NEBA

NORTH EAST BATTERY ALLIANCE

North East Battery Alliance Progress Event

Wednesday 14th June

University of Sunderland

Durham University

Newcastle University

North East Local Enterprise Partnership

THE FARADAY INSTITUTION

Teesside University

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Northumbria University NEWCASTLE

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Mike Capaldi

Dean of Innovation and Business
Newcastle University

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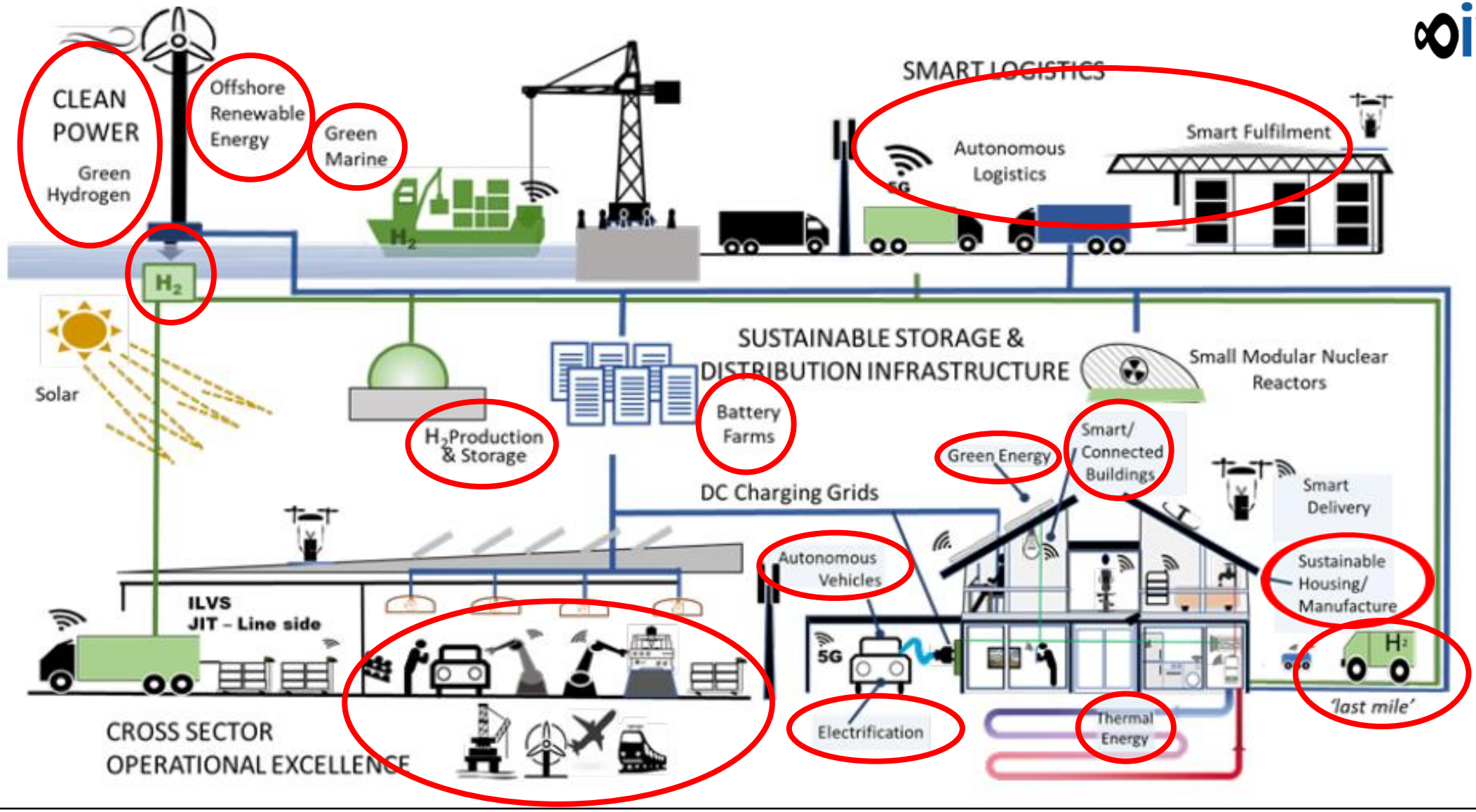
Advance Northumberland

ELECTRIC NORTH EAST ENGLAND

Electrification Process Innovation Cluster

Professor Mike Capaldi
Dean of Innovation and Business

The Green Industrial Revolution



North East – centre of the electrical revolution

Newcastle University

Batteries

ALEXANDER BATTERY TECHNOLOGIES

RECHARGE INDUSTRIES

saft

Envision AESC

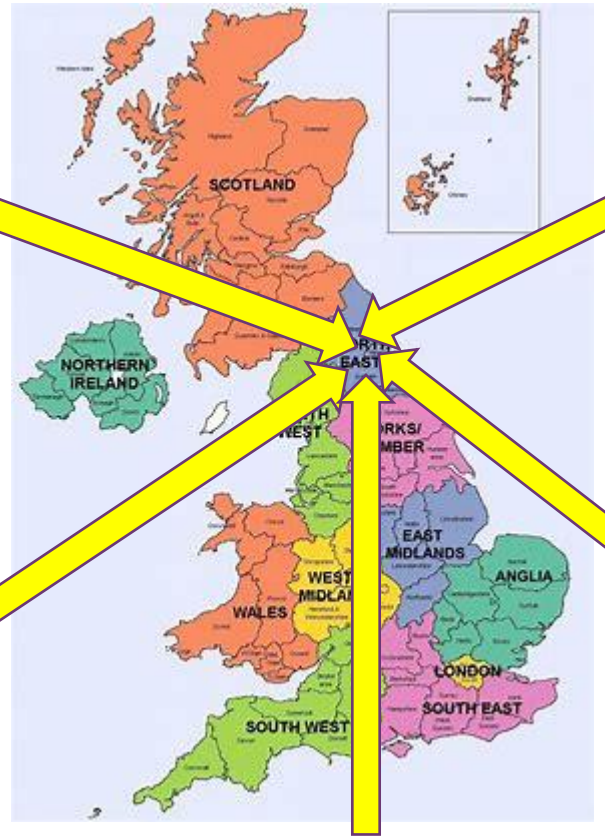
GREEN LITHIUM

NORTHERN NLi LITHIUM

sembcorp

Peak RARE EARTHS

CONNECTED ENERGY



Original Equipment Manufacturers

NISSAN

KOMATSU

CATERPILLAR

HITACHI

Cummins

Power Electronics, Machines & Drives

BorgWarner

MARELLI

snop

TURNTIDE

SIEMENS

Gestamp

LEAR CORPORATION

THARSUS

Offshore Renewable Energy

CATAPULT Offshore Renewable Energy

DOGGER BANK WIND FARMS BY sse equinor

IPR

Research and Technology

DER Driving the Electric Revolution Industrialisation Centres

Newcastle University

Teesside University

cpi

THE FARADAY INSTITUTION

University of Sunderland

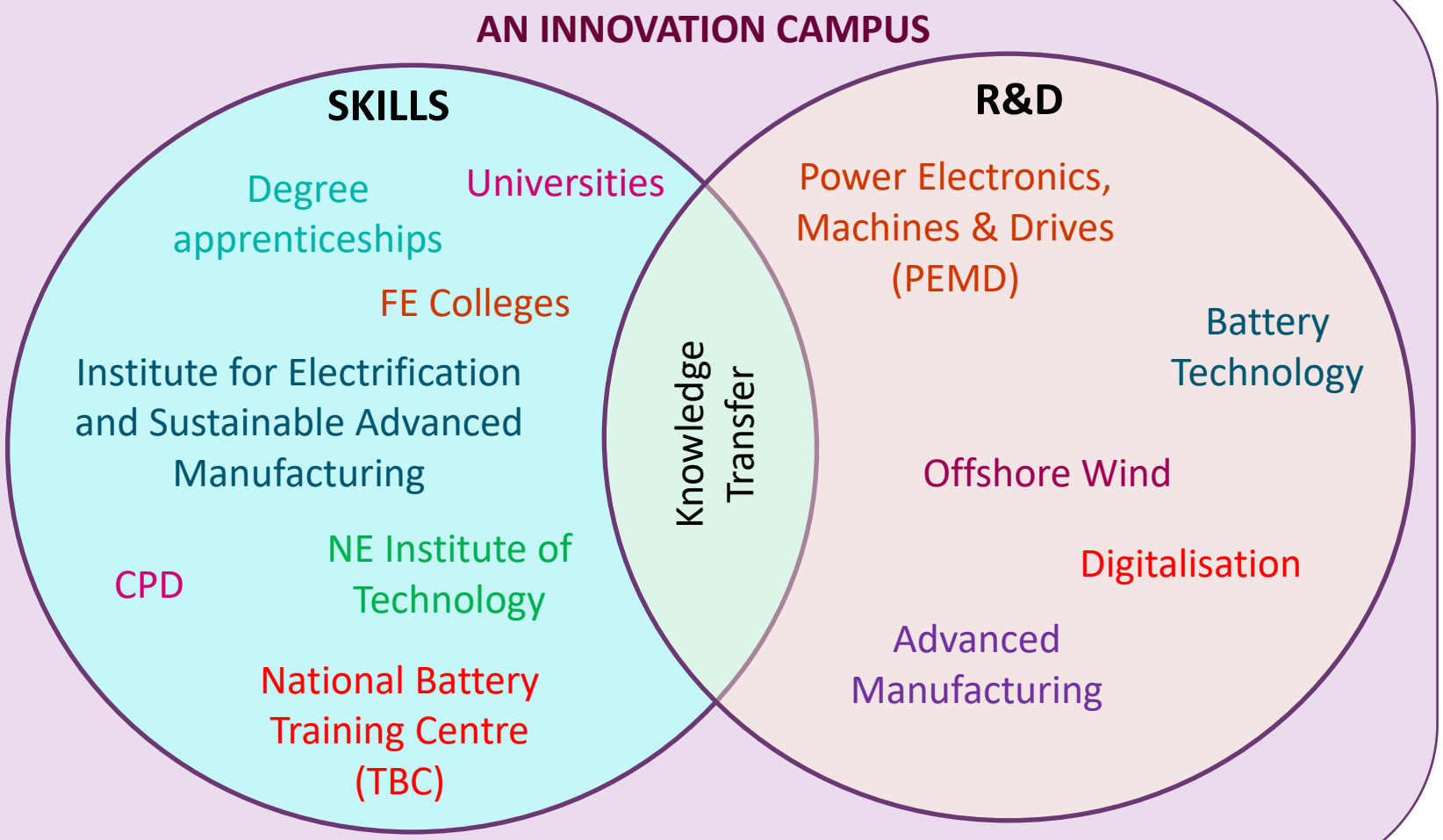
Durham University

Northumbria University NEWCASTLE

Electrification Process Innovation Cluster (EPIC)

EPIC is a collection of engineers, technicians and academics, with core skills and technical knowledge in PEMD and battery, manufacturing, process development, data, and business.

