UK supply chain opportunity for rare-earths and permanent magnets

Dissemination webinar 18th August 2022

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Innovate UK KTN exists to connect innovators with new partners and new opportunities beyond their existing thinking – accelerating ambitious ideas into real-world solutions.

Net Zero | Diversity & Inclusion | Global Innovation | Innovation Adoption & Diffusion | Place

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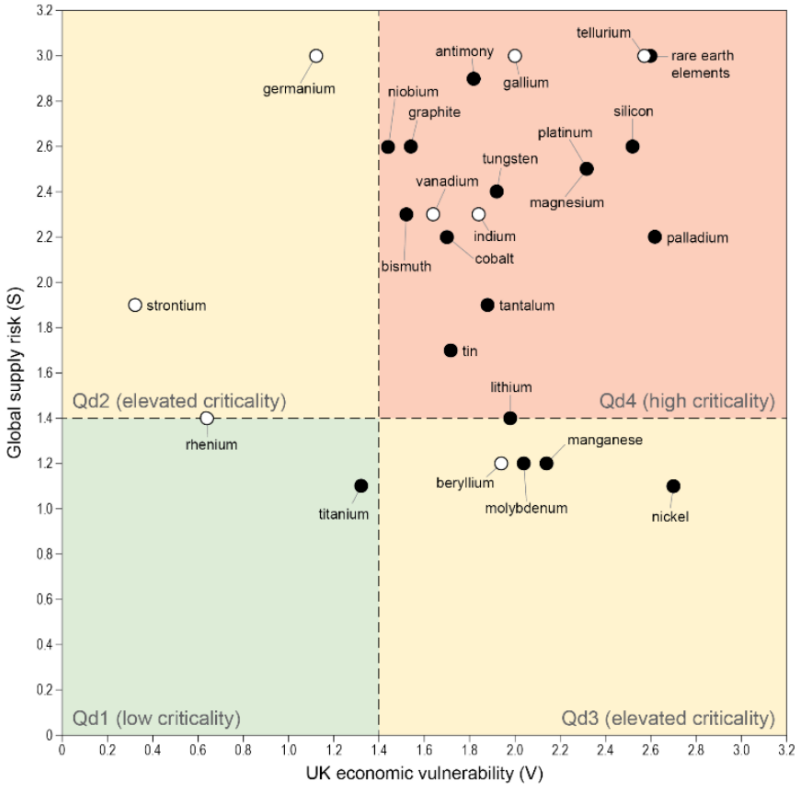
Summary

- Electrification and decarbonization commitments leading to increased demand for a range of raw materials
- Global supply chain instability and geopolitical shocks
- Raw material production and processing largely wound down in the UK since the 1980s
- UK science, innovation and manufacturing base vulnerable to supply shocks
- Recent UK criticality assessment published by BGS, commissioned by BEIS, shows rare earth elements high on the list
- IUK KTN working with IUK Driving the Electric Revolution team to scope out the UK opportunity in the supply chain for rare-earths, primarily for use in permanent magnets
- We are sharing here our findings and the direction of travel over the coming years
- **We want you to reach out to us if you want to get involved! Download the report - rebrand.ly/ktnmagnets**



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Background

- High performing permanent magnets, made from alloys containing the elements NdFeB (and small amounts of others e.g. Dy), are used in many important applications
- Nd, Dy are “rare earth elements”, produced and supplied to the market almost exclusively by China
- The supply crisis of 2010/11 highlighted the vulnerability of supply of these critical materials for several important manufacturing processes conducted outside of China
- We are interested in the question of what the opportunity is for the UK to become more involved in the supply chain for REEs, as other countries ask the same question of themselves
- We broke the question down into 4 parts:
  - Global Market trends and opportunities
  - Chemical treatment and refining of primary supply
  - Recycling of REE-containing magnets/devices for secondary supply
  - Research into next-gen magnet materials

