DEVELOPING A UK SUSTAINABLE BATTERY INDUSTRY

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Adoption of electrification has been led by the automotive industry, but other sectors are increasingly embracing electrification, from marine and aviation to energy storage. Due to this, the UK government's vision is for the UK to have a globally competitive battery supply chain to support economic prosperity and the net zero transition [1]. UK localisation provides environmental opportunities due to the high environmental standards and low-carbon energy available.

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Batteries are a complex balance of techno-economic interactions. It is typically not possible to meet all the requirements with the current technology, therefore trades must be made. Cost reduction dominates the technical agenda, followed by faster charging, degradation and safety.

Recent development has been driven by the automotive industry, which is expected to dominate UK demand at around 80-90GWh out of 100GWh in 2030. The UK has a very long tail of companies that require battery supply to support existing businesses that generate significant GVA and employment.

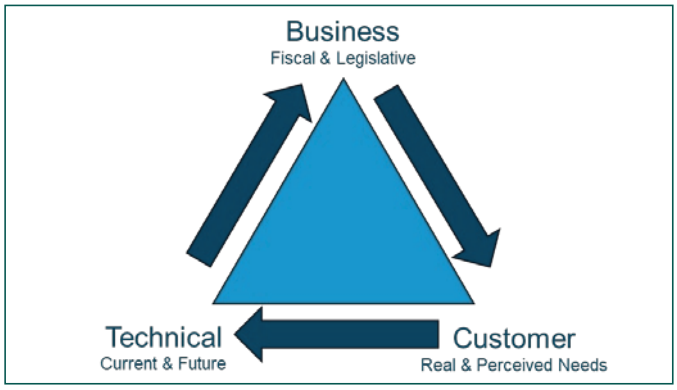

Figure 1 – Techno Economic Modelling Net-Zero & Sustainability Framework

However, there is more forecast demand than planned cell production capacity, this has potential to either result in imports with a potential strategic vulnerability for the UK, or loss of industry. For automotive it is expected that cell manufacture must be located close to vehicle manufacture for viability.

THE RACE TO DEVELOP BATTERY SUPPLY CAPABILITY

The UK is in a global race to develop appropriate battery

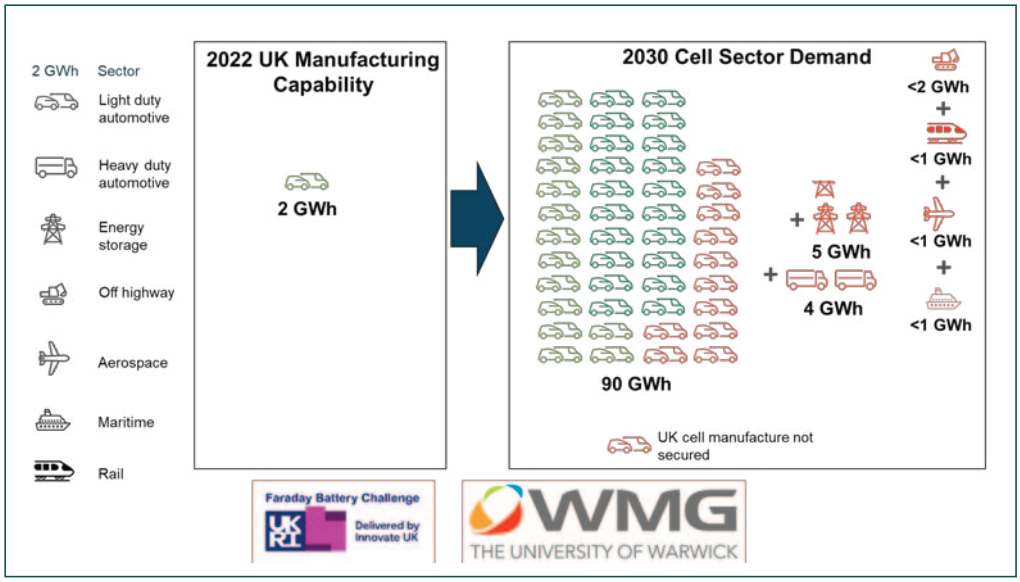

Figure 2 - Projected 2030 UK Battery Demand

supply industry and capability both to support sustainability of existing manufacturers and to benefit from new opportunity. The UK's low-carbon electricity will enable more sustainable production than many other countries, along with high social standards for extraction, processing and manufacturing.

Figure 3 – Simplified Battery Supply Chain

The UK has some established & planned material extraction and processing capability, e.g. production of up to 52,000t/yr lithium carbonate[2,3,4,5] and ~8,000t/yr lithium hydroxide[6] (The UK likely requires ~40% more, assuming 850g/kWh[7]). There is existing and planned lithium processing[8,9], but an expected 48% global shortfall in 2040[9].

The Humber refinery is the only European facility producing anode coke, with production for about 1.3m BEVs/yr[10], giving the UK an advantage over many neighbours. Electrolyte is produced in Tees Valley[11].

China accounts for 78% of global cathode and 91% of global anode production[12], with no volume UK electrode manufacturing[12] . Work is underway at research and pilot scale[13,14,15], with plans to produce at volume[16].

Cells are manufactured in the UK by Envision AESC and AMTE Power. The Agratas (Tata Motors) plant in Somerset is also progressing with expectation to supply approximately 40GWh/yr[17].