EPIC combines FE, HE and industry partners to upskill the workforce and drive new technological developments in innovative manufacturing processes.



Why do we need EPIC?

1. To capitalise economically on the NE's current leading position in PEMD, batteries and offshore wind

2. To anchor the manufacture of more electrical components in the UK to meet EU Rules of Origin (otherwise export tariffs will force UK manufacturers abroad)

3. To ensure the NE workforce has the appropriate skills to meet the demands of the NE's growing electrification industry

4. To help deliver our Net Zero targets

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NORTH EAST BATTERY ALLIANCE

Jamie Driscoll

Elected Mayor
North of Tyne Combined Authority

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ELECTRIC NORTH EAST ENGLAND

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NORTH EAST BATTERY ALLIANCE

North East Battery Alliance

PRESENTED BY

Professor Colin Herron CBE

University of Sunderland · Durham University · Newcastle University · North East Local Enterprise Partnership · The Faraday Institution · Teesside University · cpi · Northumbria University Newcastle

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NORTH EAST BATTERY ALLIANCE

THE FARADAY INSTITUTION

POWERING BRITAIN'S
BATTERY REVOLUTION

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FARADAY INSTITUTION OPENS NORTH EAST REGIONAL OFFICE IN NEWCASTLE UNIVERSITY

Professor Colin Herron CBE
MD: Zero Carbon Futures (UK) Limited
Newcastle University School of Engineering
Faraday Institution North East Office (FINE)
North East Battery Alliance

Lois Warne
Project Manager: Zero Carbon Futures (UK) Limited
Newcastle University School of Engineering
Faraday Institution North East Office (FINE)
North East Battery Alliance

International strategy (politics)

The package — billed by Sunak as the “Atlantic Declaration” — would see the US and UK begin talks on a trade deal over critical materials like cobalt, graphite, and nickel that are crucial to batteries used in electric vehicles.

National strategy (politics)

We will maximise what the UK produces along the critical minerals value chain – through mining, refining, manufacturing and recycling – in a way that creates jobs and growth and protects communities and our natural environment. We will re-establish the UK as a skills leader and continue to do cutting-edge research and innovation in exploration, mining, refining and manufacturing.

The Strategy sets out our ambitions to work with other countries to strengthen trading and diplomatic relationships, and efforts to make supply chains more diverse, transparent, responsible and resilient. This will create opportunities for UK companies overseas and make sure UK businesses are trading on a level playing field.

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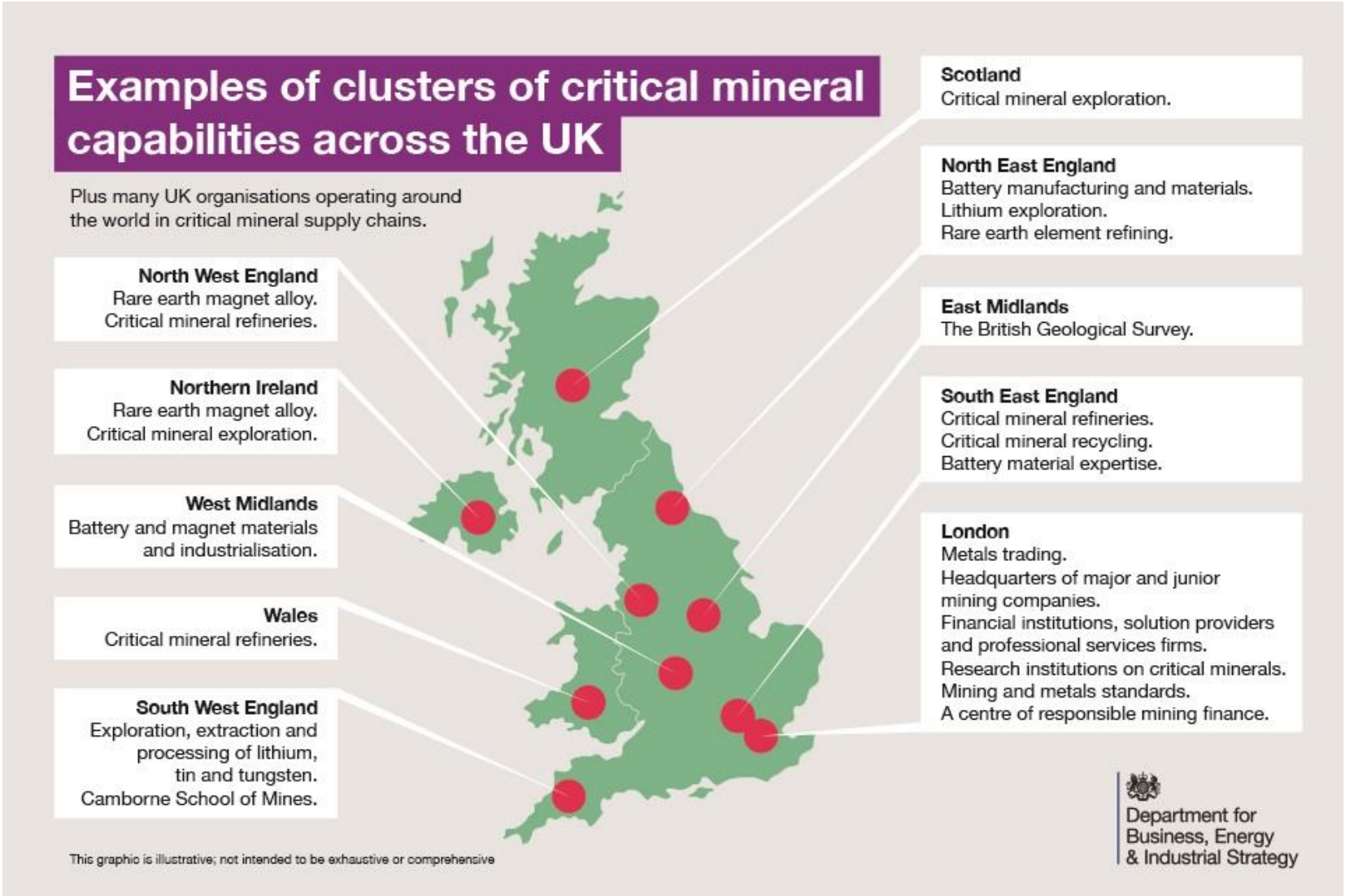
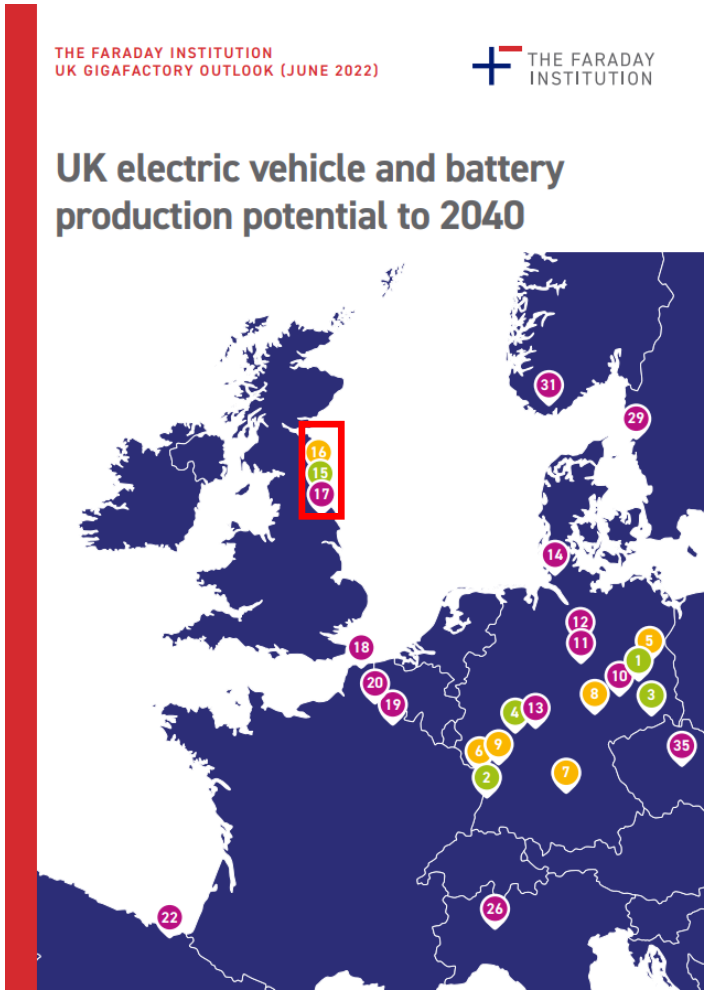
National capabilities

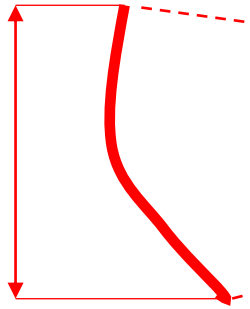


The epicentre of battery manufacture



The epicentre of electrification

45miles/72km



Base materials

PEMD

Cell and pack manufacturing

Vehicle manufacturing

Second life

Recycle (discussions)

