



Electric Machines

Innovation Opportunities Report

2026



ADVANCED
PROPELLION
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1 | Foreword



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Global demand for clean mobility is growing. To support the UK's competitiveness, secure jobs, and achieve the transition to zero-emission vehicles and towards a net-zero automotive industry, innovation will be key. Yet, taking innovative technologies to rapid commercialisation is a challenge for the automotive industry and the broader industry supply chain. Even then, possibilities are limited by supply chain's capabilities, strengths, and gaps. Building on the Automotive Council UK's Technology Roadmaps, this series of Innovation Opportunities reports examine key technology priorities and associated supply chain opportunities for the UK automotive industry.

The Innovation Opportunities reports provide insights on how strategic collaboration and investment can accelerate the commercialisation of these key technologies for the transition of the automotive industry to net zero, including: batteries, power electronics, electric machines, lightweighting technologies, hydrogen fuel cells and storage, and internal combustion engines (ICEs). By focusing industry efforts on the trends and drivers outlined in the Automotive Council roadmaps

and associated innovation opportunities, the UK can secure leadership in the global clean mobility revolution.

We highlight areas where collaboration between industry, government, and research institutions can accelerate commercialisation and encourage investment. These can strengthen the UK automotive industry.

The reports investigate trends and drivers up until 2050, which might be at different levels of maturity or market readiness. We do this across different regions, showing how even if a technology is at the point of implementation, the underpinning supply chain might not be geared up for change at scale and pace.

The Innovation Opportunities report for Electric Motors provides a deep dive into all themes and sub-themes identified on the E-Motor roadmap and maps them against the European and UK supply chain capabilities within the context of traction motors. This analysis provides an overview of key focus areas and associated strengths, and gaps to guide the industry's direction of travel across the global landscape across the Electric Motor value chain.

The report covers a range of metrics to identify innovation opportunities, focussing on feasibility and significance. Innovation opportunities for electric motors are split into two broad categories: 1. technical innovation and 2. Innovations in supply chain and cross-cutting enablers. Innovation areas are mapped against technology roadmaps trends and drivers. This is to highlight UK opportunities across the global electric motor and automotive industry.

A key theme across the report has been design, materials and manufacturing capabilities and associated opportunities, where UK manufacturing supply chain can play a key role in anchoring such opportunities for the future of the automotive industry.

By clarifying key industry challenges and associated R&D opportunities in electric motor technologies, this report provides an insight into building a resilient and competitive supply chain for the UK automotive industry.

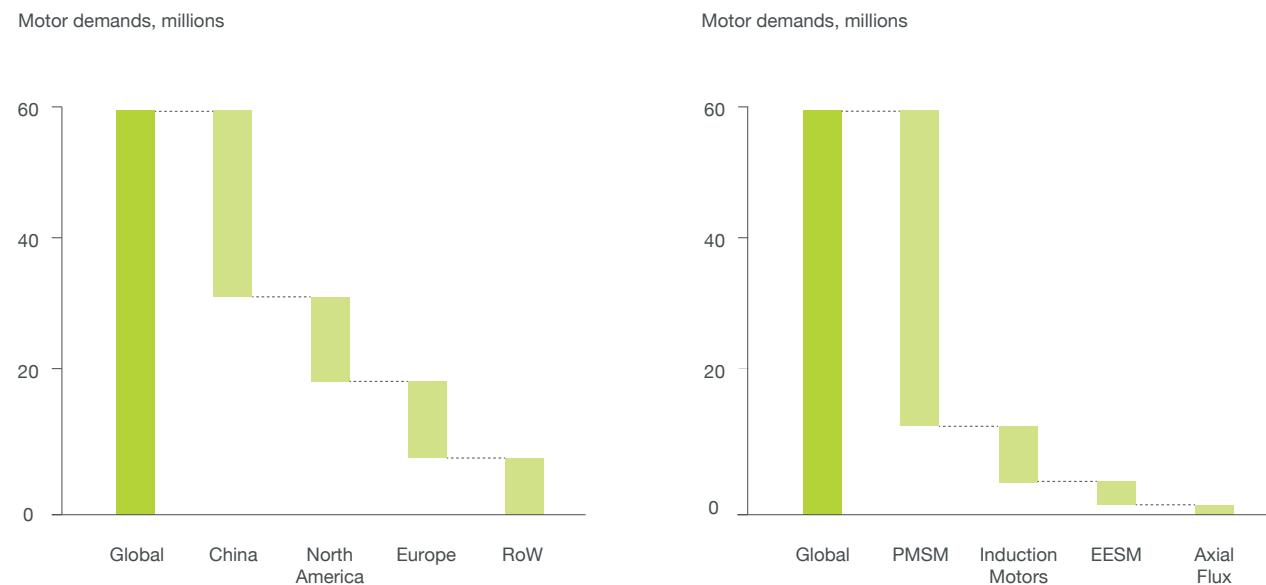
2 | Introduction

The UK electric motor (E-motor) demand is set to increase as electric vehicle (EV) sales are expected to rise over the next 12 years, as predicted in the APC's Q3 2025 automotive demand forecast report. Europe is a significant player, averaging around 20% of global motor demand over the next 15 years. By 2030, global motor supply and demand are projected to balance at 60 million units, as shown in Figure 1, with Permanent Magnet Synchronous Motors (PMSM) continuing to dominate the motor landscape.

