Summary Report

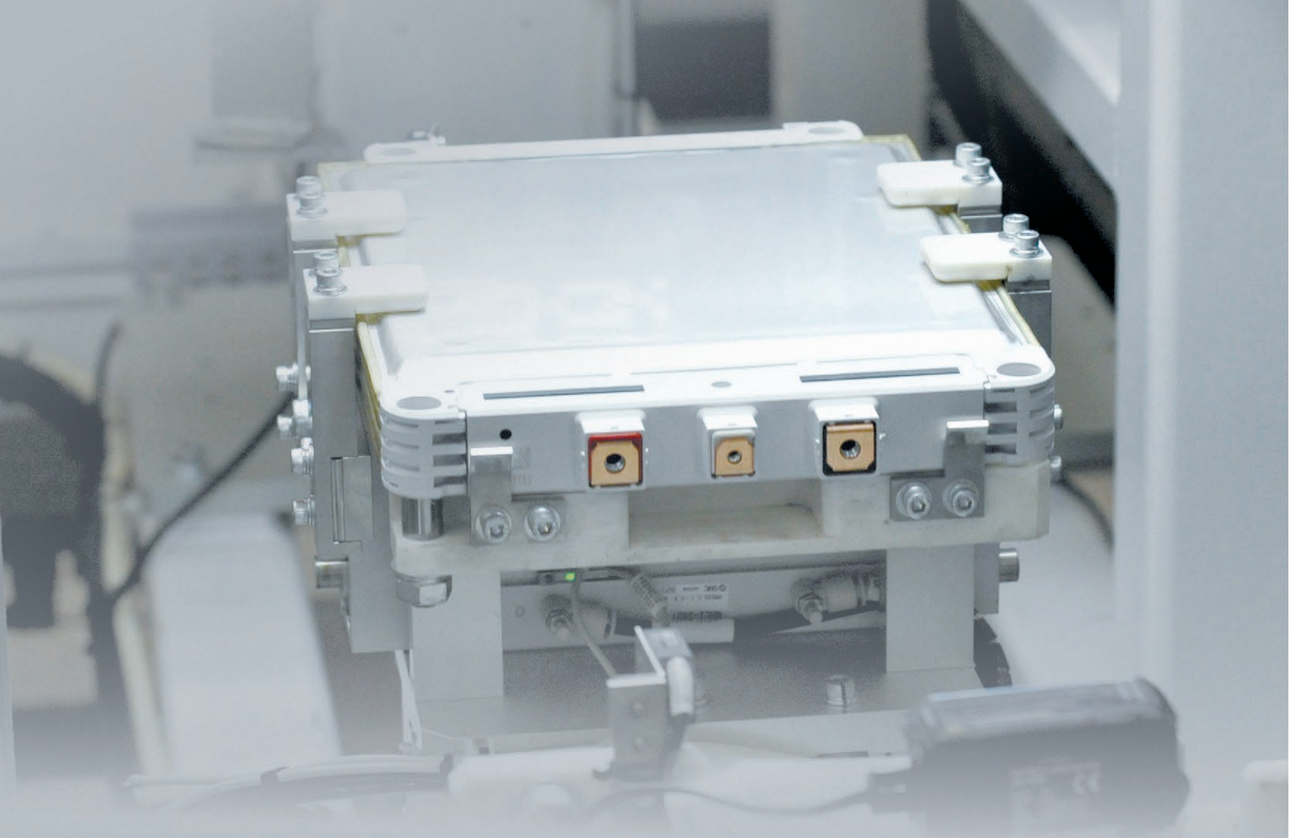
Strategic UK opportunities in passenger car electrification

An assessment of the commercial opportunities arising from the electrification of passenger cars.

This summary outlines potential growth in the manufacture of batteries, electric machines and power electronics, along with their supporting materials and processes.

ADVANCED PROPULSION CENTRE UK

Accelerating Progress



Contributors

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The Advanced Propulsion Centre (APC) accelerates the industrialisation of technologies that will help to realise net-zero emission vehicles. It is at the heart of the UK government's commitment to end the country's contribution to global warming by 2050.