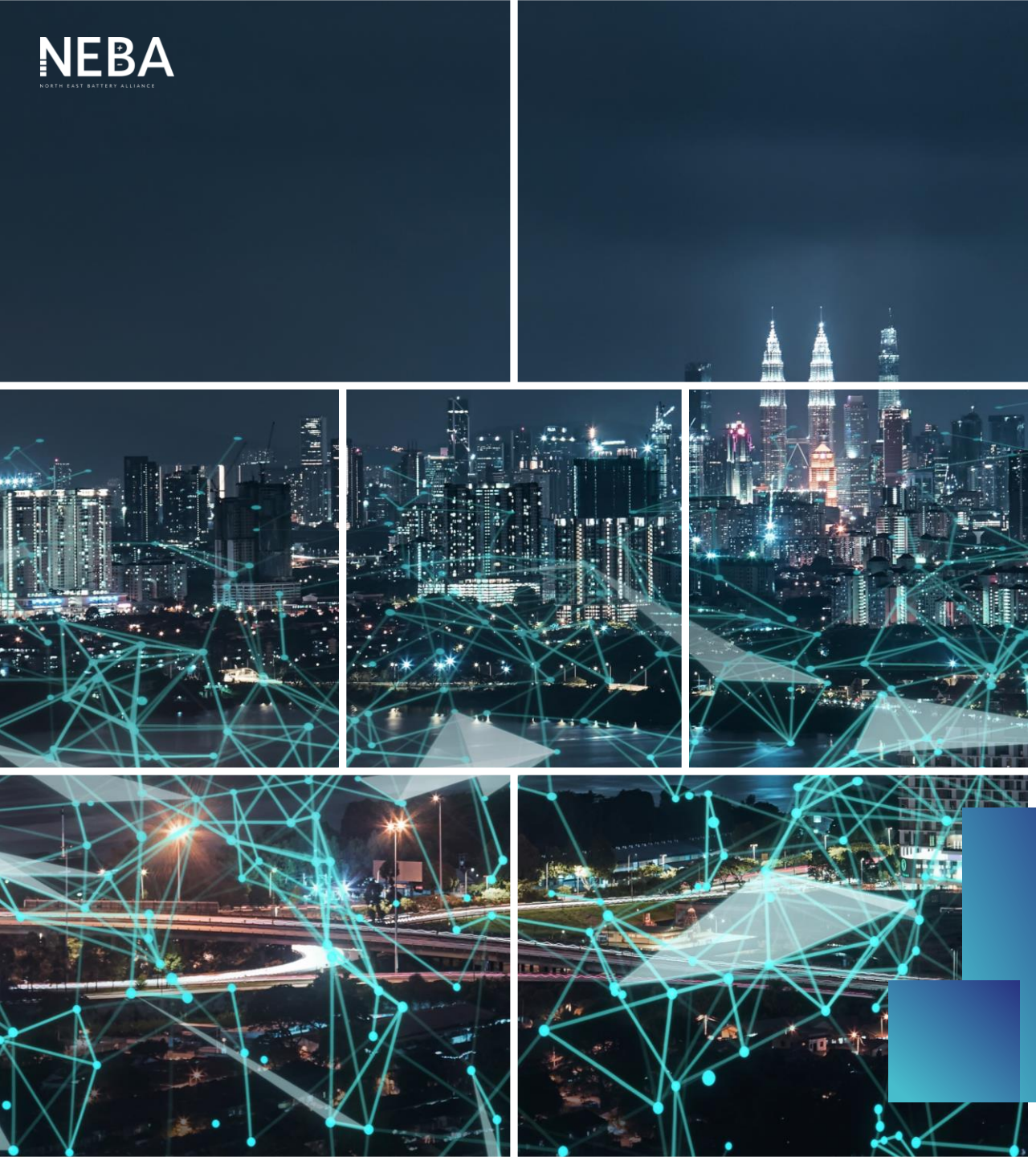
Research

About NEBA

The North East Battery Alliance (NEBA) is a collective of the region's universities and CPI focused on the Net Zero agenda specifically lithium ion battery and research, development and innovation.

NEBA Objectives

- To support large scale manufacture of batteries in the North East, including associated supply chains
- Maximising the potential the NE can offer industry in research and skills
- Bring together research institutions to determine our current strengths and capabilities in the area of batteries and identify gaps
- Understand the gaps in the industry for research, skills and future Research, Development and Innovation needs
- Build engagement across the partners
- Identify challenges
- Identify investment needs
- Lobby Government



NEBA story so far

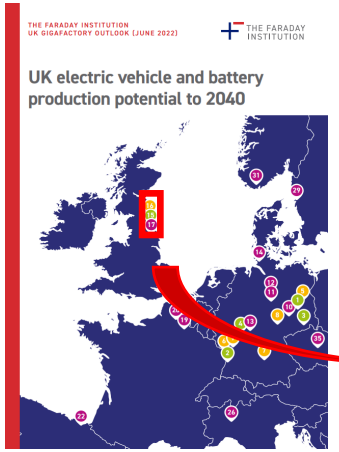
Since NEBA was formed in March 2022, the region's five universities (Durham, Newcastle, Northumbria, Sunderland and Teesside) and CPI are collaborating, forming work groups reviewing all aspects of battery production - from raw materials to recycling, to strengthen the region's research offering in this space.

Over 200 researchers working in the battery sphere engaged

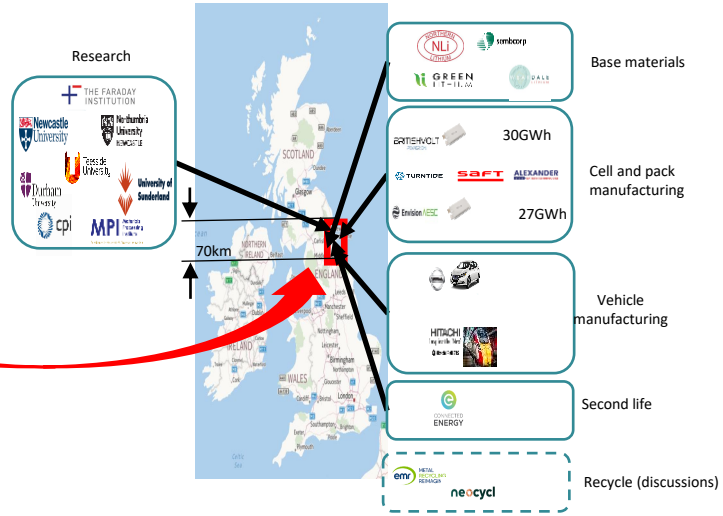
Over 500 contacts

Over 130 companies engaged

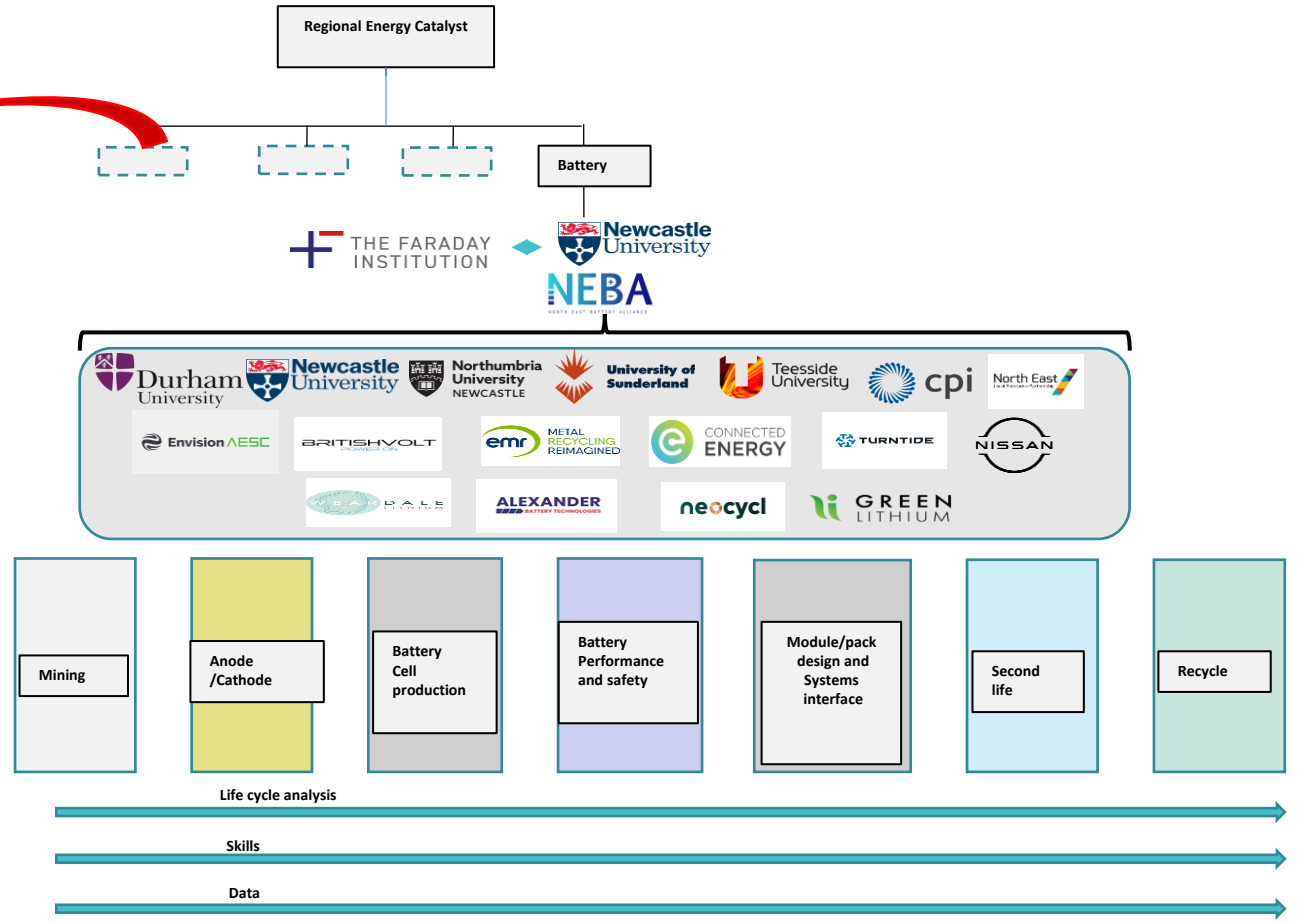
The epicentre of battery manufacture in the UK



The national demographics



The regional demographics



The regional battery cluster

Progress Since Mar 22

Conference in May

NEBA Progress – Good news

Green Lithium

- Large scale lithium refinery to supply Gigafactory demand
- 1,000 jobs during construction
- 250 high skilled jobs for local people in operation
- 3 years construction, commissioning during 2025

Tees Valley Lithium

- Lithium hydroxide production in Wilton Chemicals Park, Teesside
- 500 jobs during construction
- 500 high value skilled jobs in operation
- Securing supply chains of critical minerals

Weardale Lithium

- Drilling has commenced

NEBA Progress – Good news

Envision-AESC site

AESC envision Plant 1 opened 2013

AESC envision New plant

December 2022

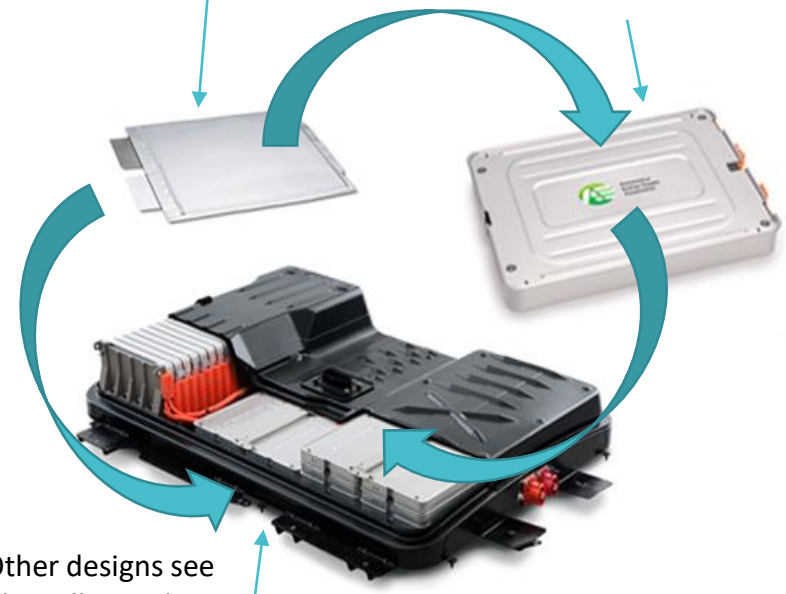
Image of final condition (12GWh)

NEBA Progress – Recharge?

