DRIVING THE ELECTRIC REVOLUTION CHALLENGE – FINAL IMPACT EVALUATION

MARCH 2025

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Acknowledgements

Some of our secondary data analysis was produced using statistical data from the Office for National Statistics (ONS). The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce ONS aggregates.

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1 Executive Summary

1.1 Context of the evaluation

This report presents the findings of the final impact evaluation of the Driving the Electric Revolution Challenge (‘the DER Challenge’) delivered by Innovate UK for UK Research and Innovation (UKRI) on behalf of the UK Government.[1] It is the fourth and final phase of an evaluation of the DER Challenge, following on from a process and interim impact evaluation completed in early 2023.[2] These evaluation results build on a baseline report completed in 2022 and an evaluation framework report completed in 2021.

The DER Challenge[3] is a £234 million investment programme, including £80 million committed by UKRI and a further £154 million expected to be catalysed by the DER Challenge activities. The DER Challenge has achieved a total realised co-investment of £403 million, almost doubling the initial target set by the DER Challenge (£234 million) and reaching a catalysed funding ratio of nearly 16:1. As per the original business case, the DER Challenge has four high-level objectives:

- Leverage the UK’s world-leading research capability in Power Electronics, Machines and Drives (PEMD) to help industry create the supply chains necessary to manufacture the PEMD products developed in the UK;
- Identify gaps in the supply chains and help industry to fill them;
- Ensure cooperation and collaboration so that we do not duplicate effort and waste time and can reuse solutions across sectors; and
- Help fill skills gaps across supply chains by retraining and upskilling workers.[4]

The DER Challenge has focused on various sectors, including aviation, automotive, energy generation and supply, manufacturing, marine, off-road, rail, robotics and AI, semiconductors, and skills.

The DER Challenge began in 2019 and will run until 31 March 2025. This final impact evaluation was conducted while the DER Challenge and projects funded by it were ongoing. All conclusions must be read in that light.

The DER Challenge has taken forward four strands of activity to meet the objectives set out above. It has:

- provided grant funding to industry-led consortia to undertake a series of collaborative research and development (CR&D) competitions;

[1] UKRI. Driving the Electric Revolution.

[2] Driving the Electric Revolution phase 3: process evaluation and interim impact evaluation

[3] https://iuk-business-connect.org.uk/electronics/der-iscf-challenge/

[4] Only £6 million of funding was allocated to this objective. Following two exploratory studies which investigated the best use of this available budget, the Skills Hub was established.

- provided grant funding via a competitive process to academic-led consortia to establish a network of Driving the Electric Revolution Industrialisation Centres (DER-ICs) which provide access to specialist equipment and help firms access additional funding opportunities;[5]
- tackled skills gaps by producing reports, promoting PEMD career opportunities and running dedicated skills-focused competitions; and
- facilitated knowledge exchange activities via widespread engagement in conjunction with Innovate UK Business Connect.[6]

As with many other areas of the UK economy, COVID-19 and Brexit are likely to have had a significant impact on UK PEMD. Trying to understand the counterfactual of what would have happened to the impact of the DER Challenge in the absence of those events is beyond the scope of this work. However, further context around the importance of COVID-19 and Brexit is provided in the interim impact evaluation completed in early 2023.[7]

1.2 Approach

We undertook a contribution analysis for the final impact evaluation. This is an example of a theory-based evaluation. This has allowed us to come to a considered view – based on a range of evidence – on the contribution that the DER Challenge has made to a range of indicators spanning the seven evaluation themes identified in the evaluation framework report. These themes were informed by a theory of change (ToC), agreed with the DER Challenge, and draw heavily on the business case objectives set out above. The themes are:

1. Has the DER Challenge accelerated innovation and commercialisation of PEMD technologies?
2. Has the DER Challenge increased the productivity of the UK PEMD supply chain?
3. Has the DER Challenge contributed to growing PEMD knowledge and skills in the UK?
4. Has the DER Challenge increased the value of investment in UK PEMD companies?
5. Has the DER Challenge helped foster a collaborative PEMD ecosystem?
6. Has the DER Challenge led to an expansion of UK PEMD manufacturing capacity?
7. Has the DER Challenge driven environmental, societal and policy benefits?

Given the nature of the intervention and the complex set of objectives that the DER Challenge is working towards, we did not attempt to derive a single 'impact estimate'. Rather, we adopted a mixed-methods approach in which quantitative and qualitative evidence was triangulated to establish the contribution of the DER Challenge and understand the counterfactual of what might have happened without it. Where different pieces of evidence about the indicators or

[5] The DER-ICs therefore emerged as a result of DER funding but were not directly managed by the DER.

[6] Formerly KTN https://iuk-business-connect.org.uk/

[7] Driving the Electric Revolution phase 3: process evaluation and interim impact evaluation

the DER Challenge's contribution suggested different conclusions, we assessed the relative strengths and weaknesses of each in determining our views based on the data available.

The metrics, methods and data sources used in this evaluation are:

1. Three types of in-depth case studies, including self-reported counterfactuals, drawing on desk research and interviews in which respondents were asked to reflect in detail on what had happened or what they had achieved as a result of their engagement with the DER Challenge. These are:
    a. An **activity-based case study** which focuses on the activities of the Midlands DER-IC over the last 18 months and any longer-term benefits. This builds directly on the interim impact evaluation activity-based case study of the same DER-IC.
    b. Two **project-based** case studies which describe the technical, commercial and social impacts of specific DER Challenge-funded projects. These are **GaNSiC**, which builds on findings from the interim impact evaluation, and **SCREAM**, a new case study for this final evaluation. Annex B provides further detail on the project-based case studies.
    c. A **thematic case study** which explores the impact of the DER Challenge on the wider PEMD supply chain and UK economy based on interviews with academic institutions, PEMD firms, trade associations and policy stakeholders;
2. A survey of organisations and individuals in the PEMD sector who have engaged with the DER Challenge;
3. Analysis of monitoring data that was shared directly by the DER Challenge, Innovate UK Business Connect and the Electric Revolution Skills (ERS) Hub;
4. Analysis of secondary data from public sources, to provide context to the evaluation; and
5. Benchmarking analysis using the Office for National Statistics (ONS) Business Structure Database. This involved tracking companies that have been involved in DER Challenge competitions or other DER Challenge activities via firm-level administrative datasets.

1.3 Thematic summary of findings

In the last five years, the DER Challenge has provided investment and undertaken activities to support the development of the PEMD sector in the UK. Based on a range of evidence sources, we find that the additional impact of the DER Challenge has been positive overall.

The DER Challenge has facilitated innovation and commercialisation of UK PEMD technologies by providing public investment and access to specialised equipment. This has enabled companies to de-risk their activities and create the right incentives for crowding in further private sector investment in PEMD. The DER Challenge has also significantly exceeded its targets in relation to co-investment, with a total realised co-investment of £403 million, almost doubling the initial target set by the DER Challenge (£234 million) and reaching a catalysed funding ratio of nearly 16:1. Some of the funded projects have led to improved productivity in the form of automation and repeatability. Further productivity improvements are expected to be unlocked if additional public support is able to build on the groundwork already set out by the DER Challenge.

The DER Challenge has raised the profile of UK PEMD and built a widespread network that would have not been possible without the DER Challenge. This network has connected firms and academics around the UK and across the supply chain, a supply chain that reaches into almost everything electrical that is manufactured in the UK. The DER Challenge has also contributed to closing the skills gap and increasing the manufacturing capacity of the UK. However, issues remain in relation to skills and the UK's manufacturing capacity. These are outside the scope of the DER Challenge and should be tackled through further public investment to build on the successes achieved by the DER Challenge to date.

The DER Challenge has helped shape recent government policies that relate to the PEMD sector. Other environmental, social and policy benefits may materialise in the future.

Below we outline our final impact evaluation findings in more detail. The findings are structured around our seven evaluation themes.

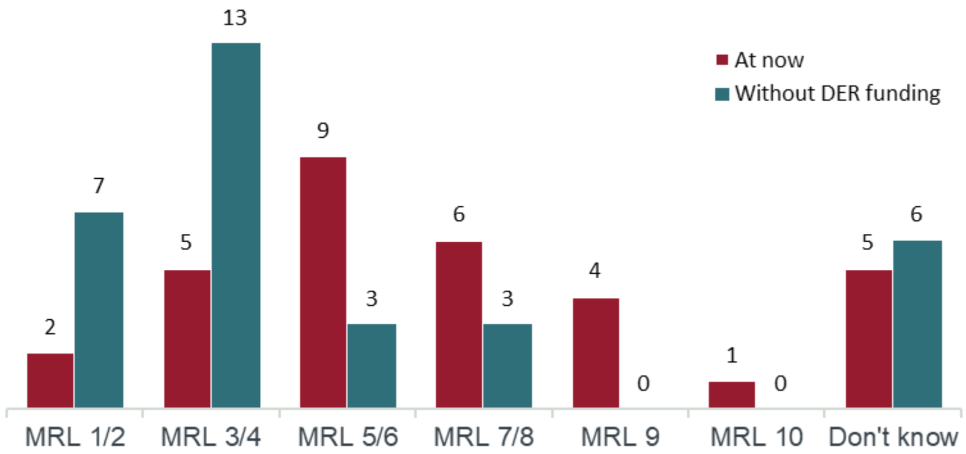
1.3.1 Theme 1: Has the DER Challenge accelerated innovation and commercialisation of PEMD technologies?

The DER Challenge has had a positive impact on innovation and commercialisation of PEMD technology.

- The DER Challenge has supported project consortia to progress their manufacturing readiness level (MRL)[8] and has facilitated the development of innovative PEMD technology. For example, survey respondents (see Figure 1) typically reported that technologies were closer to market readiness than would have been the case without DER funding.

[8] https://www.twi-global.com/technical-knowledge/faqs/manufacturing-readiness-levels

Figure 1 MRL level compared to expectation if funding had not been received



Source: Contact survey. C5. And what level is the manufacturing process at now? C5A. If your application for funding had been declined by DER, what level do you think it would be at now?

Note: Base: Successful applicants, final impact survey (32)

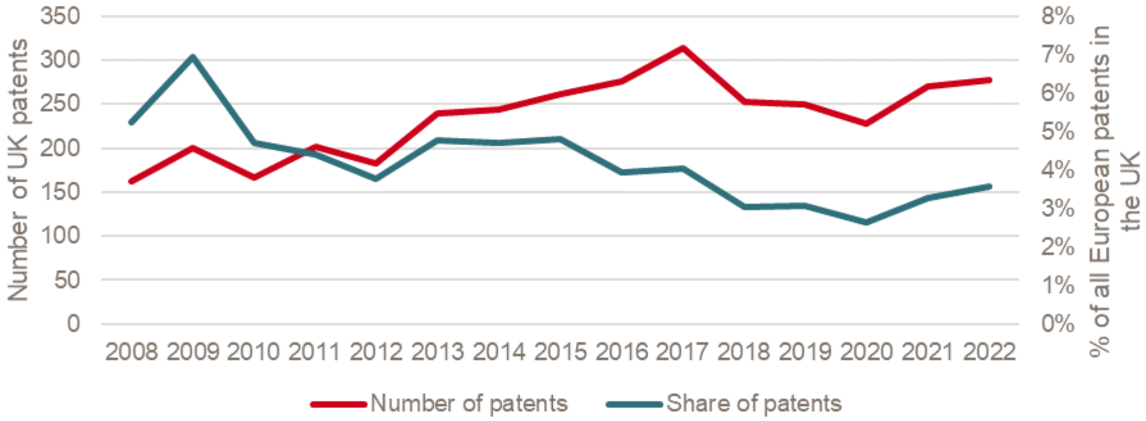
- The additionality of this DER funding is likely to be high as we were told that these projects would not otherwise have been prioritised by businesses. Stakeholders noted that this was due to the financial risks involved (absent the DER Challenge's intervention) and because other opportunities were seen as 'lower hanging fruit'. *"We would have struggled to sell it internally if we had to find all of the funding ourselves […] DER support allowed us to take risks we wouldn't otherwise. This is risky. If you invested money with uncertain outcome there would be less appetite internally"* (Company engaged with the Midlands DER-IC).

- The projects funded by the DER Challenge have unlocked further opportunities. We were told that the GaNSiC project, for example, has been a catalyst for a further ten R&D projects. This follow-on work has also sought to develop innovative power electronics solutions for applications relevant for automotive, telecoms, power and aerospace.

- Secondary data does not yet show a clear impact on the overall level of UK patents in sectors relevant to PEMD technologies (Figure 2).[9] This is in line with our ToC and the business case for the DER Challenge given expected lags between investment and final impacts.

[9] European Patent Office. Global Patent Index.

Figure 2 Number of PEMD patents in the UK and share of European patents filed in the UK



Source: *[European Patent Register. Global Patent Index.]*

Note: *The year of the patent is determined based on 'filing date'. Data from 2023 is not presented as applications are published after 18 months of the date of filing or when priority is claimed, from the earliest priority date.*

- The DER-ICs have facilitated innovation and commercialisation of UK PEMD technologies by providing access to equipment and enabling knowledge sharing. The DER-ICs have allowed companies to de-risk their activities and start to manufacture new products faster.

"*This was quite an important step that we could test out some of these theories and quite quickly assess the feasibility of that approach. With WMG´s expertise and some of the testing, validation [we were doing at the DER-IC] we could iterate quite quickly, cross it off the list, and then go do something else that is more valuable.*" (Company engaged with the Midlands DER-IC)

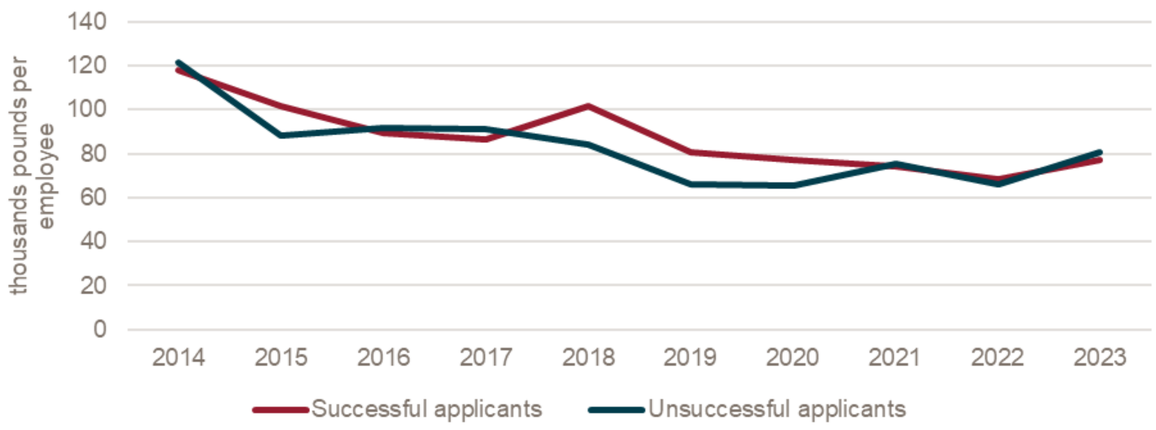
- Looking ahead, business leaders emphasised the need for continued support for new PEMD technologies and capabilities. We were told that this additional support would build on the successes of the DER Challenge. Stakeholders identified a funding gap associated with the commercialisation and scaling-up of PEMD technologies. DER-IC colleagues indicated that the existing funding opportunities, such as competitions run by the Advanced Propulsion Centre (APC) and the Aerospace Technology Institute (ATI), do not currently fill this gap and cannot directly replace current DER Challenge funding. This is because other sources of funding are targeting projects with higher costs and therefore may exclude small and medium-sized enterprises (SMEs) and startups with interest in using the DER-IC equipment. Other funding options do exist via UKRI. However, we were told that in some cases these funding opportunities are "*enough to gain some basic understanding work, but not enough to take projects to the next level*" (DER-IC colleague).

1.3.2 Theme 2: Has the DER Challenge increased the productivity of the UK PEMD supply chain?

The DER Challenge has enabled early-stage improvements which can unlock productivity gains in the future. Additional public funding may be needed to achieve these gains.

- Our ToC and the targets set out by the DER Challenge's own business case suggest that widespread productivity improvements would not be expected at this stage.
- Analysis of secondary data comparing productivity (measured as turnover per employee) for successful and unsuccessful applicants to the DER Challenge does not suggest any clear impact so far (see Figure 3, which reports findings for small firms).[10]

Figure 3 Average labour productivity of small companies that participated in DER Challenge competitions



Source: ONS Business Structure Database. This work was undertaken in the Office for National Statistics Secure Research Service using data from ONS and other owners and does not imply the endorsement of the ONS or other data owners

Note: Productivity is calculated as the ratio between turnover (thousand pounds) and number of employees. Small companies are companies with fewer than 50 employees or a turnover of less than £10 million. Medium companies are companies with fewer than 250 employees and turnover of less than £50 million

- Among DER Challenge beneficiaries in our contact survey, 17 reported a positive impact on their company's overall productivity and 16 reported a positive impact on labour productivity. However, approximately half did not report any impact so far on their company's overall productivity (20 out of 41) or labour productivity specifically (23 out of 41) as a result of engaging with the DER Challenge.
  - More broadly, we identified a perception among firms which have engaged with the DER Challenge that the DER Challenge has laid the ground for future productivity

[10] ONS Business Structure Database. Productivity is calculated as the ratio between turnover (thousand pounds) and number of employees for small, medium and large companies separately.

improvements. The improvements that have been realised include automation, repeatability and knowledge-sharing opportunities that have collectively led to improved design and faster manufacture of improved prototype products.

- The DER-ICs have also played a role in productivity improvements. For example, firms have used equipment to carry out automated winding, which has applications in the automotive and aerospace sectors. In the future, this form of automation can allow for higher throughput and repeatability of design in the manufacture of electric motors. In some cases, there is evidence that these investments have led to scale-up, moving the process from the laboratory to pilot plant facilities.

- However, further scaling may be beyond the direct remit of Innovate UK and may require additional public support after the DER Challenge. Firms interviewed indicated that additional public funding is required to unlock the potential longer-term productivity improvements that PEMD can bring. This additional funding would build on the earlier-stage improvements in manufacturing readiness that have been enabled by the DER Challenge. These include automation and repeatability as well as knowledge-sharing opportunities that have collectively led to improved design and faster manufacture of improved prototype products.

1.3.3 Theme 3: Has the DER Challenge contributed to growing PEMD knowledge and skills in the UK?

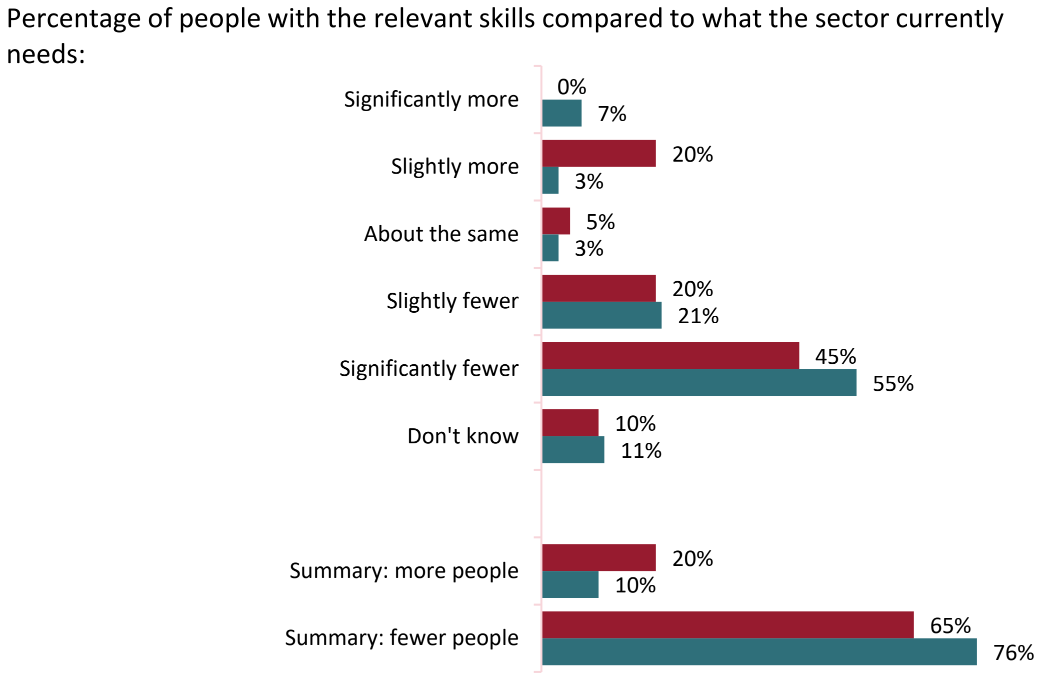
The DER Challenge has had a positive impact on skills gaps. However, issues persist.

- Stakeholders interviewed indicated that skills gaps remain a key barrier for the progression of PEMD technology in the UK, and awareness of PEMD career opportunities among students is low. It is not reasonable to expect the DER Challenge to have significantly closed existing skills gaps, but the DER Challenge has grown relevant knowledge bases and improved skillsets. The funding allocated specifically to skills is a relatively small portion of overall DER Challenge budgets and some of the initiatives are still in their early stages. For example, the Electric Revolution Skills Hub (ERS Hub) was launched by the DER Challenge in March 2023 to raise awareness of PEMD career opportunities and is a new DER Challenge activity since our interim evaluation report. Therefore, final impacts will not yet be visible.

- Survey results indicate some improvement in perceptions around skills gaps relative to the baseline among respondents (Figure 4). Findings from the case studies also indicate that the DER Challenge has had a positive impact on skills development and overall awareness of the PEMD career opportunities. This is predominantly driven by the funding allocated to projects – which has provided funding to recruit new staff – and the knowledge-sharing activities and access to world-class equipment facilitated by the DER-ICs.

- “*[The technical support from the DER-IC] took us from a design that was not really possible into a design that is possible.*” (Company engaged with the Midlands DER-IC)

Figure 4 Perceptions of level of skills in the PEMD sector



Source: *Contact survey. Which of the following best describe your experience of the level of skills in the PEMD sector as a whole?*

Note: *Base: All business respondents to final impact survey (20), all business respondents to baseline survey (18). Please note that, to compare across survey waves, we need to use % despite sample sizes*

1.3.4 Theme 4: Has the DER Challenge increased the value of investment in UK PEMD companies?

The DER Challenge has had a positive impact on the value of investment in UK PEMD companies and the DER Challenge has significantly exceeded its targets in relation to co-investment.

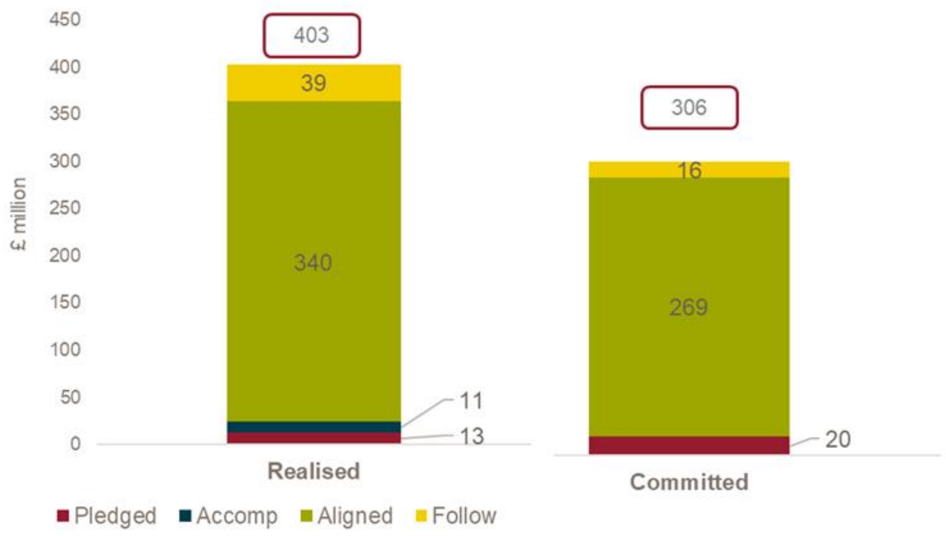
- Total realised co-investment[11] over the period from 2020 to 2024 (£403 million) almost doubled the initial target set by the DER Challenge (£234 million) and the realised co-investment was one-third higher than the committed co-investment (£306 million), which

[11] Source: DER Challenge monitoring data. Total co-investment includes (i) pledged co-investment (investment by the consortia receiving the grant funding), (ii) accompanying co-investment (public and/or private extra investment above the pledged co-investment in business cases but necessary to achieve the agreed objectives), (iii) aligned co-investment (investment in a closely thematic project, prompted by the DER investment), and (iv) follow-on co-investment (public and/or private investment to take to market, or exploit, outcomes from Challenge-funded R&D projects).

indicates that a considerable amount of additional investment was realised beyond what was initially agreed.

- Overall the DER Challenge has achieved a catalysed funding ratio[12] of nearly 16:1. This represents an excellent leveraged return on public investment (see Figure 5).

Figure 5 Cumulative co-investment, 2020-2024



Source: DER Challenge monitoring data

Note: Total co-investment includes (i) pledged co-investment (investment by the consortia receiving the grant funding), (ii) accompanying co-investment (public and/or private extra investment above the pledged co-investment in business cases but necessary to achieve the agreed objectives), (iii) aligned co-investment (investment in a closely thematic project, prompted by the DER investment), and (iv) follow-on co-investment (public and/or private investment to take to market, or exploit, outcomes from DER Challenge-funded R&D projects)

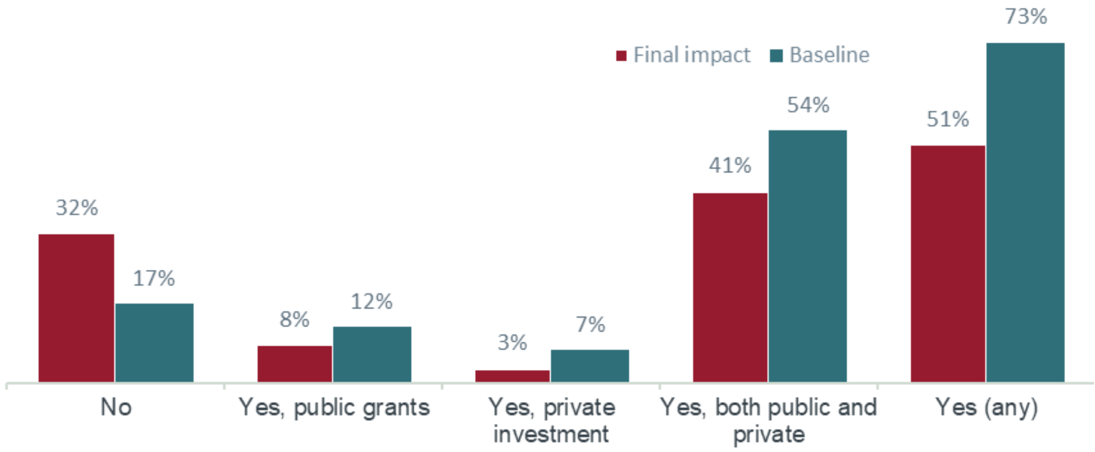
- Businesses surveyed had positive perceptions of securing follow-on investment as a result of DER Challenge engagement. Half (19 of 37) of the survey respondents who had received DER Challenge funding or engaged with the DER-IC indicated that they had received further funding (private or public) as a direct consequence of their engagement. Also, around half of the same survey respondents expected to receive further funding in the future as a direct consequence of their engagement (Figure 6).

- UKRI Financial Transparency Data[13] shows that public sector expenditure in PEMD projects by UKRI has fallen in the last year, having increased in recent years (see Figure 7). This is likely only partially explained by the planned completion of many of the large projects funded through DER. There may also be other contributory factors such as the simultaneous conclusion of other competitions that relate to PEMD and/or reporting lags.

[12] Catalysed funding ratio calculated as pledged plus accompanying co-investment divided by aligned and follow-on co-investment.

[13] UKRI Financial Transparency Data. Innovate UK funded projects since 2004.

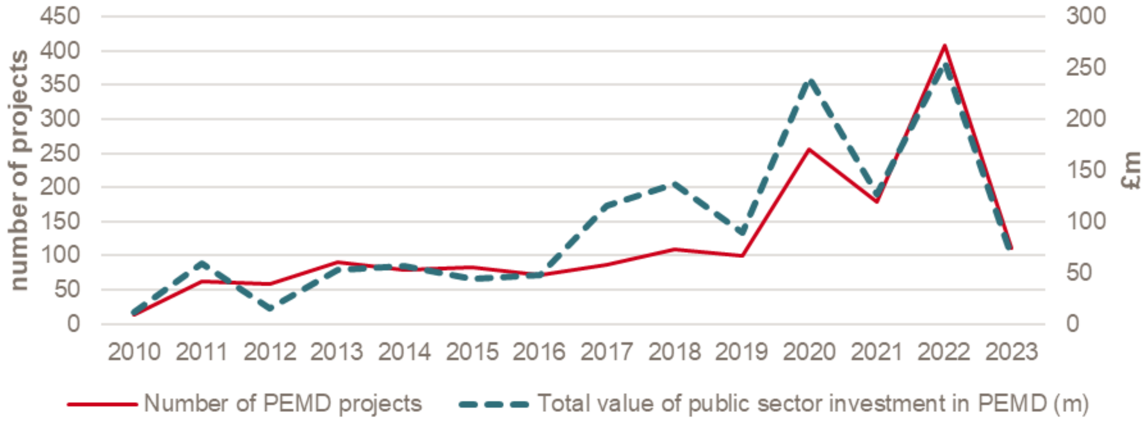
Figure 6 Business expectations of further funding as a result of DER Challenge engagement



Source: Contact survey. C7. Do you expect to secure any further public grants or private investment as a result of your engagement with the Driving the Electric Revolution DER Challenge?

Note: Base: Successful applicants or those who have engaged with the DER-IC, final impact survey (37), successful applicants, baseline survey (41). Please note that to compare across survey waves, we need to use % despite sample sizes

Figure 7 Public sector investment in PEMD research projects by UKRI



Source: UKRI Financial Transparency Data

Note: The long list of search terms used to capture PEMD activity is outlined in Annex E1 and agreed following discussion with the DER Challenge

1.3.5 Theme 5: Has the DER Challenge helped foster a collaborative PEMD ecosystem?

The DER Challenge appears to have helped foster a collaborative PEMD ecosystem.

- Interviewees and survey respondents both indicated that the DER Challenge has had a positive impact on collaboration. Specifically, (34 out of 41) survey respondents felt that the DER Challenge has increased collaboration. The DER-ICs have also been successful in connecting firms with other businesses and academic organisations across the supply chain. These connections have allowed firms to share ideas and access mutually beneficial expertise that would not have been possible otherwise. This in turn has led to benefits such as better understanding of supply chain structure, which can lead to final impacts in years to come.

- Stakeholders who participated in the thematic, project-based and activity-based case studies also highlighted the positive impact of the DER Challenge in improving PEMD marketing and awareness-raising via a range of communication channels within the UK market. Stakeholders noted the importance of DER Challenge-run events (e.g. conferences, Engage With… events) in improving commercial outreach and attracting industrial customers.

- Connections made through the DER-ICs and competition-winning project teams have allowed firms to access mutually beneficial expertise which would not have been obtained otherwise. These connections have also led to opportunities for further collaboration beyond the scope of the initial engagements.

1.3.6 Theme 6: Has the DER Challenge led to an expansion of UK PEMD manufacturing capacity?

Some firms reported positive impacts on their manufacturing capacity as a result of their engagement with the DER Challenge. In line with expected timelines, no statistically significant expansion of overall UK PEMD manufacturing capacity has yet been observed.

- Analysis of secondary data sources suggests that there has not yet been an expansion in overall UK PEMD manufacturing capacity.[14] For example, measures of turnover, employment and the number of firms in Standard Industrial Classification (SIC) codes relating to PEMD have remained flat (see Figure 8 for turnover data).[15] This relates to all firms in relevant SIC codes rather than just firms which have engaged directly with the DER Challenge.
  - It is important to note that there are limitations associated with using SIC codes to define relevant markets in this context as the PEMD supply chain cuts across a variety of industries. In particular, a lot of PEMD activity will take place in other SICs and some of these codes below will cover non-PEMD technology activities.

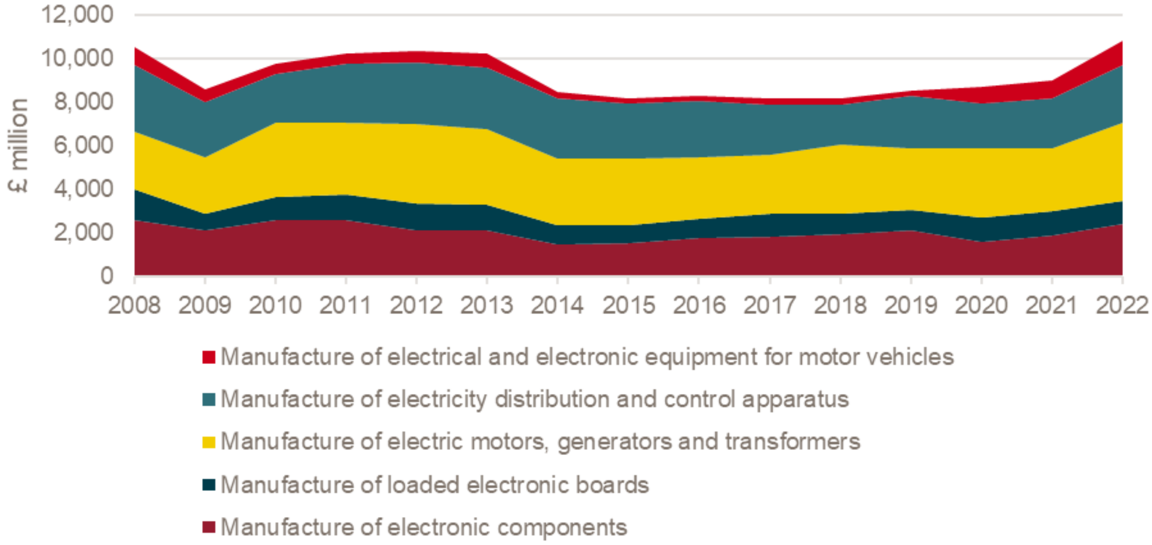
- This is expected given that expansion of the manufacturing capacity is a longer-term benefit (as set out in our ToC and the DER Challenge Business Plan). Most companies which have engaged with the DER Challenge have not yet started mass manufacture of

[14] ONS Annual Business Survey (UK) and ONS Business Register and Employment Survey (GB)

[15] https://resources.companieshouse.gov.uk/sic/

new products. There are also lags in some data sources, which means that the full picture is not yet available.

Figure 8 PEMD supply chain turnover (split by SIC code)



Source: Office for National Statistics, Annual Business Survey 2023

- The value of UK PEMD commodities internationally traded (i.e. imports and exports)[16] has grown in the last ten years and this growth has accelerated since 2020, when the DER Challenge has been active. The nominal value of UK exports of PEMD commodities increased from £733 million in 2019 to £905 million in 2023, and the nominal value of UK imports of PEMD commodities increased from £1.3 billion in 2019 to £1.9 billion in 2023. These figures on the value of UK PEMD commodities internationally traded represent our best estimates. However, due to the difficulties in identifying PEMD commodities specifically, we may be missing considerable additional value. Also, the PEMD elements that we measured are often integral parts of larger systems and may contribute to significantly wider competitive advantage as a result.

- Firms which have engaged with the DER Challenge expressed positive views regarding the DER Challenge's impact on boosting manufacturing capacity. Most respondents (13 of 20) to the final impact survey indicated that the DER Challenge had had a positive impact on the number of employees that they had subsequently hired. Eight out of 20 also indicated they had observed an increase in turnover attributable to their engagement with the DER Challenge. A large proportion of survey respondents also expected positive

[16] UN Comtrade.

impacts on turnover (13 out of 20) and employment (13 out of 20) to occur in the near future.

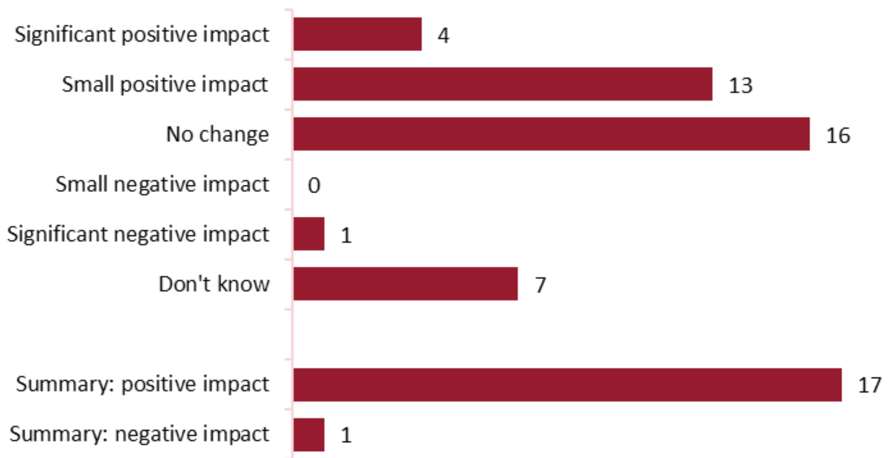
- Firms which engaged in the project-based case studies also indicated that positive benefits have occurred as a result of the DER Challenge's activity. This included development of a UK-based supply chain for rare earth magnets (SCREAM) and increased demand for products which rely in part on innovative PEMD technology (GaNSiC). Stakeholders in the thematic case study also acknowledged that the DER Challenge has laid the groundwork for further advancements in the PEMD supply chain in the UK. As such, the DER Challenge has contributed to enhancing capabilities around advanced power electronics, positioning the UK to capitalise on emerging market opportunities.

1.3.7 Theme 7: Has the DER Challenge driven environmental, societal and policy benefits?

The DER Challenge has raised the profile of the PEMD sector. Clear environmental, social and policy benefits have not yet been identified.

- Government policy in regard to PEMD technology was perceived as an enabler of PEMD technology in the UK by most survey respondents (22 out of 41). Survey respondents and case study stakeholders expressed mixed views on the success of the DER Challenge in influencing government PEMD policy. Seventeen out of 41 survey respondents felt that the DER Challenge has had a positive impact on the development of government policy related to PEMD (see Figure 9).

Figure 9 Impact of the DER Challenge on government policy related to PEMD



Source: *Contact survey: F7. Thinking about the Driving the Electric Revolution DER Challenge overall, what impact, if any, has it had on the following over the past 3 years? Government policy related to PEMD*

Note: *Base: All respondents to final impact survey (41)*

1.4 Next steps for UK PEMD and further evaluation work

Some stakeholders who took part in the thematic and project-based case studies told us that the relatively low budget available for the overall DER Challenge and the fragmented nature of PEMD technology within UK industries have been recognised as a key limiting factor in regard to the DER Challenge's aggregate impacts on metrics such as the UK's overall PEMD manufacturing capacity.

Their view was that a broader, more strategic approach may be needed to realise the UK's potential in the competitive global landscape. Further public sector investment in PEMD could build on the successes of the DER Challenge. Additional public funding in the future is particularly important to attract the large-scale private investment which is required to enable mass manufacturing and commercialisation. This may be needed to unlock longer-term benefits such as improved productivity and competitiveness of the UK in the PEMD sector.

Also, more public support for PEMD technology in the UK could allow the UK to compete more effectively with other countries and regions (such as the US and EU). Some UK successes have already been already achieved, however. These successes include private sector investments in UK PEMD by major automative firms,[17] and appear to relate to attractive features of the UK for inward investment.

Some of the longer-term benefits of the DER Challenge will only be realised in the future, i.e. in more than ten years. Therefore, given that final impacts will not yet have materialised, further evaluation of DER Challenge activities would be helpful in the future. This further evaluation work could include additional engagement with project teams when they reach project completion as well as further case studies which consider longer-term impacts. Finally, secondary data analysis of aggregate UK impacts could be revisited and updated as part of a future evaluation.

1.5 Progress relative to business case objectives

According to our independent evaluation, the DER Challenge is on track to meet the objectives set out in the original business case.

[17] e.g. Ford's investment at Halewood to scale up electric vehicle production and Jaguar Land Rover's ongoing investment in electrification

The first business case objective covered *leveraging the UK's world-leading PEMD research capability to help industry create manufacturing supply chains*. The DER Challenge has provided funding for PEMD projects and world-class equipment (via the DER-ICs). As such, the DER Challenge has contributed to translating the UK's research capability into industrial applications, which is necessary if the UK wants to manufacture more PEMD products domestically.

Encouragingly, some firms which have worked directly with the DER Challenge have already reported positive impacts on their manufacturing capacity as a result of their engagement. Furthermore, the value of UK PEMD commodities internationally traded (i.e. imports and exports) has grown in the last ten years and this growth has accelerated since 2020.

In terms of the second business case objective (*identify gaps in the supply chains and help industry fill them*), the network established by the DER Challenge supported by the DER-ICs as well as the collaboration fostered through the research projects funded by the DER Challenge have allowed companies to better understand their supply chain structure. In addition, research undertaken by the DER Challenge has helped firms and other stakeholders to quantify existing skills gaps which will need to be filled in the future in order for supply chains to work more effectively.

In relation to the third business case objective (e*nsure cooperation and collaboration so that we do not duplicate effort and waste time and can reuse solutions across sectors*), the DER Challenge has facilitated collaboration between firms across the supply chain and academic organisations. The DER Challenge's efforts to connect stakeholders and build new connections has led directly to beneficial projects being undertaken and reduced wasteful duplication by sharing lessons learned via the DER-IC network.

The final business case objective covered skills specifically (*help fill the skills gap by retraining, upskilling and repurposing engineers from traditional internal combustion businesses into PEMD supply chains*). We observed positive impacts around skills thanks to the DER Challenge's efforts around retraining and upskilling, which is relevant for PEMD supply chains. These activities, especially the ones undertaken by the Skills Hub (e.g. providing training and networking opportunities) and the skills projects (i.e. training projects which were funded via the competition 'Building Talent for the Future'[18]), are in their early stages and further impacts will likely be observed in the future.

[18] Five of these projects are above £100,000: (i) Manufacturing based power electronics design and manufacturing training courses, (ii) Scalable Delivery of Applied Power Electronics, Machines and Drives Training (SD-APT), (iii) Warwick Electrification Deployment (WELD), (iv) Institute of Electrification and Sustainable Advanced Manufacturing (IESAM): Building Talent for Growth of north-east PEMD Supply Chain, and (v) Practical Power Electronics, Machines And Drives for all.

2 Introduction

2.1 Purpose and structure of this report

In 2021, Frontier Economics with its partners BMG Research (BMG) and ERM were commissioned by Innovate UK to carry out an evaluation of the DER Challenge. This report presents the findings of the final impact evaluation of the Driving the Electric Revolution DER Challenge ('the DER Challenge') delivered by Innovate UK for UK Research and Innovation (UKRI) on behalf of the UK Government. It is the fourth and final phase of an evaluation of the DER Challenge, building on a process and interim impact evaluation completed in early 2023,[19] an evaluation framework report completed in 2021 and a baseline report completed in early 2022.

In line with HM Treasury's Green Book,[20] an impact evaluation should attempt to assess what an intervention has delivered. In particular, an impact evaluation seeks to understand '*What difference has an intervention made?*' and focuses on demonstrating the benefits that a programme or policy has delivered or contributed to.

The remainder of this report is structured as follows:

- The remainder of **Section 2** provides some context to the DER Challenge, including the theory of change (ToC) and impact evaluation themes outlined in the evaluation framework.
- **Section 3** outlines the approach taken for the final impact evaluation, including a description of the evidence sources used to triangulate the contribution analysis findings.
- **Section 4** reports the findings of the final impact evaluation, with findings across each of its seven evaluation themes and conclusions.
- **Section 5** reflects on learnings and lessons learned for future evaluations.

2.2 The Driving the Electric Revolution DER Challenge

2.2.1 Rationale, objectives and structure

As part of what was previously known as the Industrial Strategy,[21] the government launched the Industrial Strategy DER Challenge Fund (ISCF), which seeks to invest in sectors across the UK economy to strengthen the UK's base of highly innovative businesses. This fund is administered by UKRI and the DER is one of its component programmes.

[19] Driving the Electric Revolution phase 3: process evaluation and interim impact evaluation

[20] The Green Book (2022)

[21] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664563/industrial-strategy-white-paper-web-ready-version.pdf

Electrification is one of the key pathways to low carbon energy solutions to meet net zero greenhouse gas emissions by 2050, and power electronics, machines and drives (PEMD) are used in diverse applications fundamental to enable electrification.

The UK is world leading in academic and industrial research, design and development across the PEMD supply chain. As such, the UK has the potential to achieve a substantial share of this rapidly growing global market, leveraging existing competitive advantages to become world leading in design for manufacturing and the manufacture of these components.

However, a range of market failures and institutional barriers are preventing the UK from gaining an advantage. These include a traditionally siloed sector focus; a skills shortage; a lack of UK manufacturing leadership and collaboration; a lack of strategic overview leading to coordination failures; investment gaps, including under-investment in research and development (R&D); regulatory barriers; Brexit effects for trade rules; and the impact on supply chains due to the COVID-19 pandemic.

PEMD has been identified for intervention due to its potential to provide high-quality jobs and economic growth, while reinforcing key industrial sectors as they transition through the green industrial revolution.

The Driving the Electric Revolution DER Challenge is a £234 million investment programme, including £80 million committed by UKRI and a further £154 million of funding invested that is expected to be catalysed by the DER Challenge activities. As per the original business case, the DER Challenge has four high-level objectives:

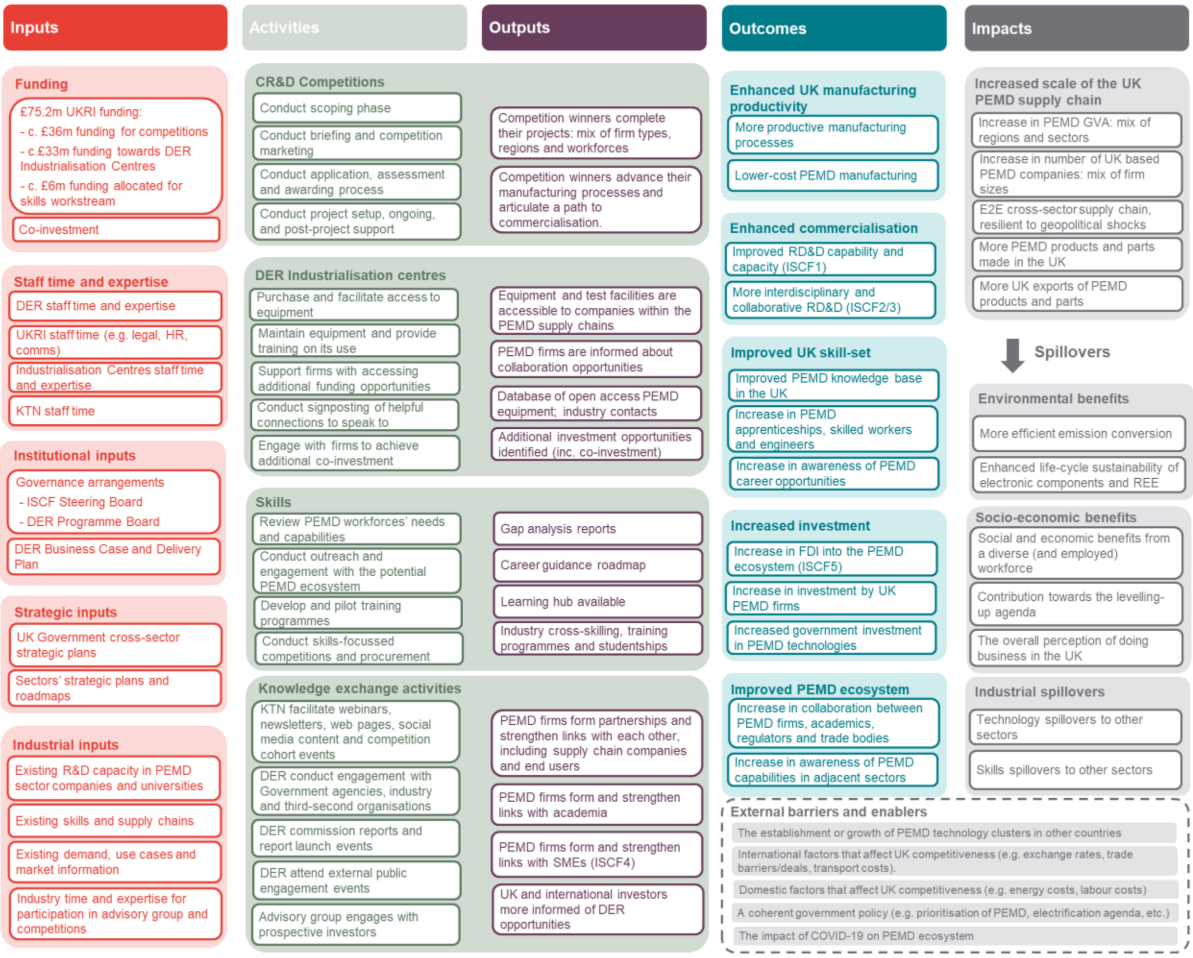
- Leverage the UK's world-leading research capability in PEMD to help industry create the supply chains necessary to manufacture the PEMD products developed here;
- Identify gaps in the supply chains and help industry fill them;
- Ensure cooperation and collaboration so that we do not duplicate effort and waste time and can reuse solutions across sectors; and
- Help fill skills gaps across supply chains by retraining and upskilling workers.

2.2.2 Theory of change

The theory of change (ToC) describes how the DER Challenge is expected to transform inputs and activities into outputs, outcomes and impacts. The theory, summarised below and represented in Figure 10 as a visual logic model, was developed collaboratively with the DER Challenge as part of the evaluation framework report. The ToC was critical to developing our overall, theory-based approach (see next section for further details on approach) to evaluating the DER Challenge, including the evaluation themes and metrics used in this report.

There are five categories of DER Challenge inputs and, collectively, these inputs drive four categories of activities and outputs: competitions, the DER-IC, the skills workstream, and knowledge exchange activities by Innovate UK Business Connect. These in turn drive five categories of outcomes that contribute towards the ultimate desired key impact of the programme: increased scale of the UK PEMD supply chain.

Figure 10 Theory of Change (ToC)[22]



Source: DER Challenge Evaluation Framework

Note: ISCF (Industrial Strategy DER Challenge Fund) numbers refer to the five ISCF high-level objectives

2.2.3 Impact evaluation themes

Informed by the ToC and agreed with the DER Challenge based on the DER Challenge business case objectives, the impact evaluation framework is structured around seven evaluation themes. A thematic approach recognises that attempts to test all the components and relationships expressed in the ToC would not be feasible or proportionate; by focusing on themes, we capture the most important aspects of the theory to explore within the evaluation. The themes are:

[22] Innovate UK Business Connect is the new name for Innovate UK KTN https://iuk-business-connect.org.uk/

1. Has the DER Challenge accelerated innovation and commercialisation of PEMD technologies?
2. Has the DER Challenge increased the productivity of the UK PEMD supply chain?
3. Has the DER Challenge contributed to growing PEMD knowledge and skills in the UK?
4. Has the DER Challenge increased the value of investment in UK PEMD companies?
5. Has the DER Challenge helped foster a collaborative PEMD ecosystem?
6. Has the DER Challenge led to an expansion of UK PEMD manufacturing capacity?
7. Has the DER Challenge driven environmental, societal and policy benefits?

Table 1 below presents the list of themes, metrics and sources used in the final impact evaluation.

Table 1 List of themes, metrics and sources

Theme	Metric	Source
Theme 1: Has the DER Challenge accelerated innovation and commercialisation of PEMD technologies?	Manufacturing readiness level	Contact survey
	Patent filing	European Patent Register
	Number of first-of-a-kind PEMD pilots	Project-based case study Activity-based case study Thematic case study Contact survey
Theme 2: Has the DER Challenge increased the productivity of the UK PEMD supply chain?	Total factor productivity	Contact survey Activity-based case study
	Labour force productivity	Contact survey ONS company microdata
Theme 3: Has the DER Challenge contributed to growing PEMD knowledge and skills in the UK?	Perception of skills as a barrier to expanding the PEMD supply chain	Contact survey
		Activity-based case study
		Monitoring data from the ERS Hub
	Awareness of PEMD career opportunities	Activity-based case study Thematic case study
		Number of university students in relevant courses from HESA
		Apprenticeship and traineeship data from the Department of Education
	Value of co-investment	DER monitoring data

Theme	Metric	Source
Theme 4: Has the DER Challenge increased the value of investment in UK PEMD companies?		
	Perceptions of ease of securing investment and follow-on funding	Contact survey
	Value of public sector investment in PEMD companies	UKRI Financial Transparency Data
	Value of R&D spending by UK/overseas PEMD companies	Contact survey
		Thematic case study
	Share of PEMD companies which are foreign owned	ONS microdata
	UK operations of leading manufacturers of PEMD products	Project-based case study
	Value of venture capital investment in PEMD companies	Thematic case study
Theme 5: Has the DER Challenge helped foster a collaborative PEMD ecosystem?	Number of introductions made by Innovate UK Business Connect by sector	Innovate UK Business Connect monitoring data
	Number and strength of collaborations between PEMD companies in different sectors and companies producing different technologies	Activity-based, thematic and project-based case studies
		Contact survey
	Number and strength of collaborations between PEMD companies and academics, and PEMD companies and SMEs	UKRI Financial Transparency Data
Theme 6: Has the DER Challenge led to an expansion of UK PEMD manufacturing capacity?	Value of turnover	ONS Annual Business Survey ONS business structure microdata
	Number of employees	ONS Business Register and Employment Survey ONS business structure microdata
	Number of companies	ONS Annual Business Survey

Theme	Metric	Source
	Perceptions of impact on expansion and manufacturing capacity	Contact survey Activity-based, project-based and thematic case studies
	Growth projections of leading UK-based PEMD companies	Contact survey
	Size of the sector	Contact survey
	Export and import volume and value	UN Comtrade
Theme 7: Has the DER Challenge driven environmental, societal and policy benefits?	Perception of impact on policy	Contact survey
		Thematic case study
	Distribution of winning organisations	DER monitoring data
	Distribution of PEMD companies	ONS company microdata

Source: Frontier Economics

3 Approach taken

This section sets out the approach taken to deliver this final impact evaluation.

3.1 Overall approach

Theory-based impact evaluation aims to understand the extent to which an intervention or policy caused a change in the outputs, outcomes and impacts of interest. At a high level, the approach involves drawing on the ToC to develop a set of research themes or hypotheses which can be tested during the evaluation.

Impact evaluation can be based on both quantitative and qualitative analysis. Quantitative or empirical impact evaluation involves comparing an outcome or impact to an estimate of what would have happened in the absence of the intervention (the 'counterfactual'). Where robust counterfactual analysis is not feasible, quantitative analysis can draw descriptive or non-causal conclusions about the effect of an intervention on an outcome or impact. Qualitative analysis can provide important context to support and augment quantitative analysis and can be used as a substitute where quantitative analysis is unlikely to be robust. Qualitative insights can explain how and why particular effects are realised.

We employ contribution analysis for the final impact evaluation, an example of a theory-based evaluation. This allows us to come to a considered view – based on the evidence – on the contribution that the DER Challenge has made, while using different approaches to understand what the counterfactual (what would have happened without the DER Challenge) looks like, tailored to different evaluation themes and the data available.

As described in Section 2, the logic model sets out the critical pathways through which the economic and wider impacts of the DER Challenge are expected to be realised. The seven impact evaluation themes then structure the metrics and measures that will help determine whether the DER Challenge's activities are generating observable changes in line with those pathways. The contribution analysis seeks to identify evidence from a range of methodologies that help to derive a narrative conclusion about the extent to which the DER Challenge (rather than external factors) has been the driver of changes observed in the indicators over time.

Given the nature of the intervention and the complex set of objectives that the DER Challenge is working towards, we do not attempt to derive a single 'impact estimate' (quantitative or qualitative). Where appropriate, we employ different approaches, both qualitative and quantitative, and then seek to triangulate across them to determine the contribution narrative. Where different pieces of evidence about the indicators or the DER Challenge's contribution suggest different conclusions, we assess the relative strengths and weaknesses of each in determining our views based on the data available.

