THE FARADAY INSTITUTION

The Gigafactory Boom: the Demand for Battery Manufacturing in the UK

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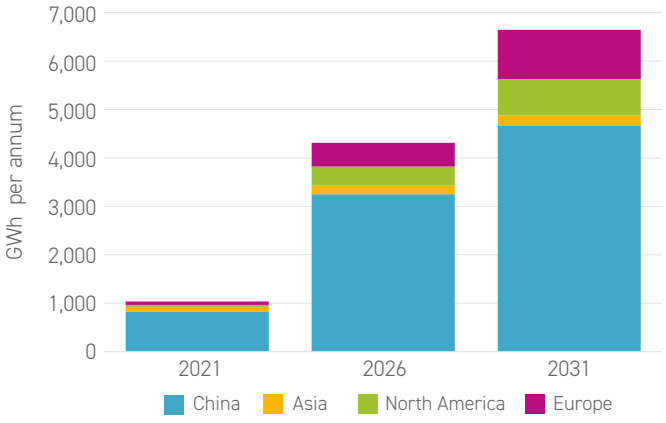
The transition to electric vehicles will substantially increase the demand for batteries. Across Europe, there is a race to develop battery manufacturing factories to meet this demand. The UK is well-positioned to be a major player in this market. By 2040, the Faraday Institution estimates that ten gigafactories will be needed in the UK, which could support 170,000 jobs in the automotive industry and a further 100,000 jobs in battery manufacturing and the wider battery supply chain.

The Global Race Is On

The manufacture of lithium-ion batteries is increasing at an exponential rate, which is driven by the global growth in electric vehicles (EVs). Global supply is expected to increase nearly seven-fold over the next decade from 1,000 GWh per annum in 2021 to around 6,700 GWh per annum in 2031 (Figure 1). China has secured first-mover advantage and cornered a substantial proportion of the market. In 2021, China accounted for around 79% of lithium-ion battery manufacturing capacity, compared to 5% in North America and 7% in Europe. However, with the global market set to increase substantially, there is a massive opportunity for Europe to take a bigger portion of the market.

Figure 1: Global battery manufacturing capacity to 2031



Source: Benchmark Mineral Intelligence, Lithium-ion Battery Gigafactory Assessment (June 2022).

"The UK will need the equivalent of ten UK gigafactories by 2040, with each plant producing 20 GWh per annum. Significant reskilling and upskilling programmes will be needed to cater for the 35,000 jobs in gigafactories and 65,000 jobs in the battery supply chain that could be created."

Europe Playing Catch-up

With a stream of high-volume battery manufacturing plants ('gigafactories') coming online over the next decade (Figure 2), Europe can recover some of the ground lost to China. Europe's market share of the global battery supply market is expected to reach 11% by 2026 and 15% by 2031.[1] European gigafactories serving the growing European market have an advantage over Chinese manufacturing facilities in that they face lower transportation costs and can avoid import tariffs.

European growth is being achieved by a mixture of Asian,

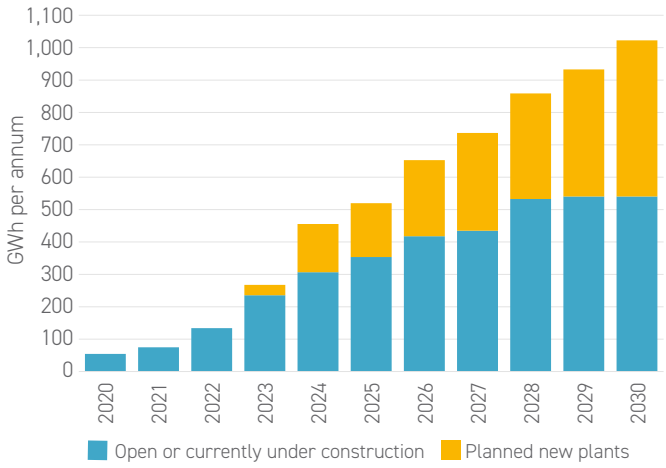
*This Faraday Insight 2 is an update to the version first published in August 2019. Photo courtesy of Nissan.

[1] Benchmark Minerals Intelligence (June 2022), Lithium-ion Battery Gigafactory Assessment.

