Insight report

Rare-earth resilience for UK's automotive industry

ADVANCED
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Contents

Department for
Business & Trade

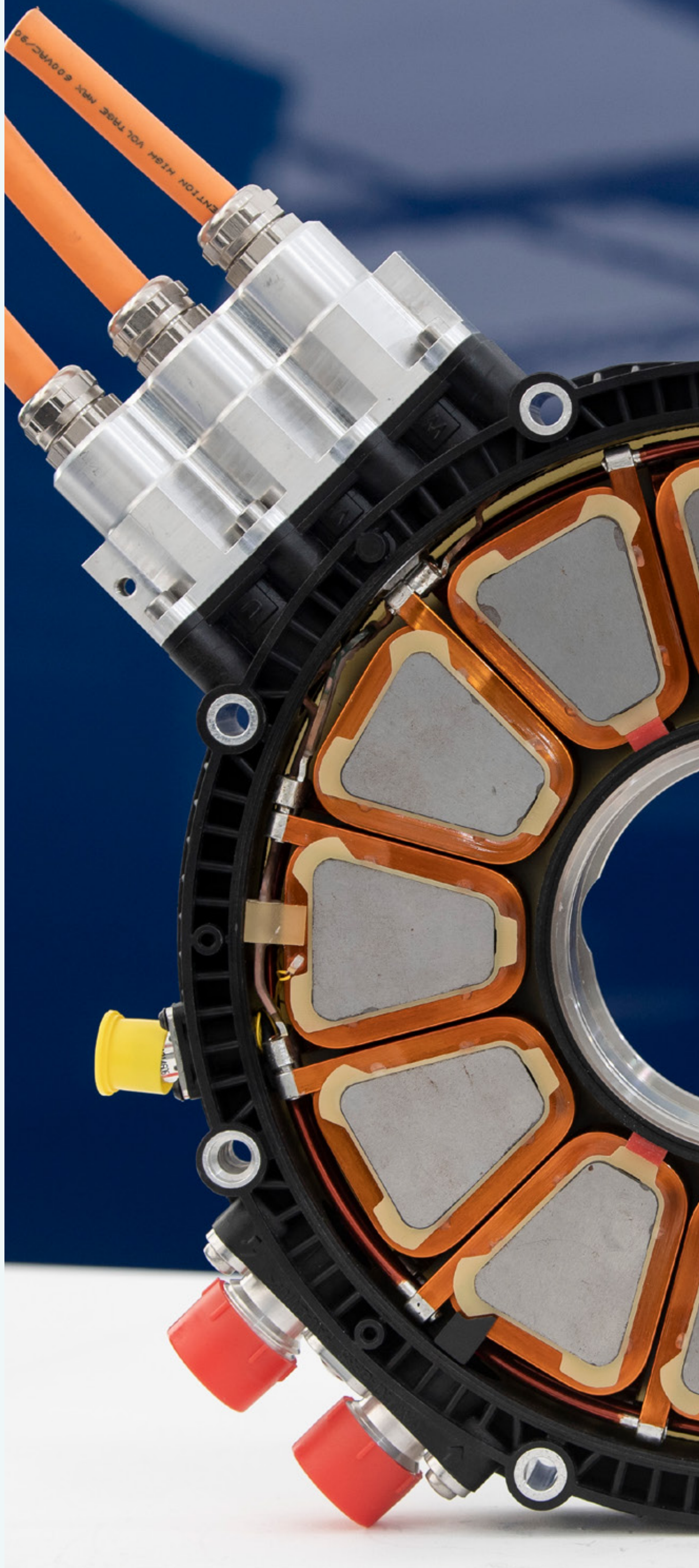
The Advanced Propulsion Centre UK (APC) operational costs are funded by the UK Government's Department for Business and Trade (DBT) and industry contributions. DBT is the ministerial department for economic growth, supporting businesses to invest, grow, and export, creating jobs and opportunities across the country. Our combined mission is to accelerate the development of advanced propulsion technologies to reduce greenhouse gas emissions, minimise embedded carbon, and improve air quality.

Introduction

Traction electric motors are the powerhouse of battery electric and hybrid cars. Thanks to major leaps in technology, these motors are now incredibly efficient and deliver impressive performance. E-motors are highly efficient with more than 95% of the electrical energy converted into mechanical energy. This is primarily due to the usage of permanent magnets within the rotors of E-motors, which provides high power to weight ratio (kW/kg) that are critical for automotive applications.

The E-motors used in electric vehicles (EVs) fall into three major categories: permanent magnet synchronous motors (PMSM), Electrically Excited Synchronous Motors (EESM), and induction motors (IM). PMSM is the dominant type used in the industry. PMSM uses, as the name suggests, permanent magnets that are made of rare-earth materials like neodymium (Nd) and Praseodymium (Pr). Though the rare-earth materials themselves are not rare to extract, they are currently sourced and refined from a single nation China. More than 90% of the refinement of the rare-earth materials are done in China, that has caused supply chain risks and vulnerabilities due to the recent tariff and geopolitical issues.

Since 2025, there has been a strategic, coordinated effort across nations to increase magnet supply and enhance its resilience. This includes efforts to recycle permanent magnets from end-of-life applications in EVs, wind turbines and consumer electronics. Also, to move towards rare-earth-free motors, that will diversify the technologies used for automotive applications. The report will discuss the landscape of permanent magnet recycling within the UK supply chain and provide an overview of advances in rare-earth-free motor technologies that are being innovated and adopted by the industry.



Executive Summary

The accelerating transition to electric mobility and renewable energy is driving unprecedented demand for rare earth permanent magnets, particularly neodymium (NdFeB) magnets used in high-efficiency traction motors. Permanent magnet synchronous motors (PMSMs) are the dominant E-motor used in EV industry due to their superior performance and efficiency. However, these machines rely on rare-earth materials, which are predominantly processed in China. According to Advanced Propulsion Centre UK's (APC) Q4 2025 Automotive industry demand forecast, PMSM will be dominating the European traction motor landscape until 2035, with a demand of 13 million motors.[1].

Recent Chinese export controls on rare earth oxides, magnet technologies, and dual use applications have intensified global supply chain vulnerabilities, prompting governments and industry to seek alternative sources and recycling pathways. This includes focused efforts in the EU and USA for increasing rare-earth oxides supply. The critical challenges are around scaling new rare-earth mines as it can take anywhere between 9 to 20 years to operationalise and produce rare earth oxides at scale.

