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DRIVING THE ELECTRIC REVOLUTION CHALLENGE

Phase 3: Process evaluation and interim impact evaluation

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CONTENTS

Executive summary 5

Context 5

The process evaluation 6

The interim impact evaluation 12

1 Introduction 19

About this report 19

The Driving the Electric Revolution Challenge 20

2 Approach taken 26

Structure of the evaluation 26

Evidence sources informing the evaluation 31

3 Process evaluation findings 42

Theme 1 – Management and governance of the Challenge 42

Theme 2 – Design and delivery of the Challenge competitions 53

Theme 3 – Design and delivery of the DER-IC and knowledge transfer activities 62

Theme 4 – Design and delivery of the Challenge skills gap activities 70

Theme 5 – Delivery and outcome monitoring 72

Conclusions and recommendations 76

4 Interim impact evaluation 81

Theme 1 – Has the Challenge accelerated innovation and commercialisation of PEMD technologies? 82

Theme 2 – Has the Challenge increased the productivity of the UK PEMD supply chain? 85

Theme 3 – Has the Challenge contributed to growing PEMD knowledge and skills in the UK? 86

Theme 4 – Has the Challenge increased the value of investment in UK PEMD companies? 90

Theme 5 – Has the Challenge helped foster a collaborative PEMD ecosystem? 96

Theme 6 – Did the Challenge lead to an expansion of UK PEMD manufacturing capacity? 103

frontier economics

Theme 7 – Did the Challenge drive environmental, societal and policy benefits? 109
Conclusions 113

Annex A Case studies for the interim impact evaluation 115
Project-based case study 1 – DER Hairpin 115
Project-based case study 2 – GaNSiC Direct-Dispense 122
Activity-based case study 128
Thematic case study 139

Annex B Survey development and analysis 154
Survey overview 154
Survey methodology 158
Survey questionnaire 159
Survey results 161
Theme 1 – Has the Challenge accelerated innovation and commercialisation of PEMD technologies? 161
Theme 4 – Has the Challenge increased the value of investment in UK PEMD companies? 164
Theme 6 – Did the Challenge lead to an expansion of UK PEMD manufacturing capacity? 166
Theme 7 – Did the Challenge drive environmental, societal and policy benefits? 169

Annex C Analysis of monitoring data 171
Challenge ED&I (Theme 7) 171
Challenge investment data (Theme 4) 172
Innovate UK KTN Data (Theme 5) 173

Annex D Materials for the process evaluation 176
Delivery lead interviews 176
Academic and industry workshop topic guide 180
Survey 184

Annex E Materials for the interim impact evaluation 201
Impact metrics across baseline and interim impact evaluation 201
Topic guide – Project-based case studies 205
Topic guide – Activity-based case study 206
Topic guide – Thematic case study 209

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Annex F Metrics that are used in the interim impact evaluation (and their methodology) 210

Executive summary

Context

This report presents the findings of a process evaluation and an interim impact evaluation of the Driving the Electric Revolution (DER) Challenge. The work is delivered by a consortium, led by Frontier Economics alongside BMG Research and E4tech (a member of the ERM Group), which was commissioned by the Challenge to lead the evaluation. The approach taken follows the Evaluation Framework Report delivered by the consortium in 2021.

- The **process evaluation** seeks to understand perceptions of how the Challenge has been delivered and how well the implementation is working in support of delivering intended benefits. It also seeks to identify any actionable recommendations for changes that can be made while the Challenge is operational or for future initiatives where relevant.
- The **interim impact evaluation** provides an early assessment of what difference the Challenge has been making against a set of thematic evaluation questions and metrics.

The final impact evaluation will be completed in 2024.

The Challenge seeks to support the UK's net zero ambitions by growing the power electronics, machines and drives (PEMD) supply chain and ecosystem, which are critical to the electrification of applications across multiple sectors. The UK is world leading in terms of research relating to PEMD. Despite previous successes in the area, there are a range of market failures and institutional barriers that are preventing the UK from also becoming world leading in PEMD manufacturing. The aim of the Challenge is therefore to support the UK in expanding its PEMD manufacturing capability, with a focus on supporting projects closer to technological and manufacturing readiness, and in expanding the support available to innovative organisations.

The Challenge is a £234 million programme, with £80 million committed by UK Research and Innovation (UKRI) and a further £154 million of investment that is expected to be catalysed by the Challenge activities. It provides grant funding to industry-led consortia seeking to conduct collaborative research and development (CR&D) projects, and to an academic-led consortium to establish the DER Industrialisation Centres (DER-IC). The Challenge has also conducted a range of supporting activities to facilitate knowledge exchange and enhance the UK skill-set.

As with many other areas of the UK economy, COVID-19 is likely to have had a significant impact on UK PEMD. The inability to access laboratory space will have affected projects funded by the Challenge and delayed experiments (particularly relevant for higher manufacturing readiness level (MRL) projects which are the focus of the Challenge, where access to physical equipment is particularly important), and the need to adapt to changes in working patterns will have generated some disruption. While trying to understand the counterfactual of what would have happened to the running or impact of the Challenge without COVID-19 is beyond the scope of this work, the pandemic is an important backdrop to bear in mind throughout the evaluation.

The process evaluation

Approach

The process evaluation was organised around five broad themes:

1. Management and governance of the Challenge: including communication, risk management and financial accountability.
2. Design and delivery of the Challenge competitions: including the process of engaging stakeholders and alignment with industry needs.
3. Design and delivery of the DER-IC and knowledge transfer activities: including the implementation of these activities and the effectiveness of engagement with a range of stakeholder organisations.
4. Design and delivery of the Challenge skills gap activities: including how well the implementation of these activities supported achieving project objectives and met sector needs.
5. Delivery and outcome monitoring: including the design and effectiveness of monitoring processes.

As part of the Evaluation Framework Report, we developed a set of indicators under each theme which then informed the design of research instruments to capture evidence for the process evaluation. Details of these indicators are given in Section 3.

The process evaluation drew on four main sources of data and evidence:

1. A contact survey of PEMD organisations that have engaged with the Challenge. Fieldwork took place in October and November 2022, achieving 69 responses and an overall response rate of 31% among the 226 organisations invited to take part. It should be noted that, as the overall number of PEMD organisations in the UK is likely to be much larger than this, we cannot guarantee that the survey findings are representative of the PEMD community as a whole. Most of the survey respondents (54) represented organisations that had been successful in their funding applications.
2. In-depth interviews with those responsible for the delivery of the Challenge (delivery lead interviews). We conducted 12 semi-structured interviews with people knowledgeable about the delivery of CR&D competitions, the DER-IC, skills-related activities and knowledge transfer.
3. Beneficiary workshops. We held two workshops, one with five academic beneficiaries of the Challenge and another with six PEMD industry beneficiaries. Workshops were structured around the evaluation themes.
4. Monitoring data collected by the Challenge/DER-IC.

Key findings and recommendations

Summaries of findings are organised around the process evaluation questions. Recommendations are highlighted in **bold type**.

Theme 1: Management and governance

There was consensus among delivery leads at UKRI that the Challenge's funding and resources were being managed and distributed according to the business case, in a way that was seen to be fair. Some

stakeholders felt that additional funding could have been allocated to skills activities (and indeed to the broader objectives of the Challenge), recognising that funding allocations to different activities were delivered in line with the original business case for the Challenge and some efforts to reallocate funding were being made where possible. That funds were allocated to skills at all was seen as a positive as this is a new area that Innovate UK has focused on for this Challenge.

> *"The amount we have to put to skills is probably not enough. It was not set out as a core pillar [of the programme] at the beginning though."* Delivery lead (UKRI)

The process for decision-making around competitions follows the standard Innovate UK process, which was seen as effective in ensuring that decisions are made in a transparent and unbiased way. The process can take six to nine months from conception of the competition calls to allocation of funding and was seen as a 'one size fits all' approach which could potentially put applicants off lower value competitions. **Innovate UK could consider fast-track processes for lower value competitions** to help speed up decisions, mindful of checks needed for proper allocation. This would involve having faster processes for competitions when it comes to doing financial and other checks rather than giving applicants less time to apply for competitions. We understand from the Challenge that these faster check processes have already been implemented for other Challenge competitions, such as the competitions launched by UKRI as a response to the COVID-19 pandemic, where checks were carried out within three months to fund projects with a value of under £50,000.