The global automotive motor technology is dominated by PMSM due to its advantages in performance and efficiency in automotive applications. However, the dominance of PMSMs is set to be challenged by efforts to develop rare-earth-free alternatives. Induction motors and Electrically Excited Synchronous Motors (EESMs) are given more importance due to supply chain and geopolitical risks arising from sourcing of rare-earth materials that are vital in production of permanent magnets.

The UK has opportunities for innovation within this geopolitically challenging environment to strengthen and expand its electrification capabilities. Expanding on the technology roadmaps APC produced in 2024 on behalf of Automotive Council¹, this report highlights opportunities where the UK can develop its manufacturing and innovation capabilities.

Figure 1: Global motor demand by region and type by 2030



Source: Benchmark 2025

3 | Executive summary

The report identifies two categories of innovation as shown in the figure opposite:

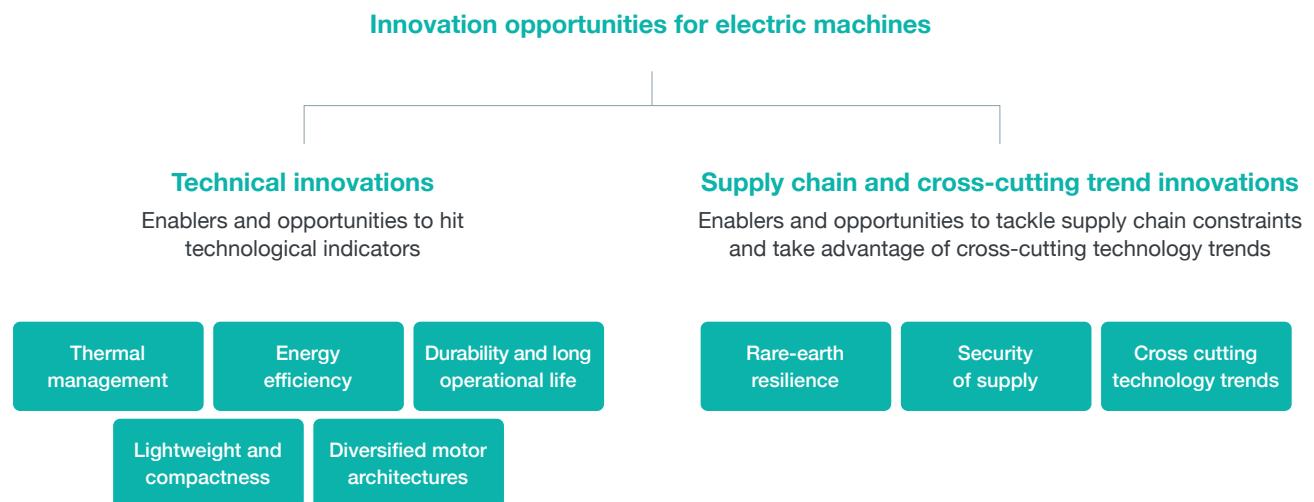
Technical innovations or technical pathways

Innovations to achieve the ambitions of technology metrics laid out in the 2024 APC technology roadmaps.

Supply chain and cross-cutting trend innovations

Supply chain-related developments and cross-cutting technology trends that are needed to scale and produce electric motor technologies in the UK.

Figure 2: Major categories for innovations in E-motor capabilities for the UK



Technical innovations

This report identifies some of the key technological enablers required to meet the ambitious roadmap indicator targets outlined in the APC technology roadmaps 2024. The enablers are:

- 1 Thermal management
- 2 Energy efficiency
- 3 Durability and long operational life
- 4 Lightweight and compact design
- 5 Diversified motor architecture

Within these five enabling capabilities, the report identifies 14 distinct innovation priority areas. Each area has been assessed for its strategic importance to the UK and the feasibility of domestic development. The prioritised innovation areas are shown in the figure opposite.

Capabilities such as thermal management, energy efficiency, and diversified motor architecture are key to accelerating the future of E-motor innovation in the UK as highlighted in Figure 3.

Figure 3: Prioritised innovation opportunity to tackle technical enablers and metrics



Supply chain and cross-cutting trend innovations

To successfully scale the identified technical capabilities in figure 3, there are supply chain and cross cutting technology trends that are to be tackled and leveraged respectively.

This report examines 12 supply chain and technology trend pathways and identifies the central themes to strengthen the UK's E-motors supply chain. They are broadly categorised into two recommendations as shown in figure 4.