Permanent magnet recycling has emerged as a strategic lever for supply resilience. Short-loop hydrogen decrepitation and long-loop hydrometallurgical processes can recover rare-earth materials from end-of-life EV motors, wind turbines, and consumer electronics. However, recyclers face significant barriers, including labour-intensive magnet extraction, oxidation-related degradation, high processing costs, and the absence of standardised certification.

Despite these challenges, the UK has a strong opportunity to build a competitive domestic recycling ecosystem. APC analysis indicates that if scaled effectively end-of-life (EoL) EV motors and wind turbines could supply up to 25% of the UK's future permanent magnet demand by 2035. Wind turbines alone represent a major resource, with a 3 MW turbine containing up to 600 kg of neodymium magnets. Early initiatives such as Hypromag's new hydrogen decrepitation facility demonstrate growing industrial capability, but there is potential for more recycling in the UK capacity. The strong opportunity in the UK is well aligned with its recently published critical minerals strategy. The strategy has laid out a vision of meeting 20% of the annual demand of critical minerals like rare-earths through recycling by 2035.[2]

At the same time, global automotive manufacturers are accelerating development of rare-earth-free motor technologies including EESM, switched reluctance motors (SRM), synchronous reluctance motors (SynRM), and ferrite-based PM machines to reduce exposure to rare earth volatility. Patent activity is dominated by companies in the US, Japan, and South Korea, reflecting global strategic urgency.

Overall summary is that the UK has opportunity to establish rare-earth recycling infrastructure, secure feedstock flows, and support innovation in magnet-free motor technologies. Doing so will strengthen national supply chain resilience, reduce dependence on geopolitically sensitive materials, and position the UK as a leader in the emerging circular economy for critical minerals.

"APC analysis indicates that if scaled effectively end-of-life (EoL) EV motors and wind turbines could supply up to 25% of the UK's future permanent magnet demand by 2035."

[1] https://www.apcuk.co.uk/knowledge-base/resource/q4-2025-automotive-industry-demand-forecast-2/
[2] https://assets.publishing.service.gov.uk/media/6937fa7833c7ace9c4a41e25/uk-critical-minerals-strategy-vision-2035.pdf

1. The role of permanent magnets in electric motors and the importance of rare-earth materials

Why permanent magnets?
For traction applications, motors must exhibit high performance and efficiency. This is provided by permanent magnets embedded in the rotor cores of electric motors as explained in the APC E-motors value chain report[3]. The key properties that influence the performance of magnets are listed below:

- **Magnetic flux density (B):** Denotes magnetic flux passing through a surface per unit area.
- **Magnetic strength:** Measures the intensity of the magnetic field at a particular point.
- **Remanence (Br):** Retentivity of the magnetic field in the magnet, when the external magnetic field is removed.
- **Coercivity (Hc):** Corresponds to the magnetic field strength to demagnetize the magnet.

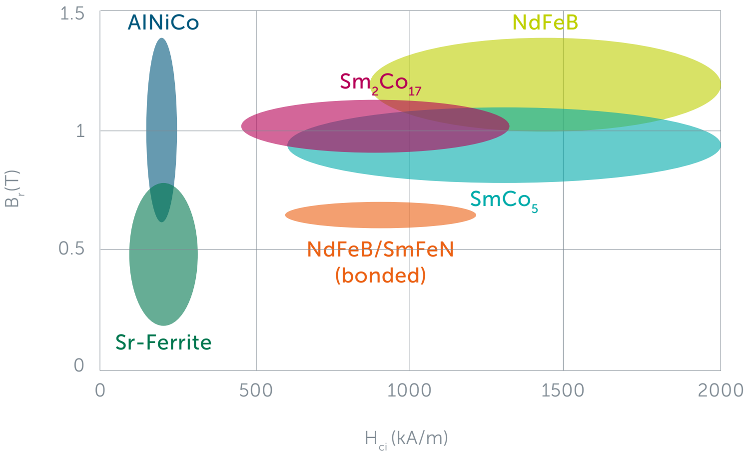
There are various types of permanent magnets suitable for use in motors[4].

i) Ferrite magnets
ii) AlNiCo magnets
iii) SmCo magnets
iv) NdFeB magnets based on rare earths. Generally doped with praseodymium and known as NdPr.

Of all the candidates for permanent magnets, the rare-earth-based perform better given the strength and their ability to stay magnetised, as shown in the graph below.

Figure 1: Magnetic strength of various material candidates

Source: Yousef Ghorbani, 2025



Coupled with the strength and volumetric size needed to provide a similar magnetic field, the rare-earth-based neodymium magnets perform better. This illustrates the significance and importance of rare-earth to the automotive industry.

“Of all the candidates for permanent magnets, the rare-earth-based perform better given the strength and their ability to stay magnetised.“

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[3] https://www.apcuk.co.uk/wp-content/uploads/2024/05/2024-e-motors-value-chain-insight.pdf

[4] Rare earth permanent magnets for the green energy transition. Yousef Ghorbani, et.al 2-025.

2. Current challenges for permanent magnets and REE exports across the globe

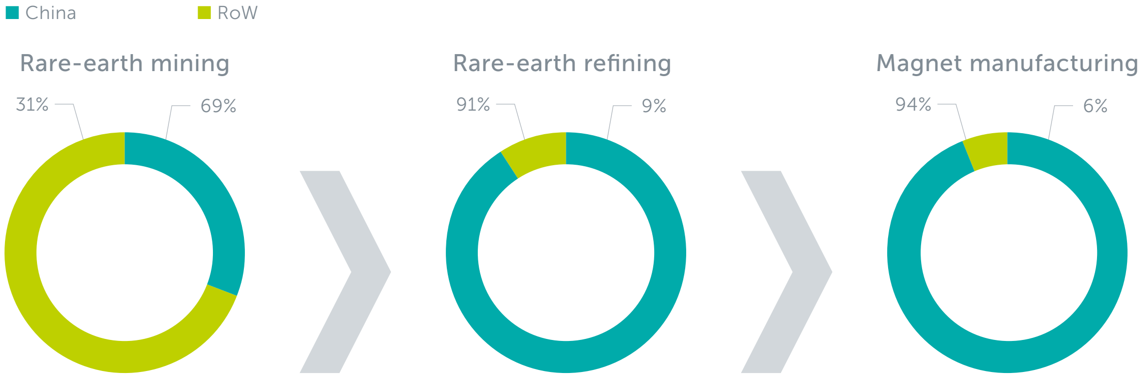
With access to domestic mines, relatively cheap labour and relaxed mining regulations China dominates the production of rare-earth oxides needed for critical applications[5]. China controls over two-thirds of the mining sites (shown in the figure below), followed by the US and Myanmar in terms of mining capacities.