Delivery lead interviews felt that some sectors, including marine, rail and offshore renewables, were at earlier stages of their 'journey' to electrification and so had been harder to engage.

Survey respondents felt that Challenge communication channels were effective in engaging stakeholders. Conversations with the Challenge (69% rated informative), the 'Engage with' sessions (67%) and other Challenge events (67%) were most often rated as informative. Social media (40%) and communications around the DER-IC (37%) were rated as the least informative communications. The Challenge was seen to be well-aligned with other government initiatives in the UK. Eighty percent of survey respondents felt that the Challenge was very or fairly strongly aligned, with only 7% saying it was not very strongly aligned.

Internal communication across the different strands of activity within the Challenge happens through largely informal channels. While this is often effective, most delivery leads felt there could be better coordination particularly between skills gaps activities and other workstreams. **More formal processes for coordination across workstreams could be beneficial** to maximise the impact of the Challenge as a whole.

The fact that most funding competitions had allocated awards before the DER-IC sites were fully operational was also seen to be a missed opportunity. This was in part due to the design of the DER-IC's role in the Challenge but also to delays caused by COVID-19 in the DER-IC becoming operational.

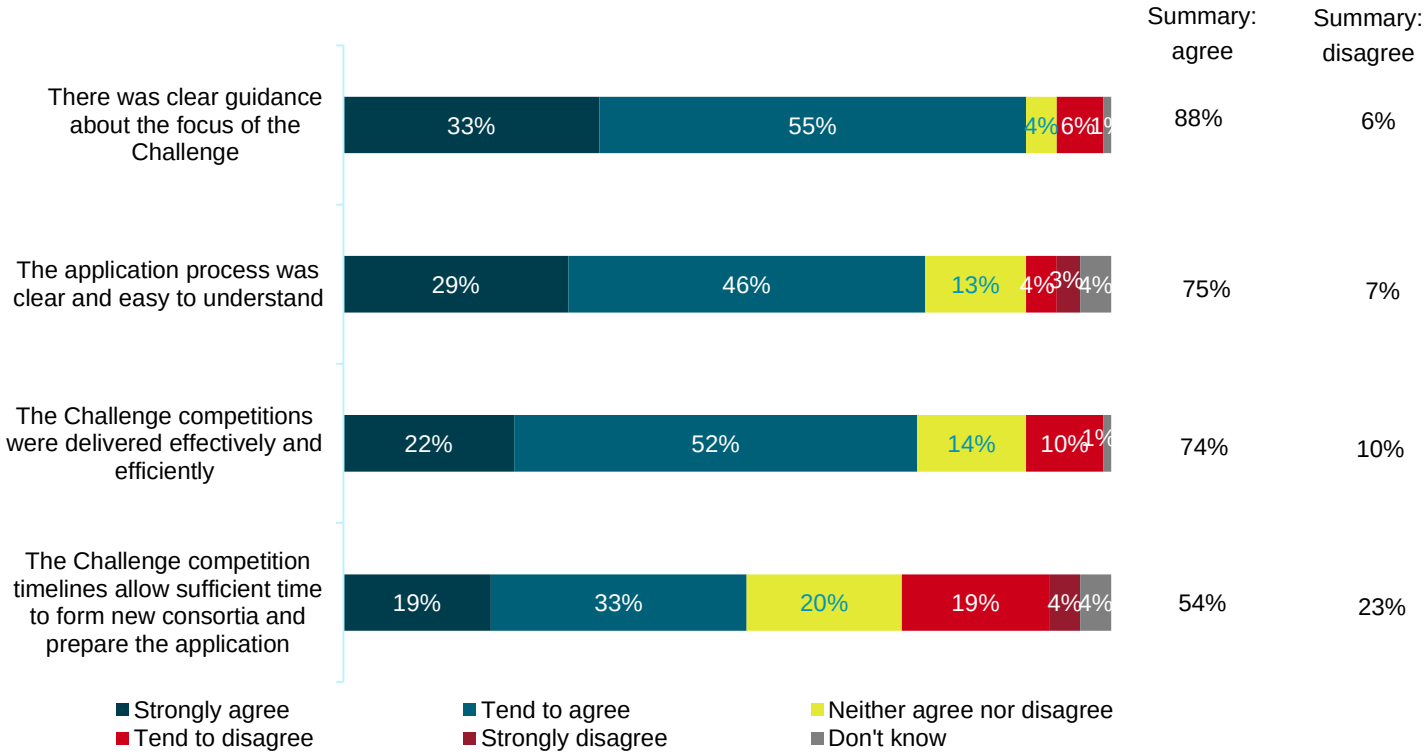
> *"Funding from DER has already been committed [for competitions] so funding to use the equipment of the Industrialisation Centres will not come from the DER Challenge. We'll have to look elsewhere e.g. APC, ATI and other Innovate UK funding streams. That's quite disappointing I think for everybody and including the Challenge team themselves."* Delivery lead (DER-IC)

For future programmes incorporating initiatives similar to the DER-IC, we **recommend that these initiatives are fully integrated into the design of the programme from the outset**. The Challenge could also **consider whether any additional funding could be sought for use of the DER-IC equipment**.

Theme 2: Design and delivery of competitions

The majority of survey participants agreed that the focus of competitions was clear and that the application process was easy to understand. It should be noted that, given the low number of survey responses (69), the findings should be seen as indicative of perceptions, as we cannot guarantee that results are representative of the population.

Figure 1 Views of competitions



Source: *Contact survey. K1. Thinking about the Driving the Electric Revolution Challenge competitions, including the application process, how much do you agree or disagree with the following statements?*

Note: *Base: all respondents – process and interim impact survey (69).*

While, as noted earlier, there was an appetite for speedier 'fast-track' competitions, there was some indication that competition timelines did not always allow sufficient time to form consortia and prepare the application, with 23% of survey respondents disagreeing that there was sufficient time (19% tended to disagree that timelines were sufficient and 4% strongly disagreed). Workshop participants noted that, while briefing events were useful for networking, the time between briefing sessions and the deadline for submission of proposals was sometimes too short to allow them to form new consortia, particularly where internal approvals around intellectual property (IP) were needed. We recommend that **sufficient time (at least two months) is allowed for competition applicants to form consortia for competitions where consortia are likely to be needed**.

"The turnaround time is extremely small and a constraint as we need heavy involvement of industries. It actually takes them more time to get internal approval to allocate resources, to agree on the project scope to work with academia. So getting that industrial approval consent is time consuming. And it's very hard to get this whole cycle completed with the current timing allocated by Innovate." Academic workshop participant

Some applicants also felt that greater clarity in advance about the questions that would be asked at the interview stage would be helpful to assist with preparation, and feedback from some delivery leads highlighted inconsistency in assessor scoring at interviews. **Further guidance around the interview process may be helpful.**

More than three-quarters of survey respondents (77%) felt that competitions were aligned with industry needs and 72% stated that the Challenge competitions aligned with their own business needs. Qualitative findings suggest that the work done by the Challenge to understand needs ahead of competitions is important, with industry engagement via industry bodies and the Advisory Group being effective.

"I don't think we've ever used the Advisory Group as a right bottom up [approach]. They've been very useful as the voice of industry." Delivery lead (UKRI)

Academic workshop participants felt that the Challenge could better support small and medium-sized enterprises (SMEs) with the application process given lower familiarity. We recommend that the **Challenge engages with SMEs and academics to publicise the support that is already being provided by the Innovate UK KTN (Knowledge Transfer Network) in this regard**.

"For smaller companies, they almost feel like they're trying to answer an exam question and then they're told they failed at the end rather than having a second attempt or being told how to improve it somehow. I think it's about explaining to companies and really supporting them to build up their argument rather than just expecting them to do this really good submission where they understand completely what they're meant to be doing at the first instance." Academic workshop participant

Consideration could also be given to **allowing refinement and resubmission of applications through competitions with rolling contiguous submission dates,** as the Aerospace Technology Institute (ATI) does.

