Batteries for Electric Vehicle Manufacturing: Submission to the Inquiry

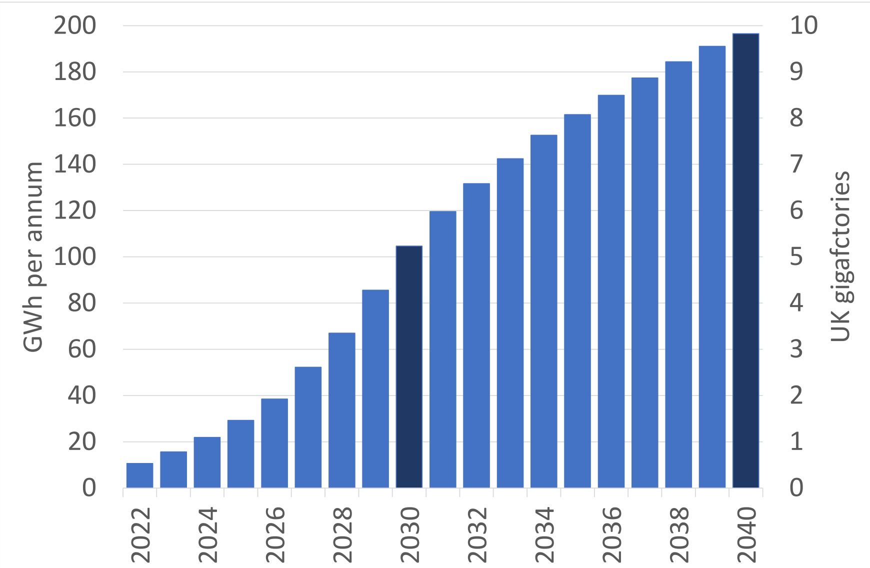
1. The Faraday Institution is the UK's flagship programme for electrochemical energy storage research, skills development, market analysis and early-stage commercialisation. It brings together research scientists and industry partners on major projects with commercial potential to reduce battery cost, weight, and volume; improve performance and reliability, and develop whole-life strategies including recycling and reuse. The Faraday Institution regularly publishes evidence-based assessments of the market, economics, commercial potential, and capabilities for energy storage technologies and the transition to an electrified economy.

2. **Is there enough UK vehicle manufacturing demand in the UK to support gigafactories?**
   a) The long-term strength of the UK automotive production industry and UK sales markets, combined with UK Government policies to decarbonise the transport sector, suggests that there is more than enough potential vehicle manufacturing demand in the UK to support gigafactories.

   b) The Faraday Institution's 'UK Electric Vehicle and Battery Production Potential to 2040' study published in July 2022 estimated project vehicle and battery manufacturing demand would support the equivalent of five UK gigafactories by 2030 and ten UK gigafactories by 2040 (Figure 1), with each plant producing on average 20 GWh of battery capacity each year.

   c) UK EV battery manufacturing demand reaches 100 GWh per annum in 2030 and 200 GWh per annum in 2040. Batteries manufactured for private cars and light commercial vehicles are expected to dominate, accounting for around 80% of total UK battery demand in 2040, with the remainder manufactured for HGVs, buses, micromobility and grid storage.

   d) **Figure 1: Potential demand for UK-produced batteries and UK gigafactories**



Source: The Faraday Institution (July 2022). UK electric vehicle and battery production potential to 2040.

   e) The above analysis is based on a scenario where the UK automotive sector experiences a stable transition to electric vehicles (EVs), with the level of UK vehicle production remaining close to historical long-term averages. UK vehicle production is assumed to recover to pre-pandemic levels by 2030 and then increase in line with the annual growth in European and global vehicle production to 2040.

f) On the UK production side, the UK automotive industry manufactured between 1.6 to 1.8 million per annum over the 2015-2018 period[1] and historically is the 4th largest vehicle manufacturer in Europe.[2] The volume of the UK production market has recently suffered in the 2020-22 period, with production falling to 921,000 in 2020 and 775,000 in 2021[3], but these difficulties are largely caused by global macroeconomic shocks. Government responses to the pandemic and geopolitical tensions have contributed to inflation, rising energy prices and a 'cost of living' crisis. Interest rates have also increased to tackle inflation and to move away from near-zero rates that have been in place since the global financial crisis of 2007-08. These factors are likely to be short-term difficulties which will have less of an impact on the longer-term prospects for the UK automotive industry and should not dictate the strategy and policy for the medium term.

g) On the UK sales side, battery electric vehicles (BEVs) are growing in popularity accounting for 11.6% of all new car sales in 2021 and 16.6% in 2022.[4] The UK's Net Zero Strategy: Build Back Greener, mandates that the sale of all new petrol and diesel cars and vans in the UK must end by 2030.

