UK SUPPLY CHAIN CHALLENGES FOR BATTERY ENERGY STORAGE SYSTEMS

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ENERGY
STORAGE
Li-ion
Energy storage
CAUTION

Contents

Executive Summary

Battery Energy Storage Systems are devices that store electrical energy and release it as required. They are typically for levelling supply and demand from intermittent renewable energy sources and microgrids in remote regions. In the UK, they play a key role in the transition to net zero as they store energy from renewable sources and provide it to the grid during low periods of renewable energy generation. Rapid growth of installations is predicted in the foreseeable future. With a similar bill of materials to Electric Vehicles batteries, the question whether the supply can meet the growing demand and whether the supply chain is reliable arise. This white paper investigates the supply chain of BESS according to its downstream, upstream and midstream.

Relevant statistics show that the UK has the highest demand for grid scale in Europe, and aims to install more renewable energy infrastructure, leading towards significant demand growth for BESS to store this energy. The interest in manufacturing BESS components locally appears to be relatively modest, and the reliance on importation seems to be the current preference for industry. In the case of raw materials, the demand for critical minerals keeps increasing and the reliance on foreign countries remains significant. Although the current supply chain is showing some weaknesses, the government intends to build battery supply chain resilience, as published in the UK battery Strategy. Main elements of the approach undertaken include activities around raw materials (such as lithium) and signing of bilateral agreements.

To grow the UK supply chain for BESS, several challenges remain to guarantee a stable and resilient supply chain. These include:

- Lowering the risk of battery components and critical mineral shortage.
- Ensure supply chain traceability and ethical mineral extraction.
- Developing appropriate business models.

Among those challenges, substantial opportunities can be distinguished:

- Build a domestic supply chain.
- Pursue the research and development of new technologies, such as Sodium ion, to lower the dependence on critical minerals.
- Repurpose Electric Vehicles batteries at their end-of-life batteries for Battery Energy Storage Systems as they are predicted to be available in large amounts in the near future.
- Provide leadership and drive for digital traceability and verification of Battery Energy Storage Systems material supply.
- Bring together industrialists, academics and the supply chain to better understand system requirements and develop technologies and appropriate business models.

Abbreviations

Acronym	Description
BESS	Battery Energy Storage System
BMS	Battery Management System
EV	Electric Vehicle
EVB	Electric Vehicle Battery
PbAB	Lead-Acid Battery
LiSB	Lithium Sulphur Battery
MAirB	Metal-air Battery
RFB	Redox Flow Battery
NiB	Sodium-ion Battery
SSB	Solid-state Battery
TRL	Technology Readiness Level
VRFB	Vanadium Redox Flow Battery

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1. Introduction

1.1 BACKGROUND

With the goal to reach net zero emissions by 2050, the UK set very ambitious targets to reduce greenhouse gas emission by 68% by 2030 compared to 1990 levels. It is also the only major economy to have set a target of 78% for 2035 (gov.uk, 2023). In this race, the demand for batteries is growing exponentially with a high prioritisation for transport applications, as the Electric Vehicle (EV) manufacturing industry is racing to align with the government plans. However, there is also a battery need for non-EV applications such as Battery energy Storage Systems (BESS) that cannot be neglected. Typically used for levelling supply and demand from intermittent renewable energy sources and microgrids in remote regions, BESS play a critical role for the transition to net zero. There is nevertheless little information regarding BESS supply chains in the UK in the available literature despite the significant growth of its market in the foreseeable future.

1.2 OBJECTIVES

This white paper focusses on BESS. In the following sections we will explain what BESS are, and how they play such an important role in the race for net zero. An overview of the market and the supply chain in the UK is provided, and aims to provide some answers to the following questions:

- What is the current situation for BESS and how will the demand and the market grow?
- What are the sourcing options in the BESS manufacturing industry?
- How reliable is the current UK BESS supply chain?
- What are the challenges to overcome in order to supply the increasing demand?

2. What is a Battery Energy Storage System?

Battery energy storage systems (BESS) are devices that store electrical energy and release it as required. They play a crucial role in modern power grids, providing stability and reliability. BESS offer many benefits over traditional grid storage solutions: greater flexibility, greater scalability, lower costs, higher efficiency. BESS can respond quicky to changes in the power grid to balance it and provide backup power. They are important for energy transmission and distribution by frequency and load levelling, voltage reduction, and peak shaving/reduction. BESS are also used for EV charging infrastructure to support peak demand periods and in energy arbitrage to buy/store energy during off-peak hours and use it during peak hours, when energy cost is high.

BESS are a key technology for supporting the transition to a greener future in the UK as they are essential to speed up the process of replacing fossil fuels with green energy. BESS store energy from renewable sources (solar, wind, hydropower, and bioenergy) and help to balance the energy demand in the grid by storing the excess energy and providing it to the grid during low periods of renewable energy generation.

2.1 BATTERY ENERGY STORAGE SYSTEMS COMPONENTS

BESS are battery systems converting chemical energy intro electrical energy. They consist of battery cells arranged in racks that are then arranged to create energy storage system. BESS have four main levels of components (Figure 1) (Maisch, et al., 2023):

1. **Battery cell:** anode, cathode, electrolyte, separator, housing.
2. **Battery module:** battery cells, wiring, housing, electrical components.
3. **Rack:** battery modules, wiring, housing, electrical components, and Battery Management System (BMS).
4. **Enclosure:** racks, wiring, container, electrical components, fire suppression system, thermal management system, heat/gas detectors, explosion controls.

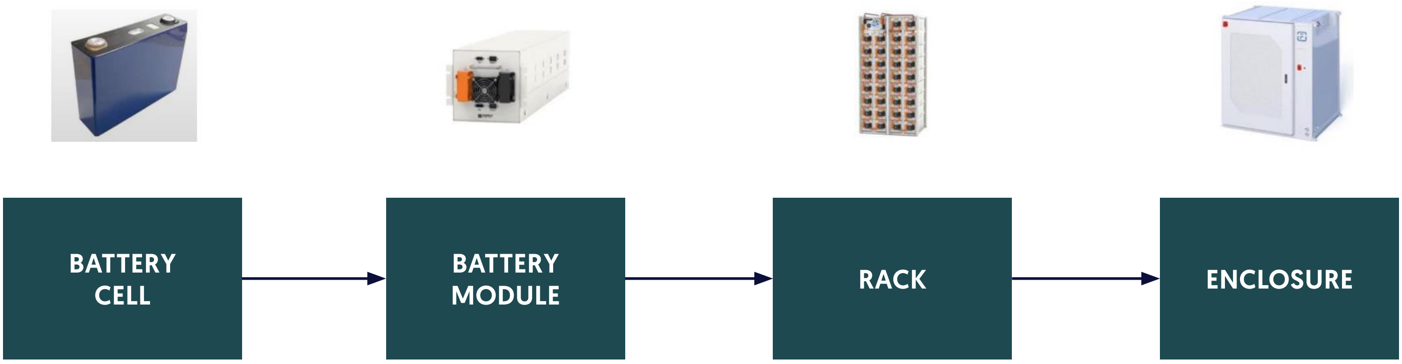

Figure 1: BESS components, adapted from (Maisch, et al., 2023)

A question arises, how BESS are different to electric vehicle batteries (EVBs) as they both are built from battery cells, battery modules, electrical systems, and thermal management systems. Specific applications lead to different performance criteria for BESS and EVBs. BESS R&D focuses on storage capacity optimisation, grid compatibility, and providing scalable solutions for different energy storage needs. EVBs R&D focuses on increasing range, charging speed, and thermal management.