Theme 3: Design and delivery of the DER-IC and knowledge transfer activities

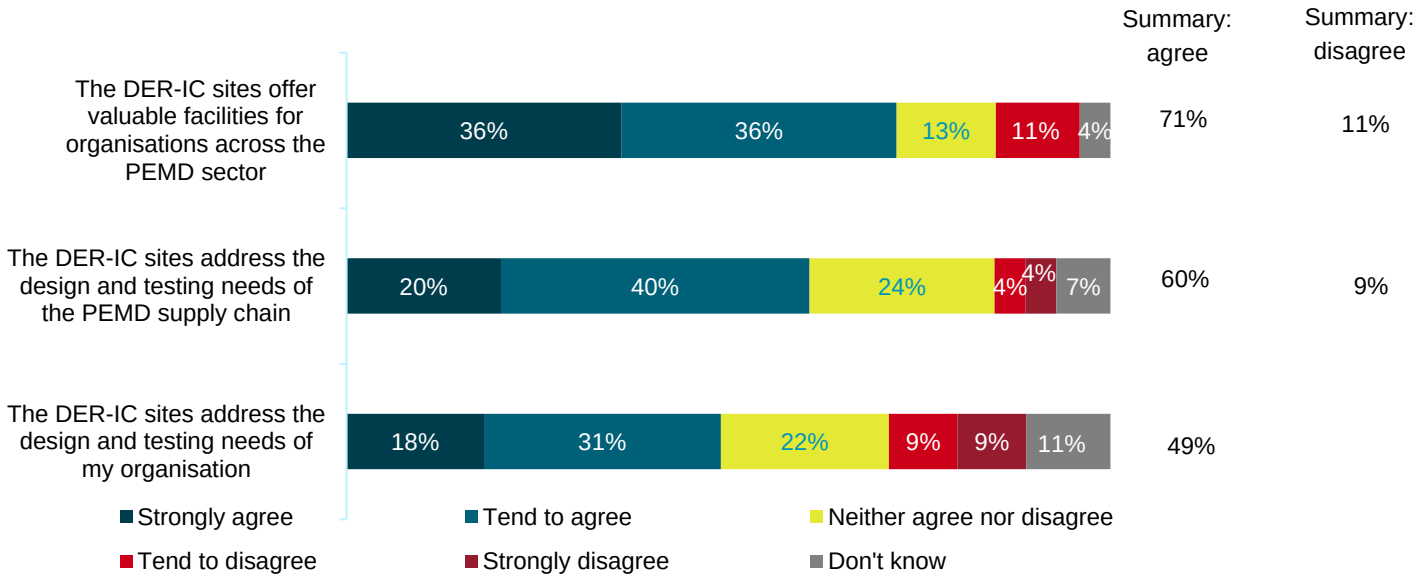
Reflecting the delay in DER-IC sites becoming operational, knowledge of the DER-IC was somewhat limited among stakeholders: one-third of survey respondents were not aware of the DER-IC sites.

Innovate UK KTN events were an important channel to raise awareness of the DER-IC. While work to promote the DER-IC is underway, and there have been recognised COVID-19 related delays in procuring equipment, we recommend that **targeted communications are sent to industry about the DER-IC to raise awareness of the opportunities and funding available that could support the use of DER-IC facilities,** building on the work already underway. For example, more information about the facilities available and launch events was seen as important by industry workshop participants. It will also be important to ensure that industry is supported in using the equipment from a skills perspective, given that the equipment is likely to be very specialised and novel.

"Semiconductor tools is a very specialised engineering discipline that you do need the expertise in. So I guess when we engage with the centres what we'll ask is 'can you do this for us?' rather than 'can we have access to your tool and go and use your tool [ourselves]?'." Industry workshop participant

Among those who were aware, there were signs that the DER-IC sites provide valuable facilities. Sixty percent of survey respondents felt that the sites addressed design and testing needs of the PEMD supply chain.

Figure 2 Views of the DER-IC



Source: *Contact survey. F3. To what extent do you agree or disagree with the following statements about the Driving the Electric Revolution Industrialisation Centre (DER-IC)?*

Note: *Base: where aware of DER-IC – process and interim impact survey (45).*

Similarly, industry workshop participants who were aware of the DER-IC had positive views.

"I think if you look at the way that it's being set up, I think it makes a lot of sense the way it's been done. They've got the right experts at the right areas with the right equipment […] I'm sure there'll be a lot of up-take once this is ready to go." Industry workshop participant

In relation to knowledge transfer activities, there were broadly positive perceptions in the survey about their effectiveness (see Figure 16). Among survey respondents, 65% felt that the activities had engaged a wide range of stakeholders across the PEMD sector, 54% felt that they were being delivered effectively and efficiently, and 51% felt that they were engaging a wide range of organisations across other sectors.

'Engage with' sessions (both online and face to face) were highly valued by stakeholders for networking and collaborating and were particularly useful during the pandemic. While these sessions have now stopped as registration and attendance had declined, likely once funding competitions had completed, we **recommend that this 'Engage with' format is used in future initiatives to encourage collaboration and knowledge sharing among industry**.

Theme 4: Design and delivery of the skills gap activities

The skills competitions in the Challenge were intended to provide evidence on the types of interventions that work to improve skills. Prior to the skills competitions being launched in 2022, the Challenge had gathered evidence on skills needs by commissioning a training needs analysis and engagement with industry. As the results of the training needs analysis were of limited use, skills needs were also captured in individual competition applications. Qualitative delivery leads at UKRI fed back that, based on their engagement with industry, they believed that skills gap activities were aligned to industry needs:

"*If you speak to the PEMD community, the one thing everyone is struggling with is recruiting skilled people or they are trying to upskill their own people to meet their industry needs*." Delivery lead (UKRI)

There was some sense of fragmentation in how the skills gap activities were being delivered, in part resulting from the way that evidence on skills needs and gaps had been identified.

"The only bit that I would question is the skills piece. It should have been a national skills provision rather than a lot of small competitions." Delivery lead (DER-IC)

Nonetheless, there was an expectation by the Challenge from the start that the £6 million of funding allocated to skills was not going to allow for a national skills provision, with the focus instead being on funding specific activities that could demonstrate impact.

Skills gap activities are seen as integral in supporting the Challenge to achieve its objectives given that a skilled workforce is a pre-requisite to the development of the PEMD supply chain.

"*The objective of the Challenge is when people are making investment decisions in board rooms, when they are thinking where should I put my money for PEMD, the UK is in that conversation being a globally recognised place for investment for PEMD. And one of the things that's considered at that level is 'is there a skilled workforce available or am I going to have to bring people in or retrain?' And skills activities feed into this. There's such a massive skills gap globally. If you can't find the people, then everything else falls apart*." Delivery lead (UKRI)

As noted above, while the Challenge is limited by the original proposal, the growing centrality of skills to the Challenge and its overarching objectives suggest that future similar programmes will need additional funding that is targeted at skills.

There was also feedback from DER-IC colleagues that the skill gap activities could be better integrated with other workstreams, particularly the DER-IC. Universities engaged with the DER-IC were already delivering training on PEMD to companies on an ad hoc basis. We recommend that the **Challenge explores ways of better coordinating these workstreams to allow for knowledge sharing and to maximise impacts**.

"Skills are not part of what [DER-IC] sites are doing and that's an issue/mistake. Actually, most of my time [at the DER-IC] is spent discussing skills over and above anything else. In [region], we have 30,000 shortage [of skilled staff] each year for the next three years." DER-IC colleague

Theme 5: Delivery and outcomes monitoring

There was consensus among workshop participants that the monitoring process was helpful in keeping the project on track. Almost three-quarters of survey respondents involved in CR&D projects felt that the monitoring process was efficient, compared to only 11% who said it was not.

Quarterly review meetings were viewed positively by delivery leads and workshop participants. Innovation leads being present in meetings was highly valued to help consortia address issues, and they felt this was something that was working well in the Challenge relative to other Innovate UK programmes. We recommend that **this process is maintained in this and future initiatives** because of the value it gives.

"I thought one of the most useful things about the entire project was the innovation lead showed up to all of our quarterly meetings. And I really appreciate [them] actually taking the time to show up … a very experienced monitoring officer was absolutely invaluable, I have to say, at navigating Innovate processes, but also thinking

of suggestions for how to promote the technology within the PEMD sphere in the UK, which for us was very important because we're new to that." Industry workshop participant

Some potential improvements to the monitoring process were highlighted. Industry stakeholders felt that the process for submitting project change requests was overly complicated and took too long to resolve. Where possible, **options to speed up the project change request (PCR) process would be valued**. Industry workshop participants suggested that, if possible, **additional authority to approve requests could be given to monitoring officers** given their familiarity with the projects.