3. **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?**

h) The UK has over a decade of experience in EV battery cell and pack production, following the establishment of the AESC battery plant in Sunderland in 2010, which at the time was the first battery production facility in Europe. This plant currently has a capacity of 2 GWh, so is relatively small in comparison to others.

4. The UK is also making good progress in developing new battery plants for 2025 and 2030.

i. Envision AESC is constructing a second UK battery plant in Sunderland with an initial capacity of 12 GWh, a target operational date of 2025, with the ability to increase capacity to 25 GWh by 2030 and ultimately up to 35 GWh capacity;

ii. The potential of the Britishvolt site in Blyth could still be met by the Australian startup Recharge Industries. The site was granted planning permission in July 2021 for 30 GWh by 2027 and had the potential for full capacity of 38 GWh;

iii. AMTE has set out plans for a new 10 GWh plant in either northeast England, Scotland or Wales to be operational by 2025; and

iv. the West Midlands Combined Authority has identified Coventry Airport as a preferred gigafactory site.

i) However, the UK is not moving fast enough to meet potential UK demand or compared to European competitors. On the optimistic side, UK battery manufacturing plants could probably reach a combined capacity of around 50 GWh to 60 GWh by 2030 if Recharge Industries stick to the original expansion plans set out by Britishvolt. However, even under this scenario, UK battery production supply would only be around one-half of 2030 UK battery demand. It is also equivalent to only around 5% of the total predicted European GWh capacity in 2030 compared with the 34% provided by Germany.

j) Given that gigafactories take at least five years to be constructed and reach operational capacity, the investment and location decisions to meet the remaining half of the required UK battery supply in 2030 will need to be made in the next 2 to 3 years.

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[1] SMMT Motor Industry Facts 2016, 2017, 2018 and 2019.
[2] International Organization of Motor Vehicle Manufacturers, 2021 Production Statistics.
[3] SMMT Vehicle Production January 2022.
[4] SMMT Cars Registrations (5 January 2023).

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

k) The presence of an EV battery industry in the UK helps to ensure that automotive production also remains in the UK. Strong synergies can be achieved when vehicle producers and battery manufacturers are situated in proximity to one another, either at the same site or within the same region of a country. These synergies include greater flexibility for just-in-time production, greater reliability of supply chains against geo-political shocks and the formation of a knowledge ecosystem. The Nissan plant in Sunderland, for example, sources its batteries from Envision AESC factory which is co-located in Sunderland. Envision AESC is expanding its UK presence to increase annual production from 2 GWh to 25 GWh by 2030, to meet future demand from Nissan.

l) EVs and batteries must be produced as cheaply as possible to be economically viable in the competitive mass market segment. Profit margins are thin so there is a strong drive from the OEMs to reduce transportation costs and supply chain risks, although this is less of a consideration for premium markets. Co-location offers the additional advantages of increased safety, greater control over production quality, potential avoidance of import tariffs and the flexibility to introduce new design iterations quickly. The move towards direct cell-to-chassis architectures, where battery cells are integrated into the vehicle without the need for a battery pack, will inherently require the co-location of the vehicle and cell production.

m) There is a degree of two-way causality. Investments in UK gigafactory battery production will depend upon the presence in the UK of major EV production lines, while the presence of EV production lines will also depend upon battery manufacturers investing in the UK. Gigafactories require substantial amounts of capital investment and economies of scale to be cost-competitive. The geography, available power, electricity costs and government subsidisation constrain the number of suitable locations for battery manufacturing. So, even though there is causality both ways, the location of new battery manufacturing plants is likely to be by far the key determinant of the location of new EV production plants, rather than the other way around.