Battery life

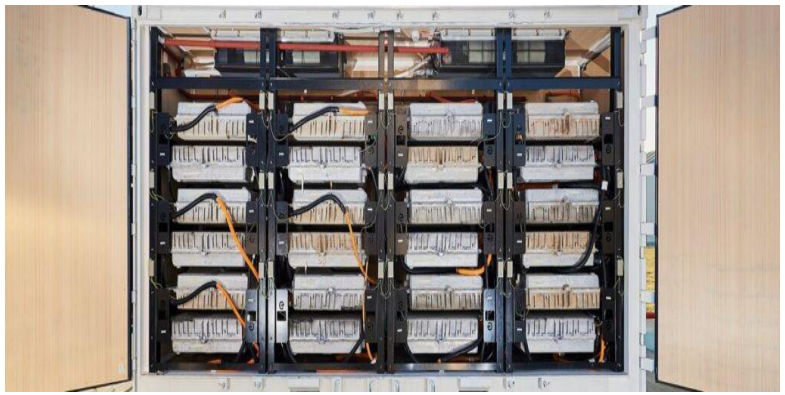
Cell

Module



Other designs see the cell straight into the battery

Pack



When will the trigger point be reached

Recycling

Increased recycling and reuse

•It’s a current requirement that, at least, 50% of a battery’s weight must be recycled. From 2025, this requirement will increase to 65% for lithium-ion batteries and to 70% from 2030. Specific recycling requirements will also be introduced for the lithium, cobalt, copper, nickel, and lead content of batteries. For example, the required recycling rate for lithium will increase from 35 to 70% between 2026 and 2030. The EU is seeking to set a 90% recycling rate for cobalt, copper, nickel, and lead from 2026.

•Recyclers will have to report annually on the quantity of batteries they handle and recycle, as well as the recycling rates of the various materials extracted. It will also be a requirement to measure the efficiency of their recycling processes.

•The export of used batteries outside the EU will only be permitted if the recipient's battery management procedure meets EU's requirements.

Increased use of recycled raw materials

•As early as 2027, the proposed EU legislation will require manufacturers to provide transparent information on the quantity of recycled cobalt, lithium, nickel, and lead in new car batteries. The required amount of recycled cobalt and lithium will more than double from 2030 to 2035.

Where next?

G = Gravity

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James Gaade

Research Programme Director
The Faraday Institution

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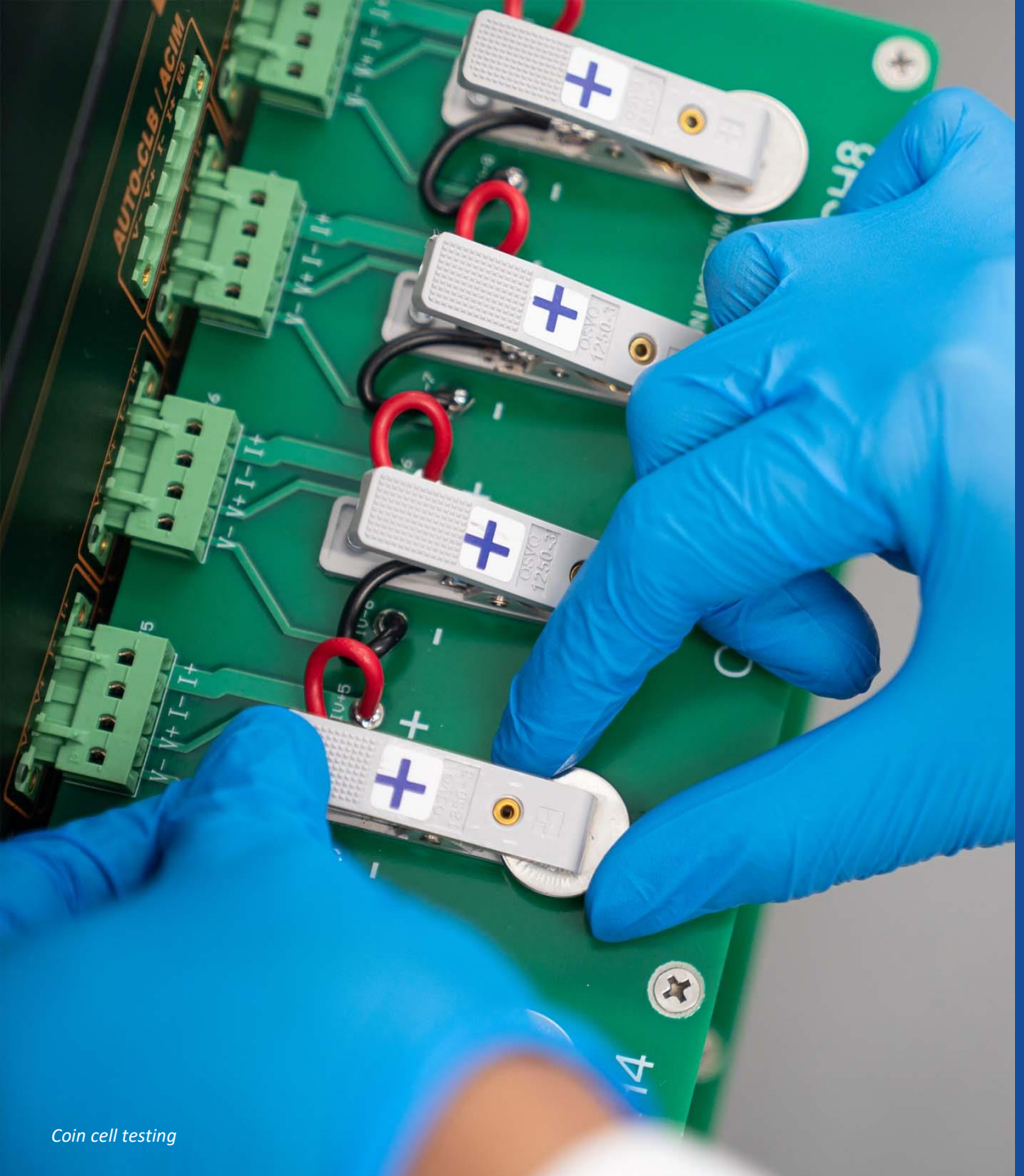


Coin cell testing

James Gaade
Research Programme Director
14th June 2023

THE FARADAY INSTITUTION

THE FARADAY INSTITUTION

- The UK’s flagship programme for electrochemical energy storage research, skills development, market analysis and early-stage commercialisation.

NEBA

5 Years of High-quality Impacts in Energy Storage

The Faraday Institution has generated a great return on the UK's investment from a standing start in 2018

Lead 10 major research programmes

across **27 UK universities** and research partners and **85 industrial partners**

United a community of 500+ researchers

45% new to field, to solve battery challenges through breakthrough science

Training and directly funding 71 PhDs

for UK industrial and academic careers, and an additional **100+ affiliated** with our projects

Published 648+ scientific papers

63% in top 10% journals
46% in top 10% most cited
50% with international collaborators

Supported 8 entrepreneurial spin-outs

16 industry fellows & **11** industry sprints

International collaboration

MOU with US on joint battery research on recycling and cathode materials

36 inventions identified

18 patents filed and **6** published

Shaped policy

through **16 Faraday Insights, 10 major reports, 7 national consultations,** numerous briefings including a House of Commons inquiry and a House of Lords inquiry

Hosted 6 Royal Institution Events

attracting **290,000 online viewers**

Last updated April 2023

The Continued Challenge for Batteries

Fit for Purpose

Optimised for Better Performance

Cheaper and Mass Producible

Increasingly Safer, Sustainable and Recyclable

Power Density

4x power density

Now	2035
3 kW/kg (pack)	12 kW/kg (pack)

Energy Density

2x energy density

Now	2035
700Wh/l, 250Wh/kg (cell)	1400Wh/l, 500Wh/kg (cell)

1st Life

Pack life equivalent to life of the car

Now	2035
8 years (pack)	15 years (pack)

Temperature

50% increase in operating temp. range (°C)

Now	2035
-20° to +60°C (cell)	-40° to +80°C (cell)

Cost

2/3 cost reduction

Now	2035
$130/kWh (cell) $280/kWh (pack)	$50/kWh (cell) $100/kWh (pack)

Predictability

Full predictive models

2035: Full predictive models for performance and aging of battery

Safety

Battery packs 'inherently safe'