Since its foundation in 2013, APC has funded over 110 low-carbon projects, involving more than 290 partners. The technologies developed in these projects are projected to save over 179 million tonnes of CO_2, the equivalent of removing the lifetime emissions from around 7 million cars.

APC projects have helped generate economic benefits too. Companies involved have seen turnover increases of 14–17%, with new jobs increasing by 8–10%. Together these have generated a 17% Gross Value Added uplift.

With its deep sector expertise and cutting-edge knowledge of new propulsion technologies, APC's role in building and advising project consortia helps projects start more quickly and deliver more value. In the longer term, its work to drive innovation and encourage collaboration is building the foundations for a successful UK industry.

AVL

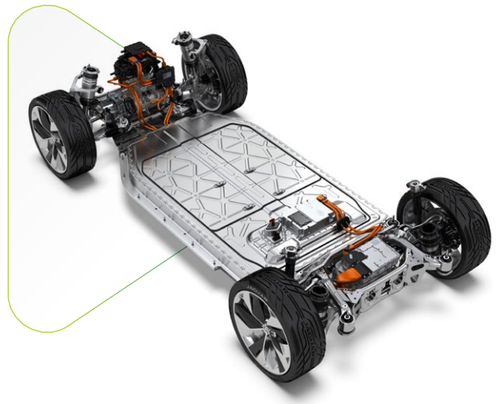
With more than 10,400 employees, AVL List GmbH is the world's largest independent company for the development, simulation and testing of all types of powertrain systems (hybrid, combustion engine, transmission, electric drive, batteries, fuel cell and control technology), their integration into the vehicle and is increasingly taking on new tasks in the field of assisted and autonomous driving as well as data intelligence. The company was founded in 1948 with the head office in Graz, Austria. It provides industry-leading technologies and services based on the highest quality and innovation standards to help customers reduce complexity and add value.

Report overview

The Advanced Propulsion Centre (APC) has worked with AVL to identify opportunities for UK suppliers from the electrification of passenger cars over the next five years.

The study has focused on batteries, electric machines and power electronics. In the short term these three areas of the electrified powertrain are most important from a cost, functional and performance perspective. Future demand means that manufacturers need to act quickly if they are to secure their share of key markets that are projected to grow significantly in the next five years.

This report demonstrates that the UK already has the building blocks of a thriving supply chain and therefore provides a good backdrop for investments across these new value chains to meet domestic, European and in some cases global demand.



Area of focus	UK opportunity for the electrification of passenger cars
Report timeframe	5 years
Value of opportunity	£24bn

£24 billion represents the serviceable available market across 12 opportunities considering geographic access for UK-based manufacturers.

Additional insight

Please contact Dave OudeNijeweme at the Advanced Propulsion Centre if you would like further information on the opportunities identified in this report.

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Transition to electrification

The transition to greater electrification of vehicles is gathering pace. Governments around the world have set bold targets for CO_2 emissions, and to improve air quality supported by legislation.

Average EU wide fleet targets for new cars will be 95gCO_2/km from 2021, mandated to fall a further 37.5% by 2030. Electrification is currently the main commercially viable option for passenger cars that can meet these targets.

In areas of particularly high emissions around the world, zero tail-pipe zones are being created. Internationally, some governments are mandating the proportion of electrified and electric vehicles that must be sold or are accelerating moves to phase out new diesel and petrol powered vehicles altogether.

As a result, 100% of all new passenger cars sold in the EU are expected to have some form of electrification by 2030 (as shown in the chart opposite).

As an outcome of the consultation on bringing forward the end of ICE-powered cars in the UK to 2035 or earlier, other nations are taking similar action. This may accelerate these opportunities further if approved.

100%

of new passenger cars sold in the EU are expected to have some form of electrification by 2030

Market opportunity for the UK

Methodology

AVL have worked with the APC to identify specific opportunities in the UK electrified powertrain supply chain by 2025. The study focussed on batteries, electric machines and power electronics, the three high-value components essential for the future development of electrified light duty vehicles. Together these account for approximately 40% of the value of the vehicle and are therefore critical to a competitive automotive sector.

Through detailed analysis of the value chain in each area, and an assessment of the UK's competitive strengths relative to EU and global competition, the team have identified and evaluated the best opportunities available to UK suppliers.