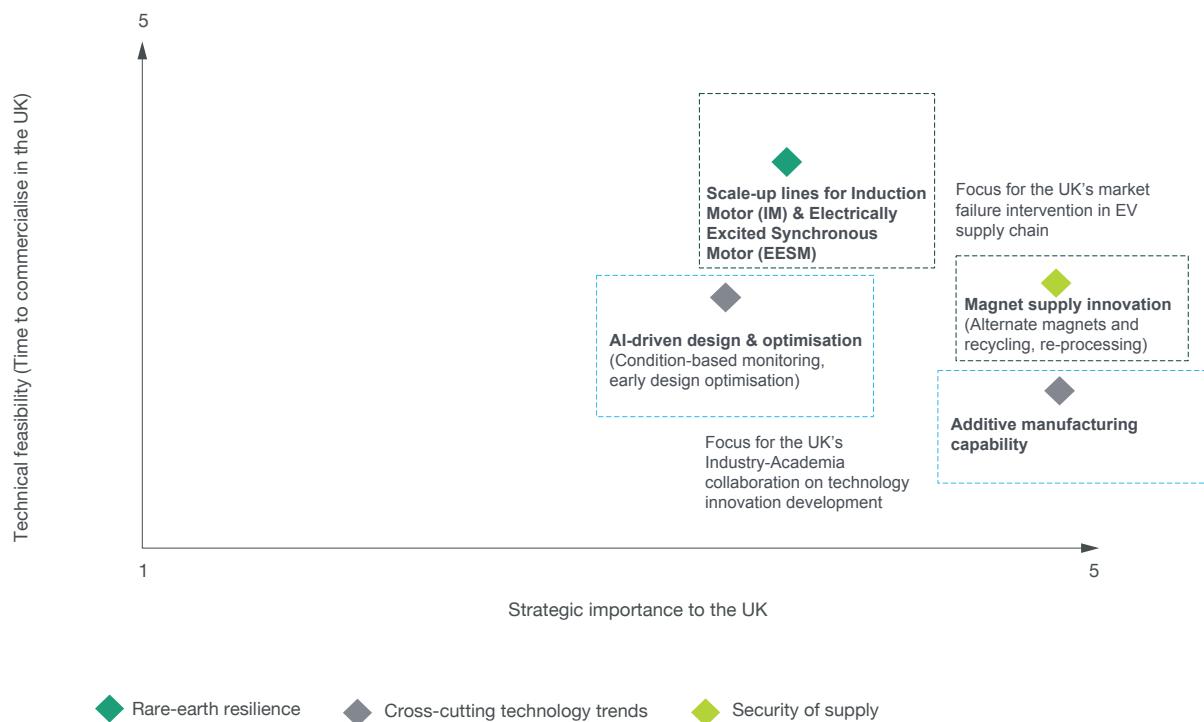
Focus for the UK's market failure intervention

This includes supply chain resilience for rare-earth materials, scaling up plants for non-permanent magnets like EESM and IM

Focus for UK-Industry academia collaboration

Adopting innovative technologies such as AI-based design and additive manufacturing for unique electric motor configuration and designs.

Figure 4: Innovation opportunity to tackle supply chain challenges



4 | Methodology for technical innovation opportunities

The technical opportunity list arrived following a 4-step process, as shown in the figure opposite.

Pillar 1

Data collection formed the foundation for the report's analysis. It included stakeholder engagement to identify innovation requirements across the UK's E-motor value chain, an academic literature review, and an analysis of current technological trends influencing E-motor adoption in the automotive sector.

Pillar 2

These inputs were then analysed and aggregated into five technology capabilities needed to meet the identified innovation requirements.

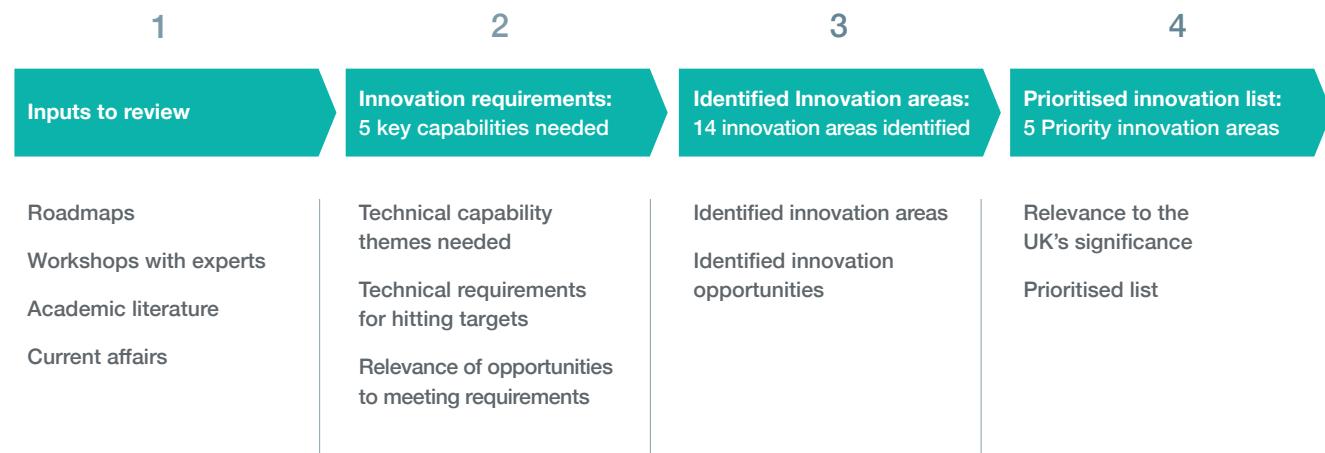
Pillar 3

The capabilities were then mapped against the APC technology roadmaps to define the 14 key innovation areas/opportunities to focus.