When EV batteries come to the end of their first life, they might still live a second life, despite no longer meeting EV performance standards. The second life EVBs can be used in BESS if they pass assessment criteria such as: mechanical integrity, state of health, remaining useful life, safety, economic feasibility. An example from the industry is Jaguar Land Rover partnering with Wykes Engineering to repurpose second life Jaguar I-PACE EVBs for BESS (Portal, 2023).

2.2 TYPES OF BATTERY ENERGY STORAGE SYSTEMS

A range of technologies are used in BESS with differing characteristics including energy density, performance, lifespan, and weight. There are a wide range of factors to consider such as the specific application, cost of the system, energy density requirements, safety risks, and environmental impact. Advancements in battery technology continue to expand the range of options available for energy storage solutions.

Lithium-ion is the most popular and mature type of batteries used for stationery storage because of their high energy density, fast charging capability, small size, light weight, and long lifespan. There are two main lithium-ion chemistries specifically used for BESS (Edina, n.d.) (BSL-BATT, 2023):

- Nickel manganese cobalt (high energy density,fast charging),
- Lithium-iron phosphate (durable, efficient charging and discharging, long lifespan, robust safety profile, lower cost, fewer critical minerals).

Lead-Acid batteries (PbAB) have been in use for many years and are known for their reliability. They are often used in applications where cost is a significant consideration. A great advantage of PbABs is their recyclability as nearly 100% of lead can be recycled from the battery pack and reused with no performance capacity loss (AltEnergyMag, 2022). PbABs have certain disadvantages that make them less appealing option for BESS e.g. low energy density, limited life cycle, maintenance requirements. PbABs environmental impact is a major disadvantage as they contain lead which is a toxic heavy metal.

Sodium-ion batteries (NiB) are a promising technology for BESS on account of their low environmental impact, safety (they are less prone to thermal runaway), and the potential to be less costly than lithium-ion batteries (LiBs) (McKinsey, 2023). Although NiBs are not a perfect replacement for LiBs because of their lower cycle life and lower energy density they are predicted to take a share in the BESS market with LiBs and they have the potential to be a lithium-ion alternative in the future as their technology advances (McKinsey, 2023). NiBs do not require critical minerals (e.g. lithium, cobalt, nickel) which gives them supply chain advantage over LiBs and reduces the risk of material shortages as sodium is the sixth most abundant element on the earth.

Solid-state batteries (SSB) are increasing in popularity after Toyota's announcement of their technological breakthrough in improving durability of SSBs (Site, 2023). Instead of liquid electrolyte, SSBs contain solid-state electrolyte which improves thermal stability and durability, provides lower flammability, and battery design simplicity (Y. Wang, 2019). SSBs have demonstrated outstanding performance in small-scale applications however, additional effort is required to enable cost-competitive manufacturing at an industrial scale (Department for Business & Trade, 2023).

Lithium Sulphur batteries (LiSB) are an emerging technology that have the potential to replace LiBs in large scale BESS. The biggest advantage of LiSBs is their theoretical high energy density (three to five times higher than LiB). LiSBs are also cost-effective as they contain sulphur (fifth most abundant on Earth) which contributes to the lower cost. Their great disadvantages are high value of internal resistance, self-discharging, and rapid capacity failing. (W. Jan, 2023)

Redox Flow batteries (RFB) store energy in liquid electrolytes contained in external tanks unlike conventional batteries where energy is stored in the electrodes. The mostly widely deployed RFB is the Vanadium Redox Flow battery (VRFB) which have multiple advantages over other battery technologies, e.g. long lifespan (20+ years), improved safety (non-flammable and non-explosive) and an option to scale power and energy independently (Limited, n.d.) (StorEn, 2021). As vanadium does not degrade the electrolyte can be reused which is a valuable sustainable aspect. The downside of VRFBs is the system complexity and the higher upfront cost (due to expensive vanadium electrolyte) compared to LIBs.

Metal-air batteries (MAirB) are a viable candidate to replace LIBs in the next 10-15 years (Energy, n.d.). They use reactive metal (usually lithium and zinc) as the anode, and oxygen from the air as the active cathode material. MAirBs have a high energy density, better safety (as they do not contain flammable electrolytes) and have the potential to be high-performance lightweight batteries as the research progresses (Department for Business & Trade, 2023). The current challenges with MAirBs are related to the metal electrode degradation and cathode decomposition. As the degradation and decomposition gets worse over time, it can affect the battery lifespan, performance, and efficiency.

3. BESS Market and Supply Chain

The supply chain for BESS can be divided into three streams, defined as below:

- The downstream: which refers to BESS usage and applications.
- The midstream: which refers mainly to BESS components manufacturing.
- The upstream: which includes raw materials extraction and processing.

In the following, an overview of the current state of each stream will be given to highlight relative challenges and opportunities in the UK.

3.1.1 DOWNSTREAM: DEMAND AND MARKET SIZE

The demand for energy storage systems has significantly increased in the past few years. On a global scale, the market is expected to reach between $120 billion and $150 billion by 2030, as shown in Figure 2 (Jarbratt, et al., 2023). On the European scale, the UK has the highest demand for grid-scale storage (Figure 3), leaving behind its usual competitors, Germany, Italy and France.