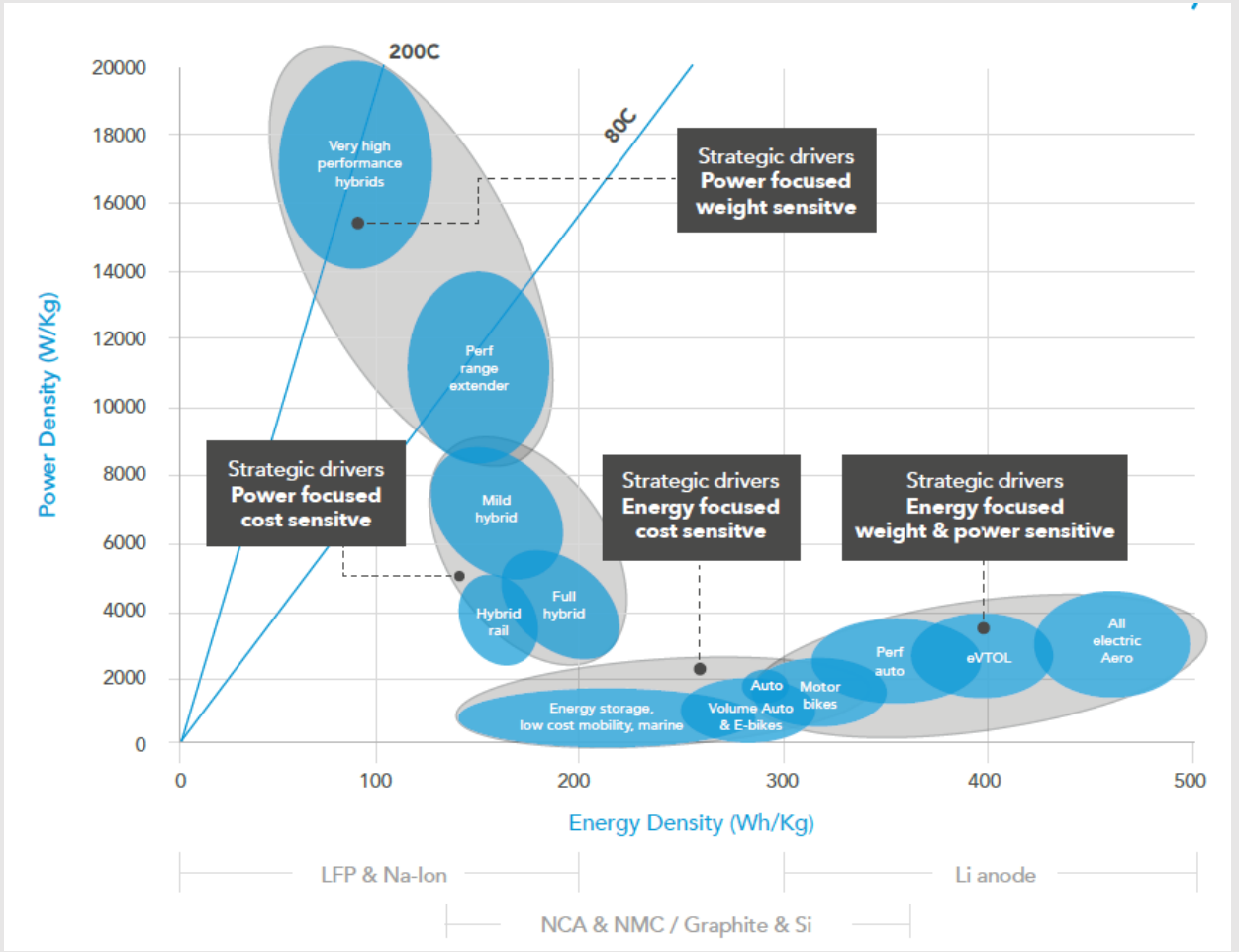
2035: Eliminate thermal runaway at pack level to reduce pack complexity

Recyclability

Closed-loop recycling system in place

Now	2035
10-50% (pack)	95% (pack)

The Great Application Power/Energy/Chemistry Trade-off



Ref: WMG Discussion Document for the UK Battery Community

National Research Programme

Application-inspired programme focused on technical targets

RESEARCH STREAM 1

Lithium-ion

Nearer-term market challenges

Projects optimising current generation lithium-ion based batteries where there are still considerable gains to be made and where breakthroughs could start to be realised in commercial settings within 3-4 years.

In addition, our recycling and reuse project is focused on battery end-of-life and the circular economy.

- Degradation
- Multi-scale Modelling
- ReLiB
- FutureCat
- CATMAT
- Nextrode
- SafeBatt

RESEARCH STREAM 2

Beyond Lithium-ion

Longer-term market challenges

Projects that are higher risk, higher reward and could facilitate the long-term commercialisation of next-generation battery technology that still require considerable research in materials discovery and optimisation.

- SOLBAT
- LiSTAR
- Nexgenna

RESEARCH STREAM 3

Batteries for Emerging Economies

Shorter-term projects focused on reducing the cost and improving the performance of battery technologies for use in developing countries and emerging economies. Funded from UK Aid as part of its Transforming Energy Access (TEA) programme

- RELCo-Bat
- Low-Cost Graphite Polysulphide Single Liquid Flow Battery

April 2020 start | Autumn 2019 start | Oct 2020 start | April 2021 start

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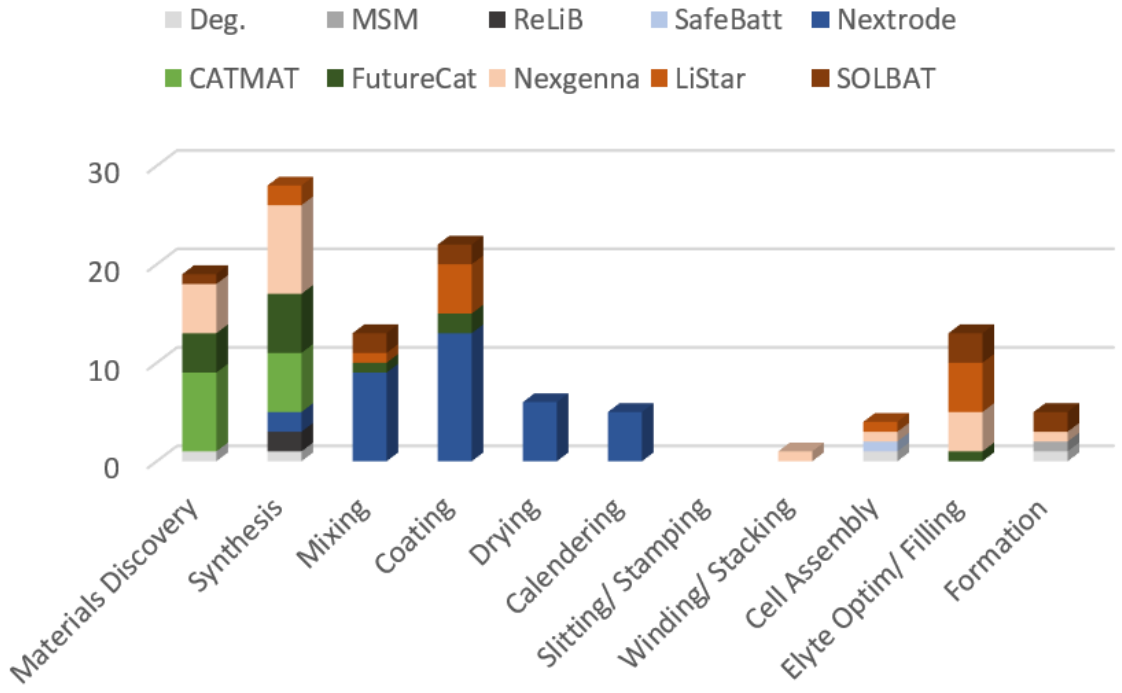
2022/23 FI Project Reshaping – manufacturing process example

Reviewed research alignment to manufacturing process steps across all projects and instigated actions to improve collaboration with UKBIC and industry to focus on major challenges of manufacturing process.

Note some are unique to the flexibility of UKBIC operations

- Manufacturing process: Research project activity

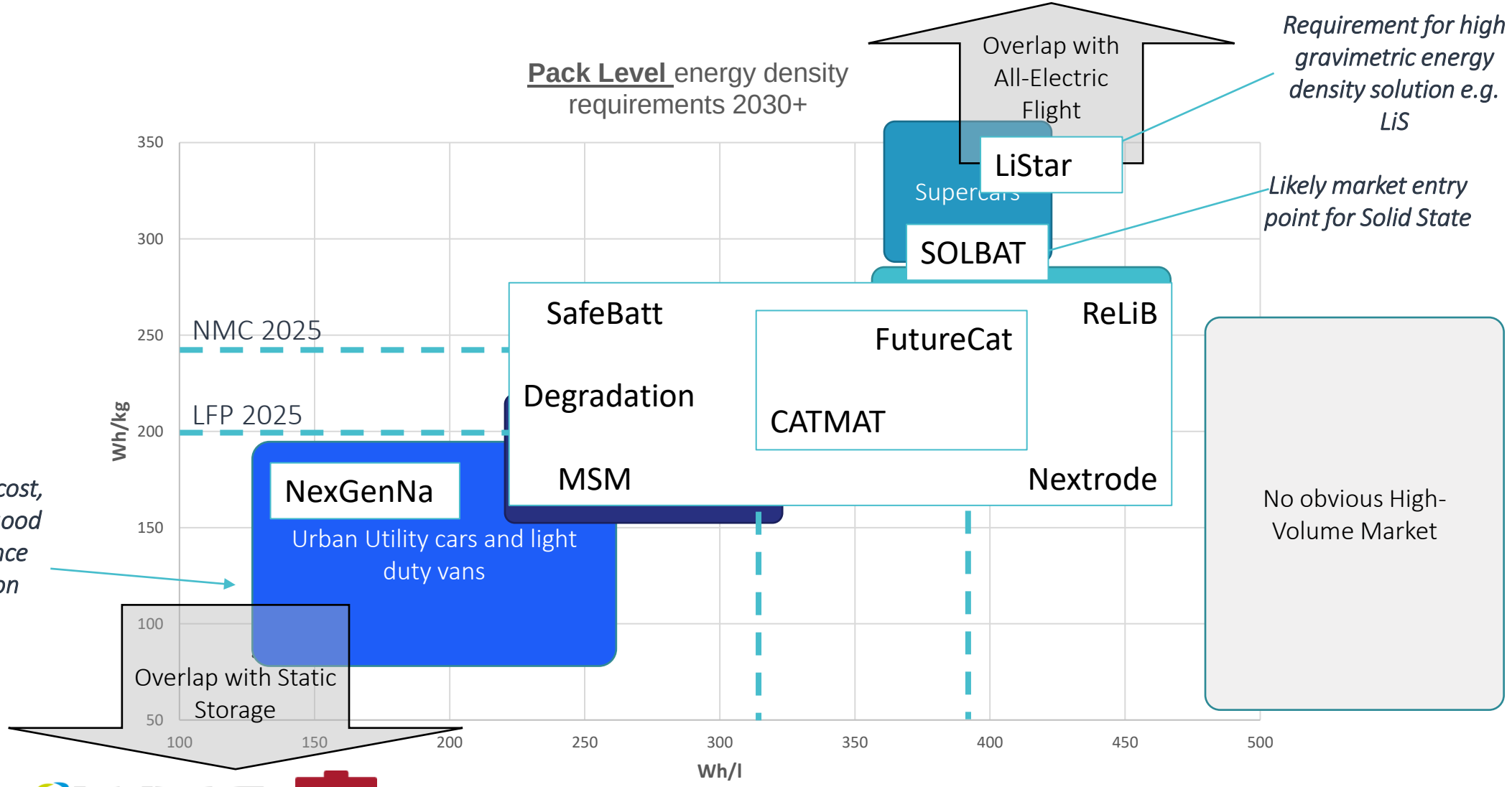
WPs/PDRAs sat across multiple sections are included in each area



- Identified 'Top 6' Manufacturing Research challenges. Work is ongoing to improve FI research alignment in:
  - Formation studies
  - Rheology - mixing
  - Mechanical modelling / Cell design
  - Defects in coatings
  - Calendering modelling

Reviewed alternatives for Slitting/stamping and cell side reactions

- Gaps remain, however in some instances other higher TRL research organisations are better placed to focus in these areas e.g. Laser cutting for Slitting/Stamping linking to Catapults