12 key opportunities worth £24 billion

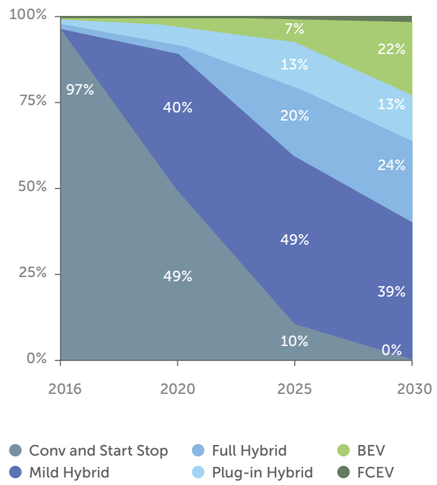
Within batteries, electric machines and power electronics, the total global addressable market is forecast to reach £97 billion in 2025. The analysis of the value chain and the UK's competitive strengths shows that there are 12 key opportunities which the UK is particularly well placed to address. The market opportunity within geographic reach of UK players in these 12 areas is forecast to be £24 billion in 2025.

Growth for UK suppliers

Future electrified light duty vehicle supply chains are being localised to ensure they are cost-effective and competitive. Suppliers within the EU currently represent a relatively small proportion of global supply chain capacity – for example, in lithium ion cell manufacturing it's less than 5%. Our demand forecasts indicate that supply chain capacity will, in many cases, need to increase five to ten-fold over the next five years, representing a significant opportunity for suppliers to EU markets.

Having conducted a thorough inventory of the entire value chain at home and abroad it seems that the UK is particularly well positioned to address these opportunities, as shown in the following sections.

Projected EU Passenger Car Production to 2030



£24 billion opportunity by 2025 for UK players

Batteries	£12bn
Power Electronics	£10bn
Electric Machines	£2bn
Total UK opportunity at least	£24bn

Batteries and Electric Machines are primarily EU opportunities, Power Electronics is primarily a global opportunity.

Opportunity by region for UK players

£2bn	£12bn	£7bn
		China USA, Mexico & Canada

Batteries

£12 billion opportunity

The complete process from mining raw materials to the finished pack involves over 40 distinct manufacturing processes and at least 30 semi-finished product stages.[1] Five of the key UK opportunities lie within the components used to make a battery cell, notably in cathode and anode manufacturing, electrolyte supply, as well as in final cell assembly. A further opportunity lies within supply of components for battery modules and packs.

Opportunity 1

Cathode materials refining

As battery cell chemistries use higher nickel content in pursuit of better performance, cathode mixers are increasingly setting up their facilities closer to nickel refineries to secure supply agreements. The UK has a long-standing tradition of nickel refining, dating back to 1902 in South Wales. Today, with 40kT battery grade capacity, the UK has one of the largest nickel refineries in Europe. Their recent and current investment in raising productivity and improving environmental performance are making it a highly sustainable business.

Increases in capacity are certainly possible and largely depend on raw material allocations.

The existing Intellectual Property (IP) in battery grade nickel powder and pellet production is truly world-leading and could be extended to cobalt refining. All this combined with access to low-carbon, low-cost energy makes the UK a serious option for cathode active manufacturing investments.

Opportunity 2

Cathode manufacturing

Li-ion battery performance and cost are to a large degree determined by the cathode. In the case of NMC and NCA (Lithium Nickel Manganese Cobalt Oxide and Lithium Nickel Cobalt Aluminum Oxide) chemistries, mixing the cathode materials of nickel, cobalt and lithium are value-add processes.

Cathode mixing is rich in IP and very energy intensive, while the trend to higher nickel compositions makes the material less stable. As a consequence, the industry is locating cathode active mixing facilities in areas with access to low-cost, low-carbon electricity, near sources of pre-cursor materials with good transport links to their customers. This trend is illustrated by BASF's recent investment (co-located next to Nornickel's facility in Finland) where access to material and site sustainability have been cited as key drivers.

This opportunity has additional knock-on effects on nickel refining and lithium hydroxide production. The difficulty of transporting the hydroxide makes localisation more attractive. The UK is well placed with two lithium hydroxide and carbonate producers who supply to existing cathode manufacturers.

