DEVELOPING A SUSTAINABLE UK BATTERY INDUSTRY

Dr Billy Wu
Dyson School of Design Engineering, Imperial College London
Email – billy.wu@imperial.ac.uk

A GENERATIONAL ENERGY TRANSITION

We are now at the crossroads of a once-in-a-generation energy transition; from an economy reliant on fossil fuels to one where there is the potential for abundant clean renewable energy. The technology transitions that are enabled by this will have a dramatic impact on society. Internal combustion engine (ICE) vehicles will be replaced by electric vehicles (EVs) and use of renewable solar/wind energy will only increase; reducing reliance on hydrocarbon fuels. However, to enable these technologies, cheaper, longer lasting and more sustainable batteries are needed.

THE END OF THE ICE AGE

UK vehicle production peaked in 2016 with over 1.8 million vehicles produced, but fell to approximately 1.0 million in 2022 (mostly ICE vehicles)[2] due in part to the global pandemic. With the sale of new petrol and diesel vehicles in the UK coming to an end in 2035, the direction of travel is clear; EVs will be the dominant vehicle technology. Forecasts from the Faraday Institution[2] suggests that vehicle production could recover to 1.6 million in 2030, however this is highly reliant on whether a large-scale UK battery industry can be created. Growth to 1.8 million by 2040 is possible, however in the absence of UK gigafactories, the worse-case scenario would mean the production of only 20,000 vehicles in 2040, with significant loss of employment and export potential in the UK automotive sector.

> **"The stone age came to an end, not because we had a lack of stones, and the oil age will come to an end not because we have a lack of oil"**
> Sheikh Ahmed Zaki Yamani, former Saudi oil minister [1]

A GLOBAL RACE TO MAKE BATTERIES

The importance of developing a strong battery industry has been recognised globally. Benchmark Mineral Intelligence has tracked >400 battery gigafactories that are in the pipeline to 2030, with two thirds of the ~9,000 GWh/year capacity coming from China (see Figure 1). The Faraday Institution estimates 100 GWh/year worth of battery production is needed in the UK by 2030, with this growing to 200 GWh/year by 2040 as demand grows for in sectors such as EVs and grid energy storage. Expertise in UK battery production does exist, with notable large-scale examples being AESC Envision's 2 GWh Sunderland plant (with the addition of 12 GWh by 2025) and Agratas's (Tata's Group's global battery business) planned £4bn 40 GWh plant, with battery production planned to start in 2026, bringing potentially 4,000 jobs to the Somerset region[3]. However, based on current announcements, the UK is still far behind in meeting this future battery demand, which will impact competitiveness.

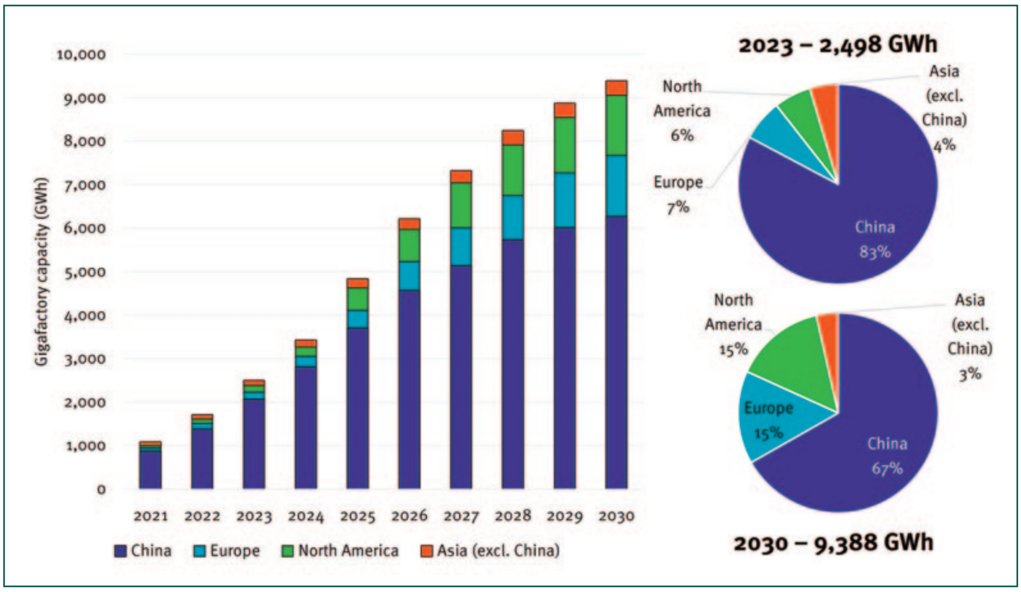

Figure 1 – >400 announced battery gigafactories in the pipeline to 2030, with most of these in Asia. Adapted from Benchmark Mineral Intelligence data