With forecast UK demand of 100GWh in 2030, more capacity is required to avoid reliance on imports and a potential strategic vulnerability. Lead times for such large-scale facilities mean that the window to attract investment is limited, e.g. up to a decade for critical minerals mines and chemical plants[18].

The high-volume module and pack applications will likely be covered by cell manufacturers. The UK has many other niche applications and these require support such as standardised modules[19], allowing shared development costs and expertise.

At End-of-Life (EoL) it is expected that batteries will primarily be recycled rather than used for second life. Recycling will be an important future feed of material in the long term, but short-term supply is limited, driven by an average car life of 14 years. EoL supply is likely to only meet demand close to 2050.

Battery supply is about more than just the cell assembly gigafactories, and includes other items such as connectors, current collector foils, thermal management systems and pack enclosures. It is critical that these are considered for the UK supply chain.

Innovation must be proven at each scale of manufacture and needs the ecosystem to support this. This starts at small scale for fundamental research, growing to larger scales as success is demonstrated by the technology.

Gramme Scale - Typically university scale research of hand-made materials for fundamental research and initial half-cell experiments.

Kilogramme Scale - Typically corporate R&D lab or University / Catapult centre, used to demonstrate scalability of materials to full size cell processes and formats.

50kg – tonne Scale -Full scale manufacturing facilities used at low rate. Expensive, inflexible, and often impossible to access except by owner. UKBIC provides bespoke facility for this purpose, used to develop and prove materials, cell design, manufacturing processes and parameters "at-rate".

Kilotonne Scale - Full-scale, high-volume manufacturing plant. Typically, 6-50GWh/year, used to deliver very large volumes of cells with no variation or flexibility to chemistry, format or quality.

SKILLS DEVELOPMENT

Research has found that significant change will impact the existing workforce[20]. Across automotive manufacturing roles related to batteries, power electronics and electric machines, 63% of job roles will be subject to significant change. Examples include 61% of current powertrain jobs and 91% of power electronics quality engineers and technicians will have significant competency gaps requiring training[20].

By 2030, 90,000 automotive technicians will be required to service zero-emissions vehicles, with IMI forecasting a shortfall of 35,700 technicians[21]. Up to 182,000 mechanics across the automotive sector will need reskilling by 2030[20]. National Grid has estimated that 117,000 skilled recruits are required by 2030 to support the energy sector[22].

In manufacturing, the Faraday Institution estimates 100,000 will require reskilling by 2035[23]. For cell manufacturing in 2030 up to 10,000 workers could be needed[23].

Delivering the workforce requires new skills, upskilling and reskilling[22]. Organisations including Faraday Institution, Innovate UK, Faraday Battery Challenge, UKBIC and UK universities are contributing to filling the skills gap.

FUNDING

It is critical that funding be provided to target the technical challenges of delivering batteries with the needed performance profiles for their intended purpose. The existing funding framework is split by TRL, which can be classified as fundamental research, proof of concept, product pre-production and series manufacture.

Figure 4 - UK Funding Framework and Support Mechanisms

This has created a coherent funding ecosystem to support battery development from research to industrialisation however the job isn't finished. We need continued funding aligned to overall strategy to ensure this can meet the demands of industry.

THE RACE IS ON

The EU trade agreement requires a percentage of local content for EV's and batteries, this is driving the race to secure the supply chain to avoid tariffs. The existential risk is that vehicle manufacture will be closely tied to battery manufacturing location, therefore, it is both an opportunity and a risk to existing vehicle manufacturing. Europe is in competition with the US, which has overtaken following the IRA.

Faraday Battery Challenge have created 6 Battery "Big Plays" to focus industry and ensure future UK success:

Secure the supply chain in the UK

1. "Double down" on all efforts to secure competitive, sustainable UK manufacturing of Nickel-rich batteries & associated supply chain.

2. UK supply chain for very high performance, high value, relatively modest volume solutions at cell, module & pack level.

Develop the next generation technologies

3. UK technical capability and physical supply chain for Li metal anode solutions.

4. Low cost / Good enough (for high volume auto) energy density pack level solutions.

Make it all sustainable

5. Total end-to-end life cycle assessment optimisation, use of earth-abundant materials, manufacturing energy reduction, end-to-end cost of ownership optimisation, robustness to first use duty cycles, efficient recovery and recycling.

Leverage digital tech developments

6. The "5 Dimensions of Digital" - Big Data & AI for materials discovery- Digital Design Optimisation Performance Verification- Test and field data analytics- Digitisation of the end-to-end bill of process- Digitisation of "Provenance" and State

KEY TAKE OUTS

- Whole life cost reduction is the key factor driving innovation in electrochemistry, battery design, manufacturing processes and recycling.
- Batteries are critical to UK manufacturing, and a key building block to NetZero and sustainability targets. A heavy reliance on imports creates a potential strategic vulnerability.
- A UK battery supply chain can offer improved environmental sustainability due to the high standards and low-carbon electricity supply available.
- Strategic alignment is required to ensure the development of skills, investment in research and investment in the supply chain happens in a timely manner to meet the needs of industry.
- Without strategic intervention, we will lose the battery race.
- Sustained policy and intervention is required, e.g. financial support, electricity supply, transport infrastructure and tariff-free access to global markets.

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