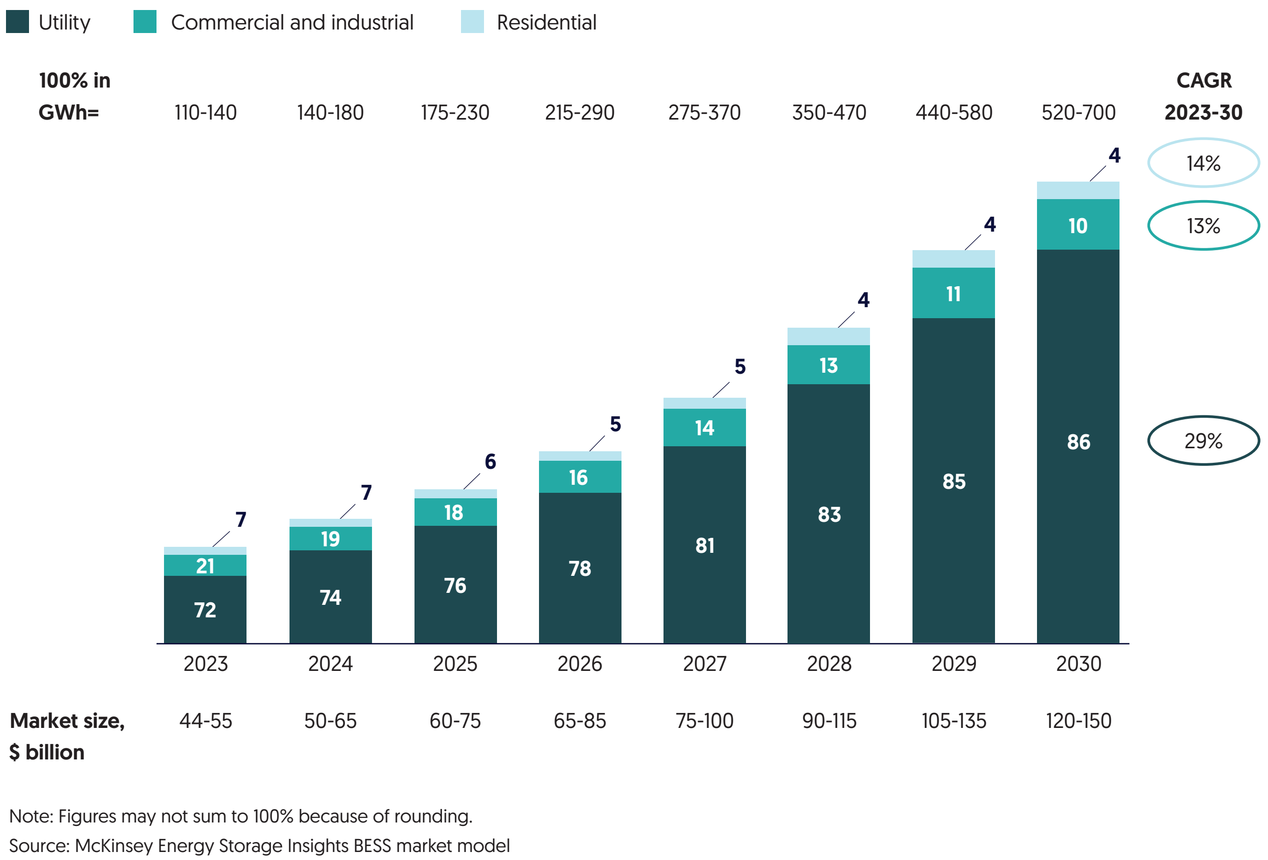

Figure 2: Annual added BESS capacity in %

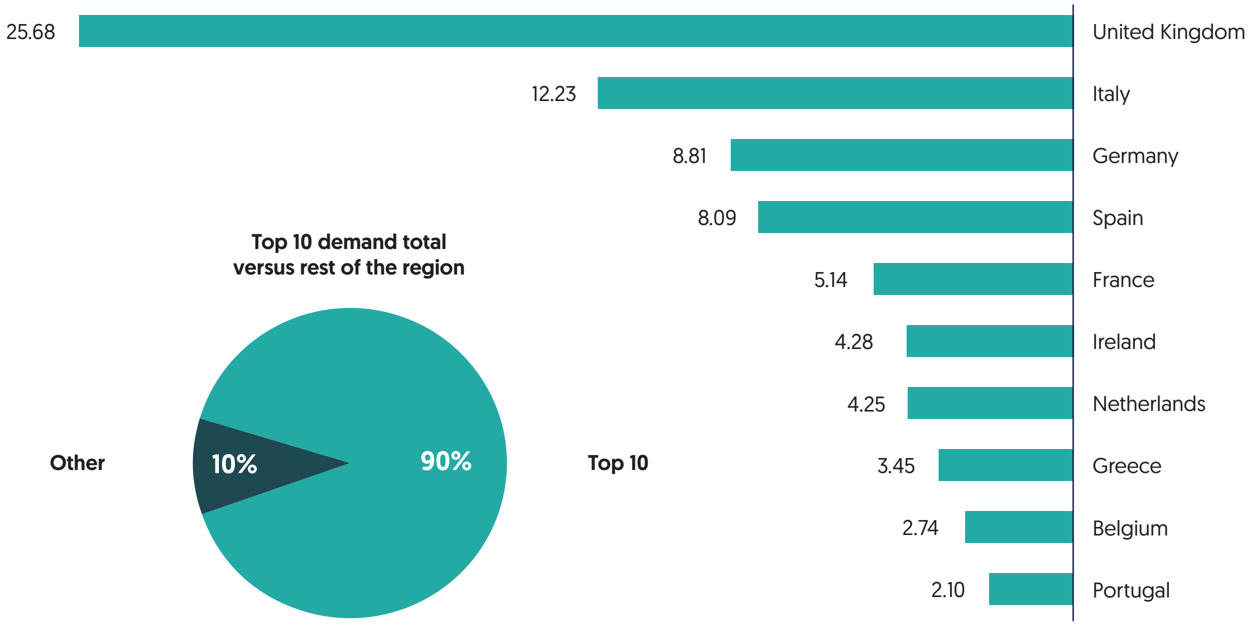

Figure 3: Top 10 European grid-scale energy storage markets; new capacity 2022-2031 (GWh) (Mackenzie, 2022)