CRITICAL INDUSTRY NEEDS CRITICAL ELEMENTS

In order to meet this demand, the UK will need to source the critical minerals that are used to manufacture batteries, which includes: lithium, nickel and cobalt, amongst others. The supply chains for all of these elements are complex. Taking lithium as an example, the vast majority of raw material supply currently comes from Australia, Chile and Argentina (see Figure 2). However, this needs to be processed into suitable forms for use into batteries, with China being the dominant supplier of the lithium hydroxide and lithium carbonate used in battery production. The global trek that these battery materials make; from Chile to China and then to the UK, opens important questions around sustainability and resilience.

These challenges are compounded by the fact that setting up new mines is extremely capital and time intensive; with highly volatile commodity prices being a key area of uncertainty for the economic viability of future projects. As such, there will likely be mismatches between battery cell production and the supply of critical minerals. In the case of battery grade lithium chemicals, whilst there are potential supply streams that can be ramped up, this is unlikely to keep up with demand in the near term. This potential shortage is estimated to occur towards the end of the decade; limiting cell supply and EV deployment plans.

Developing battery recycling capacity will help but not address all supply demands, with significant lags between old EVs entering the system and the material becoming available for manufacturing. The economic viability of recycling is compounded by current high costs, however, innovations in recycling are certainly possible, though supporting regulations will be needed. The EU Battery Regulation for instance is putting into place rules around recycling efficiency, carbon footprint thresholds and minimum levels

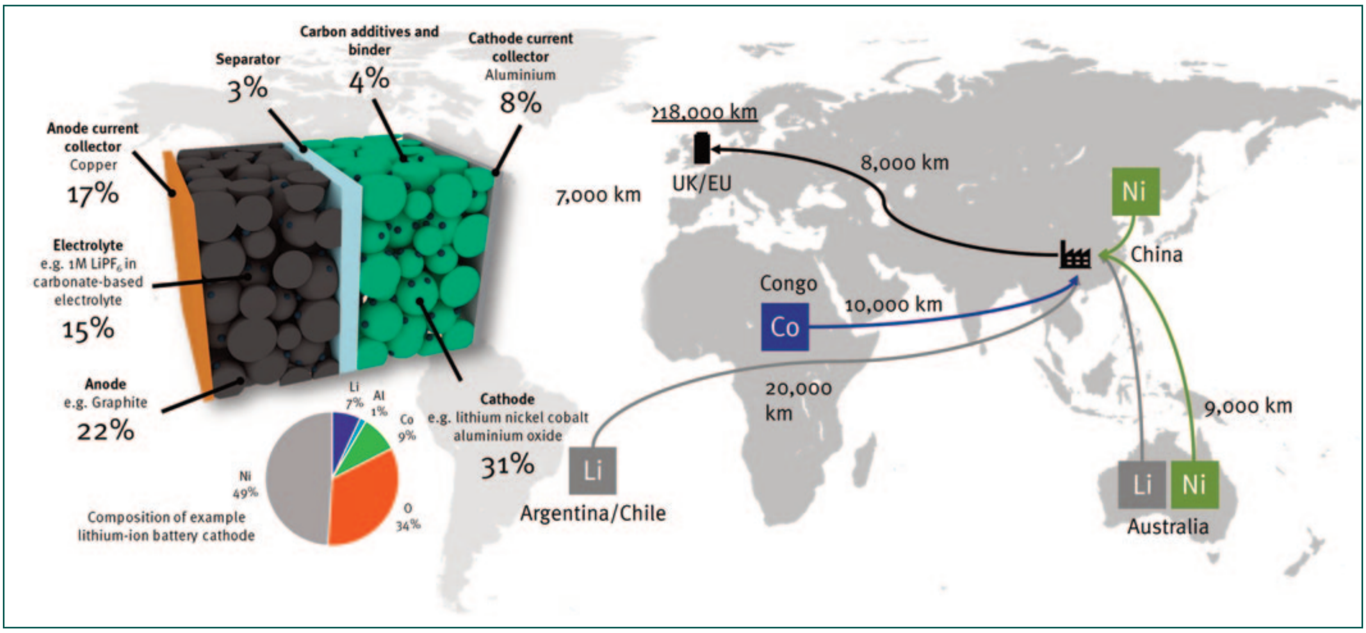

Figure 2 – Critical elements within a lithium-ion battery and typical supply chain route

of recycled battery material to be used in future batteries, supported by a battery passport system to track key metrics. Given that ~80% of UK vehicles produced in 2020 were exported, half of which were to Europe[2], ensuring UK batteries are low-carbon is not just an environmental imperative, but an economic one if alignment to EU markets is sought.