n) For the Faraday Industry's gigafactory study[5], we asked leading battery firm executives to list the factors that have the most impact on their decisions to locate in one country rather than another. Proximity to customers (i.e. EV manufacturers) emerged as the most important factor, although they were also influenced by investment incentives, timely permitting and licensing arrangements, cheap and clean energy and a skilled and productive workforce. The UK ranks well across these attributes, offering a flexible and dynamic labour force, a relative ease of doing business and is in the vanguard of decarbonising the electricity grid. Consultations with industry representatives and battery manufacturers also indicated that financial, legal and regulatory barriers could be reduced when automotive OEMs and battery manufacturers are located in close proximity to one another.

o) The strategies adopted by Asian battery manufacturers for the European market provide further evidence of the importance of co-location. Manufacturers such as CATL, Samsung and SK Innovation are building battery factories in mainland Europe, predominantly in Hungary, to supply German automotive companies from a European rather than an Asian base.[6] Furthermore, European car makers such as VW Group, BMW Group and Volvo have

[5] The Faraday Institution (July 2022). UK electric vehicle and battery production potential to 2040.
[6] EE Times (November 2021). Analyzing Strategic Partnerships Between Main EV OEMs, Battery Suppliers in Europe, America, and Asia.

built plants with Northvolt, while TotalEnergies, Stellantis and Daimler have set up the joint venture Automotive Cells Company.[7]

[7] Automotive News Europe (September 2021). Daimler joins Stellantis as partner in the European battery cell venture ACC.

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

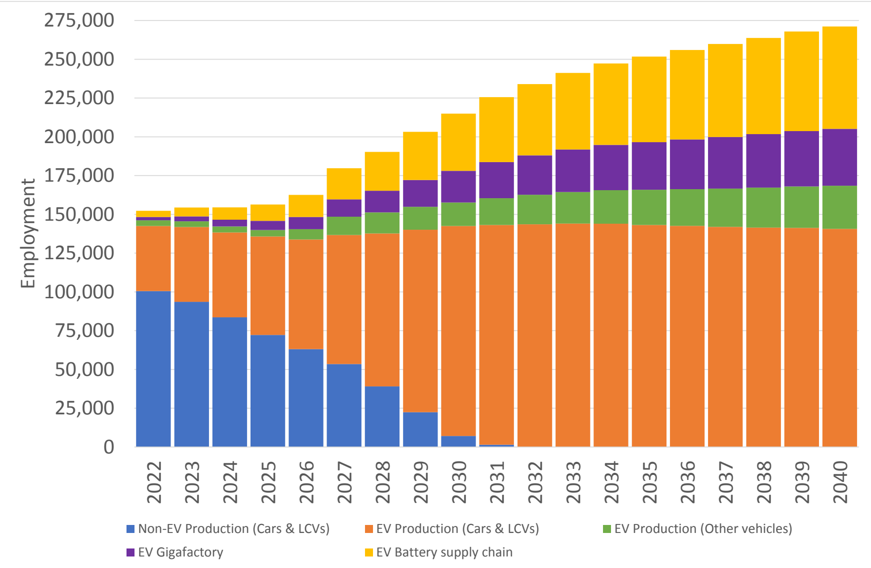
   p) Electrification of transport provides the UK with the opportunity to boost the manufacturing sector. Attracting inward investment to establish new UK battery and vehicle production capabilities or to expand existing plants will create additional manufacturing jobs and increase exports. By 2040, the Faraday Institution estimates that the equivalent of ten gigafactories will be needed in the UK to meet battery demand. This battery and vehicle manufacturing activity could support around 270,000 full-time equivalent (FTE) jobs, split as follows:

v. 145,000 FTE jobs supported by the manufacture of passenger and light commercial EVs;

vi. 25,000 FTE jobs supported by the manufacture of HGVs, buses and micromobility vehicles;

vii. 100,000 FTE jobs in the battery manufacturing industry, comprised of 35,000 direct jobs in battery manufacturing plants and 65,000 indirect jobs in the wider battery supply chain.

   q) **Figure 2: Potential employment in the UK automotive and battery industry to 2040**



Source: The Faraday Institution (July 2022). UK electric vehicle and battery production potential to 2040.

   r) Automotive employment is also concentrated in certain regions. The three largest regions for employment are the West Midlands (33%), Northwest (12%) and Northeast (9%), which together accounted for well over half (55%) of the UK's automotive industry employment in 2018.[8] Increasing employment opportunities in these regions will be important to delivering the UK Government's levelling-up commitments.

   s) This growth in the automotive industry is unlikely to be realised without sufficient battery production capacity in the UK. Indeed, with no large-scale UK battery production, and in a worst-case scenario, there is a risk that the existence of the UK automotive industry itself could be threatened. If the UK does not attract and develop a battery manufacturing industry, then there is a likelihood that international car makers will only invest in the production of future EV models in plants outside the UK, as this would maximise synergies and minimise barriers. UK vehicle production could, therefore, slowly move out of the UK and gravitate towards where the batteries are manufactured, such as in Europe, Asia or the United States.

