Department for Business & Trade

UK Battery Strategy

Call for evidence on the scope and priorities for the UK Battery Strategy

Closing date: 28 September 2023

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Headings

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1. Ministerial Foreword

As the world swaps fossil fuel power for emissions-free electrification, batteries are becoming a vital storage tool to facilitate the energy transition. Global demand for lithium-Ion batteries to power electric vehicles and energy storage has seen exponential growth, increasing from just 0.5 gigawatt-hours in 2010 to around 526 gigawatt hours a decade later. We know where the UK has a comparative advantage and are committed to keeping up R&D and investment to supercharge our connected ecosystem of knowledge, skills, and experience.

UK innovation has been at the heart of the battery transition and is leading the way in next generation battery technologies. The lithium-ion battery was invented in Oxford and, just last year, Rolls Royce's battery-powered plane, Spirit of Aviation, was crowned the world's fastest ever electric vehicle.

That success is underpinned by the Government's world-leading support for battery development. For example, our commitment to our Faraday Institution, Faraday Battery Challenge and UK Battery Industrialisation Centre has provided some £541m since 2017 alone. We're seeing more and more investment along the UK battery value chain:

- Critical minerals such as lithium, nickel, cobalt, and graphite are being sourced or processed in the UK, from Cornwall to Lincolnshire. There are many further actions underway by government and industry, as recognised in our Critical Minerals Strategy, which we refreshed just four months ago.

- The new Envision AESC gigafactory now being built in Sunderland with an initial capacity of 12GWh, bringing over 1,000 new jobs to the region, and building on almost a dozen years of UK battery production in the region.

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- WAE Technologies announced a new battery manufacturing facility in Banbury, Oxfordshire, to support decarbonisation of rail and mineral industries essential for our transition to Net Zero.

- Tata has also announced the construction of a new gigafactory that will produce 40GWh of batteries per year and will create 4,000 new jobs, as part of the electrification of the Jaguar-Land Rover brand.

- Investments in cutting edge battery recycling facilities such as those in construction in London and the West Midlands.

I see this call for evidence as the natural evolution of our actions thus far. I want to harness ideas and ambition from across UK industry to shape not just this generation of skilled workers, infrastructure, and technologies, but also to lay the foundations for the UK's leadership and commitment to delivering a safe, thriving, and effective battery industry for the future. This is another step towards stronger and greener industries.

We are determined to hear from the widest voices, and this call for evidence is your opportunity to contribute. Whether you have data, ideas, challenges, opportunities, or priorities to share with us – I look forward to hearing from you.

Nusrat Ghani MP
Minister of State at the Department for Business and Trade and the Cabinet Office

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2. Call for Evidence Description

The government expects battery design, development, manufacturing, and recycling to play an essential role in meeting our net zero targets, as well as supporting economic growth, productivity, and jobs.

We seek views and evidence to inform the development of a UK Battery Strategy, to be published in the coming months. Stakeholders can have a say on the opportunities, challenges, and priorities for the sector, by submitting a call for evidence response before the end of the six-week call for evidence period.

This call for evidence will be of interest to:

- The battery industry and related sectors, including those involved in the battery supply chain – from design through to manufacture, materials, and reuse/repurpose/recycling. It also includes those with energy storage demands in the mobility (personal and commercial, on- and off-highway) and energy transmission and storage sectors.

- Designers, developers and innovators of batteries or their component parts, in the commercial, industrial, and academic sectors.

- Investors and developers involved in potential battery projects, from gigafactory and other manufacturing development to those involved in supply chain investments and recycling infrastructure.

- Non-governmental organisations (NGOs) and other organisations with an interest in energy storage.

Responses are being collected via a separate website, which is available here:

https://beis.fra1.qualtrics.com/jfe/form/SV_0Hze5yTyFmG5koK

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3. General Information

Why we are consulting

We intend to publish a full UK Battery Strategy in the coming months, building on the significant activity already underway within UK industry, academia, and across government. We are issuing this call for evidence to seek stakeholder views on our proposed scope of work, and to ensure we have access to the widest possible evidence and perspectives from industry, academia, and civil society.

What we are seeking

We have asked specific call for evidence questions in relation to the priorities and outline scope we have set out in sections Four and Five.

We have also set out some further evidence questions, where stakeholders can share relevant evidence that is not already available to government by drawing on recent reports and submissions.

We are not asking stakeholders to provide submissions or evidence that has already been provided in recently published or active UK inquiries and reports. We will be drawing on existing published literature from government and from key partners including the Faraday Institution, Faraday Battery Challenge, UKRI, the Advanced Propulsion Centre and the Critical Minerals Intelligence Centre. We will also draw on recent inquiries and calls for evidence (including public submissions to those inquiries, and their reports), including:

- Select Committee Inquiry on Batteries for EV Manufacturing (2023) (Batteries for electric vehicle manufacturing - Committees - UK Parliament)
- Lords Science & Technology Committee Report on The Role of Batteries and Fuel Cells in Achieving Net Zero (2021) (Role of batteries and fuel cells in achieving Net Zero - Committees - UK Parliament)
- Recent engagement undertaken by Defra as part of its commitment to consult on Waste Batteries & Accumulator Regulations by end of 2023.
- Government's Consultation on Facilitating the deployment of large-scale and long-duration electricity storage (2021) (Facilitating the deployment of large-scale and long-duration electricity storage: consultation)

Call for evidence details

Issued: 17 August 2023

Respond by: 28 September 2023

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How to respond

Responses should be provided via the Qualtrics platform:

https://beis.fra1.qualtrics.com/jfe/form/SV_0Hze5yTyFmG5koK

Confidentiality and data protection

All responses will be treated as confidential and will be stored in the Department for Business and Trade (DBT) IT infrastructure. The data will only be accessible by a limited number of government officials working on the development of the UK Battery Strategy.

Any personal data included in responses will be collected in accordance with Article 13 of the UK General Data Protection Regulation (UK GDPR). The data controller for your personal data is the DBT.

You can contact the DBT Data Protection Officer at: DBT Data Protection Officer Department for Business and Trade Old Admiralty Building, Admiralty Place, Whitehall, London, SW1A 2DY. You can also email: data.protection@trade.gov.uk.

Information provided in response to this call for evidence, including personal information, may be subject to publication or release to other parties or to disclosure in accordance with the access to information regimes.

