

UK ELECTRIC VEHICLE AND BATTERY PRODUCTION POTENTIAL TO 2040

EXECUTIVE SUMMARY MARCH 2019



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Governments and legislatures around the world are increasingly committed to the electrification of road transport. Car manufacturers are responding. They are investing now in the production of electric vehicles (EVs), which will result in a corresponding decrease in internal combustion engine (ICE) vehicle production. Given the lead-times involved, it will not be long before they stop investing in new production lines for vehicles equipped with internal combustion engines.

The question is not whether this transition will occur. Rather, the question is whether some of the new generations of EVs⁺ will be produced in the UK, or whether the UK will gradually cease to be a manufacturer of vehicles and become an importer.

The answer to this question will depend in part, of course, on whether the UK remains a sensible place for manufacturers to locate the production of vehicles, the vast majority of which are currently destined for export. This will heavily depend, in turn, on the final outcome of the Brexit negotiations. But, alongside the issue of Britain's trading relationship with the EU, the most important determinant of the future health of the automotive industry in this country will be whether batteries are manufactured in the UK.

Strong synergies¹ can be achieved when vehicle producers and battery manufacturers are situated in close proximity to one another. Given the fierce competition within global automotive production networks, these synergies will heavily affect the location of vehicle production. As a result, if the new gigafactories required to assemble the batteries used in EVs are solely built outside of the UK, there is a high risk that international car makers will also only invest in production of future EV models in plants outside the UK.

For this reason, the switch to the production of EVs puts jobs in the UK automotive industry at risk. In a worst-case outcome, with no large scale UK battery production, domestic vehicle producers would gradually wind down their production of internal combustion engine vehicles, progressively eliminating the jobs of the 186,000 people directly employed in the UK automotive sector. The speed of this change is difficult to predict, since it depends on a number of variables that we have modelled. But, under any plausible set of modelling assumptions, the scale of the effect would be considerable. In the absence of any gigafactories producing batteries and associated EV manufacturing, we forecast that 114,000 direct automotive jobs would be lost by 2040.

At the opposite end of the spectrum of possibilities, the UK-in partnership with investors from Asia and elsewhere-could become a leader in the production of both batteries and EVs. In this scenario, the UK would build upon its strong existing automotive industry, and greatly expand its global market share by establishing itself as a European centre for battery and EV production. This could lead to a substantial increase in UK vehicle production relative to today. However, this outcome will be challenging to achieve and will depend both on successes within the UK that will be difficult for UK governments to bring about, and failings elsewhere in Europe.

We have accordingly focussed not on this upside scenario, but on the actions necessary to avoid the downside case of progressive decline in our automotive industry. Our starting point is the question:

How can the UK Government and participants in the UK automotive industry ensure that the UK has sufficient battery assembly plants to sustain a level of electric vehicle production in the UK at least equal to the UK's current share of the internal combustion engine vehicle market, and hence a number of jobs in the industry at least equal to current levels of employment?

For the purpose of answering this question, we have assumed in our base case that the UK automotive sector otherwise remains stable (e.g., in terms of aggregate UK vehicle demand and post-Brexit trading relationships), and that demand for EVs in the UK keeps pace with the trends in global demand for such vehicles.

¹These include greater flexibility for just-in-time production, greater reliability of supply chains against political and climate shocks, and the formation of a knowledge ecosystem around battery systems.

^{*}In this report, EV is taken to include battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs).

BACKGROUND: THE ICE TO EV TRANSITION - OUR BASE CASE

The growth of the UK EV production and battery production industry in this base case will depend upon a range of factors, including:

- 1) the volume of global vehicle sales,
- 2) global emissions regulations,
- 3) the rate of decline in EV battery costs,
- 4) growth in EV battery power, and
- 5) the import-export environment.

We use optimistic and pessimistic assumptions about these factors in order to calculate the upper and lower bounds for predictions. Export markets are clearly the key issue, given that Britain exported 80% of its 1.6 million domestically produced vehicles in 2018, of which over half were exported to Europe. In these export markets, our model projects aggregate vehicle sales to grow by 1.3% per year between 2019 and 2040, driven mainly by demand outside of Europe and the United States, most notably from China. Applying different assumptions about emissions regulations, the decline in EV battery costs and the increase in EV battery power, this generates our base case



Maintaining current production rates for key markets allows UK automakers to produce 1.1 to 2m EVs by 2040. While global growth is projected to be 1.3% p.a., our model predicts a more conservative growth path of 1.1% for the UK.

projection that the UK will be producing between 1.1 million and 2 million EVs by 2040.

It is worth noting that, as the battery makes up 40% of an EV's value, meeting the UK's EV battery demand under this scenario would increase annual UK imports by £5-12 billion per year by 2040 if the batteries were (implausibly) sourced 100% from overseas suppliers. But, given that EV production at this level will almost certainly depend upon the establishment of a **secure domestic EV battery supply**, the more interesting point is that the accompanying UK battery production facilities represent a considerable industrial opportunity for Britain.