In addition to being able to support current facilities, the UK provides a rich research network, enabling companies to explore future cathode material compositions and develop new manufacturing processes.

1. www.apcuk.co.uk/app/uploads/2019/04/Automotive-Batteries-Report-Summary-April-2019.pdf

Opportunity 3

Anode manufacturing

The UK is a significant European producer of high grade needle coke. This is a key material in the development of synthetic graphite, which is typically blended with natural graphite, silicon and other conductive additives for lithium ion battery anodes. Currently, most of the needle coke produced in the UK is sent to China. There is an opportunity for an anode manufacturer setting up in the UK to benefit from lower shipping costs, tariffs and access to UK R&D networks into new anode materials, such as graphene or lithium metal anodes. Anode mixing and potentially graphitisation of needle coke are processes currently not conducted in Europe. The UK can address this gap (or need) as it provides access to pre-cursor materials and IP, with low-cost and low-carbon energy available for manufacture.

Opportunity 4

Electrolyte manufacturing

The UK has a well-established electrolyte production supplier with significant IP, serving UK and European cell manufacturers, making it one of only two significant players in Europe.

Growth forecasts suggest production capacity within Europe will be fully utilised by 2021 and thus additional capacity will be needed. This growth presents opportunities for the UK to build on its strong heritage in chemicals to significantly increase electrolyte capacity and localise supply of raw materials such as electrolyte salt and additives. As electrolytes are typically difficult and costly to ship, cell suppliers will often source this locally, so the production plant on the East coast of the UK is ideally placed to supply local and European demand.

Looking forward, the industry is investing in solid state batteries (replacing the liquid or polymer electrolyte with a solid electrolyte) which promise greater energy density and durability. The UK has a strong R&D base and leading companies working in this area, which would help to future-proof electrolyte supply.

Opportunity 5

Cell assembly

The UK currently has a 1.9 GWh battery cell manufacturing plant producing Nissan electric vehicle products. Conservative estimates suggest that the UK will need between 10 and 20 times its existing production capacity to meet the rapidly growing demand from electrified passenger cars by 2025. While not all OEMs have publically revealed their cell suppliers, various OEMs are selecting their preferred partners and are attracting gigafactories close to vehicle assembly plants. Since 50-60% of the bill of materials cost is driven by six key materials (cathode, anode, electrolyte, separator, aluminium and copper foils), securing access to those materials at a competitive cost-point is an area where the UK can further enhance its attractiveness to cell manufacturers.

The UK has a number of additional attributes: several battery customers in automotive and beyond; a significant investment in battery research, development and industrialisation; a supportive environment for innovation and business together with strong commitment from government. Finally the UK is de-carbonising its grid the fastest among the G8, meaning that batteries made in the UK have extremely low embedded CO_2.

Opportunity 6

Battery pack components

The UK produces approximately 10% of all the vehicles in the EU and battery pack manufacturing will mostly occur in very close proximity to vehicle manufacturing. This makes the UK an attractive location for manufacturers of battery modules and packs (OEMs and Tier 1s) to source components including busbars, cooling plates, housing seals and the battery management system hardware. Much of this capability and IP lies within the UK's extensive high-performance automotive sector or in adjacent sectors that are transitioning to automotive, offering the scope to develop higher performing systems in the future.

Electric machines[2]

£2 billion opportunity

All passenger cars, whether battery or hydrogen powered, are likely to be propelled by electric motors in the future. Although current electric machines for automotive propulsion are based on industrial drives, they are rapidly being developed into efficient, high-performance machines at the costs needed for automotive applications. The UK has a large number of highly innovative electric machine developers and producers working on a wide range of technologies, topologies and applications. The main opportunities in the supply chain relate to the manufacturing of magnets, manufacturing of electrical steel and assembly of the electric machine.