Some academic and industry stakeholders felt there were different interpretations of the role of monitoring officers and their willingness to engage with technical aspect of projects, although all those we engaged with were positive about the role of their own monitoring officer. Some delivery lead interviews highlighted challenges with the consistency of monitoring officers as well. **Guidance on the role and expectations of monitoring officers** could be reviewed and refreshed to ensure greater consistency.

Potential improvements for gathering feedback were suggested in relation to knowledge transfer events.

"*We don't hear much negative feedback and I don't know if that's because we're not asking things in the right way or because people don't want to be negative."* Delivery lead (UKRI)

Review of the feedback sessions could look at whether these sessions are the best way of gathering feedback or whether other approaches could encourage more open feedback.

The interim impact evaluation

Approach

The interim impact evaluation was organised around seven broad thematic evaluation questions:

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

Within each question, we identified specific evaluation indicators and sources of evidence which formed the basis of our evaluation findings (see Section 4 for details). The focus of this interim impact evaluation is on leading indicators which are reasonably expected to have been influenced by the Challenge at this stage of delivery and are expected to be correlated with longer-term effects. Recommendations and conclusions are highlighted in **bold type**.

Our overall evaluation approach is contribution analysis, an example of theory-based evaluation particularly relevant to large-scale interventions such as Challenge funds which seek to deliver a range of benefits and operate in complex environments. The evaluation questions and indicators used through this interim impact

evaluation were informed by the theory of change for the Challenge developed in the Evaluation Framework Report. We draw on and triangulate all of the qualitative and quantitative evidence captured to arrive at an informed view about the contribution the Challenge has made so far to each evaluation question, taking into account other factors that may be important influences. This Executive Summary presents the key conclusions and supporting evidence from this process (see 'key findings' below). More detail of the evidence base is found in Section 4, organised around each evaluation question in turn. The methods deployed in support of the contribution analysis consist of:

- Three types of in-depth case studies:
  - An *activity-based case study* focusing on the activities of the Midlands DER-IC site, based on eight interviews with stakeholders within the DER-IC and firms engaged with it so far;
  - Two *project-based case studies* which describe the technical, commercial and social impacts of specific CR&D projects, based on interviews and exchanges with participating stakeholders as well as desk-based research; and
  - A *thematic case study* which explores the impact of the Challenge on the wider PEMD supply chain and UK economy, based on interviews and panel discussions with academic institutions, PEMD firms, trade associations and policy audiences not immediately supported by the Challenge to date, and supplemented with desk-based study.
- Analysis of survey data collected from the sample of 69 respondents to the process evaluation survey. We selected priority impact questions to include in the survey to provide targeted evidence on key leading indicators for this interim assessment.
- Analysis of monitoring data that was shared directly by the Challenge and Innovate UK KTN.

More details of each method, including design and implementation, can be found in Section 4.

As with any evaluation, our approach is grounded in attempting to understand the counterfactual of what would have happened absent the Challenge. By triangulating insights from different approaches, we can arrive at reasoned conclusions based on the weight of the evidence. The methodologies we used to consider counterfactuals were:

- Self-reported views from those involved in case studies where participants reflected in detail on what they had achieved as a result of their engagement with the Challenge, their expectations of future impacts and the additionality of the Challenge;
- Comparison of results to the baseline survey from 2021 to understand whether there has been any systematic change across respondents; and
- Trend analysis of monitoring data with due reflection on other factors which may have influenced the trends observed.

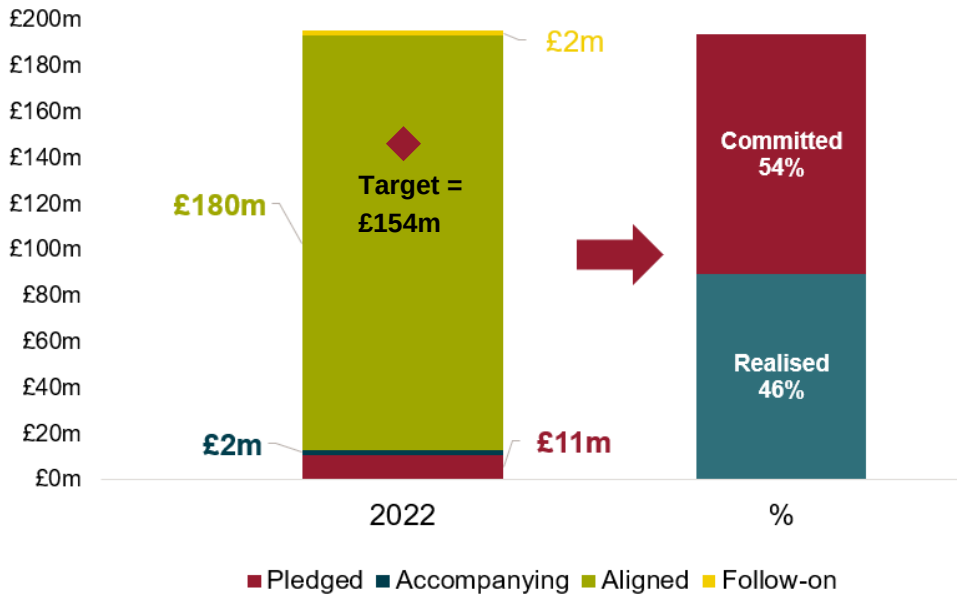
Key findings

In Section 4 we present both summary and detailed findings for each evaluation theme in turn. Rather than replicating those summaries here, we provide a broad narrative assessment. **Our overarching conclusion, drawing across each theme, is that the Challenge appears to be doing well and is on track to meet expected future outcomes and impacts**. **We have not identified any obvious 'early warning signs' which would suggest that things are significantly off track in terms of impact at this stage.**

In particular, we note **positive signs relating to key leading indicators such as investment** (theme 4). This is likely to have resulted from the direct CR&D funding that the Challenge has provided and the funding given to the DER-IC, which has allowed them to collaborate with firms directly, point firms towards further funding opportunities and provide firms with open-access equipment to test processes with minimal risk.

Based on monitoring data, the Challenge appears to have been very successful in catalysing co-investment, reaching approximately £195 million cumulative in 2022, thereby exceeding its original £154 million target for the lifetime of the Challenge (2021 to 2025) with the result that the target has been forecast upwards by 40% to £256 million. As expected by the Challenge from the outset, co-investment mainly comes from aligned and follow-on investment, because match-funded pledged investment would not be enough to make up the scale of expected leveraged private investment. Although approximately half of the co-investment has not yet been realised, **the Challenge seems to be on track to achieve this**.

Figure 3 Co-investment levels



Source: Frontier analysis of Challenge monitoring data

This co-investment is not necessarily fully additional, in the sense that some of it might have been invested absent the Challenge either in the same or other projects. The survey and qualitative evidence provide more insights into the nature of additional investments:

- For example, over half (32 of 60) of business respondents in the survey that were competition winners or had engaged with the DER-IC said they expected to secure additional investments from either public or private sources as a result of their Challenge engagement. Both sources were important: 27 out of 60 respondents expected to secure additional public investment and 24 of 60 expected additional private investment.
- More than one-third of successful applicants in the survey had *already* received additional funding since their interaction with the Challenge.
- Over half of business respondents expected to spend more on research, development & deployment (RD&D) as a result of their Challenge engagement.

- The case studies suggest that Challenge funding can increase the interest of both public and private investors through the provision of infrastructure, being able to build on successful technology development, or through helping to raise awareness of investment opportunities. Many stakeholders commented that the scale of investment needed to foster the PEMD supply chain in the UK will be much larger than that available through the Challenge because of investments being made overseas.

The broad perspective was that, given the budget available, the Challenge had helped to increase investors' support in order to develop and build a more resilient PEMD supply chain.

The distribution of funding is used to proxy the distribution of the Challenge's impact across the UK, as it is not possible with the interim findings to assess regional impact directly. Challenge data suggests that **the distribution of funding is largely outside of London and the South East, in line with wider 'levelling-up' objectives to increase investments across the country** (theme 7). Only 10% of funding is estimated to have gone to London and the South East, compared with around 27% to the West Midlands, 15% to both the North East and Wales, and 12% to Scotland.