Pillar 4

Finally, each innovation was assessed for strategic importance and feasibility, resulting in five prioritised innovation list for E-motor technologies in the UK.

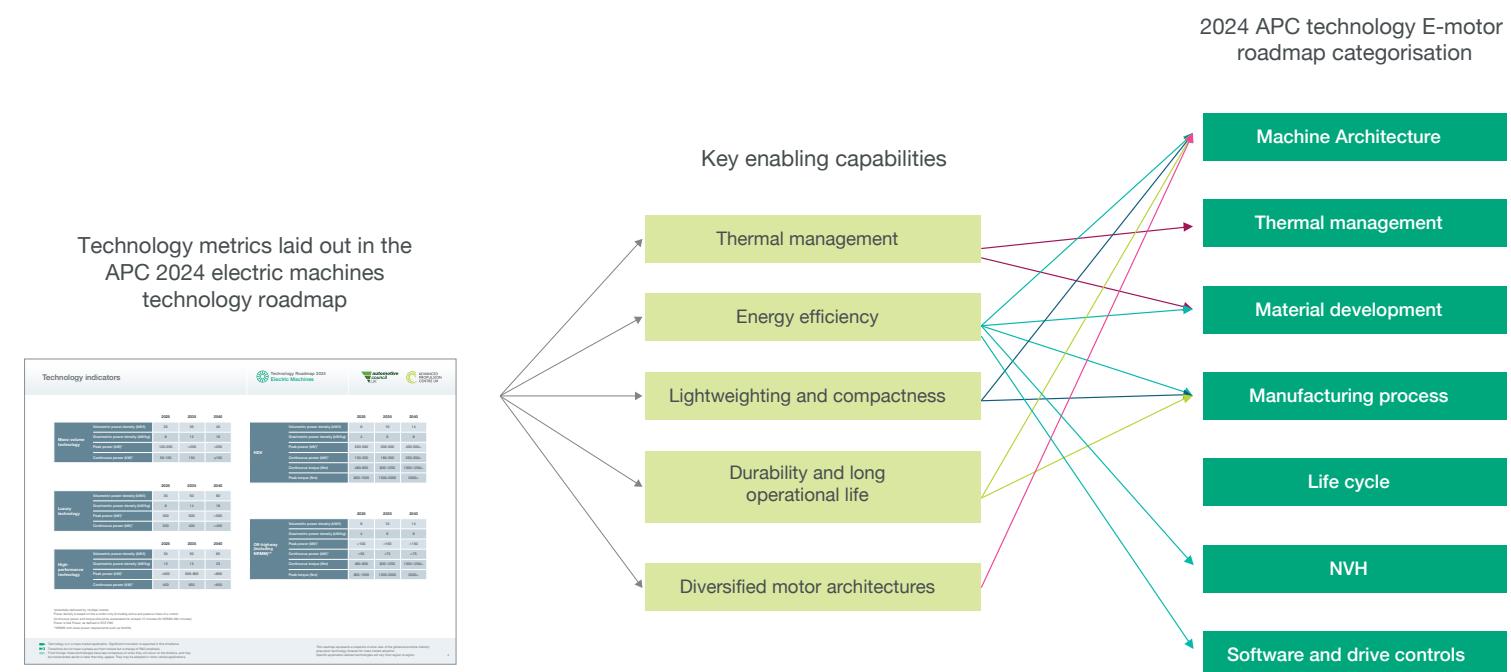
Figure 5: Methodology for the technical innovation opportunity list



5 | Key technical innovations

The E-motor APC technology roadmaps 2024 provided various technology categories needed to advance electric motor technologies.

Figure 6: Mapping innovation capability enablers with APC technology roadmap



There were 14 identified innovation technology priorities for the five capabilities as listed in the table.

Table 1: Identified technology innovation areas.

Capabilities	Identified technology priorities	Key 2024 APC technology roadmap categories it covers
Thermal management	1 Novel cooling methods such as dielectric fluids and solid (resin) cooling 2 Active cooling methods such as embedded cooling paths in stators and rotor shafts 3 Advanced thermal interface materials such as graphene-based composites and gallium-based liquids	<ul style="list-style-type: none"> • Thermal management • Material development
Energy efficiency	4 Using soft magnetic composites (SMC) in place of laminated steel. 5 Innovative ultra-low loss winding designs 6 AI-based adaptive control strategies and variable magnetisation designs 7 Using silicon carbide inverters, which have better switching speed and efficiency than silicon inverters	<ul style="list-style-type: none"> • Material development • Manufacturing process • Noise Vibration harnessing (NVH) • Software and drive controls
Lightweight and compactness	8 Using inherently lightweight and compact designs such as axial flux motors 9 Using lightweight material such as aluminium for motor housing 10 Increasing integration levels and modularity whilst reducing the number of fasteners and standalone individual components	<ul style="list-style-type: none"> • Machine architecture • Manufacturing process
Durability and long operational life	11 Self-diagnosing systems: embedded with sensors with motor baseline operating parameters 12 Design with fatigue-resistant windings and bearings 13 Hermetically sealed for harsh environments	<ul style="list-style-type: none"> • Manufacturing process • Software and drive controls
Diversified motor architectures	14 Axial flux motors that can offer high torque density in compact, lightweight packages conducive to in-wheel or near-wheel mounting	<ul style="list-style-type: none"> • Machine architecture

