-2022-Quarterly-Automotive-Industry-Demand-Forecast-Report.pdf

tt) From January 2024 the high value of cells - if imported from outside of the region - will make qualification at a vehicle level extremely challenging. It is difficult to forecast accurately the position of each manufacturer in the UK by January 2024 (and where known, it cannot be declared due to commercial sensitivities), but it seems likely that some specific models or derivatives may fail to qualify at the deadline date, and manufacturers may choose to either restrict sales of those derivatives, raise prices, or absorb the tariff, depending on individual strategic and operational priorities.

uu) From January 2024, the rules of origin (ROO) are clear: using UK or EU-made batteries alone will not qualify an EV for tariff-free trade with the EU. The cathode active material (CAM) that is used in batteries should be processed and sourced from the UK or EU for tariff-free trade of EVs, *or* at least 50% of the material value in each battery cell must be sourced from UK or EU production which is very challenging to achieve without originating CAM.

vv) From 2027, regionally produced CAM must be used in practical terms in order to produce an originating cell and battery.

ww) At a vehicle level, loss of the value of regionally produced engines and gearboxes, and the current shortage of industrialised capacity to produce motors (especially) and drive units (including gearbox and inverter) for EVs further adds to the challenge of satisfying the regional value threshold condition for ROO and subsequent tariff-free trade. Motors in particular are a localisation challenge as the highest value input material for permanent magnet designs (one of the most common) is rare earth magnets, and this supply-chain is centred in China for upstream rare earth materials, and for magnets themselves in Asia (China, Malaysia, Japan and elsewhere in the region) - China currently controls 90% of the REE magnet market worldwide. Ref: Building-a-robust-magnet-supply-chain-for-the-UK-1.pdf (apcuk.co.uk)

xx) The UK exports 40% of its domestically produced vehicles to the EU, and this is expected to continue out to 2030 according to IHS Markit data.

yy) Therefore, both battery production and CAM plants are necessary to support the manufacture of electric vehicles in the UK and remain competitive under the TCA ROO.

12. What can the UK learn from investment in other countries in the establishment of gigafactories?

zz) Across the EU and USA a variety of incentives mechanisms are in evidence such as direct subsidy, competitive loans and tax breaks. These interventions are targeted at growing large parts of the supply chain with a clear onshoring strategy in the case of the US Inflation Reduction Act with 'at retail' and 'at manufacture' tax incentives combined with qualifying conditions for such subsidies linked to local materials inputs (or at least from free trade partners). These policies seem likely to be challenged under World Trade Organisation Agreement on Subsidies and Countervailing Measures (ASCM) procedures but likely will take years before due process is executed and any countervailing measures are authorised if the challenge is successful; by that time, industry sentiment suggests investment will already have been drawn to the region to the detriment of Europe in particular.

aaa) Given the nascent nature of the battery industry outside of Asia, both the US and the EU members have made sizeable funding allocations to support the growth of domestic start-ups (such as Tesla in the US, Northvolt in the EU) through early pre-revenue phase support. Mechanisms such as European Investment Bank loan guarantees and early R&D/scale-up funding in the case of Northvolt and loan underpins and tax incentives in the case of Tesla have allowed and encouraged the sector to develop domestic capability that goes beyond R&D and transition into manufacturing at scale.

bbb) The approaches have been balanced, with direct subsidy available to inward investment from established Asian battery makers who have established manufacturing capacity in the regions, (but little significant core R&D activity). This has encouraged the establishment of the upstream supply base for materials, making the development journey for domestic start-ups and rapid growth technology companies easier.

ccc) Large individual interventions have been made, and policy intent has been clear, consistent and assertively translated into action, with evidence of somewhat 'forward-leaning' offers from several EU countries to industrial investors (based on dialogue with those companies) despite common perceptions that the EU State Aid processes are uncertain and cumbersome.

ddd) There are positives for the UK however; multi-agency coordination, site location support, and a strong UK R&D ecosystem and a benign and 'safe' business operating environment are generally recognised by potential investors and cited in discussion.

eee) As part of the 'Green Deal Industrial Plan for the Net-Zero Age' the EU is providing significant sums in state-aid subsidies and loans. In 2022 alone €51 billion in state aid was spent on decarbonisation of production, this figure is across all production and not limited to automotive, but gives a sense of the scale of aid available.

fff) Streamlined schemes such as the two EU IPCEI (Important Projects of Common European Interest) tranches directed at the batteries sector and the recent Spanish national scheme have clear appeal to investors, unlocking growth and capacity in the sector.

ggg) Northvolt is an example of a gigafactory success story. The EIB (European Investment Bank) supported the first demonstration line with a €52 million loan, following the success of that project a loan of €350 million was provided to build the first gigafactory in Sweden. Northvolt now counts Volvo, BMW and VW among its strategic partners who have directly invested and has an order book of more than €55 billion which allows Northvolt to invest and expand.