This distribution of funding may reflect the distribution of key sectors, particularly the automotive sector. Wider analysis of the portfolio of Challenge projects and the perceptions of some stakeholders interviewed for our thematic case study suggest a potential overrepresentation of lower-scale (below 1MW) and automotive applications. Sixty-eight percent of projects appear to relate to the transport sector, and the Midlands (which has received over a third of Challenge funding) is a locus for automotive and lower-scale PEMD. However there was recognition of the potential spillover benefits to other sectors.

"When I looked at the projects that the Challenge was covering, not many of them resonated with me in terms of the applications that we've got within the power industry … but I guess that's because some of the innovation and the technology will naturally cross." Technical expert, thematic case study

There is also **evidence of positive impact around another leading area, collaboration in the PEMD ecosystem** (theme 5). The Challenge appears to have increased its reach into the ecosystem, with contact data provided by Innovate UK KTN increasing from fewer than 500 'DER community' contacts in mid-2019 to over 3,000 by Spring 2022. Generally, this growth in reach has slowed over time since the launch of the Challenge, although large competitions, including the Catalysing Green Innovations S1 and Supply Chains for Net Zero competition in May to June 2020 and February to April 2021, align with significant increases in Challenge contacts. The level of engagement between the Challenge and the community, as measured by registrations and attendance at Challenge events, has remained relatively flat in absolute terms over time and, apart from spikes at the time of large competition events engagement, it has not grown at the same trajectory as the Challenge's reach.

Survey respondents were positive about the impact of the Challenge on collaboration, with 61 out of 69 feeling that the Challenge had increased collaboration significantly or slightly. The in-depth case studies provide examples of the Challenge increasing the number of current collaborations, with the potential for these to become sustained and increase the overall collaboration within the PEMD ecosystem in future.

"Before GaNSiC Direct-Dispense, they [UK automotive players] wouldn't have touched us." CIL (project-based case study)

This increased collaboration was between a range of actors – large organisations, SMEs, academics – and is not limited to a particular technology or sector. The most common types of collaboration partners reported by survey respondents were researchers and SMEs, with the vast majority of respondents rating these as successful collaborations. Partners outside PEMD were less common, although two-thirds of those collaborating with non-PEMD partners rated the collaborations as successful.

Evidence from the in-depth case studies supported these survey results. A member of the DER Hairpin project said that the project had strengthened the relationship between diverse and complementary consortium members and there was a significant opportunity for future knowledge exchange. This is also evidenced in the GaNSiC case study where both consortium members said there was cross-referral of new business leads after completing the project.

"There are companies that are now approaching us [Nottingham] post DER-IC that had never contacted us before. We have [historically] had a lot of expertise in the aerospace sector. But when we started promoting our activities in the DER-IC and the facility in place, we have received a lot more clients from the automotive sector which we did not [initially] expect. Our BD pipeline has grown by five times compared to when we did not have the DER-IC." DER-IC colleague

Our primary research findings also **suggest examples of positive impacts of the Challenge in accelerating innovation and the commercialisation of PEMD technologies** (theme 1). The Challenge has achieved this through providing a total of £30 million in CR&D funding to around 100 firms and by funding the DER-IC, which have provided open access to equipment.

Survey responses suggest optimism about the impact of Challenge support on technology development. Only one survey respondent reported being at MRL 7 or above at project commencement, but 17 (out of 54) expected to reach that point by the end of the Challenge engagement.

Qualitative evidence provided examples relating to this theme. One of the project case studies had increased the MRL to level 9 (demonstration of low rate production and capability to begin full rate production) and had been focusing on commercialisation within the UK. The Midlands DER-IC site case study also provided examples of projects using the testing facilities to advance innovation, including examples where the Midlands DER-IC site facilities had allowed projects to perfect their own equipment orders and to continue to develop while waiting for their own equipment to arrive. Moreover, the facilities had helped to increase the scope and ambition of one case study project by providing reassurance that the required experts and equipment were available to them.

"Without the involvement of WMG and the [Midlands] DER-IC [site] (which is using cutting edge, impressive manufacturing gear) we would perhaps [have] bid for a project less ambitious in scope, rather than one that is currently effectively developing a supply chain and manufacturing design. [This is because] we would need to de-risk some of the aspects [that] the [Midlands] DER-IC [site] is now supporting us with, including the advanced manufacturing processes." Large manufacturer

Stakeholders who were part of the thematic case study gave examples of where Challenge funding for offshore wind had allowed the project to be commercially viable without public funding, describing it as a 'real success story'.

Similarly, we also identified examples of **the Challenge expanding the manufacturing capacity of firms** (theme 6). One project case study expected to see an increase in capacity from 2,200ft^2 to 46,000ft^2, along with expected growth in revenues and employment, with interviewees attributing around half the growth to the technology developed under the Challenge and to the follow-on projects that the Challenge had unlocked. Interviewees in this case felt that the funding had sped up the project, and it would have taken longer to secure other investment finance to develop the idea without the Challenge.

"Approximately half the increase in staff from 132 persons to the planned 300 persons are as a direct result of project GaNSiC Direct-Dispense and follow-on projects such as @FutureBEV (BMW), PE2M and EleVAIT (JLR) and hopefully Future Drive." GKN (project-based case study)

The case studies and survey suggest optimism about the broader impact on business performance for firms engaged by the Challenge: the vast majority of business respondents who expected their business to grow in the next few years felt that the Challenge had had at least a small impact on their growth projections, with around a quarter saying the impact had been significant. More than half of business respondents said that the Challenge had already led to an increase in the number of employees they had hired. One specific case study example was a competition winner who had already hired nine graduates and was looking to hire another twelve.

The impacts on business performance, manufacturing capacity and commercialisation are largely individual examples at this stage, along with signs of wider optimism of future impacts from survey respondents. Together these changes suggest the Challenge has the potential to increase sectoral productivity (theme 2). **We do not yet have strong evidence of more widespread and systemic changes in productivity resulting from the Challenge**, although this would not be a realistic expectation at this relatively early stage of Challenge delivery given that productivity is a longer-term outcome.

We also have **limited evidence of the Challenge having a significant positive impact on skills, although this is to be expected as the skills-related activities are at an early stage** compared with the CR&D activities. It should be noted that, while the value of the funding put aside for skills-related competitions is substantially smaller than that for CR&D competitions – £6 million vs. £30 million – this is still a substantial allocation focused on skills in the context of Challenge funds, highlighting the importance of skills gaps in the PEMD sector. The Challenge is attempting to tackle this problem though competition funding and through the DER-IC. Skills competition funding and CR&D funding are allowing the upskilling of the number employees in the workforce, and the DER-IC provide technical expertise to PEMD companies as well as training for their open-access equipment.

Given the qualitative case study evidence that we collected, we think it is **reasonable to expect the Challenge's efforts to lead to productivity and skills benefits in the future**.

Specific findings relating to the interim impact evaluation identify a few areas that it may be useful for the Challenge to consider in order to be able to maintain early promising signs and do its best to ensure that its activities have a positive and significant impact on the UK PEMD supply chain:

- Use its network to support the DER-IC in their efforts to publicise the opportunities they have on offer, so that firms are aware of the DER-IC and take up the equipment and services they provide;

- Boost efforts in PEMD companies that have received less support so far, perhaps by moving the focus from well-covered areas (such as automotive and applications below 1MW) towards less well-covered areas (including industrial heat and power and applications above 1MW);
- Continue promoting the connection and interaction of the PEMD ecosystem through Challenge-led engagement in support of collaboration between companies within it;
- Consider options within the initial Challenge agreement to further tackle the issue of skills, which has consistently been seen as a significant barrier to PEMD growth and development; and
- Continue to help the UK government develop a clear high-level industrial strategy for the development of a UK PEMD supply chain by tying investment and development efforts together.

1 Introduction

About this report

This report presents the findings of a process evaluation and an interim impact evaluation of the Driving the Electric Revolution Challenge ('the Challenge') delivered by Innovate UK for UK Research and Innovation (UKRI) on behalf of the UK government. It is the third phase of a four-phase evaluation of the Challenge, following an Evaluation Framework Report completed in 2021 and a baseline report completed in early 2022. The fourth and final phase, the final impact evaluation, will be completed in 2024.

From the *Magenta Book*,[1] **process evaluation** seeks to understand 'what can be learned from *how* the intervention was delivered?'. The focus is on elements of the implementation of a policy or programme and how well they are working, including in support of delivering the intended benefits. **Impact evaluation** seeks to understand 'what difference has an intervention made?' and focuses on demonstrating, as robustly as possible, the benefits that a programme or policy has delivered or contributed to.