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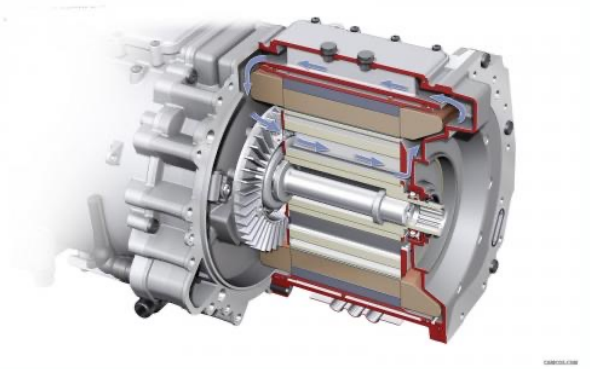
Why rare earths?

- Current designs of many important technologies from electric motors, wind turbines and consumer goods, rely on the high performance characteristics of rare earth permanent magnets
- High magnetic energy density, high coercivity, and performance at elevated temperatures
- Rare earths are amongst the most difficult metals to extract from mines, using a convoluted, energy intensive chemical treatment and separation process
- Recycling methods are underdeveloped
- Hence there is significant opportunity for the UK to deploy its expertise and research assets to innovate in these areas and establish market share
- This becomes a matter of **strategic importance**, dollar values of magnet markets will always look small in comparison to batteries for EVs, renewable energy production, etc. but they are an integral component of these!



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Market outlook and opportunity

- Rare-earth metals market is projected to grow from $2.8bn to $5.5bn by 2028 at a CAGR of 10.0 %
- The market in APAC (Asia-Pacific) is projected to grow at a the fastest rate, APAC being the largest region for rare earths production and consumption. North America is expected to be the second-largest region for the rare-earth metals market.
- Increasing use of rare earths in end use applications such as permanent magnets, metal alloys, phosphors, catalysts, polishing, and glass additives
- One concern over rare earths is that materials are traded privately not on the open market
- Several companies and projects being developed in Australia (Lynas Rare Earths), Africa (Rainbow Rare Earths), Canada (Avalon Advanced Materials), US (MP Materials) and Europe (Greenland Minerals) looking to secure rare earths supply outside APAC
- Supply of rare earths is considered a risk for OEMs who are looking to diversify their supply chains

Recommendation

Studies into the development of incentives for OEMs to support market development in the UK for magnet production and end of life management.

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Chemical Processing and refining of primary supply

- Several process steps are required to extract pure REE powders from mining output
- 2 steps of interest are strong alkali/acid treatment, and the solvent extraction process
- These both have bad ESG credentials and have innovation potential
- Some orgs in UK already have interest in innovating in this space at relatively high TRLs, and there are a number of burgeoning new treatments at lower TRLs
- Current methods are intensive in either solvent use or energy use - difficult to make UK the go-to place for deploying current methods
- Could we become the go-to place for deploying next-generation processing and refining if we can invent and develop the IP here? Already have leading expertise in metal refining and green chemistry

Recommendation

Collaborative Research and Development programme focused on new innovations for the chemical treatment and separation of REEs, with a particular interest on the development of more sustainable processes than those currently in use.

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Recycling of RE-containing products for secondary supply

Currently less than 1 % of magnets are recycled

- Economically unfavourable, difficult to collect material
- Little support for developing novel processes
- Processes not demonstrated at scale

UK Opportunity

- Industrial magnet recycling; known volumes, composition, ease of collection
- Large volumes of magnets in wind turbines - about to come offline (keep in UK!)
- Several UK based companies with technology being utilised / developed in adjacent industries
- Introduces an alternative supply of rare earths to a UK magnet industry
- Establishing a secondary supply chain could stimulate further innovation in magnet production and refining

Recommendation

Feasibility studies leading to CR&D funding to explore the development and demonstration of recycling processes for rare earth materials from a variety of sources.