Projected demand for UK-produced batteries



Based on the three scenarios, UK and EU demand for UK-produced batteries could reach 60-200 GWh per year by 2040, the equivalent of 4-13 gigafactories. While global growth is projected to be 1.3% p.a., our model predicts a more conservative growth path of 1.1% for the UK.

Under our base case assumptions, the Faraday Institution battery demand forecasting model (based on IHS data) projects that UK EV battery manufacturing capacity in 2040 will need to be between 60 and 200 GWh per year (i.e. between 5% and 17% of the projected 1,200 GWh per year European battery production capacity in 2040). This implies a very considerable growth in UK battery manufacture—with the establishment over the next twenty years of somewhere between 4 and 13 high-volume, battery production plants ("gigafactories") in the UK, each producing on average 15 GWh of battery capacity each year. The global transition from producing internal combustion engine vehicles to producing EVs will have a considerable impact on the UK labour market. Job creation will outpace job losses in the UK only if the UK secures both EV and battery manufacturing.

Under our base case scenario, we project that battery pack, battery cell and electrode manufacturing will all be located in the UK. In this scenario, the overall industry workforce of the EV and EV battery ecosystem would grow by 32% from 186,000 to 246,000 employees by 2040 with:

 83,000 new jobs created in the new UK battery gigafactories and in their battery material supply chains; • 38,000 jobs remaining in ICE vehicle production; and

• 125,000 jobs remaining in powertrain manufacturing serving both ICE and EV production.

Of the 83,000 new jobs by 2040, around 8,000 would be created in EV manufacturing, 26,000 jobs in battery manufacturing, 47,000 jobs in the battery supply chain and 2,000 jobs in battery R&D.

The shift toward EVs will also necessitate the retraining of auxiliary personnel, including vehicle technicians, mechanics and electricians, as well as staff at service stations. These changes to the labour market will depend on the UK's uptake of EVs rather than on the UK's production of EVs, a trend that falls outside the scope of this study².



Under our base case scenario, we project that powertrain indifferent jobs remain unchanged over the period to 2040 at 125,000, based on the assumption that the 1.2% per annum growth in EV and ICE vehicles produced in the UK is offset by the same per annum increase in labour productivity.

ICE and EV employment 2017 to 2040

²We also analyse the labour market effects of the less plausible possibility that the UK will manage to replace ICE vehicle production with EV production, despite failing to achieve an increase in battery manufacturing capacity. We project that the lower labour-hours necessary to assemble an EV drive train compared to an ICE vehicle drive train – partly owing to increased automation – will result in a 12-33% reduction in the vehicle assembly workforce in this case.

COMPETITIVE LANDSCAPE AND REQUIRED INVESTMENTS

Assuming successful resolution of post-Brexit trading relationships, the UK currently offers a competitive business environment for attracting prospective battery cell producers when compared with other countries in Europe. The UK is the 4th largest vehicle manufacturer

European lithium-ion battery capacity ramp-up until 2025

Göd and a 14 GWh per year CATL battery plant in Erfurt. The most notable plan put forward by a less established player is Northvolt's plan for a 32 GWh per year battery factory in Skellefteå. Based on current plans alone, total battery manufacturing capacity in the major centres in continental Europe will reach 130 GWh per year six years from now.

Without urgent action from stakeholders, the UK is

BMZ CATL LG Chem Samsung SDI SK Innovation Northvolt Tesla, BYD 45 GWh 20 GWh 8 GWh 14 GWh¹ 32 GWh 16 GWh Capacity: tbc Wroclaw Göd Komarom Tbo Erfurt Skellefteå Undecided GWh p.a 150 125 100 75 Nissan Sunderland battery factory (est. 2010) capacity 2016 ~2 GWh p.a. 50 25 2016 17 18 19e 20e 21e 22e 2025e 23e 24e

European battery production capacity is expected to reach 130 GWh per year by 2025.

in Europe, with nearly a decade of experience of EV battery cell and pack production, following the establishment of the first and largest battery production facility in Europe (the AESC battery plant in Sunderland) in 2010.

But other European countries are currently working hard to replace the UK as leaders in this field. Germany, Sweden, Poland and Hungary have emerged as key competitors by creating favourable business conditions to attract battery manufacturers. Germany, for example, has recently announced a €1 billion federal support programme for EV battery production. In Poland and Hungary, special economic zones have been set up that offer tax relief to EV battery producers. Plans for new battery manufacturing capacity in continental Europe currently announced by top-five battery manufacturers include a 45 GWh per year LG Chem battery plant in Wroclaw, a 16 GWh per year Samsung battery plant in in danger of losing out in the race to develop a large scale domestic EV battery supply through the required investment in new factories. Our modelling shows that, in order to realise a successful EV transition through a ramp-up of UK battery manufacturing capacity by 2040, investment in the range of £5-18 billion will be required. This level of investment in UK battery production is currently being put at risk, as domestic vehicle manufacturers are already negotiating longterm contracts with battery suppliers outside the UK. In recent months, a flurry of deals between EV battery manufacturers and vehicle producers have been announced. Focussing on European car producers, for example:

- LG Chem has announced relationships with Volkswagen³ , PSA⁴ and Renault⁵; and
- CATL has announced a relationship with BMW⁶.