By delivering a process and interim impact evaluation while the Challenge is still operating, this report also seeks to provide an understanding of how delivery processes are influencing realised or expected impacts, and to provide actionable recommendations for the Challenge.

The remainder of this report is structured as follows:

- Section 1 provides some context to the Challenge, including the process and impact evaluation themes outlined in the evaluation framework and used throughout this report.
- Section 2 outlines the approach taken for both the process and interim impact evaluations, including their structure and a description of the evidence sources used.
- Section 3 reports the findings of the process evaluation, split by its five evaluation themes and offering conclusions and recommendations for the Challenge.
- Section 4 reports on the interim impact evaluation, with findings across each of its seven evaluation themes and conclusions.

The report then finishes with a number of annexes that contain more detailed write-ups on the materials and research findings.

[1] HM Treasury (2020), *Magenta Book: Central Government guidance on evaluation.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/879438/HMT_Magenta_Book.pdf)

The Driving the Electric Revolution Challenge

Rationale, objectives and structure

Electrification is one of the key pathways to meet net zero by 2050, and power electronics, machines and drives (PEMD) are used in diverse applications fundamental to enable electrification.[2]

The UK is demonstrably world leading in research and design across the PEMD supply chain, both in terms of academic and industrial development. Previous grant funding for UK PEMD generally focused on early-stage research for lower manufacturing readiness level (MRL) projects. The focus of the Challenge, however, has been on the delivery of higher-level MRL projects, presenting a divergence from previous funding. In terms of MRL, we understand that there are multiple possible definitions and scales. For the purposes of this report we use the MRL scale defined in Table 1. We use this scale throughout the report when we refer to MRL.

Despite previous successes in the area, there are a range of market failures and institutional barriers that are preventing the UK from also becoming world leading in PEMD manufacturing. These barriers include a traditionally siloed sector focus, a skills shortage, coordination failures and regulatory barriers, among others. COVID-19 is also likely to have had a significant impact on UK PEMD, as it has done on all of UK society and business, not least through changes in working patterns. The inability to access laboratory space will have affected projects funded by the Challenge and will have delayed experiments. This is particularly relevant for the higher MRL projects which are the focus of the Challenge, where greater access to physical equipment is important. It is impossible to know how the running or impact of the Challenge would have been different without COVID-19 and, therefore, that does not form part of the evaluation. However, it is worth noting the massive disruption that COVID-19 caused to all of UK society and business as a backdrop to the findings about the Challenge in this and further reports.

Despite these factors, the UK has the potential to achieve a substantial share of this rapidly growing global market, providing high quality jobs and economic growth as an enabler of the green industrial revolution in transport, energy, industry, agriculture and construction. Therefore PEMD has been identified for intervention, with the Challenge aiming to help to remove some of the key barriers facing the UK and enable electrification across multiple sectors. The Challenge business case identified 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 the skills gap by retraining, upskilling and repurposing engineers from traditional internal combustion businesses into PEMD supply chains.

[2] 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, invertors, convertors, 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.

The Challenge is a £234 million investment programme, with £80 million committed by UKRI and a further £154 million of investment expected to be catalysed by the Challenge activities. The Challenge provides grant funding to industry-led consortia seeking to conduct collaborative research & development (CR&D) projects and to an academic-led consortium to establish the Driving the Electric Revolution Industrialisation Centres (DER-IC). The Challenge has some continual oversight of the projects it funds (e.g. through monitoring officers), but the individuals running the CR&D consortia and the DER-IC consortium are not Challenge employees. The Challenge has also conducted a range of supporting activities to facilitate knowledge exchange and enhance the UK skill-set.

Table 1 MRL scale

Scale	Definition
MRL 1 and MRL 2	Developing basic principles or formulating the concept
MRL 3 and MRL 4	Developing the proof of concept or testing in laboratory conditions
MRL 5 and MRL 6	Producing prototype components, systems or subsystems in a production relevant environment
MRL 7 and MRL 8	Producing systems, subsystems or components in a production representative environment or demonstrating pilot line capability
MRL 9	Low rate production demonstrated and capability in place to begin full rate production
MRL10	Full rate production demonstrated and lean production practices in place

Source: Frontier Economics

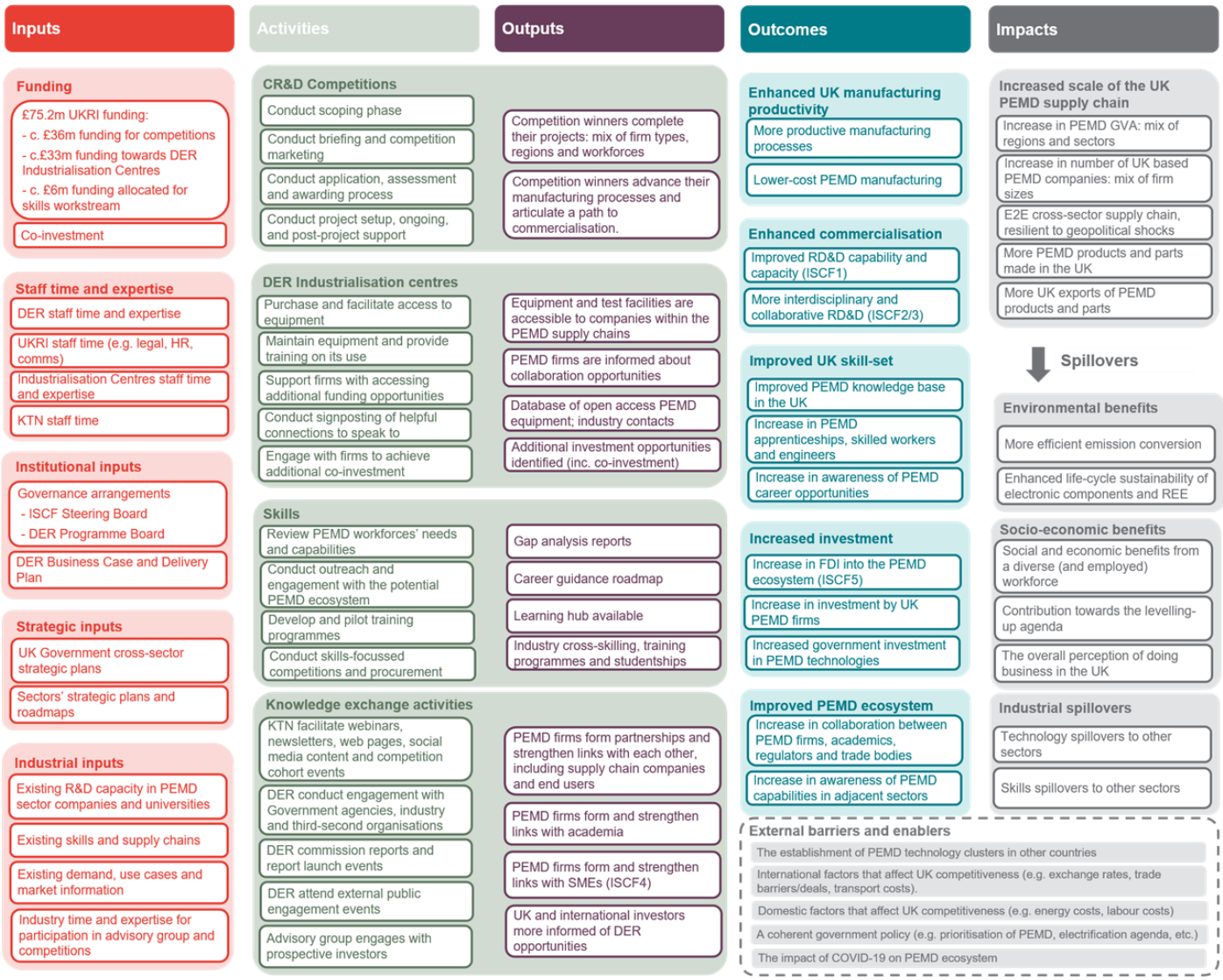
Note: This scale was agreed with the Challenge for the baseline report and was also used in the baseline and process and interim impact contact survey.