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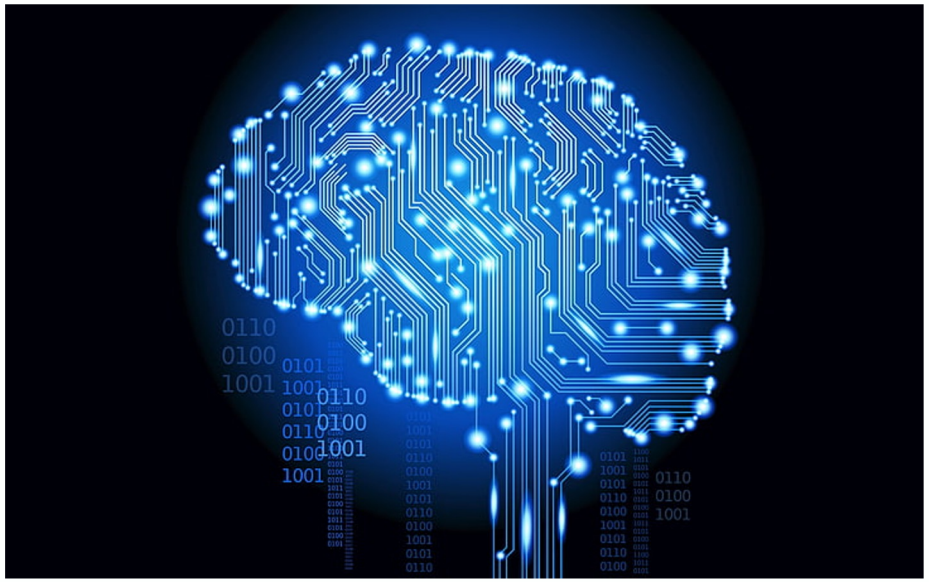
Next generation magnet materials

- Current design (NdFeB) invented in response to a supply crisis of cobalt in late 1970s
- Supply crisis of 2010/11 in REEs prompts us to consider the potential for inventing a new design (history repeating itself?)
- NdFeB has high magnetic energy density and high coercivity
- Rare-earth free permanent magnets offer worse performance characteristics on at least one of these fronts
- Very challenging task for materials science - computational high throughput screening of material designs plus experimental verification of magnetic properties
- UK has world leading expertise in these areas - does not appear that it is being deployed to this challenge currently



Recommendation

Coordination and application of UK research infrastructure to the materials science challenge of creating the next generation of magnet materials, utilising established UK strengths in computational and experimental materials development.

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Next generation magnet materials

1. Collaborative Research and Development programme focussed on new innovations for the chemical treatment and separation of REEs, with a particular interest on the development of more sustainable processes than those currently in use. (*EPSRC, IUK, CPI, IUK KTN)*
2. Feasibility studies leading to CR&D funding to explore the development and demonstration of recycling processes for rare earth materials from a variety of sources at scale. (*EPSRC, IUK, CPI, IUK KTN*)
3. Address a market coordination failure by running community-building activities to connect the chemical and material sectors to magnet manufacturers and end-users to explore, develop and integrate the rare earth magnet opportunity across the supply chain. (*IUK, IUK KTN*)
4. Studies into the development of incentives for OEMs to support market development in the UK for magnet production and end of life management. (*IUK, IUK KTN*)
5. Coordination and application of UK research infrastructure to the materials science challenge of creating the next generation of magnet materials, utilising established UK strengths in computational and experimental materials development. (*EPSRC, IUK, STFC, MIF, CPI, IUK KTN*)

Short - medium term

Long term

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What next?