Pack Level energy density requirements 2030+
Overlap with All-Electric Flight
Requirement for high gravimetric energy density solution e.g. LiS
LiStar
Likely market entry point for Solid State
SOLBAT
SafeBatt
ReLiB
FutureCat
Degradation
CATMAT
MSM
Nextrode
NMC 2025
LFP 2025
NexGenNa
Urban Utility cars and light duty vans
Opportunity for low-cost, highly sustainable "good enough" performance solutions e.g. Na Ion
No obvious High-Volume Market
Overlap with Static Storage
Wh/kg
Wh/l
350
300
250
200
150
100
50
100
150
200
250
300
350
400
450
500

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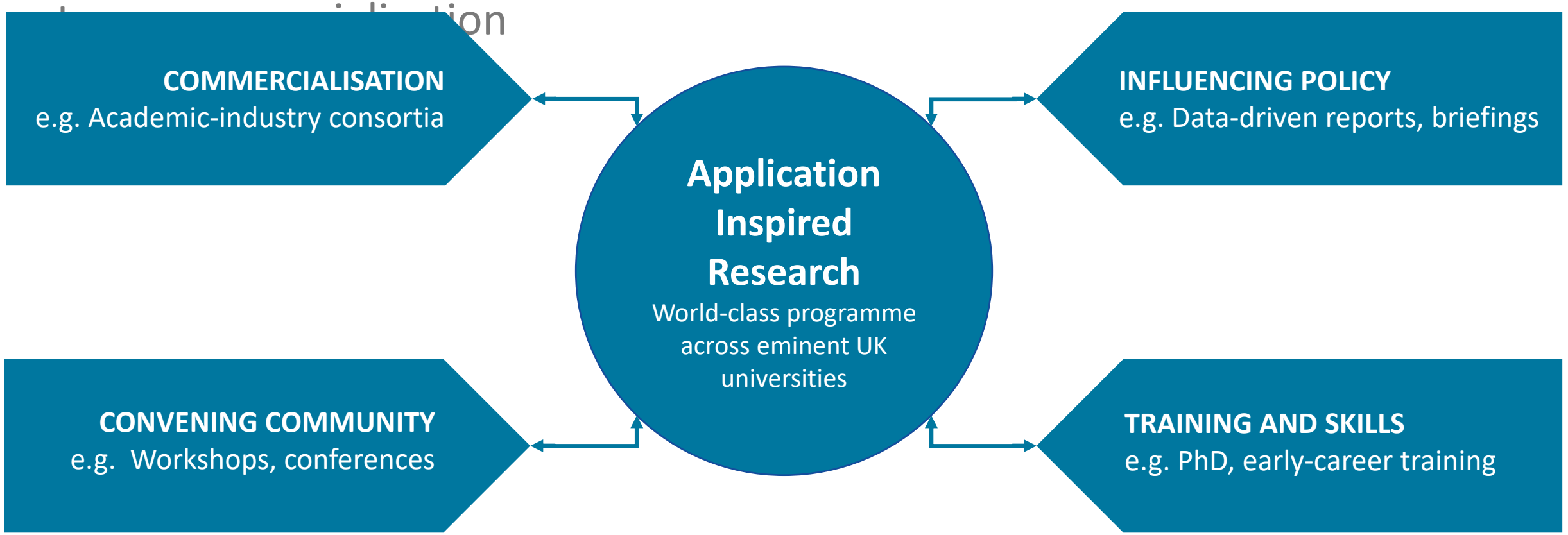
Strategic Priorities

The Faraday Institution is the UK's flagship programme for electrochemical energy storage research, skills development, market analysis, and early-



Maximising UK Economic Impact of Battery Research

35

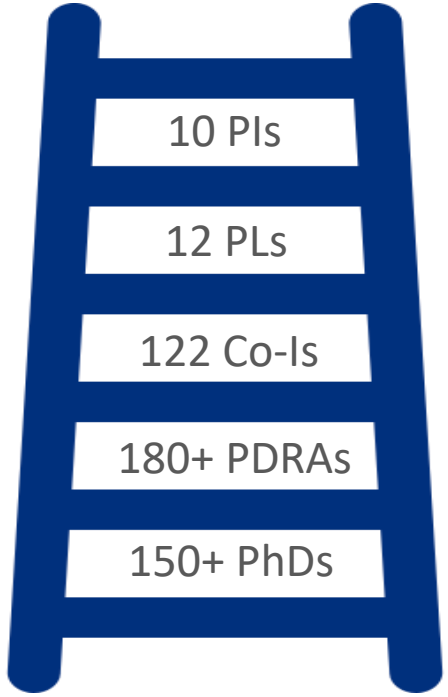
Assembled a World-class Energy Storage Research Community

85

Industry partners

27

Academic & research partners



500+

Researchers from many disciplines

Grown interest and excitement

- Levelling up across UK
- 30% female
- 74% under 40
- 45% new to battery research

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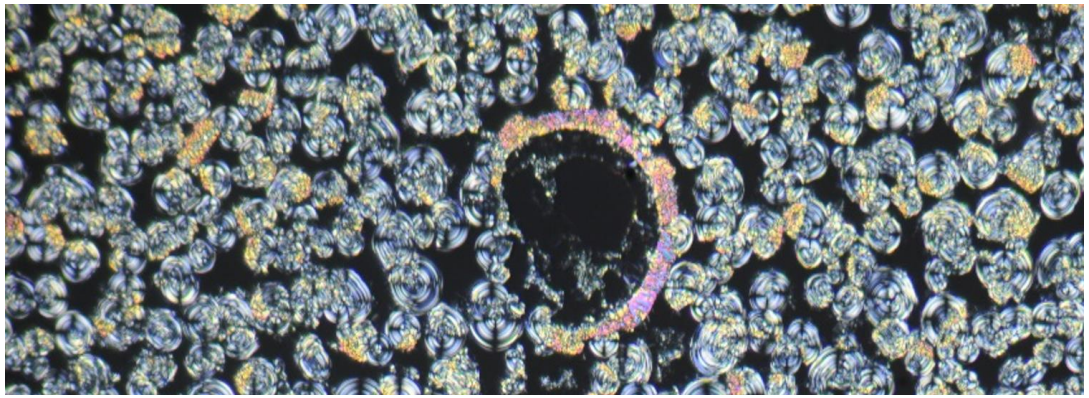
Faraday Institution Research – Smaller Projects

Short, focused research projects and industrial fellowships

Seed Projects

Small, fast-paced, focused projects, widening the organisation's research scope, and set of university partners, in an initiative that will inform future research priorities



Entrepreneurial Fellowships

Providing start-ups in the area of energy storage technologies with financial and business support to drive battery innovation

Industry Sprints

Focused projects where short-term research needs have been identified by industry, which lie within the broad scope of FI research projects, and which are of wider interest to industry

Industry Fellowships

Enabling academics and industrialists to undertake mutually beneficial and collaborative energy storage research projects

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Faraday Battery Challenge - 2

UK Battery Industrialisation Centre

Open access, scale up centre, rapidly moving products to market

UK BATTERY INDUSTRIALISATION CENTRE

Faraday Institution

Harnessing the strengths of the UK research base

THE FARADAY INSTITUTION

Engineering and Physical Sciences Research Council

Collaborative R&D

Creating new solutions and demonstrations

Innovate UK

UK Research and Innovation

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Dr. Graeme Cruickshank

Chief Technology &
Innovation Officer
CPI

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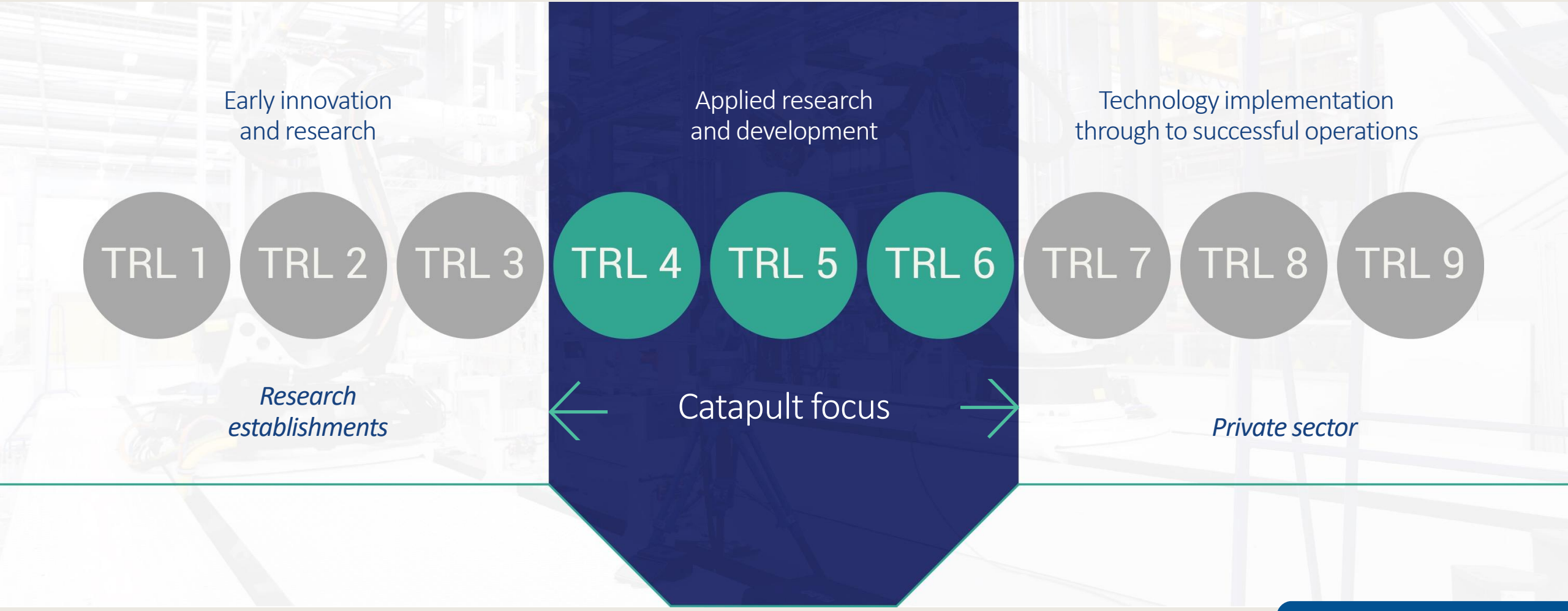
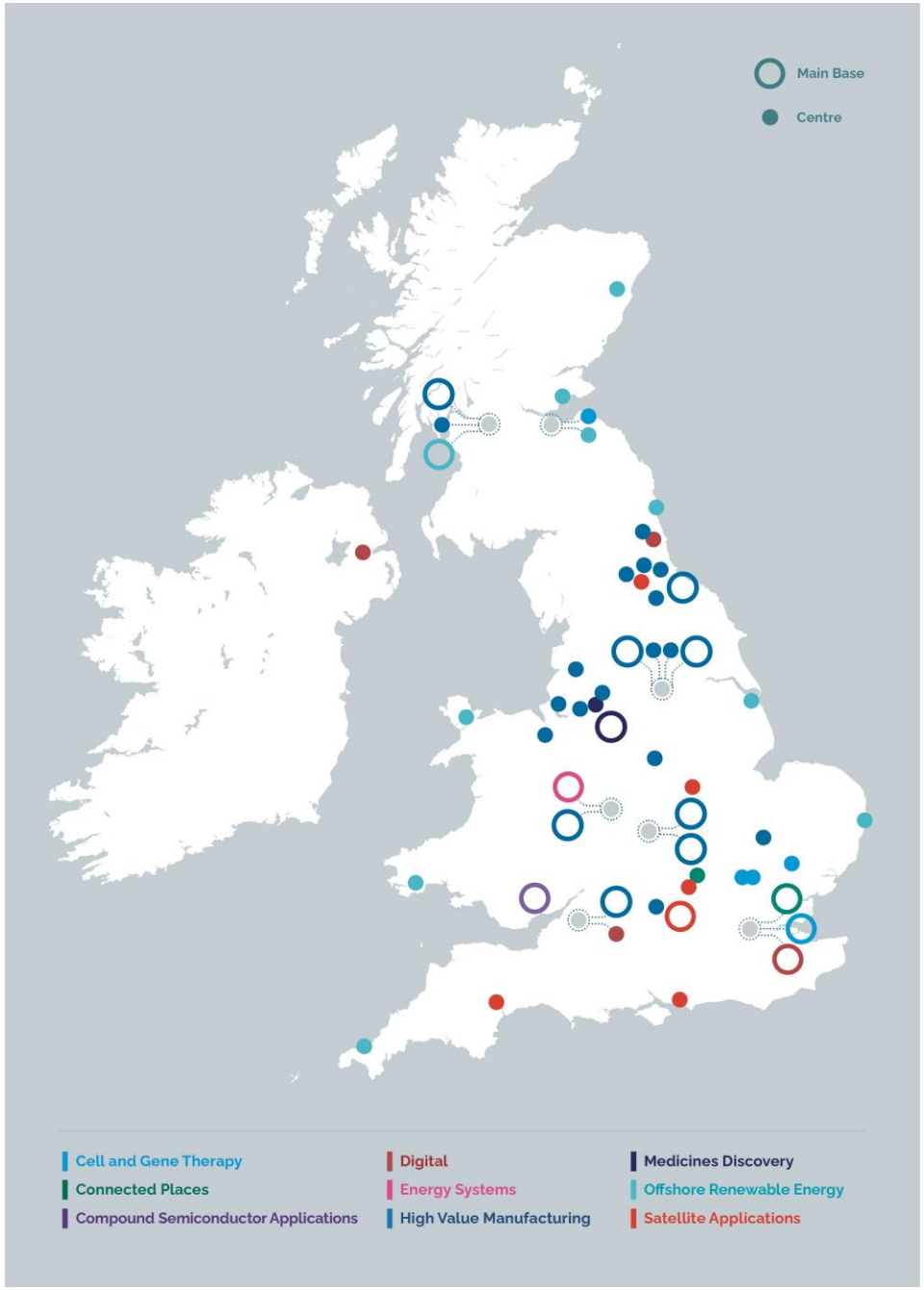
Market failure: Bridging the Valley of Death