Theory of change and associated evaluation themes

Theory of change

The theory of change describes how the Challenge is expected to transform inputs and activities into outputs, outcomes and impacts. The theory, summarised below and represented in Figure 4 as a visual logic model, was developed collaboratively with the Challenge as part of the Evaluation Framework Report. The theory of change was critical to developing our overall, theory-based approach to evaluating the Challenge, including the evaluation themes and metrics used in this report, and so a brief restatement is useful to contextualise the approach and findings of this report. Full details of the theory of change are in Section 2 of the Evaluation Framework Report.

Figure 4 Challenge Logic Model



Source: *Challenge Evaluation Framework*
Note: *ISCF (Industrial Strategy Challenge Fund) numbers refer to the five ISCF high-level objectives.*

There are five categories of inputs into the Challenge, 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 KTN. 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.

Process evaluation and themes

Process evaluations are used to understand how effective the delivery of an intervention has been and the factors contributing to this. Process evaluations aim to:

- Help understand how the intervention was delivered (and who was responsible);
- Identify what parts of the intervention were most critical in delivering outcomes and impacts; and
- Understand what worked well and less well to enable improved delivery in the future.

The process evaluation framework was based on extensive desk research and stakeholder engagement carried out as part of the overall Evaluation Framework Report (see Section 3 of that report for details), including an understanding of the processes involved in delivering different activities of the Challenge and the stakeholder groups engaging with different parts of the process. There are five evaluation themes:

1. Management and governance of the Challenge;
2. Design and delivery of the Challenge competitions;
3. Design and delivery of the DER-IC and knowledge transfer activities;
4. Design and delivery of the Challenge skills gap activities; and
5. Delivery and outcome monitoring.

Section 3 of this report outlines the focus of each of these five themes and the associated evaluation questions and indicators that sit underneath them. Our findings are structured around these themes.

Interim impact evaluation and themes

Informed by the theory of change, and agreed with the Challenge, 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 theory of change 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:

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

More details of these themes can be found in Section 4 of the Evaluation Framework Report.

Section 4 of this report outlines the focus of each of these seven themes, as well as the evaluation metrics that sit within them. As this is an interim impact evaluation, not all of the evaluation metrics identified in the evaluation framework are explored in full at this stage. More details can be found in Section 4 of this report on the selection of metrics for the interim impact evaluation.

Table 2 Glossary of key terms and abbreviations

TERM	DEFINITION
APC	Advanced Propulsion Centre
ATI	Aerospace Technology Institute
BEIS	The Department for Business, Energy and Industrial Strategy
BEV	Battery electric vehicle
CAGR	Compound annual growth rate
CIL	Custom Interconnect Limited
CR&D	Collaborative research and development
CSAC	Compound Semiconductor Applications Catapult
CSAM	Confocal scanning acoustic microscopy (measurement method)
DCMS	Department for Digital, Culture, Media and Sport (UK)
Delivery leads	Individuals employed by UKRI who are involved with delivering one or more of the workstreams of the Challenge (competitions, skills, and knowledge transfer activities)
DER	Driving the Electric Revolution
DER-IC	Driving the Electric Revolution Industrialisation Centres – an academic consortium project, funded by the Challenge but not run by Challenge colleagues
DORNA	Development of high-reliability motor drives for next-generation propulsion applications (EU Horizon 2020 funded project)
ED&I	Equality, diversity and inclusion
EPSRC	Engineering and Physical Science Research Council (UK)
ESC	Energy Systems Catapult
EV	Electric vehicle
GaN	Gallium nitride; a material used in power electronic switching devices
GaNSiC	Gallium Nitride Silicon Carbide (Direct-Dispense) (UKRI Challenge-funded project)
GKN	GKN Automotive
GWp	Giga-Watt (10^9 W) capacity at peak
H1	First half (of a given year)
IGBT	Insulated-gate bipolar transistor
IP	Intellectual property
ISCF	Industrial Strategy Challenge Fund
JLR	Jaguar Land Rover
KPI	Key performance indicator

TERM	DEFINITION
KTN	Knowledge Transfer Network
kW	Kilo-Watt (10^3 W)
LCA	Life-cycle analysis
MDL	Motor Design Limited
MRL	Manufacturing readiness level
Mt	Mega-tonne (10^6 tonnes)
MW	Mega-Watt (10^6 W)
OEM	Original equipment manufacturer
ORE Catapult	Offshore Renewable Energy Catapult
PCB	Printed circuit board
PCR	Project change request
PE2M	Power Electronics Modules by Rapid Moulding (UKRI Challenge-funded project)
PEMD	Power electronics, machines and drives
R&D	Research and development
RD&D	Research, development & deployment
rpm	Revolutions per minute
SAIC	Shanghai Automotive Industry Corporation
SEM	Scanning electron microscopy (measurement method)
Si	Silicon
SiC	Silicon carbide; a material used in power electronic switching devices
SME	Small and medium-sized enterprise
STEM	Science, technology, engineering and mathematics
TDAP	APC's technology developer accelerator programme
TRL	Technology readiness level
TWh	Tera-Watt-hour (10^{12} Wh)
UCAS	University and Colleges Admission Service (UK)
UKRI	UK Research and Innovation
WBG	Wide bandgap (device)
WLTP	Worldwide harmonized light vehicles test procedure
WMG	Warwick Manufacturing Group

2 Approach taken

Structure of the evaluation

Process evaluation

Process evaluation aims to understand how an intervention was delivered and to identify the factors that helped or hindered its effectiveness.

While impact evaluation is helpful in isolating the outcomes and impacts caused by an intervention, it is less useful for explaining why these occurred or if they might have occurred differently in other circumstances. Process evaluation provides context to help evaluators understand, amongst other things:

- How the intervention was delivered and in what context;
- Who was responsible for delivering the intervention and how decisions about implementation were made;
- What parts of the interventions were most critical to delivering planned outcomes and impacts;
- What parts of the process worked well, and what parts worked less well;
- How the intervention was experienced by participants and the delivery group; and
- How it could be improved in the future.

In addition to providing a long-term perspective on the intervention process, process evaluation is important for providing actionable feedback to the organisations responsible for delivering an intervention, allowing the process to be refined in real time.

The process evaluation of the Challenge was implemented based on the process evaluation framework developed as part of the overall Evaluation Framework Report. We provide a brief summary of the approach here, with more details available in the full Evaluation Framework.

Process evaluation themes

The process evaluation was organised around five broad **process evaluation themes**:

1. Management and governance of the Challenge;
2. Design and delivery of the competitions;
3. Design and delivery of the Industrialisation Centres and knowledge transfer activities;
4. Design and delivery of the skills gap activities; and
5. Delivery and outcome monitoring.

Within each theme, we developed a set of process evaluation questions to be explored and success indicators, and we identified data sources or methodologies to answer the questions. Our approach highlighted the use of surveys and industry workshops as common approaches to evidence-gathering across all themes and the use of relevant accounting and other monitoring data. In some cases, the evaluation questions were specifically about the processes around the Challenge; in others, they spoke to how process appears to relate to impacts.

1. Management and governance of the Challenge

This theme focuses on the overall governance and programme management of the Challenge, including risk management and financial accountability. Table 3 describes the evaluation questions, success indicators and data sources for this theme.

Table 3 Process evaluation questions – 'programme management'

Evaluation question	Success indicators	Data sources
a) How effectively did the different activities and workstreams of the programme work together and make the programme as a whole more effective as opposed to delivering individual strands?	Evidence of iterative learning and development across the workstreams.	■ Delivery group interviews
b) To what extent did the programme use its resources efficiently and effectively?	Perceptions that the funding and resources were appropriately split between activities and workstreams.	■ Delivery group interviews
c) To what extent is the Challenge governance structure appropriate to maximise impact?	Decisions regarding the Challenge were made at the right level in a timely manner.	■ Delivery group interviews
d) Did the Challenge meet budgetary expectations?	The Challenge met its business case as anticipated, without unforeseen issues or additional costs.	■ Delivery group interviews
e) How were any unforeseen issues and hidden costs addressed?	Evidence of unforeseen issues if applicable, their likely impact on programme success, and how any hidden costs were addressed.	■ Delivery group interviews
f) How effective was the due diligence process?	If project failures occurred, no evidence that due diligence could have identified and/or mitigated the failure.	■ Delivery group interviews
g) How effective was the governance and communication in engaging a diversity of stakeholders in the Challenge?	Evidence that the Challenge has reached and was able to engage successfully with a range of wider stakeholders in addition to target competition participants.	■ Delivery group interviews ■ Industry and academic workshops
h) How effective was the programme in communicating and working (transparency, timeliness and clarity of understanding) with external project participants?	Evidence that the Challenge has reached and was able to engage successfully with the full range of target organisations in a clear and timely manner.	■ Delivery group interviews ■ Contact survey ■ Industry and academic workshops
i) To what extent has the Challenge design increased equality, diversity and inclusion across the sector?	Evidence of how programme design has increased equality, diversity and inclusion across the sector.	■ Delivery group interviews
k) To what extent has the Challenge delivery influenced 'levelling up' across UK regions?	Evidence of how programme design has facilitated intended levelling up.	■ Delivery group interviews
l) How does the programme align or complement other government initiatives? (i.e. grand challenges, sector deals, net zero, 2.4% R&D	Organisations can demonstrate that complementary funding enabled greater innovation. Evidence of engagement	■ Contact survey ■ Industry and academic workshops ■ Delivery group interviews

Evaluation question	Success indicators	Data sources
expenditure target, or other initiatives in the relevant sector)?	between the Challenge and the management teams of related initiatives.	