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4. Introduction & Priorities

Batteries are a ubiquitous and often unremarked feature of modern life. Portable batteries are used in everything from clocks, mobile phones, remote controls, children's toys, and an ever-increasing range of household tools. But our use of batteries is changing at a rapid pace and, increasingly, our national requirements for batteries will be dominated by battery applications in personal mobility – such as cars, e-scooters, e-bikes – commercial transportation - hybrid and fully electric buses, vans, and lorries – and stationary storage – from domestic battery systems through to grid-scale battery energy storage systems (BESS) to balance the electricity grid.

The government is taking action to tackle climate change and decarbonise the UK's fleet of vehicles in a way that will create new, high-value jobs, stimulate investment and drive innovation. British industry can continue to lead this global transition as the UK realises the commitment to end the sale of all new petrol and diesel cars and vans by 2030, and for all new cars and vans to be zero emission at the tailpipe by 2035. Recent investments include public-private partnerships to facilitate over £4bn of investment by Tata Group to build one of Europe's largest gigafactories, £1 billion for Nissan and Envision to create an electric vehicle (EV) manufacturing hub in Sunderland, £100 million for Stellantis for its site in Ellesmere Port, and £380 million for Ford to make Halewood its first EV components site in Europe.

The UK has committed to decarbonising the electricity system by 2035, building a secure, home-grown energy sector that reduces reliance on fossil fuels and exposure to volatile global wholesale energy prices. Batteries will enable us to use energy more flexibly and decarbonise our energy system in a cost-effective manner by, for example, helping to balance the system at a lower cost, maximising the usable output from intermittent low carbon generation (e.g., solar and wind), and deferring or avoiding the need for costly network upgrades and new generation capacity. Energy storage will have a key role to play at the network level, as well as in supporting industrial, commercial, and domestic applications.

To supply these and other applications, battery technologies will continue to evolve at pace, both domestically and globally. We are determined to put the UK at the forefront of this transition, leading the development and deployment of the range of battery technologies that will be required, and ensuring that this leads to a safe and sustainable industry.

As well as underpinning our energy transition and key manufacturing industries, batteries also underpin our national security. The UK's ability to deploy cutting-edge military capability – whether land, air, sea, space or cyberspace – is dependent on batteries, which are found in military systems ranging from the simplest communications systems to fighter jets and nuclear submarines. The Ministry of Defence (MoD) works with key suppliers to mitigate supply chain risks. Current battery production features complex value chains, spanning multiple continents and currently heavily focused in East Asia. Developments will continue to be driven internationally, and our UK battery strategy will set out how the UK approach can reflect global markets and opportunities.

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Purpose

The Government plans to publish a clear battery strategy enabling a joined-up government-industry approach to delivering a battery ecosystem that unleashes economic prosperity, delivers on our net zero ambitions and ensures our access to technologies and applications that are vital to our security.

This call for evidence aims to seek views on the scope and content of a UK battery strategy.

Strategic Priorities

Our strategic priorities for batteries are for the UK to be leading the charge, based on actions taken across each pillar of a **DESIGN-BUILD-SUSTAIN** approach:

1. **DESIGN:** Design and develop the batteries of the future that are smaller, lighter, and offer better capacity and value, building on UK world-leading research and innovation.

2. **BUILD:** Working in partnership with our domestic industry and international partners to secure a resilient UK battery manufacturing supply chain that supports our strong domestic growth and thriving export markets.

3. **SUSTAIN:** Enable the development of a thriving and sustainable sector, supported by proportionate regulations that drive investment across the supply chain, from raw materials through to end of life and recycling.

Some illustrative (but non-exhaustive) examples of existing UK activity under each of these pillars are provided in

Table 1**.**

Table 1: Selected examples of existing UK activity in relation to batteries.

	DESIGN	BUILD	SUSTAIN
Government	• Faraday Institution • Faraday Battery Challenge • UK Battery Industrialisation Centre • Advanced Propulsion Centre (APC) • Aerospace Technology Institute (ATI) • UK Research and Innovation (UKRI) funding	• Automotive Transformation Fund (ATF) provides support across the supply chain, including feasibility and capital support (e.g., lithium in Cornwall) • APC eases supply chain bottlenecks and gaps directly and by securing investment into materials processing (e.g., graphite in Lincolnshire)	• National Institute for Circular Economy Research (NICER) programmes • Waste Battery & Accumulator Regulations • Battery safety is an active consideration for Government, including the Maritime & Coastguard Agency (MCA), National Fire

	(including for Energy Storage research) • Net Zero Innovation Portfolio: Longer Duration Energy Storage competition	• Potential investments through UK Export Finance (UKEF), UK Infrastructure Bank (UKIB), British Business Bank, and others	Chiefs' Council, Health & Safety Executive (HSE) and others
Industry	• Innovative battery start-ups and spin-offs (some case studies in this document)	• Existing and under-construction Gigafactories (Envision, Tata) • Leading specialist battery manufacturing (e.g., Hyberbat, WAE)	• Battery recycling facilities (e.g., Veolia in the West Midlands, LTS in London) • Recycling technologies (e.g., Altilium in Southwest England)
Academia	• Faraday Institution and wider research projects across multiple expert academic collaborations • Advanced characterisation at UK National Facilities (e.g., Diamond Light Source, ISIS Neutron and Muon Source)	• UK Battery Industrialisation Centre • Warwick Manufacturing Group Energy Innovation Centre • University College London Advanced Propulsion Lab • High Value Manufacturing Catapult Centres	• Recycling and circular economy institutes – for example, Universities of Birmingham, Edinburgh, and Leicester on the Faraday Institution's ReLiB (Recycling and Reuse of Li-ion Batteries) project

CALL FOR EVIDENCE QUESTIONS: STRATEGIC PRIORITIES

4.1 Do you have comments on the strategic priorities for the UK Battery Strategy outlined above?

4.2 Are there any additional strategic priorities you think the UK Battery Strategy needs to include?

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5. Scope of the UK Battery Strategy

International and national landscape

As part of an updated UK Battery Strategy, we propose to:

- Set out UK policies and Government activity relevant to batteries, including in relation to their design, manufacturing, transportation, use, re-use, and end-of-life, that reflect both the international and national context.

International Context

Battery development, construction and recycling are all international endeavours, and battery supply chains from raw materials through to end of life will remain global. We recognise that while the UK is active in this space, so are many of our partners and competitors. Our strategy will aim to address:

- The anticipated **supply shortfalls** in battery minerals – recognising the leading work that the UK is doing in this area as set out in our Critical Minerals Strategy, published in 2022 and refreshed in March 2023.