China's Ministry of Commerce (MOFCOM) has announced sweeping new export controls on lithium-ion battery components and rare earth elements. In October 2025 China's MOFCOM announced expanding restrictions beyond raw materials to encompass production technologies and processing equipment, marking a major expansion of Beijing's export controls. The recent controls also target heavy rare-earth elements like holmium, erbium, thulium, europium and terbium that are used in semiconductors and defence applications[6]. These measures, target defence and semiconductor applications while widening the battery technology gap with the rest of the world.

The above restrictions have created an urge within the nations to create magnet and rare-earth supply outside of China. This has resulted in a series of investments including that of sovereign wealth funds to invest in rare-earth mines and magnet manufacturing facilities.

Figure 2: China's control on rare-earth supply

Source: Benchmark Intelligence



99% of the rare-earth permanent magnets are made of NdFeB, and 95% of the NdFeB used in EVs are sintered magnets.

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[5] https://www.bbc.co.uk/news/articles/cj6ny24j0r3o

[6] https://www.europarl.europa.eu/RegData/etudes/ATAG/2025/779220/EPRS_ATA(2025)779220_EN.pdf

Some of the key rare-earth mining and processing sites outside China are mentioned in the map below:

Figure 3: Global Ex-China REE and magnet manufacturing facilities

Source: APC analysis based on benchmark data

Company list is not exhaustive

https://www.vecteezy.com/free-photos/quarry

On 6 January 2026, China announced tighter export controls on dual-use items to Japan, including seven medium- and heavy-rare-earth elements and any products containing them, such as rare-earth permanent magnets (REPM). This resulted in knock on effects for Japan, with automotive companies in its supply chain. Proterial in Japan produces 2,500–3,000tpa of sintered NdFeB magnets for traction motors and supplies Toyota, Lexus, Honda, Nissan, and Mazda. Shin-Etsu operates around 3,400tpa of sintered magnet capacity across Japan and Vietnam, supplying Toyota, Subaru, and Suzuki. Any prolonged delays in raw material licensing could constrain magnet output, affecting EV and wind turbine production schedules.

EU has taken focus on the importance of rare-earth by adopting a rare-earth resource action plan to accelerate its permanent magnet supply chain[7]. The US administration has agreed to invest $1.6bn with USA Rare Earth, which will give the government a stake at the firm and improve the rare-earth supply in North America[8].

The UK has laid out the Vision 2035 for critical minerals including rare-earths to increase the resilience of its supply chain. As part of the strategy it has targeted to have 20% of the annual demand by 2035 for criticial minerals to be recycled. It has also set its ambition to locally produce at least 10% of the demand by the same year.

However rare-earth plants are not easy to establish and scale within the required timelines. A typical rare-earth mineral project from exploration to construction takes 9 years[9] This is due to the need for clearance on environmental, tailings and wastewater management issues.

The above export control restrictions, coupled with the barrier to scale new rare-earth mines at pace, are creating a bottleneck and challenges for the automotive supply chain. This provides an opportunity for magnet recycling and the utilisation of materials available from end-of-life vehicles and wind turbines.

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[7] https://circulareconomy.europa.eu/platform/en/news-and-events/all-news/european-commission-adopts-resourceeu-action-plan

[8] https://www.bbc.co.uk/news/articles/ckgxrvln4qeo

[9] https://www.ft.com/content/1af222f5-fcbc-4530-bcbf-9f886ed9ecb1

3. REE magnet recycling value chain and major challenges

The value chain for permanent magnet recycling has been illustrated opposite (figure 4), the more detailed report on the recycling value chain can be followed in the Innovate UK Rare-Earth circular economy report released in 2025[10].

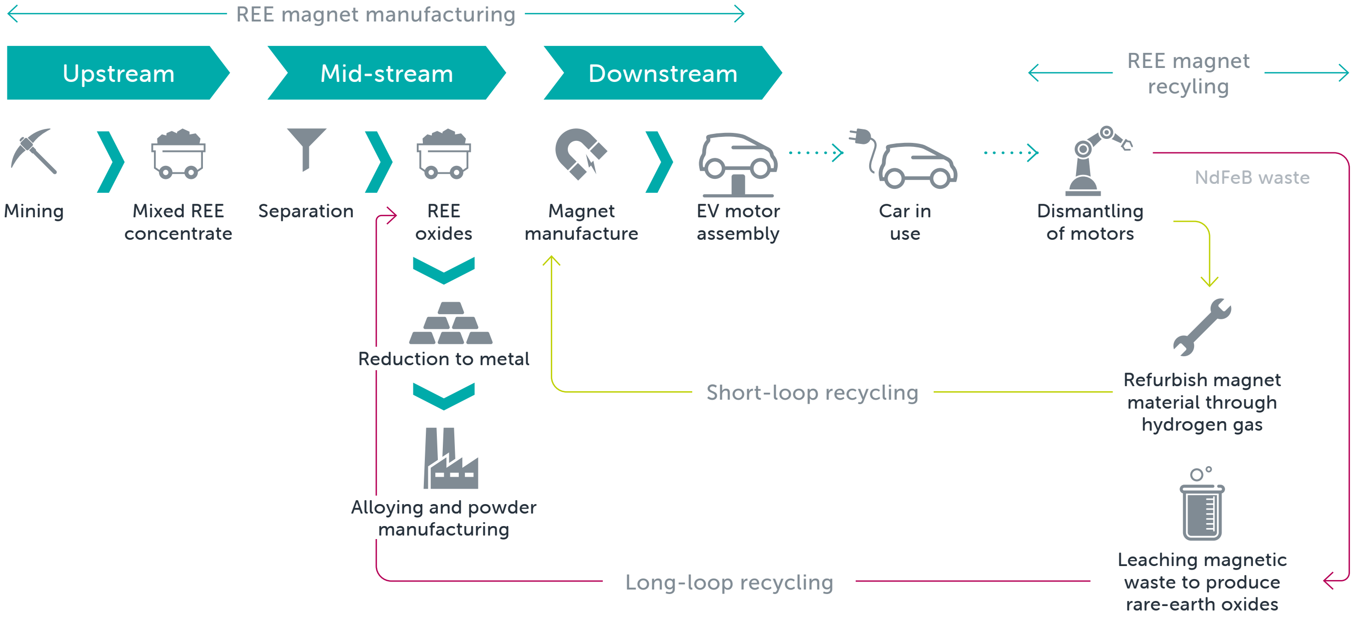
In short summary, there are two key recycling loops for magnets:

Short-loop recycling:
It is the process of refurbishing used secondary permanent magnets by reshaping them. Typically done through hydrogen decripitation process, which uses hydrogen gas to demagnetise and disintegrate NdFeB magnets.