- Disseminating the findings and recommendations
- Engage key stakeholders in the innovation ecosystem
- Deeper dive into the technology areas
- Engage with you!
- Programmes of support and funding are in the pipeline through various routes for this topic – please do get in touch if you want to find out more and get involved – matthew.reeves@ktn-uk.org

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Driving the Electric Revolution:

An introduction

Venn Chesterton - Deputy Director

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Driving the Electric Revolution - Summary

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Power Electronics, Electric Machines and Drives (PEMD)

Identify key gaps in the UK PEMD supply chain and **help industry** fill them enabling delivery of **Net Zero**

Funding for industry

Investing **£80m of ISCF funding** for R&D projects, **accelerating and de-risking** business innovation

Networking and collaboration

Connecting industry, academia, RTOs & the government to ensure **cooperation & collaboration** to efficiently use solutions across the UK

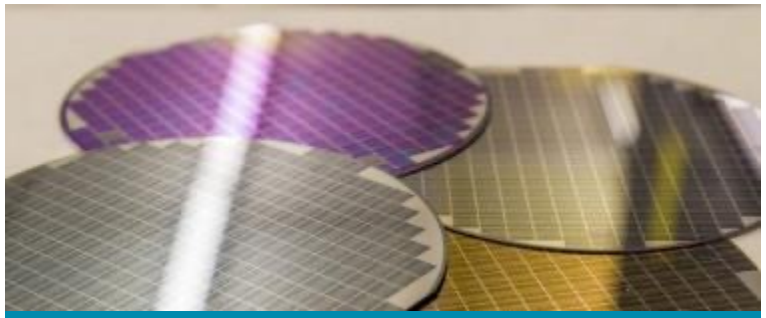
Industrialisation and manufacturing

Leverage the **UK's world leading research** capability in PEMD to **create the supply chains necessary to manufacture PEMD** products

Talent growth

Define & **fill the PEMD skills gap** by **training, upskilling & reskilling** to **grow an evolving diverse & inclusive PEMD workforce** across all levels

Driving the Electric Revolution – Supply chain

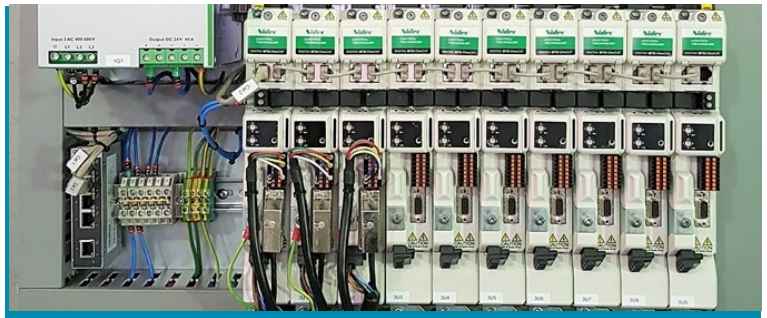


Power Electronics

Development of semiconductors (Si, SiC, GaN) and their packaging to enable switching of high power (voltage and/or current) whilst minimising loss

Electric Machines

Conversion between electrical energy and kinetic energy through electromagnetic, mechanical & thermal design optimised for each application



Drives

Intelligent digital control systems embracing power electronics, passive components, thermal management, mechanical design and the overall system