- The high level of **international competition** in sectors such as automotive manufacturing, where the Government will take decisive action in the following months. We are committed to ensuring the UK remains one of the best locations in the world for automotive manufacturing, and to seizing opportunities to develop capabilities in growth markets such as the manufacture of energy storage batteries.

- How we will continue to **engage with allies and partners** – where our international leadership and engagement on batteries is illustrated by recent developments including the Atlantic Declaration, agreed between the Prime Minister and US President Biden in June 2023, which sets out a joint commitment to:

  "…deepening cooperation to develop and strengthen clean energy supply chains, including building diverse, resilient, and secure critical mineral and battery supply chains that reduce unwanted strategic dependencies to meet our defence, economic, energy security, and climate goals." (See **Error! Reference source not found.**).

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Table 2: Spotlight on… International leadership

INTERNATIONAL LEADERSHIP
International partnerships – such as those recently advanced with the US and others - should enable us to influence battery value chains on the global stage
Commitments advanced in the US-UK Atlantic Declaration: • "We are committed to deepening cooperation to develop and strengthen clean energy supply chains, including building diverse, resilient, and secure critical mineral and battery supply chains that reduce unwanted strategic dependencies to meet our defence, economic, energy security, and climate goals." • With congressional consultation, we intend to immediately begin negotiations on a targeted critical minerals agreement covering the five relevant critical minerals most important for electric vehicles – cobalt, graphite, lithium, manganese, and nickel – that are extracted or processed in the United Kingdom count toward sourcing requirements for clean vehicles eligible for the Section 30D clean vehicle tax credit of the Inflation Reduction Act. • We intend to conduct public-private consultation across key clean energy supply chains, including offshore wind and electric vehicle batteries, and conduct rapid stress-test exercises across key clean energy supply chains, which could form a model for future work on supply chain resilience. This builds on previous UK-US work on batteries, such as Innovate UK and Faraday Institution **summits**, **workshops** and research programmes on batteries. In addition, the UK is developing relationships with other partners, such as **Canada** and **Australia**.

UK Context

Net Zero

The UK has set out ambitious plans to reduce emissions across key sectors of the economy – including an Energy White Paper, Transport Decarbonisation Plan, Industry Decarbonisation Strategy, Hydrogen Strategy, Heat and Building Strategy, and the British Energy Security Strategy. A comprehensive Net Zero Strategy, setting out the government's vision for transitioning to a net zero economy was published in October 2021, and we have set out our progress on delivering this across a number of sectors, including Powering Up Britain: The Net Zero Growth Plan in March 2023.

Our wider strategies and plans outline measures to transition to a green and sustainable future, helping businesses and consumers to move to clean power, supporting hundreds of thousands of well-paid jobs and leveraging up to £90 billion of private investment by 2030 and a goal of reaching net-zero greenhouse gas emissions by 2050. Batteries are expected to play an important role in this ambition.

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Table 3: Spotlight on… Future role of batteries in Net Zero

FUTURE ROLE OF BATTERIES IN NET ZERO
Battery technologies will underpin many of our future sectors
Mobility: Hybrid and fully electric cars and e-mobility devices, as well as planes, trains, and HGVs. Batteries will play a particularly important role in fuel cell electric vehicles powered by hydrogen. **Grid flexibility:** Helping to balance the system at lower cost, maximising the usable output from intermittent low carbon generation (e.g., solar and wind), and deferring or avoiding the need for costly network upgrades and new generation capacity. **Industrial decarbonisation:** Industrial processes are increasingly electrified, and batteries will be essential to supporting the delivery of large-scale decarbonised operations. **Domestic storage & use:** Enabling flexibility will empower people to change their consumption patterns to match times of cheap and abundant low carbon electricity, reducing costs for those who engage with smart products. This could lower system costs for everyone by reducing the amount of generation and network capacity needed as well as the cost of balancing the system.

Table 4: Spotlight on… Industrialisation

INDUSTRIALISATION
The UK Battery Industrialisation Centre (UKBIC) delivered by the Faraday Battery Challenge is a £130 million manufacturing scale-up facility which provides skills for the growing battery sector
Since first opening its doors in 2021, the gigafactory-relevant facility, has already played a crucial role in supporting some low carbon projects that are set to propel the UK's path to Net Zero by 2050. Through industrial collaboration, UKBIC has enabled acceleration of opportunities for the most promising mid-stage research and development activities to accelerate scale-up and commercial exploitation.   

Productivity and Growth

The battery industry presents a unique economic opportunity that the UK is well-placed to capitalise on, with world-class research institutions, specialised government programmes and leading companies already growing in this space across the Union. Investment in the battery ecosystem provides the opportunity to create jobs across the UK over the whole supply chain, from mining to processing and manufacturing to recycling.

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The UK's **EV battery industry** is growing fast as demand increases from our strong automotive industry, and it could grow even further after 2030 as EV demand increases across the world. The Faraday Institution estimates that the automotive industry is projected to manufacture around 1.8 million private cars and commercial vehicles by 2040, of which 95% will be electrified. Furthermore, while current demand is dominated by EV batteries, by 2040 up to one-third of UK battery demand (of up to 200GWh) could be for **energy storage** – across both domestic and network storage. Furthermore, a successful battery industry could employ **100,000 people** by 2040 (35,000 in gigafactories and 65,000 in the battery supply chain)[1]. These advances clearly align with our levelling up agenda, including regional opportunities across the value chain that support high-wage manufacturing jobs.

There are also significant spillover opportunities for the local economies that host initial R&D investments. As the battery ecosystem develops and complementary parts of the supply chain open in the vicinity, more direct and indirect jobs are created. Findings from the Advanced Propulsion Centre programme's interim impact evaluation showed that agglomeration and local clustering are key funding impacts. The evaluation showed positive effects on growth and productivity for firms located near grant recipients, and that additional firms move to those areas. R&D spillovers can therefore unlock wider societal benefits in the form of productivity gains, higher wages, and living standards.