Within these identified innovation areas, based on the significance and the feasibility to the UK's capability, the 14 opportunities were further aggregated into the following five prioritised innovation opportunities:

- Diversified motor architecture
- Soft-magnetic composites
- Advanced cooling methods:
Active and novel cooling methods
- AI-based control strategies for E-motor control
- Innovative and ultra-low-loss winding techniques

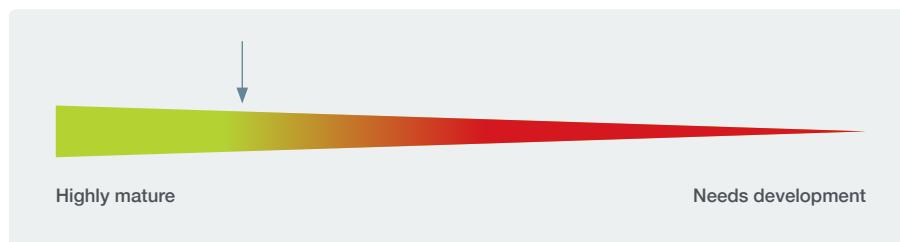
Deep dive summary

1 Diversified motor architecture

Technology description

High-performance vehicles present some of the most stringent requirements for electric motor design. These include extreme peak power, torque, and rotational speed, all within narrow constraints on mass and volume. As such, these applications demand electric motors with high volumetric and gravimetric power densities. Axial flux motors are particularly advantageous in this context due to their compact form factors and superior torque-to-weight ratios. Axial flux generates magnetic field parallel to the axis of rotation opposed to the traditional radial flux motors. They are a good candidate to be used as an in-wheel motor.

Maturity of capability within UK



Market potential for the UK

The UK has a strong base for local supply of axial flux motors where major auto OEMs can rely on for their high performance traction motor needs.

Key companies present in the UK

YASA, Lynch Motor Company, Evolito, Helix, Protean*

Challenges

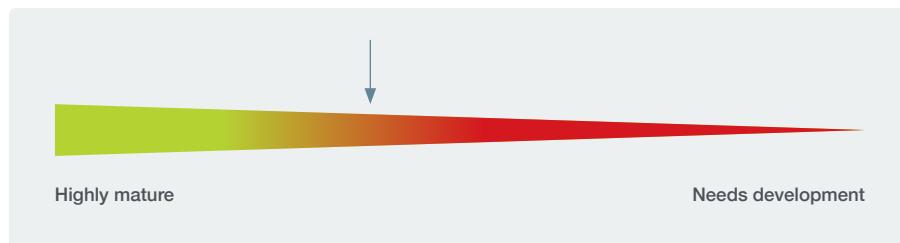
Axial flux motors are suited to lightweight, high-power-density applications but face drawbacks in thermal management and the presence of axial loads. There could be challenges in cost of manufacturing due to the design complexities.

2 Soft magnetic composites (SMC)

Technology description

Higher-silicon-content electrical steels reduce motor core losses, improving overall range and efficiency. The next generation stators and rotors will need to incorporate materials with enhanced strength and reduced magnetic losses. Soft magnetic composites (SMC) could be a potential candidate for this. SMCs are described as ferromagnetic powder particles surrounded by an insulated film like silica. They exhibit 3-dimensional magnetic flux capabilities with very low eddy current loss and reduced weight.

Maturity of capability within UK



Market potential for the UK

Increasing magnetic flux and reducing current losses are critical for motor designs like axial flux motors due to the complexity in geometric design and manufacturing challenges. To enable and scale soft magnetic composites material into motor manufacturing will unlock the potential of innovative motor design configurations.

Key companies present in the UK

GTB components and SG technologies.

Challenges

There are manufacturing challenges in producing SMCs. The difficulty is in getting high density iron powder layers without degradation in performance. Doping iron ferrite with Silicon can reduce eddy current losses, however may make the SMC powders brittle. Therefore currently the processing cost for producing SMCs are expensive than current lamination products.