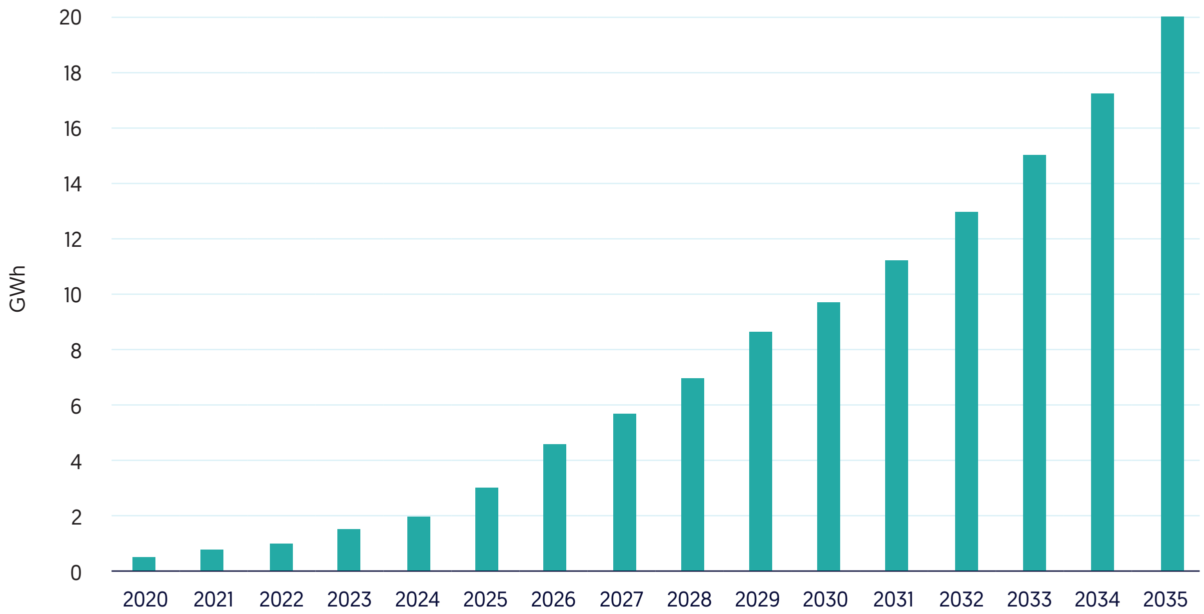

Figure 4: UK Annual demand forecast for stationary storage (GWh by Year) (Department for Business & Trade, 2023)

The UK is currently one of the most advanced markets for large scale battery storage [Mackenzie, 2022]. In 2022, it counted 4GW/2.6GWh of operational energy storage across 161 sites; and added a record 800MWh of new utility energy storage capacity, representing the highest annual deployment rate to date [EPS, 2023]. Also, the UK will be home to one of Europe's largest battery storage projects, led by InterGen, that will be able to provide 320MW / 640MWh, with the potential to expand to up to 450MW / 900MWh. This will use Lithium-ion battery technology. [InterGen, 2022]

The UK is also actively engaged in installing more renewable energy infrastructure with a goal of increasing solar energy installations to 70GW by 2035 [Government, March 2023] and 50GW of offshore wind by 2030 [Government, March 2023]. Consequently, reliable storage solutions such as BESS will be increasingly required to store these intermittent renewable sources. [Pratheeksha & Busby, 2023]. According to the UK Battery Strategy [Department for Business & Trade, 2023] , the demand for stationary storage is due to rise to nearly 10GWh by 2030, and double to 20GWh by 2035 as shown in Figure 4. This scale up is supported by the Government through regulation relaxations [EPS, 2023] and innovation competitions such as the recent longer duration energy storage demonstration, which made £69 million of capital funding available to start-ups and was open to novel battery technologies [Department for Business & Trade, 2023].

All the above shows the engagement of the UK in the global battery industry. However, the question of whether the supply chain can accommodate the future demand arises. In the following subsections, the midstream and the downstream are analysed to provide some answers and identify opportunities and challenges for the BESS supply chain.

3.1.2 MIDSTREAM: MARKET SIZE AND SUPPLY CHAIN

To the best of our knowledge, little material relative to BESS supply chain midstream is available in the literature.

According to [Jarbratt, et al., 2023], any component, ranging from battery cells to semiconductors in inverters and control systems, relies on vulnerable supply chains susceptible to raw material shortage or regulation change. The supply of transformers is also becoming problematic for the global energy storage sector, as the industry is facing supply shortages leading to rapid cost increases, and significant lead times of more than a year, which has a direct impact on BESS system integrators as transformers are integral for grid connection [Mackenzie, 2023].

Additionally, from the unscreened information in the Innovate UK Cross-Sector Battery Systems Landscape Map [IUK, 2023], only 29 manufacturers, 56 technology developers and 49 service providers currently have a focus on stationary storage. These figures are doubled in the domestic automotive industry.

As the industry is in full expansion, many barriers to scale-up of domestic component manufacturing capacity have been identified by stakeholders. The UK Battery Strategy [Department for Business & Trade, 2023] identifies the following, as the main ones:

- **High cost of manufacturing:** As shown in Figure 5, the UK ranks thirteenth on the Cost of Doing Business (CoDB) index [KPMG, 2020]. This however results in considering primary costs only such as wages, utilities, real estate costs, and taxes. However, this statement is arguable as the UK ranks sixth if secondary costs, defined as costs related to the business environments and the ease of doing business, are considered [KPMG, 2020].

- **Lack of market clarity for BESS developers:** Stakeholders believe that certain regulatory barriers need to be removed to facilitate the process of planning and permitting. This statement is nevertheless challengeable as some BESS have been installed nevertheless in the UK.
- **Other barriers** can be the grids own regulation, the ability to connect into the grid system and the availability of qualified professionals.

Countries	Ranking	**CoBD Primary Score Index by Country** (1=best, 5=worst)
Malaysia	1	2.40
China	1	2.40
Mexico	1	2.40
Vietnam	1	2.40
India	5	2.60
Canada	6	2.80
Taiwan	6	2.80
Italy	6	2.80
South Korea	9	3.00
Ireland	9	3.00
France	9	3.00
Germany	12	3.20
United Kingdom	13	3.20
United States	14	3.40
Switzerland	14	3.40
Brazil	16	3.60
Japan	17	4.00

Figure 5: Country ranking - Primary CoDB index (KPMG, 2020)

3.1.3 UPSTREAM: MARKET SIZE AND SUPPLY CHAIN

As previously shown in section 2.2, BESS can have different chemistries. BESSs with Li-ion batteries are currently the most widespread. However, as shown in Figure 6, certain materials required in Li-ion batteries, such as lithium and cobalt are at risk regarding their supply chain and are classified as critical minerals (Department for Trade, 2023).