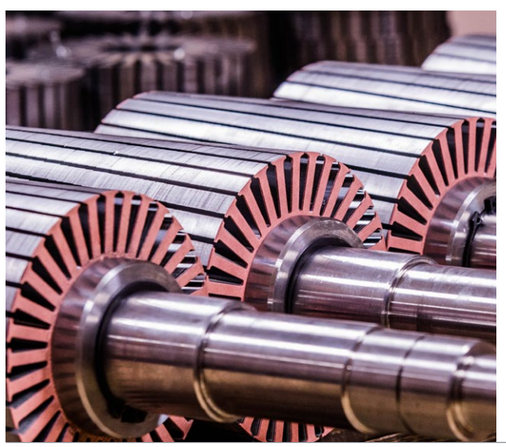
Opportunity 7

Magnet manufacturing

Magnets represent approximately 40-50% of the bill-of-materials cost for each electric machine – this makes magnet manufacturing a critical process in the value chain. A supply chain delivering high-performance, cost-effective magnets will be critical to enable growth markets in automotive and wind power, supporting the transition to net zero.

China has a dominant position with a near global monopoly in rare earth oxides (the working ingredients of magnets), mining, refining and magnet production. The UK has the only rare earth magnet alloy powder producer outside China and Japan, while Germany has sintered magnet manufacturing capability. Although the UK and Germany could together meet 12% of 2025 European electric passenger car demand, there is a pressing need to build a more diversified and competitive supply chain, all the way from mining through to recycling.

The UK can play a significant global role in building this supply chain and is well positioned for the future, with a significant cluster of expertise around permanent magnets, an existing supplier of alternative magnet materials and R&D capability in recycling of permanent magnets.



Opportunity 8

Electrical steel

Electrical steels (or soft magnetics) are key to almost all automotive electric machines. The IP to manufacture thin, silicon-based electrical steels resides in the UK, even though it is not produced here currently.

There is an opportunity to develop local production capacity of non-grain oriented electrical steel to meet the growing demand from the EU and the varied UK electric machine manufacturer segment.

The UK can build on the capabilities of growing numbers of local companies and key foreign companies who can stamp these steels. Most of the know-how and infrastructure is in South Wales and a relatively modest investment could make the UK a significant player in this area.

Opportunity 9

Electrical machine assembly and testing, including stator winding and housing manufacture

The UK has a relatively large number of innovative electric machine manufacturers that are becoming Tier 1 suppliers. As vehicle manufacturers increasingly transition to (part) electric propulsion and seek value addition, there is a trend by OEMs to bring electrical machine development and manufacturing in house. The added-value step here is the expertise to manufacture and test the electric machine to demanding automotive specifications at low cost. The automation of highly complex processes, such as stator windings, magnet insertion and quality control steps, is key to the competitiveness of many of these companies. Local sourcing of highly complex housing assemblies and other components with high levels of development potential, present further opportunities for the UK.

2. Electrical machines are considered as a separate part of an Electronic Drive Unit, E-axle, etc. as they can exist on their own or fully integrated. The value chain remains similar.

Power electronics

£10 billion opportunity

To achieve the optimal performance in terms of power, weight and range, electrified vehicles will require a new breed of high-performance power electronics (for inverters, converters and charging equipment) based on compound semiconductors, such as SiC (silicon carbide) and GaN (gallium nitride), which will, over time, replace traditional silicon-based devices. This change of material means that it is now critical for the end customer to influence the design and manufacturing process of the semiconductors on a wafer level, as well as how these semiconductors are integrated within the product. This is reflected by industry trends of vertical integration and consolidation.

Opportunity 10

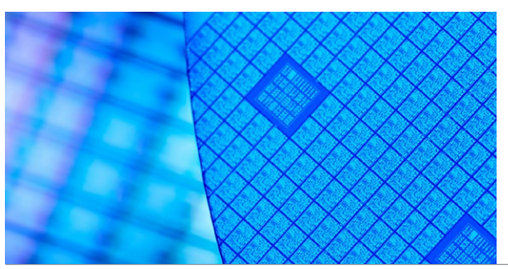
Semiconductors

The UK has significant capability in the design and manufacture of power electronics, machines and drives. Indeed, there is a cluster of highly innovative companies that span the value chain, which have the breadth, depth and capacity to serve specific customer requirements. For example, the UK has a world-leading company that manufactures over 500,000 drives per annum for domestic and export markets. This technology is directly applicable to electric vehicles, although it is currently based on silicon semiconductors. As these companies adopt new wideband-gap semiconductors, they will be in prime position to address the growing market for electric vehicles.