CATAPULT
High Value Manufacturing

…part of the UK's Catapult Network

We help companies to develop, prove, scale-up and commercialise new products and processes

Let's innovate together
www.uk-cpi.com

cpi

State-of-the-art facilities and offices across the United Kingdom

Let's innovate together
www.uk-cpi.com

cpi

Proof of concept and scale-up

to prove the feasibility of your new ideas before approaching investors, stakeholders, or funding programmes

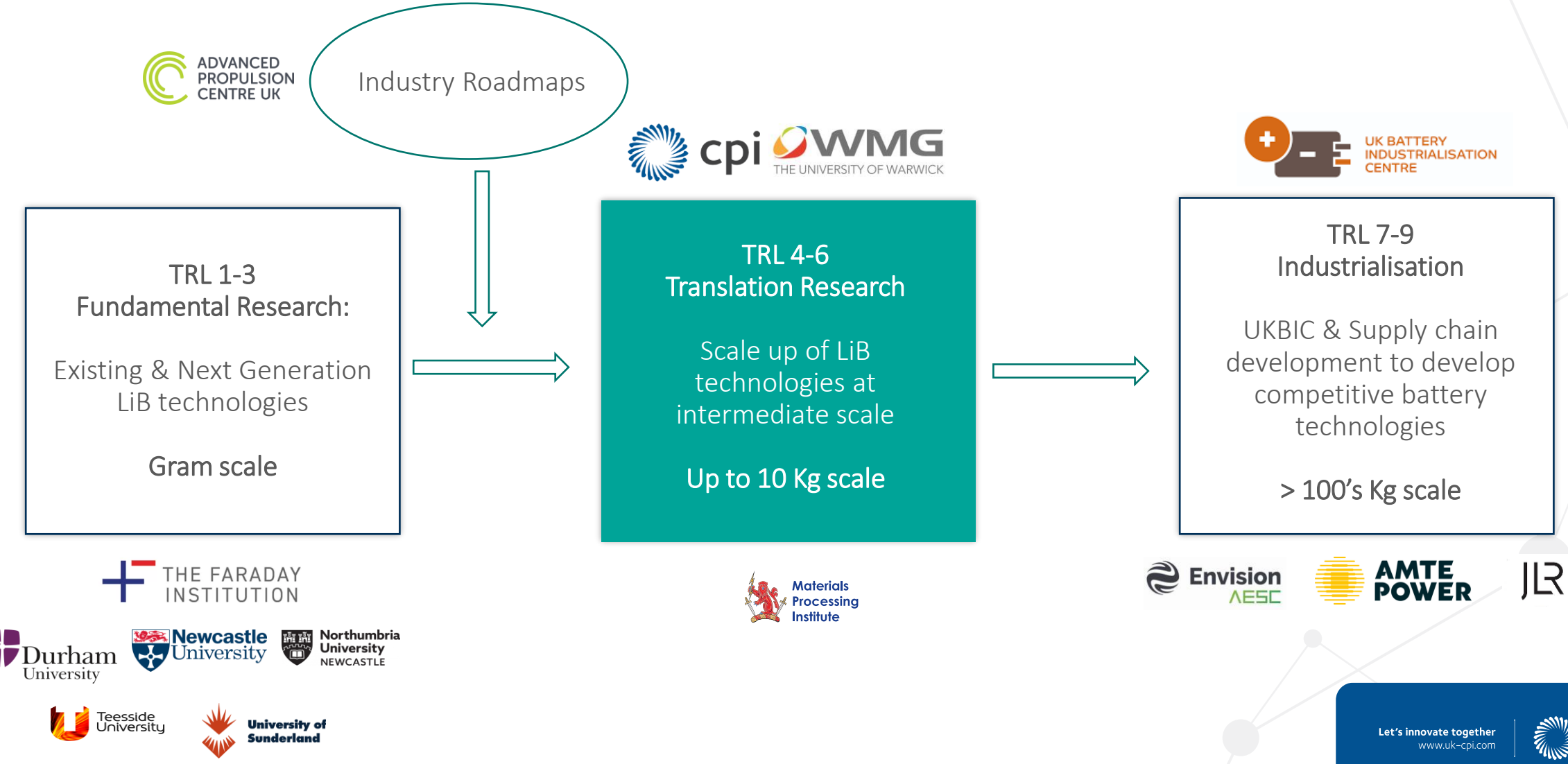
Reduce risk

by helping prove and refine your novel technologies before investing further in new facilities and equipment

Decreasing time to market

by providing access to proven demonstration assets and industry expertise

UK Battery Ecosystem



Our battery materials innovation capabilities

Leverage assets and expertise across the Catapult Network

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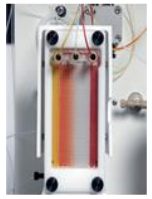
WMG Innovative Solutions

Synthesis | Formulation | Electrode Fabrication | Cell Assembly | Cell Testing and Forensics







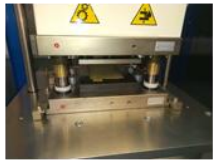










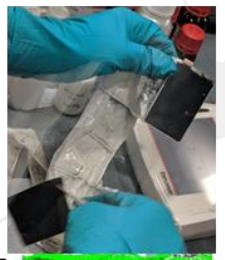
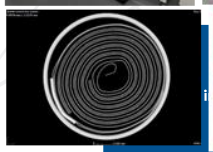
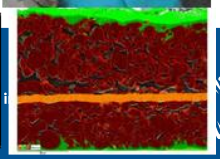










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CPI areas of battery materials innovation

Materials

CAPABILITIES

- Development support in **scalable processes** for existing and next-generation electrode materials, including solid-state batteries and the **recovery of high-value battery electrode materials**
- **Surface engineering** of materials and structures to maximise performance

Formulation

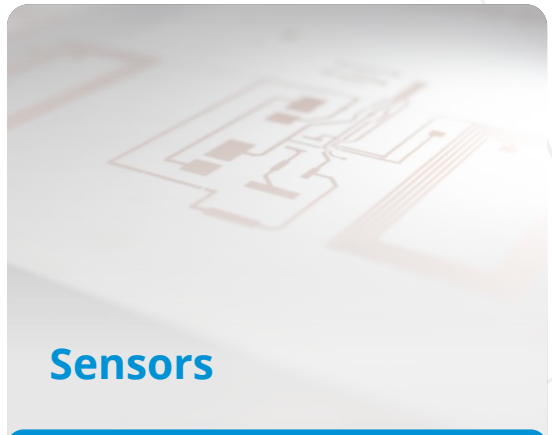
CAPABILITIES

- Utilise **automated formulation** to screen and optimise existing chemistries
- Processing with a wide range of **mixing technologies** to maximise performance from grams to kilograms
- Optimise the evaporation and drying of **slurries**

Coating and structuring

CAPABILITIES

- **Wet coating, and vacuum deposition** process development and optimisation
- Photonic and plasma processing for **improved surface adhesion** and increased efficiency
- Optimisation of electronic **structures and interfaces** to obtain the maximum benefits in electrode performance



Sensors

CAPABILITIES

- Developing **Integrated and multifunctional smart sensors** for high-value battery management solutions
- Distributed solutions to enable individual **cell monitoring**
- **Embedding intelligent sensors** in cells to better inform second-life applications