Table 5: Spotlight on… Programmes: Advanced Manufacturing

PROGRAMMES: ADVANCED MANUFACTURING
The UK's leading capabilities and government programmes to promote advanced manufacturing will support battery advances
Advanced Propulsion Centre (APC): The Government has committed to investing nearly £500 million as part of its ambition to develop and embed the next generation of zero emission technologies and vehicles over 10 years. Headquartered at the University of Warwick, the APC facilitates funding for projects that research, develop, and commercialise the technologies for the vehicles of the future. A recent success is that of Norfolk-based company Equipmake, which developed the fully electric New Routemaster red double-decker bus with £3.7million of APC support. In the process, the company has built a £400 million pipeline, grown from 15 to 75 employees, and floated on the Aquis Stock Exchange (AQSE). The Advanced Propulsion Centre also offers the Automotive Transformation Fund programme.
Automotive Transformation Fund: The ATF supports the development of a high-value, end-to-end electrified automotive supply chain, including battery gigafactories and supply chain capabilities, with targeted investment in motors, drives, power electronics and hydrogen fuel cells. This commitment boosts international investment into our strong manufacturing bases and support the 167,000 existing jobs in the automotive sector, including the clusters of activity in the Midlands and North East (ONS, Annual Business Survey 2018 data, 2020). Ford's October 2021 announcement to base its e-Drive production plant in Halewood, Merseyside, is just one of a series of carbon-cutting projects delivered through this public-private partnership.

[1] The Gigafactory Boom: The Demand for Battery Manufacturing in the UK, July 2022. The Faraday Institution.

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Aerospace Technology Institute: Funds industrial research and investment that makes the civil aerospace sector more competitive. Since 2013, the ATI has backed over 300 innovative R&D projects led by world-renowned companies including Airbus and Rolls-Royce. They will be delivered alongside over 40 UK-based partners, helping to develop greener, lower carbon and more efficient aircraft equipment. Moreover, the ATI supports the industry towards achieving Net Zero carbon emissions for commercial aircraft by 2050, improving its competitiveness in sustainable design, manufacture, assembly, and operations. One such project is ONEHEART, a £42m collaborative effort with Airbus to shorten the development time for new aircraft using digital technology.

CALL FOR EVIDENCE QUESTIONS: INTERNATIONAL AND NATIONAL LANDSCAPE

5.1 Considering the international context, are there any additional aims that the UK Battery Strategy should have?

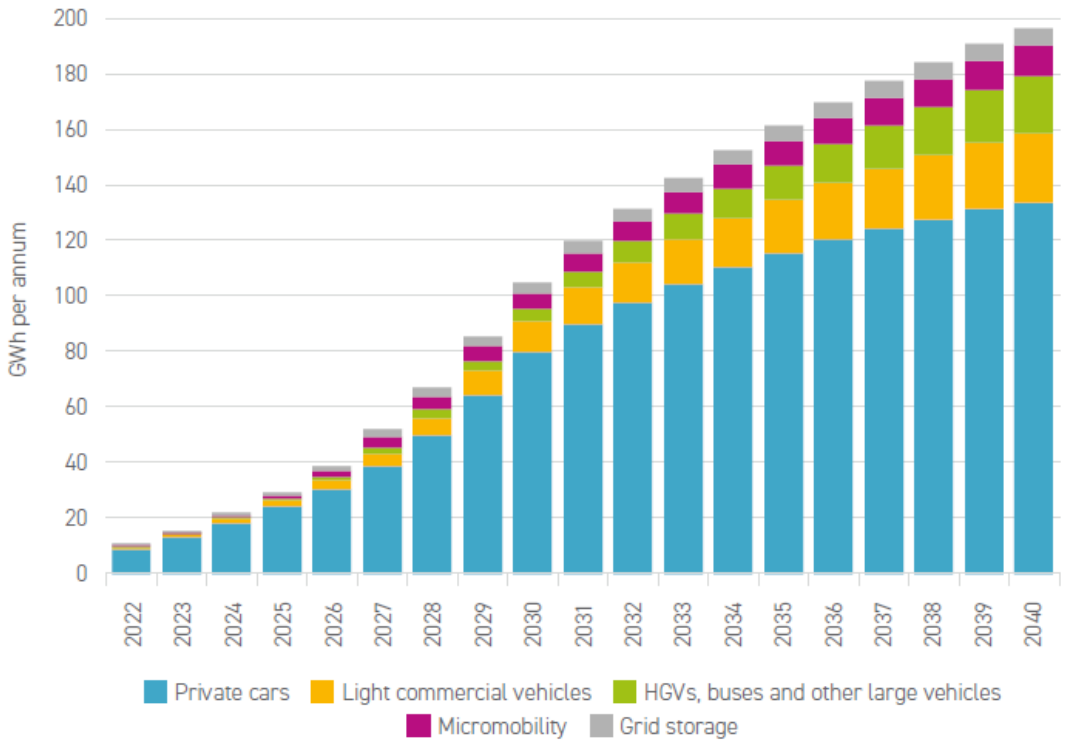
5.2 Considering the national context, are there any additional aims that the UK Battery Strategy should have?

6. Emerging Business Models

A. Market and Investment

A substantial economic prize could await the UK in the development, manufacture and recycling of batteries used across a wide range of current and potential future applications. For this to happen, it is essential that the battery market is well-functioning and continues to attract investment across the value chain, bridging the gap between planned production capacity and market-driven demand. The UK currently has capacity to produce around 2 GWh/year of batteries, with gigafactories under construction from Envision and Tata that are expected to generate 13 GWh/year by 2024 and 67 GWh/year by 2030.

Figure 1: Potential demand for UK-produced batteries by end use, 2022-2040



Source: UK Electric Vehicle and Battery Production Potential to 2040 – update published June 2022. The Faraday Institution.

The core scope of our strategy will take a cross-economy approach, focusing on the development of the following areas of the battery market:

- Transportation and mobility
- Energy storage systems
- Development and production in the UK
- Circular economy and end-of-life considerations

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The UK Battery Strategy will help unlock investment by identifying where investment is needed, signposting battery demand and promoting the use of suitable financial instruments to bring it about. To this end, we propose to:

- Develop a model to forecast energy storage demand across UK economic sectors and applications served by batteries, as well as those served by other technologies (such as flywheels, compressed air, pumped hydro storage, and hydrogen for storage).
- Provide illustrative future projections on battery demand and use, through a scenario-based approach.
- Highlight where there are opportunities for the supply and/or recovery of batteries.

Our scenario-based approach will draw on existing expertise where available, such as technology roadmaps produced by the Advanced Propulsion Centre, and the Future Energy Scenarios developed by National Grid ESO. We will then facilitate demand forecasts for the other sectors in scope of the updated Battery Strategy. In turn, this will allow us to identify where investment is needed and promote the use of suitable financial instruments to bring it about.