Long-loop recycling:
It is the process of breaking permanent magnets into their constituent rare-earth oxides, which are then purified and alloyed to produce permanent magnets. This is generally done through hydrometallurgical processes by using sulfuric and hydrochloric acids.

Figure 4: Magnet manufacturing and recycling value chain

Source: REIA and Innovate UK



> "Export control restrictions, coupled with the barrier to scale new rare-earth mines at pace, are creating a bottleneck and challenges for the automotive supply chain. This provides an opportunity for magnet recycling."

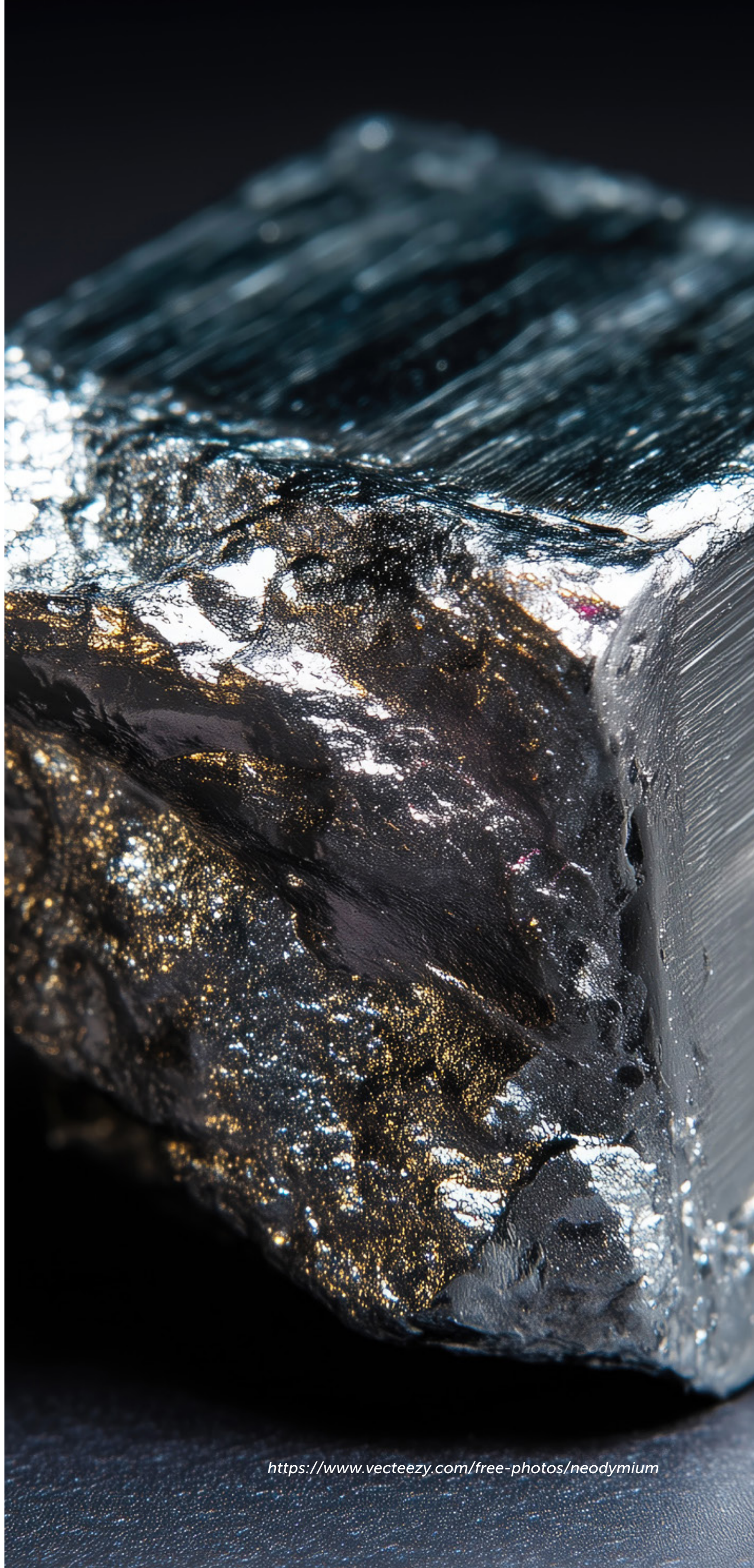
[10] https://iuk-business-connect.org.uk/wp-content/uploads/2025/07/IUK-Climate-Circular-Economy-Report-TW-D4-compressed.pdf

The major technical challenges and barriers in magnet recycling are listed below:

Table 1: Magnet recycling challenges and innovation opportunity

Category	Key barrier	Innovation opportunity
Certification	Lack of credible labels and certification for the composition/content of permanent magnets present in the EoL product	Creating a digital REE-magnet passport system similar to EU battery passport system
Sorting and extraction	Extracting magnets from motors is often a labour-intensive process that incurs substantial operational costs and resource demands. Removing the magnet coatings is an additional challenge.	Investment in automated disassembly robots. Designing electric motors with modular principles to enhance recycling efficiencies
Limitations of hydrogen process	Limitations in Hydrogen process due to oxidation of used magnets, reducing the quality of recycled magnets. Limited to homogenous magnetic compositions and therefore restricting the use of recycled magnets to the same type of application.	Investment in R&D techniques and processes to understand and improve the technological maturity of hydrogenated process for short loop recycling.
Long-loop recycling process	Costlier and energy-intensive process. Disposal of by-products from the hydrometallurgy process	Providing the necessary volume and feedstock for the hydrometallurgical facilities to operate at scale. Opportunity to create new magnetic alloys and materials.

"Structural issues, such as the economics of recycling, permits, and regulations, can pose barriers to scaling up recycling plants."



https://www.vecteezy.com/free-photos/neodymium

In addition to the technical challenges highlighted above, structural issues, such as the economics of recycling, permits, and regulations, can pose barriers to scaling up recycling plants.

Economics:
The cost of rare-earth elements will influence the economics of recycling. Currently, due to export controls, the price of neodymium has fluctuated, directly affecting recycling costs.

The effects of these incoming export controls are evident in the graphs on the right, as European prices for Dysprosium and Terbium oxides are up to 4 times Chinese prices.