[8] ONS, SIC code 29, Business register and employment survey, 2019, via NOMIS database.

t) As vehicle manufacturers gradually wind down their production in the UK, there will be an associated reduction in direct employment and indirect supply chain jobs. Although it is difficult to predict what level of employment would remain, one plausible outcome is that by 2040 the industry would have shifted to be entirely focused on niche and high-value automotive markets where the UK could maintain a competitive advantage. In this situation, UK automotive employment could perhaps have fallen to around 30,000 FTE jobs.

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

u) UK battery production could support several domestic uses, including stationary storage, aviation/aerospace, maritime, drones and defence. Although the automotive industry will be the dominant user of batteries for at least the next decade or so, these other domestic markets will be increasingly valuable from 2030 and 2040 in terms of both economic and decarbonisation impacts.

v) There is an opportunity for the use of stationary battery systems to store renewable energy from the grid. Storage provides the increased flexibility needed to fully utilise renewable generation during periods of low demand so that it can be used at peak times. Energy storage is useful for delivering balancing services, energy shifting and frequency response to ensure the stability of the grid. The National Grid's recent Future Energy Scenarios study estimated that to meet net zero the UK will need 50 GW of installed energy storage by 2050 in the best-case 'leading the way' scenario.[9] Wider market applications for storage include uses for mini-grids, local microgrids, off-grid industrial facilities and hybrid solar and wind plants.

w) Battery-powered flight is expected to feature prominently over short-haul distances for both general and commercial aviation, with batteries offering cost savings, less noise and reduced air pollution compared to alternative sustainable aviation fuels. Although batteries have been used to power onboard systems in aircraft for decades, fully electric-powered flight is still in its infancy. Electric aircraft offering short-range flights and vertical take-off/landing, the most likely first market applications for batteries, is expected to be adopted from the mid-2030s. Demand is then set to increase substantially, with the proportion of person trips undertaken by battery electric aircraft estimated to reach over 30% by 2050[10], although the share in terms of passenger kilometres will be much less given that the use of batteries will be concentrated on the short-haul market. For medium and long-haul, pure battery electric aviation is unlikely to be viable before 2050, unless there is considerable technological advancement, however, batteries may be used in a hybrid capacity together with hydrogen fuel cells.

x) Applications in shipping and the marine environment are areas where batteries have the potential to meet demand where previously only liquid fuels were thought to be suitable. Battery technology is expected to gain a substantial market share in domestic and short-distance shipping, particularly on rivers and lakes and for tourism and commuter trips. For long-distance and deep-sea applications, the energy density of batteries is not expected to be high enough to allow battery only operation, but batteries are expected to be increasingly used within hybrid shipping including in plug-in hybrid propulsion systems.

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[9] National Grid, Future Energy Scenarios 2022 Data Workbook FL.01: Electricity and gas storage capacity in 2021.

[10] DNV (2023). The role of hydrogen and batteries in delivering net zero in the UK by 2050, with publication scheduled for April 2023.

y) Battery technology is beginning to be used more extensively in satellites, drones and military vehicles. The global market for unmanned aerial vehicles is expected to increase from US$ 26 billion in 2018 to US$ 70 billion in 2029, with potential uses in both the industrial and commercial space, including applications infrastructure, agriculture, transport and security. Similarly, unmanned ground vehicle technology is predicted to reach US$ 7 billion by 2025, with the defence sector at the forefront of this market. In the maritime environment, unmanned surface vehicles and unmanned underwater vehicles are forecast to reach over US$ 1 billion and US$ 5 billion respectively by the early 2020s, driven by maritime security and the offshore oil and gas industries.