The methodologies we use to consider counterfactuals are:

- Detailed evaluative case studies which included self-reported counterfactuals, where respondents were asked to reflect in detail on what had happened or what they had achieved as a result of their engagement with the DER Challenge. This involved sharing their opinion on expectations for the future as well as what would have happened in the absence of the DER Challenge;
- Comparison of results to the baseline survey conducted in 2021 to understand whether there had been any systematic change across respondents; and
- Trend analysis of secondary and monitoring data over time, assuming that the pre-DER Challenge data represents the best counterfactual for what would have happened without the DER Challenge. This analysis takes relevant non-DER Challenge trends into account in a qualitative manner but does not attempt to quantitatively or statistically isolate the impact of the DER Challenge.

3.2 Evidence sources informing the final impact evaluation

The metrics, methods and data sources used in this evaluation were agreed in the evaluation framework report in 2021. This section presents the methods deployed in the final impact evaluation.

3.2.1 Case studies

We conducted three types of in-depth case studies: an activity-based case study, two project-based case studies and a thematic case study.

Activity-based case study

This case study follows on from the case study that we conducted at the interim impact stage and presented in the interim report. As such, the case study focused on the activities of the Midlands DER-IC, which was chosen for the following two reasons:

1. Equipment provision was expected to be a fundamental part of the DER-IC offering and the majority of the funds allocated to the DER-IC were for the purchase of capital equipment. The Midlands DER-IC was one of the first DER-ICs to have equipment installed.
2. The Midlands DER-IC, which specialises in machines, was expected to present higher interconnectivity with other DER-ICs, e.g. the North East and Scotland, which look at drives.

As part of this final impact evaluation, we interviewed four senior colleagues from within the DER-IC. Three of these were from the Midlands DER-IC site itself, and one was the head of the overall DER-IC network. The purpose of these interviews was to understand the evolution of activities undertaken by the Midlands DER-IC in the previous 18 months and to gauge the internal view of the DER-IC’s impact and longer-term benefits and challenges.

We also interviewed representatives from three firms that had interacted with the DER-IC in the previous 18 months: McLaren Applied, Safran and Ricardo. The purpose of these interviews was to understand how the firms had interacted with the Midlands DER-IC site to date, the effect of these interactions so far (including what would have happened without the DER-IC) and the expected impacts and challenges going forward.

Project-based case studies

We selected two projects from the DER Challenge portfolio to serve as case studies. These case studies allowed us to evaluate the impact of funding on UK PEMD companies and the wider industry. We conducted interviews with the project teams for the following:

1. **GaNSiC project:** This project was also included as a case study in the interim impact evaluation. Inclusion within this final impact evaluation allowed us to see how the project consortium had progressed over the last 18 months following a successful project completion and enabled us to explore follow-on benefits and growth as a result of receiving DER Challenge funding and support. *(Consortium: Custom Interconnect Limited (CIL) – Lead, Compound Semiconductor Applications Catapult (CSAC)).*

2. **SCREAM Project:** This case study focused on a project that received significant DER Challenge funding and involved a number of PEMD companies across the supply chain. We selected this project because it involved an aspect of the PEMD supply chain (material recycling), which has not been deeply evaluated to date, and it was an example of a large project targeting more applications than the automotive sector alone, as well as electric machines, instead of power electronics. *(Consortium: Hypromag – Lead, GKN Hybrid Power (GKN), Bowers and Wilkins Group (B&W), Jaguar Land Rover (JLR), University of Birmingham, European Metal Recycling (EMR), Mkango Rare Earths UK, (Mkango))*.

For both case studies, we interviewed lead members of each organisation within the consortia. The purpose of the interviews was to determine what the progress of the technology development had been throughout the project and what they had achieved as a result of their engagement with the DER Challenge. Interviewees also reflected on what would have happened without the DER Challenge.

Thematic case study

In line with the interim evaluation, the thematic case study focused on specific themes that were less well covered by other evaluation methods. These themes included knowledge sharing and skills development (3) and environmental and policy spillovers (7). During the interviews, we also asked for expert opinion as to whether the DER Challenge has had an impact on the UK PEMD industry as a whole.

In order to get a rounded view of the health of the UK PEMD industry and the DER Challenge's impact, we facilitated panel-style, semi-structured interviews and open discussions with a mix of expert stakeholders. We targeted representatives from academic institutions, policy audiences and industry trade associations.

3.2.2 Contact survey

A bespoke survey was developed to explore issues aligned to the logic model and evaluation indicators. The survey was developed by BMG in collaboration with Frontier Economics and the DER Challenge. The survey focused on questions designed to help gather impact measures and it was designed to be comparable to the baseline and interim impact questions asked during previous phases of the evaluation.

The sample for the survey was made up of a number of different groups that had interacted with the DER Challenge in various ways:[23]

- Those who had applied for funding from the DER Challenge and had been successful in at least one of their applications;
- Those who had applied for funding from the DER Challenge and had not been successful in any of their applications;
- Those who had provided initial letters of support for the DER Challenge;
- Those who had presented during Engage With... events; and
- Members of the Advisory Group.

Fieldwork for the survey took place between 17 May and 5 August 2024. An online link was sent out to contacts, followed by two email reminders directly from BMG and one from the DER Challenge (to 'successful' contacts only) to encourage participation. To maximise response rates as much as possible, telephone chasing was also used to encourage participation by those for whom telephone numbers were available.

A total of 41 respondents completed the survey (five by telephone and 37 online). Table 2 below shows the response rates achieved at each stage of the evaluation broken down by firms' engagement type with the DER Challenge for all three surveys that have been conducted as part of the evaluation. Overall, the response rate for the Phase 4 survey is noticeably lower than those for the baseline and interim impact surveys. This is despite increased efforts from BMG and the DER Challenge to engage respondents. In part, this is due to some individuals moving on from the organisations where they had their engagement with the DER Challenge. It is also likely to reflect the fact that some of the engagement with the DER Challenge took place a number of years ago.

Table 2 Response rate by main engagement with the DER Challenge

	Baseline		Process and interim impact		Final impact	
	Completed interviews	Response rate	Completed interviews	Response rate	Completed interviews	Response rate

[23] Attempts were also made to reach members of the wider PEMD sector who had not directly engaged with the Challenge through membership bodies and Innovate UK Business Connect contacts. Unfortunately, these surveys received a very low number of responses, meaning that the data is not robust enough to contribute to the evaluation.

Successful application for funding	32	31%	54	78%	36	34%
Unsuccessful application for funding	4	19%	4	6%	1	5%
Engage With,,, presenters	7	18%	4	6%	2	5%
Letters of support	7	13%	6	9%	2	4%
Advisory group	7	88%	1	1%	0	0%
Total	**57**	**25%**	**69**	**31%**	**41**	**19%**

Source: BMG

Limitations of the contact survey

There are some limitations that apply to the sample achieved. These limitations influenced our analysis and should be borne in mind when interpreting the results.

Firstly, the majority of the responses in the survey came from individuals who had been successful in at least one of their applications to the DER Challenge for funding (36 out of the 41 respondents). The relatively small number of completed interviews with individuals who had been unsuccessful in their applications or had engaged with the DER Challenge in another way (five in total) means that specific analysis of these sub-groups is not possible. As a result, the reported primary survey results are aggregated across all different types of engagement but should be considered most 'representative' of successful applicants.

Secondly, as noted above, the response rate is noticeably lower than those achieved in previous surveys. A low response rate increases the risk that the responses are biased towards a certain type of contact. Given the DER challenges with recruiting respondents for this survey, it is likely that the most 'engaged' contacts are better represented than those with lower levels of engagement. Where possible, survey results were combined with other data sources to help mitigate against this risk.

The relatively low number of responses in the survey overall means that comparisons between sub-groups are unlikely to be statistically significant and the findings should be interpreted as indicative of experiences and views. We cannot guarantee that the results are representative of the population at large.

In analysing the findings, where possible, we compared the results with those of the baseline survey conducted between September 2021 and February 2022 and to those of the interim impact survey conducted between October and November 2022. The different compositions of the samples should be borne in mind when interpreting the findings. For example, the sample from the final impact survey has a higher proportion of successful applicants (88%) than the baseline (56%) and interim impact (78%) surveys.

It could be argued that respondents who have received funding from the DER Challenge are more likely to be positive about the DER Challenge and the DER Challenge is more likely to have a positive impact on those it has directly funded.

3.2.3 Monitoring data

This final impact evaluation also draws on analysis of monitoring data collected internally by the DER Challenge (including the ERS Hub), as well as by Innovate UK Business Connect.[24] In particular:

- Courses and jobs posting data from the ERS Hub provide evidence for evaluation themes 3 and 7.
- Investment and co-investment data from the DER Challenge provide evidence for evaluation themes 4 and 7.
- Engage With... events information from Innovate UK Business Connect provides evidence for evaluation theme 5.

Limitations of the monitoring data sources

The information available for the final impact evaluation is not as extensive and detailed as the information presented for the interim report. This is due to organisational changes within the DER Challenge (e.g. the Knowledge Transfer Network is now known as Innovate UK Business Connect) and updated data protection requirements. This means that for some indicators (e.g. number of engagements, workforce diversity) comparisons cannot be drawn between the final impact and the interim evaluation results.

3.2.4 Secondary data sources

Secondary data sources provide a contextual understanding of the wider PEMD sector, which is helpful to inform themes 1, 3, 4, 5 and 6. For this final impact report, the metrics and sources that we analyse include the following

Patent data from the European Patent Register (Theme 1)

The patent data from the European Patent Register[25] can be used to explore changes over time in the number of patents which relate to PEMD technologies and changes in the share of all patents accounted for by PEMD technologies worldwide (broken down by UK vs. non-UK). The analysis of these trends can provide non-causal descriptive insight into the relationship between the DER Challenge and R&D and investment.

[24] Innovate UK Business Connect is the new name for Innovate UK KTN. Business Connect links up innovators with new partners and new opportunities beyond their existing thinking.

[25] European Patent Office. Global Patent Index.

We analysed data from the European Patent Register. This is a public register kept by the European Patent Office which contains legal information relating to published European patent applications and European patents granted under the European Patent Convention.

Each patent is categorised using the Cooperative Patent Classification (CPC). It is divided into nine sections, A-H and Y, which in turn are subdivided into classes, sub-classes, groups and sub-groups. The PEMD-related CPC codes are described in Table 3.

Table 3 CPC codes used to capture relevant patents

CPC code	Description
HO2B	Boards, substations, or switching arrangements for the supply or distribution of electric power
H02H	Emergency protective circuit arrangements
H02J	Circuit arrangements or systems for supplying or distributing electric power; systems for storing electric energy
H02K	Dynamo-electric machines
H02M	Apparatus for conversion between AC and AC, between AC and DC, or between DC and DC, and for use with mains or similar power supply systems; conversion of DC or AC input power into surge output power
H02P	Control or regulation of electric motors, electric generators or dynamo-electric converters; controlling transformers, reactors or choke coils
H03L	Automatic control, starting, synchronisation, or stabilisation of generators of electronic oscillations or pulses

Source: Frontier Economics and ERM

Due to the cross-cutting nature of the PEMD supply chain and the nature of the classification system, there are limitations associated with usage of CPC codes to capture PEMD supply chain-related work. In particular, a lot of PEMD supply chain-related work will take place in other CPC codes which we did not examine (e.g. anything related to specific industries such as automotive and aerospace), and some of the in-scope codes will capture some non-PEMD supply chain-related work. Therefore, while we analyse CPC codes to determine wider trends in the PEMD ecosystem, this limitation should be borne in mind when interpreting results.

Apprenticeship starts by sector pathway, framework and standard; from the Department for Education (Theme 3)

The Department for Education publishes an apprenticeship starts dataset.[26] This data provides non-causal descriptive insight into the relationship between the DER Challenge and the PEMD knowledge and skills base in the UK. For this metric, we used information on 'apprenticeship

[26] Department of Education - Apprenticeships and traineeships data by pathway

starts by sector pathway, framework and standard'. The 'sector pathways' considered most relevant for the PEMD supply chain as agreed following discussion with the DER Challenge are set out in Table 4.

The PEMD supply chain cuts across a variety of industries and professions. Therefore, there are limitations with using the 'sector pathways' to capture apprenticeships related to the PEMD supply chain. In particular, a lot of PEMD-related skills will be covered by other 'sector pathways'. This limitation should be borne in mind when interpreting results.

Table 4 Sector pathways used to capture apprenticeships

Sector pathway
Aerospace Manufacturing Electrical, Mechanical and Systems Fitter
Building Energy Management Systems
Electrical / Electronic Technical Support Engineer (Degree)
Electrical and Electronic Servicing
Electrical Power Networks Engineer
Electrical Power Protection and Plant Commissioning Engineer
Electrical, Electronic Product Service and Installation Engineer
Embedded Electronic Systems Design and Development Engineer (Degree)
Highway Electrical Maintenance and Installation Operative
Installation Electrician / Maintenance Electrician
Lift and Escalator Electromechanics
Maritime Electrical / Mechanical Mechanics
Power Engineer (Degree)
Power Network Craftsperson
Systems Engineer (Degree)

Source: Frontier Economics and ERM

Student enrolments data from Higher Education Statistics Agency (HESA) (Theme 3)

Student enrolments data from HESA[27] provides non-causal descriptive insight into the relationship between the DER Challenge and the awareness of PEMD career opportunities in the UK. We used data from HESA on student enrolments by subject of study. The courses

[27] HESA - Student enrolments by HE provider and subject of study

considered most relevant for the PEMD supply chain as agreed following discussion with the DER Challenge are found in Table 5. Similar limitations apply to this metric as noted above.

Table 5 Degrees used to capture student participation in PEMD-related courses

Relevant courses
10-01-08 Electrical and electronic engineering
10-01-02 Mechanical engineering
10-01-03 Production and manufacturing engineering
10-01-09 Chemical, process and energy engineering
10-03-02 Materials technology
10-03-07 Materials science

Source: Frontier Economics and ERM

Public sector investment and collaborations from UKRI Financial Transparency Data (Themes 4 and 5)

The UKRI Financial Transparency Data[28] provides non-causal descriptive insight into the relationship between the DER Challenge and investment and collaboration indicators. This UKRI dataset includes information about the projects funded by Innovate UK from 2004 onwards. To identify PEMD-related projects, we searched project titles and abstracts using a list of key words and search terms. This list is outlined in full in Annex E1.

The UKRI Financial Transparency Data specifies the amount of public funding per consortium member in each project. Adding up the public funding granted to each consortium member provides the amount of public funding per PEMD-related project. This enables the value of public sector investment in companies involved in the PEMD supply chain to be determined.

The UKRI Financial Transparency Data indicates whether a project participant is a company, academic or of another category. We therefore identified projects involving collaboration between companies and academics. The UKRI Financial Transparency Data also provides an indication of the size of each company. We therefore identified PEMD-related projects involving collaboration between SME companies and other companies.

[28] UKRI Financial Transparency Data. Innovate UK funded projects since 2004.

Data from ONS Annual Business Survey (Theme 6)

The ONS Annual Business Survey[29] can provide non-causal descriptive insight into the relationship between the DER Challenge and the size of the PEMD ecosystem. This dataset includes information on turnover and number of companies in the UK by SIC code. The SIC codes outlined in Table 6 and agreed following discussion with the DER Challenge are used to capture PEMD activity.

Due to the nature of the PEMD supply chain cutting across a variety of industries, there are limitations with using SIC codes to capture the entirety of the PEMD supply chain. In particular, a lot of PEMD activity will take place in other SICs and some of these codes below will cover non-PEMD technology activities. Therefore, while we use SIC codes as means to measure activity trends in the PEMD sector, this analysis is subject to certain limitations.

Table 6 List of PEMD supply chain SIC codes

SIC	Description
26110	Manufacture of electronic components
26120	Manufacture of loaded electronic boards
27110	Manufacture of electric motors, generators, and transformers
27120	Manufacture of electricity distribution and control apparatus
29310	Manufacture of electrical and electronic equipment for motor vehicles and their engines

Source: Frontier Economics and ERM

Note: Additional SIC codes were considered but subsequently rejected on the basis that they were either too broad and therefore contained too much non-PEMD-related activity or were based on too small a sample size and therefore either had large fluctuations or had numerous years where the data was not presented by the ONS

Employment data from ONS Business Register and Employment Survey (Theme 6)

The employment data from ONS Business Register and Employment Survey (BRES) can provide non-causal descriptive insight into the relationship between the DER Challenge and the size of the PEMD ecosystem, in particular around employment. The latest version of the ONS Annual Business Survey (described above) does not include information on employment. For the final impact evaluation, we used the ONS BRES,[30] which includes data on number of employees in Great Britain (i.e. excluding Northern Ireland) split by SIC code. We used the SIC codes outlined in Table 6 to capture PEMD activity. The limitations discussed above around the ability of SIC codes to identify PEMD activity should also be noted for this data.

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[29] ONS Annual Business Survey

[30] ONS BRES, table 2.

Import and export data from UN Comtrade (Theme 5)

The UN Comtrade[31] data provides non-causal descriptive insight into the relationship between the DER Challenge and the manufacturing capacity of the PEMD supply chain. In particular, UN Comtrade data, at the commodity level for a set of HS6 codes,[32] provides a proxy for the international trade in products relevant to the PEMD supply chain (see Annex E2). A lot of PEMD products and technologies will be captured under other HS6 codes. These are excluded to avoid capturing a large volume of non-PEMD-related activity. Therefore, while we rely on HS6 codes to analyse wider trends in the PEMD ecosystem, they will not capture all PEMD activity.

Limitations of the secondary data sources

As noted above, due to the cross-cutting nature of the PEMD supply chain, the secondary data sources relied on proxy definitions of the sector using a set of search terms and classification codes. The search terms and classification codes used as a proxy to capture PEMD activity (outlined in Annex E2) were carefully developed with the DER Challenge for the evaluation framework report.

These terms and codes were designed to capture PEMD activity as closely as possible. However, the lack of specific definitions of the PEMD supply chain means that these terms and codes are likely to capture unrelated activity and may also miss some PEMD-related activity. Furthermore, the classification codes lag the changes in economic activities driven by emergence of new technologies.

As such, the conclusions of this final impact evaluation do not rely solely on the trends observed in the secondary data. Instead, these trends are used to provide wider contextual understanding of trends in sectors related to PEMD and any findings are complemented by the triangulation of findings from the primary sources.

3.2.5 Company-level microdata

For this final impact evaluation we conducted a benchmarking analysis (i.e. trend and distribution analysis) using the ONS Business Structure Database (BSD) for companies that have participated in the DER Challenge competitions. We identified successful and unsuccessful applicants and matched their Company Registration Numbers (CRNs)[33] to the BSD. We also examined the wider PEMD sector by tracking all companies classified under the SIC codes outlined in Table 6.

This analysis explores the differences regarding turnover, employment (theme 6); productivity, (theme 2); foreign ownership (theme 4); location size, age and region (theme 7) between

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[31] UN Comtrade

[32] HS6 codes are universally recognised codes for trade products assigned by the World Customs Organization.

[33] https://www.gov.uk/get-information-about-a-company

companies that have been successful in their application, unsuccessful companies and other UK PEMD companies that have not engaged with the DER Challenge.

Limitations of the company-level microdata

It is not possible to derive conclusions around the PEMD ecosystem as a whole by looking at the evolution of engaged companies only, given the small sample size of successful and successful companies (143).

To complement these findings, we compare their evolution with that of companies that have not engaged with the DER Challenge. However, the SIC codes used to identify other PEMD companies are likely to capture unrelated activity and also to miss a certain amount PEMD-related activity.

As such, although the primary focus of this analysis is the comparison between successful and unsuccessful companies, we use the imperfect proxy of other PEMD companies to get a sense of the impact of the DER Challenge on the broader PEMD ecosystem.

3.3 Developing the contribution analysis

Evidence from the different evaluation metrics and methods was analysed and mapped against the seven impact evaluation themes. The consortium worked closely with the DER Challenge to interpret the findings from the primary and secondary analysis and build an evidence-based cohesive narrative.

In particular, the DER Challenge provided support to interpret the results from the monitoring and secondary data analysis, outlining the extent to which the DER Challenge may have contributed to the trends observed.

The preliminary findings were presented at a meeting attended by representatives from the DER Challenge, UKRI, and the Evaluation Working Group, part of the DER Advisory Group. Feedback and comments were collected, and the consortium reviewed and incorporated the feedback to revise and complement the draft contribution narrative.

4 Final impact evaluation findings

This section presents the findings of the final impact evaluation structured across the seven evaluation themes.

4.1 Theme 1: Has the DER Challenge accelerated innovation and commercialisation of PEMD technologies?

This theme reflects the DER Challenge's ambition to advance the commercialisation of PEMD technologies in the UK in order to accelerate the growth of the UK PEMD supply chain and increase the contribution of the industry to the economy.

Key findings: The DER Challenge has had a positive impact on innovation and commercialisation of PEMD technology

- The DER Challenge has supported project consortia to progress their manufacturing readiness level (MRL)[34] and has facilitated the development of innovative PEMD technology. For example, survey respondents typically reported that technologies were closer to market readiness than would have been the case without DER funding.
- Additionality here is likely to be high as we were told that these projects would not otherwise have been prioritised by businesses. Stakeholders noted that this was due to the financial risks involved (absent the DER Challenge's intervention) and because other opportunities were seen as 'lower hanging fruit': *"We would have struggled to sell it internally if we had to find all of the funding ourselves […] DER support allowed us to take risks we wouldn't otherwise. This is risky. If you invested money with uncertain outcome there would be less appetite internally"* (Company engaged with the Midlands DER-IC).
- The projects funded by the DER Challenge have unlocked further opportunities. We were told that the GaNSiC project, for example, has been a catalyst for a further ten R&D projects. This follow-on work also sought to develop innovative power electronics solutions for applications relevant for automotive, telecoms, power and aerospace.
- Secondary data does not yet show a clear impact on the level of UK patents in sectors relevant to PEMD technologies (Figure 2).[35] This is in line with our ToC and the business case for the DER Challenge given expected lags between investment and final impacts.
- The DER-ICs have facilitated innovation and commercialisation of UK PEMD technologies by providing access to equipment and enabling knowledge sharing. The DER-ICs have allowed companies to de-risk their activities and start to manufacture new products faster: *"This was quite an important step that we could test out some of these theories and quite quickly assess the feasibility of that approach. With WMG´s expertise and some of the testing, validation [we were doing at the DER-IC] we could iterate quite quickly, cross it off the list, and then go do something else that is more valuable*" (Company engaged with the Midlands DER-IC). Looking ahead, business leaders emphasised the need for continued support for new PEMD technologies and capabilities. We were told that this additional support would build on the successes of the DER Challenge. Stakeholders identified a funding gap associated with the commercialisation and scaling-up of PEMD technologies. DER-IC colleagues indicated that the existing funding opportunities, such as competitions run by the Advanced Propulsion Centre (APC) and the Aerospace Technology Institute (ATI), do not currently fill this gap and cannot directly replace current DER Challenge funding. This is because other sources of funding are targeting projects with higher costs and therefore may exclude SMEs and startups with interest in using the DER-IC equipment. Other funding options do exist via UKRI. However, we were told that, in some cases, these funding opportunities are "*enough to gain some basic understanding work but not enough to take projects to the next level*" (DER-IC colleague).

Table 7 Final impact evaluation metrics – evaluation theme 1

Metric	Source	Methodology
Manufacturing readiness level (MRL)	Contact survey	Stated impact of the DER Challenge on MRL
Patent filing	European Patent Register	Time series analysis of count and share of filings for PEMD technologies in the UK
Number of first-of-a-kind PEMD pilots	Project-based case study Activity-based case study Thematic case study Contact survey	Framework analysis of case study interviews with PEMD companies, DER-IC colleagues and other policy and industry stakeholders UK position compared to other countries as a centre for innovation

Source: Frontier Economics

4.1.1 Activities undertaken by the DER Challenge

Activities undertaken by the DER Challenge to advance innovation and commercialisation of PEMD technologies include:

- Providing around £90 million in collaborative research and development (CR&D) grant funding across around 100 projects to around 160 different entities, according to DER Challenge monitoring data[36]. These entities are firms that are in the early stages of developing new technologies and those that already have a proof of concept but need help to advance the MRL. Thus the funding directly enables innovation and commercialisation. Annex A provides further detail around the evolution of grant funding over the course of the DER Challenge.
- Funding the DER-ICs (£33 million in 2020 and additional £16.6 million in 2023[37]), which has provided access to equipment that allows innovative firms to explore how best to fill gaps in the UK's current manufacturing capabilities by allowing those firms to test and explore ways of improving their techniques and processes. Annex A provides further detail around the allocation of DER-IC funding over the course of the DER Challenge.

[34] https://www.twi-global.com/technical-knowledge/faqs/manufacturing-readiness-levels

[35] European Patent Office. Global Patent Index.

[36] Note this includes all the DER grant offered (not only CR&D).

[37] £16.6 million boost to power up chips used in electric cars and green energy industry

4.1.2 Findings

The DER Challenge has had a positive impact on innovation and commercialisation of PEMD technology. In particular, the DER Challenge has facilitated the development of innovative PEMD technology and supported projects to progress their MRL.

Manufacturing Readiness Level (MRL)

Stakeholders from the thematic case study indicated that the DER Challenge's emphasis on manufacturing capacity has helped advance the manufacturing readiness of innovative technologies in the UK. This is in line with the findings from the survey. Respondents indicated that 19 of the 32 successful projects discussed in the survey have seen an increase in MRL phase (a phase is generally 2 MRL stages) from the start of their engagement with the DER Challenge to the end of their funding. More importantly, 14 out of the 32 respondents thought that their projects would be at a lower phase than it was if they had not received funding from the DER Challenge

Table 8 shows that eight of the successful projects that were discussed in the survey have increased by 1 MRL phase (e.g. from MRL1 and 2 to MRL 3 and 4), nine by 2 MRL phases, one by 3 MRL phases and one by 4 MRL phases. Only eight of the successful projects that were discussed in the survey did not see a change in their MRL phase. However, as noted previously, as an MRL phase generally contains two stages, there may still have been progress on these eight projects even if they did not progress to the next stage.

These findings are generally in line with expectations captured as part of the baseline survey. As per the results of the interim impact evaluation, the majority of survey respondents (34 of 54) expected their manufacturing process to progress by at least one MRL stage by the end of their DER Challenge funding. A quarter (8 of 32) of baseline survey respondents who discussed a successful project expected their manufacturing process to progress by 2 MRL stages, two expected their manufacturing process to progress by three MRL stages and one did not expect any progression by MRL stage.

Survey respondents were also asked during this wave about the MRL level they had achieved relative to their expectations if no funding had been received. Figure 11 shows that five respondents thought that the manufacturing process would have been one MRL phase lower (in the absence of funding), seven thought that it would have been two MRL phases lower, one thought it would have been three MRL phases lower, and one thought it would have been four MRL phases lower. The remaining ten respondents thought that the project would have been in the same MRL phase without DER funding.

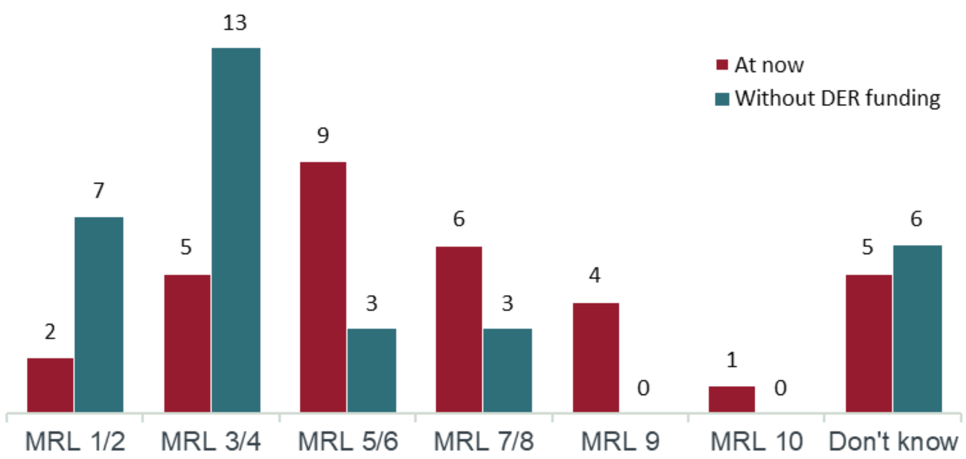
Table 8 Change in MRL for projects funded by the DER Challenge

		At end of funding						
		MRL 1 and MRL 2	*MRL 3 and MRL 4*	*MRL 5 and MRL 6*	*MRL 7 and MRL 8*	*MRL 9*	*MRL 10*	*Don't know*
At start of engagement	MRL 1 and MRL 2	2	-	4	1	1	-	1
	MRL 3 and MRL 4	-	5	4	4	-	-	1
	MRL 5 and MRL 6	-	-	1	1	1	-	1
	MRL 7 and MRL 8	-	-	-	-	2	-	-
	Don´t know	-	-	-	-	-	1	2

Source: *Contact survey. Summary of results from C4 and C5*

Note: *Base: Successful applicants, final impact survey (32)*

Figure 11 MRL level compared to expectation if funding had not been received



Source: *Contact survey. C5. And what level is the manufacturing process at now? C5A. If your application for funding had been declined by DER, what level do you think it would be at now?*

Note: *Base: Successful applicants, final impact survey (32)*

Patent Filing

Figure 12 shows that both the absolute number and share of PEMD patents filed in the UK increased slightly since the start of the DER Challenge (from 228 / 2.6% in 2020 to 278 / 3.6% in 2022).[38]

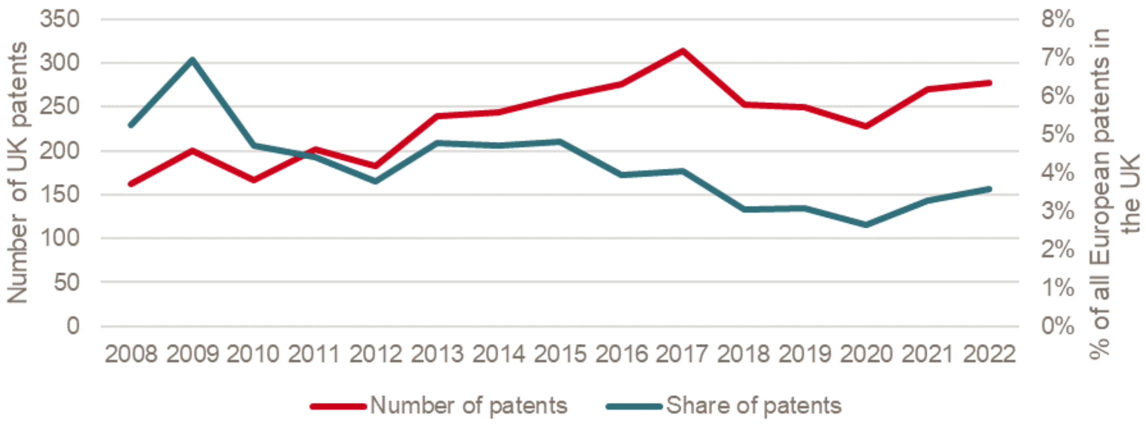
Each patent is categorised using the Cooperative Patent Classification (CPC). In the evaluation framework report, we carefully developed and agreed with the DER Challenge a

[38] European Patent Register. Global Patent Index

list of CPC codes to identify PEMD-related patents. Due to the cross-cutting nature of the PEMD supply chain there are limitations associated with usage of CPC codes to capture PEMD supply chain-related work. In particular, a lot of PEMD supply chain-related work will take place in other CPC codes (e.g. anything related to specific industries such as automotive and aerospace) and some of these codes will capture some non-PEMD supply chain-related work.

This trend we observe in the European Patent Registry data is in line with the results from the survey. Figure 13 shows that just over a third (14 out of 41) of respondents to the final impact survey felt that the DER Challenge had had a positive impact on their volume of patent filing over the past three years. This is made up of three who felt the DER Challenge had had a significant positive impact and just over a quarter (11 out of 41) who felt it had had a slight positive impact. The remaining 27 thought the DER Challenge had had no impact on their volume of patent filing over the past three years.

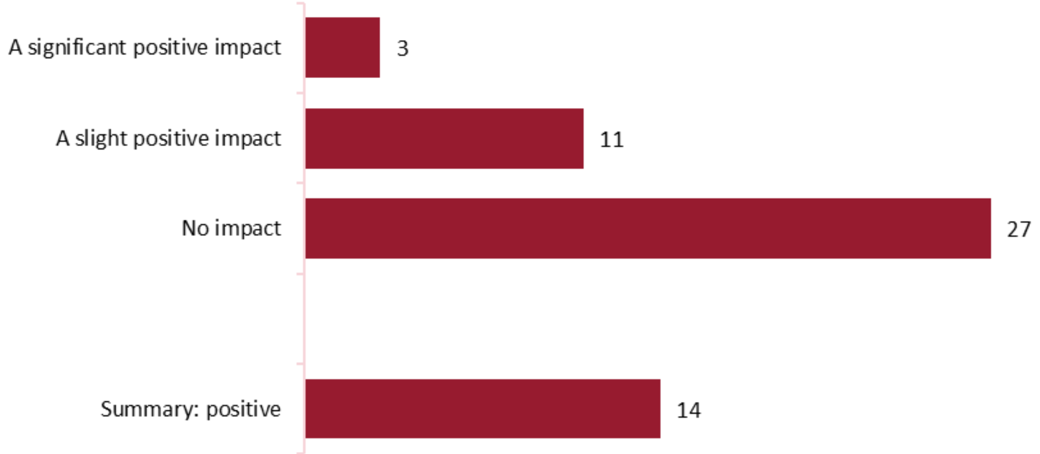
Figure 12 Number of PEMD patents in the UK and share of European patents filed in the UK



Source: [European Patent Register. Global Patent Index](#).

Note: The year of the patent is determined based on 'filing date'. Data from 2023 is not presented as applications are published after 18 months of the date of filing or, when priority is claimed, from the earliest priority date

Figure 13 Impact of the DER Challenge on volumes of patent filing



Source: Contact survey. F7. Thinking about the Driving the Electric Revolution DER Challenge overall, what impact, if any, has it had on the following over the past 3 years? Your volume of patent filing

Note: Base: All respondents to final impact survey (41)

These findings are broadly consistent with views expressed by stakeholders who took part in the thematic case study. Thematic case study stakeholders also indicated that more time is needed to demonstrate clear progress with respect to the commercialisation of PEMD technologies.

"*I think it might be a bit early to quantitatively measure the impact. […] As soon as you make a decision and you do something, it takes 5 to 10 years to have an impact. So I think it's important that you keep doing this [evaluation], probably year on year, and seeing if the needle is moving.*" (Engineering operations manager at an SME and trade association)

Number of first-of-a-kind PEMD pilots

Stakeholders from the thematic case study indicated that the DER Challenge has advanced PEMD technology readiness in the UK. They highlighted the enabling role of the DER-ICs, which have gained greater recognition since Phase 3. We were told that DER-ICs have facilitated the establishment of facilities and made expertise accessible.

"*What is needed from an academic perspective is to take the world-leading work that we are genuinely doing and translate that into [practical solutions for] the wider world. So, I think, from my perspective, […] the DER Challenge helped to do that at a time where capital expenditure was really difficult to justify for companies. The capital expenditure that was made through the DER-IC programme has really […] catalysed that industry engagement. People coming to use manufacturing and testing facilities that we've been able to put in place*." (Academic and commercial industry representative)

Stakeholders who had engaged with the Midlands DER-IC confirmed the view that the DER-IC had had a positive impact on innovation. Access to the Midlands DER-IC equipment allowed firms to move their production process away from their own facilities and so they did not need to interrupt their current processes or make risky upfront investments in equipment in order to test new innovations.

“This was quite an important step that we could test out some of these theories and quite quickly assess the feasibility of that approach. With WMG´s expertise and some of the testing, validation [we were doing at the DER-IC] we could iterate quite quickly, cross it off the list, and then go do something else that is more valuable.” (Company engaged with the Midlands DER-IC)

As such, DER funding means firms can undertake riskier projects which could have significant long-term benefits and widespread applications, in a timely manner.

“*We would have struggled to sell it internally if we had to find all of the funding ourselves […] DER support allowed us to take risks we wouldn’t otherwise. This is risky. If you invested money with uncertain outcome there would be less appetite internally. We would focus on lower hanging fruit*.” (Company interviewed)

Firms also told us that the guidance and technical support provided by the DER-IC had led to a reduction in risk and a faster production of an improved prototype. In the longer term, we were told that this knowledge transfer is expected to foster innovation for companies that have brought the design knowledge provided by the DER-IC in house.

“*When you are creating an innovative design you want to give it as much chance to succeed as possible. So not taking the risks you don´t need to, to avoid going through lessons re-learned.*” (Company interviewed)

Stakeholders from the thematic case study also noted the positive contribution of the DER-ICs to encourage innovation and commercialisation of the UK PEMD technology. However, they also argued that the DER-ICs’ geographical spread and rules governing usage of equipment may in some cases have limited their supportive role within the PEMD sector. Some of these stakeholders told us that if the DER-ICs, key manufacturing centres and commercial organisations had been more geographically concentrated, the potential for shared technology development might have been higher. This in turn could have provided greater reassurance for long-term employment, while reducing companies’ technology costs. Greater geographic concentration would also have had downsides such as a reduced contribution of the DER Challenge to balanced economic growth and prosperity.

The DER Challenge competitions have also had a positive impact on innovation and commercialisation of UK PEMD technology. Stakeholders from the GaNSiC project indicated that the DER Challenge had provided essential funding to facilitate the development and commercialisation of the innovative direct-dispense technology. The process developed during the GaNSiC project has attracted interest from major automotive players and customers across different end-use sectors. It is now used in products that Custom Interconnect Ltd. (CIL) would otherwise have been unable to manufacture.

“*[The direct-dispense technology] is used on multiple products that we are now manufacturing that, if it wasn't for that technology [developed under the DER programme], we wouldn't be able to manufacture.*” (CIL)

The GaNSiC direct-dispense solution has been deployed in several subsequent projects. As such, we were told that the DER Challenge-funded GaNSiC project had been a catalyst for a further ten R&D projects which also sought to develop innovativee power electronics solutions for automotive applications or high-power computing in internet servers.

“If it wasn't for GaNSiC, it wouldn't have led to @FutureBEV, to EleVAIT, to Elips, and I can just go on and on and on… It all started with that project, and it's all been about networking and [leveraging] the community.” (CIL)

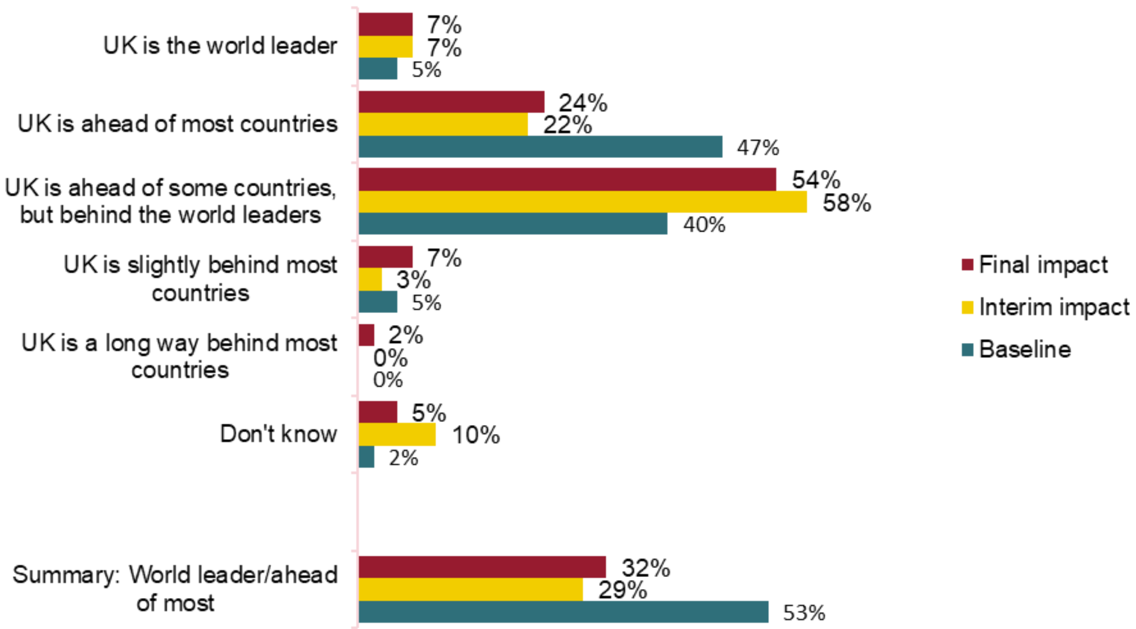
Stakeholders noted that if the SCREAM project had not gone ahead, technology development and industry involvement within the rare earth recycling space would have been delayed.

“*Recovery of rare earth magnets isn't something that is commercially viable on anyone's agenda or a large enough value opportunity […]. So it is one of those topic areas that would always be on the back burner was it not for projects like this.*” (EMR)

“*Maybe it would have happened another way, but if you looked at the way we want to progress without this funding and this project, we would be a long way backwards.*” (Hypromag)

Overall, perceptions regarding the UK’s position as a centre for innovation in PEMD technology have remained broadly stable relative to the impact evaluation. Figure 14 shows that just under a third (13 out of 41) of respondents to the final impact survey thought the UK was a world leader or ahead of most other countries as a centre for innovation in PEMD technology. These results are similar to when the question was asked in the interim impact evaluation (20 out of 69 respondents, asked in November 2022), but notably lower than when asked in the baseline survey (53%, asked between September 2021 and February 2022). However, these changes may in part be driven by changes in sample composition between waves. Respondents to the final impact survey were most likely to say that the UK was ahead of some countries, but behind the world leaders (22 out of 41).

Figure 14 Change in perceptions of UK as a centre for innovation in PEMD technology



Source: *Contact survey. B2. Overall, how would you rate the UK's current reputation compared to other countries as a centre for innovation in PEMD technology?*

Note: *Base: All respondents to final impact survey (41), all respondents to interim impact survey (69), all respondents to the baseline survey (57). Please note that to compare across survey waves, we need to use % despite sample sizes*

Stakeholders from the thematic case study indicated that the modest amount of DER funding made available may not have been sufficient to significantly boost the entire UK's PEMD commercialisation rate. They pointed to the UKRI-led Faraday DER Challenge[39] for battery development in UK as an example of a programme that received significantly more funding than DER and had an alternative approach to its distribution and use. This helps to put into context the success that the DER has achieved

There was a concern around the continuity of future public support for PEMD, which some stakeholders felt was needed to build on the successes that the DER Challenge has achieved. Business leaders emphasised the need for continued support for new PEMD technologies and capabilities. We were told that this support should be integrated into a long-term industrial strategy with sustained government funding and policy measures.

"The really important bit in all this post-DER stuff is that no doubt you've deployed the foundation, but how to build the bricks on top of it and to build a house, what are the next steps?" (Engineering operations manager at an SME and trade association)

Stakeholders felt that DER had established a solid foundation for advancing the technology readiness of various PEMD manufacturing solutions. However, we were told that transitioning

[39] For battery research, innovation and scale-up.

to commercialisation is a very difficult and expensive step that may require further investment support.

"A lot of what has been done in DER has funded a growth of TRL level in many different areas. The gap that remains then is even bigger, call it crossing the chasm to get from TRL 7 to a successful product. [...] Funding innovation is very important, it's a very necessary step, but it's actually typically the cheapest step. It's the commercialising and gearing up that's actually more expensive. So how do we build on this to make sure that in the future [...] the ecosystem is either there or we've supported the ecosystem for companies to prosper?" (Industry representative)

In particular, stakeholders from the thematic case study indicated that there is a significant funding gap associated with the commercialisation and scaling-up of PEMD technologies. Existing innovation bodies, such as the Advanced Propulsion Centre (APC) and the Aerospace Technology Institute (ATI), already support technology development in the higher TRL range in the automotive and aviation industries. However, DER-IC colleagues indicated that APC and ATI funding opportunities involve projects with much higher costs than an average project funded by the DER Challenge and may therefore be out of the scope for SMEs. The DER-IC is still finding interest from SMEs and startups to use the equipment, so the DER-IC has been directing them to UKRI small funding opportunities which "*is enough to gain some basic understanding work but not enough to take projects to the next level*" (DER-IC colleague).

4.2 Theme 2: Has the DER Challenge increased the productivity of the UK PEMD supply chain?

This theme reflects the Driving the Electric Revolution DER Challenge's ambition to advance the productivity of the UK PEMD supply chain in order to increase the contribution of the industry to the economy and to increase exports while simultaneously encouraging *substitution away from imports. It covers activities, outputs and outcomes described in the ToC.*

Key findings: The DER Challenge has enabled early-stage improvements which can unlock productivity gains in the future.

- Analysis of secondary data comparing productivity (measured as turnover per employee) for successful and unsuccessful applicants to the DER Challenge does not suggest any clear impact so far.[40]
  - Among DER Challenge beneficiaries in our contact survey, 17 reported a positive impact on their company's overall productivity and 16 a positive impact on labour productivity. However, the majority did not report any impact so far on their company's overall productivity (20 out of 41) or labour productivity specifically (23 out of 41) as a result of engaging with the DER Challenge. Our ToC and the targets set out by the DER Challenge's own business case suggest that widespread productivity improvements would not be expected at this stage. More broadly, we identify a perception among firms which have engaged with the DER Challenge that the DER Challenge has laid the ground for future productivity improvements. The improvements that have been realised include automation, repeatability and knowledge-sharing opportunities that have collectively led to improved design and faster manufacture of improved prototype products.
- The DER-ICs have also played a role in productivity improvements. For example, firms have used equipment to carry out automated winding, which has applications in the automotive and aerospace sectors. In the future, this form of automation can allow for higher throughput and repeatability of design in the manufacture of electric motors. In some cases, there is evidence that these investments have led to scale-up, moving the process from the laboratory to pilot plant facilities.
- However, further scaling may be beyond the direct remit of Innovate UK and may require additional public support after the DER Challenge. Interviewed firms indicated that additional public funding is required to unlock the potential longer-term productivity improvements that PEMD can bring. This additional funding would build on the earlier-stage improvements in manufacturing readiness that have been enabled by the DER Challenge. These include automation and repeatability, as well as knowledge-sharing opportunities that have collectively led to improved design and faster manufacture of improved prototype products.

Table 9 Final impact evaluation metrics – evaluation theme 2

[40] ONS Business Structure Database. Productivity is calculated as the ratio between turnover (thousand pounds) and number of employees for small, medium, and large companies separately.

Metric	Source	Methodology
Total factor productivity	Contact survey	Stated perceptions of the productivity of the supply chain as a barrier or enabler for the progression of PEMD
	Activity-based case study	Framework analysis of case study interviews with PEMD companies
Labour force productivity	Contact survey	Stated impact of the DER Challenge on labour force productivity and productivity of the domestic supply chain
	ONS company microdata	Trend analysis of average productivity for companies that won a DER Challenge competition, unsuccessful companies and other PEMD companies not engaged with DER Challenge

Source: Frontier Economics

4.2.1 Activities undertaken by the DER Challenge

The activities undertaken by the DER Challenge to increase the productivity of the UK PEMD supply chain include:

- The DER Challenge has provided around £90 million in CR&D grant funding across around 100 projects to around 160 different firms, according to DER Challenge monitoring data.[41]
- The DER Challenge has funded the DER-ICs which have provided open access to equipment, facilitated connections and knowledge sharing between academia and companies across the supply chain, and signposted firms to funding opportunities.
- The DER Challenge has facilitated networking events hosted to enhance the engagement between companies across the supply chain as well as with and academia and other research organisations. Further detail around the network events facilitated by the DER Challenge is provided in Section 4.5.

4.2.2 Findings

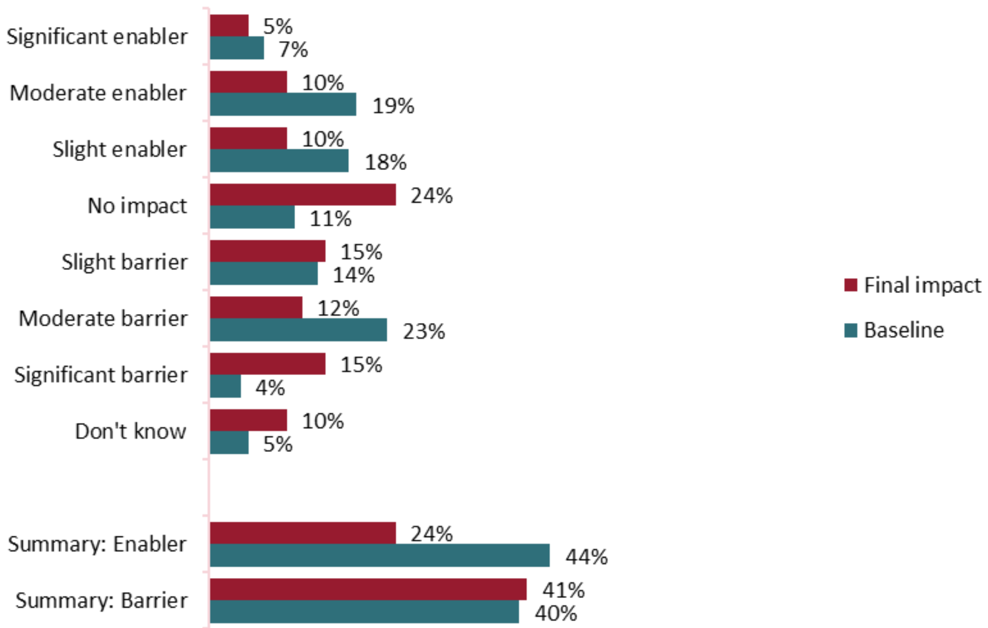
Although productivity improvements are not expected at this stage, some firms which we engaged with as part of this evaluation noted that they had already benefitted from productivity improvements. Other firms indicated that it was too early to confidently identify widespread productivity impacts and that additional funding was required to unlock the potential PEMD productivity improvements across the UK.

[41] Note this includes all the DER grant offered (not only CR&D).

Total factor productivity

Survey respondents provided a mixed view on whether they considered the productivity of the domestic supply chain to be a barrier to or an enabler of the progression of PEMD technology in the UK. Just over two in five (17 out of 41) respondents to the final impact survey felt that domestic supply chain productivity was a barrier to the progression of PEMD technology in the UK and just under a quarter (10 out of 41) reported that it was currently an enabler. Fewer respondents now thought that this was an enabler than did so in the baseline survey (25 out of 57), while a similar proportion felt that it was a barrier (23 out of 57 in the baseline survey). However, these changes may in part be driven by changes in sample composition between waves.

Figure 15 Change in perceptions of the productivity of the domestic supply chain being a barrier to or enabler of the progression of PEMD technology in the UK



Source: Contact survey. B3. For each of the following, please indicate whether you think they are a barrier or an enabler to the progression of PEMD technology in the UK: Productivity of the domestic supply chain

Note: Base: All respondents to final impact survey (41), all respondents to the baseline survey (57). Please note that, to compare across survey waves, we need to use % despite sample sizes

Some of the opportunities identified in the activity-based case study as a result of the provision of DER-IC facilities include producing more efficient motors and drawing on automation to boost repeatability and reliability of new products. For example, firms use equipment to carry out automated winding, which has applications in the automotive and aerospace sectors. In the future, this form of automation can allow for higher throughput and repeatability of design in the manufacture of electric motors.

However, the companies interviewed did not yet report major impacts on productivity or expansion as a direct result of their engagement with the DER-ICs. This was expected given that most companies have not yet started to mass manufacture the products they have been developing and testing with support from the DER Challenge.

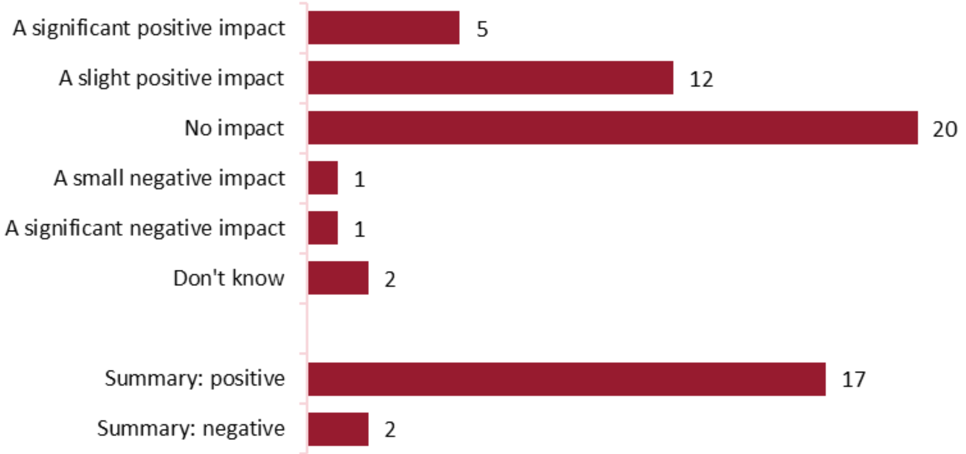
This lag between provision of support and realisation of productivity impacts has been exacerbated by delays in accessing equipment (mostly driven by external factors, i.e. suppliers struggling to meet the required quality standards). For example, one firm noted that, if successful, its new production process could lead to an expected eight-fold productivity improvement. However, it had not yet been able to test whether this new process was fully functional and fit for purpose.

Yet, despite these external DER challenges, the project case studies provide concrete examples of how the DER Challenge has contributed to the scaling-up of companies. For example, Mkango has moved from lab-scale chemical recycling (TRL 4) to the establishment of a pilot plant (TRL 6) thanks to this DER funding. Without the DER funding, Hypromag stated that it would not have had the resources to demonstrate the NdFeB magnet recycling process at scale. The DER funding facilitated the REAP project, which demonstrated the hydrogen processing of magnetic scrap (HPMS) recycling concept developed by the University of Birmingham (UoB), enabling Hypromag to extract magnets at a scale beyond the laboratory. This means that the UK can now monetise magnet recycling across all permanent magnet applications, giving it an advantage over other nations. Moreover, scaling the magnet recycling process improves the circularity of the rare earth supply chain, which reduces the UK's reliance on imports, and the emissions of the supply chain.

As such, the companies stressed the importance of being able to secure additional investment going forward to scale up the production and commercialise the products they have been designing and manufacturing with the DER-IC.

This is in line with the results from the contact survey. Figure 16 shows that just over two in five (17 out of 41) respondents to the final impact survey felt that the DER Challenge had positively impacted their organisation's productivity over the last three years. This includes five who felt that the DER Challenge had had a significant positive impact on the productivity of their organisation as a whole, and 12 who felt that the DER Challenge had had a slight positive impact. Only two felt that the DER Challenge had had a negative impact on the productivity of their organisation, while just under half (20 out of 41) felt it had had no impact.