UK Research and Innovation

US and European battery manufacturing and automotive companies, with co-location of OEMs and battery manufacture becoming the dominant business model. Notable plans include Tesla's construction of a 100 GWh p.a. plant in Berlin, Samsung's 30 GWh p.a. plant in Hungary and Northvolt's 32 GWh p.a. plant in Sweden.[2]

Figure 2: European lithium-ion gigafactory battery manufacturing capacity to 2030



In the UK, there are three gigafactories in various stages of development:

- The Envision AESC (Automotive Energy Supply Corporation) plant in Sunderland has planning permission for 11 GWh of capacity. This will be in the same vicinity as the existing 2 GWh p.a. plant that has been operational since 2010, when it was one of the first sites in Europe to manufacture EV batteries.[3]
- Britishvolt has already started the construction of a plant in Northumberland with an anticipated opening date of 2023, capacity of 30 GWh expected by 2027 and potential full capacity of 38 GWh.[4]
- AMTE has set out plans for a new 10 GWh plant to be operational by 2025 in either northeast England, Scotland or Wales.[5]

The UK Demand for Gigafactories

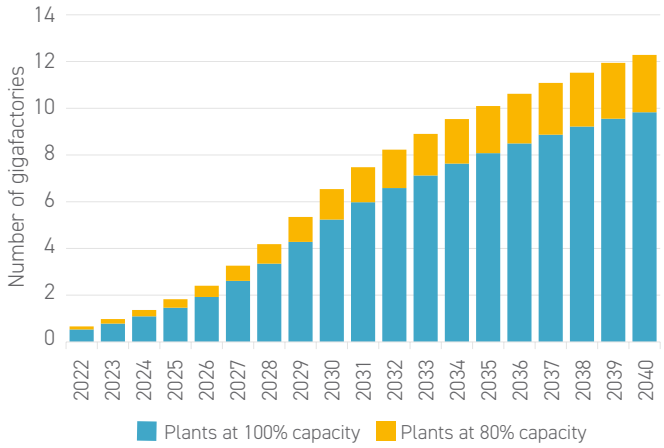
The Faraday Institution expects UK battery demand for private cars, commercial vehicles, HGVs, buses, micromobility and grid storage to reach over 100 GWh per annum by 2030. This is sufficient to support the equivalent of five UK gigafactories assuming each plant has a production capacity of 20 GWh per annum.[6] Such domestic demand (which assumes no battery import or export) represents 10% of the projected 1,000 GWh p.a. of European 2030 battery capacity in development.

However, the UK needs to move fast to ensure that these gigafactories are built in the UK instead of mainland Europe.

Given that three gigafactories are already in development, business planning for the other two gigafactories required in the UK by 2030 will need so start by 2025 at the latest given it typically takes up to five years to design and build new gigafactories. A considerable amount of time is often spent on locating a suitable site and securing permits/licences, as well as the construction of the plant itself. Once a gigafactory is operational, it takes time for production to be ramped up to reach levels close to its potential capacity.

Over the longer-term, demand for EV battery production in the UK is expected to reach nearly 200 GWh p.a. by 2040.[6] This would support about ten gigafactories in the UK with each plant running at a full production capacity of 20 GWh per annum or twelve 20 GWh gigafactories running at 80% capacity.

Figure 3: Gigafactory demand in the UK to 2040



Source: Faraday Institution, UK Electric Vehicle and Battery Production Potential to 2040 (2022)