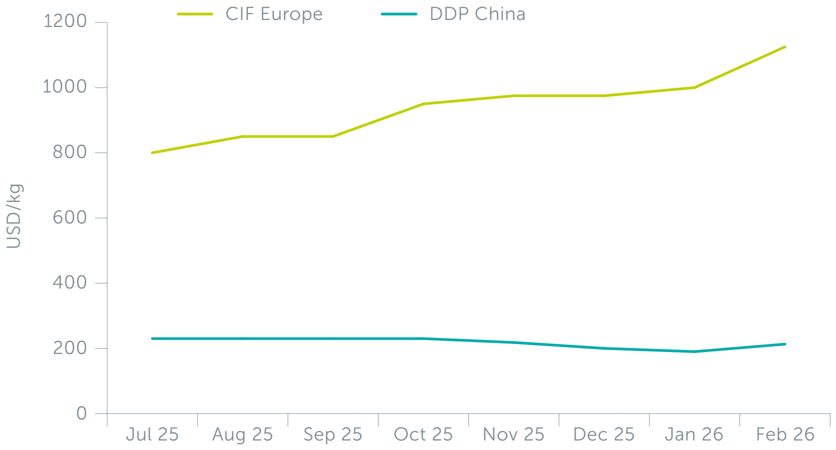
However, an increase in virgin prices provides recyclers with an opportunity to extract greater value from recycled magnets, improving the viability of recycling plants.

Permits and regulations:
Local permitting and regulations for magnet recycling can be complex, making it difficult for recyclers to establish facilities. End-of-waste classifications and clear requirements on extended producer responsibility for magnets, like those for batteries, will help to improve the dynamics of magnet recycling.

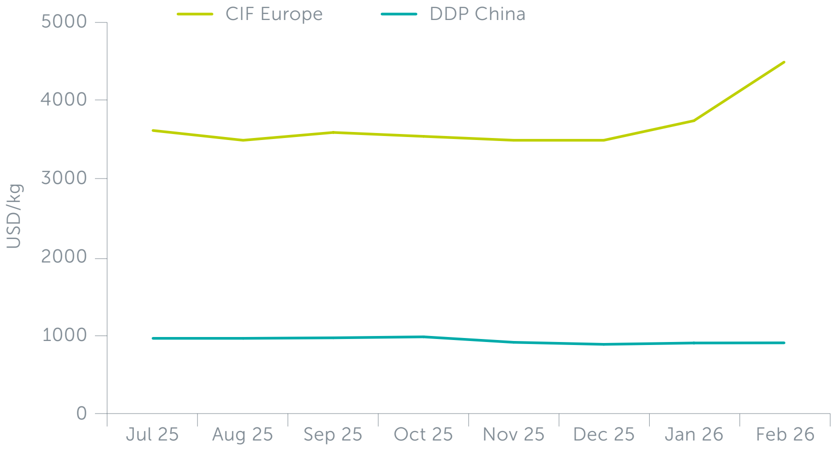
Figure 5: Rare-earth price fluctuations between China and Europe

Source: Benchmark intelligence

Dy oxide prices



Tb oxide prices



> “An increase in virgin prices provides recyclers with an opportunity to extract greater value from recycled magnets, improving the viability of recycling plants.”

4. The UK potential for magnet recycling and the European value chain for REE recycling

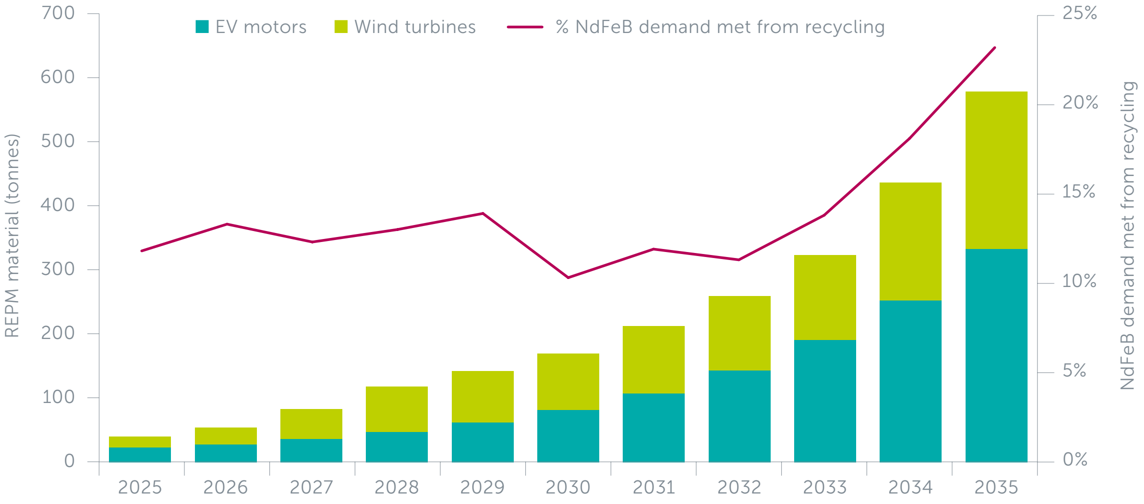
One of the major challenges in magnet recycling is the availability of feedstock and the volume required for recycling plants to be commercially viable.

APC assessed the potential for magnet recycling in the UK using feedstock derived from used electric vehicle motors and end-of-life wind turbines. The assessment indicates that recycling could meet up to one-fourth (25%) of the overall demand for permanent magnets by 2035, as shown in the figure below, if we are to successfully recover magnets from the specified end-use applications.

Wind turbines are major users of neodymium magnets to exploit the rotational energy from wind to generate electricity. A 3 MW wind turbine can contain up to 600 kg of neodymium and 50 kg of dysprosium magnets[11]. There is significant potential to extract rare-earth materials from end-of-life wind turbines as they are decommissioned. Thus, the retirement age of wind turbines will play a key role in the future of rare-earth feedstocks. The lifespan of a wind turbine could be between 20 and 25 years[12].

Figure 6: Magnet demand vs recycling material availability

Source: APC analysis



“There is significant potential to extract rare-earth materials from end-of-life wind turbines as they are decommissioned.”

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[11] https://acfequityresearch.com/wind-turbines-drive-ree-pricing-not-evs/

[12] https://www.kent.ac.uk/news/science/27849/ageing-offshore-wind-turbines-could-stunt-the-growth-of-renewable-energy-sector

Magnet recycling landscape across Europe:
China remains dominant, with around 30 known magnet recycling companies and an expected recycling capacity of approximately 67 kt total rare-earth oxides in 2025.

By comparison, the recycling pipeline outside China remains modest but is growing, with projects expected to come online by 2027 total around 6.9 kt of separated rare earth oxides, 1.8 kt of magnet powders, and 1.8 kt of rare earth alloys and magnets[13].