Table 6: Spotlight on… Grid storage and stability investments

GRID STORAGE AND STABILITY INVESTMENTS
The UK Infrastructure Bank (UKIB) committed £62.5 million in debt finance to support the development of new energy storage and grid stability facilities
With UKIB's support, Pulse Clean Energy (PCE) plans to invest over £1bn in the deployment of grid-scale battery energy storage systems across 20 sites in England, Scotland, and Wales between 2023-26. The assets will save around 1.9 million tons of CO2 over their lifetime, with significant cost savings that could translate to lower consumer bills. PCE is also building a synchronous condenser under the National Grid's Pathfinder programme to help support grid stability. These projects will create approx. 200 jobs in areas with low rates of income and employment.      UKIB offers senior debt guarantees, and now a mezzanine loan product, with the aim of increasing the pool of banks willing to lend to grid-scale lithium-ion battery projects. It also aims to support the development of markets for long duration storage, including by taking greater risk than private investors, to help ensure first-of-a-kind projects are delivered.

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Table 7: Spotlight on… Future scenarios: Stationary storage for Grid applications

FUTURE SCENARIOS: STATIONARY STORAGE FOR GRID APPLICATIONS
Demand forecasts

Grid-scale battery energy storage systems (BESS) will play a fundamental role in transforming how we manage energy. A smart and flexible energy system is essential to improving system resilience and security, efficiently matching supply and demand and minimising waste.

Forecasts of storage demand are dependent on many assumptions, including the pace of technology development, the scale of investment and adoption, policy decisions and consumer, commercial and industrial uptake. Considering the UK smart energy system of the Future, National Grid Electricity System Operator (ESO)'s Future Energy Scenarios represent a range of different, credible ways to decarbonise our energy system as we strive towards the 2050 target.

Across a range of different scenarios, this would suggest that BESS could provide 10-20GW of capacity to the UK grid by 2030, and 30-35GW by 2050 (Figure 2a), representing the largest installed capacity compared to other storage technologies. However, as can be seen in Figure 2b, batteries (chosen for their short-duration cycling) would still reflect a relatively small overall fraction of energy storage for grid flexibility (c. 50GWh by 2050) compared to the deployment of long duration storage technologies such as Pumped Hydro Storage (PHS), liquid or compressed air energy storage (LAES/CAES).

Figure 2a: Electricity storage installed capacity

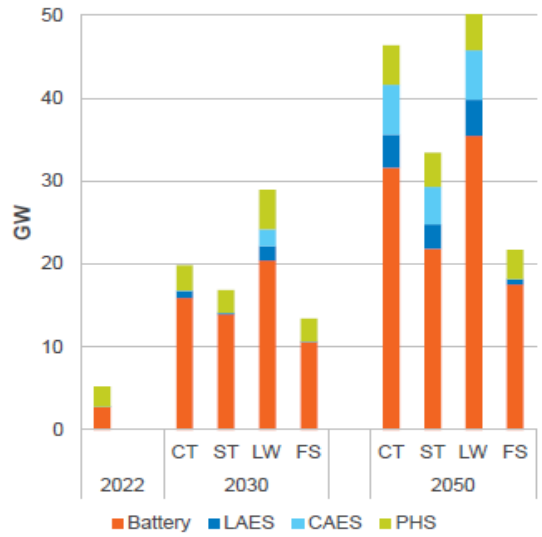
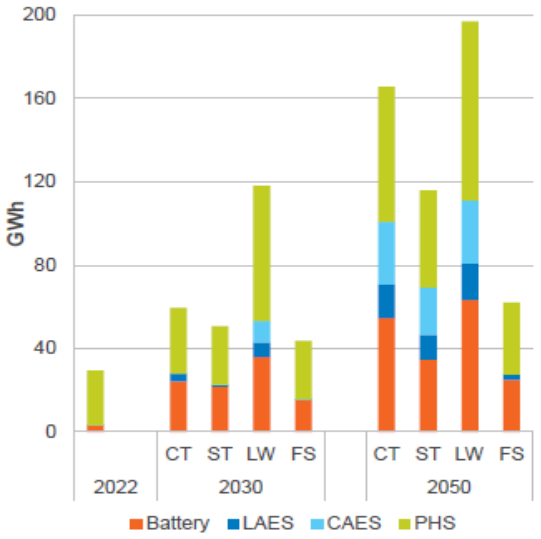


Figure 2b: Electricity storage volume



SOURCE: FUTURE ENERGY SCENARIOS, JULY 2023. ESO. NOTE: THE FOUR SCENARIOS ARE CONSUMER TRANSFORMATION (CT), SYSTEM TRANSFORMATION (ST), LEADING THE WAY (LW) AND FALLING SHORT (FS).

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CALL FOR EVIDENCE QUESTIONS: MARKET AND INVESTMENT

Applications:

6.A.1 What applications or sectors should we consider when looking at the battery market? *Please provide context and evidence (including forecasts/trends) wherever possible.*

6.A.2 What are the barriers for companies entering the auxiliary systems and integration markets for grid storage?

Supply chain:

6.A.3 What should the government's priorities be in developing a battery supply chain?

6.A.4 Is there evidence of supply constraints to service UK battery markets? *Please provide evidence of the impacts of any such constraints identified.*

6.A.5 What are the barriers to investment in development and operations for companies involved in the battery value chain?

6.A.6 Is there evidence of any gaps in the regulation of the storage of batteries in the UK? *Please provide evidence of the impacts of any such gaps identified.*

6.A.7 Is there evidence of any gaps in the regulation of the shipping of battery precursors and finished batteries in the UK? *Please provide evidence of the impacts of any such gaps identified.*

Investment Landscape:

6.A.8 What are the current barriers to investment in battery development, manufacturing, and recycling? *Please provide context and evidence (including forecasts/trends) wherever possible.*

6.A.9 What are the anticipated future barriers to investment in battery development, manufacturing, and recycling? *Please provide context and evidence (including forecasts/trends) wherever possible.*

6.A.10 Is there evidence of any business environment constraints specific to battery manufacturing, whether in the UK or overseas? *Please provide evidence of the impacts of any such constraints identified.*

6.A.11 Are there other solutions that could help address barriers to investment across the value chain? *Please provide context and evidence (including forecasts/trends) wherever possible.*

Regulatory environment:

6.A.12 How has current UK battery regulation impacted the growth of the battery market? *Please provide context and evidence (including forecasts/trends) wherever possible.*

6.A.13 Can you give specific examples of impacts that the absence of regulations has on the UK battery market which could be considered as part of the UK Battery Strategy?

6.A.14 In which ways should the UK Battery Strategy seek to protect consumer interests?

6.A.15 Some grid solutions involve smart charging and discharging of batteries which can enhance battery life, according to some studies. What considerations should be made to maximise battery health?

6.A.16 Are there any additional aims the UK Battery Strategy should have when considering the battery market?