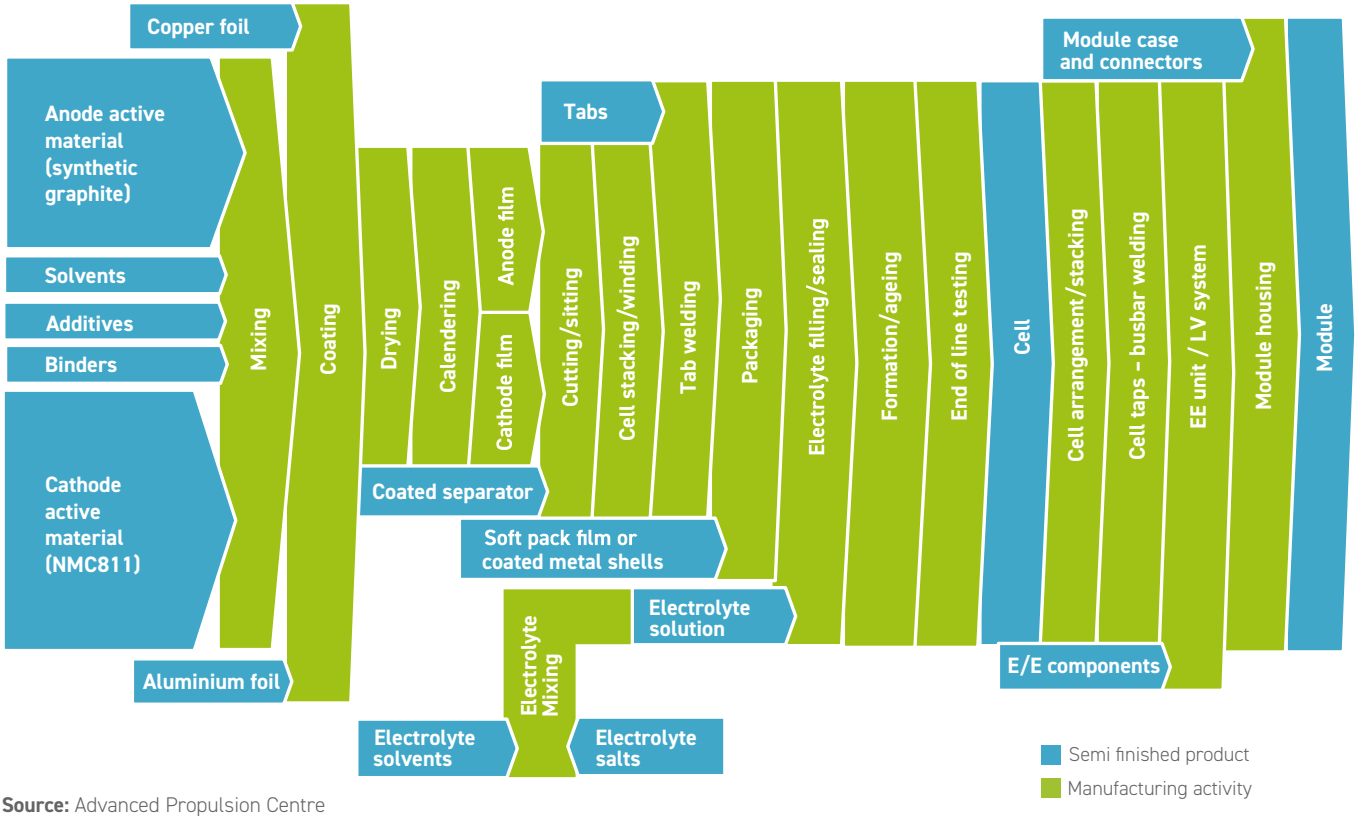
What Does a Gigafactory Look Like?

The term 'gigafactory' was initially coined by Elon Musk as a name for one of Tesla's lithium-ion battery and EV manufacturing plants, such as the 'Gigafactory 1' plant located in Nevada. It is now used more widely to define any large battery manufacturing plant, such as the Northvolt gigafactory in Sweden. A typical gigafactory produces cells and modules used in EVs, as well as undertaking wider activities such as laboratory analysis, prototype engineering and R&D.

Figure 4 illustrates the activities undertaken in the manufacture of a lithium-ion EV battery module. Many gigafactories go a step further and also assemble the battery pack from battery modules. A 20 GWh gigafactory undertaking these activities in the UK in 2025 is expected to directly support around 3,600 jobs at the plant, with a further 6,500 jobs indirectly supported in the wider battery supply chain.

[2] Faraday Institution, UK Electric Vehicle and Battery Production Potential to 2040 (2022)
[3] The Sunderland plant was first established in 2007 as a joint venture (AESC) between Nissan, NEC and Tokin and then subsequently sold to Envision Group in 2018.
[4] Britishvolt begins construction on Blyth factory (7 September 2021).
[5] The Coventry centre helping to drive Britain's electric car dreams (April 2022).
[6] The five gigafactories estimate is illustrative as companies such as Britishvolt and Envision AESC could build plants with capacities in excess of 20 GWh per annum.

Figure 4: Materials and processes undertaken in a typical gigafactory



Source: Advanced Propulsion Centre

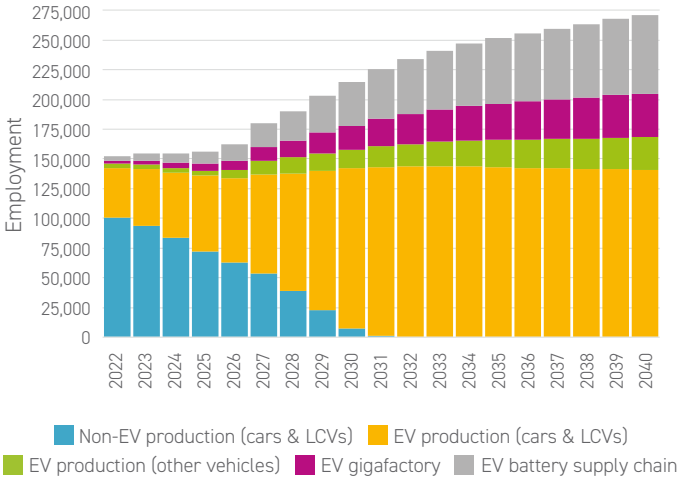
Gigafactory Employment and Skills

If the UK managed to supply all its domestic battery demand through ten new gigafactories, employment in the automotive and battery industry could increase to around 270,000 full-time equivalent (FTE) jobs by 2040 (Figure 5). In particular:

- 145,000 jobs could be directly supported through the production of passenger and light commercial EVs;
- 25,000 jobs supported by the manufacture of HGVs, buses and small lightweight vehicles; and
- 100,000 jobs in the battery manufacturing industry, comprised of 35,000 jobs in battery manufacturing plants and 65,000 jobs in the wider battery supply chain.

Each gigafactory will need a highly skilled workforce to ensure the batteries manufactured have maximum performance and minimum cost, and the plant has high safety standards. Many of the workers required for the new automotive and EV industry will transition from the existing automotive industry as people start to purchase EVs in greater numbers. The processing and manufacturing skills required are very similar and many parts of the vehicles manufactured will be the same, irrespective of whether the vehicle has an ICE or EV powertrain. However, significant reskilling and upskilling programmes will still be required to deliver the numbers of workers required at the right time and the right place. Skills shortages may also be more acute in certain UK regions where the concentration in new gigafactory developments is particularly strong.

Figure 5: UK automotive and battery manufacturing industry jobs to 2040



Source: Faraday Institution, UK Electric Vehicle and Battery Production Potential to 2040 (2022)

The Faraday Institution, WMG University of Warwick and the High Value Manufacturing Catapult have developed the Electrification Skills Framework[7] to describe the key principles and skills needed to make the UK a world leader in battery technology and the green industrial revolution. The framework offers a structure and an integrated approach across employers, training providers and accreditation organisations. The framework provides clarity around the required capabilities, competencies and course provision, in terms of required standards, training provision, continuous professional development courses. Pilot courses and train-the-trainer content were rolled out in 2021, with additional courses scheduled for 2022.

Different skills and qualification levels will be required by gigafactory workers (see Table 1). Production staff and equipment technicians account for around 60% of the workforce in a gigafactory. Production staff are predominantly on-the-job trained against product quality, cost and delivery criteria and operating environment controls, while equipment technicians, typically apprentice trained, work closely with production staff to service and maintenance of process equipment. These two categories would typically require level 2 or level 3 qualifications such as a BTEC Level 2 Diploma in Manufacturing or a BTEC Level 3 Certificate in Applied Science.

The remaining positions within the gigafactory are highly skilled, most requiring degree qualifications. Some of the engineering positions such as systems engineer, database development engineer and thermal management engineer would require a very high level of skills and qualifications (e.g., PhDs). These higher skills would not only be required for the technical nature of cell manufacturing but also to develop a competitive edge.

Risks to the Automotive Industry Without Battery Manufacturing

The increase in UK automotive employment is far from certain. Our research and discussions with the automotive industry and battery manufacturers suggest that financial, legal, regulatory and safety considerations will push automotive OEMs and battery manufacturers to be in close proximity to one another.

Lithium-ion batteries are classified as miscellaneous dangerous goods, which means they need to be carefully handled, packed and transported. As volumes increase this could become more costly and challenging for the industry. Locating battery production close to EV production also helps support a just-in-time manufacturing system by reducing working capital, shortening the cross-border supply chain and lowering carbon emissions caused by transportation.

If the UK does not attract and develop a largescale battery manufacturing industry in the next few years, there is a risk that the production of EVs could move out of the UK and gravitate towards where the batteries are manufactured.

Without UK battery manufacturing, car production in the UK is likely to slowly decline. The speed of the reduction is difficult to predict but, in a worst-case scenario, employment in the automotive industry could fall to perhaps just 20,000 jobs by the early 2030s.

What Needs to Happen?

The UK is making good progress with developing a new gigafactory industry in the UK. Key successes include the ongoing construction of the Britishvolt plant in Northumberland, planning permission for a second Envision AESC plant in Sunderland and business plans from AMTE for a new plant in northeast England, Scotland or Wales. The UK Government has also played its part with a £1 billion UK electrification fund and £500 million earmarked for UK gigafactories.