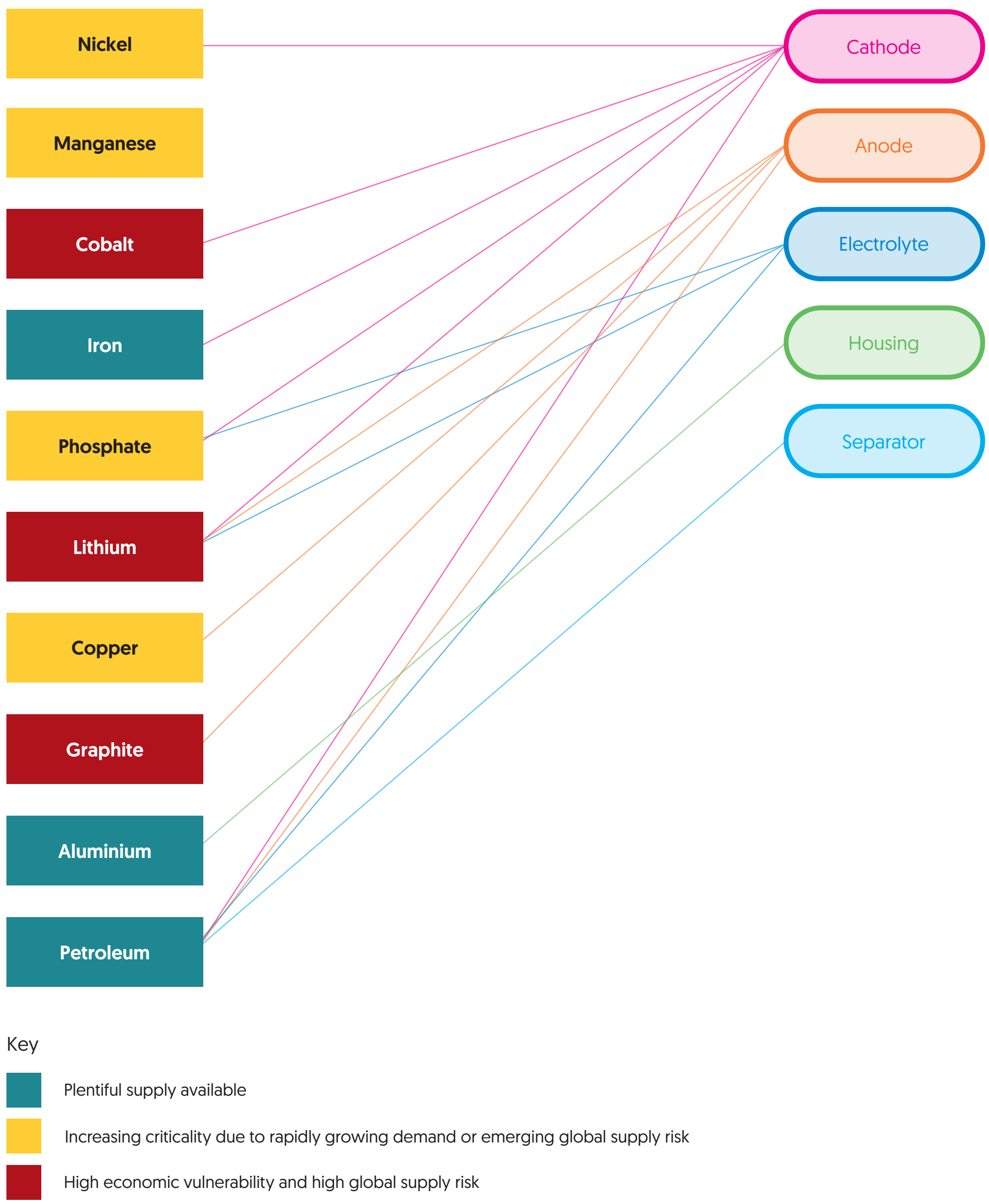

Figure 6: Key lithium battery raw materials and supply risk, adapted from (Maisch, et al., 2023)

Currently, lithium is one of the key materials for clean energy applications, and the demand is continuously growing as shown in Figure 7.

The main driver for demand growth remains EVs. However, the demand for energy storage is significant and is expected to reach 84.97kt in 2045 (Figure 7).

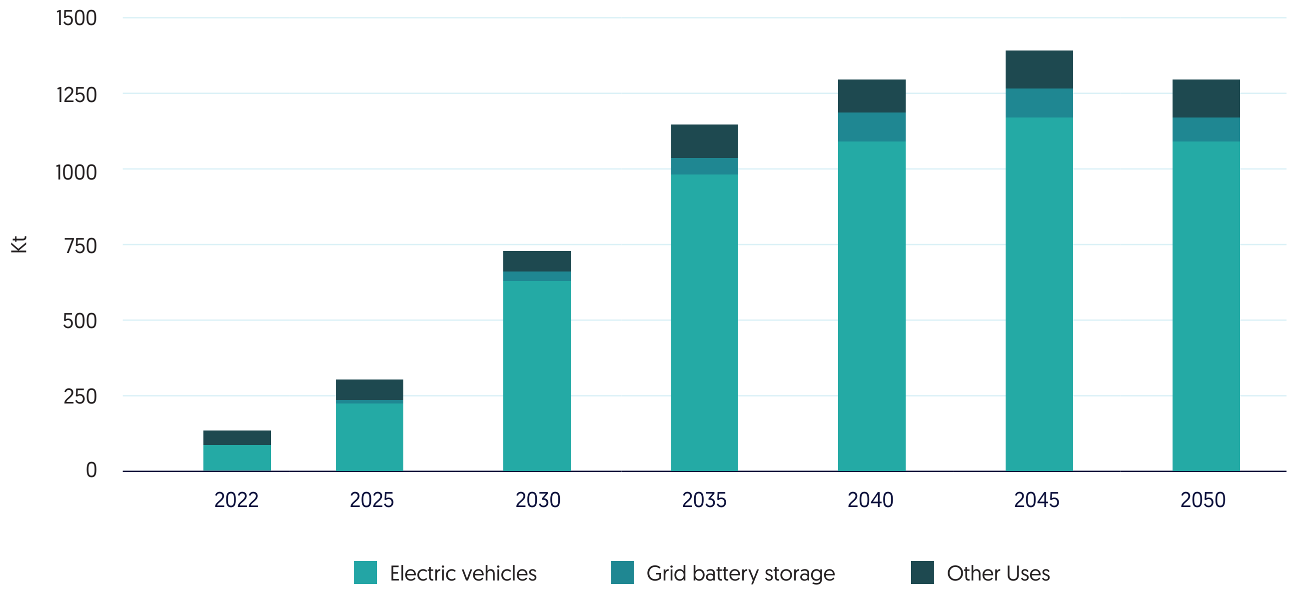

Figure 7: Total demand for lithium in the Net Zero Emissions by 2050 Scenario (IEA, 2023)

In the case of cobalt, a continuous demand increase is also anticipated, particularly for EV. As shown in Figure 8, the demand for grid battery storage ought to decrease from 2045. This can be explained partly by the rise of new grid storage technologies developed with alternative materials.