Figure 16 Impact of the DER Challenge on organisation productivity



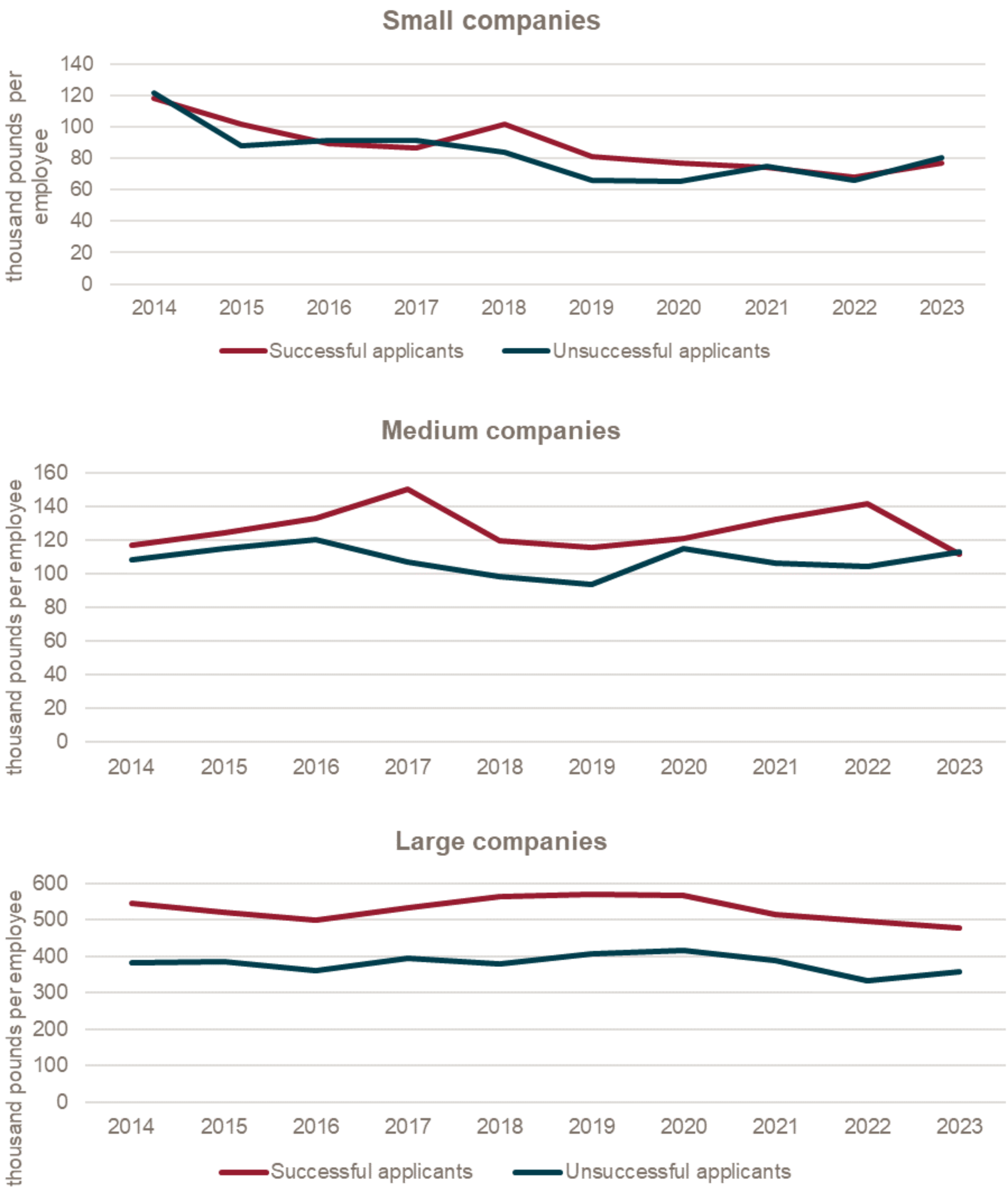
Source: Contact survey. F7. Thinking about the Driving the Electric Revolution DER Challenge overall, what impact, if any, has it had on the following over the past 3 years? The productivity of your organisation as a whole

Note: Base: All respondents to final impact survey (41)

Labour force productivity

An impact on labour force productivity was not observed in the ONS BSD data. The average labour force productivity (calculated as the ratio between turnover and number of employees) of companies that participated in DER Challenge competitions (both successful and unsuccessful applicants) remained fairly constant from 2014 to 2023 (see Figure 17).

Figure 17 Average labour productivity of companies that have participated in DER Challenge competitions

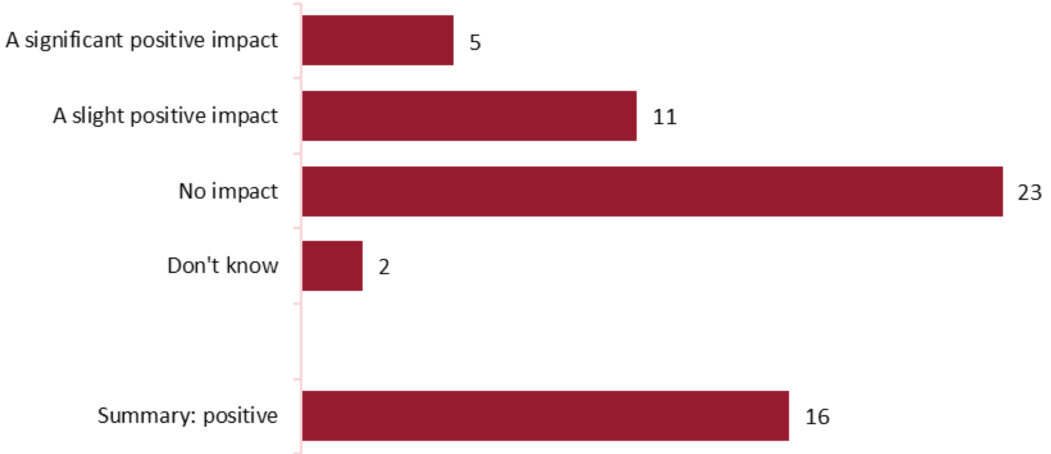


Source: *ONS Business Structure Database. This work was undertaken in the Office for National Statistics Secure Research Service using data from ONS and other owners and does not imply the endorsement of the ONS or other data owners*

Note: *Productivity is calculated as the ratio between turnover (thousand pounds) and number of employees. Small companies are companies with fewer than 50 employees or a turnover of less than £10 million. Medium companies are companies with fewer than 250 employees and turnover of less than £50 million*

Most survey respondents also indicated as part of the contact survey that the DER Challenge had had no impact on the productivity of their employees. Respondents to the final impact survey were asked what impact the DER Challenge had had on the productivity of their employees over the past three years. Figure 18 shows that just under two in five (16 out of 41) felt the DER Challenge had had a positive impact on the productivity of their employees, with five stating that the DER Challenge had had a significant positive impact. However, the majority (23 out of 41) felt that the DER Challenge had not impacted them in this area.

Figure 18 Impact of the DER Challenge on employee productivity



Source: Contact survey. F7. Thinking about the Driving the Electric Revolution DER Challenge overall, what impact, if any, has it had on the following over the past 3 years? The productivity of your employees

Note: Base: All respondents to final impact survey (41)

4.3 Theme 3: Has the DER Challenge contributed to growing PEMD knowledge and skills in the UK?

This theme reflects the Driving the Electric Revolution DER Challenge's ambition to increase the PEMD knowledge and skills base in the UK in order to increase the capability to grow the UK's PEMD supply chain. It covers activities, outputs and outcomes described in the ToC.

Key messages : The DER Challenge has had a positive impact on skills gaps. However, issues persist.

- Stakeholders interviewed indicated that skills gaps remain a key barrier for the progression of PEMD technology in the UK, and awareness of PEMD career opportunities among students is low. It is not reasonable to expect the DER Challenge to have significantly closed existing skills gaps. The funding allocated specifically to skills was a relatively small portion of overall DER Challenge budgets and some of the initiatives are still in their early stages. For example, the Electric Revolution Skills Hub (ERS Hub) was launched by the DER Challenge in March 2023 to raise awareness of PEMD career opportunities. As it is a new DER Challenge activity since our interim evaluation report, final impacts will not yet be visible.
- Survey results indicate some improvement in perceptions around skills gaps relative to the baseline among respondents. Findings from the case studies also indicate that the DER Challenge has had a positive impact on skills development and overall awareness of the PEMD career opportunities. This has been predominantly driven by the funding allocated to projects – which has provided funding to recruit new staff – and the knowledge-sharing activities and access to world-class equipment which has been facilitated by the DER-ICs.
    - “*[The technical support from the DER-IC] took us from a design that was not really possible into a design that is possible*” (Company engaged with the Midlands DER-IC).

Table 10 Final impact evaluation metrics – evaluation theme 3

Metric	Source	Methodology
Perception of skills as a barrier to expanding the PEMD supply chain	Contact survey	Stated impact of Driving the Electric Revolution on skills
	Activity-based case study	Framework analysis of case study interviews with PEMD companies and DER-IC colleagues
	Monitoring data from the ERS Hub	Reported information from ERS Hub analysis
Awareness of PEMD career opportunities	Activity-based case study Thematic case study	Framework analysis of case study interviews with PEMD companies, DER-IC colleagues, policy, and wider industry stakeholders
	Number of university students in relevant courses from HESA	Time series analysis of share of students enrolled in university courses relevant for the PEMD sector
	Apprenticeship and traineeship data from the Department of Education	Time series analysis of apprenticeships starts for relevant sector pathways, by apprenticeship level

Source: Frontier Economics

4.3.1 Activities undertaken by the DER Challenge

The DER Challenge has conducted a range of supporting activities to facilitate knowledge exchange and enhance the UK skill set. These include:

- Dedicating £6 million to support skills and training provision for school leavers to experienced engineers. The DER Challenge is funding competitions for various skills projects – for example, building interactive learning tools on specific engineering topics – as well as developing the ERS Hub.
- Provision by the ERS Hub of inclusive access to specialised training and employment opportunities across the UK. The ERS Hub also facilitates networking and knowledge sharing. For example, between March 2023 and May 2024 the ERS Hub advertised 910 PEMD-related courses and 702 PEMD-related job postings. The ERS Hub provides support to: (i) individuals, helping them to understand the skills necessary for a career in electrification, providing them with access to relevant training and connecting them with job opportunities; (ii) employers, providing training for their employees and helping them attract talent; (iii) course providers, who can share their courses on the ERS Hub online platform; and (iv) recruitment agencies, which can use the ERS Hub jobs board. This builds brand awareness and connects job postings with individuals seeking electrification roles. The ERS Hub has also undertaken marketing and outreach activities such as distributing a newsletter to 700 subscribers and hosting 17 events, with five more events planned for 2024. The ERS Hub will also be hosting an annual conference at the Advance Engineering Show.
- Funding the DER-ICs, which have (i) invested in a new role focused on rolling out the skills agenda, including developing training packages for the industry; (ii) created online platforms in Coventry and Nottingham which deliver training modules related to PEMD; (iii) organised detailed workshops to disseminate knowledge with the companies using the DER-IC equipment; (iv) shared knowledge and expertise with collaborators in several projects, knowledge which is then retained within firms and likely builds future capabilities; and (v) offered the PEMD workforce the opportunity to work with new manufacturing equipment and provided training on the use of this equipment.
- The DER Challenge has prioritised activities centred around CR&D projects. While these do not necessarily focus on the skills gap, they can play an important role in increasing the UK PEMD knowledge base and have helped to develop and upskill workers involved in funded projects.

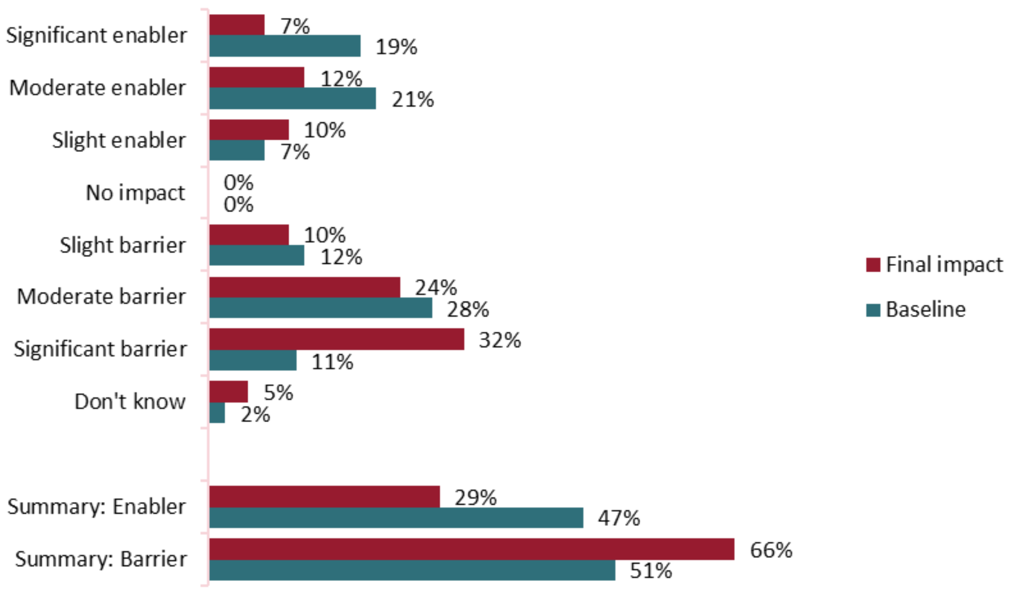
4.3.2 Findings

Stakeholders increasingly recognise the importance of skills to unlock potential PEMD benefits. This was reflected in the explicit incorporation of skills within the overall objectives of the DER Challenge. However, the funding allocated to skills specifically within DER was a relatively small portion of overall DER Challenge funding (£6 million)[42] and some of the initiatives are still in their early stages. In that sense, it is not expected that the programmes and activities promoted by the DER-ICs will close the skills gaps. Despite these DER challenges, we found that the DER Challenge has had a positive impact on skills and awareness of PEMD opportunities.

Perception of skills as a barrier to expanding the PEMD supply chain

Skills gaps are considered a key barrier for PEMD technology development in the UK. In particular, Figure 19 indicates that two-thirds (27 out of 41) of respondents to the final impact survey felt that the skills of the workforce were a barrier to progression of PEMD technology in the UK. This compares to just over half (29 out of 57) who felt this was the case in the baseline survey. However, results are mixed and a little over a quarter (12 out of 41) felt that this was an enabler to progression of PEMD technology in the UK (compared to 27 out of 57 who felt it was an enabler in the baseline survey). These changes in perceptions may in part be driven by changes in sample composition between waves.

Figure 19 Change in perceptions of the skills of the workforce being a barrier to or enabler of the progression of PEMD technology in the UK



Source: Contact survey. B3. For each of the following, please indicate whether you think they are a barrier or an enabler to the progression of PEMD technology in the UK: Skills of the workforce

Note: Base: All respondents to final impact survey (41), all respondents to the baseline survey (57). Please note that to compare across survey waves, we need to use % despite sample sizes

[42] Other forms of DER support, e.g. funding of CR&D projects, will also have led indirectly to positive skills impacts, as we note below.

The DER Challenge has had a positive impact on skills development from knowledge-sharing activities and providing access to guided usage of specialised equipment, both of which have been facilitated by the DER-ICs. Companies which collaborate with the Midlands DER-IC mentioned the importance of the technical knowledge, best practices and expertise provided by the DER-IC, which they could not have accessed from other sources in the absence of the DER Challenge.

"[The support from the DER-IC] took us from a design that was not really possible into a design that is possible." (Company engaged with the Midlands DER-IC)

The equipment provision and active connecting of firms have also had positive spillover impacts. The use of equipment has helped uncover skills gaps that could then be addressed, and we were told that the projects have catalysed skills transfer from universities to the companies. However, there was some concern that the DER-ICs have increased competition for skilled staff among other local companies with demand.

The DER programme has enabled CIL and CSAC (involved in the GaNSiC project) to recruit new staff and develop training programmes. Multiple consortium members of the SCREAM project have increased their experienced skills base and hired new staff from funding allocated to the project teams.

This perception that the DER Challenge has positively contributed to growing PEMD knowledge and skills in the UK was corroborated in the survey responses. Most survey respondents indicated that the DER Challenge had had a slight positive impact on skills, although the role of the DER Challenge in retraining and reskilling was less clear.

Business respondents to the final impact survey were asked what impact they felt the DER Challenge had had on the level of skills in the PEMD sector. Although only 20 respondents answered this question, the indicative findings are positive, with 14 of them feeling that the DER Challenge had had a small positive impact. Only two felt that the DER Challenge had had no impact in this area, while the remaining four felt they did not know enough to give a view.

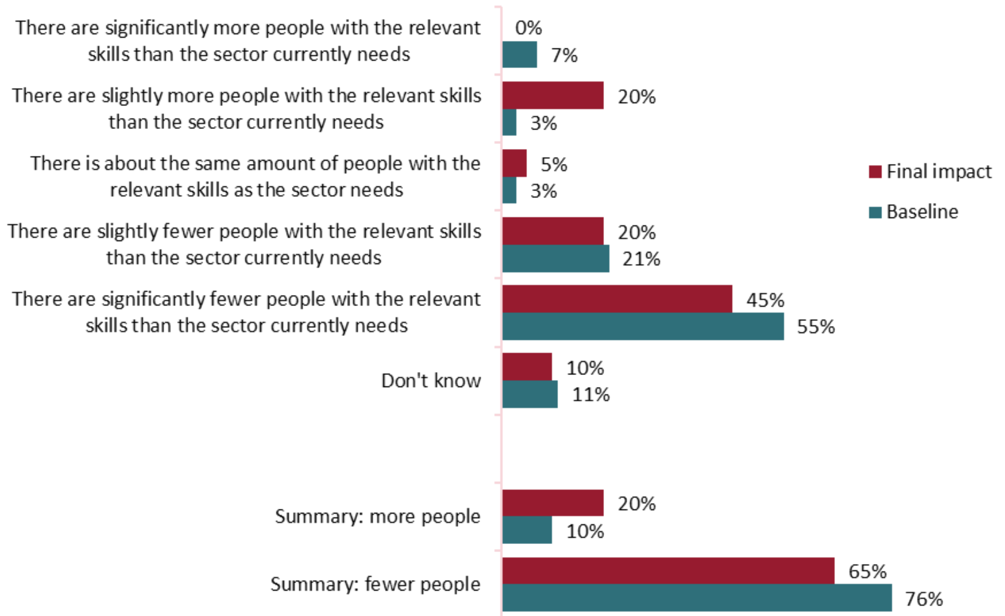
The same 20 respondents were also asked about the extent to which they agreed that the DER Challenge had facilitated the retraining of mid-career professionals into PEMD roles. There was more uncertainty here, with six respondents unable to give a view and eight neither agreeing nor disagreeing with the statement. However, four agreed that the DER Challenge had facilitated this and only two disagreed. Findings from the survey are in line with views expressed by some stakeholders who participated in the thematic case study. They told us that they had not yet noticed a quantifiable difference in the retraining of staff within the PEMD sector in the past two years. Stakeholders interviewed indicated that the programmes and activities promoted by the DER-ICs had not yet managed to close the skills gap, partially due to the growth cycle of the industry and magnitude of the underlying issue. However, stakeholders who took part in the thematic case study indicated that, while the impact of the DER Challenge was difficult to quantify, it was likely that this gap would have been even larger without the DER Challenge. Therefore, the DER Challenge has helped to partially tackle a barrier which is hindering the sector's growth and competitiveness.

Looking ahead, the lack of continuation of the funding is expected to have an impact on the improvements that have been made around skills. DER-IC colleagues mentioned that the work that has been done around skills and knowledge transfer has contributed to an improvement in the PEMD skills ecosystem, but:

"[the DER Challenge activities] have only scratched the surface" and "*unless there is some well-focused industry strategy around it, there is a danger that some of the progress will stall.*" (DER-IC colleague)

These qualitative findings are in line with the contact survey results which indicate that skills gaps still persist in the UK PEMD sector, although perceptions have improved over time. Figure 20 shows that just under two-thirds (13 out of 20) of respondents to the final impact survey felt there were fewer people with the relevant skills in the PEMD sector than currently needed. This includes nine who felt there were significantly fewer people with the relevant skills than the sector currently needs. However, views were mixed: four felt there were more people with the relevant skills than the sector needs. Views were also slightly more positive than when asked in the baseline survey, where just over three-quarters (22 out of 29) felt there were fewer people than the sector needs and three out of 29 felt there were more than the sector needs.

Figure 20 Perceptions of level of skills in the PEMD sector



Source: Contact survey. F8. Which of the following best describe your experience of the level of skills in the PEMD sector as a whole?

Note: Base: All business respondents to final impact survey (20), all business respondents to baseline survey (18). Please note that to compare across survey waves, we need to use % despite sample sizes

Awareness of PEMD career opportunities

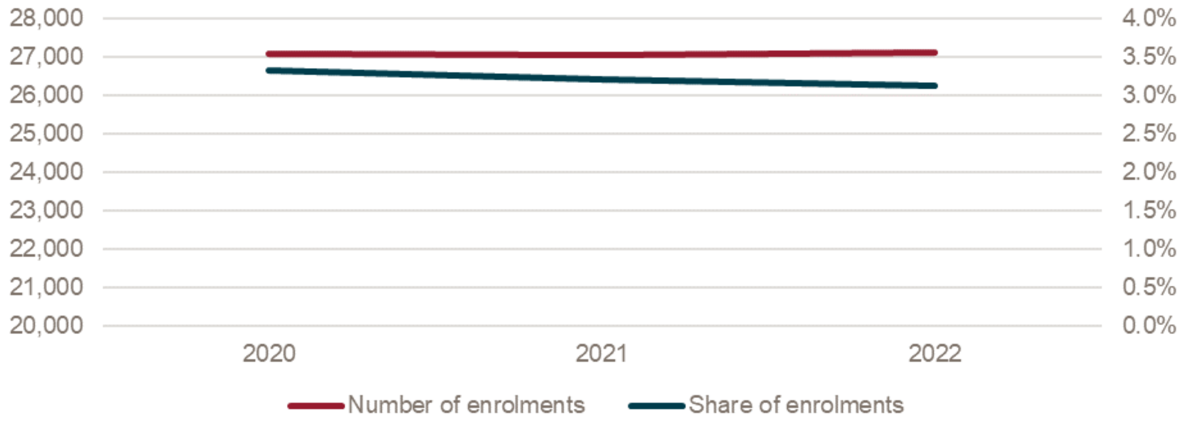
Stakeholders who participated in the thematic and activity-based case studies indicated that the DER Challenge had increased awareness of PEMD career opportunities among students. Stakeholders who participated in the thematic case study indicated that there had been an increase in the number of graduates and PhDs involved in PEMD over the past decade and that relevant courses continue to be oversubscribed. An academic interviewed in Phase 4 mentioned how the DER Challenge's efforts were noticeable across the wider PEMD ecosystem. Specifically, they highlighted an increase in the number of staff/students in the UK. Other stakeholders mentioned an increase in international students due to the UK being highly regarded in R&D and academic research and an increase in global uptake of careers in PEMD.

However, it is difficult to measure the impact that the DER Challenge has had, especially because of concurring external events (e.g. Brexit) and the time lag in establishing clear impacts. On the whole, quantitative indicators that were included in the original DER Challenge business case do not yet show aggregate impacts. We observe no improvement in the number of student enrolments in PEMD-related courses (see Figure 21) or in the number of apprenticeships in PEMD-related disciplines (see Figure 22).[43]

Moreover, due to the cross-cutting nature of the PEMD supply chain and the nature of the classification system, there are limitations to identifying PEMD-related courses and apprenticeships. These limitations need to be considered when interpreting these findings. Moreover, it should be noted that the drop in PEMD-related apprenticeships is in line with a drop in apprenticeships across all disciplines and should not be attributed to the DER Challenge.

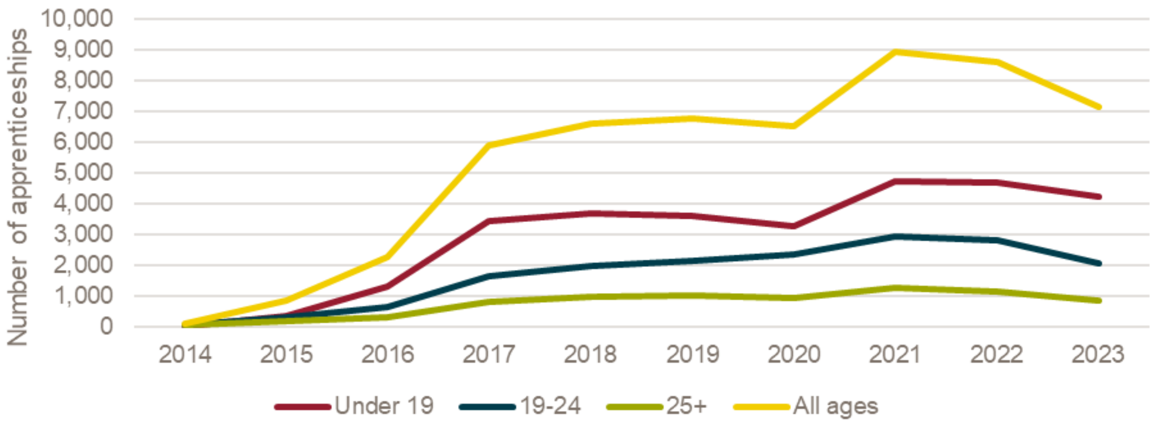
[43] The list of PEMD-related apprenticeships was developed in collaboration with the Challenge for the evaluation framework report, and the list of PEMD-related courses was developed in collaboration with the Challenge and the ERS Hub for this final impact evaluation. Section 3.2.4 provides further detail around these data sources.

Figure 21 Student enrolments on PEMD-related courses



Source: *HESA - Student enrolments by HE provider and subject of study*
Note: *Data is only available from 2020*

Figure 22 Number of apprenticeships in the PEMD sector



Source: *Department of Education - Apprenticeships and traineeships data by pathway*

Looking ahead, stakeholders who took part in the thematic case study indicated that improving awareness of career opportunities by showcasing potential career pathways within the PEMD space was key to attracting talent. However, improving perceptions of PEMD technologies within wider society will require more substantial structural changes beyond the DER's scope.

Multiple stakeholders who took part in the thematic case study indicated that more effective communication of successful DER programme outcomes could demonstrate its benefits to the broader PEMD ecosystem. This in turn could raise awareness about opportunities within PEMD. In that sense, two interviewees noted that some excellent projects were ongoing, and significant work still needs to be done before case studies can be developed which highlight their technical achievements and broader impacts

4.4 Theme 4: Has the DER Challenge increased the value of investment in UK PEMD companies?

This theme reflects the Driving the Electric Revolution DER Challenge's ambition to increase the value of investment in UK PEMD companies in order to grow the UK's supply chain and facilitate exports. It covers activities, outputs and outcomes described in the ToC.

Key messages: The DER Challenge has had a positive impact on the value of investment in UK PEMD companies and has exceeded its co-investment targets

- Total realised co-investment[44] over the period from 2020 to 2024 (£403 million) almost doubled the initial target set by the DER Challenge (£234 million) and the realised co-investment was one-third higher than the committed co-investment (£306 million), which indicates that a considerable amount of additional investment has been realised beyond what was initially agreed.
- Overall, the DER Challenge has achieved a catalysed funding ratio[45] of nearly 16:1. This represents an excellent leveraged return on public investment.
- Businesses surveyed had positive perceptions of securing follow-on investment as a result of DER Challenge engagement. Half (19 of 37) of the survey respondents who had received DER Challenge funding or engaged with the DER-IC indicated that they had received further funding (private or public) as a direct consequence of their engagement. Also, around half of the same survey respondents expected to receive further funding in the future as a direct consequence of their engagement.
- UKRI Financial Transparency Data[46] shows that public sector expenditure in PEMD projects by UKRI has fallen in the last year, having increased in recent years. This is only partially explained by the completion of several large projects funded by the DER Challenge. There may also be other contributory factors such as the simultaneous conclusion of other competitions that relate to PEMD and/or reporting lags.

[44] Source: DER Challenge monitoring data. Total co-investment includes (i) pledged co-investment (investment by the consortia receiving the grant funding), (ii) accompanying co-investment (public and/or private extra investment, above the pledged co-investment in business cases but necessary to achieve the agreed objectives), (iii) aligned co-investment (investment in a closely thematic project, prompted by the DER investment), and (iv) follow-on co-investment (public and/or private investment to take to market, or exploit, outcomes from Challenge-funded R&D projects).

[45] Catalysed funding ratio calculated as pledged plus accompanying co-investment divided by aligned and follow-on co-investment.

[46] UKRI Financial Transparency Data. Innovate UK funded projects since 2004.

Table 11 Final impact evaluation metrics – evaluation theme 4

Metric	Source	Methodology
Value of co-investment	DER monitoring data	Trend analysis of value of co-investment
Perceptions of ease of securing investment and follow-on funding	Contact survey	Stated funding achieved or expected as a result of DER engagement
Value of public sector investment in PEMD companies	UKRI Financial Transparency Data	Trend analysis of value of public sector investment in PEMD
Value of R&D spending by UK/overseas PEMD companies	Contact survey	Stated impact of value of Driving the Electric Revolution on value of R&D spending
	Thematic case study	Framework analysis of policy and wider industry stakeholders
Share of PEMD companies which are foreign owned	ONS microdata	Proportion of companies which are not UK headquartered
UK operations of leading manufacturers of PEMD products	Project-based case study	Framework analysis of PEMD companies
Value of venture capital investment in PEMD companies	Thematic case study	Framework analysis of policy and wider industry stakeholders

Source: Evaluation consortium following engagement with the DER Challenge

4.4.1 Activities undertaken by the DER Challenge

The activities undertaken by the DER Challenge to increase the value of investment in the PEMD sector include:

- The DER Challenge has provided around £90 million in CR&D grant funding across around 100 projects to around 160 different firms[47]; and
- The DER Challenge has funded the DER-IC s which have:
  - Signposted firms to relevant funding opportunities
  - Allowed firms to use world-class equipment, which has raised awareness of the PEMD opportunities and opened the floor to fruitful discussions

[47] Note this includes all the DER grant offered (not only CR&D).

- Provided the opportunity for companies to present at conferences, helping to attract attention from the market and highlighted sources of future investment
- Helped catalyse the co-investment from other sources such as regional, charity and local enterprise funds.

4.4.2 Findings

The impact of the DER Challenge on the value of investment in UK PEMD companies has been positive overall: co-investment has almost doubled the target set by the DER Challenge and firms have managed to secure further investment as a result of their engagement with the DER Challenge. The DER Challenge has also encouraged firms to increase their R&D expenditure.

However, overall public sector expenditure in PEMD projects[48] (of which the DER only represents a small proportion) has fallen in the last year and stakeholders indicated that the UK may be falling behind other countries. There was also a perception which some stakeholders shared with us that linking commercial opportunities with technology development is a key missing piece within the UK PEMD sector.

Value of co-investment

Total realised co-investment[49] over the period from 2020 to 2024 almost doubled the initial target set by the DER Challenge: £403 million of investment was realised vs. the targeted £234 million. Realised co-investment is 30% higher than committed co-investment, which indicates that a considerable amount of additional investment has been realised beyond what was initially agreed.

Figure 23 shows the total cumulative realised and committed co-investment. We observe that most realised co-investment is aligned co-investment (84%). This is expected given the scale of the co-investment target (£234 million) compared with the funding received by the DER Challenge (£80 million). Pledged and accompanying co-investment is only 6% of total realised co-investment. This indicates that the DER Challenge has catalysed funding on a ratio of nearly 16:1. This represents an excellent leveraged return on public investment.

Figure 24 shows the evolution of committed and realised co-investment from 2020 to 2024. Before 2023, committed co-investment was higher than realised co-investment. However, this changed in 2023 and 2024 and, overall, realised co-investment is higher than committed co-investment.

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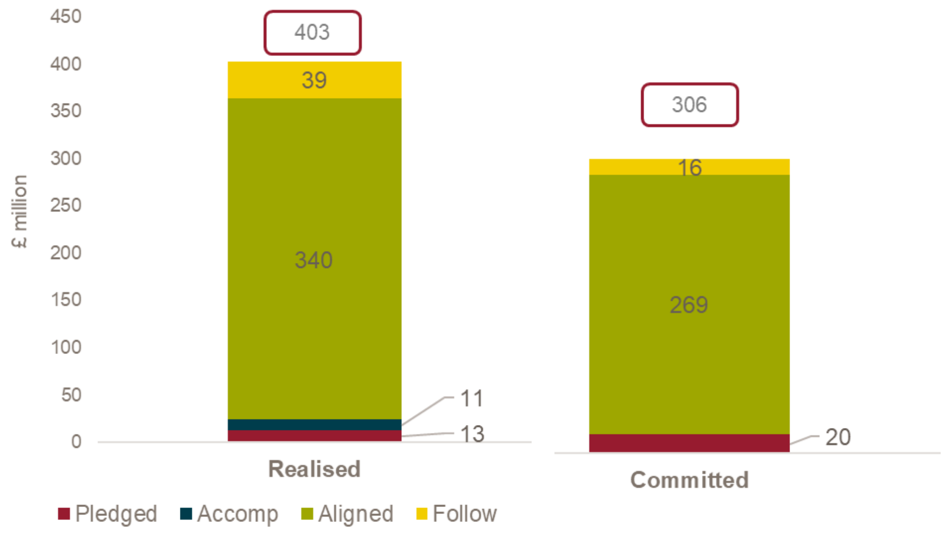
[48] Based on the UKRI Financial Transparency Data

[49] Total co-investment includes (i) pledged co-investment (investment by the consortia receiving the grant funding), (ii) accompanying co-investment (public and/or private extra investment, above the pledged co-investment in business cases but necessary to achieve the agreed objectives), (iii) aligned co-investment (investment in a closely thematic project, prompted by the DER investment), and (iv) follow-on co-investment (public and/or private investment to take to market, or exploit, outcomes from Challenge-funded R&D projects).

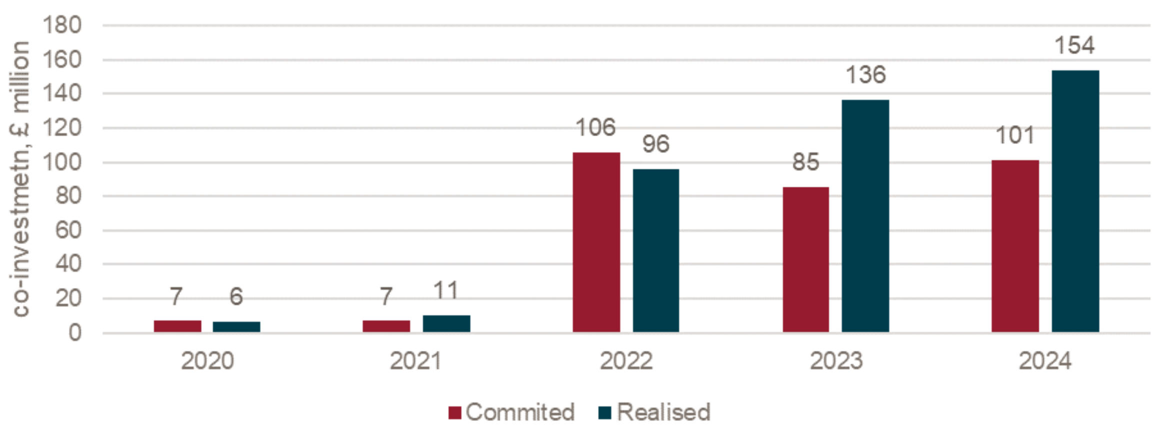
Figure 23 Cumulative co-investment, 2020-2024



Source: DER Challenge monitoring data

Note: Total co-investment includes (i) pledged co-investment (investment by the consortia receiving the grant funding), (ii) accompanying co-investment (public and/or private extra investment, above the pledged co-investment in business cases but necessary to achieve the agreed objectives), (iii) aligned co-investment (investment in a closely thematic project, prompted by the DER investment), and (iv) follow-on co-investment (public and/or private Investment to take to market, or exploit, outcomes from DER Challenge-funded R&D projects)

Figure 24 Evolution of committed and realised co-investment

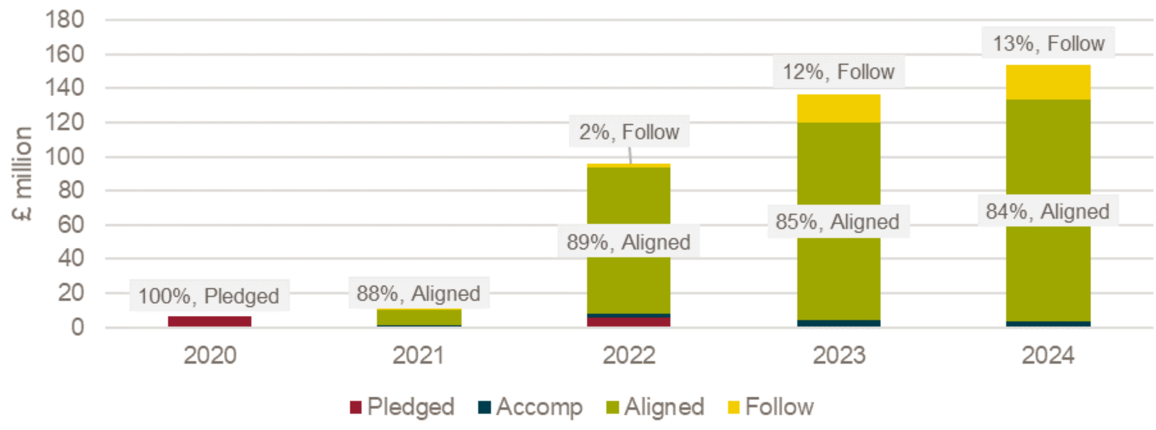


Source: DER Challenge monitoring data

Figure 25 shows the evolution of realised co-investment by co-investment type. We observe that pledged co-investment occurred in 2020 and 2023 (those are the only years where grant funding was realised). After 2020 most co-investment was aligned. This indicates that the initial DER Challenge funding and pledged co-investment increased confidence in the PEMD sector and prompted additional co-investment from elsewhere. Moreover, the share of follow-on co-investment increased in 2023 and 2024. This indicates that after three to four years of

DER Challenge support, engaged companies have managed to produce outputs to take to market.

Figure 25 Evolution of realised co-investment, by type



Source: *DER Challenge monitoring data*

These figures are supported by qualitative insights from the stakeholders engaged as part of the thematic case study. Stakeholders had noticed clear signs of increased finance flowing into the PEMD space. We were told that this funding had allowed SMEs to move into production and startups to gain ground in the value chain. Stakeholders also mentioned examples of co-investment that was unlocked through the DER support: Clas-SiC Wafer Fab raised £29.2 million in equity in 2022, with its latest deal in June 2022 totalling £25.7 million (after a DER funding of £280k in 2020[50]) and PNDC has leveraged £17 million additional investment from regional public funds and about £7 million from commercial revenue streams (£24 million in total) since 2020.

Ease of securing investment and follow-on funding

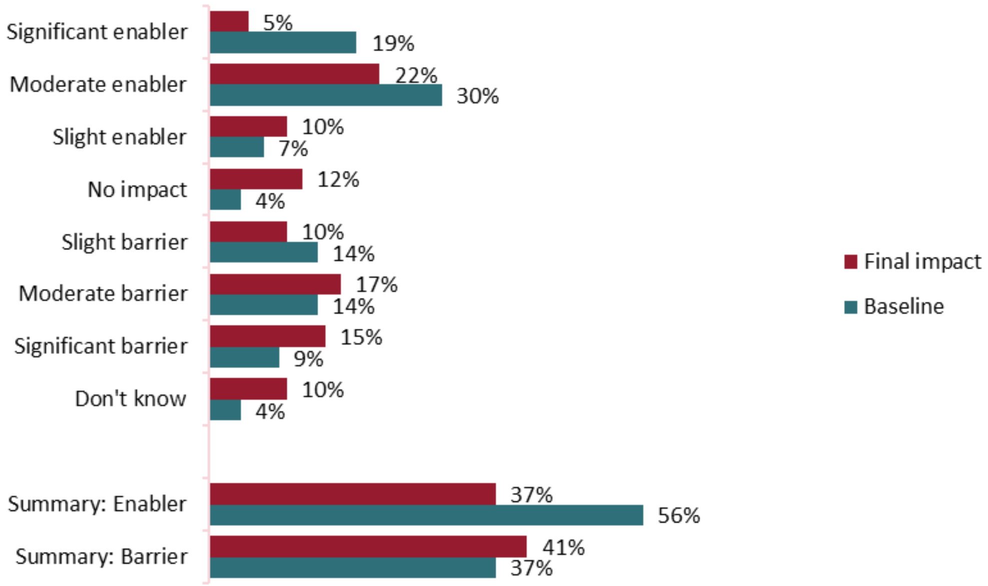
Perceptions around the contribution of the DER Challenge to securing investment were positive: half of the survey respondents who had engaged with the DER Challenge indicated that they had received further funding (private or public) as a consequence of their engagement, and half of the survey respondents who had engaged with the DER Challenge expected to receive further funding in the future as a consequence of their engagement.

Survey respondents provided a mixed view regarding the current role of private investment as either a barrier to or an enabler of the progression of PEMD technology in the UK. Figure 26 shows that little over a third (15 out of 41) of respondents to the final impact survey felt that private sector investment in the PEMD sector was an enabler of the progression of PEMD technology in the UK.

50 https://www.discover.ukri.org/clas-sic-case-study/index.html

However, a similar proportion (17 out of 41) viewed it is a barrier. The proportion who felt it was a barrier is relatively unchanged since the baseline survey, while the proportion who felt that it was an enabler is noticeably smaller (32 out of 57 in the baseline survey).

Figure 26 Perceptions of private sector investment in the PEMD sector being a barrier to or enabler of the progression of PEMD technology in the UK

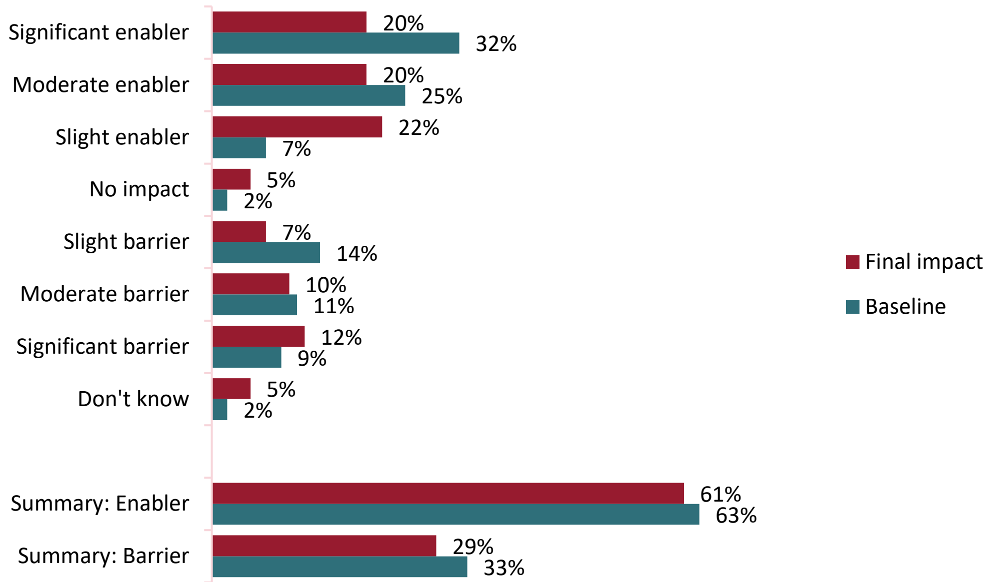


Source: Contact survey. B3. For each of the following, please indicate whether you think they are a barrier or an enabler to the progression of PEMD technology in the UK: private sector investment in the PEMD sector

Note: Base: All respondents to final impact survey (41), all respondents to the baseline survey (57). Please note that to compare across survey waves, we need to use % despite sample sizes

Most survey respondents indicated that government funding was currently an enabler for the progression of PEMD technology in the UK. Figure 27 shows that a little over three-fifths (25 out of 41) of respondents to the final impact survey felt that government funding or investment in the PEMD sector was an enabler of the progression of PEMD technology in the UK. This included eight who felt it was a significant enabler. However, a little under a third (12 out of 41) felt that this government funding was a barrier. These proportions have not changed materially since the question was asked in the baseline survey.

Figure 27 Perceptions of government funding in the PEMD sector being a barrier to or enabler of the progression of PEMD technology in the UK



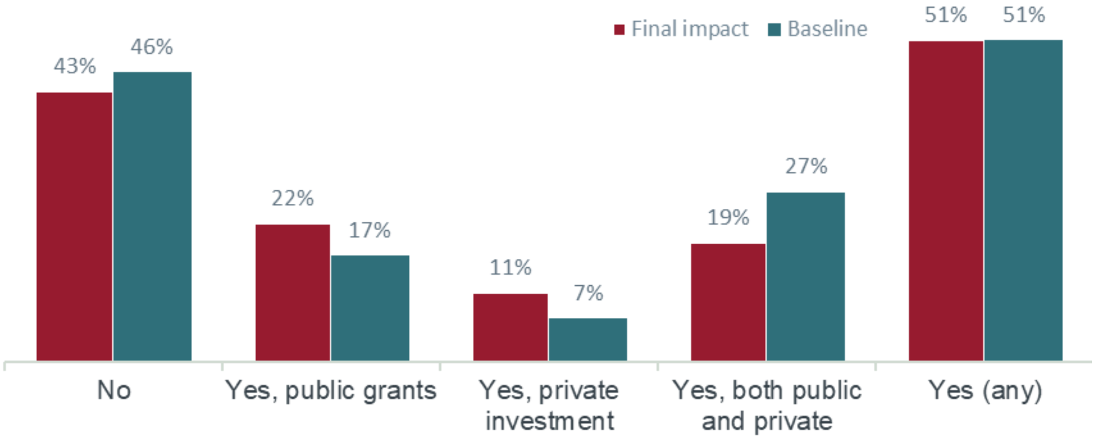
Source: Contact survey. B3. For each of the following, please indicate whether you think they are a barrier or an enabler to the progression of PEMD technology in the UK: Government funding or investment in the PEMD sector

Note: Base: All respondents to final impact survey (41), all respondents to the baseline survey (57). Please note that to compare across survey waves, we need to use % despite sample sizes

Figure 28 shows that just over half (19 out of 37) of the respondents to the final impact survey who had either received funding from the DER Challenge or had engaged with the DER-IC had received further public or private funds as a result of this engagement. Eight of these had received public grants only, four had received private investment only, and seven had received both public and private investment. These proportions are similar to when this question was asked as part of the baseline survey.

We observed significant variation in the amount of private finance received by survey respondents. Amounts ranged from £50,000 to £15 million, with an average of £3.7 million. The range of public funding magnitudes received is smaller. Amounts ranged from £25,000 to £3.5 million, with an average of £698,500.

Figure 28 Receipt of other public or private funds

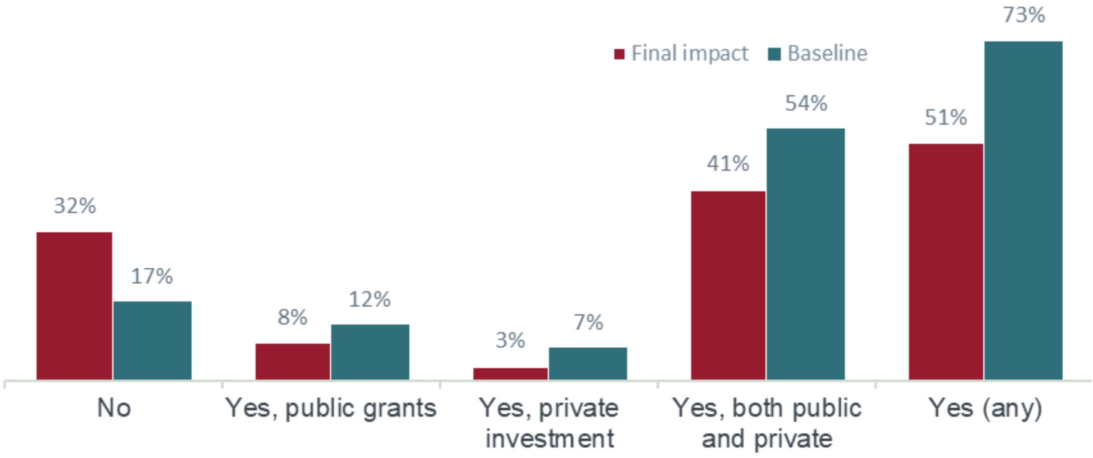


Source: Contact survey. C6. Have you received any further public grant or private investment as a result of your engagement with the Driving the Electric Revolution DER Challenge?

Note: Base: Successful applicants or those who have engaged with the DER-IC, final impact survey (37), successful applicants, baseline survey (41). Please note that to compare across survey waves, we need to use % despite sample sizes

Figure 29 shows that just over half (19 out of 37) of respondents to the final impact survey expected to secure further investment as a result of their engagement with the DER Challenge.

Figure 29 Business expectations of further funding as a result of DER Challenge engagement



Source: Contact survey. C7. Do you expect to secure any further public grants or private investment as a result of your engagement with the Driving the Electric Revolution DER Challenge?

Note: Base: Successful applicants or those who have engaged with the DER-IC, final impact survey (37), successful applicants, baseline survey (41). Please note that to compare across survey waves, we need to use % despite sample sizes

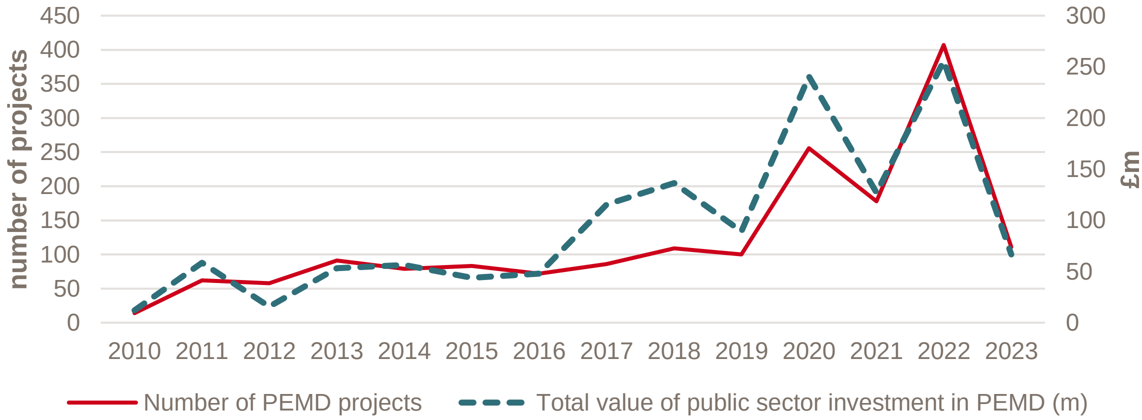
This included three who expected to receive public grants only, one who expected to receive private investment only, and 15 who expected to receive both public grants and private investment. This is lower than the proportion who expected to do so in the baseline survey (30 out of 41 expected to receive either public grants or private investment). This is in line with expectations given that some of that investment will have been secured in the period between the baseline and final impact surveys.

Respondents to the final impact survey who had used or planned to use DER-IC equipment were asked how the DER-IC had impacted their business in terms of signposting towards funding opportunities. Of the 23 respondents to this question, 16 felt that the DER-IC had had a positive impact in this respect. This included four who felt it had had a significant positive impact and 12 who felt it had had a small positive impact.

Value of public sector investment in PEMD companies

Figure 30 shows that the value of public sector investment (measured by grant offered by UKRI) in PEMD projects increased from 2019 until 2022 but that in 2023 it dropped to 2019 levels. According to the UKRI Financial Transparency Data, there were 100 PEMD-related projects that started in 2019. The number of projects that started in 2022 was four times higher (407). However, the number of projects that started in 2023 dropped back to 2019 levels (111 projects). The value of public investment in PEMD projects followed a similar trend, with the value of PEMD public investment increasing from £89 million in 2019 to £256 million in 2022 before dropping to £67 million in 2023.

Figure 30 Public sector investment in PEMD research projects by UKRI



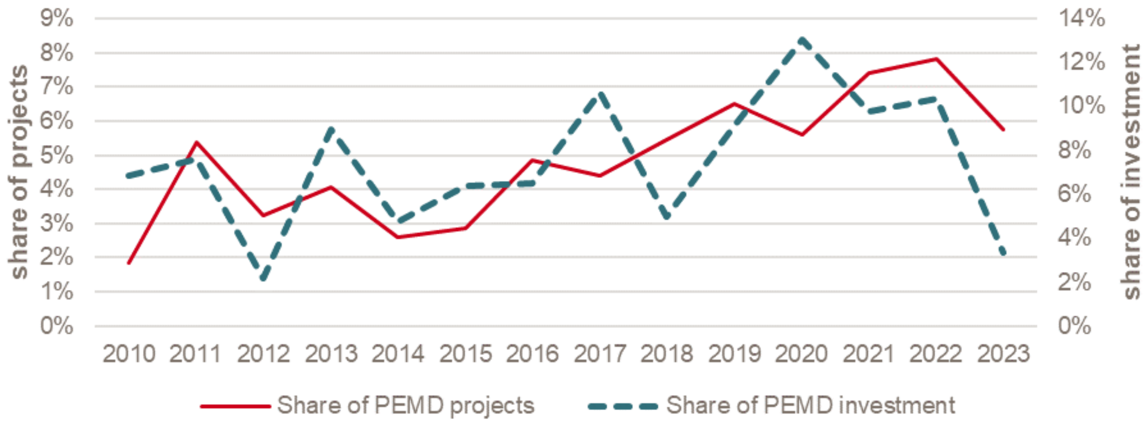
Source: UKRI Financial Transparency Data

Note: The long list of search terms used to capture PEMD activity is outlined in Annex E1 and was agreed following discussion with the DER Challenge

Figure 31 shows that PEMD-related projects accounted for 6.5% of all listed projects in 2019. The equivalent figure in 2022 was 8%. However, this proportion then fell below 2019 levels (6%) in 2023. The share of PEMD investment as a proportion of recorded public sector investment has dropped since 2019, and especially from 2022 onwards (from 9% to 3%).

Only a small percentage of PEMD projects identified in the UKRI Financial Transparency Data are DER funded. In particular, the share of PEMD projects that are DER funded ranged from 15% in 2021 to 7% in 2022, and none of the identified PEMD projects in 2023 are DER funded.

Figure 31 Share of public sector investment related to PEMD by UKRI



Source: UKRI Financial Transparency Data

Note: The long list of search terms used to capture PEMD activity is outlined in Annex E1 and agreed following discussion with the DER Challenge

Value of R&D spending by UK/overseas PEMD companies

Business respondents to the final impact survey were asked about their spend on research, development and demonstration activities in the past financial year. For those who could provide a figure (12 respondents), budgets ranged from £200,000 to £43 million.

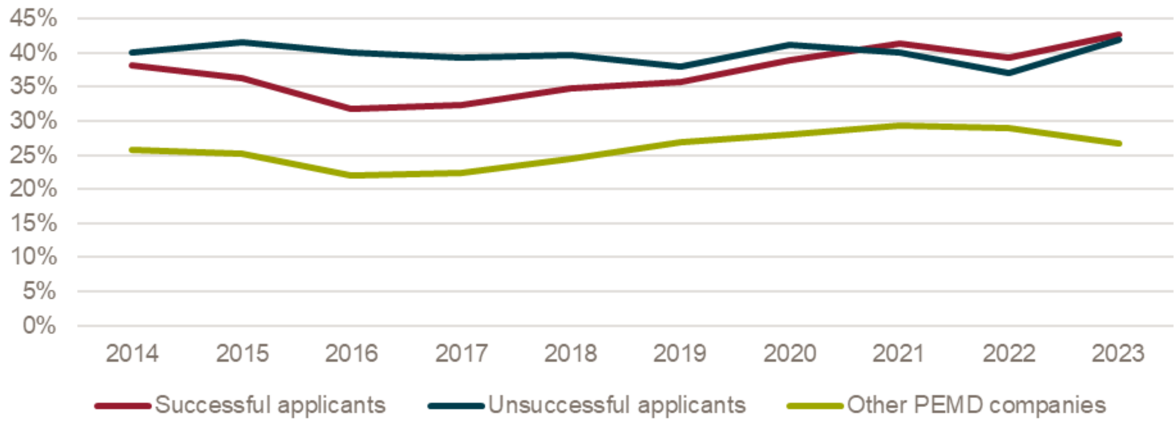
Most (16 of 19 respondents) agreed that their research, development and demonstration (RD&D) budget had increased compared to the year before, with only one reporting that their budget had decreased. The same respondents were asked how much of an impact the DER Challenge had had on the amount spent on RD&D activities in the past year. Just over half (11 out of 19) indicated that they had spent more due to the DER Challenge, with six reporting they had spent significantly more.

Those who had spent more as a result of the DER Challenge were asked to estimate how much more they had spent on RD&D activities in the past financial year as a result of their engagement with the DER Challenge. Of those who could give an estimation, the amounts ranged from £50,000 to £3 million.

Share of PEMD companies which are foreign owned

Figure 32 shows that, according to ONS administrative data, companies applying for DER grant funding are more likely to be foreign owned than other PEMD companies not engaged with the DER Challenge. However, the share of PEMD companies that are foreign owned has remained fairly stable over the last ten years.

Figure 32 Share of PEMD companies that are foreign owned



Source: ONS Business Structure Database. This work was undertaken in the Office for National Statistics Secure Research Service using data from ONS and other owners and does not imply the endorsement of the ONS or other data owners

Note: Successful and unsuccessful applicants include companies that applied for DER Grant funding. Other PEMD companies are identified through the SIC codes listed in Table 6

UK operations of leading manufacturers of PEMD products

The GaNSiC and SCREAM case studies provide clear examples of how the DER Challenge has helped to catalyse high levels of co-investment in the UK PEMD sector. For example, Hypromag (SCREAM) has secured funding for several follow-on projects in the UK that build upon the results of the SCREAM project. CIL (GaNSiC) now has manufacturing facilities and office space four times larger than before the start of the project.