³https://uk.reuters.com/article/us-lg-chem-volkswagen-batteries/lg-chem-to-supply-ev-batteries-to-volkswagen-from-late-2019-idUKKCN1ME0VZ ⁴https://www.reuters.com/article/us-autoshow-geneva-psa-lg-chem-idUSKBN16E0XM

⁵https://uk.reuters.com/article/lgchem-renault-battery/south-koreas-lg-chem-to-supply-batteries-to-renault-idUKBJL00207320100930 ⁶https://uk.reuters.com/article/uk-bmw-catl-batteries/chinas-catl-to-build-its-first-european-ev-battery-factory-in-germany-idUKKBN1JZ161

In the UK, there are only a handful of volume producers (factories producing more than 100,000 units per year). These are Nissan, Jaguar Land Rover (JLR), BMW Mini, PSA's Vauxhall and Toyota. There is no reason to suppose that these firms will naturally gravitate towards establishing all, or even any serious proportion, of their European battery manufacturing capacity in the UK. If, on the contrary, they enter long-term relationships with overseas battery suppliers, then the chances of securing UK gigafactories (and hence the chances of sustaining an EV production industry in the UK) will diminish.

The UK Government could increase the probability of securing UK gigafactories by helping to facilitate the winning of new volume EV model lines to UK-based plants. For instance, should half of the production of a single volume model of a larger vehicle produced in the UK be fully electrified, this would generate nearly enough demand for one additional gigafactory in the UK.

Various promising initiatives have already been announced by British vehicle manufacturers. JLR has stated that every Jaguar and Land Rover launched from 2020 will be electrified⁷. JLR already has a fullyelectrified vehicle in its model line-up, the Jaguar I-PACE, and has further announced plans to build a battery pack assembly centre at Hams Hall near Birmingham. Production of a fully-electrified Mini will also soon begin at the BMW Mini plant in Oxford.

With the 'Road to Zero' strategy, launched in summer 2018, the UK Government has also set ambitious targets for EV sales in the UK. The strategy sets out the intention that at least 50%, and possibly as many

as 70%, of new vehicle sales in 2030 will be of ultra-low emissions models. The UK Government has additionally identified EV and EV battery manufacturing as a strategic priority.

FACTORS INFLUENCING GIGAFACTORY INVESTMENT DECISIONS

But this is a case of two-way causality. Just as the investments in UK gigafactory battery production will depend upon the presence in the UK of major EV production lines, so the presence of EV production lines will depend upon the willingness of the battery manufacturers to invest in the UK. Therefore, UK industry and government stakeholders need to consider carefully how to secure gigafactory investments. As a battery plant generally takes five to seven years to reach full operational capacity, a decision about the siting of a gigafactory would need to be made now in order to meet the EV battery demands of the mid-2020s.

We asked leading battery firm executives to list the factors that have 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; hence, if the UK can build upon its existing vehicle manufacturing base, it can hope to attract the battery manufacturers and therefore sustain significant EV production. But the battery manufacturers also told us that they were influenced by investment incentives, timely permitting and licensing arrangements, cheap and clean energy and a skilled and productive workforce. We need to recognise that the UK is in a global, country versus country, competition, and



Average cost structure of Li-ion cell in 2016

⁷https://www.jaguarlandrover.com/news/2017/09/every-jaguar-and-land-rover-launched-2020-will-be-electrified

that others are forming persuasive propositions.

These responses were not surprising. In our analysis of the cost components of lithium-ion battery cells, the majority of costs are not production-location specific. Most notably, raw materials make up over half of the cost of a lithium-ion battery cell. Only three components of the cost of batteries are location specific, namely direct labour, energy and utility, and depreciation. None of these (other than energy infrastructure costs) can easily be affected by specific government actions; and, combined, they account for only 22% of overall costs.

The UK accordingly cannot hope to attract gigafactories through the provision of an intrinsically low cost-base and therefore needs to match or come closer to matching the financial and administrative incentives that have been offered by other European countries to EV battery manufacturing firms. We conclude that HM Government, working with relevant Local Enterprise Partnerships (LEPs) and Combined Authorities, should consider the following actions:

1) further moves to establish coordinated, ambitious and centralised leadership on this issue⁸;

2) further efforts to communicate the attractiveness of the UK as a global and regional battery manufacturing location; drawing on the content of this report; and

 a) new efforts to de-risk the business case by undertaking prospective site selection, the preapproval of relevant permissions, the construction of basic on-site physical (especially energy) infrastructure and the development of the requisite EV battery skills and training infrastructure.

Overall, the UK has had a head start with the establishment of the largest European battery factory in Sunderland in 2010, yet we risk falling behind in the race to secure the next generation of battery factories. Within a year, most car producers and battery manufacturers will make their decisions about where in Europe the next generation of gigafactories will be built. We need a timely and coordinated effort by government and industry leaders to attract these gigafactories to the UK, and to secure the future for our automotive industry.



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