13. Do we have the skills in the workforce required for the production of batteries? If not, what needs to be done?

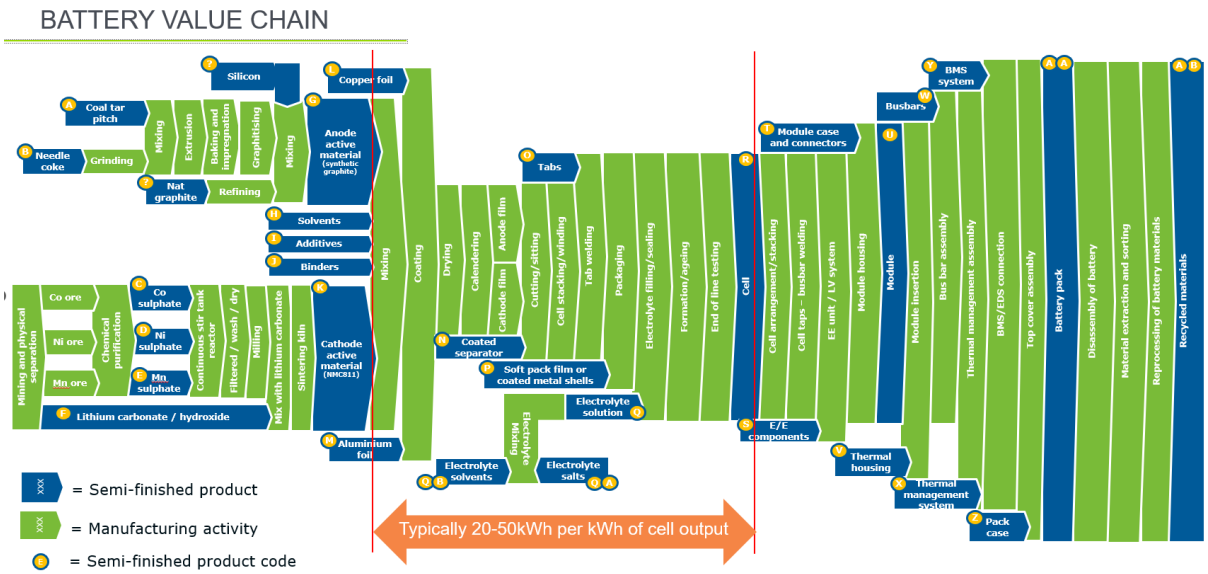
hhh) Battery manufacturing shares some common processes and production skills requirements with other sectors. The National Electrification Skills Framework and forum, launched by Faraday Institution, the High Value Manufacturing Catapult and the University of Warwick, and supported by a number of organisations (including APC) have been mapping the upskilling, reskilling and new skills requirements across the electrification revolution (batteries, power electronics, motors and drives) to develop a framework to address those across the UK education and training ecosystem, in partnership with industry. National-Electrification-Skills-Forum-Brochure-FINAL.pdf (catapult.org.uk)

iii) The APC does not have a primary remit in skills development save for supporting competency development through the projects that are funded through our programmes. Applications into our capital programme, the Automotive Transformation Fund, and our late-stage R&D collaborative R&D programmes frequently see skills and competency development as an associated objective, and shortage of higher skill levels from technician to degree+ are very commonly cited on project risk analyses, together with difficulties and delays in cross-border recruitment (common in this sector) due to new UK visa requirements.