However, GaNSiC stakeholders indicated that significantly more public support was required to enable the commercialisation of PEMD innovative solutions given the requirements to scale up and meet the needs of the most demanding industries, e.g. automotive customers. And SCREAM stakeholders indicated that public investment was considered to be easier to access in the US and Germany relative to the UK.

Value of venture capital investment in PEMD companies

Similarly, thematic case study stakeholders indicated that attracting additional critical investments in PEMD would require significantly more public support. An industry stakeholder highlighted that the public funding that is available in the UK is most often directed towards R&D and early-demonstration levels. However, this R&D funding is not always supported by strong scaling mechanisms. This prevents UK technology developers from attracting crucial additional investments. It should be noted, however, that scaling is not part of the remit of UKRI and, hence, is outside the scope of the DER Challenge.

Thematic case study stakeholders also indicated that linking commercial opportunities with technology development is a key missing piece within the UK PEMD sector. Public support and funding programmes have focused on technology development, rather than creating business opportunities for PEMD technology developers. This results in a lack of clear commercial paths for innovators to feed into the UK PEMD supply chains and to sell to players within the wider market.

4.5 Theme 5: Has the DER Challenge helped foster a collaborative PEMD ecosystem?

This theme reflects the Driving the Electric Revolution DER Challenge's ambition to advance the PEMD ecosystem in order to foster collaboration and knowledge sharing between companies across the supply chain and in adjacent sectors. It covers activities, outputs and outcomes described in the ToC.

Key messages: The DER Challenge appears to have helped to foster a collaborative PEMD ecosystem

- Interviewees and survey respondents both indicated that the DER Challenge has had a positive impact on collaboration. Specifically, (34 out of 41) survey respondents felt that the DER Challenge has increased collaboration. The DER-ICs have also been successful in connecting firms with other businesses and academic organisations across the supply chain. These connections have allowed firms to share ideas and access mutually beneficial expertise that would not have been possible otherwise. This in turn has led to benefits such as better understanding of supply chain structure, which can lead to final impacts in years to come.
- Stakeholders who participated in the thematic, project-based and activity-based case studies also highlighted the positive impact of the DER Challenge in improving PEMD marketing and awareness-raising via a range of communication channels within the UK market. Stakeholders noted the importance of DER Challenge-run events (e.g. conferences, Engage With… events) in improving commercial outreach and attracting industrial customers.
- Connections made through the DER-ICs and competition-winning project teams have allowed firms to access mutually beneficial expertise which would not otherwise have been obtained. These connections have also led to opportunities for further collaboration beyond the scope of the initial engagements.

Table 12 Final impact evaluation metrics – evaluation theme 5

Metric	Source	Methodology
Number of introductions made by Innovate UK Business Connect by sector	Innovate UK Business Connect monitoring data	Reported information from connectivity events and web tracking metrics

Metric	Source	Methodology
Number and strength of collaborations between PEMD companies in different sectors and companies producing different technologies	Activity-based, thematic and project-based case studies	Framework analysis of case study interviews with PEMD companies, DER-IC colleagues and wider industry stakeholders
	Contact survey	Stated Impact of Driving the Electric Revolution on number and strength of collaborations
Number and strength of collaborations between PEMD companies and academics, and PEMD companies and SMEs	UKRI Financial Transparency Data	Time series analysis of share of projects involving collaborations with academics and share of projects involving collaborations with SMEs

Source: Frontier Economics

4.5.1 Activities undertaken by the DER Challenge

The DER Challenge has undertaken activities to facilitate collaboration in PEMD. These include:

- The competitions, which require collaborative research by winners and which aim to foster immediate collaboration with the intention of building relationships between individuals and organisations that lead to follow-on collaboration in the future;
- The funding of the DER-ICs, which have supported the creation of a UK-wide network providing firms with a group of sector experts to engage with as well as being a central source with lots of links to connect players in different parts of the PEMD ecosystem;
- General communications, which foster collaboration by making companies more aware of one another and therefore more likely to reach out. The communications include virtual and in-person events held by Innovate UK Business Connect – such as the ‘Engage With …’ series – as well as regular newsletters; and
- Introductions across the supply chain, facilitated by the contribution of a well-respected PEMD business leader as a DER Challenge director: Matt Boyle and then Will Drury.

4.5.2 Findings

The DER Challenge has fostered a collaborative ecosystem, successfully connecting firms with universities and with other firms in other stages of the supply chain. This has led to knowledge sharing and skills transfers that would not have been possible in the absence of the DER Challenge.

Number of introductions made at face-to-face events

In the last 18 months, under the UKRI DER Challenge, Innovate UK Business Connect has organised three in-person exhibition events: Engage With LIVE! 2022 hosted in Sheffield, Engage with LIVE! 2023 hosted in Birmingham, and one multiple occupancy stand at the Advanced Engineering 2024 exhibition hosted at the NEC.

- **Engage With LIVE 2022** was the first post-COVID in-person event. This event, hosted in March 2022 in Sheffield, concluded the two-year virtual 'Engage With…' series which started at the beginning of COVID-19.[51] The event focused on UK industry's ability to seize the economic opportunities from the global transition to clean technologies and electrification. More than 275 people attended and more than 50 companies showcased their involvement in the PEMD industries. Forty-nine percent of the attendees were industry representatives who interacted with representatives from academia (16%), research and technology organisations (13%) or government (5%), among others.

- **Engage With LIVE 2023**, hosted in November 2023 in Birmingham, attracted 300 attendees and 40 presenting companies including SMEs, multinational and financial institutions. Forty-eight percent of the attendees were industry representatives who interacted with representatives from academia (20%), research and technology organisations (13%) or government (5%), among others. This resulted in both new and existing businesses engaging with Innovate UK products and services, developing new business opportunities and accessing non-grant funding. In particular, the event led to 118 relevant introductions, four collaborations and two outcomes (i.e. new product or innovation, new partnership, a case study, etc.).

- **Innovate UK Driving the Electric Revolution at Advanced Engineering 2024**. The DER stand at Advanced Engineering 2024 showcased 25 innovative businesses, organisations and Catapults which are at the forefront of electrification and leading in electrification supply chains. All the organisations had received DER Challenge funding or had collaborated with the DER Challenge. There were nearly 1,000 visits to the 23 companies and two Catapults which presented cutting-edge technology products and services and shared their transformative and sustainable solutions with the 9,800 exhibition attendees. This business-to-business event resulted in 70 new introductions and several potential new business opportunities.

Innovate UK Business Connect holds a community database consisting of over 3,000 business contacts who receive DER Challenge newsletters and are notified of events (including those described above) and other upcoming relevant funding opportunities. The LinkedIn DER group has grown in terms of interactions and memberships, with 337 members

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[51] The Engage With webinars took place 57 times and attracted 3,057 people, who asked 565 questions. The sessions led to around 125 new introductions exploring future opportunities for partnerships, collaborations and projects. 2022 Annual Report - Driving the Electric Revolution.

and 6,031 posts as of June 2024. Other success metrics include 2,725 views from 1,185 unique users on the DER landing page on the Innovate UK Business Connect website and 8,562 views from 4,553 unique users on the Engage With LIVE 2023 webpage.

Innovate UK Business Connect also publishes articles and thought pieces on PEMD. Examples include the Driving the Electric Revolution: Metals Technology Deep Dive Report,[52] Driving the Electric Revolution: UK Power Semiconductors Landscape Report[53] and Driving the Electric Revolution in the AgriFood sector report.[54]

Number and strength of collaborations between PEMD companies in different sectors and companies producing different technologies

Case study stakeholders indicated that the DER-ICs have been connecting companies with other companies operating at different points in the supply chain. The DER-ICs have also connected firms to academia. These connections have allowed firms to access mutually beneficial expertise that would not have otherwise been obtained and identify opportunities for further collaboration beyond the scope of the direct engagement with the DER-ICs.

"*The capability that DER-IC brings is state of the art, so it helps them in opening the door to conversations with other collaborators and universities. The equipment is not available anywhere else.*" (DER-IC colleague)

These qualitative findings are in line with the survey results. Respondents to the final impact survey who had used or planned to use DER-IC equipment were asked specifically about the impact of the DER-ICs on facilitating collaboration. Of the 23 respondents who had used or planned to use DER-IC equipment, 19 felt that the DER-ICs had had a positive impact on facilitating collaboration. This includes 11 who felt they had had a significant positive impact. The remaining four felt that the DER-ICs had not had an impact in this area.

Most stakeholders engaged in the thematic case study also indicated that the DER Challenge has significantly accelerated system-wide collaborations between academia and industry and across different organisations involved in PEMD. As a result of DER funding, project partners have gained a better understanding of supply chain structures and established essential connections to accelerate the commercialisation of PEMD technologies.

"*The result of projects [that bring partners together to show how they can fit into the supply chain] may be or may not be that we create a supply chain, but what it enables you to do […] is understand actually how these companies could fit into a supply chain either in the UK or globally or wherever. […] We have to demonstrate where we can be part of a chip supply chain, and so I think that's an important role that the DER has played in those projects to say*

[52] Driving the Electric Revolution: Metals Technology Deep Dive Report - Innovate UK Business Connect

[53] Driving the Electric Revolution: UK Power Semiconductors Landscape Report - Innovate UK Business Connect

[54] Driving the electric revolution in the agri-food sector – UKRI

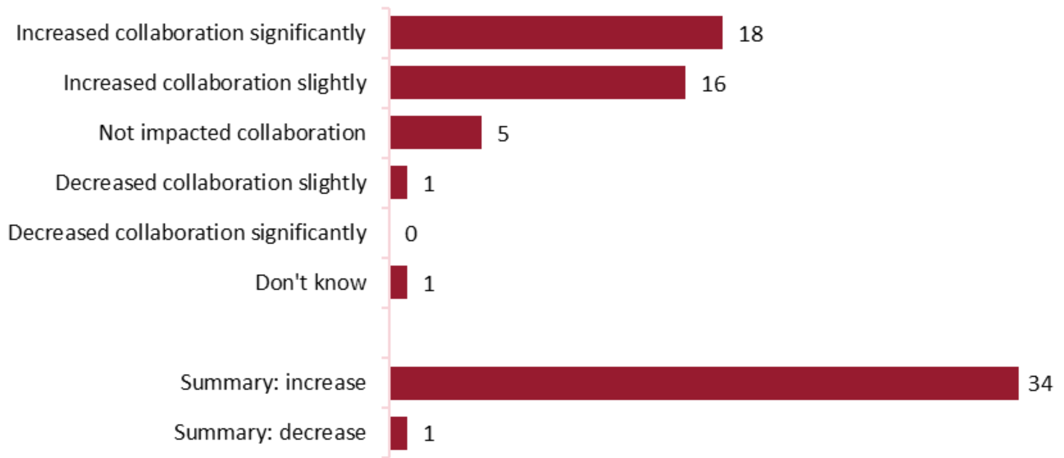
you have to think about what the supply chain looks like because we're weak on supply chains." (Network facilitator at trade association)

Stakeholders who we interviewed as part of the GaNSiC and SCREAM case studies also indicated that the DER Challenge has fostered a collaborative ecosystem. GaNSiC stakeholders gave credit to DER for improving marketing and communications within the UK market, boosting mutual awareness among PEMD companies and diversifying the customer base and project types. They also highlighted the DER Challenge´s impact on commercial outreach via participation in conferences and stakeholder events. SCREAM stakeholders indicated that the project has fostered a collaborative environment where knowledge sharing, industry connections and understanding of supply chain dynamics have been instrumental in driving collective progress and innovation.

Another indicator of improved collaborations are the examples of acquisitions that were discussed in the context of the thematic and project-based case studies. As such, it should be noted that, in March 2024, US chipmaker Vishay acquired Newport Wafer Fab for £144 million. The new owner is collaborating with the DER-IC centres in South Wales and with the University of Warwick to expand the facility's capacity and accelerate silicon carbide (SiC) and gallium nitride (GaN) semiconductor production and technology development. Also, in March 2023, one year after the start of the SCREAM project, Mkango UK was integrated within Maginito. In May of the same year, Maginito acquired Mkango's partner Hypromag with the aim of supporting the company's efforts in accelerating the roll-out of HPMS technology across the UK and Europe.

The final impact survey also explored perceptions around the DER Challenge's impact on collaboration and tested the level of collaborations across survey participants and whether those were considered to have been successful or not. The vast majority of respondents (34 out of 41) felt that the DER Challenge had increased collaboration, with more than two in five (18 out of 41) highlighting a significant increase in collaboration. Only five felt that the DER Challenge had had no impact in this area, and only one felt the DER Challenge had decreased collaboration slightly.

Figure 33 Impact of the DER Challenge on collaboration in general



Source: *Contact survey: D3. How much do you think the Driving the Electric Revolution (DER) DER Challenge has impacted collaboration in general?*

Note: *Base: All respondents to final impact survey (41)*

Survey respondents were also asked how many partners of different types they were currently collaborating with on PEMD sector projects. Table 13 shows the average number of collaborations within each group, the number who were collaborating with at least one partner from each group, and the number not collaborating with any partners from that group.

Researchers were the group most commonly collaborated with, with over two-thirds of respondents (28 out of 41) collaborating with this group, and the average number of collaborations per researcher being 5.1. Slightly less than half of respondents were collaborating with SME companies in the same sector, large companies in the same sector and companies outside the PEMD sector. Around a third were collaborating with end-users, large companies that produce different technologies, SME companies in different sectors, large companies in different sectors and SME companies that produce different technologies.

Table 13 Collaborations on PEMD sector projects

	Average collaborations	Collaborating with this group	Not collaborating with this group
Researchers	5.1	28	13
SME PEMD companies in the same sector	2.9	20	21
Large PEMD companies in the same sector	3.0	18	23

	Average collaborations	Collaborating with this group	Not collaborating with this group
Companies outside the PEMD sector	4.9	17	24
End-users	3.4	15	26
Large PEMD companies that produce different technologies	2.1	14	27
SME PEMD companies in different sectors	2.9	13	28
Large PEMD companies in different sectors	2.1	13	28
SME PEMD companies that produce different technologies	1.7	12	29
Others	0.4	3	38

Source: *Contact survey. D1. How many of the following types of partners are you currently collaborating with on PEMD projects?*

Note: *Base: all final impact survey respondents (41)*

Survey respondents were also asked to rate how successful their collaborations with these different groups were. Table 14 shows how many of those who were collaborating with each group rated their collaborations with that group as 'successful' or 'unsuccessful'.

In general, collaborations were seen to be 'successful', particularly for researchers and SME PEMD companies in different sectors. The vast majority of these groups (25 out of 28 and 11 out of 13 respectively) rated collaborations as successful. Although collaborations with SME PEMD companies that produce different technologies were less likely to be rated as 'successful' (6 out of 12), none of the respondents rated them as 'unsuccessful'.

Table 14 Success of collaborations on PEMD sector projects

	No. collaborating with this group	Successful	Unsuccessful
Researchers	28	25	1
SME PEMD companies in the same sector	20	14	2

	No. collaborating with this group	Successful	Unsuccessful
Large PEMD companies in the same sector	18	12	1
Companies outside the PEMD sector	17	12	1
End-users	15	11	1
Large PEMD companies that produce different technologies	14	8	1
SME PEMD companies in different sectors	13	11	-
Large PEMD companies in different sectors	13	10	-
SME PEMD companies that produce different technologies	12	6	-
Others	3	2	-

Source: Contact survey. D1. How many of the following types of partners are you currently collaborating with on PEMD projects?

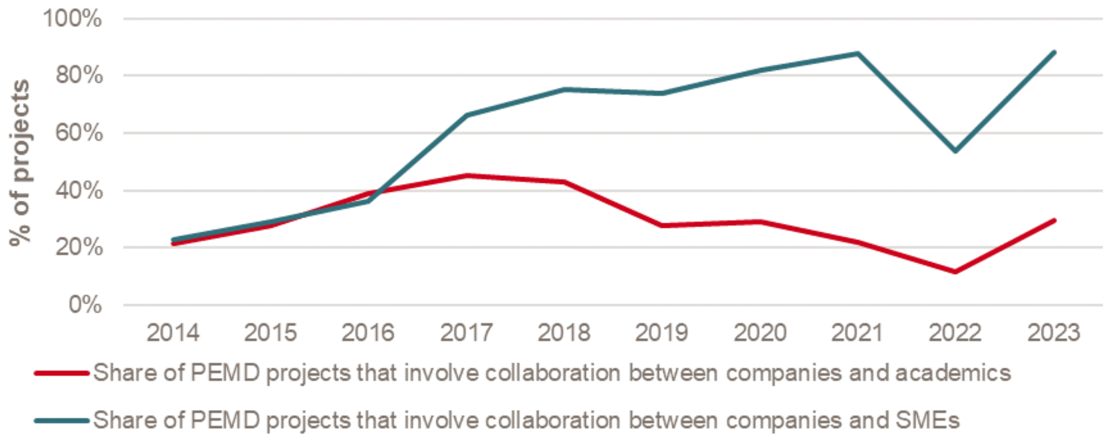
Note: Base shown in table

Stakeholders we engaged with as part of the thematic case study indicated that intellectual property (IP) ownership remains a key concern for organisations collaborating on projects. We were told that this can potentially hinder collaboration between PEMD organisations. Although the DER Challenge has provided clear templates for managing IP in collaborative projects, barriers to IP ownership sharing persist. We were told that a new approach to standard creation for PEMD could be considered. This is outside of the scope of the DER Challenge.

Number and strength of collaborations between PEMD companies and academics and between PEMD companies and SMEs

Figure 34 shows an increase in the share of PEMD projects (identified in the UKRI Financial Transparency Data) that involved collaborations with SMEs from 2014 to 2024.

Figure 34 Collaboration between companies and academics on the UKRI Financial Transparency Data



Source: UKRI Financial Transparency Data

Note: The long list of search terms used to capture PEMD activity is outlined in Annex E1 and agreed following discussion with the DER Challenge. Only a small proportion of PEMD projects are DER funded

We observe a slight decrease in the share of PEMD projects that involve collaborations with academics. Collaborations with SMEs are, on the other hand, much more likely and have been increasing over the last decade.

4.6 Theme 6: Has the DER Challenge led to an expansion of UK PEMD manufacturing capacity?

This theme reflects the Driving the Electric Revolution DER Challenge's ambition to expand UK PEMD manufacturing capacity to increase the size of the PEMD supply chain and its contribution to the economy. It covers activities, outputs and outcomes described in the ToC.

Key message – Some firms reported positive impacts although an overall expansion of the UK PEMD manufacturing capacity has yet to be observed.

- Analysis of secondary data sources suggests there has not yet been an expansion in overall UK PEMD manufacturing capacity.[55] For example, measures of turnover, employment and the number of firms in SIC codes relating to PEMD have remained flat.
- Due to the nature of the PEMD supply chain cutting across a variety of industries, there are limitations in using SIC codes to capture the entirely of the PEMD supply chain. In particular, a lot of PEMD activity will take place in other SICs and some of these codes will cover non-PEMD technology activities. This is expected given that expansion of the manufacturing capacity is a longer-term benefit (as set out in our ToC and the DER Challenge Business Plan). Most companies which have engaged with the DER Challenge have not yet started mass manufacture of new products. There are also lags in some data sources, which means that the full picture is not yet available.
- The value of UK PEMD commodities internationally traded (i.e. imports and exports)[56] has grown in the last ten years and this growth has accelerated since 2020, when the DER Challenge has been active. The nominal value of UK exports of PEMD commodities increased from £733 million in 2019 to £905 million in 2023, and the nominal value of UK imports of PEMD commodities increased from £1.3 billion in 2019 to £1.9 billion in 2023.
- Firms which have engaged with the DER Challenge expressed positive views regarding the DER Challenge's impact on boosting manufacturing capacity. Most respondents (13 of 20) to the final impact survey indicated that the DER Challenge had had a positive impact on the number of employees that they had subsequently hired. Eight out of 20 also indicated that they had observed an increase in turnover attributable to their engagement with the DER Challenge. A large proportion of survey respondents also expected positive impacts on turnover (13 out of 20) and employment (13 out of 20) to occur in the near future.
- Firms engaged in the project-based case studies also indicated that positive benefits had occurred as a result of the DER Challenge's activity. This included development of a UK-based supply chain for rare earth magnets (SCREAM) and increased demand for products which relied in part on innovative PEMD technology (GaNSiC). Stakeholders in the thematic case study also acknowledged that the DER Challenge has laid the groundwork for further advancements in the PEMD supply chain in the UK. As such, the DER Challenge has contributed to enhancing capabilities around advanced power electronics, positioning the UK to capitalise on emerging market opportunities.

Table 15 Final impact evaluation metrics – evaluation theme 6

Metric	Source	Methodology
Value of turnover	ONS Annual Business Survey	Trend analysis of value of turnover for PEMD companies

[55] ONS Annual Business Survey (UK) and ONS Business Register and Employment Survey (GB)

[56] UN Comtrade.

Metric	Source	Methodology
	ONS business structure microdata	Trend analysis of average turnover of applicants to DER Challenge competitions
Number of employees	ONS Business Register and Employment Survey	Trend analysis of number of employees in PEMD companies
	ONS business structure microdata	Trend analysis of average employment of applicants to DER Challenge competitions
Number of companies	ONS Annual Business Survey	Trend analysis on number of PEMD companies
Perceptions of impact on expansion and manufacturing capacity	Contact survey	Stated impact of DER on turnover, number of employees and number of PEMD companies
	Activity-based, project-based, and thematic case studies	Framework analysis of case study interviews with PEMD companies, DER-IC colleagues and policy and wider industry stakeholders
Growth projections of leading UK-based PEMD companies	Contact survey	Stated impact perceptions on the growth of the PEMD sector
Size of the sector	Contact survey	Stated perceptions of the capacity of the supply chain as a barrier to or enabler of the progression of PEMD
Export and import volume and value	UN Comtrade	Trend analysis of imports and exports of PEMD technologies

Source: Frontier Economics

4.6.1 Activities undertaken by the DER Challenge

The DER Challenge's activities that have focused on increasing manufacturing capacity include:

- Funding CR&D projects that advance the MRL of the UK PEMD supply chain and enhance firms' manufacturing capacity; and
- Funding the DER-ICs, which have:
  - provided open-access testing facilities and equipment, which could enable firms to trial equipment and then increase their manufacturing capacity and

- secured funding for firms by collaborating with them, therefore boosting growth projections.

4.6.2 Findings

We do not observe an expansion of aggregate UK PEMD manufacturing capacity based on secondary data. However, the value of PEMD-related technologies that the UK trades internationally has increased over the last ten years. The expansion of the UK manufacturing capacity is a longer-term benefit which, according to our ToC, we would not yet have expected to materialise. The DER Challenge's original business case targets 2050 as the date by which a significant re-shoring of manufacturing should have occurred.

Encouragingly, some companies which have engaged with the DER Challenge reported positive impacts on their manufacturing capacity as a result of their engagement with the DER Challenge. Survey respondents also reported that they expected the UK PEMD sector to expand in the near future.

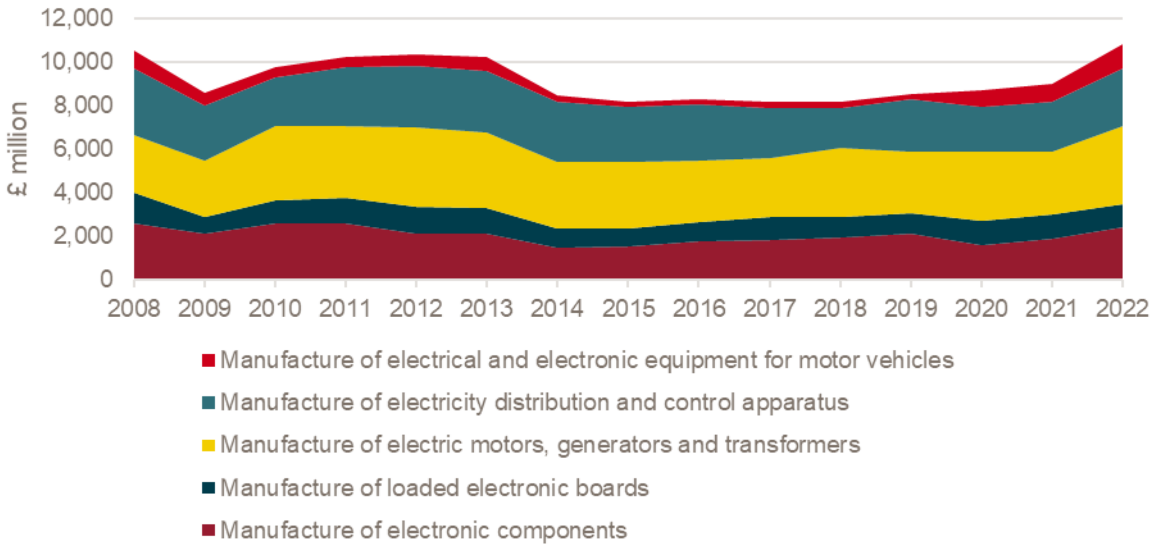
Value of turnover, number of employees and number of companies

Overall, we do not observe an increase in the size of the PEMD sector in the UK.

Figure 35 shows that the turnover of the PEMD sector in the UK has remained fairly constant over the last 15 years, increasing in 2022 (in nominal terms). In 2022, companies operating in SIC codes relevant to the PEMD supply chain had a total turnover of £10.8 billion, equating to around £5.3 million on average per company. Stakeholders indicated that this increase in turnover (26% with respect to 2019) is largely explained by the inflationary pressures affecting the UK, and more particularly the microchip supply shortages and the rising cost of semiconductors in 2022.

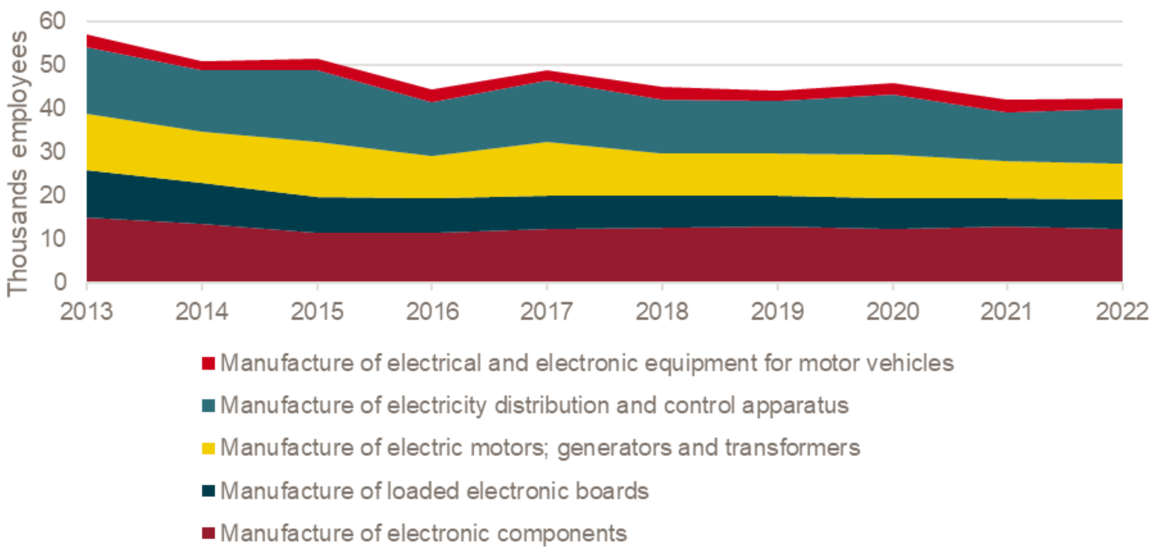
Employment figures are not comparable with the baseline as the ONS Annual Business Survey stopped publishing information on employment. To fill this gap, we used ONS data from the Business Register and Employment Survey, which does include employment information but does not include information on Northern Ireland (i.e. it is GB only). As such, Figure 36 shows that the level of employment in 2019 was lower than the 2019 employment presented in the baseline. Overall, we observe that employment in the PEMD sector in GB has decreased slightly over the last ten years. The total number of employees working in companies that operate in SIC codes relevant to the PEMD supply chain in 2022 was 42,300 (4% less than in 2019).

Figure 35 PEMD supply chain turnover (split by SIC code)



Source: *Office for National Statistics, Annual Business Survey 2023*

Figure 36 PEMD supply chain employment (split by SIC code)

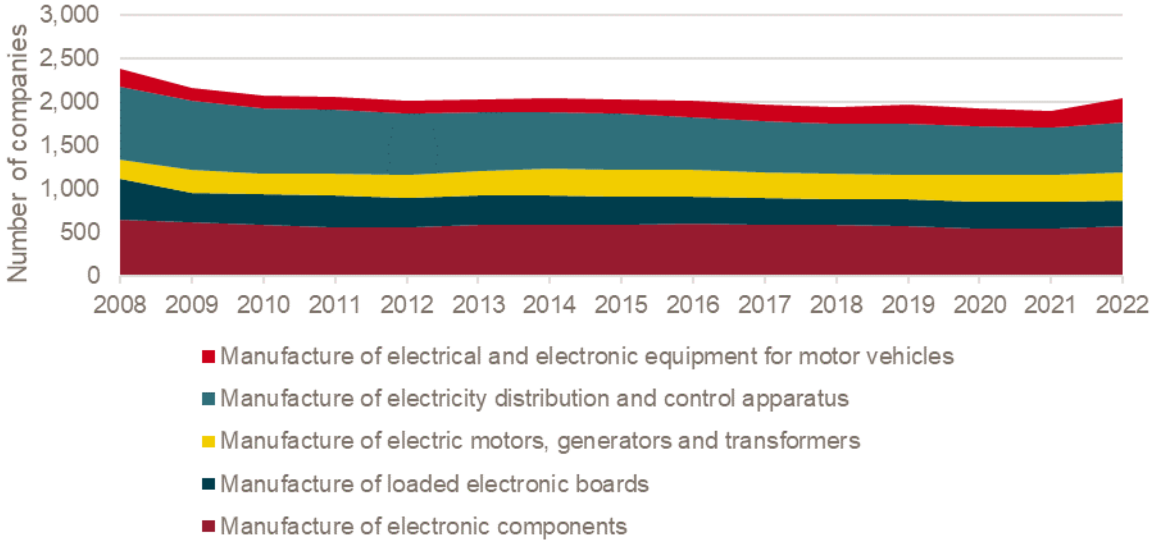


Source: *ONS. Business Register and Employment Survey. GB. 2022-2013.*
Note: *Employment data excludes Northern Ireland*

Figure 37 shows that the number of companies in the PEMD sector has remained fairly constant over the last 15 years. There were 2,048 companies operating in the PEMD supply chain in 2022, 4% more than in 2019. The largest increased was observed in the SIC code which covers *Manufacture of electrical and electronic equipment for motor vehicles* (38% higher than in 2019).

As we outlined earlier in the report, the SIC codes that we chose are those that are most relevant to PEMD activity. However, this approach will not capture all relevant activity as some companies will not be categorised under PEMD-related SIC codes but will engage in PEMD-related activity. Moreover, wider-sector macro trends are largely driven by factors that are outside the control of the DER Challenge.

Figure 37 Number of companies in the PEMD supply chain (split by SIC code)



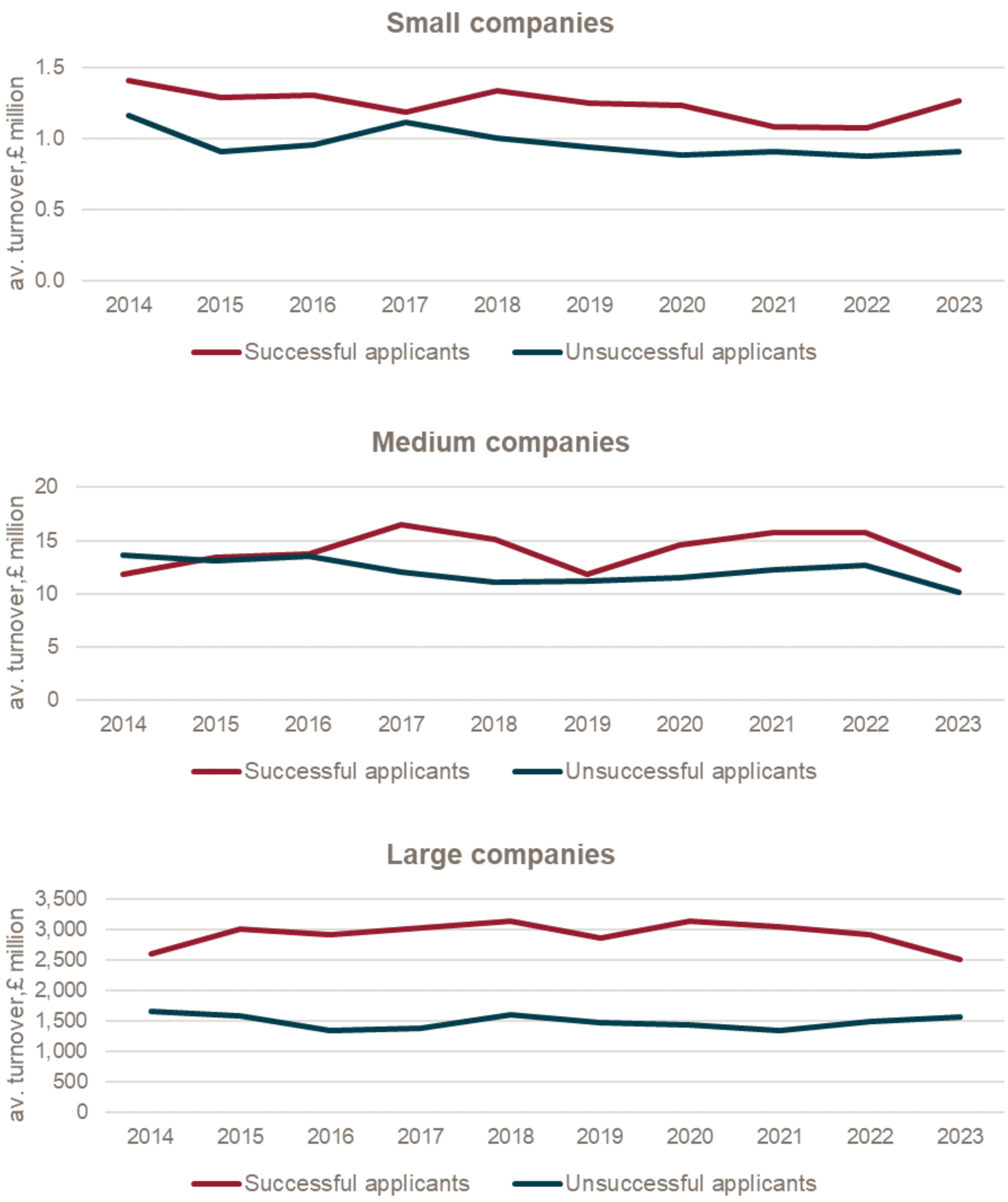
Source: Office for National Statistics, Annual Business Survey 2023

We also do not observe any significant temporal trend impact in the average turnover and the average number of employees of companies that have participated in DER Challenge competitions (both successful and unsuccessful applicants) in the BSD data.

Figure 38 shows that successful applicants tend to have a higher turnover than unsuccessful applicants. In 2023, average turnover of small successful companies increased whereas average turnover of medium and large successful companies decreased slightly. However, the trend has remained mainly flat over the last ten years.

Figure 39 shows that successful applicants tend to have more employees than unsuccessful applicants. In 2023, the average number of employees of medium and large applicants decreased slightly. However, the trend has remained mainly flat over the last ten years.

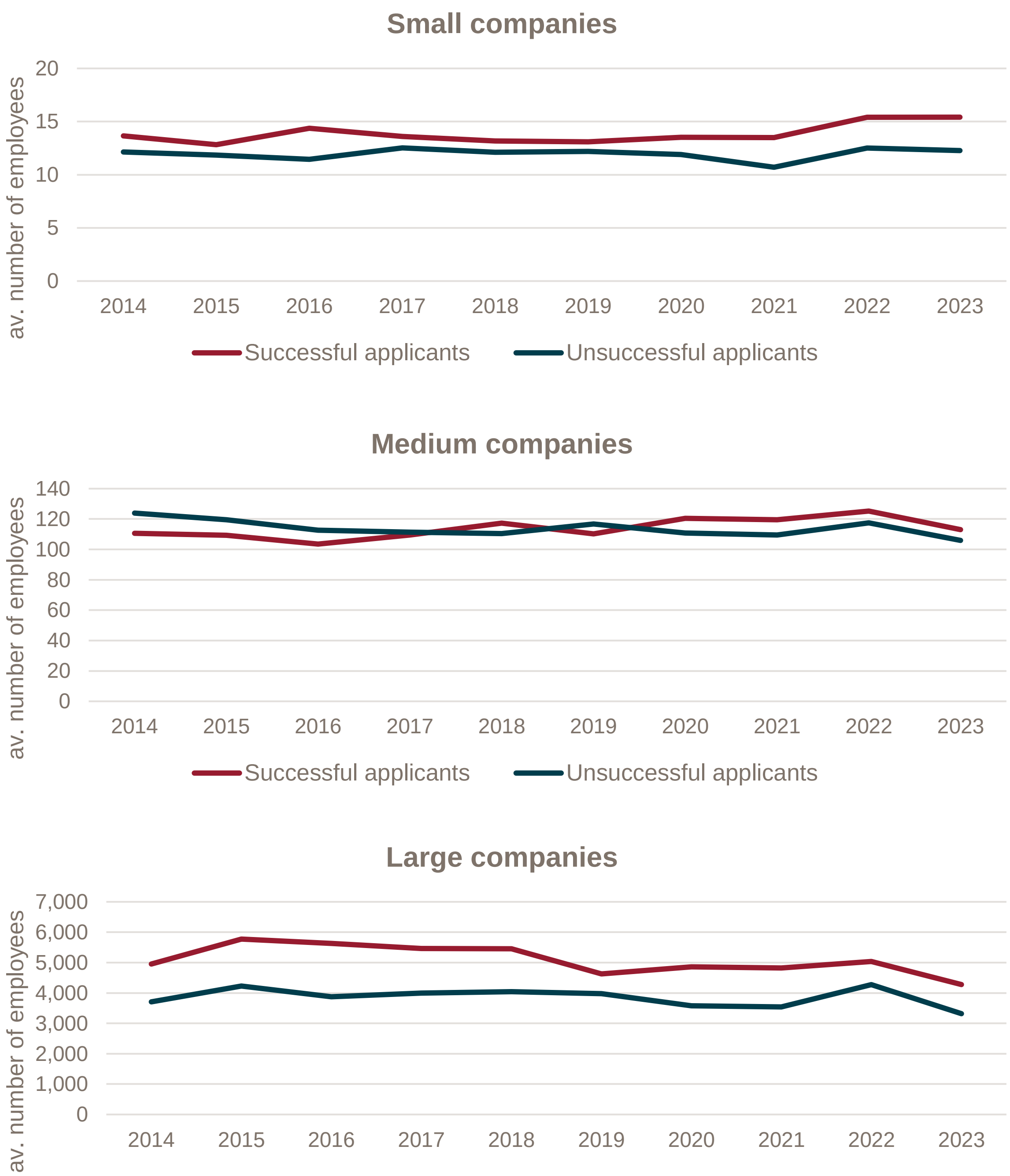
Figure 38 Average turnover of companies that participated in DER Challenge competitions



Source: ONS Business Structure Database. This work was undertaken in the Office for National Statistics Secure Research Service using data from ONS and other owners and does not imply the endorsement of the ONS or other data owners

Note: Small companies are companies with fewer than 50 employees or a turnover of less than £10 million. Medium companies are companies with fewer than 250 employees and turnover of less than £50 million

Figure 39 Average employment of companies that participated in DER Challenge competitions



Source: ONS Business Structure Database. This work was undertaken in the Office for National Statistics Secure Research Service using data from ONS and other owners and does not imply the endorsement of the ONS or other data owners

Note: Small companies are companies with fewer than 50 employees or a turnover of less than £10 million. Medium companies are companies with fewer than 250 employees and turnover of less than £50 million

Perceptions of impact on expansion and manufacturing capacity

Most survey respondents (consisting of companies who had engaged with the DER Challenge) indicated that the DER Challenge had had a positive impact on the number of employees they had hired, and some also indicated that they had observed an increase in turnover attributable to their engagement.

Business respondents to the final impact survey were asked about the impact of the DER Challenge on the number of employees they had hired over the past three years. Thirteen of the 20 respondents who answered the question said that the DER Challenge had increased the number of employees hired, while five said the DER Challenge had had no impact in this area. The number of new employees hired ranged from 1 to 30, with a mean of 6.2.

The same group of respondents were asked what impact, if any, the DER Challenge had had on their UK turnover in the past three years. Ten stated that the DER Challenge had had no impact on UK turnover, while eight felt the DER Challenge had increased their turnover. The increases in turnover ranged from £20,000 to £1 million, with a mean amount of £402,857.

Just over two in five (17 out of 41) survey respondents thought that the number of companies in the PEMD supply chain in the UK had increased in the last three years. Most respondents could not estimate how many companies the supply chain had increased by, but the estimates for those who could do so ranged from 2 to 250. Ten respondents felt that the number of companies in the supply chain had stayed the same, while five felt it had decreased.

Our qualitative engagement on the impact of the DER Challenge on expansion and manufacturing capacity yielded mixed results. The companies interviewed for the activity-based case study did not report major impacts on manufacturing capacity expansion as a direct result of their engagement with the DER-ICs as of then. This was expected given that most companies had not yet started to mass manufacture the products they had been developing and testing.

Stakeholders engaged in the project-based case studies indicated a positive impact of the DER Challenge on their manufacturing capacity. In particular, SCREAM stakeholders recognised that the DER funding had enabled the technology developers to establish a UK-based supply chain to recover and manufacture rare earth magnets. GaNSiC stakeholders indicated that, following the DER programme and the development of the direct-dispense process, the consortium members were experiencing increased demand from their customers and new customers, and they had increased their manufacturing footprint with an additional 64,000 ft^2 facility (more than twice the size of its original facility prior to the project, and currently the largest semiconductor production facility in the UK). However, there was still a gap to achieve the production volumes necessary for them to be selected by major automotive customers.

Stakeholders who engaged as part of the thematic case study acknowledged that the groundwork for advancing the PEMD supply chain in the UK had been successfully laid. The

DER Challenge had contributed to enhancing capabilities around advanced power electronics, positioning the UK to capitalise on emerging market opportunities. Some stakeholders told us that the UK's overall manufacturing capacity for PEMD technologies remains fairly limited. The low budget available was recognised as a limiting factor of the DER Challenge in this regard. Some stakeholders also noted that the DER Challenge has failed to develop mechanisms that can open market opportunities for PEMD technology developers.

Other stakeholders told us that, although the DER Challenge has made a notable positive contribution to the manufacturing readiness of the UK PEMD sector, a broader, more strategic approach may be needed to fully realise the UK's manufacturing potential.

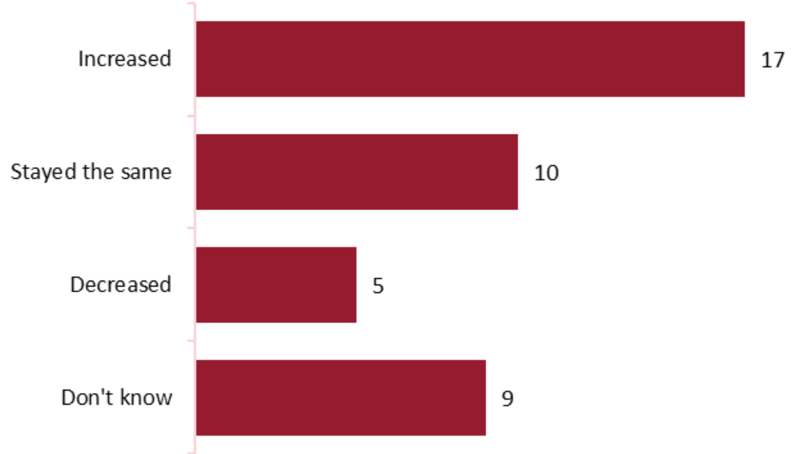
Growth projections of leading UK-based PEMD companies

Looking ahead, perceptions from the survey respondents were positive. Most respondents expected positive impacts on PEMD employment and turnover to materialise in the next three years. Moreover, the vast majority of respondents expected the PEMD sector to grow in the future.

Respondents were also asked what impact, if any, the DER Challenge had had on the number of employees they expected to hire over the next three years. Just under two-thirds (13 out of 20) said they expected the number of employees they hired to increase as a result of the DER Challenge. Only four expected there would be no impact of the DER Challenge on the number of employees they hired in the next three years.

In terms of turnover in the next three years, a similar number (13 out of 20) expected the DER Challenge to result in an increase in their turnover. Similarly only four expected the DER Challenge to not impact their turnover in the next three years. Respondents to the final impact survey were also asked how they expected the UK PEMD sector to change over the next few years. Nearly all (37 out of 41) expected the sector to grow. Fifteen respondents expected it to grow significantly.

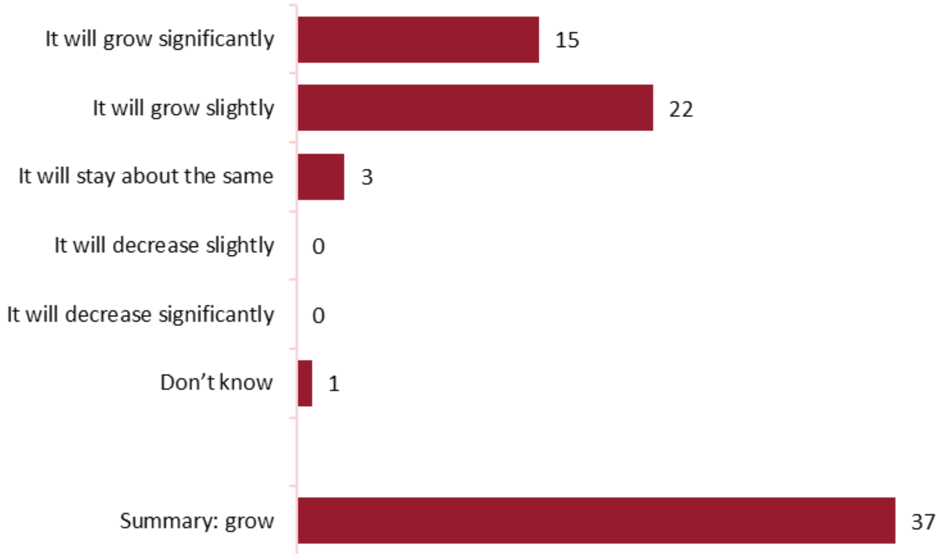
Figure 40 Perceived change in number of companies in PEMD supply chain



Source: Contact survey: B3D. How do you think the number of companies in the PEMD supply chain in the UK has changed in the last three years?

Note: Base: All respondents to final impact survey (41)

Figure 41 Expected change in PEMD sector over next few years



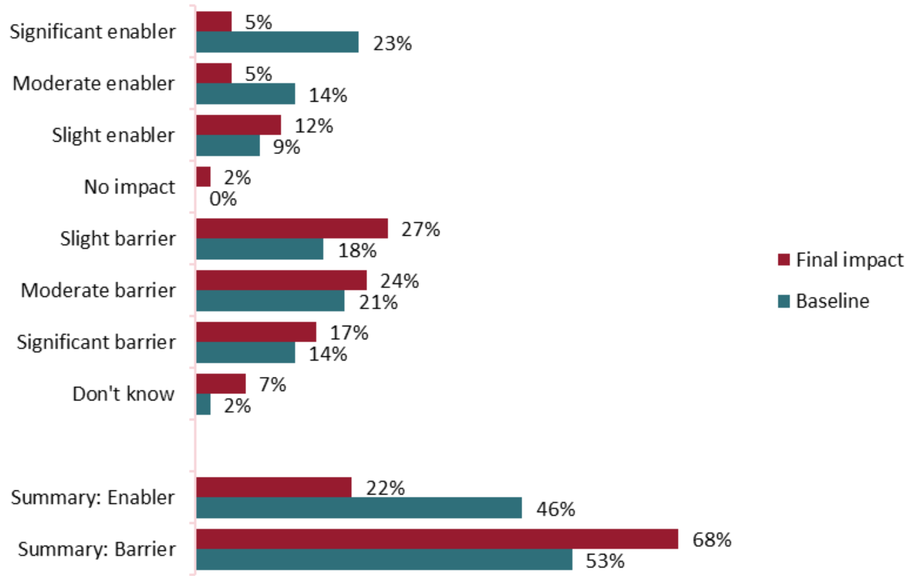
Source: Contact survey: B6. And which of the following best describes how you expect the UK PEMD sector to change over the next few years?

Note: Base: All respondents to final impact survey (41)

Size of the sector

Figure 42 shows that just over two-thirds (28 out of 41) of survey respondents saw capacity of the domestic supply chain as a barrier to progression of PEMD technology in the UK.

Figure 42 Change in perceptions of the capacity of the domestic supply chain being a barrier to or enabler of the progression of PEMD in the UK



Source: *Contact survey. B3. For each of the following, please indicate whether you think they are a barrier or an enabler to the progression of PEMD technology in the UK: Capacity of the domestic supply chain*

Note: *Base: All respondents to final impact survey (41), all respondents to the baseline survey (57). Please note that to compare across survey waves, we need to use % despite sample sizes*

Less than a quarter of respondents (9 out of 41) saw it as an enabler. There has been a change in perceptions compared to the baseline survey according to this metric. At baseline just under half (26 out of 57) of respondents saw domestic supply chain capacity as an enabler and just over half (30 out of 57) saw it as a barrier. However, these changes may partly be driven by changes in sample composition between waves.

Export and import volume and value

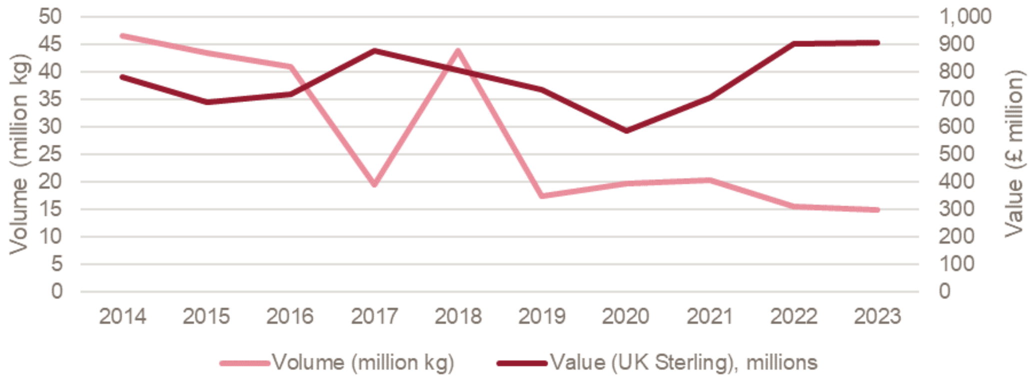
In Figure 43 and Figure 44 we illustrate the evolution in the volume and value of the set of commodities most aligned with the PEMD supply chain. Overall, the value of international trade in PEMD-related commodities has increased over the last ten years.

In 2023, the value (in nominal terms) of UK exports of PEMD commodities was £905 million. This increased from £733 million in 2019, after a drop in 2020. The value of UK imports of PEMD commodities also increased in 2023 to £1.9 billion from £1.3 billion in 2019.

The volume of UK PEMD commodity exports decreased slightly, to 15 million kilograms in 2023 down from 17 million kilograms in 2019. The volume of UK PEMD commodity imports also decreased in 2023 to 90 million kilograms from 172 million kilograms in 2019. This could be explained by the fact that PEMD commodities have become smaller over time.

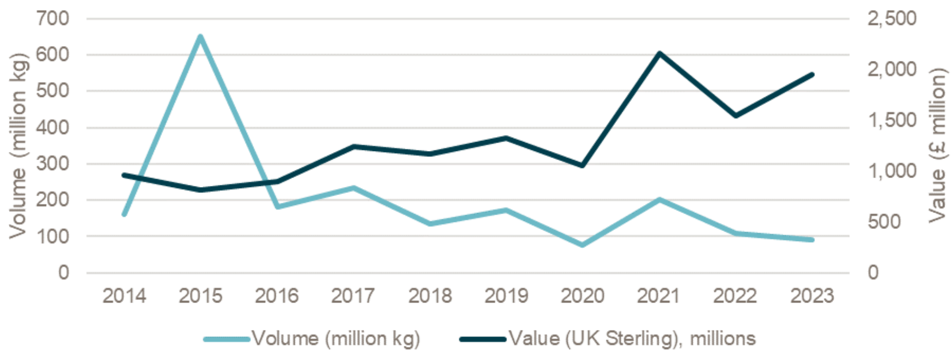
As we explained earlier in the report, focusing on the most relevant HS6 codes to measure PEMD international trade is a useful indicator but has its limitations. A lot of PEMD products and technologies will be captured in other HS6 codes and, similarly, some of the codes that we analysed will cover non-PEMD products and technologies.

Figure 43 Total volume and value of UK exports of PEMD commodities



Source: UN Comtrade
Note: The data has changed significantly with respect to the data available for the baseline report

Figure 44 Total volume and value of UK imports of PEMD commodities



Source: UN Comtrade
Note: The data has changed significantly with respect to the data available for the baseline report

4.7 Theme 7: Has the DER Challenge driven environmental, societal and policy benefits?

This theme reflects the Driving the Electric Revolution DER Challenge's ambition to drive environmental benefits and other policy objectives such as 'levelling-up'. It covers activities, outputs and outcomes described in the ToC.

Key messages: The DER Challenge has raised the profile of the PEMD sector. Clear environmental, social and policy benefits have not yet been identified

- Government policy in regard to PEMD technology was perceived as an enabler of PEMD technology in the UK by most survey respondents (22 out of 41). Survey respondents and case study stakeholders expressed mixed views on the success of the DER Challenge in influencing government PEMD policy. Seventeen out of 41 survey respondents felt that the DER Challenge has had a positive impact on the development of government policy related to PEMD.
- Some stakeholders interviewed indicated that the DER Challenge has positively impacted the policy environment around PEMD. These respondents highlighted the influence that the DER Challenge has had in in both raising the profile of the PEMD sector and on shaping recent policies that in part targeted the PEMD sector (i.e. UK National Semiconductor Strategy or the Critical Minerals Strategy).
- Using firm-level data from the ONS (Business Structure Database) we observed that firms that have received DER Challenge grant funding tend to be larger and older than other unsuccessful applicants and other PEMD companies. This indicates the difficulties facing smaller new entrants when competing with larger established players in the market. However, our case study findings show that the DER-IC network has worked with smaller firms including startups that lack the required production facilities in house. As such, the DER Challenge can help to overcome scale barriers.
- We observe a correlation between the location of the DER-ICs and the allocation of DER grant funding. This is because, when devising the DER-ICs, the DER Challenge made a conscious decision to support existing areas where PEMD activity was strong, building on the existing network. The DER-ICs are based in the North East (Sunderland), Scotland (Glasgow), Midlands (Nottingham/Coventry), and the South West & Wales (Newport).

Table 16 Final impact evaluation metrics – evaluation theme 7

Metric	Source	Methodology
Perception of impact on policy	Contact survey	Stated impact of Driving the Electric Revolution on policy
	Thematic case study	Framework analysis from wider industry and policy stakeholders
Distribution of winning organisations	DER monitoring data	Regional distribution of winning organisations
Distribution of PEMD companies	ONS company microdata	Benchmarking analysis (i.e. trend and distribution analysis)

Source: Frontier Economics

4.7.1 Activities undertaken by the DER Challenge

The DER Challenge has undertaken activities to raise the profile of the PEMD sector and foster the development of PEMD activity across the country in line with the levelling-up agenda. Some of those activities include the funding of the DER-ICs, which have supported the creation of a UK-wide network across the country. The DER-ICs have been active in showcasing the potential the UK has in PEMD R&D, including by participating in conferences and engaging with government.