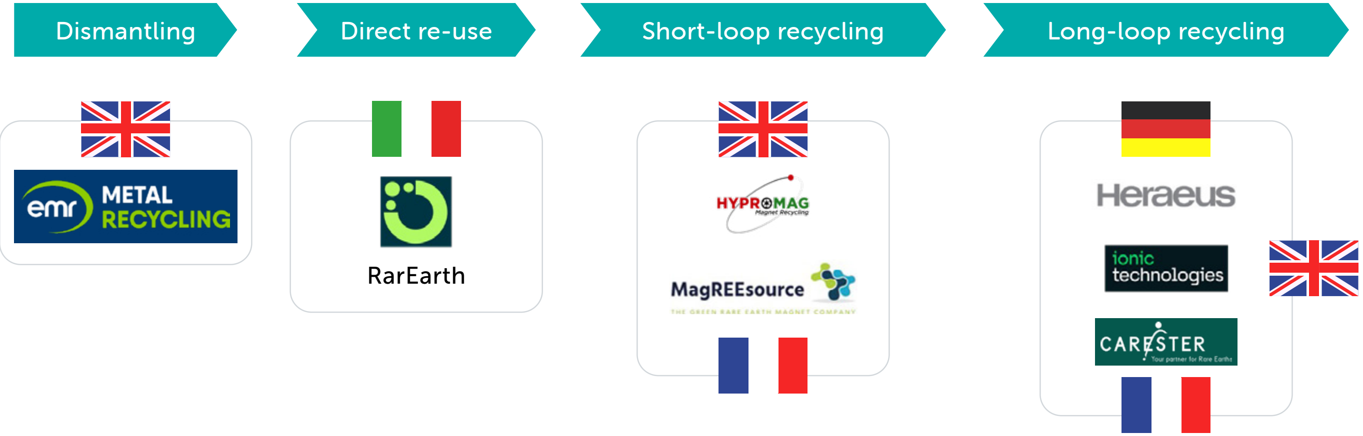
There aren't many players in Europe capable of recycling permanent magnets. However, recently, as of January 2026, in the UK, Hypromag has opened up a hydrogen decabonisation facility that can recover 400 kg of rare earths per batch[14]. Ionic Technologies, a wholly owned subsidiary of Ionic Rare Earths Ltd, has secured £11 million in government funding to advance a hydrometallurgical facility for processing used magnets[15].

Some of the major players in Europe for magnet recycling are mentioned below.

To boost the rare-earth magnet supply, the EU are planning to introduce export restrictions on permanent magnet scrap and waste by Q2 2026[16]. This could have additional impacts on the future direction of the magnet recycling value chain in the region.

Figure 7: European REE magnet recycling landscape

Source: APC analysis



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[13] Benchmark intelligence
[14] https://www.recyclingtoday.com/news/hypromag-mkango-uk-university-birmingham-rare-earth-magnet-recycling/
[15] https://www.proactiveinvestors.co.uk/companies/news/1074635/ionic-technologies-wins-11-million-uk-government-backing-for-rare-earth-magnet-supply-chain-1074635.html
[16] https://news.metal.com/newscontent/103693705-EU-to-Impose-Export-Restrictions-on-Rare-Earth-Magnet-Scrap-in-2026-Raise-%E2%82%AC3B-for-Projects

5. Non-permanent magnet motor landscape across the auto industry

Rare-earth-free motors have emerged as a strategic priority for automotive manufacturers and suppliers seeking to reduce supply risk, lower environmental impact, and maintain long-term cost stability. Although rare-earth-based motors still dominate the market, magnet-free alternatives, such as externally excited synchronous motors, switched-reluctance motors, and synchronous-reluctance designs, are gaining attention.

Key motor technologies without rare earths

Externally Excited Synchronous Motors (EESM)
Externally excited synchronous motors replace permanent magnets with rotor windings powered via slip rings or contactless excitation, enabling synchronous operation without rare earth materials. BMW, Nissan, Renault and Volkswagen are expected to be the major users of current-excited wound rotor synchronous motors. Suppliers such as Vitesco (Schaeffler) and BorgWarner have also developed EESM motors.

Switched Reluctance and Synchronous Reluctance Motors (SRMs & SynRM)
Reluctance motors generate torque through rotor geometry rather than magnets or rotor windings, allowing rare-earth-free designs. Switched-reluctance motors are robust and low-cost but, historically, have been limited by noise and torque ripple, whereas synchronous-reluctance motors provide smoother performance at the cost of more advanced control strategies and optimised rotor designs.

New high-speed synchronous reluctance variants are being developed for automotive duty cycles. Advanced Electric Machines, for example, is developing a Reluctance Drive for passenger vehicles targeting series production later this decade. Such designs can also reduce copper usage in the rotor, lowering material dependency.

Ferrite Magnet Permanent-Magnet Motors
Ferrite magnets offer a widely available and low-cost alternative to rare-earth magnets, enabling rare-earth-free permanent-magnet motors. However, their lower magnetic strength often requires larger motor size, increased mass, or higher operating speeds to achieve comparable power density.

> “Rare-earth-free motors have emerged as a strategic priority for automotive manufacturers and suppliers seeking to reduce supply risk, lower environmental impact.“

Comparison of the key motor technologies

The comparison shown in the table below highlights why PMSMs remain the dominant EV motor, combining very high efficiency and torque density, helping them secure major global market share. However, their dependence on neodymium and dysprosium introduces cost, supply chain, and geopolitical risks, driving industry interest in alternatives.

EESMs eliminate rare earths and offer fully controllable rotor flux for flexible torque and wide speed operation, but typically sacrifice some efficiency, especially at low speeds.

HEPMs (hybrid excited permanent magnet motors) represent a hybrid compromise, blending permanent magnets with controllable field windings to deliver high performance while enabling tuneable flux control and reduced reliance on rare-earth materials. Meanwhile, **SRM, ferrite PM, and induction motors** provide magnet-free or low-cost pathways with robust operation and wide speed capability, though generally at the expense of efficiency, torque density, or control simplicity. This underscores a broader industry shift toward diversified motor architectures that balance performance, cost, and supply chain resilience.