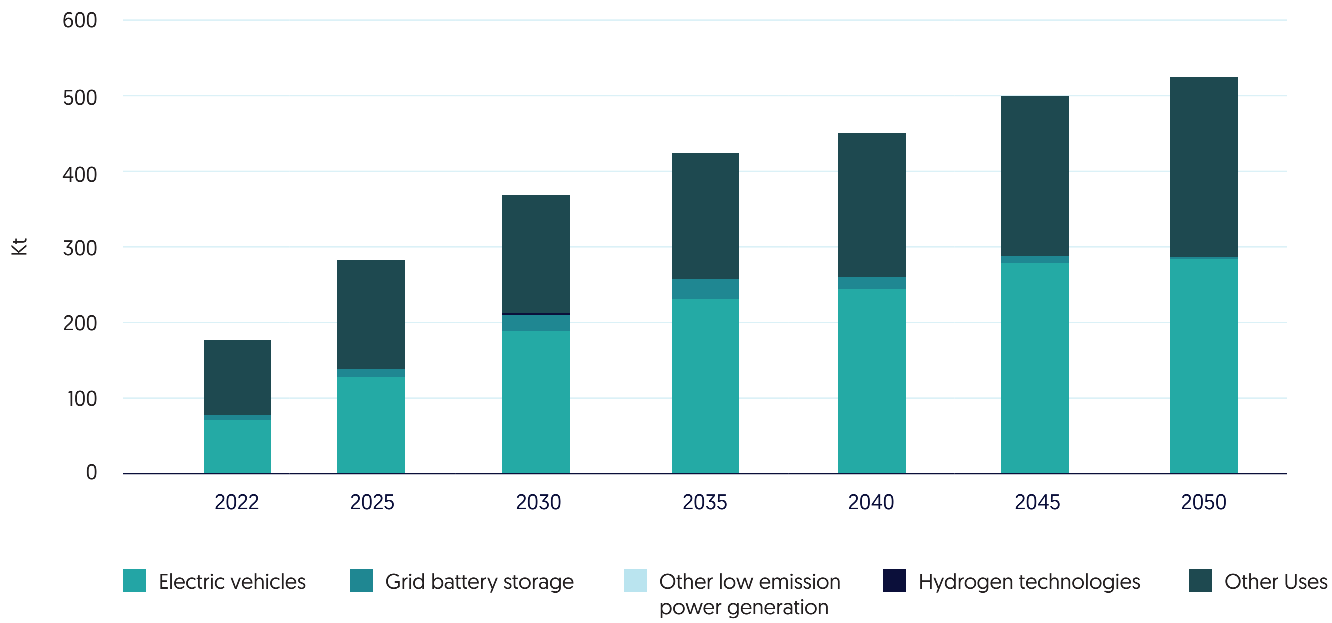

Figure 8: Total demand for cobalt in the Net Zero Emissions by 2050 Scenario (IEA, 2023)

Copper is one of the most important metals in the world as it is used in a wide range of applications. In Europe, copper use is broken down as follows: Electricity and energy: 58%, building and construction: 26%, industrial plant and machinery, furniture, coinage: 10%, and transport: 5% (Sverdrup, 2014). In the UK, it is not classified as a critical mineral and does not appear on the Critical Minerals Expert Committee's watchlist. However, for the European Commission, copper and nickel are included on the Critical Raw Material list as strategic raw materials in line with the Critical Raw Materials Act (Comission, 2023). Copper is a resource that requires attention as the demand keeps rising and a peak is expected in 2040 (Figure 9). Although it is available in abundance, several sources raised concerns around global supply. Predictive models developed by (Sverdrup, 2014) expect the global copper supply to be significantly limited in the foreseeable future.

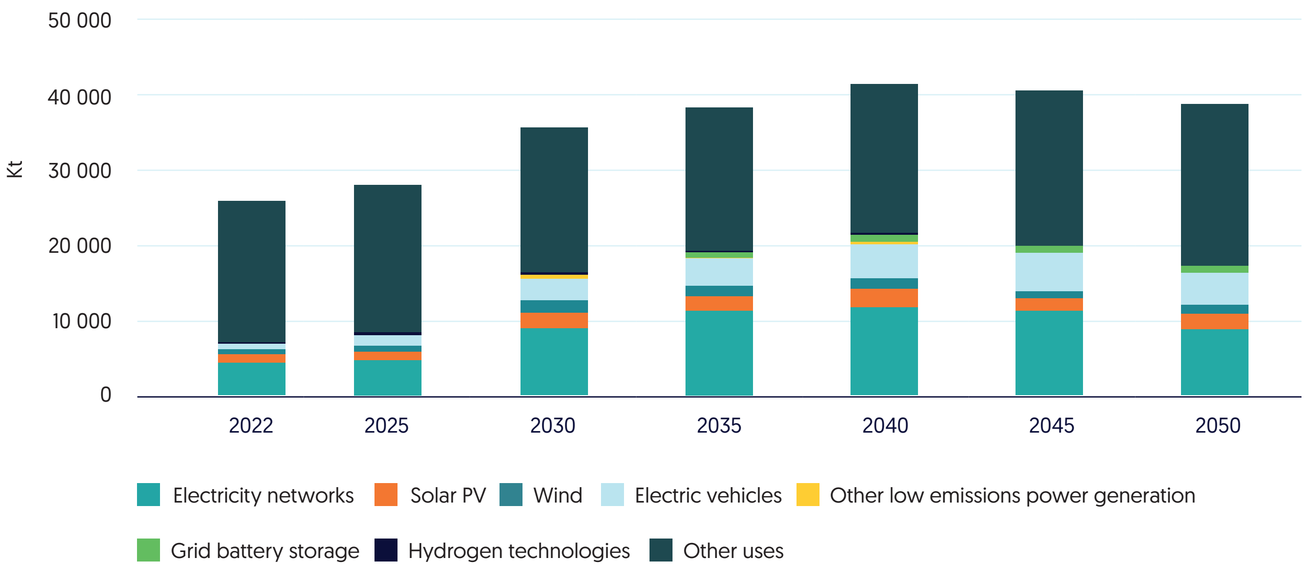

Figure 9: Total demand for copper in the Net Zero Emissions by 2050 Scenario (IEA, 2023)

From a UK supply chain point of view, lithium, cobalt, and copper are all sourced from foreign countries. In 2022, Australia held 47% of the Lithium mining share, and Chile 24% of the copper mining share (see Figure 10). The Democratic Republic of Congo still holds the majority of the cobalt mining share with 74% (Figure 10). Up to 30% of Congolese cobalt is produced by artisanal and small-scale mining, and severe human rights issues have been reported in mining operations (Baumann-Pauly, 2020). These environmental, sustainability and geo-political issues are the main drivers for the improvement of other battery technologies which do not require the use of materials like cobalt.

Also, China, as the current world's largest metal refining hub, relies heavily on imports from other countries such as the Democratic Republic of the Congo for cobalt (IEA, 2023).