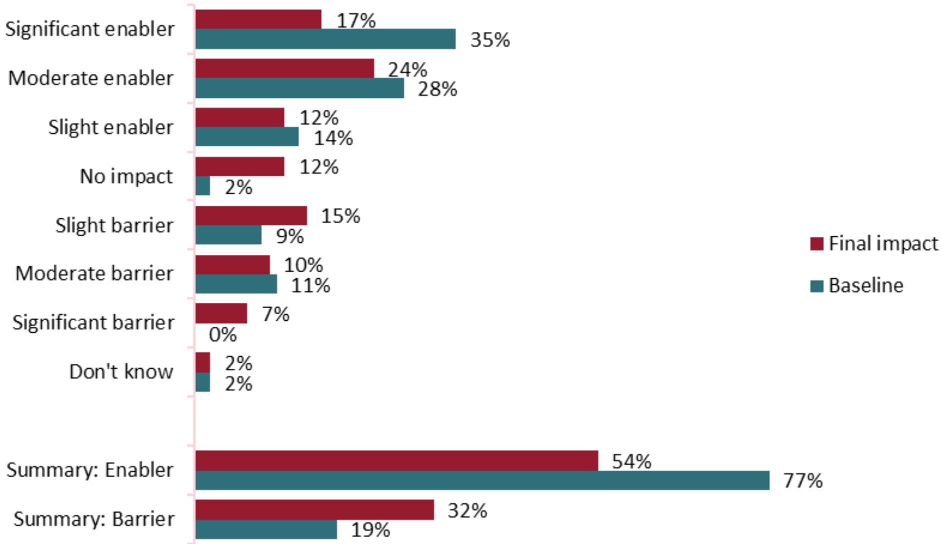
4.7.2 Findings

Government policy on PEMD is perceived as an enabler of the development of PEMD technology. Some stakeholders indicated that the DER Challenge has had a positive impact on government policy around PEMD. We were told that this has been achieved in part by raising the profile of the PEMD sector in the UK. However, the DER Challenge's impact on broader policy developments in the PEMD sector remains uncertain. We observe a correlation between the location of the DER-ICs and the allocation of DER grant funding. This indicates that the DER-ICs have played a key role in encouraging the development of PEMD activity across the country and supporting balanced economic development.

Perception of impact on policy

Government policy towards PEMD technology was perceived as an enabler by a slight majority of survey respondents. Survey respondents provided mixed views on whether PEMD standards were an enabler of or a barrier to the progression of PEMD technology in the UK. Figure 45 shows that a little over half (22 out of 41) of respondents to the final impact survey felt that government policy towards PEMD technologies was an enabler to the progression of PEMD technology in the UK. This includes seven who felt that it was a significant enabler. However, a sizeable minority (13 out of 41) felt that this was a barrier. The proportion who reported that government policy was an enabler has reduced noticeably compared to the baseline survey (44 out of 57). Figure 46 shows that just over two in five (17 out of 41) respondents to the final impact survey felt that the development of PEMD standards was an enabler to the progression of PEMD technology in the UK. Seven respondents felt that the development of standards was a barrier to progression, although none reported that it was a significant barrier.

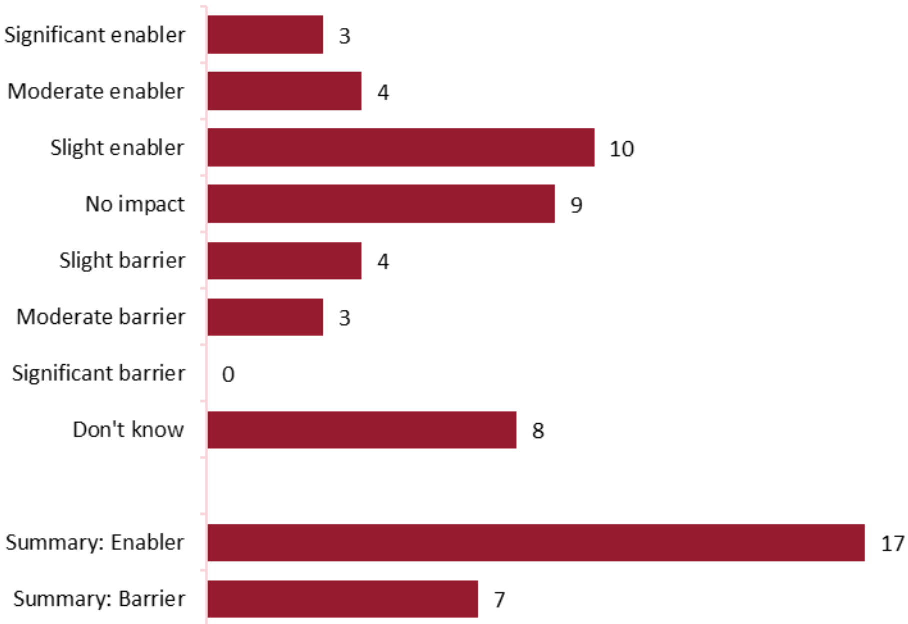
Figure 45 Perceptions of government policy towards PEMD technologies being a barrier to or enabler of the progression of PEMD technology in the UK



Source: *Contact survey. B3. For each of the following, please indicate whether you think they are a barrier or an enabler to the progression of PEMD technology in the UK: Government policy towards PEMD technologies*

Note: *Base: All respondents to final impact survey (41), all respondents to the baseline survey (57). Please note that to compare across survey waves, we need to use % despite sample sizes*

Figure 46 Perceptions of development of PEMD standards being a barrier to or enabler of the progression of PEMD technology in the UK

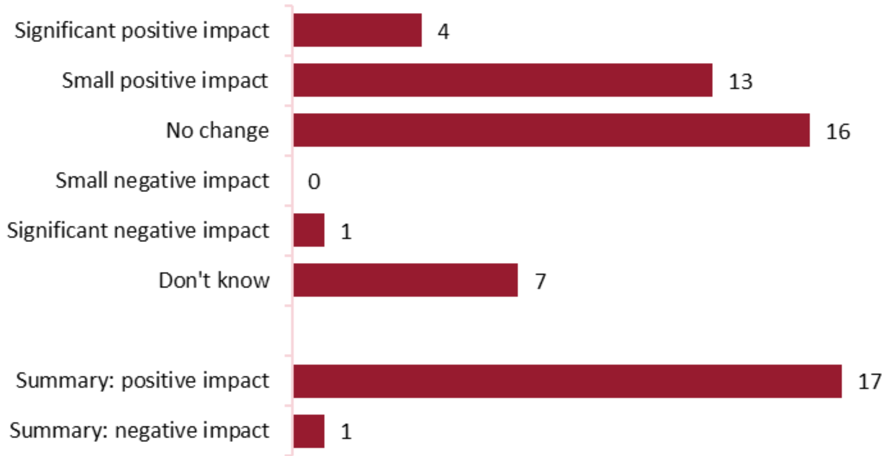


Source: *Contact survey. B3. For each of the following, please indicate whether you think they are a barrier or an enabler to the progression of PEMD technology in the UK: Development of PEMD standards*

Note: *Base: All respondents to final impact survey (41), not asked in baseline survey*

The survey respondents had mixed views on the perceived impact of the DER Challenge on government policy related to PEMD. Figure 47 shows that just over two in five (17 out of 41) respondents felt that the DER Challenge has had a positive impact on government policy related to PEMD. This includes four who felt it has had a significant positive impact. A similar number (16 out of 41) felt the DER Challenge has not had any impact in this area. Only one respondent felt that the DER Challenge has had a negative impact.

Figure 47 Impact of the DER Challenge on government policy related to PEMD



Source: *Contact survey: F7. Thinking about the Driving the Electric Revolution DER Challenge overall, what impact, if any, has it had on the following over the past 3 years? Government policy related to PEMD*

Note: *Base: All respondents to final impact survey (41)*

Stakeholders engaged as part of the thematic case study indicated that the DER Challenge has provided some benefits for PEMD sector developments. We were told that the DER Challenge has achieved these benefits despite the fragmented UK industry and policy landscape for PEMD, making it harder for the DER Challenge to have an impact compared to more narrowly focused energy transition technologies such as batteries.

In particular, we were told that the DER-ICs have helped to drive innovation in the PEMD space at the regional level and that the DER Challenge as a whole has supported government efforts to fill policy gaps. In the next subsection, we show that the locations of the DER-ICs seem to have had an impact on the distribution of PEMD grant funding.

Stakeholders also expressed a view that the DER Challenge has succeeded in raising the profile of PEMD with policymakers at the national level. Finally, in terms of environmental spillovers, some stakeholders noted that solutions that are being developed through the DER Challenge are expected to have positive impacts in terms of job creation and greenhouse gas savings.

"Has it raised the profile at the UK and Scottish government level? Absolutely, and that's why I think for me there's been more of a political impact in profile raising, through the initial

investment. Before [DER] only a few experts got it, but now, [the energy sector] does get [the importance of PEMD]." (Industry stakeholder)

This is in line with the findings from the activity-based case study. DER-IC colleagues indicated that they had been active in terms of conference presentations and their sites had received visits from high-level politicians, which had helped to boost PEMD's profile. Moreover, the DER-IC network has catalysed collaboration between the centres, creating a brand that is synonymous with UK PEMD.

"*Depending on the stage of the process and the specialisation need there is a long path that starts in South West Wales, goes to New Castle, goes to Strathclyde, West Midlands… And this network has been enabled by the DER Challenge.*" (DER-IC colleague)

Some stakeholders from the thematic case study also flagged the influence of the DER Challenge on the development of some of the most recent policies rolled out in the UK which relate to the PEMD sector. These policies include the UK National Semiconductor Strategy[57] and the updated Critical Minerals Strategy.[58]

However, the DER Challenge's impact on broader policy developments in the PEMD sector remains uncertain. Some stakeholders whom we engaged with as part of the thematic case study felt that there has been limited direct policy support for the PEMD sector since the DER Challenge was launched. Stakeholders also highlighted the limited information publicly available about the DER Challenge's successes to date.

Distribution of winning organisations

The DER Challenge grant funding has mostly been allocated to academics and companies in the manufacturing and professional, scientific and technical activities sectors. The geographical allocation of the funding seems in part to have coincided with the location of the DER-ICs across the country.

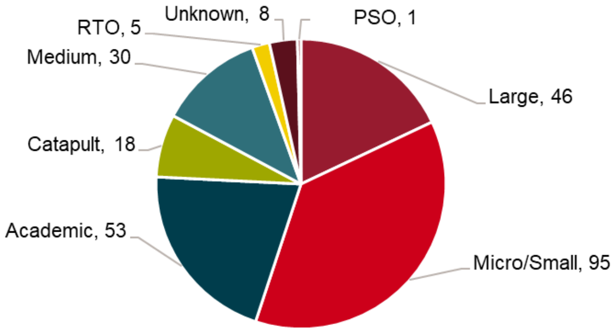
Figure 48 shows that two-thirds of the organisations that have received grant funding from the DER Challenge are companies. Of those, more than half are either micro or small companies. The other groups that have often received grant funding are academic organisations and Catapults.[59] However, the largest proportion of the funding has been allocated to academic organisations, which may be less well equipped to contribute their own funds (65%), followed by SMEs (22%) and large companies (8.5%).

[57] National Semiconductor Strategy

[58] Resilience for the Future: The UK's Critical Minerals Strategy

[59] https://catapult.org.uk/

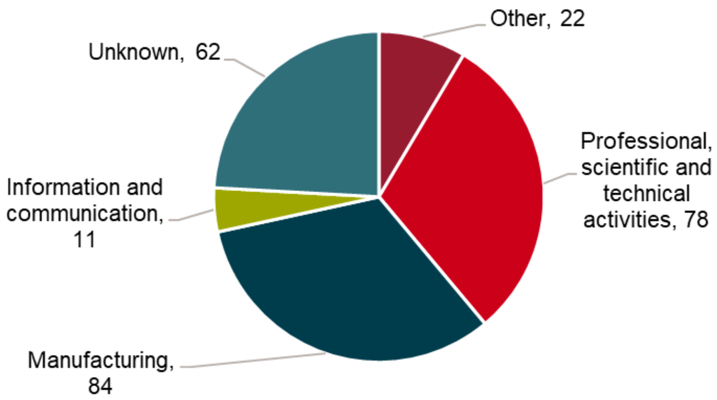
Figure 48 Distribution of organisations receiving grant funding by size or type



Source: Frontier Economics based on DER Challenge monitoring data
Note: RTO stands for Registered Training Organization and PSO stands for Professional Services Organization

Figure 49 shows that most of the firms that have received funding operate in the manufacturing sector or conduct professional, scientific and technical activities. These sectors have each received 15% of the grant funding. The rest of the grant funding has mostly been allocated to academic organisations.

Figure 49 Distribution of organisations receiving grant funding by sector



Source: Frontier Economics based on DER Challenge monitoring data
Note: 53 out of the 62 organisations with unknown SIC code are academic

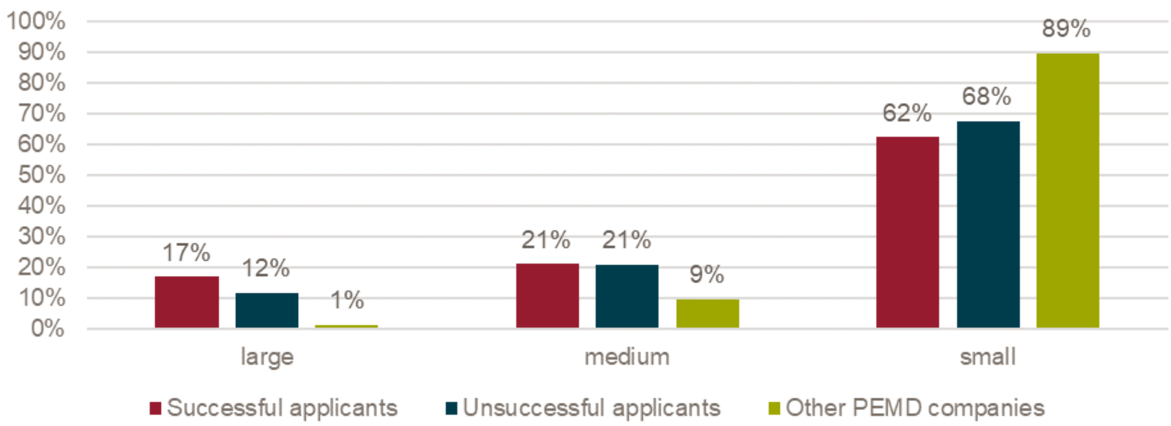
Distribution of PEMD companies

Data from the ONS BSD allowed us to compare the distribution of companies that have applied for the DER Challenge grant funding (identified through their CRNs) with other PEMD companies (identified through their SIC codes). It should be noted that this analysis excludes other organisations such as academic organisations or Catapults given that the BSD includes only information on companies (i.e. small, medium and large enterprises).

The comparisons that we present below should be treated with caution given the pervasive nature of PEMD. As such, the SIC codes used to identify other PEMD companies are likely to capture some unrelated activity and also miss a lot of PEMD-related activity.

Figure 50 shows that successful and unsuccessful applicants are more likely to be larger than the average company in PEMD SIC codes. In total, 17% of successful applicants and 12% of unsuccessful applicants are large companies, as compared with the 1% of other PEMD companies.

Figure 50 Distribution of PEMD companies, by size (2023)

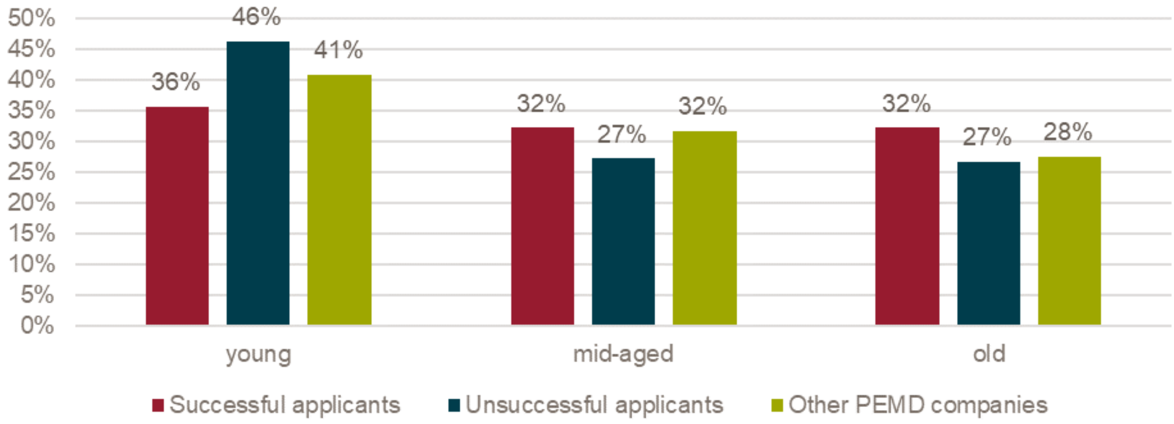


Source: ONS Business Structure Database. This work was undertaken in the Office for National Statistics Secure Research Service using data from ONS and other owners and does not imply the endorsement of the ONS or other data owners

Note: Small companies are companies with fewer than 50 employees or a turnover of less than £10 million. Medium companies are companies with fewer than 250 employees and turnover of less than £50 million

Figure 51 shows that successful applicants are more likely to be older than unsuccessful applicants and other PEMD companies (32% vs 27% and 28% respectively). Unsuccessful applicants are more likely to be younger companies than successful applicants and other PEMD companies (46% vs 37% and 41% respectively).

Figure 51 Distribution of PEMD companies, by age (2023)

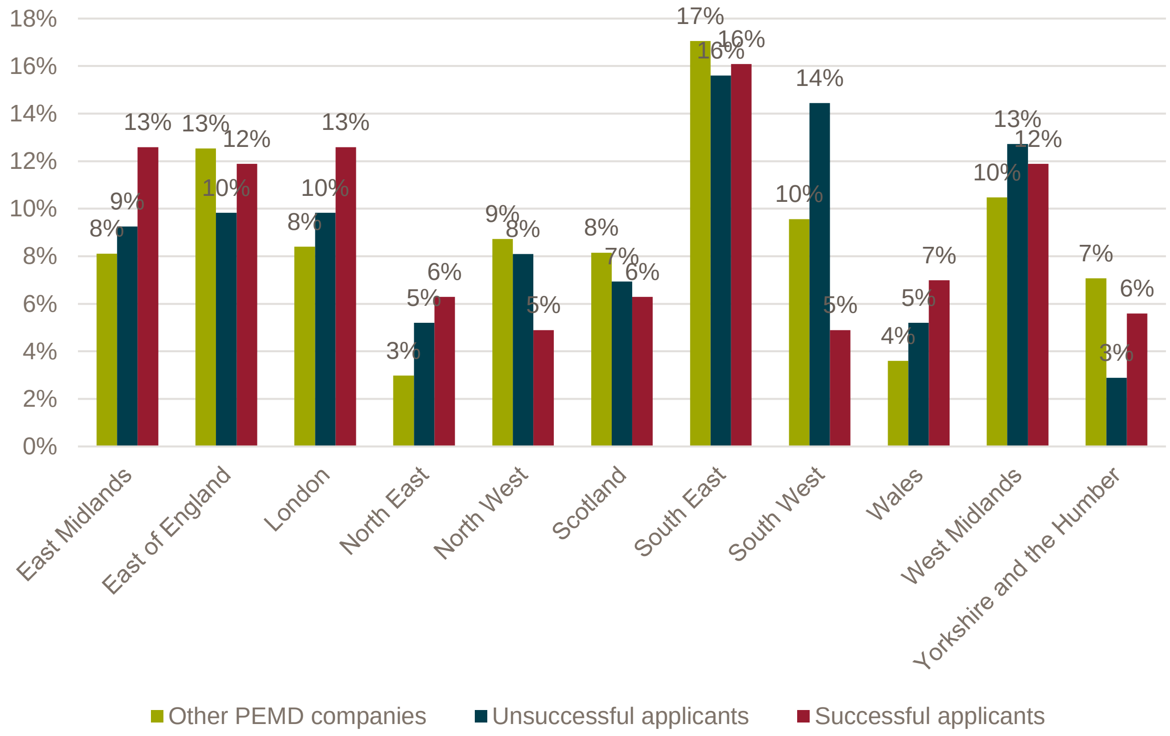


Source: ONS Business Structure Database. This work was undertaken in the Office for National Statistics Secure Research Service using data from ONS and other owners and does not imply the endorsement of the ONS or other data owners

Note: Young companies are 10 years old or younger, and old companies are over 30 years of age.

Figure 52 shows that companies that have received DER Challenge grant funding are more likely to be located in the Midlands, the North East, Wales and London than other PEMD companies not engaged with the DER Challenge. Note that, unlike the map presented in **Error! Reference source not found.**, this analysis is restricted to companies only (i.e. it e xcludes other organisations such as academic organisations or Catapults).

Figure 52 Distribution of PEMD companies, by region



Source: ONS Business Structure Database. This work was undertaken in the Office for National Statistics Secure Research Service using data from ONS and other owners and does not imply the endorsement of the ONS or other data owners

5 Learnings and lessons for future evaluation

This report represents the final output of the DER Challenge evaluation. As noted previously, some of the longer-term benefits of the DER Challenge may only be realised in the future. Therefore, this section provides some learnings and recommendations for future evaluation.

5.1 Contact survey

Survey responses gathered as part of the impact evaluation allowed us to draw conclusions on the impact of the DER Challenge and to make comparisons with the baseline. However, the number of responses received was lower than hoped for. The relatively low response rate limited our ability to undertake comparisons across sample sub-groups, e.g. successful vs. unsuccessful candidates.

Specific recommendations to increase the sample size achieved in order to provide greater robustness and ability to break down results for future evaluation include:

- The primary survey questions could be combined with project completion reports. Impact survey data could be collected at a similar point for each project, and the response rate would likely be higher as it would be administered alongside a mandatory requirement.

- The low response rate is partly due to some individuals moving on from the organisations where they had their engagement with the DER Challenge. It would be beneficial in the future to maintain the connections with the company representatives who interact with the DER Challenge and keep the list of contacts updated even when individuals move to different organisations.

- Although the contact survey was targeted to successful and unsuccessful candidates as well as organisations from the wider PEMD industry, 39 out of 41 respondents were companies that had been successful in their applications for grant funding with the DER Challenge. Continued engagement with wider industry stakeholders to increase awareness of the importance of evaluating the impact of the DER Challenge could encourage participation as part of future evaluations. Increasing the diversity of the sample would be beneficial to draw conclusions beyond the organisations engaging with the DER Challenge funding. This would enable future evaluators to gain further insights on the impact of the DER Challenge on the wider PEMD ecosystem.

5.2 Case studies

The case studies provided rich qualitative insights which helped identify positive impacts from the DER Challenge that were not obvious from the secondary analysis and contact survey responses. Conversations with the relevant stakeholders (i.e. DER-IC colleagues, organisations engaging with the DER Challenge via DER-IC or funded projects, and wider industry and policy stakeholders) provided the relevant nuance and examples to bring to life the impacts of the DER Challenge across the different evaluation themes. In particular, we were able to explore what activities contributed the most to what impacts, and what mechanisms were considered to be barriers to or enablers of the success of the DER Challenge. Perspectives about future expectations and next steps were also discussed. As such, we recommend that any future evaluation also considers including additional case studies.

A limitation of the thematic case studies is that some participants in Phases 3 and 4 were closely tied to the DER Challenge, either as contributors to the DER-IC or as early-stage participants in the DER Challenge's development, thus introducing some risk of confirmation bias. The diversity of stakeholders interviewed helps to mitigate this, and should be a consideration for future evaluations.

5.3 Secondary data analysis

The secondary data analysis allowed for a helpful contextualisation of industry-wide trends in the UK PEMD sector. However, at this stage of the programme, it was not possible to demonstrate a direct impact of the DER Challenge on the broader UK-wide metrics. Given time lags and the longer-term nature of some indicators (e.g. turnover, patents), the secondary data analysis should be revisited as part of any further evaluation.

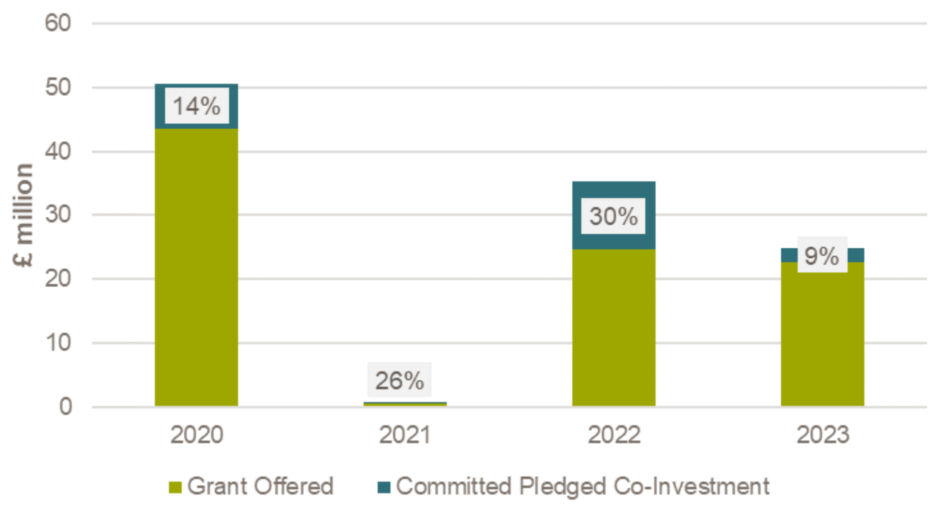
5.4 Expert review

Feedback from the DER Challenge was an effective way of cross-checking emerging insights in order to help validate our early conclusions and provide wider contextual viewpoints on the contribution of the DER Challenge to date. We therefore recommend that any future evaluation also contains an expert review process.

Annex A DER Challenge funding

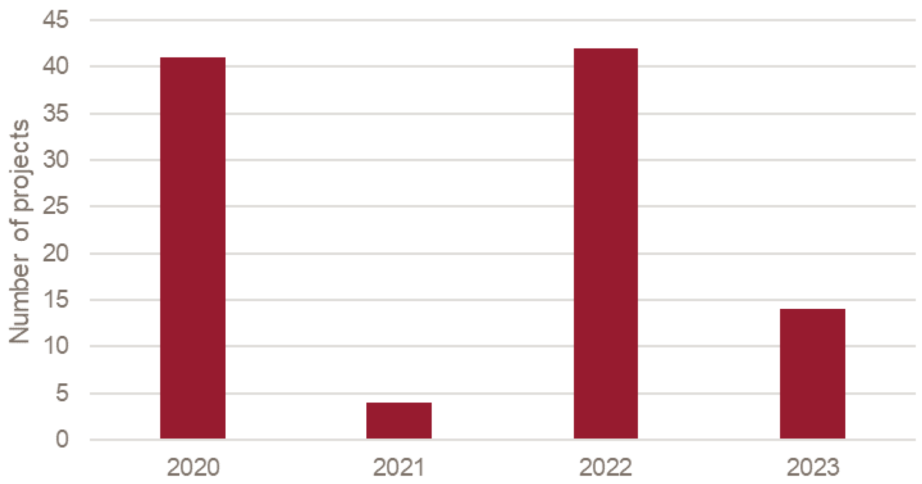
A.1 CR&D funding

Figure 53 Total DER Challenge-funded project costs, split by funding type



Source: *Frontier Economics based on DER Challenge monitoring data*

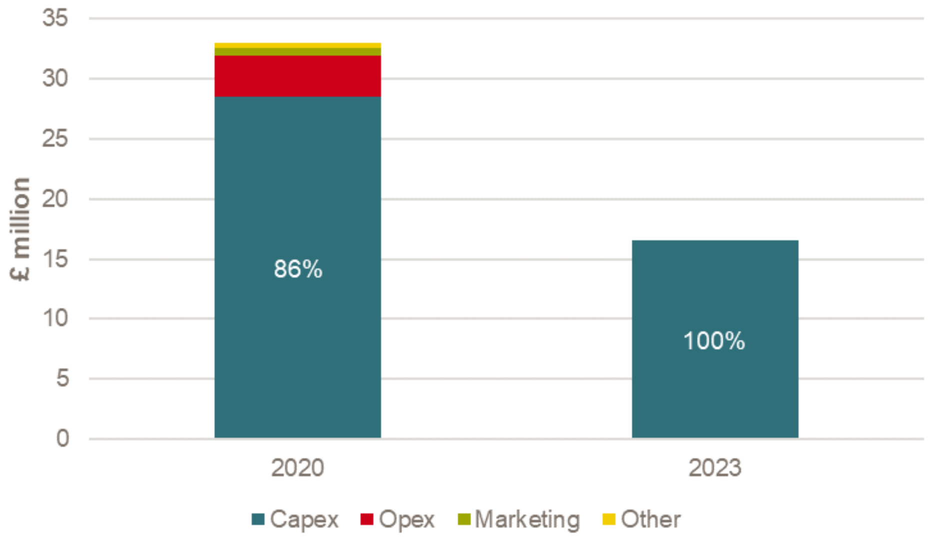
Figure 54 Number of PEMD projects funded by the DER Challenge



Source: *Frontier Economics based on DER Challenge monitoring data*

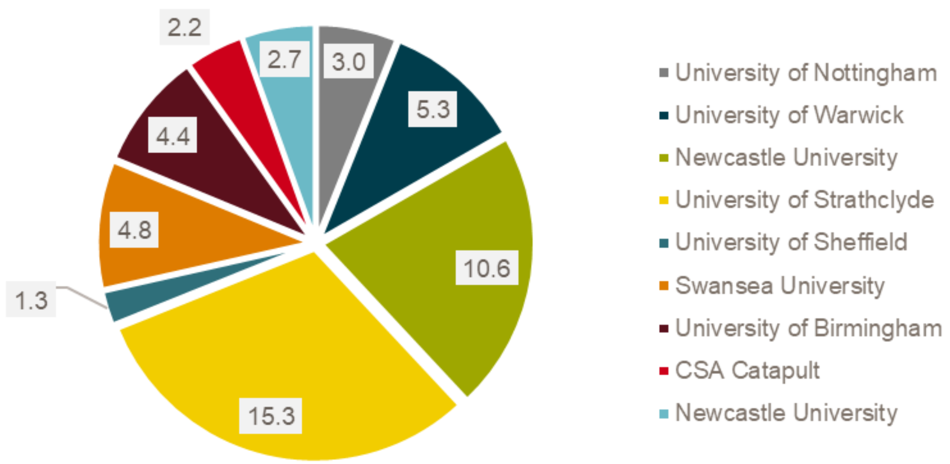
A.2 DER-IC funding

Figure 55 DER-IC funding by cost type and year



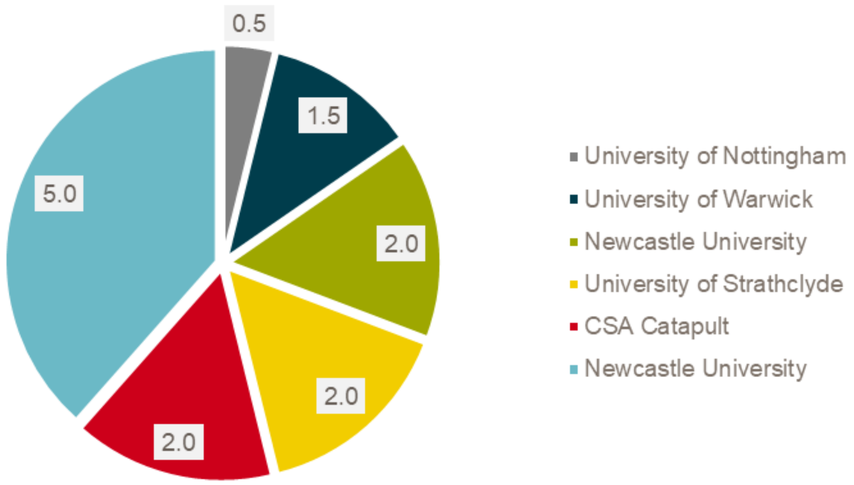
Source: Frontier Economics based on DER Challenge monitoring data

Figure 56 DER-IC funding by institution



Source: Frontier Economics based on DER Challenge monitoring data

Figure 57 Full-time equivalents by institution



Source: Frontier Economics based on DER Challenge monitoring data

Annex B Case studies for the final impact evaluation

B.1 Project-based case study 1 – GaNSiC

Technology and project description

The GaNSiC project developed an innovative ink-jet dispensing process for bonding semiconductor dies directly on circuit boards, enabling a more reliable and efficient manufacturing process for next-generation gallium nitride (GaN) and silicon carbide (SiC) power electronics crucial for the UK's electrification efforts.

The electrification of applications that currently use fossil fuels is a cornerstone of the UK Government's net zero plans, e.g. use of electrically powered heat pumps instead of natural gas and use of electricity in transport. Electrification requires devices, typically made from semiconductors, that can switch high current and high voltage. The semiconductor devices are manufactured in the form of dies,which need to be connected to the wider circuit that they regulate. Die attachment refers to how the semiconductor die is electrically, mechanically and thermally connected to its immediate environment. During product use, the die attachment must withstand significant stresses induced mechanically and thermally. Consequently, the method of die attachment strongly affects the short-term device performance, its reliability and lifetime.

The GaNSiC project developed a novel die-attachment process for next-generation power electronics, based on wide-bandgap devices (WBG) fabricated from gallium nitride (GaN) and silicon carbide (SiC) semiconductors. WBG devices can switch power faster and more efficiently than silicon devices and are being used in increasingly challenging environments, subject to high temperatures and to vibration. The level of power switched by WBG devices and the reliability needed are also increasing.

Historically, devices were bonded to a substrate using conductive epoxies or solders. Devices were wire bonded using heavy gauge wire/ribbon bonding, which is both expensive and, over a long period of time, unreliable, especially at high temperatures. In recent years there has been a shift away from traditional methods to the use of silver sinter die attach to accommodate the higher power densities of WBG devices compared with traditional ones based on silicon. The application of the silver sinter paste is currently performed using traditional printing methods. Next-generation WBG devices will require double-sided (or multi-level) silver sintering, which cannot be achieved through traditional printing methods – a problem that the DER Challenge project aimed to resolve.

The DER Challenge project developed a novel process using an ink-jet to dispense silver sinter paste directly on substrates, enabling multi-level bonding. The project sought to develop a dispensing process that is compatible with commercially available silver sinter materials, such as those supplied by Heraeus.

The DER Challenge project brought together Custom Interconnect Ltd. (CIL), responsible for developing the ink-jetting dispensing technique, and the Compound Semiconductor Applications Catapult (CSAC), which led the validation of the technology. CIL designed and manufactured SiC and GaN assemblies. CSAC provided its circuit design and testing expertise to develop innovative qualification processes for assessing the prototypes. CSAC prepared the devices for testing and assessed the performance of the direct-dispensing technology against that of rival technologies.

The project received £207k in DER funding; CIL supplied an additional £45k. CIL received 70% of the total project funds; CSAC 30%. The project was of nine-month duration, starting in November 2020.

CIL activities financed through the DER Challenge are shown in Table 17 below:

Table 17 Approximate breakdown of CIL's types of activity funded by DER Challenge

Activity	%DER funding (nearest 5%)
Construction of prototype	25
Purchase and commissioning of equipment	5
Process development	30
Experimentation and testing	30
Staff training	5
Other	5

Source: ERM

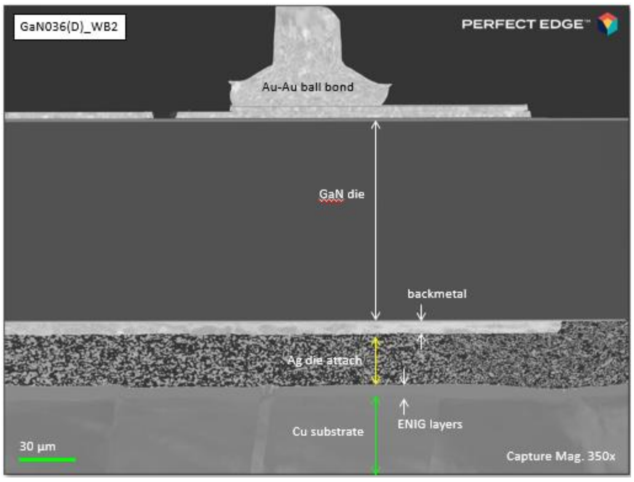
The case study was developed based on interviews with representatives from both consortium members: the interview with CIL and CSAC held in July 2024 as part of the final Phase 4 DER evaluation phase built on information gathered during the Phase 3 interview of July 2022. A desk-based review of direct-dispensing technology and power electronics die attachment was also performed.

Project outcome

In the course of the project to date, the consortium has successfully demonstrated its direct-dispense silver sintering process, which has led to follow-on work for the consortium.

CIL and CSAC view GaNSiC direct-dispense as a complete success: it validated a process to 'dispense' silver sinter onto GaN devices under pressure-less conditions and onto SiC devices under high-pressure and low-pressure conditions. It confirmed that confocal scanning acoustic microscopy – the measurement method – (CSAM) is the only effective inspection method and, for robustness, should be combined with periodic scanning electron microscopy (SEM) measurement of sectioned sample devices (a destructive testing method). The new attachment and testing process will allow future SiC dies to have bondable/solderable top-level source contact pads, reducing device heating and enabling new device geometries, thus reducing the size and weight of the systems, improving reliability in high temperatures in various applications. The project success has filtered through to many follow-on projects and activities in the UK.

Figure 58 SEM of device cross-section showing top and bottom sintered contacts



Source: CIL.: SEM of device cross-section showing top and bottom sintered contacts

Accelerating innovation and commercialisation of PEMD technologies

The DER Challenge facilitated the development of the direct-dispense technology, helped grow semiconductor packaging capabilities in the UK and helped CIL increase its turnover and operational footprint in the UK.

In Phase 3, stakeholders noted that the DER Challenge provided essential funding which allowed the project to demonstrate the direct-dispense technology. While CIL and CSAC were seeking other sources of development finance, DER support significantly accelerated the commercialisation of this transformative technology for wide-bandgap semiconductor solutions in the UK. This acceleration occurred at a time when the semiconductor market was predominantly reliant on conventional insulated-gate bipolar transistor devices. Wide-bandgap solutions can achieve higher power switching speeds in smaller and more efficient devices. The process developed during the GaNSiC project is now used in products that CIL would otherwise have been unable to manufacture.

“*The trend that we're seeing is that the silver sintering technology is not becoming a standard but becoming an option for various applications which gives superior performance. The technology that's been developed reflects on the equipment sales.*” (CIL)

Following the DER GaNSiC project, CIL has significantly grown as a company. Between the project's completion (2021) and today, the company has more than doubled its turnover and also quadrupled its operational footprint in the UK. Although most of the capital expenditure associated with CIL's growth was not funded by UK Research and Innovation (UKRI), we were told during our Phase 4 engagement that the DER project and associated funding played a critical role in helping to overcome the major development hurdle for the creation of the current largest semiconductor packaging facility in the UK.

The GaNSiC direct-dispense solution has attracted interest from major automotive players and customers across different end-use sectors.

In Phase 3, GaNSiC project stakeholders reported that the demand for direct-dispense technology was growing from a broad range of sectors, including the automotive sector, military and UK security bodies, as well as from companies involved in telecommunications, aerospace, energy and power grids. In Phase 4, market outreach activities and/or project development targeting all these applications have been reported by the project developers. They have observed a significant interest in this technology among large industry players, especially within the aerospace sector where higher operating temperatures and the lower thermal stress of the wide-bandgap devices ca improve components' reliability and lifetime and achieve a smaller and lighter overall system design.

"[The direct-dispense technology] is used on multiple products that we are now manufacturing that, if it wasn't for that technology [developed under the DER programme], we wouldn't be able to manufacture." (CIL)

The automotive sector is also rapidly adopting wide-bandgap semiconductor solutions, driven by the roll-out of advanced electric vehicles. The investments that CIL has received from major automotive players like JLR and BMW underscore the sector's growing interest. This momentum is now extending to other industries. Industries like aerospace are often more cautious, relying on others like the automotive sector as early adopters of new technologies, to help de-risk their use. The project consortium sees the importance of the GaNSiC project as an important step in proving the direct-dispense technology for use in chip manufacturing and power electronics packaging supply chains across other industries, without which the team may not have experienced the same level of interest, or as quickly.

The GaNSiC direct-dispense solution has been deployed in several projects after GaNSiC.

The GaNSiC project has been the catalyst for further R&D projects that have been developed in partnership with industry stakeholders with the support of national funding programmes, including the Advanced Propulsion Centre, Department for Science, Innovation and Technology, and DER (UKRI and Innovate UK). These projects use the GaNSiC project's technology to innovate power electronics for automotive applications or high-power computing in internet servers.

Table 18 below provides the key details of CIL's follow-on projects that build on the know-how developed under the DER GaNSiC project.

Table 18 Key CIL projects that apply the direct-dispense technology developed under the DER GaNSiC programme

Project name	Application sector	Project timeline	Project partners	Funding programme	Funding received by CIL
@FutureBEV	Automotive	Mar 21 – Jun 24	BMW; McLaren; Lyra Electronics; CSAC; Warwick University	APC-15	£1.4m
OranGaN [60]	Telecoms	Jan 22 – Mar 24	INEX Semiconductor; CSAC; Viper RF	DSIT	£250k
PE2M	Aerospace & others	Mar 22 – Nov 24	Ultrawise Innovation; Tribus-D; Warwick University; DZP Technologies; HPM	DER	£140k
ELIPS	Telecoms	Feb 23 – Mar 24	Supply Design; CSAC; GSPK Circuits; Iceotope Technologies	DER	£300k
ELEGaNT	Power	Jun 23 – Nov 24	Supply Design; University of Edinburgh; GSPK Circuits	DER	£120k
EleVAIT	Automotive	2023 – ongoing	JLR; API Capacitors; Bristol University	APC-20	£1.44M

Source: ERM

"If it wasn't for GaNSiC, it wouldn't have led to @FutureBEV, to EleVAIT, to Elips, and I can just go on and on and on… It all started with that project, and it's all been about networking and [leveraging] the community." (CIL)

Overall, ten customer projects, including projects under non-disclosure agreements and those in Table 18, have been developed building on the direct-dispense technology demonstrated under the DER programme.

[60] Although the outcome from the GaNSiC project was not directly used as part of the OranGaN project, CIL mentioned that the direct-dispense technology may be used in the future for the semiconductor packaging of radio frequency gallium nitride (RF-GaN) devices demonstrated throughout the project. CIL has indeed recently been requested to develop a similar project for £10 million.

CASC noted that many other projects it has seen come through the Catapult have benefitted from the GaNSiC project in some way on their own path to industrialisation. CSAC has also expanded its regional reach, e.g. CSA Catapult Scotland, CSA Catapult North East and Future Telecoms Hub Bristol. These activities will benefit from the learning and development experienced during the GaNSiC project and driven by the pull through from industry.

"There's evidence that there's pull from the industry to support companies like CIL to help develop some of the kind of late-stage prototyping and volume scale up that helps turn innovative technology into production-ready solutions." (CSAC)

Manufacturing capacity of the PEMD supply chain

Following the DER programme and the development of the direct-dispense process, the consortium members are experiencing increased demand from their customers and new customers.

In Phase 3, project stakeholders reported that, critically, the DER Challenge allowed the direct-dispense technology to be proven at scale. This in turn provided the validation which was needed to attract new customers and to expand manufacturing capacity.

Before the DER GaNSiC project, CIL had a manufacturing facility of 24,000ft2 in Andover, UK, and a turnover of approximately £15 million. Four years after the inception of the DER award, CIL now has 100,000 ft2 combined capacity of manufacturing and office space across three Andover sites. Its budget for the coming financial year also continues the upward trend. The new manufacturing capability is divided into a prototype, small volume printed circuit board (PCB) production facility (CIL House: 24,000ft2), and a large volume advanced semiconductor packaging, power device and volume PCB assembly facility (BP2 Facility: 64,000ft2), which is currently the largest semiconductor packaging production facility in the UK. The latter facility combines surface mount technology with the GaNSiC-developed ink-jet solder print capability, enabling at full capacity 80,000 fully assembled PCBs per week (note that the first of eight assembly lines was installed in December 2023).

"[CIL operates] one of the largest semiconductor packaging facilities in the UK. It is a direct result of the GaNSiC project. It all started with the GaNSiC project." (CIL)

There is still a gap to achieve the production volumes necessary to be selected by major automotive customers.

In Phase 4, CIL reported that big automotive manufacturers, such as BMW and JLR, require a minimum production capacity of 1 to 3 million full modules per year to commit to purchase agreements. For CIL to meet this demand, substantial scale-up and capital investments in the range of £100s of millions would be needed, without the guarantee of the customer contract. Without further support, achieving the required production volumes to enter the automotive market will be extremely difficult or will prevent it being a viable market for CIL, forcing it instead to target lower volume markets. In addition, companies like CIL will face significant

DER challenges in competing with large, global, vertically integrated industrial players that already supply complete module components, adopting the innovations developed in the UK. We conclude that this is a big missed opportunity for the UK to capitalise on.

“We're seeing that the semiconductor companies are coming up the ‘food chain’, as we call it. So, you can go pretty much now and buy a Hitachi module off the shelf, that is fully qualified that does the same thing as products that we have developed, e.g. in @FutureBEV for BMW.” (CIL)

Bilateral partnerships with large manufacturers would help UK innovators to scale up, protect IP and maximise opportunities without significant capital investment.

While the UK has strong R&D capability, demonstrated through the GaNSiC project, and companies in the UK can gain a competitive technical edge over global players, scaling up to compete globally is challenging. Without financial support from government or an industrial strategy, private investment in manufacturing is too risky. To avoid losing the technical advantage over the major manufacturers which lack the skill in R&D, bilateral partnerships with these manufacturers could allow UK developed solutions to be manufactured using other companies’ capital. There is a strong, possibly unlikely ambition, that this would lead to inward UK investment in manufacturing, but there are signals that the strength of the power electronics capability and its network in the UK can generate enough of a pull for investment.

“*Siemens put their innovation hub in [area of] the catapult because of the power electronics, packaging capability and partners around there, and the partners link up with the catapult.*” (CSAC)

Growing PEMD knowledge and skills base

The DER programme enabled CIL and CSAC to recruit new staff and develop training programmes.

In Phase 3, CIL and CSAC recognised the DER Challenge of building a strong recruitment pipeline in the UK. Nonetheless, by the summer of 2022, they had already seen additions to their workforce and increasing interest in their training programmes, which could be partly attributed to their involvement in the DER Challenge and partly to the growing market for power electronics.

During our latest engagement with CIL, the DER evaluation team noted a significant increase in the company's headcount, from 132 employees in November 2020 – when they began their involvement in the DER Challenge – to approximately 220 employees. This represents a 30% increase in skilled workforce since the Phase 3 evaluation in July 2022. Since 2020, CIL has significantly re-structured its engineering department with the number of staff growing from eight engineers to 50 engineers, signalling a 56% increase only in the last two years. Sixteen of the 42 new engineers were newly qualified graduates. CIL is also sponsoring a PhD student at Warwick University. These numbers are below the expectations set during the Phase 3 evaluation (CIL expected to employ 300 people by March 2024) but are clearly positive evidence of the increasing CIL's popularity and attractiveness to engineers.

CIL added that its operational staff and manufacturing headcount are not growing as fast as the engineering staff. In order to increase the volume and quality of production necessary to meet requirements of high-value markets, e.g. the automotive sector, CIL is undergoing a structural change to promote automation. This is leading to a reduction in operational and manufacturing staff relative to more experienced engineering staff. CIL expects this trend to continue in the future.

CSAC works in partnership with the UK Electronics Skills Foundation to help develop PEMD skills in the UK, with the aim of setting up a recruitment system that starts at school level. Specifically, CSAC has noted industry-based investment of over £480,000 in an undergraduate intern activity and a doctoral training centre linked with the programme of Cardiff University. This allows students to spend six to eight months with the researchers and residents in the centre getting hands-on engineering experience before entering the job market, making them more employable and reducing the upskilling time required when joining a company like CIL. So far, CSAC has sponsored five PhD students from across the UK, including two via the Cardiff Centre for Doctoral Training.

Collaboration across the PEMD ecosystem

The DER programme has enabled the project consortium members to establish market-leading roles within the UK PEMD space.

In Phase 3, project stakeholders reported that the DER Challenge had generated broad benefits for UK PEMD supply chains. Specifically, DER was credited with improving marketing and communications within the UK market, boosting mutual awareness among PEMD companies, and diversifying the customer base and project types. By Phase 4, CIL noted a shift towards more commercially focused engagement as a result of DER involvement. Participation in conferences and stakeholder events has increasingly attracted industrial customers rather than just academics, highlighting the DER Challenge's impact on commercial outreach.

The relationship between CIL and CSAC has strengthened as a result of collaborating on the DER project, and through new collaborative projects (see Table 18) and mutual referral of business leads. Furthermore, the expertise of the project developers is gaining broader recognition throughout the UK. CIL argues that one of the DER Challenge's most valuable outcomes is the increased acknowledgement of CIL as a leading player in the UK PEMD sector.

Investment in PEMD companies

The UKRI funding has de-risked the direct-dispense technology, thereby helping CIL to attract key private finance to scale-up.

The GaNSiC project represents a clear example of how the DER Challenge has catalysed significant levels of co-investments within the UK PEMD sector. Before the DER Challenge, CIL was not able to raise the finance needed for its ink-jet dispensing facility. However, with the support of the DER funding award, CIL not only overcame this financial hurdle but also became the first company from the DER Challenge to clearly demonstrate the allocation of leveraged follow-on funding.

The funding received from UKRI along with other subsequent public funding (see Table 18) did not cover all of CIL's capital expenditures in the past four years. Most of the costs (£14.5 million) associated with the development of the CIL large-scale semiconductor manufacturing facility in Andover were obtained as commercial lending.

However, significantly more public support is required to enable the commercialisation of PEMD innovative solutions such as the direct-dispense technology.

Although the funding received from UKRI and the involvement within the DER Challenge has contributed to CIL's 180% budget growth since 2021, the company remains a relatively small player in the global semiconductor industry. Major industry players, particularly in the automotive sector, require CIL's technology to be available at scale and fully qualified before committing to deals. However, the substantial costs involved in achieving this scale make it difficult to reach without significant additional backing. CIL has reportedly had to reject offtake opportunities (supplying its packaged components to customers) worth £150 million to £1 billion. To increase its market outreach, significantly larger investment is needed, and the project consortium sees public support from the UK government as an important part of that investment, not just for CIL but for other companies in the UK power electronics industry, if the UK is to capitalise on its R&D prowess.

Investment in capital equipment is becoming more important, as volume and quality requirements increase, driving automation.

The requirements from customers are becoming increasingly challenging. Customers are asking for high volumes, low cost and extremely high quality (zero failure rates). In order to meet expectations, more automation of the manufacturing processes may be required, avoiding human error. This drives a cost for manufacturers as they need to invest heavily in machinery capable of completing these complex tasks and assembling components.

Policy spillovers

The lack of strong public support puts UK PEMD technology developers at a competitive disadvantage relative to companies in other geographies.

Without substantial government backing, the high costs associated with manufacturing, standards development and quality demonstration for innovative technologies like CIL's direct-dispense represent a key DER challenge for the growth of the UK PEMD sector. There are high risks associated with investment as contracts with customers are not certain, facilities may lie underutilised while contracts are secured, and there is significant competition from larger industrial players. While the DER-ICs were praised for providing some assistance at R&D and demonstration scale, the project stakeholders argued that the UK lacks suitable supporting mechanisms to enable the commercialisation of its R&D capabilities. In contrast, the EU provides substantial capital funding opportunities for PEMD supply chains, such as those under the European Chips Act and the Chips Joint Undertaking. The project stakeholders argued that countries like Germany and Spain may be able to offer 50-60% and 70% of the financial support, respectively, compared to only around 15% under the UK's Automotive Transformation Fund (ATF) programme.

The UK Infrastructure Bank (UKIB) has also been mentioned as an option for support. However, for smaller companies unfamiliar with navigating such institutions, it is challenging to demonstrate the opportunities and suitably mitigate the risks of investment for the UKIB. This is particularly detrimental for PEMD businesses in the UK like CIL which have enabled their customers to have "incredibly successful years" and outperform their competitors in niche markets (e.g. Formula-E) but have been unable to access larger market opportunities.

As a consequence of the limited public support, we were told that innovative companies like CIL find themselves unable to meet the minimum capacity requirements to participate in calls for tenders in the UK, thus increasing the funding gap between them and large multinationals producing semiconductor modules at scale, e.g. Hitachi.

Bilateral relations could facilitate foreign investments to reduce the funding gap in the UK PEMD sector.

The UK National Semiconductor Strategy is a plan announced by the UK Department for Science, Innovation and Technology in 2023 to advance the UK's position in the semiconductor industry. The strategy builds on the successes of earlier supporting mechanisms for the sector, including the DER Challenge. A core objective of the UK National Semiconductor Strategy is to pursue plurilateral cooperation to develop and implement a coordinated approach to supply chain resilience.

Bilaterial relations could provide mutual benefits to the nations involved and respective organisations. By leveraging its strong R&D capabilities, the UK could enhance its competitive edge in the international market and potentially attract critical inward investment for the UK PEMD sector. Furthermore, by enabling partnerships between key technology developers and large industrial players, market linkages could be established, thus fostering an ecosystem where advanced PEMD technologies developed in UK can be rapidly commercialised and scaled.

Although CSAC argued that the amount of funding that has been leveraged through bilateral agreements is relatively small (in the order of £100s of thousands) and well short of the investment levels necessary to commercialise UK PEMD technologies (in the order of £100s of millions), the customer relationships that could be enabled provide an alternative way for product developers and manufacturers like CIL to scale up and expand their market reach.

"If we're going to play with some of those big tier partners and big global carmakers, it's not just the money we need, but an infrastructure support around working in that model. So bilaterals can help us do that, but I think they will take a bit of time to deliver." (CSAC)

List of abbreviations

£m/£b	Million (£m) or billion (£b) pound Sterling
BMW	Bayerische Motoren Werke AG
CAPEX	Capital expenditures
CIL	Custom Interconnect Limited
CSAC	Compound Semiconductor Applications Catapult
CSAM	Confocal scanning acoustic microscopy (measurement method)
DER	Driving the Electric Revolution (DER Challenge)
DER-IC	DER innovation centre
EU	European Union
ft2	Squared feet (1ft2 = ca. 0.093m2)
GaN	Gallium nitride
GaNSiC	Gallium nitride silicon carbide (direct-dispense) (UKRI DER funded project)
JLR	Jaguar Land Rover
PCB	Printed circuit board
PCBA	PCB assembly
PEMD	Power electronics, machines and drives
RF	Radio frequency
R&D	Research and development
SEM	Scanning electron microscopy (measurement method)
SiC	Silicon carbide
SMT	Surface mount technology
UK	United Kingdom

UKIB	UK Infrastructure Bank
WBG	Wide bandgap (device)

B.2 Project-based case study 2 – SCREAM

Technology and project description

The SCREAM project focuses on the development of a UK-based supply of recycled neodymium iron boron (NdFeB) magnets from end-of-life waste streams to address supply risks, environmental concerns, and high costs associated with the recovery of virgin rare earth materials that are critical for increased electrification and therefore decarbonisation.

The decarbonisation and electrification of economic sectors require the adoption of advanced power electronics and electric machines which depend on high-performance magnets for their efficiency and functionality. Neodymium iron boron (NdFeB) magnets, known for their high magnetic strength and resistance to demagnetisation, are the most powerful type of permanent magnets available. This makes them critical components in multiple clean energy technologies, e.g. wind turbine generators and electric vehicle (EV) motors. Furthermore, due to their compact size, NdFeB magnet materials have replaced previously large and heavy components in many other types of consumer, commercial, industrial and technical applications where strong permanent magnets are required.[61] Driven by the accelerating deployment of wind turbines as well as the adoption of EVs and next-generation electronics, the global demand for these materials doubled between 2020 and 2022.[62] Demand is expected to increase further in line with global decarbonisation efforts.

NdFeB magnets are composed of an alloy of neodymium, iron and boron. Neodymium is a rare earth material. The availability of rare earth materials such as neodymium is limited[63] and geographically concentrated. In particular, nearly 70% of the total mine production of raw rare earths occurs in China[64] and the same country controls 90% of the rare earth magnet market.[65] Therefore, neodymium has been identified as being a significant supply risk. The lack of supply-side diversification in relation to this element has a significant impact on the cost of materials, which have increased by about 1,200% in the last two decades.[64] These economic and supply chain risks have significant impacts on the speed of potential technological advancements in Europe and most of the Western world.[66]

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[61] https://www.magnetshop.com/magnet-applications.html

[62] https://www.statista.com/statistics/1047263/Neodymium-Iron-Boron-permanent-magnet-demand-worldwide/

[63] Although rare earths are fairly abundant in the earth's crust, economically recoverable reserves are limited. Indeed, an economically viable source should contain more than 5% rare earths (https://www.britannica.com/science/rare-earth-element/Abundance-occurrence-and-reserves).