14. Will the cost of UK batteries be competitive compared with batteries produced elsewhere?

jjj) Past studies indicate that the UK can be a competitive place to manufacture batteries relative to western European competitors, however several factors have recently impacted UK competitiveness: electricity and gas prices; cost of construction including construction materials such as steel and cement, labour costs and availability for plant construction phases in particular and the relative cost of land. Differentials in incentives schemes between competing nations have also been demonstrated to impact cost structure; of particular note is the US Inflation Reduction Act and large capital investment schemes in place across the European Union. Transitional energy cost support schemes introduced since the invasion of Ukraine in 2022 have impacted the competitiveness landscape but are not likely to be enduring.

kkk) Energy is a very important factor for battery manufacturing with energy-intensity studies indicating between 20kWh and 50kWh of electricity being required to manufacture cells for automotive use (includes the typical stages in a battery plant of electrode-coating to finished cell, and excludes input materials such as CAM/AAM and assembly into modules or packs – see value stream map below). Energy cost and supply availability of green power, together with location relative to customer (logistics considerations) and the ability to secure cost-effective input materials is one of the top three location-determining factors for battery production based on discussions with prospective investors into the UK through our engagement activities associated with the ATF.



lll) A single, large gigafactory could consume in excess of 2 TWh of electricity per annum, or around 0.7% of the total current UK annual electricity consumption of circa 300 TWh. Battery manufacturing, including crucial input materials manufacture such as CAM and AAM, would likely consume over 3% of the UK's total electricity production were it to be self-sufficient (i.e. at circa 90 GWh/annum output level) by 2030, and this excludes the extraction and production of key raw materials and intermediates (such as precursor CAM, metallic foils etc.).

mmm) A £10/MWh difference in electricity cost between the UK and other manufacturing locations can feed through to >£5/kWh of finished cell manufacture, twice that if the immediate supply chain is industrialised in the UK also. This difference alone is in excess of the forecast net operating margins for cell-manufacturers in the region and any higher price volatility in relation to competing nations in addition to relative market price would add to business risk.

nnn) The UK's forecast energy mix from the late 2020s indicates better market fundamentals with greater exposure to diversified renewables, materially lower reliance on gas, elimination of coal and some increase (later) in nuclear baseload provision, together with increased international interconnectors should bring UK wholesale electricity prices to a more

competitive level. Policy costs and transmission, distribution and balancing costs currently put the UK at a competitive disadvantage even where wholesale prices might be competitive.

ooo) Land and construction costs are typically higher in the UK than competitor nations, especially in Central and Eastern Europe, and flow thrown to fully-accounted battery costs through higher initial investment costs (unless normalised through grant schemes).

ppp) Supply chains for input materials typically involve raw materials and intermediate materials being shipped internationally, and the UK is well-served with bulk and container ports (although container shipping into the UK has suffered capacity and cost challenges in the last several years, largely as a result of the pandemic), and with appropriate location choice, inbound logistics costs for the UK can be competitive, however some operators have cited additional administration & logistics costs and delays for goods shipped between the EU and the UK - associated with the UK leaving the EU.

15. What impact will the European Union's proposed Carbon Border Adjustment Mechanism have on UK production?

qqq) At this point, the impact is uncertain as none of the initial scope areas for CBAM directly impact battery manufacturing to any significant degree, save for aluminium and steel manufacture of cell cans/prismatic enclosures and pack or module structures. It should be noted that all rolled aluminium sheet materials are currently imported into the UK as we have no domestic foundry/strip mills, and as a consequence, all recyclate of this grade is exported for reprocessing.

rrr) The treatment of the UK in respect of CBAM (viz. carbon pricing equivalence) is important in determining the potential 'bite' of CBAM upon UK exports to the EU/EEA. If the UK is treated as 'exempted' through participation in linked carbon-pricing mechanisms as a third country, then CBAM will have negligible impact on UK production, unless extended imported raw and semi-processed materials (and associated emissions) are included in a subsequent CBAM scope revision to include those input materials.

sss) Reviewing the logic that drove the selection of the six initial product areas specified in CBAM, one potential 'logical' future focus area for CBAM might be synthetic graphite, used in battery anode materials, the production of which is exceptionally energy-intensive through a graphitisation process involving electrical energy inputs. This process typically emits CO2 as an off-gas through the process, in addition to any emissions embedded through energy supply (unless such emissions are captured and stored).

ttt) The production of precursor materials for cathode active materials (CAM) and CAM itself, which utilises a high temperature calcining process step, similar to that for cement production, might also be a logical expansion of the CBAM policy.

uuu) Were these two product areas to be included in the future scope of CBAM, the energy generation mix of the UK (affecting embedded CO2 in energy inputs to UK battery and materials plants) becomes significant in determining the overall business case for battery and materials production, given that cell manufacturing itself (electrode coating to finished ex-works cell) consumes variously 20kWh-50 kWh of electricity per kWh of finished cell capacity, dependent upon chemistry and specific processing.