B. Technology Options

Different battery technologies are better suited to specific applications based on several key characteristics, including:

- Cost
- Volume (volumetric energy density), particularly in the case of energy storage applications
- Weight (gravimetric energy density), particularly in the case of transport applications
- Use-cycle and life-cycle longevity
- Power performance

However, the extent to which emerging technologies will be adopted in a rapidly evolving landscape will not only depend on these features, but also on their level of development, their sustainability, and health & safety considerations.

Lithium-ion batteries are increasingly safe, but their ever-rising use makes it more important than ever to improve their design to minimise the risk of cell fires that can occur under conditions of mechanical, thermal, or electrical stress. Improving battery safety will allow industrial users to reduce the complexity of their overall systems and so enable the adoption of new technologies.

The UK is playing an important global role in investment, patent, and research activity into battery technology families, ranking in the top 5 of research impact across different kinds of innovative material applications. According to government analysis, the UK ranks third in the world in terms of research quality.

The UK has a **significant strategic advantage** in some new battery technologies, with the potential to take a leading role in their commercialisation and industrialisation. For instance, the UK has well-established firms that produce sodium-ion batteries, such as Faradion, as well as mature suppliers of

materials and equipment to produce lithium-ion batteries that could also cater to this new technology.[2]

As part of an updated UK Battery Strategy, we propose to:

- Set out the key properties and potential of the current and future battery technologies.
- Focus on those technologies with applications in mobility, industrial and energy storage applications, with a more limited consideration of portable batteries used in consumer electronics.

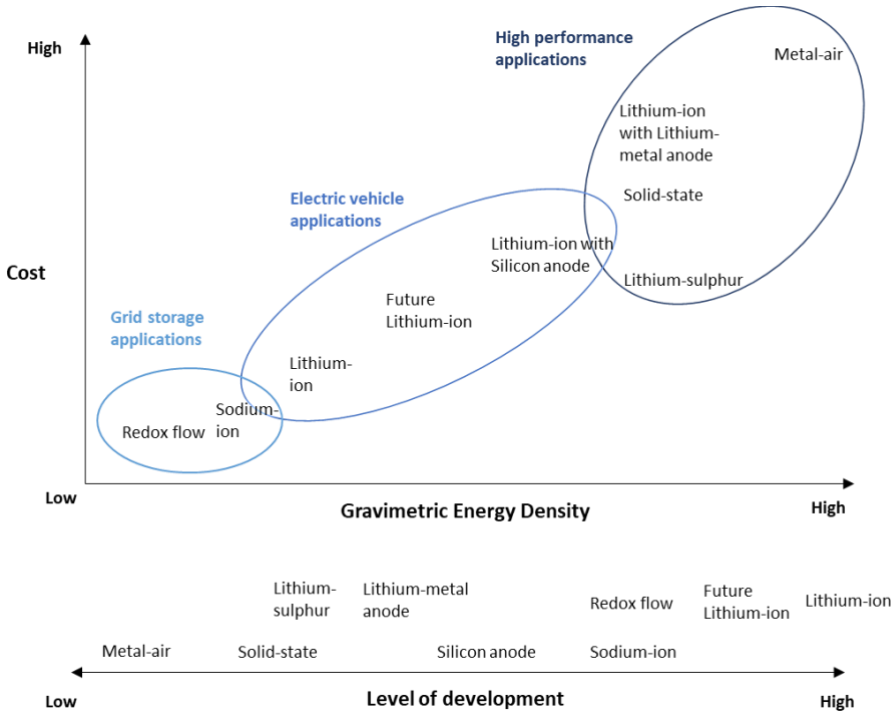
Table 8: Spotlight on… Technology: Battery technology families

TECHNOLOGY: BATTERY TECHNOLOGY FAMILIES	
Key battery technology families	**Suitable for which applications?**
Redox flow batteries use chemical components (e.g., Vanadium) dissolved in liquid electrolyte to provide energy as they flow from tanks through electrochemical cells and over the electrodes.	Redox flow batteries are particularly suited to stationary storage applications (e.g., grid storage) due to their large size, weight, and suitability for long term storage (long lifetime and minimal degradation).
Sodium (Na)-ion batteries use similar processes to Li-ion but with heavier Na ions.	Na-ion batteries may have sustainability, safety, and cost (in the longer term 20-30% reduction) advantages over Li-ion batteries, but they are not expected to match them on energy density. Na-ion technology may be better suited to certain applications where safety and cost are more important such as home energy storage, grid storage, appliances, or lower performance EVs.
Lithium-ion batteries use lithium ions as the charge carrier. Many different types of lithium-ion batteries are used with a range of combinations of materials used for the electrodes, the choice is dependent on desired characteristics such as energy density and cost.	Research aims to unlock higher energy density while maintaining or improving longevity and safety profiles. Developments in one application, such as automotive, have had positive spillovers into others. Although Li-ion batteries may be reaching technical limits, it is likely they will remain the dominant battery for at least the next 10 years due to performance, cost and the challenges associated with commercialising alternative battery technologies at scale.

[2] Sodium-ion Batteries: Inexpensive and Sustainable Energy Storage, May 2021. The Faraday Institution.

Lithium-sulphur (Li-S) batteries replace the metal rich cathodes in Li-ion with cheaper sulphur cathodes. Li-S cells have a high theoretical energy capacity and could be significantly cheaper than Li-ion for comparable performance.	Li-S batteries could offer cheaper, more lightweight batteries with a better safety profile. There are also potential sustainability and supply chain benefits with reduced requirements for phosphate, nickel, and cobalt.
Solid-state batteries have a solid electrolyte separating the electrode instead of a liquid solution used in current lithium-ion batteries. Research is long-term and high-risk, but has the potential to be high reward, offering an energy density improvement over other technologies.	Predictions suggest that by 2030, SSBs could significantly extend EV range and address safety issues of lithium-ion batteries. When fully developed, a solid-state battery cell with a lithium metal anode and a next generation cathode could provide an increase in energy density of 45% over current lithium-ion batteries.
Metal-air batteries consist of a metal anode and cathode which extracts oxygen from ambient air. Lithium ions combine with this oxygen to form lithium oxide at the positive electrode.	They have a high theoretical energy density and could be high performance lightweight batteries across a range of applications (transport, consumer electronics, military, aerospace). However, they are at a low technology readiness level (TRL) with significant research challenges remaining.

Figure 3: Gravimetric energy density and level of development of battery technology types



Source: Government Office for Science, 2022. Note: Gravimetric energy density is a measure of the weight of the materials used per unit of energy released. Volumetric energy density, a measure of the space that they take up per unit of energy released, is also a key consideration for some applications.