[64] https://pubs.rsc.org/en/content/articlepdf/2024/gc/d3gc03756h

[65] https://www.apcuk.co.uk/wp-content/uploads/2021/09/Building-a-robust-magnet-supply-chain-for-the-UK-1.pdf

[66] https://view.argusmedia.com/rs/584-BUW-606/images/MET-White_paper-How_to_build_a_rare_earth_supply_chain.pdf

In addition, the mining and refining of rare earth elements, as well as their disposal, are associated with significant environmental and social concerns. As outlined in the UK's Critical Mineral Strategy, recycling of neodymium from waste electrical and electronic equipment (WEEE)[67] represents a potential solution to the increasing demand for the material. This could provide overall economic and environmental benefits relative to virgin material extraction.[68] However, the recovery of rare earth magnets from WEEE has not represented a large enough value opportunity for most metal recyclers to date. Some proven methods have been used to separate neodymium, but they often require expensive, time-consuming and polluting activities.[69]

Under the Driving the Electric Revolution DER Challenge, the Secure Critical Rare Earth Magnets for the UK (SCREAM) project was funded with the aim of developing a UK-based supply of recycled rare earth magnetic materials from end-of-life (EoL) waste streams. The project built on:

- The previously DER-funded Rare Earth Extraction from Audio Products (REAP) project, which focused on the recycling of rare earth magnets from audio products; and
- The rare earth Recycling for E-machines (RaRE) project, funded via Innovate UK, which demonstrated the recovery of rare earth magnets from computer hard drives for the manufacture of two motors.[70]

The SCREAM project specifically aimed to recover rare earth materials from a variety of waste streams to produce a recycled NdFeB alloy powder. This powder is then manufactured into a magnet (via a short-loop process) or into rare earth carbonates or oxides (via a long-loop chemical process[71]) that are suitable for various application segments within the rare earth supply chain. The overall process aimed to produce NdFeB magnets that have significant environmental benefits and potential cost savings with respect to virgin magnets produced in China. The project started in January 2022 and is expected to finish by the end of February 2025.

The project brought together different stakeholders within the rare earth value chain with the following roles:

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67 https://www.gov.uk/guidance/regulations-waste-electrical-and-electronic-equipment

68 https://www.gov.uk/government/publications/uk-critical-mineral-strategy/resilience-for-the-future-the-uks-critical-minerals-strategy#the-uks-objectives-and-approach

69 Although rare earths are fairly abundant in the earth's crust, economically recoverable reserves are limited. Indeed, an economically viable source should contain more than 5% rare earths (https://www.britannica.com/science/rare-earth-element/Abundance-occurrence-and-reserves).

70 https://hypromag.com/wp-content/uploads/2023/09/HyProMag-Corporate-Introduction-28-July-2023.pdf

71 Short-loop recycling involves grinding rare earth magnets into powder to form new magnets, which can lead to potential performance losses. In contrast, long-loop recycling grinds the magnets and separates the pure rare earth element oxides, allowing for adaptation to changes in magnet design. https://www.iacpartners.com/wp-content/uploads/2023/03/Recycling-REE-in-the-EU-2.pdf

- The **University of Birmingham (UoB)** developed the method to recover rare earth materials from waste streams, called hydrogen processing of magnetic scrap (HPMS). This method allows for the extraction and demagnetisation of NdFeB alloy powders from magnets embedded in scrap. UoB licensed the technology to Hypromag.
- **Hypromag** (project lead) managed the project with the objective of demonstrating the production of NdFeB recycled magnets to the level of quality required by industrial customers, as well as their use in different applications.
- **Mkango Rare Earths UK** (hereafter referred to as Mkango) aimed to complement the short-loop HPMS recycling process by developing a long-loop chemical recycling process to recycle NdFeB HPMS powder that is not suitable for short-loop recycling (as it is too high in contaminants) and/or recycle magnet swarf (i.e. the powder produced from grinding and finishing magnets).
- **European Metal Recycling (EMR)** aimed to explore effective pathways for recovering rare earth materials and assess the market potential of recycled NdFeB magnets. EMR has been the primary supplier of scrap and EoL magnets for the SCREAM consortium. However, occasionally, magnets have been provided by other suppliers.
- **GKN Hybrid Power** (part of GKN Automotive, hereafter referred to as GKN) planned to re-engineer a state-of-the-art 800v e-machine with the recycled magnets. This would allow for the new motor and magnet performance and capability to be tested and validated relative to virgin material and the original machine.
- **Jaguar Land Rover (JLR)** and **Bowers and Wilkins (B&W)** have been involved in assessing the suitability of the recycled magnets for replacing virgin materials in a range of products within the automotive and loudspeaker sectors, respectively. In addition, JLR has also contributed to the lifecycle assessment (LCA)[72] of the recycled magnets production.

The total project cost is £3.4 million; the project received £2.4 million in DER funding (71% of total costs). Table 19 shows the relative size of each consortium member's activity within the project and the allocated DER funding.

Table 19 Approximate breakdown of activity funded by DER Challenge per consortium member

Organisation	Activity cost [% of total project]	DER funding [% of total project]
HYPROMAG LTD	11%	11%

[72] LCA aims to understand the environmental impact of a product or service over its entire lifecycle. The concept of LCA is to determine all the processes and products needed to produce the product, operate it during its life and at end of life, and measure the environmental impacts associated with each, in order to better understand the opportunities to reduce the impacts.

Organisation	Activity cost [% of total project]	DER funding [% of total project]
B&W GROUP LTD	1%	1%
EUROPEAN METAL RECYCLING LIMITED	11%	8%
GKN HYBRID POWER LIMITED	11%	8%
JAGUAR LAND ROVER LIMITED	9%	6%
MKANGO RARE EARTHS UK LIMITED	33%	32%
University of Birmingham	25%	35%
Total project [£]	**£3,431,092**	**£2,434,318**

Source: ERM

This case study was developed based on interviews with representatives from the consortium, a desk-based review of the project's scope and market research on NdFeB magnets and rare earth materials. All consortium members were invited to take part in an evaluation interview. In total, six of the seven consortium members took part.

Project outcome

The project has achieved a coordinated supply chain approach to the supply of recycled rare earth magnets, achieving key product metrics, and is scaling up the circular process.

Hypromag reported significant progress towards its objective of developing NdFeB recycled magnets for a range of potential applications. Although the magnets that are currently being produced are not yet meeting the performance metrics of magnets made from virgin materials, there is a clear understanding of the steps required to improve the process to achieve this. Changes are now being applied to maximise the suitability of these recycled magnets for high-performance products for GKN as part of this project.[73] Hypromag plans to reach commercial scale of production by the beginning of 2025.

The SCREAM project has been essential in demonstrating Mkango's chemical recycling process beyond laboratory scale, de-risking the development of each of its process steps, and has enabled the development of new skills which are required for larger-scale magnet production.

EMR explored approximately 30 different scrap material streams, evaluating the volume and content of magnets in each, identifying promising routes for recovery, including material extraction from wind turbines (evaluated as part of a separate project following SCREAM), electric drive motors and TV speakers. During the project, EMR developed and invested in different material recovery lines to recover magnets from such scrap streams. EMR stated this

[73] https://hypromag.com/wp-content/uploads/2023/09/HyProMag-Corporate-Introduction-28-July-2023.pdf

would not have been prioritised without the SCREAM project and has allowed EMR to get ahead of the market.

GKN has gained valuable insights through the project and its collaboration with Hypromag. The company now has a deeper understanding of the differences between recycled and virgin magnets. In particular, it has learned that the type and quality of magnets produced through the recycling process are heavily dependent on the type and quality of the input material and, therefore, the impact it has on the performance of the products it engineers and manufactures for its customers. GKN was yet to use recycled magnets at the time of writing but would be doing so through the rest of 2024.

JLR has tested recycled magnets for their potential use in Range Rover products to hold vehicle headliners to the roof. Progress on the project is being closely monitored to investigate other applications for recycled magnets, to prove their performance relative to virgin content magnets and to potentially incorporate them as part of JLR's broader reimagine decarbonisation strategy (which includes net zero targets by 2039).[74]

Magnet use by B&W for loudspeakers is occurring at a slightly slower pace. This may be because of their smaller role in the project, which is reflected in the relatively small DER funding allocation, as per the project plan.

Overall the project was seen as a very good learning opportunity by all consortium members. The project has helped to raise awareness at each of the consortium companies, increased understanding of recyclability routes and of what is needed for larger-scale production, including DER challenges and opportunities.

"*The first demonstration magnets made achieved the minimum acceptable performance KPIs put into place by the project. Thanks to the work done since then we have improved the quality of the magnets produced and are aiming to repeat that work, as well as make other magnets for demonstration, that should be close to exactly matching the performance of primary magnets.*" (Hypromag)

Consortium members reported that production of recycled vs. virgin NdFeB magnets could lead to energy savings of at least 80%. However, this is dependent on final results, which are still being developed.

Cost reductions with respect to Chinese new magnets are heavily dependent on neodymium's fluctuating market prices. The virgin metal price has decreased by about 70% since the project's start (£160/kg in February 2022 vs. £48/kg in July 2024).[75] Therefore, price parity will be hard to achieve if prices remain low. However, the project developers are confident that a market for sustainable magnets is emerging in the Western world as a response to the supply chain and environmental risks associated with the Chinese market and virgin metals.

[74] https://www.jaguarlandrover.com/reimagine

[75] https://tradingeconomics.com/commodity/Neodymium

Hypromag claimed that there may already be a far higher willingness to pay for sustainably sourced magnets relative to magnets with a large carbon footprint coming from materials mined or processed in China.

Accelerating innovation and commercialisation of PEMD technologies

Under project SCREAM, the technologies developed by the different consortium members have advanced at different paces.

The SCREAM project is clearly subdivided into work packages led by the different consortium members. The starting technology level of each supply chain step and the progress made through the project work packages have been different.

Hypromag had already demonstrated the HPMS technology concept patented by UoB before the SCREAM project (as part of the RaRE and REAP projects funded by IUK and DER). However, prior to SCREAM, it had only managed to establish its first small-scale production plant. By applying the know-how developed under SCREAM, Hypromag is building a second plant and has planned a third site. The evaluation team considers the technology progression that occurred during SCREAM to be technology readiness level (TRL) 5 to 7/8.

Mkango moved from lab-scale chemical recycling (TRL 4) to the establishment of a pilot plant (TRL 6) thanks to this DER funding.

As part of the SCREAM project, EMR developed and utilised manual disassembly methods to recover rare earth materials from items such as EV drive motors and small MRI machines, as well as an advanced robotic separation technology specifically for removing magnets form flat screen TV speakers. These are reportedly at early-demonstration level (TRL 5). Significant DER challenges remain to scale up these solutions for higher-volume streams. These relate to the costs for a fully automated process, while considering the uncertainties in market demand projections over the next three years. Demand can fluctuate due to a range of legislative, geopolitical and pricing factors affecting the supply of rare earth magnets.

Without the SCREAM project, technology development and industry involvement within the rare earth recycling space would have been delayed.

"Recovery of rare earth magnets currently isn't commercially viable or a large enough value opportunity today, thus most recyclers in general aren't focusing on extracting these materials. There is relatively low volume in current feeds, in particular with the volume of electrified end of life vehicles being very low. There aren't many players in the wind turbine recycling market outside of EMR either. So it is one of those topic areas that would otherwise be on the back burner was it not for projects like this." (EMR)

Multiple consortium members agreed that the project, along with the DER Challenge's funding, was crucial in enabling the production of recycled magnets in the UK, which would have otherwise taken much longer to achieve.

Without the DER funding, Hypromag stated that it would not have had the resources to demonstrate the NdFeB magnet recycling process at scale. The process would have remained at a much earlier stage of readiness, heavily reliant on the UoB for support. Although other funding mechanisms could have potentially been obtained, the DER funding was reportedly pivotal for Hypromag in gaining a clearer understanding of the industry. This clarity allowed it to make significant progress towards commercial production.

The DER funding facilitated the REAP project, which demonstrated the HPMS recycling concept developed by UoB, enabling Hypromag to extract magnets at a scale beyond the laboratory. Additionally, through the SCREAM project, the company managed to diversify both the magnet supply streams and the methods of utilising recycled content.

"Maybe it would have happened another way, but if you looked at the way we want to progress without this funding and this project, we would be a long way backwards."
(Hypromag)

Without the DER funding, the industry's involvement in rare earth recycling would likely have been significantly delayed. The interest of both GKN and JLR in recycled NdFeB magnets would not have accelerated to the extent that it has through the SCREAM project. In addition, the advanced research by EMR on potential scrap material streams and NdFeB magnet applications, as well as the recycling process development by Mkango, would not have been possible.

Manufacturing capacity of the PEMD supply chain

DER funding enabled the technology developers to establish a UK-based supply chain to recover and manufacture rare earth magnets.

Through the SCREAM project, EMR has demonstrated material recovery processes for EV drive motors, small MRI machines and flat screen TV speakers. Through the earlier DER-funded REAP and RaRE projects, the company also demonstrated material extraction from audio products and computer hard drives, respectively. Furthermore, through additional Innovate UK funding, EMR also opened a processing centre to extract rare earth materials from EoL wind turbines. Overall, these circularity solutions could provide alternative supply routes to mitigate the expected shortage of rare earth magnets in the UK on its path to net zero emissions. Note that, driven by the uptake of renewable energy technologies and electrification, global demand for NdFeB for magnets could increase three- to six-fold from levels in 2015 of 240kt to 633kt in 2030 (depending on demand scenario), but the same study suggests that roughly 20kt to 45kt could be supplied from EoL magnets.

Further downstream in the rare earth supply chain, partly thanks to the DER funding, Hypromag established a new £4.3 million pilot plant at Tyseley Energy Park in Birmingham, UK, in partnership with the UoB to manufacture the different recovered materials into magnets suitable for different applications. In addition, Mkango established a £1.1 million pilot plant at

Tyseley Energy Park, for which 70% of the costs are being funded by DER, to complement the rare earth recovery process of Hypromag's pilot plant for the production of magnets.

Although the full magnet recycling supply chain enabled by the SCREAM project is yet to be integrated into commercial supply for customer products, some of the outcomes of the project are already directly feeding into the motor manufacturing design development work of GKN's colleagues in Europe.

"This project has certainly accelerated [interest in using recycled material] from a GKN point of view, and we are working closely with our colleagues in Europe who design and manufacture motors for customer projects, feeding the outcomes of the project directly into some of their work." (GKN)

Growing PEMD knowledge and skills base

Most consortium members have increased their experienced skills base and hired new staff, but there is an urgent need for specialised skills development in the UK PEMD sector.

Thanks to SCREAM and other DER-funded projects, Hypromag has already recruited two students from UoB who were completing their Master's courses. As the company expands, it plans to upskill its workforce even further. Ideally, by next year, it will have the capacity to train employees with additional DER funding obtained by the UoB.

Mkango encountered significant DER challenges in its recruitment process, as the scale-up of its long-loop recycling process required advanced chemical skills that are not readily available in the UK. Mkango needed to build its UK team with generalists in chemistry and engineering, and securing individuals with the specialised knowledge needed for the chemical recycling process associated with the SCREAM project necessitated hiring external consultants from China, where the majority of technical know-how is based.

"*UoB Magnetic Materials group is around 30 people, widely considered the biggest and best permanent magnet research group in the Western world. When you compare that with a single manufacturer's R&D centre in China, there are around 80 people*." (Hypromag)

The UoB confirmed the difficulty in recruiting experienced staff. Although grant funding enables the opening of fellowship positions, PhD students with experience in magnetic and critical materials are hard to find. Additionally, individuals who receive in-house training often receive job offers from industries in the US or Europe with much higher salaries. This difficulty in recruiting and retaining staff underscores the skills shortage trends identified in the thematic case study.

GKN and JLR have not directly recruited additional staff to support the SCREAM project development. However, as a consequence of the DER funding received, the R&D departments of both companies have seen an indirect increase in interest.

Investment in PEMD companies

Mkango UK and Hypromag's integration within Maginito will accelerate the development and roll-out of rare earth recycling technologies across the UK, Europe and the US.

In March 2023, one year after the start of the SCREAM project, Mkango UK was integrated within Maginito (Mkango Resources Ltd 90%; CoTec 10%), a Mkango subsidiary focused on developing new technology opportunities in the rare earths supply chain (initially with a UK focus), including neodymium (NdFeB) magnet recycling and innovative rare earth alloy, magnet, and separation technologies. In May of the same year, Maginito acquired Mkango's partner Hypromag (100% stakes in Hypromag Ltd UK; and 90% stakes in its German subsidiary Hypromag GmbH) with the aim of supporting the company's efforts in accelerating the roll-out of HPMS technology across the UK and Europe. In addition, a new US subsidiary, to be jointly owned by Maginito and CoTec, is expected to be formed to develop rare earth recycling opportunities in the US.

Following the SCREAM project, the technology developers have secured funding and investments for scaling up operations in the rare earth recycling sector.

Hypromag has secured funding for several follow-on projects in the UK that build upon the results of the SCREAM project. One of these projects, called Re-REwind, focuses specifically on the recycling of rare earth materials from wind turbines. It is supported by Innovate UK's Critical Materials for Magnets competition and was developed in partnership with UoB and EMR. Besides the relatively minor public support (£243k awarded under Re-REwind), Maginito has played a crucial role in the development of these projects by guaranteeing the necessary matched funding. The success in generating varied grades of recycled magnets has been pivotal in demonstrating the technology's potential in the context of the UK's net zero targets. Hypromag anticipates that, within the next year, these developments will attract substantial additional investments, enabling them to scale up magnet production.

In parallel to its pilot plant in Birmingham, Hypromag's German subsidiary, Hypromag GmbH, is developing an HPMS plant in Baden-Württemberg State in Germany based on the Tyseley plant's design capacity of 100tpa NdFeB magnet production. The German plant's €6.1 million costs will be partly funded by the European Regional Development Fund (ERDF) and the regional Ministry of Economic Affairs, Labour and Tourism (60%) and by Maginito (40%).

As a consequence of the successful demonstration of its long-loop recycling process during the SCREAM project, Mkango has managed to secure a project that is looking at alternative ways to produce rare earth oxides using ionic liquids. The company reported that, without the pilot project enabled by the DER funding and the lessons learned as part of the process optimisation from laboratory scale, this would have not been possible.

UoB has attracted substantial additional public funding since the SCREAM project, as it has been named a national research hub to support the UK's transition to a robotics-enabled circular manufacturing ecosystem (£35 million) and it has been involved in follow-up projects with Hypromag. Overall, UoB expects to have attracted about £45 million of investments after the DER involvement.

To unlock larger-scale support, there is a need for wider awareness of the critical role of magnets within the PEMD sector.

Technology developers Hypromag and Mkango agreed that investment in the UK PEMD sector, particularly inward investment for magnets, remains limited. While they acknowledged the significant impact of the DER Challenge, they emphasised the need to raise awareness about the critical role of rare earth materials within the PEMD sector, to catalyse further support.

"Some people don't even know what rare earths are. I think that there needs to be a bit more work generating awareness. I think that that can be quite a big barrier actually." (Mkango)

Public investment is considered to be easier to access in the US and Germany, leaving the UK behind despite it being the home of the technology's R&D.

Hypromag stated that the German government, supported by the EU via ERDF, its German arm of the business was able to access significant funding to set up a recycling plant in Germany. €3.7 million was awarded to support the €6.1 million plant. Furthermore, it is able to pursue scaling-up in the US in parallel, with a 50% cash injection to start up a plant. This will lead other geographies to scale faster than the UK and gives the impression that critical minerals are not being taken as seriously as by those other geographies.

Collaboration across the PEMD ecosystem

The SCREAM project has enabled knowledge sharing and commercial links across the project stakeholders.

All project consortium members agreed that collaboration among the parties involved has been one of the key successes of the SCREAM project. Overall, the project has fostered a collaborative environment where knowledge sharing, industry connections and understanding of supply chain dynamics have been instrumental in driving collective progress and innovation.

JLR and GKN highlighted the value of the connections made throughout the project and the knowledge acquired from the technology developing partners. They also stressed how their fruitful collaboration may lead to the development of additional common projects.

The technology developers expressed appreciation for the sharing of their respective know-how and key learnings – in particular: Mkango for gaining a better understanding of the project's upstream and downstream impacts from a chemical perspective; Hypromag for understanding the supply and demand dynamics of the rare earth market and forging new industry relationships; UoB for receiving key feedback to continue improving its HPMS process; and EMR for differentiating scrap material streams for the production of specific magnets.

The project developers are gaining increasingly leading roles within the rare earth magnet field.

Despite significant limitations in material availability, manufacturing capacity and expertise compared to China, rare earth magnet supply chains are slowly developing in the Western world. The SCREAM project has enabled the technology developers to participate in the emerging rare earth market outside of China.

"We have started to see equipment manufacturers developing in the Western world, but I don't think SCREAM has particularly been the driver. It's been a nice way to open conversations." (Hypromag)

Although not attributable to the SCREAM project, UoB has reportedly been recognised for gathering some of the most experienced people in the rare earth magnet field and is thus attracting increasing interest from outside and within China.

"There is a real desire globally to cooperate with the UK, but also with UoB. As an example, when we've had people go out to China, they were desperate to collaborate with us, even the massive magnet manufacturers, they're desperate to collaborate with us." (University of Birmingham)

Policy spillovers

The project stakeholders stressed the importance of the DER Challenge within the context of an inadequate supporting framework in the UK.

EMR highlighted that the increasing interest in establishing a rare earth supply chain in the UK is not to be attributed to the country's legislative framework. Both EMR and Hypromag expressed concerns that the UK support, underpinned by the Critical Minerals Strategy, is lagging about a year behind similar initiatives in the EU and US in terms of support for the PEMD industry and rare earth materials in particular.

It is worth noting that Hypromag's German subsidiary was able to receive £3.7 million in public funding for the development of its HPMS-based pilot plant in Europe, while less than £300k was received from DER in the UK under both the REAP and SCREAM projects. While the EU may be a more fertile ground than the UK for developing such projects, the company mentioned that it was also actively exploring opportunities in the US, where up to 50% of facility funding could potentially be secured.

List of abbreviations

£m/£b	Million (£m) or billion (£b) pound Sterling
B&W	Bowers and Wilkins
DER	Driving the Electric Revolution (DER Challenge)

EMR	European Metal Recycling
EoL	End of life
ERDF	European Regional Development Fund
EU	European Union
EV	Electric vehicle
HPMS	Hydrogen processing of magnetic scrap
IUK	Innovate UK
JLR	Jaguar Land Rover
KPI	Key performance indicator
LCA	Lifecycle assessment
MRI	Magnetic resonance imaging (machine)
NdFeB	Neodymium iron boron (magnet)
PEMD	Power electronics, machines and drives
R&D	Research and development
RaRE	Rare Earth Recycling for E-machines (DER-funded project)
REAP	Rare Earth Extraction from Audio Products (DER-funded project)
SCREAM	Secure Critical Rare Earth Magnets for the UK (DER-funded project)
TRL	Technology readiness level
UK	United Kingdom
UoB	University of Birmingham
US	United States
WEEE	Waste electrical and electronic equipment

B.3 Activity-based case study

Purpose of the case study

The activity-based case study included in this final evaluation report focuses on the Midlands DER-IC. This builds on the previous activity-based case study presented in the interim impact evaluation.[76] For the purpose of this report, a programme of qualitative research was conducted through a series of interviews with both DER-IC colleagues and firms engaged (Table 20).[77] This qualitative engagement focused on:

- The evolution of activities undertaken by the Midlands DER-IC in the last 18 months;
- The impact of the Midlands DER-IC activities on firms engaged; and
- Longer-term benefits and DER challenges.

The case study is structured as follows:

- Overview of the DER-IC funding in the last 18 months;
- The impact of the Midlands DER-IC site equipment;
- The success of the Midlands DER-IC in connecting firms and raising the profile of the PEMD sector;
- The Midlands DER-IC role in promoting skills;
- The Midlands DER-IC role in signposting funding opportunities and raising investment; and
- Looking ahead: long-term DER challenges and opportunities of the PEMD sector.

Table 20 Stakeholders interviewed

Type of stakeholder	Role	Firm description
DER-IC colleague	Sales director and general manager for the Nottingham Drives Specialist Services	N.A.
DER-IC colleague	DER-IC chairman and DER Challenge director	N.A.
DER-IC colleague	Chief executive for the High Value Manufacturing Catapult centre at WMG	N.A.
DER-IC colleague	Midlands DER-IC lead	N.A.

[76] Driving the Electric Revolution phase 3: process evaluation and interim impact evaluation

[77] The quotes and insights presented in this case study were all taken from the interviews conducted for this phase of work.

Type of stakeholder	Role	Firm description
Firm – McLaren Applied	New product introduction engineers	McLaren Applied develops and delivers advanced engineering and technology solutions that have applications for organisations across various sectors
Firm – Safran	Technology manager	Safran is an international jet manufacturer that designs, develops and produces engines and other electrical machines
Firm – Ricardo	Engineers, team leaders and programme managers	Ricardo is a global engineering, environmental and strategic consultancy, operating across a range of market sectors

Source: Frontier Economics based on qualitative engagement

Overview of the DER-IC funding in the last 18 months

The Driving the Electric Revolution Industrialisation Centres (DER-ICs), led by Newcastle University, are bringing together a UK-wide network of over 30 academic and research and technology organisations. The network gives businesses the opportunity to develop manufacturing process technologies and industrialise the processes needed for PEMD scale-up, while reducing risk by sharing expertise, technical advice and facilities.

There are four main DER-IC sites across the country: North East, Scotland, Midlands, and South West & Wales. The centres are homed in existing organisations with evidenced competencies and capabilities in PEMD. Each of the DER-IC sites focuses on a different type of technology, and therefore the distinction between the DER-IC regions is principally based on a thematic separation rather than a geographical separation in terms of the locations being supported.

Table 21 The DER-IC locations

DER-IC	Location	Area of focus
North East DER-IC site	The Innovation Centre, Sunderland	Prototype and scale-up of motors and drives integration, quality assurance and testing

DER-IC	Location	Area of focus
Scotland DER-IC site	The National Manufacturing Institute Scotland and the Power Networks Demonstration Centre, Glasgow	High-power PEMD MW-scale machines and drives prototype & scale-up MW-scale testing
Midlands DER-IC site	The University of Nottingham and the University of Warwick	Machine manufacturing processes, power electronics manufacturing processes
South West & Wales DER-IC site	The Compound Semiconductor Application Catapult Innovation Centre, Newport	Materials (semiconductors, magnets, insulation and components)

Source: Frontier Economics

The DER-ICs received a total of £46.6 million in grant funding. This funding was composed of an initial allowance of £33 million in 2020, which was used to purchase equipment and hire staff. This allowance was subsequently increased by a further £16.6 million in 2023. The additional investment was fully allocated to purchasing additional equipment across the different DER-IC centres.

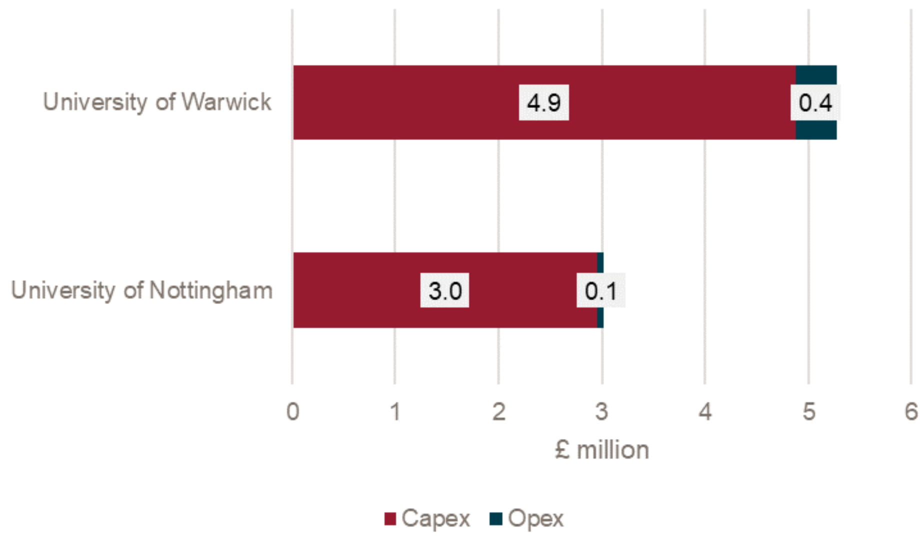
The Midlands DER-IC site is based in both the Power Electronics, Machines and Control (PEMC) Centre at the University of Nottingham and the Warwick Manufacturing Group (WMG), an academic department at the University of Warwick. While the University of Nottingham and WMG lead the Midlands DER-IC site, there are 12 organisations involved and the network is growing. The other partners include Catapult centres and academic institutions, such as Manchester and Coventry Universities, which assist the DER-IC by providing technical expertise and networking opportunities.

Figure 59 shows the total funding received by the Midlands DER-IC, split by location. WMG, within the University of Warwick,[78] received a total of £5.3 million, of which £0.97 million was granted in 2023. The additional funding was fully committed and all equipment[79] was expected to be in place and functioning by October 2024. Nottingham received a total of £3.1 million in 2020, of which nearly £3 million was allocated to equipment. Ninety-seven percent of the costs were for capital investment (capex) such as equipment and facilities and the rest were operational costs such as staff salaries.

[78] WMG is an academic department at the University of Warwick and is the leading international role model for successful collaboration between academia and the public and private sectors, driving innovation in science, technology and engineering.

[79] The funding was used to purchase equipment for power electronics manufacturing reliability testing.

Figure 59 Total funding received in the Midlands DER-IC



Source: Frontier Economics based on Monitoring data

In the previous 18 months, no additional equipment had been purchased by the University of Nottingham. However, delivery delays meant that not all of the purchased equipment had been delivered when the final phase of qualitative engagement was carried out. WMG had experienced similar delays affecting the delivery of automatic winding equipment used for winding copper wires around electric machine components that generate the magnetic field. Stakeholders noted that these had occurred because some suppliers were struggling to meet required quality standards.

Overview of the Midlands DER-IC activities in the previous 18 months

The Midlands DER-IC experienced significant growth in the admin team over the previous 18 months (from two to eight people in Nottingham University) to support a growing number of projects, which expanded from four to 27 in Nottingham University.

The Midlands DER-IC has engaged with a variety of firms, ranging from established players who have a product idea and use the equipment to de-risk their investment and pursue projects that would not otherwise have been possible to fund. The DER-IC has also continued to work with smaller firms including startups that lack the required production facilities in house. This broad engagement by the DER-IC has encouraged small and medium-sized enterprises (SMEs) to innovate and has enabled larger organisations to improve their manufacturing techniques.

"*The DER-IC provides the ability to do the manufacturing and the testing, as well as the background knowledge to understand the test regimes that these products need to go through.*" (DER-IC colleague)

In the previous 18 months, the key activities undertaken by the DER-IC were:

1. Providing access to equipment that was used in multiple projects;
2. Connecting firms and providing access to expertise, including raising the profile of the PEMD sector more generally;
3. Undertaking upskilling activities to fill identified skills gaps; and
4. Signposting funding opportunities and supporting firms in raising further investment.

The sections below outline how each of these activities has created impacts relative to a counterfactual scenario where DER funding was not available.

The impact of the Midlands DER-IC site equipment

The most prominent activity undertaken at the DER-IC over the previous 18 months continued to be providing industry with access to equipment.

During the previous 18 months, companies used the equipment to test new products, validate and analyse new processes and generate digital visualisations of forthcoming prototypes. For example, firms used equipment to carry out automated winding, which has applications in the automotive and aerospace sectors, allowing higher throughput and repeatability of design in the manufacture of electric motors. The winding centre at WMG reported that the equipment has been well utilised.

The DER-IC centres also collaborate with companies as part of consortia which have been funded via other sources. For example, WMG is working with Safran and others to explore product design in relation to electric vehicles. This project has been funded by the Aerospace Technology Institute (ATI) but draws on WMG's expertise and equipment that exists due to the establishment of the DER-IC.

This case study focuses primarily on the Midlands DER-IC. However, the DER-IC centres do not operate in isolation. In particular, the use of equipment over the previous 18 months unlocked new research opportunities which have led to new joint projects between the Nottingham branch of the Midlands DER-IC and other DER-IC centres such as the Compound Semiconductor Application Catapult Innovation Centre. Two ATI funded aerospace-related projects within the winding centre and one Advanced Propulsion Centre (APC) project have leveraged additional public funding directed towards developing new technologies.

There are also additional upcoming projects which are due to utilise WMG equipment. These include collaboration with smaller companies which will make use of the winding centre and others which will be working on a unique e-machine design.

The delays associated with delivery of certain pieces of equipment meant that the Midlands DER-IC had to modify its offering. Specifically, it focused on engineering design and processes and facilitation of connections with external providers. These activities were less reliant on specific pieces of new equipment. In some cases, these delays did mean that some firms were forced to engage with commercial equipment providers to test new product ideas, for example. In some cases, this did lead to higher costs.

The delays also mean that certain longer-term impacts have not yet materialised. For example, one firm noted that, if successful, its new production process could lead to an expected eight-fold productivity improvement. However, it has not yet been possible to verify this due to delays in accessing equipment which WMG is still waiting for. Some companies have requested an extension to their projects to accommodate these delays.

Some of the benefits realised from using the DER-IC equipment over the previous 18 months include:

1. Moving the production processes away from the companies' own facilities, so they do not need to interrupt their current processes or make risky upfront investments in equipment;
2. Getting support from the DER-IC to make the right investment decisions in their own production facilities; and
3. Knowledge transfer from the DER-IC.

Each of these impacts is discussed below.

- **Moving the production processes away from their own facilities, so they do not need to interrupt their current processes or make risky upfront investments in equipment.**

Companies that had collaborated with the DER-IC mentioned that, in certain cases, they could have accessed some of the equipment via external commercial providers. However, if this had been the only option (and DER-IC support had been unavailable), the projects would have been deprioritised and/or the companies would have struggled to get internal approval to proceed. This was due to high opportunity costs (i.e. other projects/investments may have had a higher or more certain rate of return), the high financial capital expenditure costs involved in accessing the required equipment and the associated risks.

As such, DER funding means that firms can undertake riskier projects which could have significant long-term benefits and widespread applications, in a timely manner.

"*We would have struggled to sell it internally if we had to find all of the funding ourselves […] DER support allowed us to take risks we wouldn't otherwise. This is risky. If you invested money with uncertain outcome there would be less appetite internally. We would focus on lower hanging fruit*." (Company interviewed)

The DER-IC has also allowed some companies to carry out smaller exploratory projects using the DER-IC equipment before committing to significant expenditure or applying for a much larger project grant from another funder. This has enabled the firms to start working on the project in a timely manner and effectively de-risk an innovative idea.

- **Getting support from the DER-IC to make the right investment decisions in their own production facilities**

The DER-IC has supported some companies with the virtual reality (VR) modelling of potential new production processes. Firms emphasised that they would need to make substantial investments in machinery to effectively design new winding production processes. VR modelling carried out by the DER-IC ensures that the creation of new production processes is as efficient as possible and this substantial financial outlay in the future represents value for money.

The DER-IC has capacity constraints given the size of the facilities involved. However, the DER-IC has also supported companies to design the layout of a potential future facility to scale up the manufacturing process of the prototype product they are currently working on. This will help to support firms' future growth after the project-specific interaction with the DER-IC has concluded. The DER-IC has helped to scope out production and has advised on the manufacturing process.

- **Knowledge transfer from the DER-IC**

Companies that have collaborated with the DER-IC mentioned the importance of the technical knowledge and expertise provided by the DER-IC, which they could not have accessed from other sources in the absence of the DER Challenge.

For example, a company interviewed mentioned that it had had no technical information about some parts that were part of its current production process but were designed in the 1990s and now externally produced. The information gaps included detailed dimensional information, which meant that the company did not know whether it could make any changes or what impact those changes would have. The DER-IC utilised its metrology department and provided detailed measurements (even though this was outside the core project requirements). This information has given that company a better understanding of how different parts in the current production process are put together, and now means that the company can be more proactive about updating this aspect of the production process in the future.

Another company interviewed provided an example of a separate project which it was involved in, but it did not include input from the DER-IC and as a result lacked both tools and expertise. This gap meant that the company struggled to deliver a positive outcome in that case and a feasible technological solution was not identified.

"[The support from the DER-IC] took us from a design that was not really possible into a design that is possible." (Company interviewed)

The DER-IC is able to provide the companies with guidance based on lessons learned from adjacent industries and previous projects. The DER-IC's expertise means that companies can avoid exploring 'blind alleys' during projects which DER-IC colleagues know will not be productive due to their broad experience developing best practices and working with players from a range of industries. The immediate benefit from this knowledge transfer is a reduction in risk and a faster production of a better product at the end of the prototype manufacturing process.

"*When you are creating an innovative design, you want to give it as much chance to succeed as possible. So not taking the risks you don´t need to, to avoid going through lessons re-learned.*" (Company interviewed)

In the longer term, this knowledge transfer is expected to foster innovation for companies that have brought the design knowledge provided by the DER-IC in house.

The success of the Midlands DER-IC in connecting firms and raising the profile of the PEMD sector

In the last 18 months, the Midlands DER-IC has drawn links between separate projects, organised networking events and regional meetings, and has raised the profile of the PEMD sector.

- **The Midlands DER-IC has helped to raise the profile of the PEMD sector**

The Midlands DER-IC has been actively presenting at conferences such as Cenex LCV, Future Propulsion, and a number of international conferences across Europe (e.g. Germany, Italy). These presentations have led to the Midlands DER-IC meeting and engaging with potential collaboration partners and have directly led to some of the projects that are now in gestation.

The facilities have had visits from Rishi Sunak and Keir Starmer in the last 12 months. They have hosted ten of the Labour mayoral candidates and received visits of ministers and shadow ministers. This activity has significantly boosted the profile of PEMD as an industrial opportunity for the UK within the UK government and across the public.

"We are hopeful that any future government will have an industrial strategy that recognises the industrial opportunity of PEMD and starts to put a more targeted and long-term support mechanism to allow it to fix some of the gaps mentioned earlier on." (DER-IC colleague)

The DER-IC network has catalysed the collaboration between the centres, creating a brand that is synonymous with UK PEMD. The DER-ICs have been able to capitalise on this brand to raise further investment and improve visibility with companies with foreign ownership to bring production to the UK.

"*Depending on the stage of the process and the specialisation need there is a long path that starts in South West Wales, goes to New Castle, goes to Strathclyde, West Midlands… And this network has been enabled by the DER Challenge.*" (DER-IC colleague)

- **The Midlands DER-IC has connected firms along the supply chain and with academia**

The DER-IC has been connecting companies with other companies operating at different points in the supply chain. This includes companies involved in testing machines, hairpin manufacturing machines, laser welding machines, specific electrical hardware, impregnation suppliers and aluminium wire suppliers. These connections have allowed firms to access mutually beneficial expertise that would not have otherwise been obtained and identify opportunities for further collaboration beyond the scope of the direct engagement with the DER-IC.

"*One question led to another, and therefore we were presented or given the opportunity to access that expertise on things we wouldn't otherwise have necessarily considered either available information or accessible information.*" (Company interviewed)

The DER-ICs have also connected firms to academia. This has helped firms to access new expertise around the fundamental challenges they are facing and has helped them to make informed decisions, which helps to drive down costs or generate more power density. The role of the DER Challenge is key in connecting firms because it helps smaller firms get a foot in the door with larger suppliers or potential collaborators.

"*The capability that DER-IC brings is state of the art so it helps them in opening the door to conversations with other collaborators and universities. The equipment is not available anywhere else.*" (DER-IC colleague)

Midlands DER-IC role in promoting skills

Although skills-related activities do not have the same scale as the equipment provision, they have gained importance in the last 18 months across the Midlands DER-IC. Upskilling plans are done at the individual DER-IC level and there is no central coordination across the entire network, although the Driving the Electric Revolution Skills Hub does signpost to available courses around the country

The Midlands DER-IC has put skills programmes in place to meet the needs that industrial partners have articulated. Some of the initiatives include:

- Investment in a new role focused on rolling out the skills agenda, connecting to the Driving Electric Revolution Skills Hub and working on training packages for the industry;
- Creation of online platforms in Coventry and Nottingham which deliver training modules related to PEMD. This training is aimed at people with an engineering background and working at a professional capacity who want to be retrained for PEMD topics; and
- Detailed workshops to disseminate knowledge with the companies using the DER-IC equipment.

The equipment provision and activities around connecting firms have also had positive spillover impacts on the promotion of skills by the DER-IC. The use of equipment has helped uncover skills gaps that can then be addressed, and the projects have catalysed skills transfer from the universities to the companies.

However, the programmes and activities promoted by the DER-ICs have not as yet managed to close the skills gap, partially due to the growth cycle of the industry and magnitude of the issue.

There is also some feedback from industry that skills gaps are most prevalent at lower qualification levels, which is not the primary area of focus of the DER-IC.

"The DER-ICs are working this issue at qualification levels 6 and above, but the main gaps are at levels 2 and 5. The issue is about workforce planning." (DER-IC colleague)

Midlands DER-IC role in signposting funding opportunities and raising investment

In the last 18 months, the Midlands DER-IC has been sharing funding information to help firms identify what funding opportunities they can apply for. The DER-IC has also increased the chance of success for firms by partnering with them and bolstering bids via the inclusion of their expertise and strong reputation.

The DER-IC has also provided some companies with the opportunity to present at conferences. This in turn has helped those companies and their other industrial collaborators to attract attention from the market and highlighted sources of future investment.

The DER-IC helped catalyse co-investment from other sources such as regional, charity and local enterprise funds. In particular, the Midlands DER-IC has been active in the last 18 months in engaging with the West Midlands Combined Authority, creating opportunities for firms to access regional funds.

The DER Challenge funding has played a key role in this context. The world-class equipment that the DER-IC has provided has raised awareness of the PEMD opportunities and opened the floor to fruitful discussions.

Going forward, the role of the DER-IC should be focused around facilitating introductions and connections to help firms commercialise their products and increase their activities focused on attracting investment.

Looking ahead: long-term opportunities and DER challenges of the PEMD sector

The products that the companies have been working on in collaboration with the DER-IC can play an important role in achieving net zero through electrification across a number of industries. However, it is still too early to precisely nail down these longer-term impacts.

Some of the opportunities identified as a result of the DER-IC facilities include producing more efficient motors and drawing on automation to boost the repeatability and reliability of new products. Also, as noted above, the DER-IC has enabled the transfer of technical knowledge, best practices and lessons learned from vanguard industries to other sectors.

The products that the companies have designed, tested and manufactured in collaboration with the DER-IC include key innovative components of electric motors for automotive and aviation applications. These include aluminium hairpin windings[80] replacing conventional copper windings for lightweight, high-power motors used in non-road mobile machinery, as well as key hardware components of electric motors for driving aircraft propellers.

Other opportunities that were identified going forward relate to providing further guidance to companies and enhancing connections. Companies interviewed mentioned the exceptional relationship they have built with the Midlands DER-IC and were keen to keep this relationship going forward.

Moreover, although the DER Challenge funding is currently fully committed, large companies are still showing interest in using the DER-IC equipment and facilities, and the DER-IC colleagues expect to see high utilisation of the equipment in the future. In fact, the DER-IC has started to connect firms to other funding opportunities such as APC or ATI so that larger players can make use of the equipment for their projects.

The biggest DER challenge identified relates to the lack of any continuation of DER funding and how this may impact the extent to which SMEs will be able to use the DER-IC facilities. APC and ATI funding opportunities involve projects with much higher costs than an average project funded by the DER and may therefore be out of scope for SMEs. The DER-IC is still finding interest from SMEs and startups to use the equipment, so the DER-IC has been directing them to UKRI small funding opportunities which "*is enough to gain some basic understanding work but not enough to take projects to the next level*" (DER-IC colleague).

The lack of continuation of the funding is also expected to have an impact on the improvements that were made around skills. DER-IC colleagues mentioned that the work that was done around skills and knowledge transfer has contributed to an improvement in the PEMD skills ecosystem, but they "*have only scratched the surface*" and "*unless there is some well-focused industry strategy around it, there is a danger that some of the progress will stall*" (DER-IC colleague).

The companies interviewed did not report major impacts on productivity or expansion as yet as a direct result of their engagement with the DER-IC. This was expected given that most companies have not yet started to mass manufacture the products they have been developing and testing. This lag has been exacerbated by the equipment delays set out above. Moreover, the companies stressed the importance of being able to secure additional investment going forward to scale up the production and commercialise the products they have been designing and manufacturing with the DER-IC.

[80] Conventional motors, particularly those of low power (kW), use random windings. Hairpin windings are solid flat wire conductors that can achieve higher fill factor, reduced thermal resistance in the slot, leading to the potential for higher efficiency and torque density.

List of abbreviations

APC	Advanced Propulsion Centre
ATI	Aerospace Technology Institute
CAPEX	Capital investment
DER-IC	Driving the Electric Revolution Industrialisation Centre
OPEX	Operating Expenditure
PEMD	Power electronics, machines and drives
SME	Small and medium-sized enterprise
VR	Virtual reality
WMG	Warwick Manufacturing Group

B.4 Thematic case study

Introduction

The thematic case study is part of a wider evaluation of the impact of the DER Challenge and was developed based on primary research and engagement with academic institutions, power electronics, machines and drives (PEMD) industry experts, trade associations and policymakers. The thematic study takes a step back from the immediate DER Challenge-funded activities and explores the impact of the DER Challenge on the wider PEMD supply chain and UK economy.

In line with the wider evaluation, the structure of this case study aligns with the overarching evaluation themes. The primary focus of this thematic case study is on evaluation themes 1, 3 and 7, as they are less well covered by other aspects of the evaluation methodology. The evaluation themes are:

1. Has the DER Challenge accelerated innovation and commercialisation of PEMD technologies?
2. Has the DER Challenge increased the productivity of the UK PEMD supply chain?
3. Has the DER Challenge contributed to growing PEMD knowledge and skills in the UK?
4. Has the DER Challenge increased the value of investment in UK PEMD companies?
5. Has the DER Challenge helped foster a collaborative PEMD ecosystem?
6. Has the DER Challenge led to an expansion of UK PEMD manufacturing capacity?

7. Has the DER Challenge driven societal, environmental and policy spillovers?

The bulk of our findings relate to themes 1, 3 and 7. However, in some instances, interviewees provided their perspectives on other evaluation questions, and so we consider evidence related to each theme in the reporting. Each of the themes has a distinct focus but they also overlap to some extent. However, the structure of the case study aims to follow the evaluation themes.

Our findings are primarily based on a mix of semi-structured panel discussions with groups of industry experts. This qualitative engagement was augmented by some focused desk-based study. The research aimed to:

- Identify changes in UK PEMD supply chains, skills base and general ecosystem since 2022 (when the third phase of the evaluation was carried out); and
- Assess the degree to which these changes might be attributed to activities of the DER Challenge programme.

Our primary engagement which underpins this thematic case study was conducted approximately five years after the launch of the DER Challenge.

In this case study and the evaluation more broadly, we have sought to separate the effect of the DER Challenge from larger forces affecting UK PEMD supply chains. For example, the DER Challenge seeks to expand PEMD manufacturing capability. This is partly enabled by access to raw materials and impacted by international trade restrictions, factors which are outside the scope of the DER Challenge. However, we discuss the wider context affecting the evaluation themes throughout, where relevant. Specific conclusions or insights which we have drawn from the underlying evidence are marked as such and reflect the balance of contributors' views or highlight aspects that are particularly salient to our evaluation themes. In some cases, we draw on our wider experience of the PEMD sector; in these cases we always cite 'the evaluation team'.

Contributors

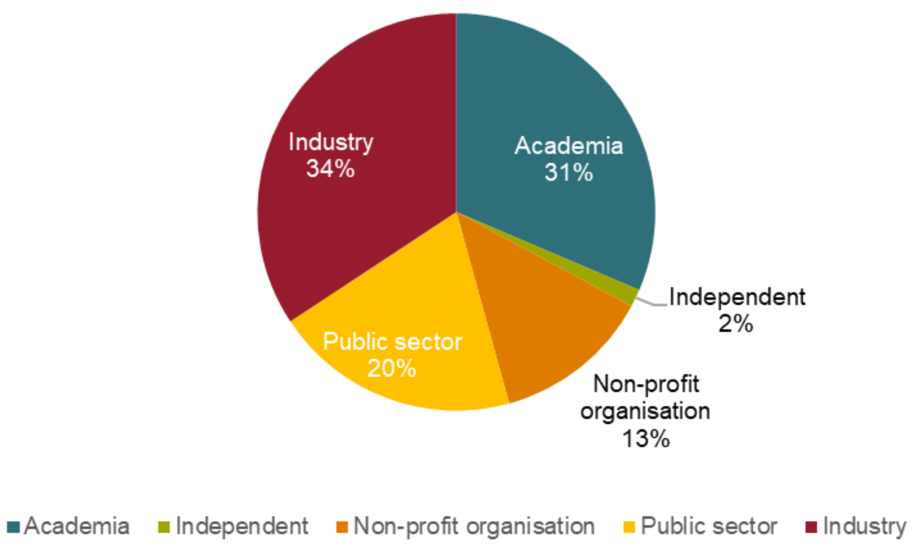
We selected external contributors who are experts in the supply chains and industries within which the DER Challenge resides, but who are not necessarily involved directly with the DER Challenge itself. Contributors were recruited from industry, academia, trade associations, non-profit organisations, and the public sector. All contributions are anonymous and are not attributed to any specific individual or organisation.[81] We do not disclose specific roles or names of people and organisations who took part. Where possible, we indicate levels of certainty and the number of contributors that supported each view.

[81] Note that one selected candidate from the contact list is retired and thus not affiliated to any of the identified sectors; this respondent is included within the 'independent' category.

We developed an original contact list of 71 contacts, chosen to provide a diverse mix of job roles, disciplines across PEMD, industrial sectors, applications of PEMD and organisation types. Thirteen of these contacts also provided viewpoints during the Phase 3 evaluation. However, the majority were new contributors for this phase of the evaluation.

We emailed each of the 71 contacts to ask them to support this case study. Out of the 71 contacts who received an email, 16 participated in at least one session. Eighteen contacts declined the invitation either because of time constraints or because they believed they would not be able to contribute. In the majority of cases, this was due to a difficulty in relating the subject of the evaluation, PEMD technologies, to the specific sectors the respondents were working in or because they had a limited overview of the contributions of the DER Challenge. In particular, public sector representatives were hard to reach around the time of the 2024 general election, when the interviews were held. A further 22 failed to respond at all, and nine emails failed to send due to out-of-date contact information.

Figure 60 Thematic case study contact list: sector split



Source: ERM, based on data based on contacts' job profile information available online

The organisations, roles and expertise of the final participants are summarised in Table 22.

Table 22 Thematic case study contributors

Organisation	Job title	Sector	PE, M, D focus
Trade association	Operations manager, skills development facilitator	Electronic	PE, D
University	Academic	Transport	PE

Organisation	Job title	Sector	PE, M, D focus
Independent	Skills development facilitator	Power, transport, industrial equipment	PE
Accelerator	Commercial	Power	M, PE
University	Academic, commercial	Power, heat, transport	PE, M, D
University	Academic	Power, electrical	PE, M, D
University	Academic, commercial, industry engagement	Digital, transport	PE, M, D
Trade association	Operations manager	Digital, transport	PE
Government	Skills development facilitator	Power	N/A
Accelerator	Operations manager	Transport	PE
Trade association, university	Academic, skills development expert	Multiple	PE, M, D
Trade association, SME	Engineering, operations manager	Transport, power	PE, M
Trade association	Industry engagement	Transport, electronic	PE
University	Academic	Multiple (mostly transport)	PE, M, D
Accelerator	Academic, commercial	Power	PE, M
Government	Commercial	Transport	PE, M

Source: ERM

Accelerated innovation and commercialisation

Summary

The DER Challenge has advanced PEMD technology readiness in the UK, but further targeted support is needed to overcome commercialisation barriers and sustain growth of the sector.

This section explores the impact of the DER Challenge on the rate of innovation and commercialisation of PEMD technologies (theme 1). Contributors highlighted the enabling role of the DER-ICs. During Phase 3 we were told that there was a low level of awareness of the DER-ICs among industry, which meant they had a limited profile. Since Phase 3, enhanced engagement activities and the translation of R&D into practical solutions for players within the UK PEMD space has led to the DER-ICs gaining greater recognition among industry players. Despite this progress, DER challenges remain, particularly concerning the geographical spread and operational rules of the DER-ICs, which have sometimes led to competition rather than collaboration. We were told that this has limited the DER Challenge's ability to unlock the full commercialisation potential of PEMD solutions.

The DER Challenge's emphasis on manufacturing capacity has helped advance the manufacturing readiness of research and development (R&D) in the UK. However, the DER Challenge has not always provided all of the necessary market connections to enable the full market potential for technologies developed. Participants felt this limitation was more a reflection of the DER Challenge's scope than a shortfall in its objectives. We were told that the relatively modest budget for the DER Challenge and the broad sector coverage constrained the DER Challenge from making substantial contributions across all PEMD application sectors. It is therefore unlikely that the industry has reached a point where it is self-sufficient and it will be unlikely to continue to grow organically without further support.

Stakeholders emphasised the critical role of future public and private support in sustaining innovation and accelerating the commercialisation of PEMD technologies in the UK. Multiple stakeholders expressed concerns about the sustainability of DER-ICs after the conclusion of the current DER Challenge.

Facilitating industry engagement through the DER Challenge

Industry awareness and engagement with DER-ICs have increased since the last phase of the evaluation.

It was noted during Phase 3 that there was a low level of industry awareness of the DER-ICs (among players not directly involved with the DER Challenge). We were told that DER-ICs were generally not well known unless companies had worked with them or sold them equipment directly.

However, as reported by several stakeholders during the latest phase of the evaluation, there is now a better general understanding of the roles and activities of the DER-ICs among industry players. The DER Challenge has facilitated the establishment of facilities and made expertise accessible. This has significantly simplified industry engagement with research and academia. This engagement is crucial for translating R&D into actionable insights for UK companies involved in the PEMD sector.

"*What is needed from an academic perspective is to take the world-leading work that we are genuinely doing and translate that into [practical solutions for] the wider world. So, I think, from my perspective, […] the DER Challenge helped to do that at a time where capital expenditure was really difficult to justify for companies. The capital expenditure that was made through the DER-IC program has really […] catalysed that industry engagement. People coming to use manufacturing and testing facilities that we've been able to put in place.*" (Academic and commercial industry representative)

Limitations of DER-IC facilities in unlocking full commercialisation potential

The DER-ICs' geographical spread and equipment use rules may have limited their supportive role within the PEMD sector.

During Phase 4, an industry representative acknowledged the supportive role played by the DER-ICs. However, they also argued that the potential of the DER-ICs has not been fully harnessed. This was because it was challenging for project developers to utilise equipment across different centres. We were told that geographical spread and parallel activities may be leading to competition among centres rather than fostering a coordinated support system for the PEMD sector.

"So the geographical basis doesn't always work: if you are getting people in the North West and another cluster in South Yorkshire, they are going to start competing against each other, which isn't necessarily what you want. We've seen it with the High Value Manufacturing Catapult centres, how they are all spread in satellite offices over in Lancashire and places like that [...] It's land grabs, almost literally, and it's not necessarily good for policy. I think it has to be capability based." (Operations manager at trade association)

Rather than aiming to distribute investment across UK centres, two interviewees reflected on whether investment into fewer larger 'clusters' (where there already was a level of technical capability usually associated with an academic institution or cluster of companies) would have been more effective in driving innovation and commercialisation of PEMD technologies. If the DER-ICs, key manufacturing centres and organisations had been more concentrated, shared technology development and upskilling efforts could have provided reassurance for long-term employment while reducing companies' technology costs. One academic added that the UK PEMD sector could have benefitted from a single larger central DER-IC location to achieve economies of scale.

"The problem is that, if we're trying to do things fairly, as such, you end up with reasons for competing against each other." (Trade association representative)

Focusing on expanding manufacturing over commercialisation of PEMD solutions

The DER Challenge has addressed the technological advancement of PEMD solutions. It has been unable to enable all possible market linkages for their commercialisation.

Those interviewed in Phase 3 and Phase 4 generally agreed that DER Challenge funds were supporting the development of technologies in the middle stage of the innovation funnel (mid-TRL). While Phase 3 interviewees had mixed views on the intended impact area of the DER Challenge, multiple interviewees in Phase 4 agreed that the DER Challenge's scope was clear in its aim to enhance the manufacturing capacity of PEMD in the UK. We were told that more time is needed to demonstrate clear progress with respect to the commercialisation of PEMD technologies.