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

z) The EV transition will substantially increase UK demand for raw materials, which are needed for all parts of the battery including the cathode powder, graphite for the anode, separators and other key chemicals that are used in the manufacturing process. Key raw materials required are lithium, nickel, cobalt and manganese for the manufacture of the cathode, graphite for the anode, neodymium and dysprosium for magnets in the electric motor and copper for various uses. The increase in UK demand will come at a time when global demand is also increasing. Global production of lithium and cobalt, for example, will need to increase by 6 times and 3 times respectively between 2021 and 2040 to satisfy the needs of the global energy transition.[11]

aa) The UK does not currently have a sufficient supply of critical materials to support BEV production. Lithium, cobalt and nickel are predominately found in a small number of countries around the world. The Democratic Republic of Congo, for example, is responsible for 60% of global supplies of cobalt while key quantities of lithium are found in Chile, Australia and Argentina.

bb) While the UK does not currently have the required critical materials to support battery production, the UK has recently put a strategy in place (the UK's Critical Minerals Strategy). The strategy will focus on three main areas: accelerate the growth of the UK's domestic capabilities, collaborate with international partners, and enhance international markets to make them more responsive, transparent and responsible.

cc) Whilst this strategy is to be welcomed, it is only one part of the jigsaw and a comprehensive strategy and action plan should be based on the following themes.

viii. Building on the existing supply chain strengths. The UK already has significant capability including the world’s largest producer of speciality graphite cokes, Europe’s second-largest nickel refinery and a large hydro-powered aluminium smelter producing suitable grade aluminium;

ix. Localising more of the battery supply chain in the UK. An efficient and effective UK supply chain will improve the availability and affordability of key materials and components. Efforts are being made to establish a national source of lithium through mining projects in Cornwall. Other infrastructure such as lithium refineries are also being established in the UK;

x. Utilising the strength of the UK chemicals industry. An Advanced Propulsion Centre study identified an opportunity of £4.8 billion per annum by 2030 for the UK chemicals industry to serve the needs of battery manufacturers and the wider battery supply chain;

[11] Faraday Insights - Issue 6 Update: September 2022.

xi. Attracting new cell component (cathode, anode, electrolyte, etc.) suppliers to the UK. The UK has a world-class chemicals industry that could benefit from the opportunity for battery manufacturing in the UK; and

xii. Development of a UK lithium battery recycling industry.[12] Key priorities would be a battery dismantling and pre-processing facility along with a recovered material processing facility. Government support may initially be needed as the industry may not otherwise develop at the required pace to tackle the substantial levels of battery waste created.

dd) Other countries are also grappling with these issues and undertaking action. The US strategy, for example, led by the Department of Energy, is designed to support domestic critical mineral and material supply chains. The strategy aims to mitigate the national critical minerals and materials challenge by diversifying supply, developing substitutes, and improving reuse and recycling. The overall goal is to re-establish US competitiveness in critical mineral and material supply chains. The strategy focuses on four primary goals: driving scientific innovation and developing technologies to ensure resilient and secure critical mineral and material supply chains independent of foreign adversaries; catalysing and supporting private sector adoption and capacity for sustainable domestic critical mineral and material supply chains; building the long-term minerals and materials innovation ecosystem; and coordinating with international partners and allies and other federal agencies to diversify global supply chains and ensure the adoption of best practices for sustainable mining and processing.

ee) Legislation has also been introduced in the US to strengthen the domestic battery supply chain along with investment. Under the Bipartisan Infrastructure Law (BIL) signed in November 2021, US$7 billion has been identified for the US battery supply chain to use in supporting upstream materials processing and to create the precursor materials for batteries. The first phase of funding was announced in October 2022, with $2.8 billion in government support being provided to 20 companies working at the early stages of the battery supply chain, from metal refining to active material production.

ff) There are also international efforts in which the UK is involved. The Minerals Security Partnership (MSP) is an international partnership[13] aimed at ensuring that critical minerals are produced, processed, and recycled in a way that supports the ability of countries to fully benefit from their mineral resources. The MSP focuses on critical minerals that are inputs for EVs and advanced batteries. The objectives of the MSP include strengthened information sharing, increased investment in secure critical minerals supply chains, and the development of recycling technologies. Additionally, in 2022, the Faraday Institution and the US National Renewable Energy Laboratory established a cooperative relationship in support of joint research to reduce reliance on critical materials and enable the recycling of lithium-ion batteries.[14]

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

gg) Meeting the rules of origin requirements will need battery cell or battery pack production to be based in the UK or EU, including the manufacture of the cathode. Locating cathode

[12] The overarching aim of the Faraday Institution's ReLiB project is to establish a technology pipeline and provide a clear roadmap for the efficient end-of-life management of electric vehicle (EV) lithium-ion batteries in the UK, encompassing both current and future battery chemistries. https://relib.org.uk/

[13] The partnership is made up of countries including Australia, Canada, Finland, France, Germany, Japan, Korea, Sweden, the United Kingdom, the United States, and the European Union.