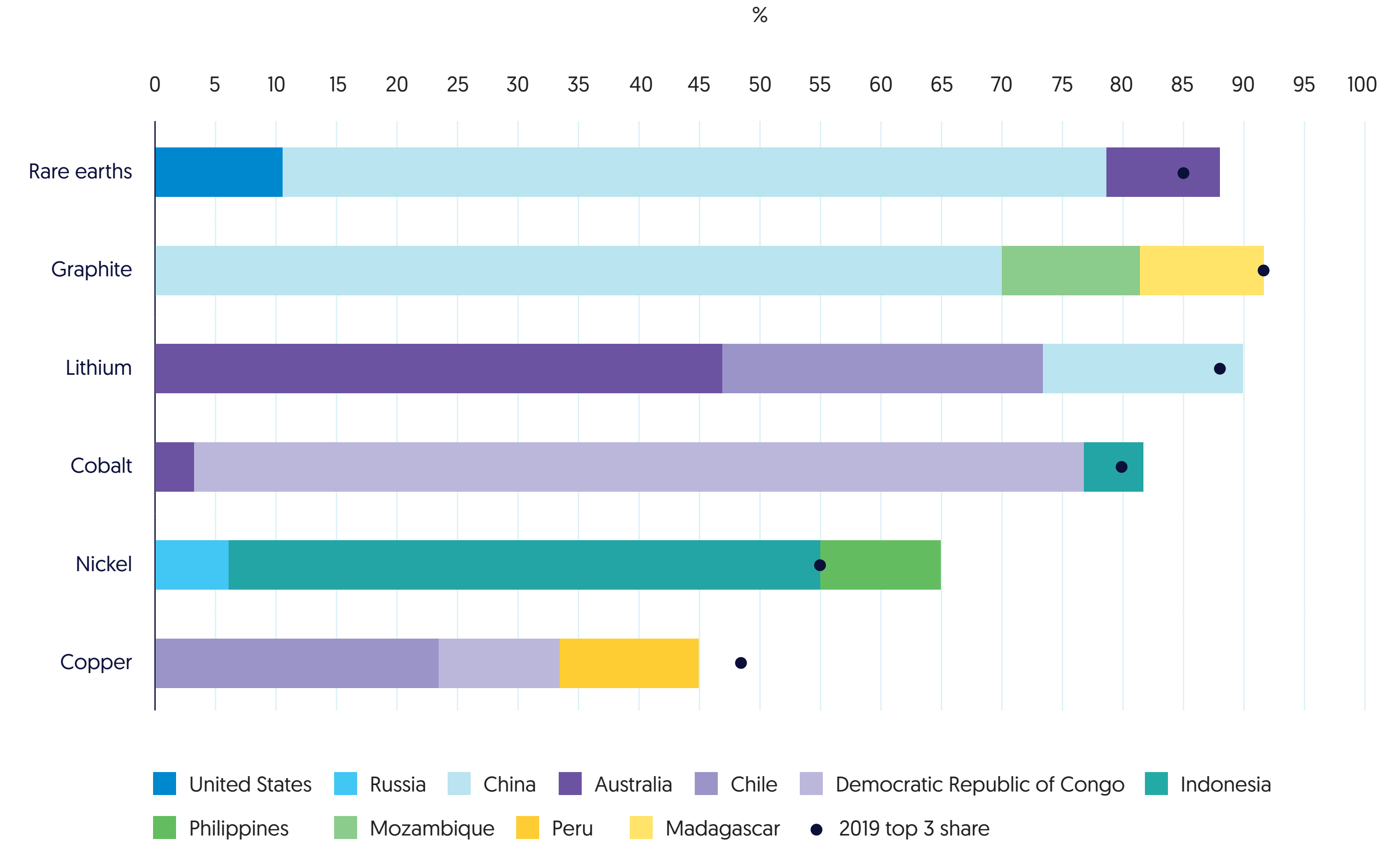

Figure 10: Share of top three producing countries in mining of selected minerals (IEA, 2022)

Nickel is also in high demand as batteries with high Nickel content are significantly used in the automotive and energy storage industries. Nickel has now been included in the UK critical mineral watchlist (Department for Trade, 2023) as a result of a significant demand increases. From 2017 to 2022, the demand for nickel showed a 40% jump, and the market size increased by 3.1 times (for Class1 and Class 2 Nickel) (IEA, 2023). It is mainly produced in Indonesia, who holds 90% of refining facilities (IEA, 2023). Unlike cobalt and lithium, only 5% of the demand for nickel comes from the battery sector. The main driver remains the stainless-steel sector, with a demand of 70% (Global, 2021). The 5% required by the battery sector is for premium grade nickel, which is necessary to produce nickel sulphate, a key precursor to high Nickel battery chemistries (Global, 2021). In (Research, 2021) the market size for nickel sulphate is estimated at 14.7% CAGR for the 2021-2031 period. Therefore, while the nickel supply seems abundant, it is actually not in the case of nickel sulphate; and meeting the continuously increasing demand for batteries appears to be challenging. New methods of production by extraction and transformation of other types of nickel show promising results, leading to reductions in the price of nickel sulphate; and yet there is a raised concern of the carbon footprint and sustainability of supply. Further actions are necessary to mitigate these future challenges (Global, 2021), (Research, 2021).

All the findings reported above demonstrate the significant dependency on foreign countries to supply key materials whose scope of applications goes beyond BESS. In this regard, one strategy for European countries to become more independent to the Asian market (Anon., 2022) is considering alternatives to LiBs. This is the case for NiBs, whose raw materials are less susceptible to resource and supply risks (Vaalma, et al., 2018). As mention in section 2.2, sodium is available abundantly. However, the current state of its supply chain indicates a lack of robustness and maturity [Gokhale, 2023]. One of the key materials used in NiBs is hard carbon, and ensuring its purity and quality to avoid issues with expansion and dendrite formation during cell reaction appears to be challenging, particularly in regions with varying temperatures [Gokhale, 2023]. This issue is currently being addressed by certain companies in Europe, Japan and India, who are working on producing high quality hard carbon. With a TRL estimated at 5-6, it is nevertheless still early days for the technology. Today, a limited number of manufacturers are transforming and providing Sodium to the battery industry [Anon., 2022], and giga factories for Sodium-ion cells are expected to start operating from 2024 [Gokhale, 2023].

In the case of the UK, growing a domestic circular supply chain for LiBs would be a viable alternative to not rely on importation. Using materials and components sourced or repurposed domestically will increase material security, minimise exposure to price volatility, reduce environmental impact and ensure that critical raw materials remain in the UK after the initial import. Building supply chain resilience is one of the Government intentions expressed UK Battery Strategy [Department for Business & Trade, 2023].