"*I think it might be a bit early to quantitatively measure the impact. […] As soon as you make a decision and you do something, it takes 5 to 10 years to have an impact. So I think it's* *important that you keep doing this [evaluation], probably year on year, and seeing if the needle is moving.*" (Engineering operations manager at an SME and trade association)

The DER Challenge's emphasis on enhancing manufacturing capacity is also beneficial to advancing the R&D capabilities in the UK. However, we were told that focusing on manufacturing risks overlooking critical stages of market introduction, which are vital for the commercial success of new technologies. A commercial director at an accelerator DER challenged whether DER's focus on the manufacturing readiness level (MRL) was the right approach, arguing that a funding programme that addressed both technology readiness level (TRL) and MRL would have been better able to foster innovation and attract the additional investment necessary for PEMD innovations to reach the commercialisation stage (beyond TRL 7).

Low budget as key limitation to the commercialisation of PEMD technologies

The limited amount of DER funding made available may not have been sufficient to significantly boost the UK's PEMD commercialisation rate.

An operations manager at a trade association noted that the DER had appropriately targeted early demonstration stage technologies to advance their TRLs. However, they also noted that the DER Challenge fell short in providing sufficient investment to enable their commercialisation. We were told that in some cases the support offered via the DER-ICs was very limited compared to actual needs. We were told that this was particularly evidenced for training.

"The investment is very tight, funding-wise, to achieve what we're trying to achieve in the DER-ICs. Although it's a good area to be in [mid-TRL area], but the realisation is that that area requires considerable funding and support to get it to the higher TRL." (Leader of trade association)

The size and focus of the investment were subject to critiques from some contributors, who pointed to the UKRI-led Faraday DER Challenge[82] for battery development in the UK as a programme that received significantly more funding than DER and had an alternative approach to its distribution and use. A skills development expert at a trade association noted that the Faraday Institution has significantly advanced battery development in the UK, making it a key player in the battery supply chain. We recognise that, when comparing the available budgets of the DER (£78 million) and Faraday (£610 million[83]) DER Challenges, it is not surprising that the former might have had more difficulties in accelerating the rate of innovation

[82] For battery research, innovation and scale up.

[83] https://www.faraday.ac.uk/faraday-institution-battery-research-moves-to-next-stage-of-commercialisation/#:~:text=The%20Faraday%20Battery%20Challenge%20(FBC,and%20national%20scale%2Dup%20infrastructure.

and commercialisation of technologies within each of the power electronics, drives and electric machines supply chains than the latter within the battery sector.

A larger budget for the DER Challenge could have contributed to both increased commercialisation and manufacturing of PEMD innovations. An industry representative claimed that the limited funding available had led to particularly hard-to-justify exclusions of high-value projects during the funding allocation period. In addition, an academic added that, from an R&D perspective, there was a frustration as many low-TRL projects were not able to be funded.

Broad sector focus as additional limitation to the commercialisation of PEMD technologies

The DER Challenge has mostly supported transport-related projects but has had a wider application outreach.

In Phase 3, there was some criticism that the DER Challenge portfolio was biased towards the transport sector. Our analysis showed that 68% of projects awarded by 2022 were transport related. Two years later, the evaluation team reports that this proportion has fallen significantly. Now, 45% of all DER projects awarded since the DER Challenge's inception solely target the transport sector.

Stakeholders interviewed in Phase 4 noted that the DER programme has also had substantial impacts on other (non-transport) sectors, e.g. the power sector. The DER Challenge's initial focus on the transport sector is likely to reflect the sector's early adoption of PEMD innovations, particularly in the automotive segment. This early adoption plays a crucial role in de-risking and driving the uptake of PEMD technologies across other industries.

However, the limited budget available to the DER Challenge was not sufficient to make significant contributions in each of the PEMD sectors and their potential applications.

In Phase 3, the broad focus of the DER programme was praised by some stakeholders. Its flexibility in accelerating commercialisation of different PEMD technologies was seen as an advantage. However, contrasting opinions from both Phase 3 and Phase 4 stressed how there is also a risk of spreading limited resources too thinly across the different PEMD application sectors.

> *"DER has a very wide range of technologies and manufacturing [scope] […] when you put it next to something like Faraday which has a much inherently narrower scope."* (Academic)

This lack of specialised, tailored support is also relevant within the context of the DER-ICs through which the majority of the DER funding (£33 million) has been disbursed. In the latest phase of the evaluation, centres were criticised for lacking specific expertise, especially in relation to the operation of the equipment made available for project developers. We were told that the DER-IC staff often needed to engage with equipment suppliers or external technology experts to provide ad-hoc support to the awarded projects. These gaps in expertise and support might have been less likely if the DER had a narrower focus, allowing for more concentrated and specialised resource allocation.

One university professor suggested that different funding mechanisms tailored to the different PEMD application sectors would have best addressed the different levels of innovation and commercialisation needs of PEMD technologies. However, the key limiting factor for this was the small budget that UK Research and Innovation (UKRI) had to develop a sector as complex as PEMD.

“DER did not have a lot of money, but it spent what it had wisely.” (University professor)

The PEMD sector needs continued support after the DER Challenge

Continuous public support is crucial for sustaining innovation and accelerating the commercialisation of technologies within the PEMD sector.

In Phase 3 interviews, business leaders emphasised the necessity for continued support for new PEMD technologies and capabilities initiated by the DER Challenge, even after the programme's completion, and in Phase 4 this appeal continued. They argued that, while government expects industry to fund late-stage innovation, this expectation is contingent upon a stable and supportive policy environment. These leaders believe that the DER Challenge should be integrated into a long-term industrial strategy with sustained government funding and policy measures. However, in this stage of the evaluation, an academic highlighted a critical concern: government projects often lack a long-term outlook and typically conclude once funding is terminated. Such concern was shared by a policy representative who stressed the importance of ensuring continuity of support towards PEMD to build on the successes of the DER Challenge. This is because speed to market is key, and the opportunities enabled by the DER Challenge need to be taken forward rather than left to stagnate.

“The really important bit in all this post-DER stuff is that no doubt you've deployed the foundation, but how to build the bricks on top of it and to build a house, what are the next steps?” (Engineering operations manager at an SME and trade association)

Both commercial and investment support are needed to build on the DER Challenge’s successes.

Stakeholders felt that DER established a solid foundation for advancing the technology readiness of various PEMD manufacturing solutions. However, transitioning from TRL7 to commercialisation is a very hard and expensive step that may require commercial exploitation as well as investment support.

“A lot of what has been done in DER has funded a growth of TRL level in many different areas. The gap that remains then is even bigger, call it crossing the chasm to get from TRL 7 to a successful product. [...] Funding innovation is very important, it's a very necessary step, but it's actually typically the cheapest step. It's the commercialising and gearing up that's actually more expensive. So how do we build on this to make sure that in the future [...] the

ecosystem is either there or we've supported the ecosystem for companies to prosper?" (Industry representative)

The DER Challenge kickstarted the commercialisation process by catalysing commercial links between project stakeholders involved in technology development, product manufacturing and market outreach. However, substantial follow-on support is needed. An industry panellist supposed that the establishment of an online platform for the sharing of technology advancements and lessons learned during the DER programme would be an easy-win mechanism to foster the commercialisation of PEMD technologies initiated by the DER Challenge. This could help connect funded project developers to industry players beyond the DER programme.

However, there is a significant funding gap associated with the commercialisation and scaling-up of PEMD technologies. A trade association's representative argued that venture capital and other private investors may be able to fill such a gap. In contrast, two industry and policy representatives emphasised the need for further public funding initiatives for PEMD beyond the DER programme. In particular, given that most innovative UK companies are in the product development stage, these stakeholders saw potential in further public funding to expand their manufacturing and meet their growing demand driven by the UK's electrification efforts. Existing innovation bodies, such as the Advanced Propulsion Centre (APC) and the Aerospace Technology Institute (ATI), already support technology development in the higher TRL range in the automotive and aviation industries. We were told that additional, ad-hoc support mechanisms are required to accelerate the rate of commercialisation within the other sectors targeted by the DER Challenge.

Some think the DER-ICs risk lacking enough backing to continue operations after the DER Challenge.

A primary goal of the DER programme is to achieve self-sustainability for the DER-ICs. Some stakeholders felt that perceived competition between DER-ICs and industry – multiple stakeholders claimed that companies are reluctant to pay for the DER-ICs' services (including equipment), as they feel they have already contributed to their establishment through taxpayer money – along with limited support beyond DER funding [84] means that the centres are at risk of depleting their financial resources once the programme concludes. This view was not universally held. An industry representative told the evaluation team that the costs associated with harnessing the DER-IC equipment are not overly burdensome and are aligned with industry.

Growing PEMD knowledge and skills base

Summary

[84] Note that the capital equipment provided at DER-ICs was indirectly funded by the grant awarded to successful project consortia under the DER programme.

Some improvements have been enabled by the DER Challenge in this area. There is still a need for enhanced communication of PEMD opportunities and a strategic, long-term alignment of R&D and industry needs to address skill shortages in the sector.

This section explores the impact of the DER Challenge on skills and knowledge development within the PEMD sector (theme 3). We highlight the growing trend of students pursuing PEMD studies in the UK but with an increase of international students and a growing reliance on foreign talent for the UK's R&D capabilities in PEMD. This is further complicated by strict visa regulations. The DER Challenge has helped attract more domestic students into this area. However, its impacts remain difficult to assess and quantify, and more time might be needed to establish a clear causality link. Additionally, stakeholders noted a shift of graduates from further studies in academia to industry (particularly to overseas companies). We were told that this is driven by high demand and competitive salaries which is beyond the direct control of DER but presents a DER challenge nonetheless for retaining academic talent and skills in the UK.

The section also covers the DER Challenge's initiatives to address skill shortages through retraining and upskilling. These efforts are limited by the DER Challenge's relatively small budget for skill development.

The slow growth of PEMD skills in the UK is further exacerbated by low awareness of opportunities among students and weak connections between university programmes and industry needs. The DER Challenge has increased awareness of PEMD opportunities. Attracting future talent at scale will require more substantial structural changes beyond the DER Challenge's capabilities. Improved communication of successful DER programme outcomes could demonstrate its benefits to the broader PEMD ecosystem. More time might be needed to showcase the successful contributions of the DER Challenge.

The section concludes by stressing that to ensure sustainable growth in this critical sector there is a need for:

- Better communication of PEMD market opportunities; and
- A more structured, long-term strategy to align academic output with industry needs.

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UK students vs. international students

The number of academics involved in PEMD is increasing in the UK, although driven by foreign students.

Overall, stakeholders agreed that there has been an increase in the number of graduates and PhDs involved in PEMD over the past decade. Two professors emphasised that relevant courses continue to be oversubscribed, which is evidence of the leading role that UK research still holds within the international PEMD sector. The total number of students is rising, but we were also told that the proportion of UK nationals taking PEMD courses in the UK is decreasing. Anecdotal evidence suggests that domestic students have been more likely to opt for digital fields in recent years. Conversely, the number of international students, particularly from China, is increasing. This is in line with findings from Phase 3 which highlighted a decline in UK nationals pursuing PhDs in engineering over the past decade.

Foreign PhD students increase the UK's R&D capability within the PEMD space. However, due to the increasingly complex visa requirements, multiple interviewees stressed that recruiting people from abroad is becoming increasingly difficult. Three academics reported that some foreign students would prefer to remain in the UK after completing their studies or PhD programmes to continue working in PEMD disciplines in industry or academia. However, stakeholders argued that the increasingly strict migration rules risk reducing the PEMD skilled workforce even more.

The UK must also compete for talent across various geographies, which could threaten its position in the international PEMD sector. However, more than one interviewee argued that the low retention of PhD students is not unique to the UK. The global shortage of PEMD skills is likely affecting the transfer of skilled engineers across sectors and geographies.

"I think there is a massive amount of opportunity in the UK, but it's not isolated to the UK… I'm aware of people going outside of the UK to meet needs elsewhere, as I understand [other countries] have similar problems." (Academic and commercial expert)

The DER Challenge may have helped attract more domestic students, but it is difficult to assess the impact.

The DER Challenge's funding to support skills and training provision has had a broad focus and a relatively limited budget. Funded activities include training programmes for school leavers, undergraduates and experienced engineers, as well as technicians looking to retrain in PEMD.

An academic interviewed in Phase 4 mentioned how the DER Challenge's efforts are noticeable across the wider PEMD ecosystem. Specifically, they highlighted an increase in the number of staff/students in the UK. However, it is difficult to measure the impact that the DER Challenge has had, especially because of concurring external events (e.g. Brexit) and the time lag in establishing clear impacts.

Transfer of skills from academia to industry

Most graduates abandon academia, driven by the soaring demand for engineers with PEMD skills within industry.

Multiple interviewees agreed that the rising demand for PEMD skills across different industry sectors is driving the shift of such skills from academic settings to the private sector, with many students receiving job offers before graduation. There are contrasting opinions regarding the location of the main employers of UK graduates. While two academics believed that most UK PhD students are hired by non-UK employers due to higher international salaries, a university professor claimed that head-hunters regularly secure roles for his PhD students in UK-based companies.

Most interviewees agreed that salary is a crucial factor for graduates when choosing a career path, especially given the burden of student loans. This makes it extremely difficult for academic employers to compete with industry and graduates are reportedly achieving salaries in industry comparable to senior professors in academia.

We recognise that the main objective of the DER Challenge is to help industry create the supply chains necessary to manufacture PEMD products in the UK by leveraging the country's strong R&D capabilities. Improving the UK's research in PEMD by retaining skills within academia is therefore not a focus of the DER Challenge, and a shift to industrial positions in the UK should support the DER Challenge's ambitions.

Shortage of experienced engineers as key DER challenge to the PEMD sector's development

The increasing demand for highly skilled engineers may outpace skills development efforts from the DER Challenge

Two years ago, Phase 3 respondents highlighted significant DER challenges faced by organisations within the UK PEMD supply chain in finding engineers with over ten years of experience. In Phase 4, respondents continued to emphasise the difficulty in meeting the demand for such experienced engineers.

The current need for experienced engineers is reportedly outpacing the ability of the DER Challenge to address this gap effectively. One stakeholder explained that the demand for expert and cross-disciplinary system engineers across the UK PEMD space is growing rapidly. As a result, these roles are increasingly difficult to fulfil due to the experience needed. Both industry and academia are stimulating the growth of PEMD skills in the UK, but there is a pressing need to continue to significantly accelerate skills development and retain that attracted talent to increase experience. While the impact of the DER Challenge is difficult to quantify, it is likely that, without the DER Challenge, this gap would have been even larger, further hindering the sector's growth and competitiveness.

Although the DER Challenge may have mitigated some of the skills gap, a skills expert noted that the pace of skill development is not as advanced as it once was.

DER-ICs have contributed to PEMD skills development in the UK, but limitations in project handling capability may undermine their potential benefits.

In Phase 3, the DER's crucial role in fostering skills training by providing access to state-of-the-art equipment through the DER-ICs was recognised. A skills expert interviewed in Phase 4 highlighted a significant DER challenge to the accessibility of this support. We were told that, in some cases, people who work at the DER-ICs managing the DER-funded equipment struggle to balance their efforts across multiple projects. These contributors are typically required to provide input to three to four different projects simultaneously, which dilutes their focus and undermines the impact of the DER Challenge on advancing skills within the sector. With their attention divided, the ability to mentor and develop the necessary skills within each project team is compromised. This issue suggests a need for revised resource allocation in some cases to maximise the benefits of the DER-ICs.

There is a concern that DER-ICs may be replicating industry's services, thus creating competition over the same skills.

In the latest phase of the evaluation, two interviewees noted that organisations outside the DER programme felt intimidated by the DER-ICs and were concerned about losing employees to these centres. Additionally, three interviewees argued that many organisations had already paid for services that DER-ICs would provide, e.g. product design, testing and validation, thus creating a competitive tension over the same engineering skills and roles.

An industry representative suggested that the DER Challenge should create incentives for companies to temporarily send engineers to DER-ICs to support awarded projects and hone their skills under the supervision of DER-IC contributors and with access to equipment. This approach could mitigate competition risks between industry and DER-ICs while ensuring the long-term employment of DER-IC contributors and the development of skills in industry.

Retraining needs and efforts within the PEMD space

Despite their high importance, retraining efforts have limitations and are difficult to implement at scale.

Most interviewees recognised that there is a pressing need for upskilling and reskilling to meet increasing demand for PEMD experienced engineers. However, most stakeholders shared a negative outlook towards retraining efforts, despite major job opportunities that exist across PEMD. Two trade association representatives highlighted a general concern that changing career paths often results in experienced workers moving to more junior-level positions. Additionally, a skills development expert pointed out the difficulty companies face in losing employees for long periods of retraining.

A skills expert argued that retraining programmes alone are not sufficient to boost new skills development in the UK. To create a suitable system for retraining, an industry representative stressed the importance of sharing both successes and failures from various approaches across different economic sectors over time. Exploring multiple retraining routes would be key to identifying suitable solutions across the PEMD sectors. For example:

- Retraining courses (e.g. doctoral training centres for PhDs) were cited as potential solutions to transform skills development in the UK, but uncertainty remains around their implementation, specifically regarding their format and funding source.
- Apprenticeship schemes, although created by policymakers to facilitate career changes, were criticised for not currently reaching the necessary audiences.

- Loan schemes could enable companies to retrain their employees without losing key members of their workforce.

A comprehensive strategy for reskilling would likely require a high-level policy plan, which is outside of the scope of the DER Challenge.

The impact of the DER Challenge's efforts to retrain engineers is uncertain.

One of the key objectives of the DER Challenge is to help fill the skills gap by retraining, upskilling and repurposing engineers into PEMD supply chains. However, some interviewees from both evaluation Phases 3 and 4 were not aware of the DER activities to upskill industry professionals and to retrain engineering students. An industry representative did report being aware of a Master's specialist course funded by DER.

We were told that no quantifiable difference could be noticed in the retraining of staff within the PEMD sector in the past two years. The evaluation team, however, recognised that most projects and initiatives that address reskilling were initiated in 2023 and are still ongoing.

Skills development is negatively impacted by the limited market awareness of PEMD

Improving awareness by showcasing the growing opportunities within the PEMD space is key to attracting talent.

There was a shared concern that the PEMD industry struggles to attract talent due to the perception of its limited application in industry, and therefore longevity of career prospects. This may be driven by the fact that the industry's diverse job opportunities and career progression prospects are not well understood. Changing the industry's image (i.e. to compete with the uptake in careers in digital) will be key to attracting talent to the PEMD space. This will require substantial changes at both academic and government level, which go beyond the DER Challenge's immediate goals.

A representative from a trade association highlighted that the poor image of the PEMD sector may be associated with the misalignment between academic curricula and the market needs. We were told that this could leave graduates unprepared for the job market. For example, a university professor noted that their mechanical engineering faculty was far more popular than electrical engineering, despite the job demand for electrical engineers outstripping that for mechanical engineers. Additionally, another stakeholder claimed that the absence of a clear linkage between manufacturers (operating equipment manufacturers – OEMs) of PEMD technologies and academia makes it harder for students to understand available market opportunities. This suggests that there needs to be a fundamental shift in how universities approach engineering education, led by the industry's demand for skills.

Improving the perception of PEMD technologies within wider society will require more substantial structural changes beyond the DER's scope.

The DER Challenge has facilitated connections among players within the PEMD sectors, but changes to the development approach of university courses take significant investment. In the short term, OEMs could also engage more actively with graduates to educate students about opportunities, and we recognise this is outside of the scope of the DER Challenge.

"[In the UK] we used to have significant manufacturing industries that spawned robust career paths through apprenticeship programmes, within OEMs, but also in the supply chain. You can't just create that demand from nothing, it's got to have a source and it's got to have a mechanism in place which generates this skill and talent and allows it to progress and, in turn, the technology to progress." (Business and skills development expert)

One university professor also noted that, to improve the diversity of academic courses and have a more tailored approach to PEMD, significantly more funding would be needed than was made available by the DER Challenge (£6 million to support skills and training provision). Coventry and Newcastle universities received some DER funding to develop tools and bespoke courses to boost skills and knowledge sharing around PEMD. This was viewed to be beneficial. However, the students' interests will ultimately determine whether such courses are viable for universities. Stakeholders reported that most universities currently prioritise digital and AI-related programmes over PEMD due to higher student demand and popularity.

Additionally, a skills development expert emphasised that the lack of industrial representation in central governments and absence of clear linkages between industry needs and policy were key barriers to attracting and retaining talent.

Better policy support is needed to demonstrate the sector's potential as a worthwhile industry and a structured process needs to be put in place to support the required skills development. Specifically, the lack of a responsible government department that understands and promotes the interests of the PEMD industry makes it hard for people to have a comprehensive overview of the sector. We were told that this is particularly detrimental for attracting young talent. More than one interviewee argued that, to significantly impact the current skills development space in the UK, there is a need for a long-term strategy which assigns specific roles to different entities within the PEMD ecosystem.

There is a need for the PEMD industry to enhance its appeal and stress its importance across the wider economy.

The need to sponsor and market the PEMD industry was reported by various stakeholders in Phase 4 as crucial to the wider economy. In particular, an industry representative questioned whether the PEMD industry needs a rebrand, suggesting it might not currently attract sufficient interest from investors or students, and a university professor proposed using terms like the '5th revolution' as effective communication tools to draw more attention to the industry.

Although potentially beneficial to the development of PEMD skills in the UK, we consider the above suggestions outside of the DER Challenge's scope.

The DER Challenge's communication efforts to boost awareness of PEMD

More effective communication of successful DER programme outcomes could demonstrate its benefits to the broader PEMD ecosystem and raise awareness about opportunities within PEMD.

The DER Challenge's communication and engagement efforts to date include organising webinars, providing newsletters to a targeted PEMD network, DER-IC representatives attending major industry events, publishing case studies on UKRI's website, targeted media outreach for coverage in sector-specific publications and magazines, and publishing annual reports with key information on awarded projects.

Despite the above efforts, multiple stakeholders from Phase 4 criticised the lack of clarity on the activities funded by the DER programme. Three interviewees criticised the limited publicising of successful skills development outcomes from awarded projects. Specifically, a university professor criticised the lack of public information regarding the skills development activities that resulted from the DER funding at Coventry University, which received the largest portion of the £6 million DER budget to support skills and training provision. We acknowledge that the Skills Hub at Coventry did not aim to deliver or create training through the DER funding, but to establish a platform, designed to run for at least ten years, connecting PEMD training and education course providers with employers and learners seeking to develop their skills. It is possible that a different outreach strategy could be more effective in demonstrating impacts to a wider audience.

"Although we're very close to Coventry University […] we don't really know what they're doing." (University professor)

"I would agree [with the above professor], has [the initiative at Coventry University] highlighted some gaps, […] where upskilling is required? Have we really seen any outcomes? No, I wouldn't say so." (Industry stakeholder)

The development of project success stories and technology developers benefitting from DER was flagged as an 'easy win' by one stakeholder. Publishing successful outcomes, as the Faraday DER Challenge does currently, for example, would showcase the benefits of the DER programme to the wider PEMD ecosystem. For example, one stakeholder argued that the DER-ICs have been able to foster a cohesive environment by aligning success stories of awarded projects that took place around Scotland.

However, more time might be needed to showcase the successful contributions of the DER Challenge. Two interviewees noted that some excellent projects are ongoing, and there is still significant work that needs to be done before case studies can be developed which highlight their technical achievements and broader impacts. We recognise that at least 28 projects are still ongoing at the time of writing (July 2024).

Fostering a collaborative PEMD ecosystem

Summary

There is wide acknowledgement of the DER Challenge's positive contributions to strengthening collaborations across the PEMD space, despite some limitations in the DER Challenge's scope.

This section explores the role of the DER Challenge in promoting a collaborative framework within the UK PEMD sector (theme 5). Our engagement indicates a significant enhancement in system-wide cooperation facilitated by the DER Challenge.

Collaborations have helped organisations better understand and integrate into PEMD supply chains, thereby promoting key commercial links to accelerate technology commercialisation. Notable examples of companies advancing their role within the UK PEMD supply chain by leveraging the DER Challenge-enabled collaborations include:

- The Power Networks Demonstration Centre (PNDC), which, through the DER Challenge's funding, has developed a cohesive narrative around its PEMD capabilities, established strategic partnerships, and enhanced its equipment to support projects within the PEMD sector; and
- Vishay, whose plans to expand the UK's manufacturing capacity for advanced semiconductors and increase collaboration with UK entities are partly attributable to the DER Challenge's role in raising awareness and fostering the manufacturing readiness of the wide-bandgap semiconductor capabilities in the UK.

The DER Challenge has been the catalyst to join up PEMD in the UK and it has had an impact through enabling collaboration in industry. There are still concerns about how best, in practice, to take advantage of these opportunities to collaborate, i.e. where intellectual property (IP) ownership remains a barrier.

DER Challenge fostering collaboration

Collaborations across PEMD enable organisations to establish key links across different levels of PEMD supply chains.

At the time, Phase 3 respondents could not assess the level of collaboration within the PEMD sector enabled by the DER Challenge. During this phase of work, six interviewees from Phase 4 agreed that the DER Challenge had significantly accelerated system-wide collaborations between academia and industry and across different organisations involved in PEMD.

Only one respondent in the latest phase of the evaluation argued that there was no evidence to suggest that the DER Challenge has led to broader system collaboration.

We were told that, as a result of DER funding, project partners had gained a better understanding of supply chain structures and established essential connections to accelerate the commercialisation of PEMD technologies. By creating commercial links with downstream organisations, technology developers had advanced their innovations and unlocked their potential for deployment. This highlights the critical role of the DER Challenge in helping participants navigate and integrate into PEMD supply chains.

“The result of projects [that bring partners together to show how they can fit into the supply chain] may be or may not be that we create a supply chain, but what it enables you to do […] is understand actually how these companies could fit into a supply chain either in the UK or globally or wherever. […] We have to demonstrate where we can be part of a chip supply chain, and so I think that's an important role that the DER has played in those projects to say you have to think about what the supply chain looks like because we're weak on supply chains.” (Network facilitator at trade association)

Collaborations may occur across organisations involved within a specific PEMD application sector, as well as across different sectors.

Multiple stakeholders acknowledged that the DER programme had initiated valuable inter-sector interactions. One stakeholder noted that the DER programme had fostered community building, bringing together players from different sectors and facilitating communication and knowledge transfer.

However, an industry representative highlighted a significant slow-down in the number of cross-sectoral collaborations in the past two years, which may be related to the way funds were disbursed during the DER Challenge.

Example 1: DER fostered collaborations at PNDC

The DER Challenge enabled the Power Networks Demonstration Centre (PNDC) to establish key connections for accelerating the commercialisation of PEMD technologies in the power sector.

An industry representative argued that the DER programme had enabled the PNDC to develop a cohesive narrative showcasing its capabilities within PEMD and establish connections with supply chain players. This had enhanced PNDC's role in advancing innovative technologies. Additionally, DER had also provided PNDC with funding to establish capability to support the heavy-duty vehicle sector and Power-to-X (PtX) technologies.

It is difficult to estimate the exact number of projects and collaborations that have resulted from the DER investment. Nevertheless, interviewees generally agreed that its influence has been evident. Notably, DER has enabled PNDC to establish a new strategic partnership with the Compound Semiconductor Applications Catapult for the sharing of know-how regarding PEMD.

One notable outcome of the increasing relevance of PNDC’s role in PEMD is the inward investment received from Analog Devices (now a key partner of PNDC). This has led to the installation of key equipment at the centre.

Example 2: DER fostered collaborations at Vishay

The DER Challenge has helped to leverage the UK strong R&D capabilities to attract large international investments needed for establishing a UK-based supply chain of advanced semiconductor technologies.

In March 2024, US chipmaker Vishay acquired Newport Wafer Fab for £144 million.[85] The new owner is collaborating with the DER-IC centres in South Wales and with the University of Warwick to expand the facility's capacity and accelerate silicon carbide (SiC) and gallium nitride (GaN) semiconductor production and technology development.[86] By raising awareness and fostering the manufacturing readiness of wide-bandgap semiconductor capabilities in the UK, the DER Challenge facilitated the collaboration of the UK entities with the major chip manufacturer.

> *"What we did with Vishay was quite a good case study and you know it's a billion-pound investment into the UK, which wouldn't have happened without some of the investment we have from DER and those projects funded by APC. There's a direct correlation between those things."* (University professor)

IP strategy and collaboration

IP ownership sharing remains a key concern for organisations collaborating on projects, but this cannot be solved by a funding programme like the DER Challenge.

In both Phases 3 and 4 of the evaluation, concerns were raised about the ownership of IP potentially hindering collaboration between PEMD organisations. The PEMD sector is highly standardised, with numerous patents and significant barriers to IP ownership sharing. Aside from providing clear templates for managing IP in the case of collaborative projects, the DER Challenge has not provided particular support regarding IP. However, the DER Challenge cannot do much more to alleviate this concern.

An industry representative interviewed in Phase 4 suggested that a new approach to standard creation for PEMD could be needed. This should aim to create an environment where digital tools and innovation copies can be used freely, which in turn could foster collaboration and minimise IP concerns. However, this approach falls outside the scope of the DER Challenge.

Increased value of investment in UK PEMD companies

Summary

The DER Challenge has sparked increased investment in the UK PEMD sector. It faces DER challenges in attracting further private investments and creating commercial pathways.

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[85] https://www.uktech.news/deep-tech/vishay-newport-wafer-fab-20231108 The UK Government forced its previous owner Nexperia to sell the company under national security rules

[86] https://newportvishay.co.uk/2024/03/08/vishay-intertechnology-to-acquire-nexperias-newport-wafer-fab-for177-million-2-2/

This section examines the role of the DER Challenge in catalysing investments in the UK PEMD sector (theme 4). Stakeholders expressed uncertainty regarding where the DER investments have been deployed, which hinders attempts to measure any causal impact. However, there are signs of heightened investment flows into PEMD, helping SMEs and startups to move up the value chain. Notable co-investments include significant funding secured by Clas-SiC Wafer Fab and the PNDC. More time may be needed to more comprehensively assess the level of investment leveraged by the DER Challenge.

Some DER challenges persist, particularly in attracting additional private investments needed to commercialise PEMD technologies. We were told that this is due to relatively low public funding levels, which could de-risk investments and limited commercial demand for technology developers' products. While the DER Challenge is not responsible for the former, its role in mitigating the latter is inconclusive: some stakeholders argued that the DER Challenge fails to enable mechanisms that can open market opportunities; others believed the low level of investments in PEMD is due to external factors to the DER Challenge.

The section also highlights the need for a strategic shift towards fostering market opportunities and securing stronger public support to sustain the sector's growth. A comprehensive policy framework may be necessary in this context.

Leveraging DER investments in PEMD

There are clear signs of increased investments into PEMD. Attribution is challenging.

During Phase 3 of the evaluation, interviewees claimed that it was too early to comment on the derived value of the DER Challenge's investments. Similarly, in Phase 4, stakeholders claimed that it might still be too early to quantitatively measure the impact associated with the DER Challenge's funding.

Although it was not clear to all interviewees what activities had been funded by the DER Challenge, some stakeholders argued that, since the establishment of the DER programme, there have been very clear signs of finance flowing into the PEMD space. In particular, such investments have led various SMEs to move into production and startups to gain ground in the value chain. Such developments are partly attributable to the DER Challenge.

Notable examples reported by the interviewees of co-investments unlocked through the DER support include:

- Clas-SiC Wafer Fab raising £29.2 million in equity in 2022, with its latest deal in June 2022 totalling £25.7 million (after DER funding of £280k in 2020[87]); and
- PNDC leveraging £17 million additional investment from regional public funds and about another £7 million from commercial revenue streams (£24 million in total) since 2020.

[87] https://www.discover.ukri.org/clas-sic-case-study/index.html

Attracting additional critical investments in PEMD would require significantly more public support.

Leveraging private funds (e.g. venture capital funds) on top of public money is key to further stimulate innovation, accelerate commercialisation of PEMD technologies and increase production of PEMD-enabled solutions.

A respondent from a trade association argued that, in contrast to other geographies (e.g. China), building on public funding in the UK is particularly challenging due to the lower 'leverage' private investors can get in the country.[88] As noted in Phase 3, the significantly lower level of public support for the PEMD sector in the UK makes it harder to attract similar levels of private investment within the UK semiconductor manufacturing supply chain relative to the other geographies, e.g. Germany or the US. The main public investment mechanisms that support the PEMD sector's development in the UK are:

- The National Semiconductor Strategy (£1 billion by 2030);
- Horizon Europe Chips Joint Undertaking (£1.3 billion to be shared among EU Member States and the UK); and
- The UK Infrastructure Bank (only a small fraction of its total £22 billion financial capacity can be used to fund semiconductor manufacturers).

In comparison, the funding available in the EU amounted to €43 billion up to 2030 under the European Chips Act alone,[89] and to $280 billion in the US under the Chips Act.[90] This shows how the US is significantly more bullish than others about investing, and even the EU is exceeding the UK's investment by at least four times on a per capita basis.

An industry stakeholder highlighted that the public funding that is available in the UK is mostly directed towards R&D and early-demonstration levels. Despite the relatively low public investment in PEMD, the UK still hosts some world-leading semiconductor developers and is particularly advanced at innovation in this space. However, the R&D effort is not supported by strong scaling mechanisms, which prevents UK technology developers from attracting crucial additional investments for their development and from competing with EU companies or globally.

Difficulty in opening market opportunities

Linking commercial opportunities with technology development is a key missing piece within the UK PEMD sector.

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88 https://www.ippr.org/articles/now-is-the-time-to-confront-uk-s-investment-phobia

89 https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-chips-act_en

90 https://www.forbes.com/sites/brianbushard/2022/07/28/chips-act-passes-house-approves-280-billion-bill-to-boost-microchip-production-and-counter-china/

In the UK, public support and funding programmes have focused on technology development rather than creating business opportunities for PEMD technology developers. This results in a lack of clear commercial paths for innovators to feed into the UK PEMD supply chains and to sell to players within the wider market. Without clear exploitation routes, technology developers struggle to attract the necessary investment to scale up and commercialise their innovations.

An industry stakeholder stressed the need for mechanisms that allow organisations to access market opportunities more easily. In our view, this a crucial next step to build on the successes of the DER Challenge. While it has enabled organisations to understand supply chain structures, after receiving the DER-IC support, awarded organisations are not being introduced to companies involved in such supply chains, and so are struggling to reach them. Without clear commercial links, technology developers lack clear demand pools to support the commercialisation of their innovations. The evaluation team thinks the success of the DER Challenge in uniting the UK PEMD industry is an excellent foundation to continue to foster collaboration and investment but, following the DER Challenge, there needs to be more facilitation of technology developers to reach their target markets.

Due to the focus on technology development rather than commercial opportunities, one stakeholder argued that, for over a decade, the UK has prioritised building technologies based on global development trends and has only at a later stage identified the actual customers for these innovations. Reversing this approach to start with demand could help with market identification at the outset. A key DER challenge in the UK is locating accessible customers and investors who are closely connected to technology developers.

"You should then say, 'what do you really want in terms of motor, drive, electric solutions over the coming 10 years and [plan] how do we then work with this supply chain to be able to supply that?' That is the kind of thinking [that is needed]." (Director at an accelerator)

A business and skills development expert further argued how, without a clear commitment from government to support the development of a PEMD industry, accessing large markets from the UK is likely to be particularly difficult. Placing obligations on manufacturers to use a certain value of their product from UK sources or setting targets in terms of product efficiency thereby necessitating the selection of high-quality UK PEMD components were mentioned by some stakeholders as potential additional regulatory solutions to boost the sector. There is a relatively high return on investment requirement in the UK (often drawing a maximum threshold for payback period at five years, e.g. in the automotive sector), and so investments in the UK are considered too risky without government backing. One stakeholder mentioned that the slow turnover and high capital intensity that characterise the semiconductor space are the main reasons why many companies left the UK about 15 years ago.

One stakeholder did express doubt as to whether the DER programme did enough to stimulate local demand effectively.

Expansion of UK PEMD manufacturing capacity

Summary

The DER Challenge has enabled progress in the manufacturing of advanced semiconductors. A broader strategy may be needed to fully harness the UK's potential.

This section delves into the impact of the DER Challenge on the growth of the UK's PEMD manufacturing sector (theme 6). Stakeholders acknowledged that the groundwork for advancing the PEMD supply chain in the UK has been successfully laid. The DER Challenge has contributed to enhancing the supply chain for advanced power electronics, positioning the UK to capitalise on emerging market opportunities. The UK's overall manufacturing capacity for PEMD technologies remains fairly limited. The low budget available has been recognised as the key limiting factor for the DER Challenge, though, in the view of some stakeholders, the DER Challenge has failed to enable mechanisms that can open market opportunities for PEMD technology developers.

Although the DER Challenge has made a notable contribution to the manufacturing readiness of the UK PEMD sector, a broader, more strategic approach may be needed to fully realise the UK's manufacturing potential in the competitive global semiconductor landscape.

The DER Challenge's uncertain impacts on supply chain developments

Stakeholders disagreed on the magnitude of the impact that the DER Challenge has had in developing PEMD supply chains, though measurable outcomes may require more time to become evident.

Phase 3 respondents noted that the UK lacked a complete PEMD supply chain and that the DER Challenge funding was too recent to show any impact on the number of UK companies. A stakeholder from Phase 4 added that the DER Challenge lacks sufficient budget to make any substantial impact on the overall PEMD supply chain.

"It [development in PEMD manufacturing] would have probably happened on its own anyway, because people would have found ways of doing it if there was a commercial benefit at the end of it." (Industry retiree)

Another stakeholder interviewed in Phase 4 highlighted the DER Challenge's key role in kicking off the semiconductor industry in the UK, stating that the DER programme has facilitated the growth of both the semiconductor industry and the broader PEMD space.

A university professor pointed out that any potential improvements within the PEMD sector might be difficult to measure due to the absence of clear metrics to monitor the DER Challenge's impact. Another industry respondent emphasised that time is needed for the broader industry to perceive the results from DER funding. These responses from the interviewees point to a lack of a clear conclusion that the DER Challenge has contributed a material difference in growing the manufacturing supply chain yet.

Manufacturing capacity for power electronics

The DER Challenge has helped to lay the groundwork for the development of a supply chain for advanced power electronics, which is critical for the whole UK PEMD sector.

In Phase 3, the UK's position in the power electronics sector was considered weaker compared to countries like Germany. In terms of production, there were mixed views on whether the UK has the necessary expertise and infrastructure for high-volume semiconductor manufacturing. A university professor in Phase 4 raised the concern that companies developing power electronic solutions in the UK are largely dependent on international suppliers. In addition, most stakeholders agreed that the UK does not have a strong power electronics domestic demand compared to other geographies. The relatively low domestic electric vehicle (EV) production to date has driven the manufacturing of conventional silicon-based semiconductor components, and the demand for advanced semiconductors is mostly associated with the low-volume production of specialised high-quality, high-performance equipment, e.g. motorsport and aviation.

Development of an advanced power electronics supply chain was identified as crucial to the success of the broader UK PEMD supply chain. Contributors in Phase 3 emphasised that without such power devices – although they constitute only 10% of the total PEMD value chain – the remaining value may not be realised. Within the advanced semiconductor category, silicon carbide (SiC) devices are likely to be key for future EVs, while GaN devices will be key for solid-state circuit breakers used in data centres. Contributors from both Phases 3 and 4 acknowledged the UK's strong R&D capabilities and the progress in establishing a robust supply chain for SiC components, as well as the potential for GaN components to gain a foothold in next-generation semiconductor manufacturing in the UK.

In Phase 3, the evaluation team noted that, given the earlier stage of the advanced semiconductor market compared to that of conventional devices, there is more opportunity in SiC and GaN device manufacturing for UK-based new entrants. Phase 4 respondents argued that the UK is likely unable to compete head to head with China and the EU in the silicon-based semiconductor market, due to their already leading positions, but that there is an opportunity to establish a competitive advantage in global GaN supply chains. Stakeholders emphasised the role of policymakers in driving the demand pool for high-efficiency and low-emission UK produced products by setting high-quality standards for advanced power electronics devices.

"We don't manufacture things anymore in the UK, not in volume." (Industry retiree and skills development expert)

One stakeholder in Phase 4 argued that the UK should prioritise enhancing its global role in manufacturing GaN semiconductors. A stakeholder stated that the demand from data centres (where GaN transistors are increasingly replacing SiC-based devices for efficient power conversion and power supply) could increase to levels comparable to the expected demand for EVs in the future,[91] thus representing a very attractive market for the UK. The stakeholder stated that existing manufacturing facilities could be converted to increase the manufacturing capacity of GaN devices in the future.

The DER Challenge funding was praised for laying the groundwork for next-generation power electronics manufacturing. Stakeholders did note that the scale of investment was relatively modest. None of the stakeholders interviewed were able to comment on what more the DER Challenge could have done, given its limited budget, to enhance the production efficiency of high-power devices, which is necessary for competitiveness in domestic and international markets. It appears that there is potential for UK-based manufacturing of wide-bandgap semiconductors to attract further international investments, particularly if Vishay's production efforts in South Wales prove successful.

Manufacturing capacity for electric machines and drives

The manufacturing capacity for electric machines and drives is fairly limited in the UK, with recent growth and investments in the automotive sector challenging to attribute.

Contributors in Phase 3 described the manufacturing capacity for electric machines and drives as very limited in the UK and acknowledged the significant DER challenges associated with attempting to develop the associated value chains. In Phase 4, stakeholders observed growth in capabilities, particularly in the automotive sector at scales of 1-100 kW. Respondents were not able to definitively attribute this growth to the DER Challenge alone. Other supporting programmes running in parallel to the DER Challenge (in particular the APC's funding programmes for the Technology Developer Accelerator Programme, Collaborative Research and Development and Automotive Transformation Fund), were mentioned as key enablers for EMs and drives alongside the DER.

Since the last phase of the DER evaluation, we have identified general trends of improvement in the sector, especially within the automotive sector, exemplified by Ford's investment to increase the capacity of its Halewood plant[92] and JLR's i54 manufacturing site moving towards production.[93] Although these are signs of increasing electric machine and drive manufacturing capacity building in the UK automotive sector, they were not noted as direct impacts of the DER Challenge.

Environmental and policy spillovers

Summary

[91] ERM has not completed a market study to verify this comment.

[92] https://www.ford.co.uk/experience-ford/news/ford-invest-in-halewood--plant-to-scale-up-electric-vehicle-range#

[93] https://www.shropshirestar.com/news/business/2023/04/19/new-name-for-jlrs-wolverhampton-plant/

The DER Challenge has likely influenced the UK PEMD sector's policy landscape. A more cross-cutting, high-level strategy is needed to guide investment, boost demand and enhance sectoral collaboration.

This section explores the impacts of the DER Challenge on the UK's policy developments within the PEMD sector (theme 7). It highlights how the DER Challenge has provided some benefits in terms of PEMD sector developments despite the fragmented UK policy landscape. The DER Challenge has also been recognised for having contributed to some social and environmental benefits within the wider UK economy.

We discuss the DER Challenge's role in shaping recent policy developments, such as the UK National Semiconductor Strategy, and more generally raising PEMD's profile among policymakers. However, the causal link between the DER Challenge and broader policy spillovers remains unclear. Stakeholders highlighted the limited information publicly available about the DER Challenge's successes to date. However, future policies may be developed building on the successes of the DER Challenge, ensuring continuity of support for the PEMD sector.

Regional development mechanisms were recognised as crucial for boosting R&D capabilities within the UK PEMD sector and the broader UK economy. The budget available to the DER-ICs was considered too low to be able to make substantial impacts. In addition, a comprehensive high-level approach is reportedly needed to address the sector's multifaceted needs and drive future growth.

The DER Challenge's contribution to policy developments

The fragmentation of the UK policy framework has been a key limiting factor for the development of a PEMD sector.

In Phase 3, slow decision making by government and poor coordination between departments such as the former Department for Business, Energy and Industrial Strategy (BEIS) and the Department for Digital, Culture, Media and Sport (DCMS) on semiconductor issues were heavily criticised. Phase 4 respondents noted that this fragmentation has led to the UK PEMD sector being primarily driven by industry. The subsequent split of BEIS into the Department for Business and Trade (DBT), the Department for Energy Security and Net Zero (DESNZ), and the Department for Science, Innovation and Technology (DSIT) was cited as having increased the DER challenges associated with a non-unified policy approach.

A skills development policy officer interviewed in Phase 4 claimed that policymakers are slowly shifting from the idea that the UK PEMD sector can solely rely on international markets. In parallel, some Phase 4 stakeholders reported a growing need for a regional strategy for the UK PEMD sector to fill the gap left within the industry innovation space after the abolition of the regional development agencies (RDAs) in 2012-13.

"Do you know that one of the biggest problems that we've had was when they destroyed the regional development agencies? Scotland still got sort of something, and Wales have still got

sort of something. In the West Midlands, it just disappeared overnight, and they used to support strategic areas like the automotive industry in the West Midlands and they're not there anymore.” (University professor)

The nine former RDAs set up in the English regions were strategic drivers of regional economic development in their region. Their abolition was mostly driven by financial reasons following the 2008-09 recession.[94] They were replaced by 39 Local Enterprise Partnerships (LEPs), which had smaller budgets and, thus, limited power to generate local economic growth.[95] The LEPs were created to administer £1.4 billion in regional growth fund investments in three years; the RDA budget had been £2.3 billion annually.[96]

The LEPs were officially closed in April 2024. Therefore, the DER-ICs have the fundamental role for driving innovation in the PEMD space at regional level. Their budget of £33 million, allocated across the four centres, may also be a limiting factor in the DER programme’s effectiveness.

Despite the limited budget available, multiple interviewees from Phase 3 and Phase 4 complimented the DER Challenge on its hard work to support government efforts to fill the policy gap, working with different UK government departments. A policy representative in Phase 4 particularly praised the DER Challenge for having responded to its key objectives of driving technical advancements, while providing social and environmental benefits to the wider UK economy. We were told that the products and solutions that are being developed through the DER Challenge are expected to have positive impacts in terms of job creation and greenhouse gas savings.

In addition to these achievements, the DER Challenge has succeeded in raising the profile of PEMD issues at both the national and regional levels.

“Has it raised the profile at the UK and Sottish government level? Absolutely, and that’s why I think for me there’s been more of a political impact in profile raising, through the initial investment. Before [DER] only a few experts got it, but now, [the energy sector] does get [the importance of PEMD].” (Industry stakeholder)

The DER Challenge was noted by some stakeholders as a having influenced the development of some of the most recent policies rolled out in the UK targeting the PEMD sector, including the UK National Semiconductor Strategy.

UK National Semiconductor Strategy

94 https://www.bbc.com/news/10391326

95 https://yorkshireuniversities.ac.uk/2020/07/16/rdas-back-to-the-future/

96 https://lichfields.uk/blog/2024/march/26/a-lep-of-faith-the-end-of-local-enterprise-partnerships-in-england

The UK National Semiconductor Strategy is the key policy for developing the UK PEMD sector post DER Challenge, but its potential to foster commercialisation of PEMD technologies remains uncertain.

The UK National Semiconductor Strategy is a plan announced by the UK DSIT in 2023. It explicitly mentions the DER Challenge as one of the direct support mechanisms for the power electronics (PE) sector that contributed to the development of the new sectoral vision. It aims to advance the UK's position in the semiconductor industry and ensure its resilience in the face of global DER challenges. The UK government pledged to spend up to £200 million over the years 2023-25, and up to £1 billion within the next decade to foster the PE sector in the UK.[97] However, while the new Labour government is committed to the semiconductor industry, it has yet to guarantee the originally announced support.[98]

While not directly related to the success of the DER Challenge, one stakeholder made the point that the Semiconductor Strategy represents a key starting point for the development of the PEMD sector in the UK. It provides a high-level vision for the PE sector, which is much needed and the lack of which has been a barrier to progress of the sectors over recent years. However, numerous stakeholders criticised its effectiveness in driving the commercialisation of PE technologies in the UK. A trade association's respondent criticised it for being structured on the basis of the US Chips Act and the EU Chips Act, despite aiming for a more tailored approach to the UK semiconductor sector's characteristics. It was said that the strategy could have provided more clear indications of roles, activities and milestones for the sector, as DSIT did for the quantum technology space.[99] A university professor further argued that the strategy fails to address application sectors that are key for the current UK PE manufacturing industry, e.g. the power sector.

"Unless we want to spend billions and billions in a strategy, we should try and focus the funding on areas of which we have a world class capability already and not try and support every idea that comes up because it's interesting." (University professor)

To support the delivery of the strategy's objectives, a new independent organisation, the UK Semiconductor Institute, was announced in May 2024 following extensive engagement with the sector's stakeholders. By bringing together government, universities and the private sector, this institute may provide a cohesive solution to the fragmented framework of supporting mechanisms within the PEMD space, which an academic interviewee criticised for contributing to almost competing initiatives (e.g. UKRI's DER, TechWorks). The institute should support the key components of the National Semiconductor Strategy, aiming to provide the tools to scale up the UK R&D capabilities, establish a supporting framework for PE technology developers and provide a commercial entry point for international partners. The institute aims to facilitate IP access and foster PE skills in the UK. Currently, its potential

[97] https://www.gov.uk/government/publications/national-semiconductor-strategy

[98] https://www.politico.eu/article/britain-1-billion-chip-investment-risk-rachel-reeves-tighten-belt-semiconductor-industry/

[99] https://assets.publishing.service.gov.uk/media/6411a602e90e0776996a4ade/national_quantum_strategy.pdf

impacts on the commercialisation of PEMD technologies in the UK are uncertain. One stakeholder argued that a longer-term strategy and supporting framework is needed to ensure a clear development pathway for skills and manufacturing capacity within the PEMD sector.

The evaluation team recognised the essential role of the strategy and its associated institute in providing continuity of support for the PE sector after the DER Challenge. In particular, the strategy's objectives target some of the sector's main issues that have been reported in this document. By providing crucial additional investments and supporting tools, the strategy may be better positioned to mitigate DER challenges in relation to skills and manufacturing capacity. It is uncertain whether the strategy will effectively provide commercial links and stimulate demand for technologies within the PEMD sector which were recognised as key DER challenges in the previous report sections.

Other relevant policy developments

The DER Challenge's impact on broader policy developments in the PEMD sector remains uncertain, despite potential influences on initiatives like the Critical Minerals Strategy.

Stakeholders in both Phases 3 and 4 expressed uncertainty about the broader policy impacts of the DER Challenge beyond the Semiconductor Strategy, suggesting it may be too early to observe any policy spillovers directly attributable to the DER Challenge. Specifically, a Phase 4 respondent argued that policy developments usually occur in response to shifts in market equilibria, which may take five to ten years to unfold.

Many interviewees felt that there had been limited policy involvement and direct support for the PEMD sector since the DER Challenge was launched. Some Phase 4 interviewees believed that the DER programme might have influenced other policy developments in the UK besides the Semiconductor Strategy, including the Critical Minerals Strategy and its 2023 update.

The causal link between the DER Challenge and these policy developments remains unclear, with an industry stakeholder pointing out that limited communication about the DER Challenge's successes may make it difficult to establish a direct connection between its contributions and the accelerated commercialisation of PEMD technologies in the UK.

Lack of a comprehensive policy framework

A high-level strategy that coordinates investment efforts, guides industry stakeholders, boosts demand and enhances collaboration is reportedly needed for the development of the UK PEMD sector.

Interviewees from both Phases 3 and 4 emphasised the necessity for a cross-cutting, high-level strategy to consolidate investments and development initiatives for the commercialisation of PEMD technologies and to drive their demand across all relevant application sectors. Such a high-level policy framework should tackle all DER challenges within the sector that have not been addressed by current policies. Multiple interviewees argued that such a high-level strategy should consist of clear roadmaps that provide clear indications of what is needed and by when, to guide the supply and demand of PEMD technologies. This roadmap would foster commercial connections and enhance collaboration across the sector's stakeholders.

Stakeholders also noted that this proactive, structured approach, similar to strategies employed by other countries or sector-specific strategies developed by large manufacturers in the past (e.g. Bosch for the automotive sector), would provide a comprehensive pathway for advancing the PEMD sector by engaging all levels of the supply chain.

"How do you get the UK to buy UK? How do we send a message to the UK supply chain that if you want a sovereign UK-based supply chain, you need to look after it when you don't need it, else it won't be there for when you need it." (Industry respondent)

List of abbreviations

AI	Artificial intelligence
APC	Advanced Propulsion Centre
ATI	Aerospace Technology Institute
£m/£b	Million (£m) or billion (£b) pound Sterling
BEIS	Department for Business, Energy, and Industrial Strategy (UK)
DBT	Department for Business and Trade
DCMS	Department for Business, Energy, and Industrial Strategy (UK)
DER	Driving the Electric Revolution (DER Challenge)
DER-IC	DER Industrialisation Centre
DESNZ	Department for Energy Security and Net Zero
DSIT	Department for Science, Innovation and Technology
EU	European Union
EV	Electric vehicle
GaN	Gallium nitride
IP	Intellectual property
JLR	Jaguar Land Rover
kW	Kilowatt (103 W)

LEP	Local Enterprise Partnership
MRL	Manufacturing readiness level
OEM	Operating equipment manufacturer
PE	Power electronics
PEMD	Power electronics (PE), machines (M), and drives (D)
PEUK	Power Electronics UK Ltd.
Phase #	DER Evaluation Phase (3 or 4)
PNDC	Power Networks Demonstration Centre
PtX	Power-to-X (technologies)
RDA	Regional Development Agencies
R&D	Research and development
SiC	Silicon carbide
SME	Small and medium-sized enterprise
TDAP	APC's technology developer accelerator programme
TRL	Technology readiness level[100]
UK	United Kingdom
UKRI	UK Research and Innovation
US	United States

[100] https://www.nasa.gov/wp-content/uploads/2017/12/458490main_trl_definitions.pdf

Annex C Topic guides

C.1 Topic guide: project-based case study 1 – GaNSiC

1. Has the DER Challenge accelerated innovation and commercialisation of PEMD technologies
   a. Has the developed "GaNSiC" die-attachment process gained new customer interest driven directly (i.e. a result of the project completion) or indirectly (i.e. through being engaged with the DER Challenge) by the DER Challenge that might impact the scale of the application?
   b. Has Direct-Dispense increased its share of die attachment process technology?
   c. Have the planned customer projects other than GaNSiC been developed? What is their status? (7 originally Direct-Dispense projects)
   d. Have there been any further developments in the follow-on projects from GaNSiC, namely @FutureBEV, PE2M, EleVAIT, Future Drive? What is their status?
2. Did the DER Challenge lead to an expansion of UK PEMD manufacturing capacity?
   a. How many next-generation semiconductor units based on the Direct-Dispense technology could be made in the UK?
   b. What progress has GaNSiC Direct-Dispense made toward achieving this scale?
   c. Has the planned expansion of CIL's manufacturing capacity been realised?
   d. Note that a 24000ft2 capacity increase in CIL's manufacturing facility thanks to Direct-Dispense technology was noted, as well as a £12m cumulative expenditure for the new facility of 46000ft2.
   e. What impact, if any, do you think the DER Challenge has had on the technological improvement of manufacturing processes of power electronics in the UK?
3. Has the DER Challenge facilitated recruitment of staff with PEMD skills?
   a. Has the headcount in your organisations grown since the start of the project?
   b. In particular, if available, what is the number of new highly skilled positions and what are their roles?
   c. Note that a total of 300 people were expected by March 2024, with the growth quoted to be 50% due to the DER Challenge and new customer work.
   d. Is CSAC's in-house training module for its graduate engineers still in place?
   e. Have there been any new recruitments from this trained staff?
4. How has the DER Challenge changed the amount of investment in UK PEMD companies?
   a. Has CIL achieved its expected revenue growth since 2021?
   b. What was the revenue increase in 2023?
   c. Note that a 50% revenue increase in 2022 was expected compared to 2021.
   d. Did you receive any funding or in-kind support from other organisations or other public funding?

   e. Would this funding have been possible without the initial UKRI funding?
5. How has the DER Challenge affected a collaboration across the PEMD ecosystem?
   a. Have there been any changes in the number, quality, or effectiveness of collaborations since your engagement with UKRI with either UK-based or international PEMD players/customers?
   b. What type of engagement or collaborations have you been part of?
   c. How valuable are these collaborations?
   d. Did the DER Challenge play any role in enabling or facilitating these collaborations other than the funding?
6. What societal, environmental and policy spillovers has the DER Challenge created?
   a. In terms of the DER Challenge's impacts on the productivity of the UK PEMD supply chain, have there been any notable developments of UK based suppliers of capacity since 2022?
   b. CIL had mentioned that an innovation cluster was gaining momentum in the UK, on the back of the DER Challenge support, as part of which key players would engage in mutually beneficial conversations to enhance the joint knowledge base
7. More generally in the industry:
   a. Have there been any improvements in the efficiency of processes and/or products?
   b. Any increase in the recycling/re-use of materials?
   c. Any development of standards and regulations?
   d. What impact has the DER Challenge made on the productivity of the UK PEMD supply chain?
   e. How has the DER Challenge affected rate of innovation of PEMD technologies?
   f. How has the DER Challenge affected rate of commercialization?