[14] 'The Faraday Institution and NREL sign MOU in support of US UK joint battery research' 15 August 2022 https://www.faraday.ac.uk/faraday-institution-nrel-mou/

manufacturing in the UK/EU is particularly important to meet the rules of origin as cathode manufacturing represents around one-half of the total cell manufacturing cost. UK vehicle producers will therefore need commercial agreements to be in place with UK or EU battery manufacturing companies to meet the phase-in of the Trade & Cooperation Agreement (TCA) by 2024.

hh) The TCA enables traded goods between the UK and the EU to be carried out at zero tariffs and zero quotas if the goods 'originate' in the UK. Whether products originate in the UK is defined by the rules of origin part of the TCA which stipulate the proportion of the product in value terms that need to be created in the UK or the EU for the product to be classed as a UK/EU originating product. From 2027, the UK can export any number of EVs and PHEVs into the EU market at a zero tariff under the following conditions:

xiii. EVs must have 55% UK/EU content and must have an originating battery pack;

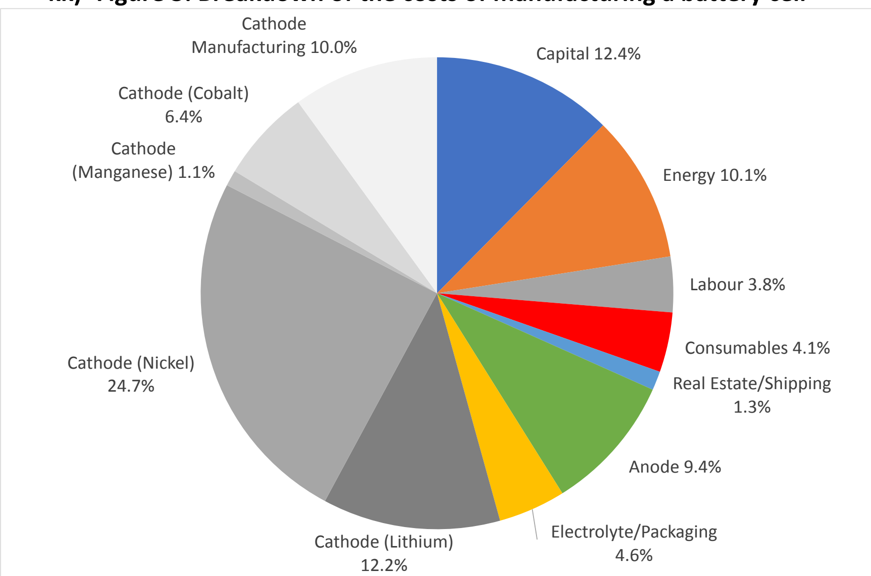
xiv. An originating battery pack must have either 65% UK/EU content for the cell or 70% for the battery pack; and

xv. Transitional rules of origin apply for the period from 2021 to 2026.

ii) The effect of these rules is to limit the components of the battery from outside the UK and the EU that can be used. The result of these rules is that battery cell or pack production, and particularly cathode production, need to be based in the UK or the EU to allow UK-produced vehicles to be exported to the EU at a zero tariff.

jj) Cathode manufacturing makes up 54% of the cost of the cell and, within this cost, a significant proportion of costs are incurred through the import of raw materials such as lithium, nickel and cobalt (Figure 3). These cathode materials are typically imported from outside the UK/EU, from areas such as South America, Australia and the Democratic Republic of Congo. While the raw materials used to manufacture the cathode are typically imported from outside the UK/EU, as long as the cathode manufacturing process is located in the UK/EU the overall value should count towards the rules of origin thresholds.[15]

kk) Figure 3: Breakdown of the costs of manufacturing a battery cell



Source: Benchmark Minerals Intelligence

[15] Centre for European Reform (October 2020). A tale of batteries, Brexit and EU Strategic Autonomy.

ll) The impact of not meeting the rules of origin could be significant given that the UK automotive industry competes in a global market. In 2019, 1.3 million cars and 2.5 million engines were manufactured in the UK, with 81% of cars exported of which 55% were exported to the European Union.