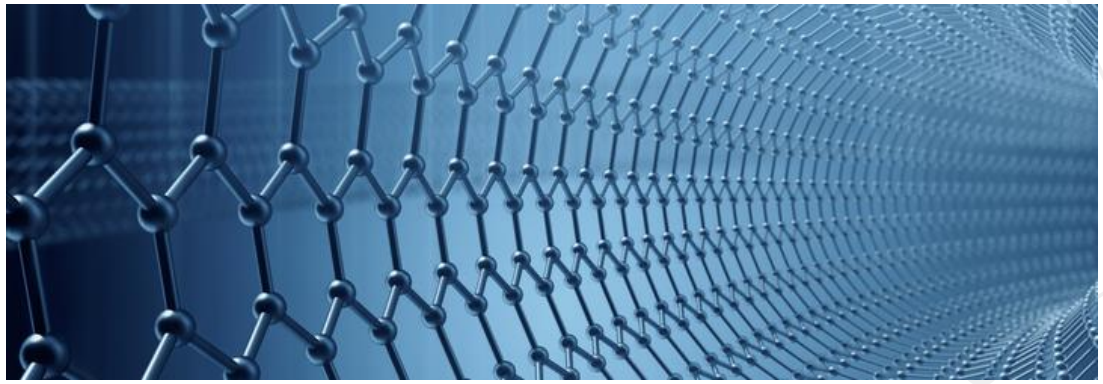
Accelerate and validate your development journey for novel battery material technologies and demonstrate early stage feasibility of any electrode coating production underpinned by Data Science Capability

Innovating together with CPI

CASE STUDY

Enhanced cathode materials for optimised battery packs

Optimising existing Li-ion cathode materials, exploring the use of greener solvents for electrode formulation and innovative carbon additives such as graphene and carbon nanotubes in the electrode structure.



JM Thomas Swan UKRI Innovate UK

Collaborative R&D project

18 months

£810,000

Outcomes and impact

- *Incorporated innovative carbons into cathode films which enhanced electrochemical performance*
- *Identified a green solvent (alternative to NMP) for cathode production using high throughput experimentation*

Optimisation of battery materials

Developing safer and higher performance cathodes

Innovative carbon functionalisation

Powder characterisation and functionalisation of graphene nanoplatelets and single-walled carbon nanotubes.

High-throughput formulation

Intelligent, high throughput formulation of cathode slurries to incorporate innovative carbons.

Exploited rheology and particle dispersion properties to identify potential candidates.

Rapid solvent screening

High-throughput screening and characterisation of green solvents for cathodes (with attributes similar to traditionally used NMP) using Hansen Solubility Parameters and Principal Component Analysis.

Electrode screening

Analysed coating using SEM to understand morphology of electrodes.

Devised a micro coating adhesion strength test method to analyse coating.

Coin cell performance

Prepared coin cells using electrode films for electrochemical performance evaluation including Electrical Impedance Spectroscopy and cell cycling to measure energy capacity.

Here to help your business

Knowledgeable support, resources and facilities

Raise investor confidence by **generating robust data**

Access our comprehensive **network of investors**

Flexible project **resources** and **service options**

Reduce risk and decrease your time to profitability

Connect with the wider **supply and value chains**

Support in navigating the complex **grant funding landscape**

Let's innovate together
www.uk-cpi.com

cpi

Faraday battery challenge round 6 competition

UK registered businesses can apply for a share of up to **£10 million** for innovation in battery technologies for electrification.

Two strands: Feasibility Studies & CR&D

Deadline: **12 July 2023**

Aims of this competition are to:

- accelerate development and commercialisation of state-of-the-art battery technologies in the UK
- support growth of the supply chain and companies in the UK battery sector
- increase UK competitiveness in the global battery industry
- demonstrate ability of battery technologies to meet the needs of specific applications

Please come and speak to us on how we can support you!

Thank you

For more information visit **www.uk-cpi.com**

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NEBA
NORTH EAST BATTERY ALLIANCE

Keith Merrin

Steam to Green
Director, Tyne & Wear Archives & Museums

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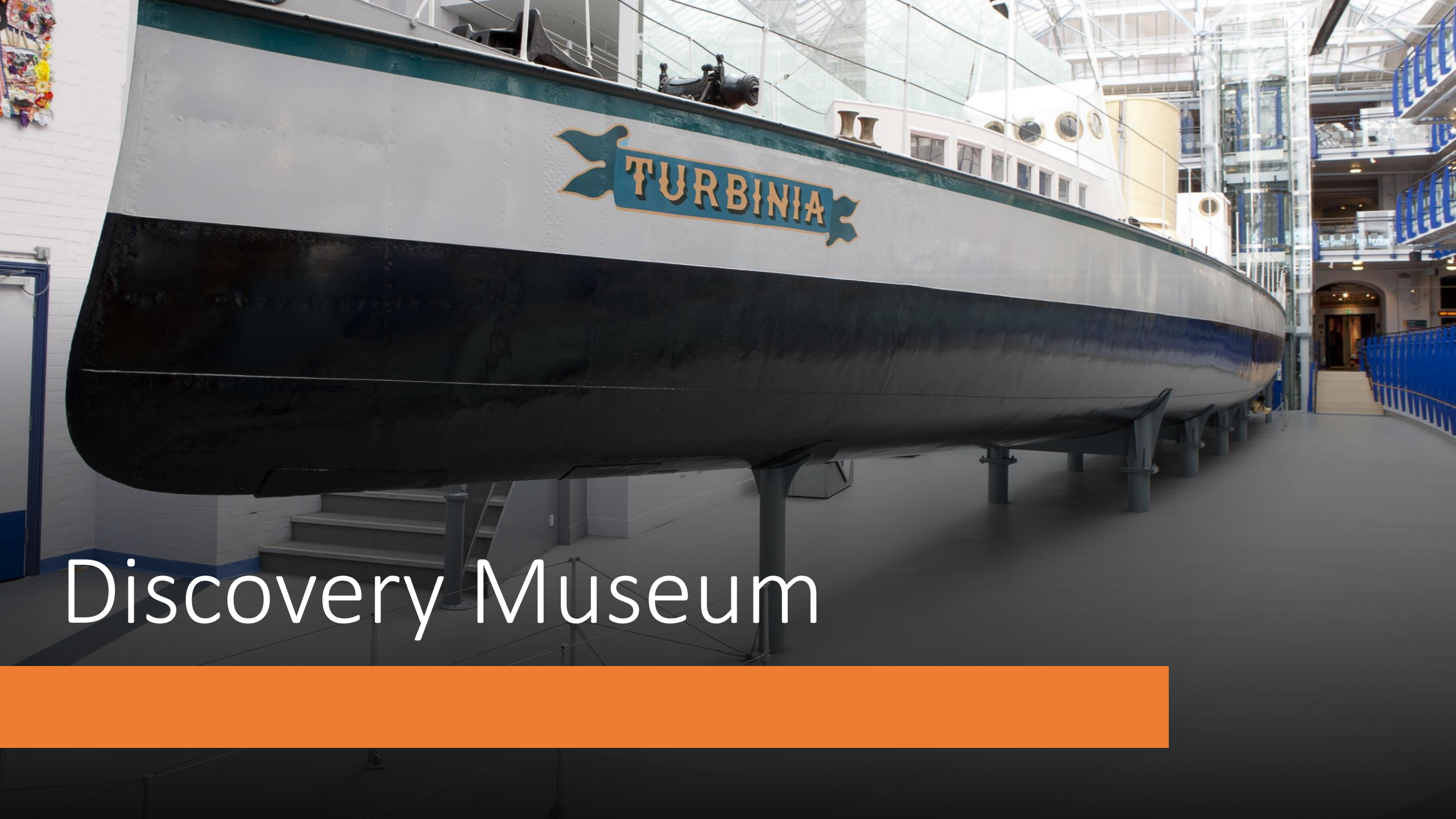


Discovery Museum

Discovery Museum collections consist of;

- Science and Industry
- Maritime
- Social History
- Costume and Textiles

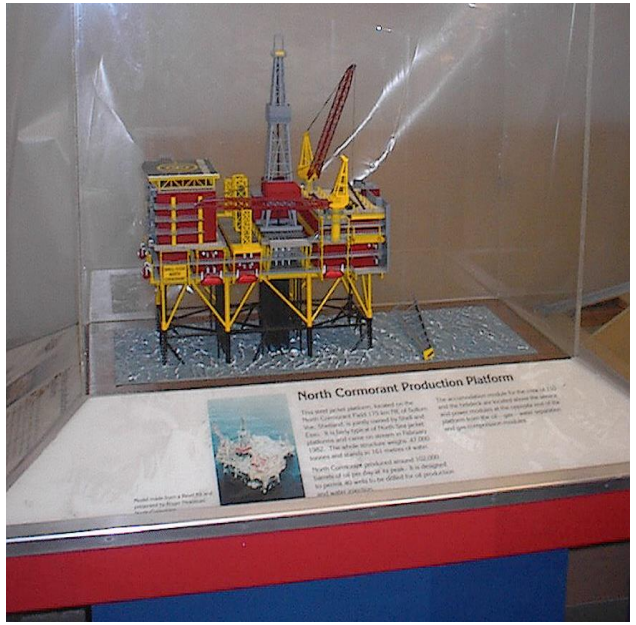
We collect items that have a strong Tyneside link

Science and Industry

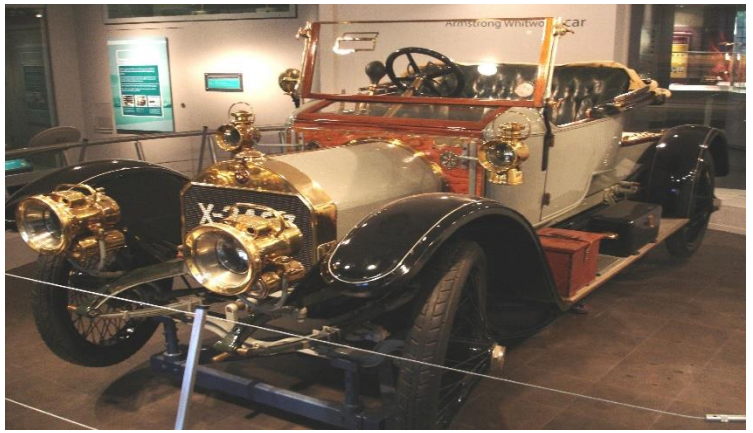
- 43,484 items
- There are items relating to; railways, electrical engineering, medical science, civil engineering, coal-mining, mechanical and marine engineering and manufacturing.
- The big local stories. Invention of the miners' safety lamp, pioneering work in the electricity grid, Stephensons' work on locos and railways and the invention of the lightbulb.


STEAM
TO
GREEN

How do we generate energy?



How do we get around?



How do we use energy in the home?

Who we want to reach?

STEAM TO GREEN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Have a safe journey home

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