Manufacturing supply chain

Materials processing

Component manufacture

System integration

Re-use and recycling

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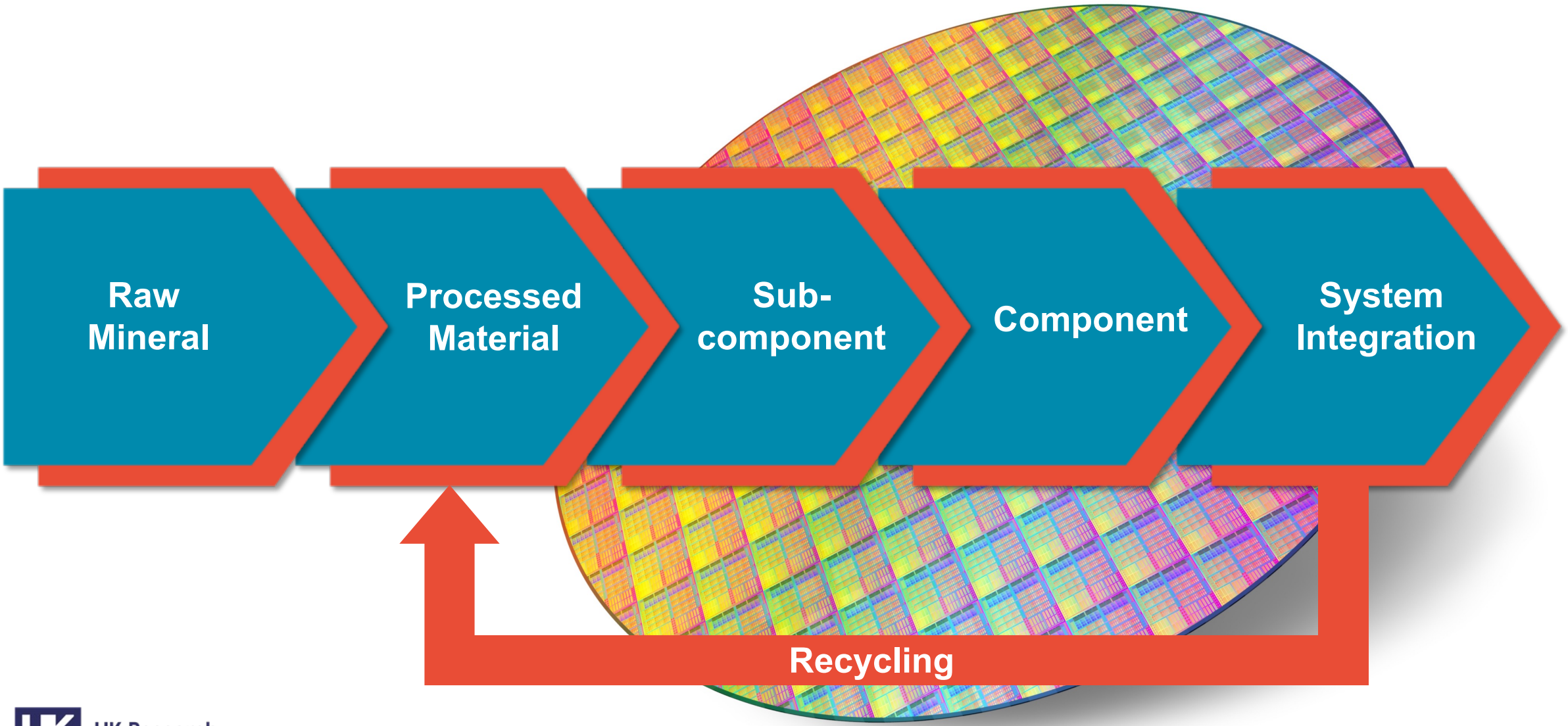
Supporting whole process, materials to product