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Table 9: Spotlight on… UK leading innovation

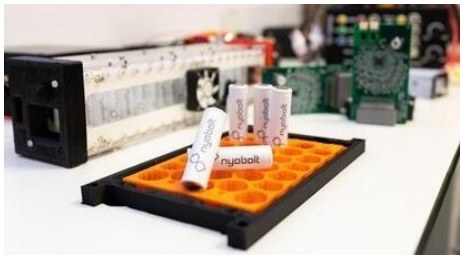
UK LEADING INNOVATION
Case studies
 **Nyobolt** develops, manufactures, and commercializes lithium-ion batteries that charge in minutes and have an extended cycle life thanks to their niobium-based anode material. The ultra-fast technology has a high-power density and an improved safety profile. The company secured new funding from through the Faraday Battery Challenge and is collaborating with WAE Technologies, Coventry University and the University of Cambridge.
faradion **Faradion** is the world leader in non-aqueous sodium-ion cell technology, providing cheaper, cleaner energy for stationary applications. It is currently manufacturing this new technology to demonstrate its cost, safety, and performance advantages in real-world scenarios such as residential and industrial storage, including in offshore sites where transporting batteries by air is restricted.

Table 10: Spotlight on… Programmes: Faraday Institution & Faraday Battery Challenge

PROGRAMMES: FARADAY INSTITUTION & FARADAY BATTERY CHALLENGE
The Faraday Institution continues to deliver excellent scientific and industry-relevant impacts since the launch of its research programmes in 2018
The Faraday Institution is the UK's independent institute for electrochemical energy storage research, skills development, market analysis, and early-stage commercialisation. It spans ten major research projects in lithium-ion and beyond lithium-ion technologies. **The Faraday Battery Challenge** is a pioneering lab to factory programme that aims to develop cost-effective, high performance, durable, safe, and recyclable batteries, with an investment of £541 million between 2017-2025 from UK Research and Innovation.   

CALL FOR EVIDENCE QUESTIONS: TECHNOLOGY OPTIONS

6.B.1 What applications or sectors should the UK Battery Strategy consider when looking at technology options? *Please provide context and evidence (including forecasts/trends) wherever possible.*

6.B.2 What new technologies or approaches, not already addressed here, could contribute to future supply? *Please provide context and evidence (including forecasts/trends) wherever possible.*

6.B.3 To what extent will emerging technologies mean that key non-transport applications (e.g., grid storage) may use a different technology to electric vehicle batteries?

6.B.4 Which emerging technologies for non-transport battery applications are likely to be adopted and over what timescales? *Please provide context and evidence (including forecasts/trends) wherever possible.*

6.B.5 Are there any additional aims that the UK Battery Strategy should have when looking at the technology options?

C. Life Cycle and End of Life

Developing the capacity to repair, repurpose, reuse, and recycle batteries is an integral part of the value chain in a world of growing competition for finite resources. The wider sector is striving to overcome a series of technical and operational challenges at each stage to realise its potential.

Beginning with the research and design process, the use of new materials requires new processes to develop and produce them. Design for recycling is also recognised as a key challenge for the sector, as inconsistent packaging and the blending of multiple parts and materials can make it difficult to automate battery disassembly. The manufacturing process is not without its challenges either, with the use of adhesives that impede material extraction and slow down recycling pathways. Innovators in the UK are making efforts to create standardised designs that allow for the maximum possible recovery of valuable materials and processes that generate fewer carbon emissions. The profitability of the recycling service sector will be tied to the steps that producers take to design for end of life.

Reusing batteries and repurposing them when they no longer meet their original performance needs – for example, by using former EV batteries for domestic energy storage – can significantly extend value of batteries. However, increasing the rate at which batteries are reused and repurposed will require new regulations that reduce the level of uncertainty around the origin and quality of second-life batteries, and there will be regulatory and commercial trade-offs between second-life, remanufacturing, and recycling as part of an emerging circular economy.

Finally, batteries employ hazardous materials that will need to be isolated and disposed of in a way that is safe both to humans and the environment. For instance, there is a non-trivial risk of fire in recycling and waste facilities from lithium-ion batteries. Regulations to require appropriate labelling

and staff training can play a part in improving these processes, as can the control of certain hazardous chemicals before they enter the supply chain.

As part of an updated UK Battery Strategy, we propose to:

- Consider the whole life cycle of battery development and use, including access to supply chains, manufacturing, use, and second life/end of life/recycling.

Table 11: Spotlight on… UK regulation

UK REGULATION
Requirements on businesses making batteries available for supply or sale in the UK
End-of-Life Vehicles Regulations 2003 and End-of-Life Vehicles (Producer Responsibility) Regulations 2005: • Requiring the removal of batteries from scrap vehicles at authorised treatment facilities. **Batteries and Accumulators (Placing on the Market) Regulations 2008:** • Restricting the substances used in batteries and accumulators. • Establishing labelling requirements for substances. **Waste Batteries and Accumulators Regulations 2009:** • Producers of automotive batteries must collect batteries and accumulators for free from their final holders, such as garages and scrapyards. • Producers of industrial batteries must ensure that they are treated are permitted facilities that meet the required recycling efficiency standards. • Producers of portable batteries that place more than 1 tonne a year on the market must join a Battery Compliance Scheme. • Preventing batteries and accumulators from being incinerated or dumped in landfills. The regulations cover all types of batteries, regardless of their shape, volume, weight, material composition or use, as well as the appliances into which a battery may be incorporated. They apply to all domestic or foreign manufacturers or importers with a UK presence that first place batteries on the market. DEFRA are currently reviewing the UK-wide Batteries Regulations that apply to both to placing on the market and waste battery issues, including recycling. DEFRA are considering the changes needed to provide an appropriate framework for the increasing number of EV batteries arising at waste and how these can be best managed within the UK market. This will include looking at the opportunities for better regulation now that we are outside the European Union. Battery manufacturing industrial installations are also generally covered by the Environmental Permitting Regulations 2016 (EPR). Plants must receive a permit from their local authority, which

protects human health and the environment by setting out conditions to prevent pollution to air, land, and water. In the 2023 Environmental Improvement Plan, the Government committed to consult on reforms to the EPR to ensure that environmental regulation keeps pace with and enables developments in the manufacture and use of batteries on the road to Net Zero.