Moreover, the UK is supporting the building of its domestic supply of critical minerals by grant funded R&D activities. Since 2019, British Lithium has received £5.5 million to develop their proprietary process for sustainable production of lithium from Cornish granite [Department for Business & Trade, 2023]. The joint venture between British Lithium and Imerys aims to produce 20,000 tonnes of battery grade lithium carbonate per year for at least 30 years, equivalent to equip 500,000 EV batteries a year [Imerys, 2023]. In August 2023, UKIB announced a £24 million equity investment in Cornish Lithium for its Trelavour hard-rock lithium extraction project [Department for Business & Trade, 2023] .

Several international agreements are also being signed to strengthen the resilience of global critical mineral supply chains. The Government has signed bilateral agreements with Australia, Canada, Japan, Kazakhstan, Saudi Arabia, South Africa, and Zambia, to help diversify supply chains and increase the UK's security of supply [Table 1]. Each agreement leverages the UK's strengths in mining services, finance, and R&D, and seeks to build high environmental, social, and governance standards [Parliament, 2023].

Country	Type of Agreement	Objectives
UK-Canada	Landmark agreement	Focuses on skill-sharing, R&D; facilitating investment and business ties; and promoting higher economic, social and governance standards.
UK-Australia 'statement of intent'	Statement of intent	Similar to UK-Canada agreement; and includes UK investment in Australian critical minerals projects
UK-South Africa	Partnership	Promote investment in exploration and beneficiation, with an emphasis on supporting clean energy jobs throughout the value chain.
UK-Saudi Arabia	Partnership	Intended to encourage new mining, bringing Saudi investment together with UK expertise in mining and mining finance and to make it easier for UK businesses to work within the Saudi mining sector
UK-Kazakhstan	Deal	Collaboration opportunities with several British businesses already present in the country

Table 1: Examples of bilateral agreement on critical minerals [adapted from [Parliament, 2023]

4. Growing the UK Supply Chain - Challenges

The analysis provided in Section 3 reveals the uncertainty of the UK supply chain regarding BESS. Although the UK has the highest demand for BESS in the European market and is implementing a strategy to secure its supply chain, an entire domestic supply chain is unlikely to be feasible (Department for Business & Trade, 2023). Several challenges remain to be overcome to guarantee a stable and resilient supply chain:

- **Potential supply shortages of critical minerals** due to growing demand for BESS batteries and the supply competition with EV batteries, as the automotive sector remains the priority for the Government. To lower the risk of supply shortage, the Government have taken several actions:

- It provided support through grant funding of the development of alternatives technologies, such as NiBs, that do not require (or require a lower amount of) critical minerals.
- As mentioned in Section 3.1.3, several international collaborative agreements with foreign countries have also been established to secure access to critical minerals. However, most of these agreements are only memoranda of understanding and the mutual benefits of respective countries require further clarification.
- Domestic extraction of lithium is also encouraged through funding. However, this mining process is time consuming and might not meet timing targets. Also, the lithium concentration available in the UK appears to be relatively low and costly, leading to an uncertain contribution to domestic supply.

- **Supply chain traceability and ethical mineral extraction:** Battery systems and components are currently predominantly sourced from abroad, thus there is no guarantee that these comply with traceable, reputable, sustainable and ethical supply chain legislation and enforcement. The Government needs to demand western standards for imported goods and c lear leadership is needed to help direct consumers, industry and government to inform, regulate, incentivise/de-incentivise and develop financial intervention where deemed necessary to meet long term objectives

- **Unclear understanding of BESS requirements:** There is a need to conduct a landscape survey; and a collaboration between all supply chain stakeholders, industrial and domestic customers and the national grid is required to better understand BESSs installation, connection and safety requirements and identify best alternative technologies that are manufacturable domestically.

- **Competition with other markets and ease of replication:** The UK should focus on differentiating its offering through development of cutting edge BMS technology, sourcing and manufacturing battery components domestically and manufacturing, traceability (i.e., with a battery passport) and regulation (i.e., UKCA) to gain a competitive edge at a global scale.

- **Lack of appropriate business models:** Innovative business models and/or targeted subsidies are needed to make UK sourced BESS competitive with foreign made systems. The UK can benefit from a consolidation of its supply chain needs by a central nonprofit body and clearer routes to supply into the domestic markets need to be provided.

Among those challenges, substantial opportunities can be distinguished:

- The government engagement to support the sector and the high demand for BESS and EVs can be seen as an opportunity for the UK to build a domestic supply chain.

- As the EV market is exponentially growing, large amounts of EV batteries are expected to reach their end of life for transport applications and will be available for second-use or recycling as some of these batteries can maintain up to 60% of their capacity after their first cycle (Power, 2022). Indeed, an estimated value of 1.2 million metric tons of EV batteries could be available for recycling in 2030 (Power, 2022) . Repurposing theses batteries for BESS is a sustainable option, as it can reduce the need for new lithium extraction and minimise the environmental impact of lithium production (Trade, 2022). In the UK, only a few manufacturers are producing BESS from recycled EV batteries. Nevertheless, this remains an uncommon practice as some issues need to be addressed:
    - The lack of standardisation in battery design and manufacturing makes it difficult to repurpose batteries because each battery may have different specifications and components (Trade, 2022).
    - The process of reusing is complex & labour extensive.
    - Unclear routes to revalidate the safety of remanufactured packs.
    - Additional government support is required to expand this activity.

- Regarding the situation there is an opportunity for Catapults to support the industry by bringing together industrialists, academics and the supply chain to better understand system requirements and develop technologies and business models that can enable reuse of second life EVBs for BESS.

5. Conclusion

With the race to net zero, the UK has the highest demand for energy grid storage in Europe. Along with the significant growing demand for EVs , there are risks in the availability of materials and components required to supply the required volume of batteries.

Building a resilient supply chain for BESS is key to facilitating the installation and use of BESS nationwide. The approach published in the UK battery strategy will contribute to achieve this goal. However, with the priority being given to EVs, demonstrating the viability of the BESS business model is key in the current climate of competition with EVs.

As shown in this white paper, additional actions can also be undertaken to improve the supply chain for BESS. The first one is facilitating the research and commercialisation of alternatives batteries technologies, such as sodium ion, that do not require critical minerals. End-of-life EV batteries can also be repurposed for BESS applications. Although several barriers need to be addressed to complete this, the quantity of end-of-life EV batteries is foreseen to be considerable in the following years, and securing funding to develop battery repurposing schemes is a commendable strategy to tackle related environmental issues.

Another challenge relates to the lack of communication between academia and industry in BESS, stifling innovation. Bringing these key players together will enable better adoption of new technologies and improved knowledge transfer to industry, helping to make UK made BESS competitive with foreign made systems. There is an opportunity for the High Value Manufacturing Catapult to play a crucial role convening stakeholders from industry, academia and government to have a big impact on the emerging UK BESS market.

6. References

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