> “PMSMs remain the dominant EV motor, combining very high efficiency and torque density.“

Table 2: Key non-permanent magnet motor technologies

Feature / Motor Type	PMSM	HEPM (hybrid excited permanent magnet motors)	EESM	SRM (Switched Reluctance)	Ferrite Magnet Motor	Induction Motor (IM)
Efficiency	Very high	High	Medium–high	Medium–high	Medium–high	Medium
Speed range	Wide (with reluctance torque)	Very wide (flux weakening)	Wide (controlled excitation)	Very wide	Moderate–wide	Wide
Torque density	Very high	High	Moderate	Moderate–high	Moderate	Moderate
Flux control	Fixed (limited weakening)	Fully tuneable	Fully tuneable	Limited / indirect	Fixed	Tuneable via current
Demagnetisation risk	Possible (overload/heat)	Low	None	None	Moderate–high	None
Thermal management	Challenging (rotor magnets)	Moderate–high	Moderate	Easier (robust rotor)	Moderate	Moderate
Control complexity	Medium	High	High	High	Medium	Medium
Startup torque	Excellent	Excellent (flux boosting)	Good	Very good	Good	Moderate
Cost	Moderate–high (rare earths)	Moderate–high	High (excitation system)	Low–moderate	Low–moderate	Low
Rare earth use	Heavy	Partial	None	None	None	None

Non-PM motor player landscape

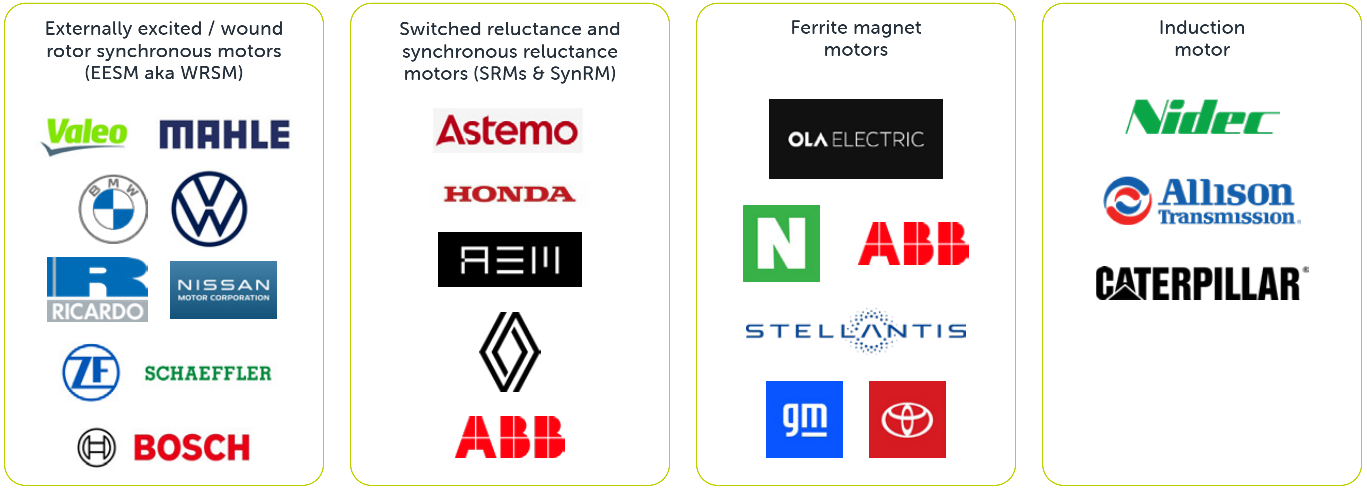
This player landscape summarises the main automotive companies and tier-1 suppliers pursuing permanent-magnet-free traction motors and groups them by the underlying motor technology.

Notable recent developments

- **MAHLE's Contactless Motor:** Their new MCT (Magnet-free Contactless Transmitter) motor reaches 95% efficiency across nearly the entire operating range, a feat previously only possible with magnets.
- **Iron Nitride Magnets:** US-based startup Niron Magnetics announced a partnership with Stellantis to develop rare earth-free EV motor designs. Niron's permanent magnet, called a "clean earth magnet," is made from iron nitride without any rare earth elements.
- **Alumotor:** A recent consortium project (Ricardo/AEM) has demonstrated motors using compressed aluminium instead of copper windings, reducing weight and cost by up to 40%.
- **Renault** has ended its joint E7A rare earth-free motor project with Valeo. Renault is now actively seeking more cost-effective stator components from China while planning to manufacture the remaining parts internally, targeting full deployment by 2028.
- **Honda's** venture arm, Xcelerator Ventures, has invested in Enedym, a Canadian startup specialising in innovative switched reluctance motors (SRMs), a technology that eliminates the need for rare earth elements entirely.

Figure 8: Non-PM motor player landscape (auto industry focus)

Source: APC analysis



Note: list is non-exhaustive and is constrained to traction motor applications only

> "The current geopolitical risks and supply chain shocks countries outside China face due to export controls, has pushed OEMs to innovate on alternate technology."

6. Patent analysis for rare-earth free motors

The patent landscape for rare-earth-free motors is presented below, with the top assignees dominated by companies headquartered in the USA, Japan, and South Korea. This illustrates the current geopolitical risks and supply chain shocks that countries outside China face due to export controls on permanent magnets.

Some of the key highlights from the patent analysis are listed below:

Denso Corporation has publicly highlighted work on electrically excited motors and high-efficiency traction systems, particularly for hybrids and next-generation EVs, where controllable excitation offers efficiency advantages at high speed.

Gree Electric applicances is the clear outlier and dominant assignee in this dataset. While best known globally as the world's largest air-conditioner manufacturer, Gree has made sustained investments in magnet-free motor architectures, particularly induction and reluctance-based designs. Public announcements around its acquisition of Zhuhai Yinlong New Energy highlight its ambition to vertically integrate into EVs, electric buses, and powertrain components.

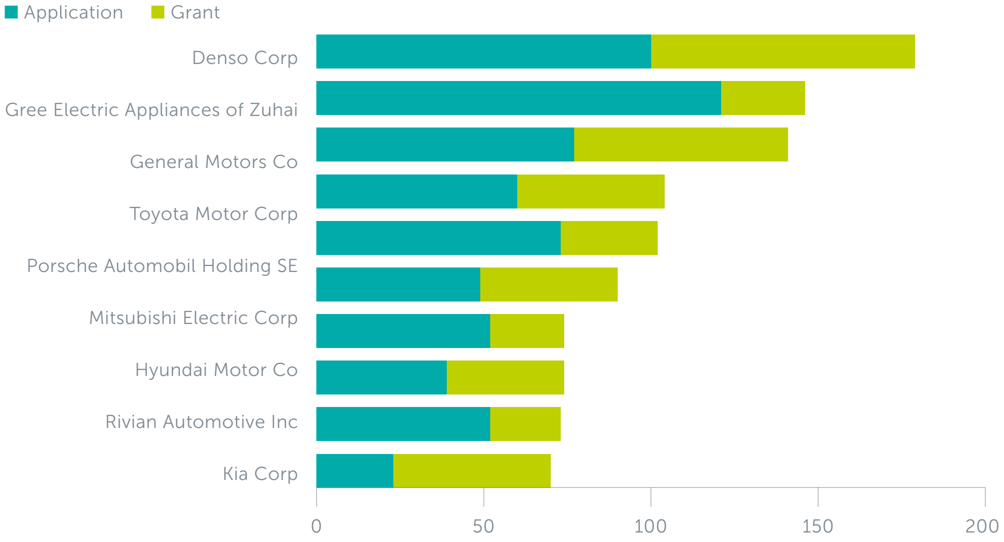
Mitsubishi Electric has extensive public research on synchronous reluctance and induction motors, leveraging its industrial automation and rail traction heritage. Its PM-free motor patents often focus on loss reduction, torque ripple mitigation, and advanced control.