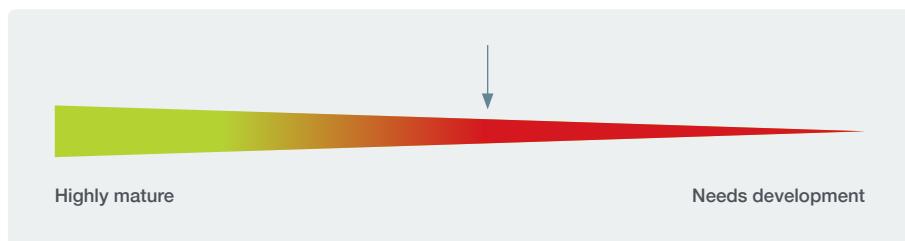
3 AI based control strategies

Technology description

Motor control is a key objective for optimal functioning of electric motors. Expected performance of a motor could be achieved through effective control of torque, speed and management of current supply. Integration with advanced power electronics and software controls is enhancing motor performance, with technology innovations such as artificial intelligence (AI). The following applications could be achieved through deployment of AI:²

- Optimisation of torque: AI could be used for torque optimisation by coupling simulation algorithms with various torque profiles.
- Motor control: Real-time monitoring and control of motor speed through AI techniques like neural network for provision of wide range of speed in different operating conditions.
- Health monitoring: sensing the physical parameter data like temperature, vibrations to assess and predict the future health of the motors in real-time operations.

Maturity of capability within UK



Market potential for the UK

Given the UK's automotive strengths in high performance, luxury and heavy duty vehicle segments, the need to have higher performance control and speed characteristics of the E-motor becomes important.

Torque ripple reduction becomes important for premium and high performance vehicle segments as it becomes noticeable at low speeds.

Key companies present in the UK

Monumo

Challenges

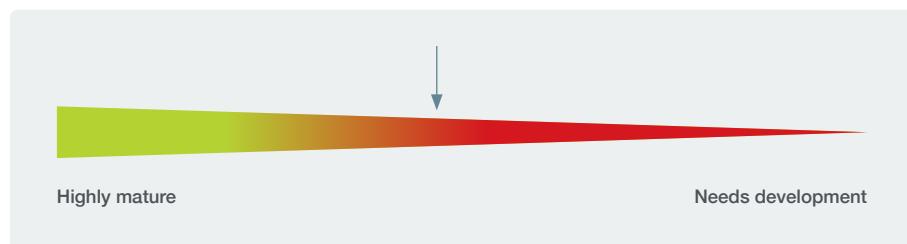
Lack of scalable current applications and data scarcity from real-world trials are current barriers for industry adoption.

4 Advanced cooling methods

Technology description

The E-motor APC technology roadmaps stipulates growth in volumetric and gravimetric power densities of 60% to 133% across all vehicle segments. As motors operate at higher power densities, heat buildup becomes a limiting factor on both motor performance and longevity. In high-performance applications, thermal management is a critical subsystem that ensures motor windings, magnets, and structural components endure transient and sustained high-load conditions without degradation or performance loss. Innovative cooling materials and novel, active cooling methods could boost the performance of motors required to handle high-performance, high-durability loads.

Maturity of capability within UK



Market potential for the UK

Based on the report's research and analysis two key innovation themes are identified as important for the UK's market potential.

- 1 Advanced materials
- 2 Design innovations

1 Advanced materials

The UK can invest in innovations in novel cooling methods and direct oil cooling techniques to improve the overall performance of electric motors. The UK also has the opportunity to invest in phase change materials that can enhance heat absorption and simplify cooling systems.

2 Design innovations

For BEVs, AI-driven simulations can optimise stator cooling channels, improving thermal transfer for high-performance applications. Combined cooling architectures that integrate motor, power electronics, and battery systems can reduce weight and complexity across UK-assembled EV platforms.

The UK also has great strengths in system integration of thermal management systems that should be leveraged.

Key companies present in the UK

Grayson Thermal Management Systems

Challenge

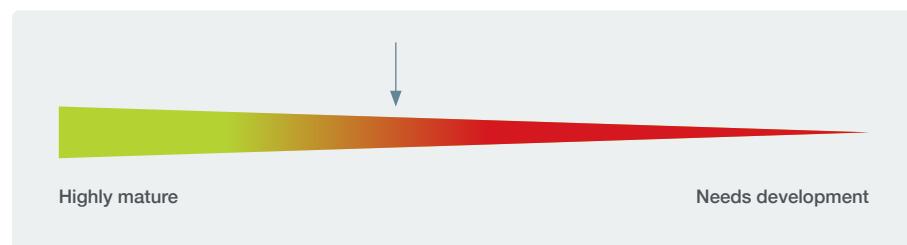
Innovative cooling methods for high performance motors have integration challenges as they are often packed in tight and constrained physical spaces. Adding cooling materials will likely add weight therefore consideration of system design before manufacturing is critical. The current TRL levels of some of the cooling methods are low and would benefit with the focus on R&D and collaborative innovation development to mature the technologies.

5 Innovative and ultra-low-loss winding techniques

Technology description

Whilst previous developments in stator winding focused on increasing the wind count, innovative winding techniques continue to evolve and have consolidated with competitive manufacturing processes, adopting hairpin windings in new designs. However, significant development capacity exists through the use of advanced joining techniques (e.g., welding) and hollow conductors, which are emerging alongside 3D printing and represent an important opportunity to improve the manufacturing process, given the intrinsic and complex nature of developing new windings.