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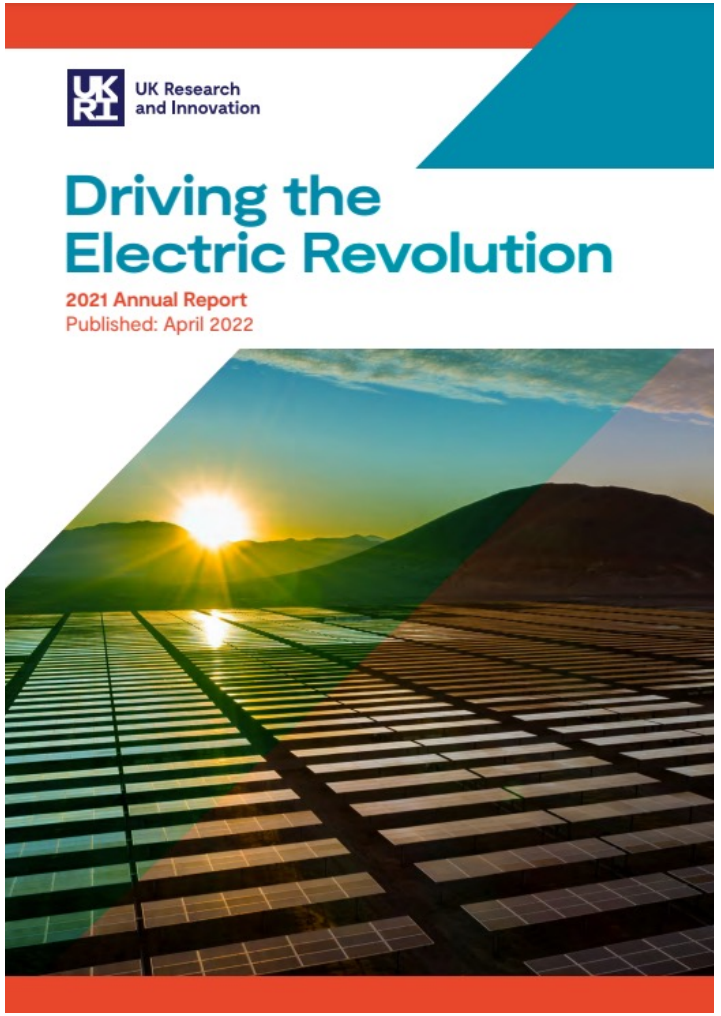
Driving the Electric Revolution Annual Report

- Contains details of all Driving the Electric Revolution funded projects and partners from across the UK PEMD community
  - Over 60 funded projects across CR&D and skills initiatives
  - Over 100 funded project partners



For details of funded projects please see our annual report:

https://www.ukri.org/wp-content/uploads/2022/05/UKRI-03052022-DER_Annual_Report_21.pdf/

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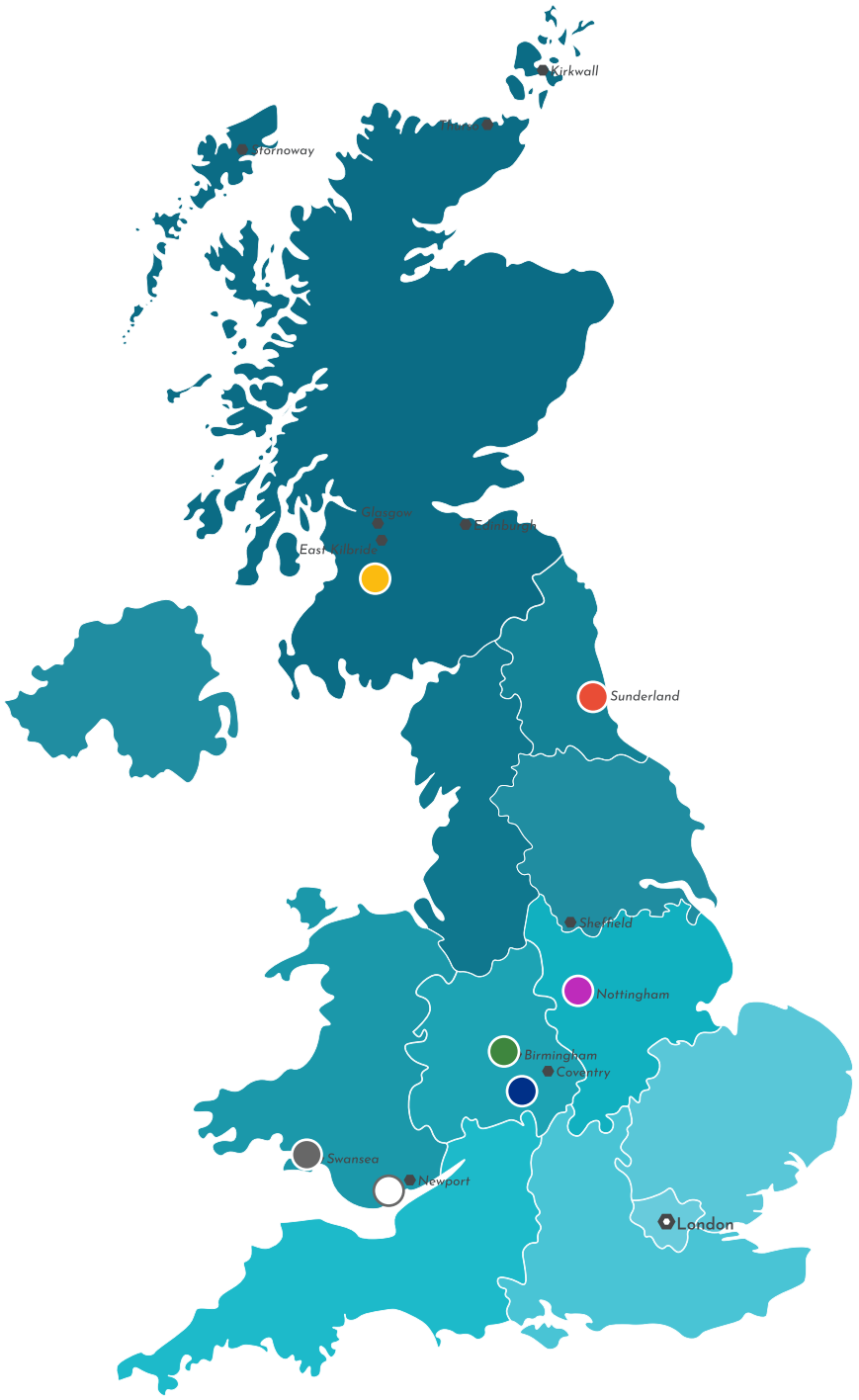
DER-IC Industrialisation Equipment