THE WINNERS WILL BE THE INNOVATORS

The UK has and continues to be an intellectual powerhouse with key strengths in battery research. Professor John Goodenough, the 2019 Nobel Prize winner in Chemistry, conducted his seminal work on lithium cobalt oxide at the University of Oxford in the 1980s, the material which would go into the first commercially available lithium-ion battery. Yet, despite the core conceptual advance being developed in the UK, Asia benefited the most, with Sony (after a decade of further research) being the first to commercialise and scale the technology. This is a cautionary tale of missed opportunities.

Ultimately, the field of batteries is rapidly evolving, and the winners of this global race will be the ones who continually innovate. Beyond the traditional lithium-ion battery, a whole family of other technologies are on the cusp of commercial viability. Current sodium-ion batteries, whilst having slightly lower specific energy (~160 Wh/kg sodium-ion vs ~250 Wh/kg lithium-ion), use earth abundant elements and would be highly suitable for smaller EVs and grid connected energy storage. Here, the UK already has significant strengths – Sheffield-based Faradion is a global technology leader and supporter of the Faraday Institution NEXGENNA project on sodium-ion batteries. China has already recognised the potential of sodium-ion technology, with scale-up facilities advancing rapidly.

Solid-state batteries have also garnered significant interest as a potentially safer and more energy dense alternative to traditional lithium-ion technology, with some demonstrating a specific energy as high as 500 Wh/kg. Lithium-sulfur batteries, which remove the need for nickel, another critical mineral, have the potential to have a key role in the electrification of aerospace applications. The UK research community has long since recognised the importance of these technologies. The Faraday Institution has built a leading community of 27 universities, >120 business and ~500 researchers pushing boundaries and forming a strong intellectual foundation, ready to reap the rewards of the investments to date.

However, translation of research takes time, with history suggesting that taking a technology from fundamental discovery to commercialisation can take up to 10 years, and potentially even longer with global scale-up of complex supply chains. Therefore, the battery industry needs to be viewed as a long-term investment, requiring sustained support to realise the significant benefits.

KEY MESSAGES

- **Pace of action needs to increase to maximise a once-in-a-generation economic opportunity.**
- **UK EV production could reach 1.8 million by 2040, but needs a domestic battery manufacturing industry.**
- **Ensuring these UK batteries are sustainable is both an environmental and economic imperative. Around 80% of vehicles made in 2020 were exported, half of which were to the EU where the Battery Directive is in force, which stipulates sustainability targets.**
- **Battery supply chains are complex. The main raw lithium suppliers include Chile, Australia and Argentina, but most of the processed battery grade lithium chemicals come from China, with demand outstripping supply potentially towards the end of the decade.**
- **The winners will be the innovators of new technologies such as sodium-ion batteries, which is on the cusp of commercialisation. Here, the UK is well placed to have a leading position in next generation batteries with an already established strong R&D base and innovation pipeline. It is poised to be an industrial leader in this area but long-term support is needed to create sovereign capability.**
- **Highly skilled people will be the innovation engine for export opportunities, with a successful EV industry potentially supporting 270,000 UK jobs.**

SKILLED WORKERS, THE INNOVATION ENGINE

With the need to innovate, developing a pipeline of skilled workers to power this industry will be essential. In the scenario where 1.8 million UK EVs are produced, this can potentially support ~270,000 jobs by 2040, with 170,000 in vehicle manufacturing, 35,000 in gigafactories and 65,000 in the broader supply chain[2]. These jobs will require skilled people across the industry from production staff to R&D leaders, with training programmes essential to meet the growing requirements.

Creating a sustainable UK battery industry has huge long-term environmental, economic and societal benefits, and needs to be done. This will not be easy, but the prize for those who win this global race will be massive.

References

1 "Sheikh Yamani predicts price crash as age of oil ends." Accessed: Mar. 08, 2024. [Online]. Available: https://www.telegraph.co.uk/news/uknews/1344832/Sheikh-Yamani-predicts-price-crash-as-age-of-oil-ends.html

2 S. Gifford, "UK electric vehicle and battery production potential to 2040 Executive summary," *The Faraday Insitution*, 2022.

3 "Tata confirms Somerset will be home to £4bn battery factory | Tata | The Guardian." Accessed: Mar. 08, 2024. [Online]. Available: https://www.theguardian.com/business/2024/feb/28/tata-confirms-somerset-battery-factory-bridgwater ■