The UK has a number of facilities producing power electronic devices for automotive and other sectors. These companies historically manufactured silicon devices and are currently migrating towards wideband-gap semiconductors, such as SiC and GaN. For example, the UK has a facility that currently manufactures around 1 billion silicon MOSFETs (a type of power electronic switch) per annum and is currently investing in GaN.

As the global demand for SiC is forecast to rapidly outstrip supply, this is encouraging UK companies to invest in new SiC fabrication technologies in readiness for the growing electric vehicle market.

Optimising wideband-gap power modules requires that the end application influences the design across the value chain, from epitaxy, to die-preparation, encapsulation and packaging. The UK has capability in all stages of the supply chain and is ready to work collaboratively to leverage the full set of capabilities.



Opportunity 11

Sensors

Next generation electric vehicles require a plethora of sensors to assess the operating environment, such as temperature, voltage, speed, etc. The transition to wideband-gap materials requires higher temperature operation and better fault tolerance mechanisms: this is where sensors play a key role in enabling the introduction of these devices. The UK has a number of advanced sensor companies and research institutes looking at next generation sensors.

While not in scope of this report, investing in sensors for power electronics applications will enable the move towards increasingly advanced driver assistance systems/autonomous vehicles; utilising a new generation of sensors to assess the proximity of other vehicles using LiDAR (RADAR using light), and to provide high-speed communication for vehicle tracking and monitoring. The UK has a £13 billion photonics and sensors market that is currently developing technologies for these applications.

Opportunity 12

High-performance passive components

Power electronic systems require the integration of semiconductors with 'passive' components, such as inductors and capacitors, including DC link capacitors. Automotive applications require high-performance passive components that can operate within the harsh environments experienced by modern vehicles, including extreme temperatures. DC link capacitors have remained relatively unchanged and will require new material innovations, such as improved dielectric materials, to operate effectively alongside wideband-gap semiconductors. There are several UK companies that design and manufacture high-performance passive components, which are gearing up production to meet the anticipated demand for electric vehicles. The UK is also developing complementary technologies, such as heat-coupling materials that provide semiconductor thermal management.

Conclusions

A substantial global opportunity

The electrification of passenger cars is proceeding at pace. Bold targets for reducing CO_2 emissions will see the launch of many new models of electrified vehicle in the next two years. By 2030 all new vehicles sold in Europe are expected to have some form of electrification.

The global market opportunity from this rapid change is conservatively estimated to be £97 billion by 2025. Within Europe, relatively immature supply chains in key areas including batteries, electric machines and power electronics will need to expand more rapidly than those in other parts of the world to meet demand. Indeed, in some areas, capacity will need to increase five-fold by 2025 and over ten times by 2030.

To benefit from this remarkable growth, companies need to be aware of the opportunities and invest as soon as possible. Those that show leadership and act quickly have the most to gain.

UK-based players are well placed to benefit

Given the pressing nature of the opportunity, the APC commissioned an independent review from AVL to identify those areas where the UK is particularly well placed compared with the rest of the world, and particularly Europe. The assessment has examined the complete value chain in batteries, electric machines and power electronics, identifying individual market opportunities and matching them against UK competitive strengths.

The work has shown that, despite some perceptions, players in the UK are already supplying or are very capable of serving many of the growth markets enabled by electrification.

In some areas, such as electrolyte mixing, nickel refining and magnet powder manufacturing, the UK is particularly strong, with established global producers, an extensive chemical supply chain and leading R&D capability.

12 opportunities have been identified within the value chains for batteries, electric motors and power electronics where the UK has capability and capacity and is best placed to gain an early and sustainable competitive advantage. Taking geographic and logistical access into account, these 12 areas represent a market for UK players worth as much as £24 billion by 2025. Europe represents the largest part of this, although the UK market is also relatively important, underpinned by demand from the premium vehicle sector.

A clear way forward

The APC has not only identified and quantified the opportunities, it has highlighted gaps in the relevant supply chains that need to be addressed. It has developed a plan in each of the 12 opportunity areas and is working with the UK government to address those gaps. It is also working across relevant supply chains, building an ecosystem of academics and companies developing new technologies and processes towards common goals. This level of coherence and determination makes the UK unique.