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

mm) The establishment of gigafactories around the world suggests there is no one-size-fits-all model for success. Different approaches have been successfully adopted in Europe, Asia, and the United States and different models have failed. Instead of relying on a set of best practice principles to implement, it is critical to tailor strategies and interventions to the unique circumstances and opportunities of the country. Such a tailored approach takes into account the needs and challenges of each location.

nn) While there is not just one off-the-shelf model that can be used, there are perhaps four methods that have been successfully applied to date. The lessons from each of these four models are as follows:

xvi. The licensing of existing battery technology. This reduces the time spent on materials and cell development, enabling cell production to start earlier. It also lowers investment risk substantially as the venture uses readily available technology. This model has been followed by Freyr Battery, a Norwegian gigafactory owner who is planning to reach 200 GWh of annual capacity by 2030. Freyr works with technology partners such as 24M (Semisolid battery cell design), Hana Technology (battery manufacturing equipment), and Aleees materials (materials licenses);

xvii. Partnering with existing OEMs, who provide start-up capital and a guaranteed customer base once production starts. Examples of this include ACC (backed by Stellantis), PowerCo (established by VW group) and Ultim Cells (a joint venture between LG Energy and General Motors). These ventures have been able to scale very quickly;

xviii. Government financial support to attract Asian cell manufacturers to Europe. In Hungary, for example, Chinese CATL and Korean companies (SK Innovations, Samsung SDI) have established gigafactories on the back of government financial support. Cheaper labour and land compared to Western Europe were also key features of the business model. CATL has recently invested $7.5 billion in a 100 GWh factory near Debrecen. Government financial support is also a feature of the US market, where the US government awarded a $2.5 billion loan to Ultim Cells for the establishment of three gigafactories in the US; and

xix. The creation of new proprietary technology. This model has been followed by NorthVolt (Sweden), ElevenEs (Serbia) and Britishvolt (UK). This model is arguably the most difficult model to execute successfully as time must be spent developing technology. It is associated with high investment risk as the construction of the plant and securing customer orders are often required before the new technology is proven. This risk is illustrated by Northvolt which was established in 2015 but did not secure investment from BMW to allow it to scale up cell manufacturing until 2019.

oo) The most important lesson to be learnt from these examples is that time has been critical. A sense of urgency is therefore needed in the UK response to the challenge. The UK is already losing ground to the EU and the US, where domestic battery supply chains are being rapidly established and large-scale government support packages have been agreed. The EU (Green Deal Industrial Plan) and the US (Inflation Reduction Act, Bipartisan Infrastructure Law) in particular are worth hundreds of US$ billions of investment. If the UK is to meet the target for a 2030 ban on ICE vehicle sales, it must work quickly to attract investment into battery and EV production and provide both financial and non-financial support.

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

pp) The UK's workforce is skilled, stable, flexible, and one of Europe's most productive. The country is highly ranked in Europe for automotive labour productivity and has a long history of EV production at Nissan's Sunderland plant. However, there will be a significant shortfall of skills required to build EVs, as well as in battery production for EVs. This increase in the demand could be tackled by developing a pipeline of skilled professionals across different qualification levels with the support of standards bodies, professional organisations and training providers, combined with initiatives focused on the near term to solve urgent skill gaps and bottlenecks.

Skills requirements for the manufacture of batteries

qq) Some of the necessary skills for battery production at scale already exist within the existing UK workforce. High-volume process sectors or industries such as food processing or pharmaceutical production, all have similar skill requirements. However, to ensure competitiveness and productivity, new training and development programs will be necessary for operators, technicians, and graduates. The different skills and qualification levels required by the gigafactory workforce depend on the complexity of the role, as illustrated in Table 1.