C.2 Topic guide: project-based case study 2 – SCREAM

1. Has the DER Challenge accelerated innovation and commercialisation of PEMD technologies?
   a. What progress has the team made toward achieving the project objectives, in general?
   b. What pilot trials/prototypes has the DER Challenge enabled?
   c. What is their status?
   d. How does this compare with full-scale implementation? / What is the expected scale of the applications?
   e. What impact, if any, do you think the DER Challenge has had on the technological improvement of recycling processes of PEMD in the UK?
   f. What progress would the project have made without the DER Challenge (counterfactual)?
   g. Would there be, or has there been access to other funding routes?

   h. Would the progress have been as fast?
   i. Would the progress have been as comprehensive/smaller scale?
2. Did the DER Challenge lead to an expansion of UK PEMD manufacturing capacity?
   a. What is the expected scale of the application? (breadth of use across different applications/sectors/industries)
   b. What is the expected benefit in material supply from this process?
   c. How could this translate to UK made components?
   d. What is the progress towards achieving this scale?
3. Has the DER Challenge contributed to growing PEMD knowledge and skills in the UK?
   a. How has the DER Challenge affected the ease of recruitment of staff with PEMD skills by the project consortium members?
   b. In addition to funding, what key enablers has the DER Challenge provided to accelerate the deployment of the developed technology, e.g. equipment, relationships?
   c. How are these enablers important to the project?
4. How has the DER Challenge changed the amount of investment in UK PEMD companies?
   a. Did you receive any funding or in-kind support from other organisations or other public funding?
   b. Would this funding have been possible without UKRI funding?
   c. Have you established or are on track to establish a UK-based operation?
   d. Overall what is your perspective on inward investment in PEMD in UK?
5. How has the DER Challenge affected a collaboration across the PEMD ecosystem?
   a. How valuable are the collaborations with the other consortium members to your organisations? (e.g. opportunities for wider knowledge exchange, potential for other joint projects)
   b. Have there been any changes in the number, quality, or effectiveness of collaborations since your engagement with UKRI?
   c. Has the DER Challenge supported any knowledge exchange or networking events
6. What societal, environmental and policy spillovers has the DER Challenge created?
   a. Have there been any improvements in the efficiency of processes and/or products?
7. More generally in the industry:
   a. Any increase in the recycling/re-use of other materials?
   b. Any development of standards and regulations?
   c. What impact has the DER Challenge made on the productivity of the UK PEMD supply chain?
   d. How has the DER Challenge affected rate of innovation of PEMD technologies?
   e. How has the DER Challenge affected rate of commercialization?

C.3 Topic guide: activity-based case study – Midlands DER-IC colleagues

High-level understanding of the DER-IC site

8. Has the regional split of how the DER-IC operates in practice changed in the last 18 months or is it still:
    - a North-East = Newcastle + Sunderland = Motors and drives (technology); Integration and testing (stage of process);
    - b Scotland = Glasgow = High power/large scale PEMD (technology); Prototype and scale-up (stage of process);
    - c Midlands = Nottingham + Warwick = Manufacturing processes for power electronics and machines (stage of process);
    - d South West & Wales = Newport = Materials?
9. How have the main activities that you have undertaken at the DER-IC site evolved over the last 18 months? Was it the split of time/investment between these three activities?
    - a Offering firms the opportunity to test new processes with specialist equipment;
    - b Helping to connect firms with appropriate expertise within the four interconnected sites of the DER-IC, and their networks;
    - c Sharing information on funding and co-investment opportunities
10. How much of total £28.5 million investment has been spent to date?
11. How has the funding split across different activities evolved over the last 18 months?
    - a More emphasis on skills as time went on.
12. What types of firms do you tend to interact with? What part of the supply chain are they in? Where are they in terms of their development? How has this evolved over the last 18 months?
13. Has the DER Challenge made better use of the DER-IC in the last 18 months?
14. Of the types of activities that the DER-IC has been involved with to date, what bucket of activities has had the greatest impact in the last 18 months?
15. Looking forward, do you think it will be the same types of activities that have an impact going forwards, or will this change?

Equipment

16. When we carried out our previous impact evaluation we found that: (1) There were long lead times for the installation of equipment due to Covid-19 (2) Access to equipment has encouraged SMEs to innovate, and enabled larger organisations to improve their manufacturing techniques
    - a Is that still the case or have any other impacts emerged over the last 18 months?

b What impacts would you expect to materialise from this equipment in the future?

17. What equipment has been purchased in last 18 months? How does that differ to previous equipment purchased? Would any of this equipment have been purchased without the DER Challenge?

18. How have companies used this equipment over the past 18 months?

19. Can you give us an example of a company that has come in and used a piece of equipment in the last 18 months bought by either WMG or Nottingham University using DER Challenge funding?

20. Where do firms who come and borrow equipment tend to be in their development? Has this changed in the last 18 months?

Connecting firms

21. When we carried out our previous impact evaluation, we found that: (1) The DER-IC has raised the profile of the PEMD sector (2) The Midlands DER-IC connects firms to new entrants or organisations they have not collaborated with previously (3) The Midlands DER-IC has enhanced the interactions between industry and academia within the PEMD sector

a Is that still the case or have any other impacts emerged over the last 18 months?

b What impacts would you expect to materialise from this collaboration in the future? Have you heard stories of how this has helped firms?

22. What networking activities have you carried out in last 18 months?

a Do you think you have been able to improve the number or strength of connections that PEMD companies have, and how?

b What impact do you expect the ability to make these sort connections is likely to have in the future?

c How has the DER Challenge changed your ability to connect firms in this way?

23. Can you think of an example of firms you have connected with in this way over the last 18 months?

Skills

24. When we carried out our previous impact evaluation, we found that: (1) The Midlands DER-IC contributes to projects by providing its technical expertise (2) Being able to rely on the Midlands DER-IC's expertise has encouraged firms to be more ambitious in their project bids (3) The Midlands DER-IC promotes tutorials and skill activities

a Is that still the case or have any other impacts emerged over the last 18 months? Has any expansion taken place?

b What impacts would you expect to materialise from this skills work in the future? Have you heard stories of how this has helped firms?

25. Would these activities have been possible to undertake in the absence of the DER Challenge?

26. Have these activities contributed to a reduction in existing skills gaps or lowering of skills shortages as a barrier?

27. How could this skills work create further impacts in the future?

Sharing funding information

28. When we carried out our previous impact, we found that: (1) Firms are more likely to be successful in winning bids if they partner with the Midlands DER-IC (2) The Midlands DER-IC actively signposts firms to funding opportunities (3) Even if firms do not necessarily have a project planned the Midlands DER-IC encourages firms to come up with new beneficial projects

    a Is that still the case or have any other impacts emerged over the last 18 months?

    b What impacts would you expect to materialise from this signposting work in the future? Have you heard stories of how this has helped firms?

29. How have you been able to help firms by sharing funding information in the last 18 months?

30. Do you think you have made it easier for firms to secure investment in the last 18 months?

31. Would you have been able to help firms in this way without the DER Challenge? How?

Specific firm/project interactions

32. We are trying to look at the impact of the DER-IC on firms so far, compared to what they would have done without the DER-IC, while also thinking about the expected future impacts of the DER-IC. During our last evaluation we spoke to:

    a AMPS

    b Electrical Cooling Solutions

    c McLaren Applied

    d Ricardo

    e Project Hairpin collaborators

        a Cummins

        b GKN Automotive

        c Nottingham University

        d Motor Design Limited

33. What stage is Project Hairpin at?

34. Have those firms continued to work with DER-IC over the last 18 months? Are their respective projects still active?

35. Do any other particular firms come to mind that you would suggest we speak to?

C.4 Topic guide: activity-based case study – firms engaging with the Midlands DER-IC

Overview (25 mins)

36. In a few sentences, can you give me a brief introduction into what your company does?
37. How does PEMD technology interact with your other activities, and how important is it to your overall activities? Where do you sit in the PEMD supply chain?
38. How long have you been working with WMG/DER-IC? What activities do they help you with?
39. Is it clear to you what parts of your activities with WMG are made possible by the DER-IC?
40. What interactions have you had with the DER-IC since 2019? What interactions specifically have you had in the last 18 months?
41. At a high-level, how have these interactions affected how you/your company operates?
    a. Have any of the connections that you've made through WMG/the DER-IC been pivotal to any innovations or productivity improvements that you've been able to make? Have they helped you expand or increase the level of investment you receive?
    b. Have you had any opportunities to trial equipment? Has trialling the equipment led to productivity gains or impacted any investment decisions? Has it led you to incorporate new processes or expand the work you do?
    c. Have you discovered new funding opportunities through the DER-IC?
    d. Has the DER-IC shared expertise or contributed to reduction in skills shortages?
42. Do you know how your activities/interactions would have been different if WMG were not part of the DER-IC?
    a. *Would you have been able to make those or similar connections? How would you have tried to replicate those connections?*
    b. *Would you have bought any equipment without trialling it? Would there have been alternative solutions to you trialling the equipment at WMG?*
    c. *Would you have put more resources into finding funding opportunities yourselves, or been able to find suitable alternatives?*
    d. *Would you have had access to similar forms of expertise? Would you have been as ambitious in applying for collaborative projects that were outside your core skillset?*
43. Do you know what you would have done without the support of WMG?
    a. *Would you have been able to make those or similar connections? How would you have tried to replicate those connections?*
    b. *Would you have bought any equipment without trialling it? Would there have been alternative solutions to you trialling the equipment at WMG?*

c. *Would you have put more resources into finding funding opportunities yourselves, or been able to find suitable alternatives?*
d. *Would you have put more resources into finding external expertise or upskilling your staff directly?*

44. Apart from the points already mentioned, have you had any other interactions with the DER Challenge?

Impacts (15 mins)

45. **Innovation**
    a. What kind of external support have you received to help commercialise new technologies in the last 18 months?
    b. Has the DER-IC/WMG helped to innovate your activities or develop/commercialise new technologies? How/through what activities?
    c. Has it had an impact on any pilot programs you've been working on?
    d. Do you expect the DER-IC/WMG to continue to help in these ways?
    e. What do you think you would have been able to achieve in terms of innovation without the DER-IC/WMG?
    f. What longer term impacts on innovation do you expect to materialise in the future?
46. **Productivity**
    a. Has the DER-IC/WMG helped to improve your productivity by increasing the amount you can produce? How/through what activities?
    b. Has the DER-IC/WMG helped to improve your efficiency, or change your productivity by bringing down input costs? How/through what activities?
    c. Do you expect the DER-IC/WMG to continue to help in this way?
    d. How do you think your productivity would have changed without the DER-IC/WMG?
    e. What long term productivity effects do you expect to see in the future?
47. **Investment**
    a. Has the DER-IC/WMG helped to increase the amount of investment you are receiving or made it easier to receive that investment?
    b. If yes, what kind of investment (public, overseas, UK)?
    c. Was this by providing you information on funding opportunities or through facilitating connections (or something else)?
    d. Do you expect the DER-IC/WMG to continue to help you access investment?
    e. What investment do you think you might have received without the DER-IC/WMG?
    f. What co-investment did your organisation provide for the DER-IC project?
48. **Skills and ecosystem**
    a. Has the DER-IC/WMG helped to improve your skills/capabilities internally?

b. Was this through the direct training on pieces of equipment, or through the connections they helped you to create?

c. If connections, who are these connections with (other PEMD companies, different sectors, different technologies, academics, SMEs)?

d. Do you expect the DER-IC/WMG to continue to help you build skills and a network?

e. How do you think you could have improved your skills and expanded your network without the DER-IC/WMG?

49. **Expansion**

a. Has the DER-IC/WMG helped you to expand the activities your firm carries out (either through doing a higher volume or through launching new products)?

b. How/through what activities has the DER-IC/WMG helped this?

c. Has this changed your growth projections for the future?

d. Has this meant you are taking on any additional employees?

e. Do you expect the DER-IC/WMG to continue to help you expand?

f. Would you have been able to expand at all without the DER-IC/WMG?

g. What other longer-term impacts would you expect to see in the future

C.5 Topic guide: thematic case study

50. Has the DER Challenge accelerated innovation and commercialisation of PEMD technologies?

51. In the last interviews, the shared perspective was that the DER Challenge funds only supported the development of technologies in the middle stages of the innovation funnel.

a. Has your perspective towards the DER Challenge's aim changed?

b. Do you think the DER Challenge is still developing the same stage companies/activities?

c. Are these the right stage technologies to focus on developing?

d. Do you see that there is continued support (either within the DER Challenge, or from other programmes) for technologies being developed and commercialised? – such that DER Challenge investments are given best chance of successful implementation/commercialisation.

e. In the last interviews and analysis of the projects, it was stated there was a bias towards the transport sector within the funded projects up to 2022, with fewer energy sector-related projects being awarded.

f. Do you think the sector focus of the DER Challenge funding has changed since then?

g. Is the DER Challenge spread too thinly across the technologies? Or was this breadth of focus appropriate?

h. It was stated that a lack of resources can prevent innovation, and the DER-ICs can be a valuable resource to support the overcoming of development hurdles.

i. How well known is the DER-IC support to companies within the PEMD space? Has the visibility or profile of the DER-ICs increased over the last 1-2 years? Why/why not?

52. Has the DER Challenge contributed to growing PEMD knowledge and skills in the UK?

53. *Relating to a lack of domestic talent to fill positions companies in the sector are looking to fill.*

    a. Has there been an increase in the PEMD positions filled by UK staff?
    b. Have PEMD positions been filled by UK staff, or is recruitment still coming from overseas?
    c. Is there a perception of skills as a barrier to expanding the PEMD supply chain?
    d. To what extent is this related to the support of the DER Challenge?

54. *Relating to uptake of university courses.*

    a. Has the DER Challenge improved awareness of PEMD career opportunities?
    b. Has there been a noticeable change in engineering undergraduate applications? What about disciplines at specific universities?
    c. Improvements in gender balance or other diversity improvements in the sector?
    d. Has any notable transfer of skills from industry to academia, or vice-versa, occurred?
    e. To what extent is this related to the support of the DER Challenge?

55. *Relating to retraining skilled staff whose disciplines are becoming obsolete.*

    a. Is any quantifiable difference being noticed in the retraining of staff within the PEMD sector, to facilitate transition to a Net-Zero economy?
    b. What are your opinions of a strategy for distributed spending and support, vs concentrated focused support?
    c. To what extent is this related to the support of the DER Challenge?

56. Has the DER Challenge helped foster a collaborative PEMD ecosystem?

    a. Is there evidence to suggest the DER Challenge has led to wider system collaboration?
    b. Are you aware of any significant examples that the DER Challenge may have played a role in (in particular from the last 1-2 years)?
    c. Is the ownership of IP still a common concern/barrier for collaborating partners within the PEMD space?

57. Has the DER Challenge increased the value of investment in UK PEMD companies?

    a. Has there been an increase in investment in companies within the PEMD? Has that come from public funding or other private investors?
    b. What are the perceptions of easiness of securing investment and follow-on funding
    c. How did the DER Challenge contribute to this?

58. Did the DER Challenge lead to an expansion of UK PEMD manufacturing capacity?

59. *Previous interviews commented on the supply shortages for critical components and the UK's relative competitiveness to neighbouring or other major economies/countries.*

   a. Has the UK's position changed in the previous 18 months?
   b. R&D vs manufacturing: Well understood that the UK has a strong R&D programme, but has there been any improvement in the foundations for an equally strong PEMD manufacturing sector?
   c. How has the DER Challenge contributed to this? / What are the other drivers?
   d. Has the UK PEMD supply chain developed since 2022?
      i. Any increase in the number of UK based PEMD companies?
      ii. Any increase in (establishment of) manufacturing capacity? In what components?
   e. Any increase in supply of raw materials?
   f. How has the DER Challenge contributed to this? / What are the other drivers?
   g. Establishment of skills relating to manufacturing in PEMD specifically?
   h. How has the DER Challenge contributed to this? / What are the other drivers?
      i. What has been the role of low carbon energy in supporting the growth of these energy intensive manufacturing processes?
      ii. Has there been a recovery in supply chain resilience since the COVID pandemic? Or are there still notable disruptions?
      iii. Follow up with additional detail on sector for which these developments are targeted (type/sector/power/size etc.)

60. Did the DER Challenge drive societal, environmental and policy spillovers?
   a. Has any new policy been developed that support further development of DER Challenge projects/activities?
   b. Has there been any activity that addresses a common policy to support the broad topics of the PEMD industry? E.g. to support semi-conductors that cross multiple sectors.
   c. Perhaps this is a place to discuss critical minerals strategy.
      i. A rock and a hard place: building critical mineral resilience - Foreign Affairs Committee (parliament.uk)
      ii. Critical Minerals Refresh: Delivering Resilience in a Changing Global Environment (published 13 March 2023) - GOV.UK (www.gov.uk)
      iii. Resilience for the Future: The United Kingdom's Critical Minerals Strategy (publishing.service.gov.uk)
      iv. Any UK-wide industrial strategy?
      v. EVs and EV charging? E.g. charger standards
      vi. Decarbonisation of buildings and heating?
   d. What about Local Value Content as part of ROO and FTA?

e. Have there been any notable societal benefits from The DER Challenge? Could you give us an example?
f. Do you think there is potential for these benefits to emerge/increase from the DER Challenge in the future?
g. Have there been any notable environmental benefits from The DER Challenge? Could you give us an example?
h. Do you think there is potential for these benefits to emerge/increase from the DER Challenge in the future?

Annex D Contact survey questionnaire

ASK ALL

S1. CATI TEXT: Before we begin can I check that you or your organisation were involved in an application for funding from the Driving the Electric Revolution DER Challenge, or have had some form of engagement with the DER Challenge?

CAWI TEXT: Before we begin can we check that you or your organisation were involved in an application for funding from the Driving the Electric Revolution DER Challenge, or have had some form of engagement with the DER Challenge?

SINGLE CODE

1. Yes – CONTINUE WITH INTERVIEW
2. No – THANK AND CLOSE

ASK ALL

S3. And are you able to answer questions about work that has been undertaken in this area?

SINGLE CODE

1. Yes
2. No

IF S3=2 (NO)

S4. CATI TEXT: Please can you tell me who is the best person to speak to regarding the work that has been undertaken in this area?

CAWI TEXT: Please can you enter the details of the best person to speak to regarding work that has been undertaken in this area.

COLLECT NAME, TELEPHONE NUMBER AND EMAIL ADDRESS WHERE POSSIBLE

Background

READ OUT (ALSO SHOW FOR CAWI): The following questions will refer to the 'PEMD sector'. By PEMD sector we mean any organisation involved in the research, manufacture or supply chain of power electronics, electric machines, or drives. We define power electronics as the development of semiconductors and their packaging to enable switching of high power while minimising loss, whereas drives are the passive components, inverters, converters, other electronic systems, and software used for powering electric machines or their control and regulation. For machines we include motors, generators, robotic actuators, positioning systems, and anything that converts electrical power into mechanical work.

ASK ALL

A1. Which of the following best describes your organisation in relation to the PEMD sector?

SINGLE CODE, READ OUT

1. An OEM/Prime producer
2. System integrator (similar to OEM but with more focus on software/IT, e.g. industrial process control system, in-use service provider)
3. Tier 1 producer/Sub-system manufacturer e.g. vehicle transmission system
4. Tier 2 producer/Large component manufacturer e.g. motor, inverter
5. Tier 3 producer/Small component manufacturer e.g. power transistor, wafers
6. Materials manufacturer e.g. raw material refiner, magnetic alloys manufacture
7. End of life service provider (e.g. component disassembly, reconditioning and recycling components)
8. Researcher (includes research institutes, universities, and academics)
9. Other (please write in) EXCLUSIVE BACKCODE ONLY
10. Don’t know EXCLUSIVE

ASK ALL BUSINESSES [CODES 1-7 AT A1]

A2A. What proportion of your organisation’s business is focussed on PEMD technologies?

Please give an estimation of the proportion of your business’s total output that is focused on PEMD technologies. Please include all sites and subsidiaries.

NUMERIC RESPONSE WITH DK OPTION. SHOW PERCENT SIGN AFTER BOX

VALIDATION WHOLE NUMBERS ONLY. MIN 0, MAX 1OO

IF A2A=DK

A2B. Which of these bands would best describe the proportion of your organisation’s business that is focussed on PEMD technologies?

SINGLE CODE, READ OUT

1. 0%
2. 1% - 10%
3. 11% - 25%
4. 26% - 50%
5. 51% - 75%
6. 76% - 99%
7. 100%
8. Don’t know

ASK ALL

A4. Which of the following areas does your organisation or research group focus on in relation to the design and development of PEMD technologies?

Please select all that apply

MULTICODE, READ OUT

1. High voltage semiconductor devices
2. Actuators
3. Motors
4. Generators
5. Alternators
6. Control systems (industrial, building, vehicle, power generation, distribution, and transmission)
7. Converters, inverters, transformers for electrical power
8. Switches or isolators
9. High voltage passive components, inductors, capacitors, resistors
10. Electrical connectors or insulators
11. Circuit boards
12. Permanent magnets
13. Sensors
14. Other (please write in) BACKCODE ONLY

ASK ALL

A9. In which, if any, of the following ways have you engaged with the Driving the Electric Revolution DER Challenge?

CAWI: Please select all that apply

MULTICODE, RANDOMISE, READ OUT

1. Engage With LIVE!
2. An application for funding
3. Through one of the Industrialisation Centres, also known as DER-ICs
4. Email newsletters
5. Networking activities
6. Offered a letter of support for the DER Challenge
7. Social media accounts on Twitter or LinkedIn

8. Attended a DER Challenge event (other than Engage with Live!)
9. Conversations with the DER Challenge
10. Read annual reports or other DER Challenge-produced publications
11. Through collaborative research
12. Other (specify) BACKCODE ONLY
13. None of the above

IF BUSINESS [CODES 1-7 AT A1]

A5A. Which of the following best describes your organisation?

Please select all that apply

MULTICODE, READ OUT

1. Headquartered in the UK, and only do work in the UK EXCLUSIVE
2. Headquartered in the UK, but also do work in Europe
3. Headquartered in the UK, but also do work outside of Europe
4. Headquartered outside of the UK EXCLUSIVE
5. DO NOT READ OUT Don't know EXCLUSIVE
6. DO NOT READ OUT Prefer not to say EXCLUSIVE

IF A5A=2,3 OR 4

A5B. And what regions, other than the UK, does your organisation do work in?

MULTICODE, READ OUT

1. European Union (Excluding UK)
2. Rest of Europe (excluding EU)
3. Middle East
4. Asia
5. North America
6. South America
7. Africa
8. Australasia
9. DO NOT READ OUT Don't know
10. DO NOT READ OUT Prefer not to say

IF BUSINESS [CODES 1-7 AT A1]

A5C. What region of the UK is your [IF A5A=4; UK] headquarters in?

SINGLE CODE, READ OUT

- East Midlands
- East of England
- London
- North East England
- North West England
- Northern Ireland
- Scotland
- South East England
- South West England
- Wales
- West Midlands
- Yorkshire and The Humber
- DO NOT READ OUT Don’t know
- DO NOT READ OUT Prefer not to say

IF BUSINESS [CODES 1-7 AT A1]

A5D. And where does the majority of your organisation’s work in the PEMD sector take place in the UK?

SINGLE CODE, READ OUT

1. East Midlands
2. East of England
3. London
4. North East England
5. North West England
6. Northern Ireland
7. Scotland
8. South East England
9. South West England
10. Wales
11. West Midlands
12. Yorkshire and The Humber
13. DO NOT READ OUT Don’t know
14. DO NOT READ OUT Prefer not to say

IF BUSINESS [CODES 1-7 AT A1]

A7A. How many members of staff does your organisation currently employ in the UK? Please think about the number of full-time equivalent employees.

If you don't know the exact number, please give an estimate.

NUMERIC RESPONSE WITH DK OPTION

VALIDATION – WHOLE NUMBERS ONLY, MIN 1, MAX 99,999

IF A7A=DK

A7B. Which of these bands would best describe the number of UK full-time equivalent employees at your organisation?

SINGLE CODE, READ OUT

1. 1-9
2. 10-19
3. 20-49
4. 50-99
5. 100-249
6. 250-499
7. 500-999
8. 1,000-4,999
9. 5,000-9,999
10. 10,000 plus
11. Don't know

IF BUSINESS [CODES 1-7 AT A1]

A7C. Has the Driving the Electric Revolution DER Challenge had an impact on the number of employees you have hired in the UK in the past three years?

SINGLE CODE, READ OUT

1. Yes, increased the number of employees we've hired
2. Yes, decreased the number of employees we've hired
3. No impact
4. Don't know
5. I prefer not to say

IF DER HAS INCREASED EMPLOYEES [CODE 1 AT A7C]

A7D. How many more full-time equivalent (FTE) employees in the UK do you estimate your business now has as a result of the Driving the Electric Revolution DER Challenge?

NUMERIC RESPONSE WITH DK OPTION

VALIDATION – ALLOW 1 DECIMAL PLACE, MIN 0, MAX 99,999

IF DER HAS DECREASED EMPLOYEES [CODE 2 AT A7C]

A7E. How many fewer full-time equivalent (FTE) employees in the UK do you estimate your business now has as a result of the Driving the Electric Revolution DER Challenge?

NUMERIC RESPONSE WITH DK OPTION

VALIDATION – ALLOW 1 DECIMAL PLACE, MIN 0, MAX 99,999

IF BUSINESS [CODES 1-7 AT A1]

A7F. And do you expect the Driving the Electric Revolution DER Challenge to have an impact on the number of employees your hire in the next three years?

1. Yes, increase the number of employees we hire
2. Yes, decrease the number of employees we hire
3. No impact
4. Don't know
5. I prefer not to say

IF BUSINESS [CODES 1-7 AT A1]

A8A. Which of the following bands would best describe your UK turnover for the previous financial year? Please think about all UK turnover, even if some operations are outside of the PEMD sector.

SINGLE CODE, READ OUT

1. Zero
2. Less than £100,000
3. £100,000 - £499,999
4. £500,000 - £999,999
5. £1m - £4.9m
6. £5m - £9.9m
7. £10m - £24.9m
8. £25m - £49.9m

9. £50m or more
10. Don't know
11. Prefer not to say

IF BUSINESS [CODES 1-7 AT A1]

A8B. Has the Driving the Electric Revolution DER Challenge had an impact on your UK turnover in the past three years?

SINGLE CODE, READ OUT

1. Yes, increased our turnover
2. Yes, decreased our turnover
3. No impact
4. Don't know
5. I prefer not to say

IF DER HAS INCREASED TURNOVER [CODE 1 AT A8B]

A8C. How much has your turnover increased as a result of the Driving the Electric Revolution DER Challenge?

NUMERIC RESPONSE WITH DK OPTION

VALIDATION – ALLOW 1 DECIMAL PLACE, MIN 0, MAX 99,999

IF DER HAS DECREASED TURNOVER [CODE 2 AT A8B]

A8D. How much has your turnover decreased as a result of the Driving the Electric Revolution DER Challenge?

NUMERIC RESPONSE WITH DK OPTION

VALIDATION – ALLOW 1 DECIMAL PLACE, MIN 0, MAX 99,999

IF BUSINESS [CODES 1-7 AT A1]

A8E. And do you expect the Driving the Electric Revolution DER Challenge to have an impact on your turnover in the next three years?

1. Yes, increase the number of employees we hire
2. Yes, decrease the number of employees we hire
3. No impact
4. Don't know
5. I prefer not to say

Perceptions on UK progress

READ OUT/SHOW IF CAWI: We now have some questions about PEMD technology development in the UK.

ASK ALL

B2. Overall, how would you rate the UK's current reputation compared to other countries as a centre for innovation in PEMD technology?

SINGLE CODE

1. UK is the world leader
2. UK is ahead of most countries
3. UK is ahead of some countries, but behind the world leaders
4. UK is slightly behind most countries
5. UK is a long way behind most countries
6. Don't know

ASK ALL

B3. For each of the following, please indicate whether you think they are a barrier or enabler to the progression of PEMD technology in the UK.

SINGLE CODE PER ROW, REVERSE SCALE, READ OUT FULL SCALE ON FIRST ROW, READ OUT STATEMENTS IN FULL

ROWS

- Private sector investment for the PEMD sector
- Government funding or investment for the PEMD sector
- Government policy towards PEMD technologies (e.g. environmental targets)
- Development of PEMD standards
- Productivity of the domestic supply chain
- Capacity of the domestic supply chain
- Skills of the workforce
- Growth of leading PEMD sector organisations
- Geopolitical issues such as the war in Ukraine and global energy prices

SCALE

1. Significant barrier
2. Moderate barrier

3. Slight barrier
4. No impact
5. Slight enabler
6. Moderate enabler
7. Significant enabler
8. Don't know

ASK IF A1=1,2 OR 7

B3A. How easy or difficult do you think it is currently to conduct first of a kind PEMD pilots in the UK? Examples of first of a kind PEMD pilots could include the first electric passenger aircraft, the first intercity pantograph for electric trucks and the first use of an HVDC connector to export power from an offshore wind farm.

SINGLE CODE

1. Very easy
2. Fairly easy
3. Neither easy nor difficult
4. Fairly difficult
5. Very difficult
6. Don't know

ASK IF A1=1,2 OR 7

B3B. Has your organisation conducted any first of a kind PEMD pilots in the UK in the previous financial year?

SINGLE CODE

1. No
2. Yes – 1 pilot
3. Yes – 2-4 pilots
4. Yes – 5 to 10 pilots
5. Yes – more than 10 pilots
6. Don't know

ASK IF A1=1,2 OR 7

B3C. And does your organisation expect to conduct any first of a kind PEMD pilots in the UK in the next financial year?

SINGLE CODE

1. No
2. Yes – 1 pilot
3. Yes – 2-4 pilots
4. Yes – 5 to 10 pilots
5. Yes – more than 10 pilots
6. Don't know

ASK ALL

B3D. How do you think the number of companies in the PEMD supply chain in the UK has changed in the last three years?

SINGLE CODE, READ OUT

1. Increased
2. Stayed the same
3. Decreased
4. Don't know

IF THINK SUPPLY CHAIN INCREASED OR DECREASED [CODES 1 OR 3 AT B3D]

B3E. Roughly how many companies do you think the UK PEMD supply chain has [IF B3D=1: increased, IF B3D=3: decreased] by in the last three years?

SINGLE CODE, NUMERIC, WHOLE NUMBERS ONLY, ALLOW DK, MIN 1, MAX 100,000

ASK ALL

B6. And which of the following best describes how you expect the UK PEMD sector to change over the next few years?

SINGLE CODE, READ OUT

1. It will grow significantly
2. It will grow slightly
3. It will stay about the same
4. It will decrease slightly
5. It will decrease significantly
6. Don't know

Collaboration

ASK ALL

D1. How many of the following types of partners are you currently collaborating with on PEMD projects? Please think about all PEMD sector projects that your organisation may be working on, and the total number of partners you are collaborating with across all projects, whether they have received Driving the Electric Revolution DER Challenge funding or not.

NUMERICAL BOX FOR EACH ROW, WHOLE NUMBERS ONLY, MIN 0, MAX 50

ALLOW DK AND PREFER NOT TO SAY

SHOW TOTAL BOX AT BOTTOM

READ OUT

1. Large PEMD companies in the same sector as your organisation (250+ employees)
2. Large PEMD companies in different sectors to your organisation (250+ employees)
3. Large PEMD companies that produce different technologies to your organisation (250+ employees)
4. Small or medium PEMD companies in the same sector as your organisation (fewer than 250 employees)
5. Small or medium PEMD companies in different sectors to your organisation (fewer than 250 employees)
6. Small or medium PEMD companies that produce different technologies to your organisation (fewer than 250 employees)
7. End-users
8. Researchers (research institutes, universities, and academics)
9. Companies outside of the PEMD sector
10. Others (please type in) BACKCODE ONLY
11. Don’t know

IF D1_9>0 (are collaborating with companies outside of PEMD sector)

D1A. You said you are collaborating with companies outside of the PEMD sector. Which sectors are these companies in?

Please type your response in the box below

OPEN, ALLOW DK AND PREFER NOT TO SAY OPTIONS

DO NOT CODE

IF TOTAL NUMBER OF PARTNERS >1

D2. And how successful would you say these collaborations are? Please think about each different type of company you are currently collaborating with. Please think about financial success as well as non-financial success.

ONLY SHOW CODES WITH >0 AT D1

1. Large PEMD companies in the same sector as your organisation (250+ employees)
2. Large PEMD companies in different sectors to your organisation (250+ employees)
3. Large PEMD companies that produce different technologies to your organisation (250+ employees)
4. Small or medium PEMD companies in the same sector as your organisation (fewer than 250 employees)
5. Small or medium PEMD companies in different sectors to your organisation (fewer than 250 employees)
6. Small or medium PEMD companies that produce different technologies to your organisation (fewer than 250 employees)
7. End-users
8. Researchers (research institutes, universities, and academics)
9. Companies outside of the PEMD sector
10. Others (please type in)
11. Don’t know

SCALE

1. Very successful
2. Fairly successful
3. Neither successful nor unsuccessful
4. Fairly unsuccessful
5. Very unsuccessful
6. Too early to tell
7. Don’t know

ASK ALL

D3A. How much do you think the Driving the Electric Revolution (DER) DER Challenge has impacted collaboration in general?

SINGLE CODE, READ OUT

1. Increased collaboration significantly
2. Increased collaboration slightly
3. Not impacted collaboration
4. Decreased collaboration slightly
5. Decreased collaboration significantly
6. Don’t know

ASK ALL

D3. To what extent do you agree or disagree with the following statements? Please note that by ‘reach’, we mean engaging with stakeholders via a range of communication channels as well as via competitions.

CAWI: Please select one answer per row

GRID SINGLE CODE PER ROW, RANDOMISE, READ OUT

1. The DER Challenge has been able to reach organisations from different sectors
2. The DER Challenge has been able to reach organisations of different sizes
3. The DER Challenge has been able to reach different types of organisations, such as businesses and academia
4. The DER Challenge has been able to reach organisations focusing on different stages of the PEMD supply chain

SINGLE CODE, REVERSE SCALE

1. Strongly agree
2. Tend to agree
3. Neither agree nor disagree
4. Tend to disagree
5. Strongly disagree
6. Don’t know

Current project progress

IF MORE THAN 1 PROJECT [DEFINED BY COMPETITION COUNT IN SAMPLE]

C1A. Our records show that [IF CODES 1-7 AT A1: you or your organisation is, or has been, IF CODES 8-10:you have been] involved in more than one project within the Driving the Electric Revolution DER Challenge. Which project are you most able to answer questions about regarding the project’s progress?

INSERT AS APPLICABLE, SINGLE CODE [NOTE THE MAX NUMBER OF PROJECTS IS 7]

- PROJECT TITLE 1
- PROJECT TITLE 2
- PROJECT TITLE 3
- PROJECT TITLE 4
- PROJECT TITLE 5
- PROJECT TITLE 6

- PROJECT TITLE 7

IF MORE THAN 1 PROJECT [DEFINED BY COMPETITION COUNT IN SAMPLE]

For the following questions please think about [INSERT RESPONSE FROM C1A] only.

OUTCOME DUMMY

PULL OUTCOME FROM SAMPLE. IF COMPETITION COUNT=1, PULL FROM OUTCOME 1. IF COMPETITION COUNT>1, PULL OUTCOME RELATED TO PROJECT SELECTED AT C1A.

IF COMPETITION COUNT>0

C1.

IF SUCCESSFUL: If your application for funding had been declined, would you have taken the project forward in any form?

IF UNSUCCESSFUL: After your application for funding was declined, did you take the project forward in any form?

SINGLE CODE

1. Yes
2. No
3. Don't know
4. Prefer not to say

IF C1=1

C2

IF OUTCOME=SUCCESSFUL: If your application for funding had been declined, would the project have gone ahead…

IF OUTCOME=UNSUCCESSFUL: Did the project go ahead…

MULTICODE, READ OUT

1. Unchanged EXCLUSIVE
2. At a later date
3. In a different country
4. At a reduced scale of investment
5. With reduced scope (e.g. met fewer objectives)
6. Over a longer timescale

7. DO NOT READ OUT Don't know EXCLUSIVE
8. DO NOT READ OUT Prefer not to say EXCLUSIVE

IF OUTCOME=SUCCESSFUL OR [UNSUCCESSFUL AND C1=1 (UNSUCCESSFUL BUT PROJECT WENT AHEAD)]

C4. At the start of your engagement with the Driving the Electric Revolution DER Challenge, what level of development was the manufacturing process at in terms of Manufacturing Readiness Level (MRL)?

SINGLE CODE, READ OUT

1. Developing basic principles or formulating the concept: MRL 1 and MRL 2
2. Developing the proof of concept or testing in laboratory conditions: MRL 3 and MRL 4
3. Producing prototype components, systems, or subsystems in a production relevant environment: MRL 5 and MRL 6
4. Producing systems, subsystems or components in a production representative environment or demonstrating pilot line capability: MRL 7 and MRL 8
5. Don't know

IF SUCCESSFUL

C5. What level is the manufacturing process at now?

SINGLE CODE, READ OUT

1. Developing basic principles or formulating the concept: MRL 1 and MRL 2
2. Developing the proof of concept or testing in laboratory conditions: MRL 3 and MRL 4
3. Producing prototype components, systems, or subsystems in a production relevant environment: MRL 5 and MRL 6
4. Producing systems, subsystems or components in a production representative environment or demonstrating pilot line capability: MRL 7 and MRL 8
5. Low-rate production demonstrated and capability in place to begin full rate production: MRL 9
6. Full rate production demonstrated and lean production practices in place: MRL 10
7. Don't know

IF SUCCESSFUL

C5A. If your application for funding had been declined by the Driving the Electric Revolution DER Challenge, what level do you think the manufacturing process would be at now?

SINGLE CODE, READ OUT

1. Developing basic principles or formulating the concept: MRL 1 and MRL 2

2. Developing the proof of concept or testing in laboratory conditions: MRL 3 and MRL 4
3. Producing prototype components, systems, or subsystems in a production relevant environment: MRL 5 and MRL 6
4. Producing systems, subsystems or components in a production representative environment or demonstrating pilot line capability: MRL 7 and MRL 8
5. Low-rate production demonstrated and capability in place to begin full rate production: MRL 9
6. Full rate production demonstrated and lean production practices in place: MRL 10
7. Don't know

IF OUTCOME=SUCCESSFUL OR A9=3 (ENGAGED WITH DERIC)

C6. Have you received any [IF OUTCOME=SUCCESSFUL; other] public grants or private investment as a result of your engagement with the Driving the Electric Revolution DER Challenge?

SINGLE CODE

1. Yes, public grants
2. Yes, private investment
3. Yes, both public and private investment
4. No
5. Don't know
6. Prefer not to say

IF OUTCOME=SUCCESSFUL OR A9=3 (ENGAGED WITH DERIC)

C7. Do you expect to secure any [IF C6=1-3; further] public grants or private investment as a result of your engagement with the Driving the Electric Revolution DER Challenge?

SINGLE CODE

1. Yes, public grants
2. Yes, private investment
3. Yes, both public and private investment
4. No
5. Don't know
6. Prefer not to say

ASK IF C6=2 OR 3

C8. How much private finance has your organisation received as a result of your engagement with the Driving the Electric Revolution DER Challenge?

OPEN

NUMERICAL RESPONSE WITH £ SIGN. ALLOW DK AND PREFER NOT TO SAY, MIN 0, MAX £100,000,000. NO DECIMAL PLACES

IF C8=DK

C8B. Would you say it was…?

SINGLE CODE

1. Less than £50,000, but not zero
2. £50,000 to £99,999
3. £100,000 to £499,999
4. £500,000 to £999,999
5. £1m to £1.9m
6. £2m to £9.9m
7. £10m to £49.9m
8. £50m or more
9. Zero – no finance received
10. Don't know
11. Prefer not to say

ASK IF C6=1 OR 3

C9. How much public funding has your organisation received as a result of your engagement with the Driving the Electric Revolution DER Challenge?

OPEN

NUMERICAL RESPONSE WITH £ SIGN. ALLOW DK AND PREFER NOT TO SAY, MIN 0, MAX £100,000,000. NO DECIMAL PLACES

IF C9=DK

C9B. Would you say it was…?

SINGLE CODE

1. Less than £50,000, but not zero
2. £50,000 to £99,999
3. £100,000 to £499,999
4. £500,000 to £999,999
5. £1m to £1.9m

6. £2m to £9.9m
7. £10m to £49.9m
8. £50m or more
9. Zero – no funding received
10. Don't know
11. Prefer not to say

Research, development & demonstration

IF A1=1-7

READ OUT The next few questions ask about your organisation's research, development, and demonstration (RD&D) activities. When answering, please think about your most recent financial year.

IF A1=1-7

E1A. In your most recent financial year, how much did your company spend on research, development, and demonstration activities?

We are interested in all research, development and demonstration activities undertaken in the reporting period either for the business or for a customer. This should be the total cost of RD&D conducted by the business, regardless of the source of funds or their treatment.

NUMERICAL RESPONSE WITH £ SIGN. ALLOW DK AND PREFER NOT TO SAY, MIN 0, MAX £100,000,000. NO DECIMAL PLACES

IF E1A=DK

E1B. Would you say it was…?

SINGLE CODE

1. Less than £50,000, but not zero
2. £50,000 to £99,999
3. £100,000 to £499,999
4. £500,000 to £999,999
5. £1m to £1.9m
6. £2m to £9.9m
7. £10m to £49.9m
8. £50m or more
9. Zero – no spend on RD&D
10. Don't know

11. Prefer not to say

IF E1A>0 OR E1B=1-8

E2. How, if at all did your UK RD&D spend change compared to the year before?

SINGLE CODE

1. It increased significantly
2. It increased slightly
3. It did not change
4. It reduced slightly
5. It reduced significantly
6. Don't know
7. Prefer not to say\

IF A1=1-7

E3A. How much of an impact, if at all, did the Driving the Electric Revolution DER Challenge have on how much your company spent on research, development, and demonstration activities in your most recent financial year?

SINGLE CODE

1. We spent significantly more
2. We spent slightly more
3. It didn't impact how much we spent
4. We spent slightly less
5. We spent significantly less
6. Don't know

IF E3A=1 OR 2

E3B. Roughly how much more do you think your company spent on research, development, and demonstration activities in your most recent financial year as a result of your engagement with the Driving the Electric Revolution DER Challenge? Please give your best estimate.

NUMERIC RESPONSE WITH DK OPTION

VALIDATION – ALLOW 1 DECIMAL PLACE, MIN 1, MAX 1,000,000,000, SHOW £ SIGN AT START OF BOX

IF E3A=4 OR 5

E3C. Roughly how much less do you think your company spent on research, development, and demonstration activities in your most recent financial year as a result of your engagement with the Driving the Electric Revolution DER Challenge? Please give your best estimate.

NUMERIC RESPONSE WITH DK OPTION

VALIDATION – ALLOW 1 DECIMAL PLACE, MIN 1, MAX 1,000,000,000, SHOW £ SIGN AT START OF BOX

DER-IC and knowledge transfer activities

READ OUT/SHOW IF CAWI This set of questions ask about the Driving the Electric Revolution Industrialisation Centre (DER-IC). The DER-IC is split across 4 main sites: North East, Scotland, Midlands, and South West & Wales, but equipment is also available at other sites. They are design and testing facilities that help industry to invest and therefore grow the PEMD supply chain. They give access to specialist equipment to help industrial partners accelerate their capability, capacity, and competitiveness.

ASK ALL

F2. Have you made use, or are you planning to make use, of the Driving the Electric Revolution Industrialisation Centre sites?

SINGLE CODE, READ OUT

1. Yes, we have used the equipment at one or more of the industrialisation centre's sites
2. No, we haven't used the equipment yet but we're planning to do so in the future
3. No, we haven't used the equipment at the industrialisation centre's sites and we're not planning to do so
4. Don't know

IF F2=1 OR 2 [HAVE USED OR PLAN TO USE DERIC EQUIPMENT]

F5. How, if at all, has the DER-IC impacted your business in terms of…?

SINGLE CODE PER STATEMENT, READ OUT

1. Signposting your firm towards funding opportunities
2. Providing access to equipment (for a fee)
3. Skills of your employees
4. Facilitating collaboration

SCALE

1. Significant positive impact

2. Small positive impact
3. No change
4. Small negative impact
5. Significant negative impact
6. Don't know

IF F2=1 OR 2 [HAVE USED OR PLAN TO USE DERIC EQUIPMENT]

F3A. Which of the following best describes how effective you think the open access, contract-based model of the Driving the Electric Revolution Industrialisation Centre (DER-IC) is in meeting current industry needs?

The DER-IC model involves customers paying DER-IC for the use of its facilities for activities to support scaling up. The customer is then responsible for large scale production through its own facilities. The DER-IC does not enter into large scale production contracts and does not benefit from any intellectual property rights.

SINGLE CODE

1. The DER-IC meets all of the current industry needs
2. The DER-IC meets most of the current industry needs
3. The DER-IC meets some of the current industry needs
4. The DER-IC meets a few of the current industry needs
5. The DER-IC doesn't meet any of the current industry needs
6. Don't know

ASK ALL

F4. And to what extent do you agree or disagree with the following statements about the Driving the Electric Revolution DER Challenge's knowledge transfer activities? By knowledge transfer, we mean the activities carried out by the DER Challenge and Innovate UK Business Connect to spread awareness of the DER Challenge, its aims, and the projects it supports.

SINGLE CODE PER ROW, READ OUT

1. The knowledge transfer activities have engaged a wide range of organisation across the PEMD sector
2. The knowledge transfer activities have engaged a wide range of organisation across other sectors
3. The knowledge transfer activities were delivered effectively and efficiently

REVERSE SCALE

1. Strongly agree

2. Tend to agree
3. Neither agree nor disagree
4. Tend to disagree
5. Strongly disagree
6. Don't know

ASK ALL

F7. Thinking about the Driving the Electric Revolution DER Challenge overall, what impact, if any, has it had on the following over the past 3 years?

SINGLE CODE PER STATEMENT, READ OUT

1. Your volume of patent filing
2. The productivity of your employees
3. The productivity of your organisation as a whole
4. Reducing the cost of key sector inputs (e.g. raw materials)
5. Government policy related to PEMD

SCALE

1. Significant positive impact
2. Small positive impact
3. No change
4. Small negative impact
5. Significant negative impact
6. Don't know

IF A1=1-7

F8. Which of the following best describe your experience of the level of skills in the PEMD sector as a whole?

SINGLE CODE, READ OUT

1. There are significantly more people with the relevant skills than the sector currently needs
2. There are slightly more people with the relevant skills than the sector currently needs
3. There are about the same of amount of people with the relevant skills as the sector currently needs
4. There are slightly fewer people with the relevant skills than the sector currently needs
5. There are significantly fewer people with the relevant skills than the sector currently needs
6. Don't know
7. Prefer not to say

IF A1=1-7

F9. And what impact, if any, do you think the Driving the Electric Revolution DER Challenge has had on the level of skills in the PEMD sector?

1. SINGLE CODE, READ OUT
2. Significant positive impact
3. Small positive impact
4. No change
5. Small negative impact
6. Significant negative impact
7. Don’t know

IF A1=1-7

F10. To what extent do you agree or disagree that the Driving the Electric Revolution DER Challenge has facilitated the retraining of mid-career professionals into PEMD roles?

SINGLE CODE, READ OUT

1. Strongly agree
2. Tend to agree
3. Neither agree nor disagree
4. Tend to disagree
5. Strongly disagree
6. Don’t know

Annex E Search terms and taxonomies

This section presents the list of search terms used to compile the datasets from the UKRI Financial Transparency Data. It also presents the list of classification codes used as a proxy for PEMD activity.

E.1 Search terms

Listed below are the searches we will use to identify PEMD technologies in research abstracts and project descriptions; note 'AND' and 'OR' refer to Boolean operators. The search terms refer to groups of technologies of similar type (see Table 23). For example, the first search should be ("neodymium" OR "dysprosium" OR "samarium" OR "cobalt" OR "rare earth" OR "critical material" OR …) AND ("power electronics" OR "electric machine" OR "electrical machine" OR "drive").

1. (*Materials*) AND ("power electronics" OR "electric machine" OR "electrical Machine" OR "drive")
2. (*Components*) AND ("power electronics" OR "electric machine" OR "electrical machine" OR "drive")
3. (*Devices*) AND ("power electronics" OR "electric machine" OR "electrical machine" OR "drive")
4. (*Systems*) AND ("power electronics" OR "electric machine" OR "electrical machine" OR "drive")
5. (*Applications*) AND ("power electronics" OR "electric machine" OR "electrical machine" OR "drive")
6. (*Materials*) AND (*Components*)
7. (*Components*) AND (*Devices*)
8. (*Devices*) AND (*Systems*)
9. (*Systems*) AND (*Applications*)
10. (*Systems*) AND ("control" AND "software") OR "data capture" OR "data transfer" OR "data storage" OR "data processing"

Table 23 Search terms by technology type

Technology type	Search terms
Materials	("neodymium" OR "dysprosium" OR "samarium" OR "cobalt" OR "rare earth" OR "critical material" OR "wide bandgap semiconductor" OR "gallium nitride" OR "silicon carbide" OR "GaN" OR "SiC" OR "superconductor")

Technology type	Search terms
Components	(“electrical insulator” OR “electrical connector” OR “copper wire” OR “solder” OR (“high voltage transistor” OR “high voltage diode” OR “high voltage inductor” OR “high voltage capacitor” OR “high voltage resistor” OR “circuit board” OR “supercapacitor” OR “permanent magnet” OR “high strength magnet” OR “high remanence magnet” OR “soft magnetic composite” OR “lubricant” OR “heat transfer fluid” OR “magnetic flux conductor”)
Devices	(“amplifier” OR “switch” OR “oscillator” OR “converter” “inverter” OR “transformer” OR “actuator” OR “motor” OR “generator” “sensor” OR “flywheel”)
Systems	(“electrical power generation” OR “electrical power transmission systems” OR “electrical power distribution systems” OR “energy storage systems” OR “mechanical drive systems” OR “electrical heating and cooling systems”)
Applications	(“wind turbine” OR “solar PV” OR “tidal flow turbine” OR “interconnector” OR “HVDC” OR “ancillary service” OR “distributed power” OR “microgrid” OR “grid-connected energy storage” OR “off-grid energy storage” OR “vehicle drivetrain” OR “vehicle drive train” OR “road” OR “rail” OR “marine” OR “aerospace” OR “combined heat and power” OR “CHP” OR “escalator” OR “walkway” OR “lift” OR “assembly” OR “material handling” OR “picking” OR “sorting” OR “packing” OR “heat transfer” OR “heat exchange” OR “chiller” OR “chilling” OR “refrigeration” OR “refrigerator” OR “heat pump” OR “compressor” OR “district heating network” OR “district heat network” OR “building heating” OR “ventilation and air conditioning” OR “HVAC” OR “datacentre”)

Source: Frontier Economics and ERM

E.2 Classification codes

Table 24 describes the primary Standard Indicator Classification (SIC) codes that describe the PEMD supply chain. Note that a lot of PEMD activity takes place in other SICs and some of these codes will cover non-PEMD technologies.

Table 24 List of PEMD supply chain SIC codes

Table 24	Description
26110	Manufacture of electronic components
26120	Manufacture of loaded electronic boards
26512	Manufacture of electronic industrial process control equipment
27110	Manufacture of electric motors, generators, and transformers
27120	Manufacture of electricity distribution and control apparatus
29310	Manufacture of electrical and electronic equipment for motor vehicles and their engines

Source: Frontier Economics and ERM

Table 25 describes the primary HS6 (Harmonized System) codes that describe PEMD technologies. Note that a lot of PEMD technologies will be covered by other HS6 codes and some of these codes will cover non-PEMD technologies.

Table 25 List of PEMD technologies HS6 codes

HS6 Code	Description
850230	Electric generating sets; n.e.s. in heading no. 8502
850231	Electric generating sets; wind-powered, (excluding those with spark-ignition or compression-ignition internal combustion piston engines)
850163	Electric generators; AC generators, (alternators), of an output exceeding 375kVA but not exceeding 750kVA
850164	Electric generators; AC generators, (alternators), of an output exceeding 750kVA
850162	Electric generators; AC generators, (alternators), of an output exceeding 75kVA but not exceeding 375kVA
850134	Electric motors and generators; DC, of an output exceeding 375kW

HS6 Code	Description
850132	Electric motors and generators; DC, of an output exceeding 750W but not exceeding 75kW
850133	Electric motors and generators; DC, of an output exceeding 75kW but not exceeding 375kW
850152	Electric motors; AC motors, multi-phase, of an output exceeding 750W but not exceeding 75kW
850153	Electric motors; AC motors, multi-phase, of an output exceeding 75kW
854130	Electrical apparatus; thyristors, diacs and triacs, other than photosensitive devices
854129	Electrical apparatus; transistors, (other than photosensitive), with a dissipation rate of 1W or more
853210	Electrical capacitors; fixed, designed for use in 50/60 Hz circuits and having a reactive power handling capacity of not less than 0.5 kVAr (power capacitors)
850423	Electrical transformers; liquid dielectric, having a power handling capacity exceeding 10,000kVA
850422	Electrical transformers; liquid dielectric, having a power handling capacity exceeding 650kVA but not exceeding 10,000kVA
850520	Magnets; electro-magnetic couplings, clutches, and brakes
850511	Magnets; permanent magnets and articles intended to become permanent magnets after magnetisation, of metal
850519	Magnets; permanent magnets and articles intended to become permanent magnets after magnetisation, other than of metal
850433	Transformers; n.e.s. in item no. 8504.2, having a power handling capacity

HS6 Code	Description
	exceeding 16kVA but not exceeding 500kVA
850432	Transformers; n.e.s. in item no. 8504.2, having a power handling capacity exceeding 1kVA but not exceeding 16kVA
850434	Transformers; n.e.s. in item no. 8504.2, having a power handling capacity exceeding 500kVA

Source: Frontier Economics and ERM

Table 26 describes the sector pathways used to capture apprenticeships which are relevant to the PEMD supply chain. Note that a lot of PEMD supply chain work will be covered by other sector pathways and some of these sector pathways will cover non-PEMD supply chain-related work.

Table 26 Sector pathways used to capture apprenticeships

Sector pathway
Aerospace Manufacturing Electrical, Mechanical and Systems Fitter
Building Energy Management Systems
Electrical / Electronic Technical Support Engineer (Degree)
Electrical and Electronic Servicing
Electrical Power Networks Engineer
Electrical Power Protection and Plant Commissioning Engineer
Electrical, Electronic Product Service and Installation Engineer
Embedded Electronic Systems Design and Development Engineer (Degree)
Highway Electrical Maintenance and Installation Operative
Installation Electrician / Maintenance Electrician
Lift and Escalator Electromechanics
Maritime Electrical / Mechanical Mechanics
Power Engineer (Degree)
Power Network Craftsperson
Systems Engineer (Degree)

Source: Frontier Economics and ERM

Table 27 describes the CPC codes used to capture patents filed in the UK which are relevant to the PEMD supply chain. Note that these sector CPC codes will also cover non-PEMD supply chain-related work.

Table 27 CPC codes used to capture relevant patents

CPC code	Description
HO2B	Boards, substations, or switching arrangements for the supply or distribution of electric power
H02H	Emergency protective circuit arrangements
H02J	Circuit arrangements or systems for supplying or distributing electric power; systems for storing electric energy
H02K	Dynamo-electric machines
H02M	Apparatus for conversion between AC and AC, between AC and DC, or between DC and DC, and for use with mains or similar power supply systems; conversion of DC or AC input power into surge output power
H02P	Control or regulation of electric motors, electric generators, or dynamo-electric converters; controlling transformers, reactors or choke coils
H03L	Automatic control, starting, synchronisation, or stabilisation of generators of electronic oscillations or pulses

Source: Frontier Economics and ERM

WWW.FRONTIER-ECONOMICS.COM