We would welcome the chance to show what the UK has to offer and to explain in detail the opportunities that have been identified. The UK has an ideal ecosystem for suppliers and a rapidly growing market for electric vehicles – the essential building blocks for a successful long-term investment.

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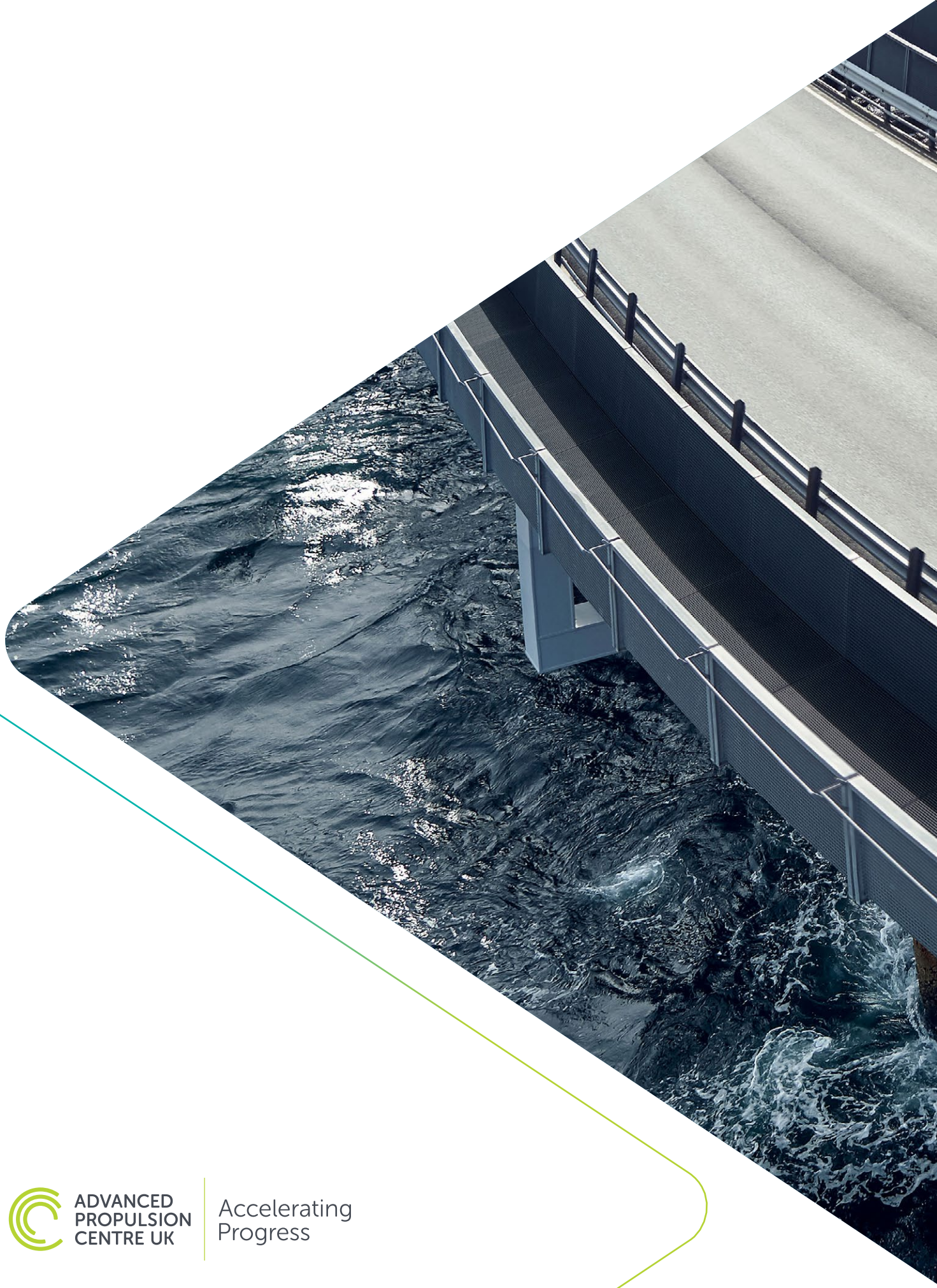

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