Table 12: Spotlight on… Battery second life industrialisation

BATTERY SECOND LIFE INDUSTRIALISATION
Case studies
The UK is incentivising the growth of battery repurposing, reuse, and recycling to create a closed-loop supply chain for battery manufacturing, increasing sustainability and reducing reliance on the mining of raw materials. **LTS:** A flagship project is that of LTS Transport Solutions which, with the support of the UK's Automotive Transformation Fund, is developing a lithium-ion battery recycling plant in London to recycle end-of-life electric vehicle batteries. It seeks to generate no additional waste, create a circular economy around strategical metals and protect the environment. **Connected Energy:** A specialist in energy storage systems that has demonstrated the commercial viability of repurposing electric vehicle batteries. They received funding from Innovate UK and collaborated with Jaguar Land Rover and Warwick Manufacturing Group. The company built the UK's first ever EV charging hub in Dundee in 2018 and have progressed to the scaling-up phase of its technology and operations.

CALL FOR EVIDENCE QUESTIONS: LIFE CYCLE AND END OF LIFE
6.C.1 What are the UK's key strengths in the battery treatment infrastructure? **6.C.2** What are the technical barriers to the development of treatment facilities for new battery chemistry types (e.g., lithium-ion batteries) in the UK? **6.C.3** What are the barriers to investment into treatment facilities for new battery chemistry types (e.g., lithium-ion batteries) in the UK?

6.C.4 What are the barriers to developing a safe battery re-use industry in the UK?

6.C.5 Can you give specific examples of positive or negative impacts from the current regulations in relation to recycling, reuse, and the circular economy?

6.C.6 Can you give specific examples of positive or negative impacts from the absence of regulations in relation to recycling, reuse, and the circular economy?

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7. Call for Evidence Questions

- We have set again here a summary of the call for evidence questions embedded through the document.
- We also include a set of further questions requiring more detailed/evidence.

Summary of Questions

STRATEGIC PRIORITIES
4.1 Do you have comments on the strategic priorities for the UK Battery Strategy outlined above?
4.2 Are there any additional strategic priorities you think the UK Battery Strategy needs to include?
INTERNATIONAL AND NATIONAL LANDSCAPE
5.1 Considering the international context, are there any additional aims that the UK Battery Strategy should have?
5.2 Considering the national context, are there any additional aims that the UK Battery Strategy should have?
EMERGING BUSINESS MODELS: MARKET AND INVESTMENT
Applications:
6.A.1 What applications or sectors should we consider when looking at the battery market? *Please provide context and evidence (including forecasts/trends) wherever possible.*
6.A.2 What are the barriers for companies entering the auxiliary systems and integration markets for grid storage?
Supply chain:
6.A.3 What should the government's priorities be in developing a battery supply chain?
6.A.4 Is there evidence of supply constraints to service UK battery markets? *Please provide evidence of the impacts of any such constraints identified.*
6.A.5 What are the barriers to investment in development and operations for companies involved in the battery value chain?
6.A.6 Is there evidence of any gaps in the regulation of the storage of batteries in the UK? *Please provide evidence of the impacts of any such gaps identified.*
6.A.7 Is there evidence of any gaps in the regulation of the shipping of battery precursors and finished batteries in the UK? *Please provide evidence of the impacts of any such gaps identified.*

Investment Landscape:

6.A.8 What are the current barriers to investment in battery development, manufacturing, and recycling? *Please provide context and evidence (including forecasts/trends) wherever possible.*

6.A.9 What are the anticipated future barriers to investment in battery development, manufacturing, and recycling? *Please provide context and evidence (including forecasts/trends) wherever possible.*

6.A.10 Is there evidence of any business environment constraints specific to battery manufacturing, whether in the UK or overseas? *Please provide evidence of the impacts of any such constraints identified.*

6.A.11 Are there other solutions that could help address barriers to investment across the value chain? *Please provide context and evidence (including forecasts/trends) wherever possible.*

Regulatory environment:

6.A.12 How has current UK battery regulation impacted the growth of the battery market? *Please provide context and evidence (including forecasts/trends) wherever possible.*

6.A.13 Can you give specific examples of impacts that the absence of regulations has on the UK battery market which could be considered as part of the UK Battery Strategy?

6.A.14 In which ways should the UK Battery Strategy seek to protect consumer interests?

6.A.15 Some grid solutions involve smart charging and discharging of batteries which can enhance battery life, according to some studies. What considerations should be made to maximise battery health?

6.A.16 Are there any additional aims the UK Battery Strategy should have when considering the battery market?

TECHNOLOGY OPTIONS

6.B.1 What applications or sectors should the UK Battery Strategy consider when looking at technology options? *Please provide context and evidence (including forecasts/trends) wherever possible.*

6.B.2 What new technologies or approaches, not already addressed here, could contribute to future supply? *Please provide context and evidence (including forecasts/trends) wherever possible.*

6.B.3 To what extent will emerging technologies mean that key non-transport applications (e.g., grid storage) may use a different technology to electric vehicle batteries?

6.B.4 Which emerging technologies for non-transport battery applications are likely to be adopted and over what timescales? *Please provide context and evidence (including forecasts/trends) wherever possible.*

6.B.5 Are there any additional aims that the UK Battery Strategy should have when looking at the technology options?

LIFE CYCLE AND END OF LIFE

6.C.1 What are the UK's key strengths in the battery treatment infrastructure?

6.C.2 What are the technical barriers to the development of treatment facilities for new battery chemistry types (e.g., lithium-ion batteries) in the UK?

6.C.3 What are the barriers to investment into treatment facilities for new battery chemistry types (e.g., lithium-ion batteries) in the UK?

6.C.4 What are the barriers to developing a safe battery re-use industry in the UK?

6.C.5 Can you give specific examples of positive or negative impacts from the current regulations in relation to recycling, reuse, and the circular economy?

6.C.6 Can you give specific examples of positive or negative impacts from the absence of regulations in relation to recycling, reuse, and the circular economy?

FURTHER QUESTIONS

7.1 What UK-specific sector demand forecasts or evidence are available for short, medium and long-term energy storage in:
Please provide links if possible.

2025 (1) _____

2030 (2) _____

2040 (3) _____

2050 (4) _____

7.2 Are there any additional sectoral or industrial market requirements for batteries in the UK not addressed in the call for evidence document? *If so, please provide details.*

7.3 Are there examples of how global demand for batteries could be serviced from the UK not raised in the call for evidence document? *If so, please provide details.*

7.4 Do you have any other evidence relevant to the development of the UK Battery Strategy?


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Any enquiries regarding this publication should be sent to us at

enquiries@businessandtrade.gov.uk.