The UK Government, industry stakeholders and research organisations need to keep up the pace and focus. Key actions include:

- Continue to communicate the attractiveness of the UK as a global and regional battery manufacturing location to global investors;
- Identify prospective sites for gigafactories and the construction of associated physical, transport and energy infrastructure by the local, regional and national government;
- Develop the requisite EV battery skills and training infrastructure;
- Provide long term commitment to mission-based research into next generation batteries that are cheaper, lighter weight, longer-lasting, safer, manufacturable and fully recyclable;
- Develop a strategy to localise and create an efficient, resilient and sustainable UK supply chain to improve availability and affordability of key battery materials for battery production; and
- Develop a strategy to create the conditions for a new lithium-ion battery recycling industry in the UK to flourish.

The challenge to secure interest from global firms should not be underestimated. Without continued effort and action, the UK may not secure the development of a largescale domestic EV battery supply industry and a significant economic opportunity will be missed. Securing battery manufacturing in the UK will not only future proof employment in the UK automotive industry but also support a rapid transition to EVs and help deliver Net Zero.

[7] An Opportunity for a National Electrification Skills Framework and Forum (September 2021).
[8] UK Government (Nov 2020). The Ten Point Plan for a green industrial revolution.

Table 1: Skills requirements for gigafactories

Division	Job Type	Job Role / Description	Level	Indicative Training Requirements	Examples of Applicable Standards*
Production Staff (50%)	Material Handling	Mixing electrochemically active materials, additives and binders to produce electrode material.	L2	Operatives come from high volume process sectors or an industry with actual or similar manufacturing ethos.	ST0420 - L2 Lean Manufacturing Operative
	Machine Loading; Machine Unloading; Module Assembly; Pack Assembly	Slit and blade; drying and stacking; tab and laminate; injections of electrolyte.	L2	GCSE/BTEC/ONC/OND trained: On the job training covering product requirements and operating environment controls.	
	Logistics (to/from/within) the battery plant	Formation and charging, modular & pack assembly, inspection.	L2/3	GCSE/BTEC/ONC/OND Trained: On the job training covering product requirements and operating environment controls.	
Maintenance & Engineering (30%)	Technicians	Service and maintenance of process equipment, tool and die, service and repair.	L3	Apprentice trained: Technicians come from high volume process sector or an industry with actual or similar manufacturing ethos.	ST0250 - L3 Science Manufacturing Technician
	Process / Production Engineers	Problem solving, tool & die, new product introduction, process improvement.	L6	Degree qualified: Engineers come from high volume process sector or an industry with actual or similar manufacturing ethos.	ST0023 - L6 Product Design and Development Engineer
	Facility Engineers	Facility management, building, utilities, fire systems.	L6	Degree qualified: Manufacturing factory and process requirements as well as legislation understanding and conformance.	
	Senior Engineers	Lead engineers and department heads	L7	Postgraduate qualified: Management of engineering qualifications.	ST0456 - L7 Postgraduate Engineer
Quality (10%)	Practitioners	Process controls. Confirmation of part/supply specification. Performance evaluation. Defect analysis.	L4	Apprentice trained: Technicians come from high volume process sector or an industry with actual or similar manufacturing ethos.	ST0853 - L4 Quality Practitioner
	Engineers	Process controls. Confirmation of part/supply specification. Performance evaluation. Defect analysis.	L6	Degree qualified: Engineers come from high volume process sector or an industry with actual or similar manufacturing ethos.	ST0025 - L6 Manufacturing Engineer
Other (9%)	IT; Data Management	Process controls. Confirmation of part/supply specification. Performance evaluation. Defect analysis.	L6	Degree qualified: Familiarisation with systems and requirements.	ST0119 - L6 Digital and Technology Solutions Professional
Management (1%)	Process Leadership	Achievement of set KPIs. Conformance to legislation.	L4	Managers have factory and process requirements as well as legislation understanding and conformance.	ST0695 - L4 Process Leader
	Engineering Management	Senior management of engineering processes across the organisation. Innovation, compliance, budget.	L7	Postgraduate qualified: Management of engineering qualifications.	ST0456 - L7 Postgraduate Engineer

* Dependent on the depth required

About the Faraday Institution and Faraday Insights

The Faraday Institution is the UK's independent research institute for electrochemical energy storage research and skills development. We bring together academics and industry partners in a way that is fundamentally changing how basic research is carried out at scale to address industry-defined goals.

Our 'Faraday Insights' provide an evidence-based assessment of the market, economics, technology and capabilities for energy storage technologies and the transition to a fully electric UK. The insights are concise briefings that aim to help bridge knowledge gaps across industry, academia and government. If you would like to discuss any issues raised in this 'Faraday Insight', or our wider battery research programme, please contact Stephen Gifford.

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