Maturity of capability within UK



Market potential for the UK

Innovative winding techniques such as hairpin winding can increase the slot fill factor in the stator that can enable higher power and torque performance. This becomes very important for high performance vehicles that are constrained for space and packaging.

Key companies present in the UK

Bradford Armature Winding Company, DER-IC WMG, JLR Wolverhampton plant.

Challenges

There will be a need to mature the innovative scaling technologies needed for successful implementation of the winding techniques for medium to high volume manufacturing.

6 | Supply chain and cross-cutting trend innovations

Alongside technology innovations, electric motor development is being shaped by several other factors, such as economic and regulatory shifts. This can be categorised as two main pathways:

- Supply chain challenges
- Cross-cutting emerging technology trends identified within the roadmap.

Table 2: Non-technical innovation areas

Pathway	Theme	Description	Strategic importance
Supply chain interventions	Magnet supply innovation	<ul style="list-style-type: none"> • To provide opportunities in the UK for de-risking rare-earth supply vulnerabilities. • To enable secondary magnet material recycling to improve security of permanent magnet supply 	High
	Scale-up manufacturing of REE-free motors	<ul style="list-style-type: none"> • To de-risk and accelerate the adoption of rare-earth-free motor types, which has clear environmental and supply chain benefits, the UK can fund pilot and demonstration lines for induction motors and EESM 	Medium-high
	Legislation	<ul style="list-style-type: none"> • Aligning local supply chain incentives with Rules of Origin (especially under UK-EU trade agreements) ensures that manufacturers gain tariff-free access to key markets while building resilient, value-added supply chains within the UK 	Medium
Cross-cutting emerging technology trend	Digital and AI-driven design	<ul style="list-style-type: none"> • Leveraging AI and machine learning, can significantly accelerate the exploration of multi-objective design spaces 	Medium-high
	Industry-academia collaboration for additive manufacturing	<ul style="list-style-type: none"> • Additive Manufacturing for stators and rotors also presents an area of opportunity, in particular for innovative winding manufacturing 	High

Based on the identified cross-cutting trends and supply chain challenges, this report prioritises the following innovation themes as strategically important and relevant to realising the APC roadmap objectives:

- Magnet supply innovation
- Scale-up manufacturing of rare-earth elements (REE)-free motors
- Digital and AI-driven design
- Additive manufacturing

Supply Chain Intervention

Magnet supply innovation

Key challenge

Whilst not a technical challenge, material supply chains are of critical concern. Over 90% of global rare earth oxide (REO) processing occurs in China, Myanmar, and USA, with China alone dominating refining and magnet production. Supply chains are geopolitically fragile, especially for heavy rare-earth elements (HREEs) like dysprosium and terbium, which are critical to high-temperature magnets.

Current trends around the world

There are various supply chain initiatives underway across the globe to decouple reliance on rare earths from China. The EU is planning to create a central body to co-ordinate the purchasing and stockpiling of critical minerals including rare-earths.

The UK opportunity

The UK can position itself at the forefront of a circular economy for critical materials by establishing advanced facilities for the recycling of Neodymium (NdFeB) magnets. Developing domestic hydrometallurgical processes to extract and re-process magnet production waste and end-of-life magnets from scrapped EVs and turbines can dramatically reduce import dependence, lower environmental impact, and capture economic value. Companies like HyProMag and Ionic Rare Earths in this space provide a solid foundation for scale-up.

Scale-up lines for Induction motor and EESM

Key challenge

The reliance on rare-earth materials has made permanent magnet motors highly dependent on the Chinese supply chain, given the recent tensions and risk of geopolitical trade wars and tariffs. It is essential to identify opportunities to diversify motor technology away from permanent magnets. The UK can be a place where technologies for Externally Excited Synchronous motors and Induction motors could be scaled up through funding programmes like DRIVE 35.

Current trends around the world

Major OEMs like BMWs are developing their new EV platform-based vehicles using EESM (Electrically Excited Synchronous Motor) technology.

The UK opportunity

To de-risk and accelerate the adoption of rare-earth-free motor types, which has clear environmental and supply chain benefits, the UK can fund pilot and demonstration lines for induction motors and EESM.

Cross-cutting emerging technology trends

AI-driven design and optimisation

Key opportunity – Design

AI based technology can improve the design process of developing electric motors. Electric motor design involves complex trade-offs between competing objectives like efficiency, NVH, thermal performance, and cost. Leveraging AI and machine learning, especially large language models and generative design algorithms, can significantly accelerate the exploration of multi-objective design spaces. This can lead to faster innovation cycles and better-performing motors.

IoT-enabled condition-based monitoring

Embedding sensors and connectivity into EV motors enables condition monitoring and predictive maintenance across entire fleets. This not only extends motor service life but also increases vehicle uptime, reduces warranty costs, and enhances residual value, critical metrics for fleet operators and OEMs in both passenger and commercial EV segments.

The UK opportunity

Motor manufacturing remains relatively cost-intensive. Integrating AI based design into motor manufacturing can increase optimised design and lower costs. Digital twins also allow for real-time optimisation of production processes and predictive maintenance, essential for scaling up with consistent quality.