- **The University of Strathclyde**
  Propulsion and powertrain systems validation capability at MW scale with hardware in the loop.
- **The Innovation Centre, Sunderland**
  Reconfigurable Power Electronics assembly line and a flexible electric machine assembly line.
- **University of Nottingham PEMC Centre**
  A high frequency coil manufacturing and magnetic test characterisation.
- **University of Warwick**
  A power electronics reliability and failure analysis facility and a Winding Centre of Excellence facility.
- **The University of Birmingham**
  A production line to for recycled sintered magnets with ‘end to end’ supply chain to enable UK supply of recycled rare earth magnets.
- **Swansea University**
  A Wide Bandgap Power Electronics Component Industrial Pilot Line.
- **Compound Semiconductor Applications Catapult**
  A facility to prototype ceramic and copper elements and sub-assemblies within highly integrated PE modules.



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DER
Driving the Electric Revolution
Industrialisation Centres

Manufacturing Scale-up for Net Zero Competition Summary – subject to change

- Focus on UK PEMD supply chain and manufacturing capability growth

Strand	Scope	Project grant	Project duration
1	Cross-sector innovations to enable manufacturing best-practise	£50k - £400k	6-12 months
2	Manufacturing process development for scale-up	£50k - £800k	6-18 months

- Business-led and collaborative
- No total project cost limit (note grant limit per project for each strand)
- Demonstrable benefit to UK PEMD supply chain
- Credible post-project investment plan

Competition opens: **12 Sept 2022**

Competition briefing: **12-20 Sept 2022**

Competition closes: **7 Dec 2022**

Projects start by: **1 May 2023**

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Collaboration building and briefing – Register now

In-person events will be held across the UK

- **13 September 2022 – Nottingham**
- **15 September 2022 – Newport**
- **21 September 2022 – Strathclyde**
- **22 September 2022 – Newcastle**

https://ktn-uk.org/news/driving-electric-revolution-scale-up-pemd-competition-briefing-event-series/

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Q&A

Download the report -
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