Toyota, for example, has publicly discussed electrically excited motors as part of its long-term electrification roadmap, while GM and Rivian's activity align with broader exploration of non-PM traction motor options to hedge against rare-earth supply risk.

> "The patent landscape for rare-earth-free motors is presented below, with the top assignees dominated by companies headquartered in the USA, Japan, and South Korea."

Figure 9: Key patent filing organisations in rare-earth free motors

Source: Global data

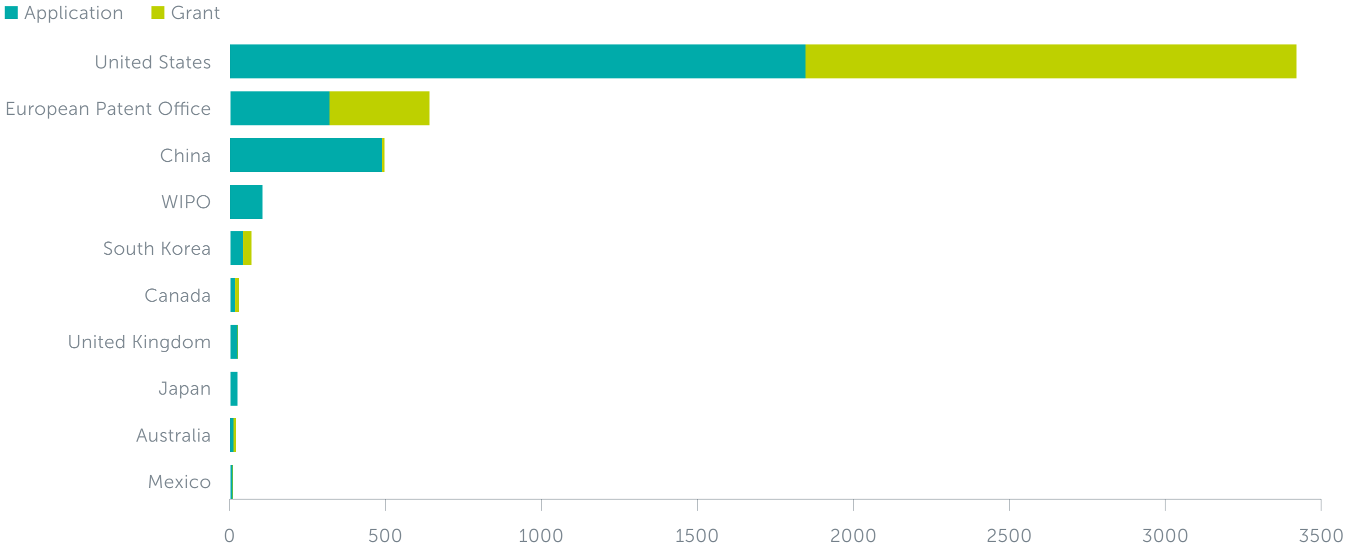


Patent filing locations

Although patent-filing organisation headquarters are diverse worldwide, patent locations are dominated by US-based assignments. The primary jurisdiction of the USA for PM-free motor, reflecting its role as the preferred market for securing high-value, strategic EV motor patents, often by both US and non-US innovators. China serves as a strong secondary hub, driven by efforts to reduce dependence on rare earths and by application-focused development across EVs, buses, industrial drives, and HVAC-derived traction systems.

Figure 10: Top assignee location for patent landscape

Source: Global data



7. Summary and conclusions

Overall, the UK has opportunity to establish rare-earth recycling infrastructure, secure feedstock flow and support innovation for rare-earth free motor technologies. Doing so will strengthen national supply chain resilience, reduce dependence on geopolitically sensitive materials, and position the UK as a leader in the emerging circular economy for critical minerals. This is even more critical given the challenges in starting and scaling new rare-earth mines within the timescales needed to achieve self-reliance.

Some of the key innovation opportunity areas are listed below:

1. **Certification:** Creating a digital REE-magnet passport system similar to EU battery passports, which will provide greater transparency and visibility to the permanent magnet supply chain.
2. **Sorting and extraction:** Extracting magnets from motors is often a labour-intensive process that incurs substantial operational costs and resource demands. Investing in automated disassembly platforms will help to improve the overall cost and efficiency of magnet recycling.
3. **Innovation in recycling processes:** Investment in R&D techniques to improve magnet recycling process and the quality of the rare earths to be extracted, will improve the business viability of magnet recycling.

Although technical and commercial challenges remain, growing industry collaboration and continued innovation are advancing the feasibility of rare-earth-free motor technologies. In the near term, rare-earth-free motors are likely to coexist with permanent magnet solutions, serving as complementary options that provide supply chain resilience and long-term strategic flexibility. Over time, improvements in performance, efficiency, and manufacturing scalability may enable broader adoption across electric vehicle platforms. This has been identified as a key opportunity within the latest released APC electric machines roadmap innovation opportunity report[17].

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[17] https://www.apcuk.co.uk/knowledge-base/resource/electric-machines-innovation-opportunities-2026/

8. Glossary

AlNiCo	Aluminium nickel cobalt
BEV	Battery electric vehicle
EESM	Electrically excited synchronous motors
E-motors	Electric motors
EoL	end of life
HEPM	hybrid excited permanent magnet motors
IM	Induction motor
NdFeB	Neodymium ferrite boron magnets
PMSM	Permanent magnet synchronous motors
R&D	research and development
REE	Rare-earth elements
SmCo	Smarium Cobalt
SRM	switched reluctance

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Further information

If you have any questions or would like more detail on any of the graphs or data email info@apcuk.co.uk

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