Additive manufacturing

Key opportunity

Additive manufacturing (AM), commonly known as 3D printing, involves creating objects by adding material layer by layer. Additive manufacturing will help improve the overall E-motor manufacturing process by introducing innovative techniques that enable lightweight designs and reduce costs. Additive manufacturing for stators and rotors also presents an opportunity, particularly in providing innovative light weight winding techniques.

There are also opportunities for 3D-printed cooling channels that will enable integrated lightweight ducts and fins that will help to reduce the overall weight of the electric motor.

The UK opportunity

Strengthen the UK's facilities for additive and winding manufacturing techniques to boost the innovation potential and invest in R&D technologies that can scale up the early-stage technology ideas for additive manufacturing in E-motor technology production. The UK's world-class universities, such as the University of Sheffield's Advanced Manufacturing Research Centre², offer opportunities to develop and pilot additive manufacturing (AM) techniques for producing stator and rotor components. AM enables intricate geometries, weight reduction, and localised material optimisation, supporting novel motor designs and smaller batch production runs ideal for customised or high-performance applications.

7 | Conclusions: Recommendations from the report

This report provides an overview of the technology opportunities important to the future of the UK's electric motor technology innovation, needed to establish the ecosystem for manufacturing the identified technology innovations. The prioritised technical innovations needed to target the technology indicators laid out in the APC's electric machines roadmap is listed here with some potential recommendations to strengthen the opportunity in the UK.

Table 3: Technical innovations

S no	Innovation opportunity	Description	Actions to strengthen the opportunity in the UK
1	Diversified motor architecture	Axial flux motors can offer high torque density in compact, lightweight packages conducive to in-wheel or near-wheel mounting	Strengthen and leverage the current scale-up facilities for axial flux motors in the UK
2	Soft magnetic composites (SMC)	Using soft magnetic composites (SMC) in place of laminated steel	Invest in R&D for improving the manufacturing readiness levels of making SMCs
3	Advanced cooling methods	Advanced cooling methods to improve the performance and efficiency of electric motors in auto applications	Invest in R&D for improving the TRL levels of novel cooling techniques
4	AI based control strategies for E-motor control	AI-based torque and speed control mechanisms	Identify and incentivise companies in the UK who have the capabilities to apply AI techniques to motor applications
5	Innovative and ultra-low loss winding techniques	Development of unique winding configurations for improving efficiency of the motors.	To invest in scale-up facilities for the winding manufacturing companies in the UK

The prioritised supply chain and cross cutting trend innovations, needed to enable a successful UK supply chain for electric motor technologies is listed here with some potential recommendations to strengthen the opportunity in the UK.

Table 3: Supply chain and cross-cutting trend innovations

S no	Innovation opportunity	Description	Actions to strengthen the opportunity in the UK
1	Magnet supply innovation	To provide opportunities in the UK for de-risking the rare-earth supply vulnerabilities	The UK can position itself at the forefront of a circular economy for critical materials by establishing advanced facilities for the recycling of NdFeB magnets
2	Scale-up lines for Induction motor and EESM	To de-risk and accelerate the adoption of rare-earth-free motor types, which has clear environmental and supply chain benefits	Set up scale-up facilities and E-motor foundries for non-PM motors in the UK
3	AI-driven design and optimisation	To leverage the strengths of AI-driven technology trends	Identify and invest in R&D use cases that can provide real-world objective data on the AI applications: both in design and in-use monitoring applications
4	Additive manufacturing	Additive manufacturing for stators and rotors also presents an area of opportunity, particularly for manufacturing innovative winding techniques	Work closely with Industry and academia to form a collaborative network on researching and advancing additive manufacturing capabilities in the UK

Glossary

AI	Artificial intelligence
AM	Additive manufacturing
BEV	Battery electric vehicle
E-Motor	Electric motors
EESM	Electrically Excited Synchronous Motors
HREE	Heavy-rare=earth elements
IM	Induction motor
NVH	Noise Vibration and Harness
OEM	Original Equipment manufacturers
REE	Rare-earth elements
SMC	Soft magnetic composites
TRL	Technology readiness levels

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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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System-Level Roadmaps



Mobility of People



Mobility of Goods

Technology Roadmaps



Electric Machines



Power Electronics



Electrical Energy Storage



Lightweight Vehicle and Powertrain Structures



Internal Combustion Engines



Hydrogen Fuel Cell System and Storage

Find all the roadmaps at

www.apcuk.co.uk/technology-roadmaps



Established in 2013 and jointly funded by the Department for Business and Trade (DBT) and the automotive industry, the APC accelerates the technologies that support the transition to zero-emission vehicle manufacturing and towards a net-zero automotive supply chain in the UK.

With a proven track record, the APC has facilitated funding for 354 low-carbon and zero-emission projects involving 614 partners. Working with companies of all sizes, this funding since 2013 is estimated to have helped create or safeguard over 59,000 jobs in the UK. The technologies and products are projected to save over 425 million tonnes of CO₂.