rr) **Table 1: Job types and skills required for a typical gigafactory**

Division	Job Type	Examples of job activities	Qualification level
Production Staff (50%)	Material Handling	Mixing electrochemically active materials, additives and binders to produce electrode material	L2
	Machine Loading	Slitting electrode into smaller pieces for welding	L2
	Machine Unloading	Drying and stacking	L2
	Module Assembly	Tab and laminate	L2
	Pack Assembly	Injections of electrolyte	L2
	Logistics	Formation and charging, modular and pack assembly, inspection	L2/3
Maintenance and Engineering (30%)	Technicians	Service, maintenance and repair of process equipment	L3
	Senior Engineers	Lead engineers and department heads	L7
	Process/Production Engineers	Problem-solving, tool and die, new product introduction, process improvement	L6
	Facility Engineers	Facility management, utilities, building, fire etc	L6
Quality (10%)	Engineers	Process controls, confirmation of part/supply specification, performance evaluation, defect analysis	L6
	Practitioners	Process controls, confirmation of part/supply specification. Performance evaluation, defect analysis	L4
Other (9%)	IT	Process controls, confirmation of part/supply specification. Performance evaluation, defect analysis	L6
	Data Management	Process controls, confirmation of part/supply specification. Performance evaluation, defect analysis	L6
Management (1%)	Process Leadership	Achievement of KPIs, conformance to legislation etc	L4
	Engineering Management	Senior management of engineering processes across the organisation, innovation, compliance, budget etc	L7

Source: The Faraday Institution (July 2022). UK electric vehicle and battery production potential to 2040.

ss) Approximately 60% of the workforce in a gigafactory will be composed of production staff and maintenance and engineering technicians. These positions will require new or updated skills through recruitment, training, and development programs. The workforce will also need to engage in continued professional development or upskilling to remain competitive.

tt) Production staff are mostly trained on-the-job and perform manual tasks that cannot be automated. Their training typically includes GCSEs, BTECs, ONCs, and ONDs, but supplementary training specific to battery production may also be necessary. Equipment technicians, who are usually trained as apprentices, are responsible for servicing and maintaining equipment. Both categories typically require level 2 or 3 qualifications.

uu) The remaining positions within a gigafactory are highly skilled and often require a degree. Technical roles such as systems engineer, database development engineer, and thermal management engineer require advanced skills and qualifications, including PhDs. To remain at the forefront of factory advances, higher skills at level 6 and above are necessary, including expertise in areas such as data-driven production, optimisation, and automation. Gigafactories that conduct their own research and development will also require PhD scientists and EngD engineers.

What needs to be done

vv) The National Electrification Skills Framework and Forum[16] identifies gaps in current skills provision and provides a strategic direction for electrification across various industries, including automotive and battery production. The Emerging Skills Project (ESP), initially supported by the Department for Education and continued by the Faraday Battery Challenge, is helping to develop a new curriculum for electrification.[17] In mid-2021, pilot courses and train-the-trainer content were introduced, with additional pilot courses in battery cell production funded by ESP and the Faraday Institution, set to be completed in April 2023. Much more work needs to be done and the Faraday Battery Challenge will be continuing this effort.

ww) The Green Jobs Taskforce has outlined the need to create and enhance career pathways into green careers. To achieve this, the taskforce recommends implementing a well-sequenced STEM curriculum, providing effective teaching of the knowledge and skills required for green jobs, attracting and retaining talented teachers, offering green career advice, and enhancing training pathways.

xx) To ensure long-term success and competitiveness in battery production, sustained support from the government, local authorities, training providers, and industry will be crucial. This support will ensure the development of necessary skills over the long term and provide workers with the right skills at the right time and place to fill positions in the field. Comprehensive training programmes in dedicated centres will need to be offered in regions where battery production is most likely to be cited, noting that skills shortages may be more acute in certain UK regions such as the North East.

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

yy) The Faraday Institution undertook a comparative analysis of the cost competitiveness of UK cell manufacturing in 2019. The study compared the potential costs of lithium battery cells manufactured in the UK with China and Germany, for hypothetically mature battery industries in each country.

[16] The Opportunity for a National Electrification Skills Framework and Forum, September 2021.
[17] Emerging Skills Project.

zz) The purpose of the study was to examine the differences in the underlying cost base, rather than any cost differences caused by industry scale. Under this assumption, the conclusion was that the UK would have a slight cost advantage over Germany, but that China would be able to deliver cells at a lower cost than both UK and Germany due to the level of Chinese state subsidies. Of course, the reality is that China already has a mature industry with large economies of scale present, enabling it to deliver much lower costs than would be the case in countries with an emerging battery industry.

aaa) The importance of government financial support is just as critical in the European context. Hungary, for example, has offered large financial incentives to Asian battery manufacturing companies to secure inward investment. In the UK, there is a £1 billion fund to support UK electrification with £500 million earmarked for the development of UK gigafactories. However, this may not be sufficient to level the playing field with other European countries.