Source: BMG

2. Design and delivery of the Challenge competitions

This theme focuses on the design and implementation of the competition activities, with an emphasis on the engagement process and the extent to which the competitions were aligned to industrial and supply chain needs. Table 4 describes the evaluation questions, success indicators and data sources for this theme.

Table 4 Process evaluation questions – 'competitions'

Evaluation question	Success indicators	Data sources
a) To what extent did the design and delivery of the competitions enable the Challenge to achieve its objectives?	Evidence that the competitions were structured and delivered efficiently and effectively and contributed to the Challenge objectives.	■ Contact survey ■ Industry and academic workshops ■ Delivery group interviews
b) To what extent were the competitions sufficiently aligned to industrial needs?	Participants perceive that the opportunities offered by the competitions address their needs and the needs of their supply chains.	■ Contact survey ■ Industry workshop
c) How successful has the Challenge been at engaging a wide range of PEMD sectors in the competitions?	Evidence of a mix of applications across PEMD sectors and, if applicable, remedial action taken to encourage engagement from specific sectors.	■ Delivery group interviews ■ Applications data
d) To what extent and how has the set up and delivery of the programme encouraged the collaboration (or partnerships) of businesses and academics?	Intervention specifically encourages collaboration between businesses and academics.	■ Contact survey ■ Industry and academic workshops
e) To what extent and how has the set up and delivery of the programme encouraged the collaboration of businesses of different sizes (e.g. large corporations with SMEs)?	Intervention specifically encourages collaboration, including with non-sector companies, international companies and small/large companies.	■ Contact survey ■ Industry workshop
f) How effective were the funding competitions set and processes at attracting the relevant target audience?	Competitions specifically encouraged applications from relevant target audiences and engaged them in an appropriate manner.	■ Contact survey ■ Industry and academic workshops

Source: BMG

3. Design and delivery of the DER Industrialisation Centre and knowledge transfer activities

This theme focuses on how the design and implementation of the Industrialisation Centre and knowledge transfer activities supported engagement and knowledge exchange with a wide variety of organisations. Table 5 describes the evaluation questions, success indicators and data sources for this theme.

Table 5 Process evaluation questions – 'DER-IC and knowledge exchange activities'

Evaluation question	Success indicators	Data sources
a) To what extent did the design and delivery of the knowledge transfer activities support the Challenge to achieve its objectives?	Evidence that the knowledge transfer activities were delivered efficiently and effectively and reached the intended audiences.	■ Delivery group interviews ■ Contact survey ■ Industry and academic workshops
b) To what extent did the design and delivery of the Industrialisation Centres support the Challenge to achieve its objectives?	Participants perceive that the development achieved has been enabled by the Industrialisation Centres and their structure and operation. They acknowledge the approach was valid.	■ Industry workshop ■ Delivery group interviews
c) To what extent has the design and delivery of the Industrialisation Centres facilitated a wide range of PEMD sector companies utilising the Industrialisation Centres?	Evidence of a broad range of PEMD sector companies using the Industrialisation Centres. Perceptions that Industrialisation Centres are available and suitable for a wide range of the PEMD sector.	■ Contact survey ■ Industry workshop ■ Delivery group interviews ■
d) To what extent are the Industrialisation Centres aligned with industrial needs (and consumer needs if relevant)?	Participants perceive that the opportunities offered by the Industrialisation Centres address their needs and the needs of their supply chain.	■ Contact survey ■ Industry workshops

Source: BMG

4. Design and delivery of Challenge skills gap activities

This theme focuses on how the design and implementation of the skills gap activities supported the achievement of project objectives and met the needs of the sector. Table 6 describes the evaluation questions, success indicators and data sources for this theme.

Table 6 Process evaluation questions – 'Skills gap activities'

Evaluation question	Success indicators	Data sources
a) To what extent has the intended design and delivery of the skills gap activities enabled the Challenge to achieve its objectives?	Stakeholders perceive that the development achieved has been enabled by the skills gap activities: they view the Challenge as a unique catalyst. They acknowledge the approach was valid.	■ Delivery group interviews
b) How aligned are the skills gap activities to industrial needs?	Stakeholders perceive that the opportunities offered by the skills gap activities address the needs of the sector and their supply chains.	■ Delivery group interviews

Source: BMG

5. Delivery and outcome monitoring

This theme focuses on how delivery and outcomes are monitored. Table 7 describes the evaluation questions, success indicators and data sources for this theme.

Table 7 Process evaluation questions – 'monitoring'

Evaluation question	Success indicators	Data sources
a) How well does delivery monitoring enable the team to respond to delivery or performance issues promptly and effectively?	Projects progress as anticipated or have been stopped or changed early with little or no wasted time or resources.	■ Industry and academic workshops ■ Delivery group interviews
b) How well does outcome monitoring enable the team to understand if the programme is on track to deliver impacts (i.e. it tracks outcomes such as project success, technical progress, commercial exploitation, supports benefits realisation and evaluation)?	Evidence that the Challenge management was able to identify issues early and resolve them effectively. Evidence that monitoring tracks outcomes (such as collaboration and technical progress).	■ Industry and academic workshops ■ Delivery group interviews
c) To what extent is the quality assurance for the monitoring data sufficiently robust (i.e. what steps have been taken to minimise errors in data entry/extraction/analysis)?	Evidence that review opportunities existed and were taken up for modified monitoring if it was found to be insufficient.	■ Delivery group interviews
d) What improvements can be made to delivery monitoring and outcome monitoring?	N/A	■ Delivery group interviews

Source: BMG

Interim impact evaluation

We employ contribution analysis for the interim 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 Challenge has made, while using different approaches to understand what the counterfactual (what would have happened without the Challenge) looks like, tailored to different evaluation themes and the data available. As described in Section 1, the logic model sets out the critical pathways through which the economic and wider impacts of the Challenge are expected to be realised. The seven impact evaluation themes then structure the metrics and measures that will help determine whether the 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 Challenge (rather than external factors) has been the driver of changes observed in the indicators over time.

The precise approach taken for this interim impact evaluation is tailored to the current stage of delivery of the Challenge and will differ for the final impact evaluation in 2024. We do not use all the impact evaluation metrics outlined in the Evaluation Framework Report as part of the interim impact evaluation. Broadly, this is because the interim impact evaluation is designed to check that the Challenge is on the 'right track' given that its activities are still in early days, and to check for any early warning signs. Hence, we focus on 'leading indicators' for the interim impact evaluation. More details on the specific selection of indicators can be found in Section 4.

In terms of methodology, a particular implication of this is that we placed relatively few impact-focused questions in the beneficiary survey conducted for this report in order to minimise respondent burden. Rather,

the focus of the survey was on questions relating to the process evaluation. In the final impact evaluation, the survey will focus on a wider range of impact metrics.

Overall, the vast majority of impact metrics have been covered through either the baseline report or this interim impact evaluation. This means that the final impact evaluation will be able to refer back to previous figures and highlight progress. Table 32 in Annex E lists all of the impact evaluation metrics and shows in what phase of the evaluation we collected evidence on them.

Given the nature of the intervention and the complex set of objectives that the 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 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 that 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 Challenge. This involved sharing their opinion on expectations for the future as well as what would have happened in the absence of the Challenge;
- Comparison of results to the baseline survey from in 2021 to understand whether there had been any systematic change across respondents; and
- Trend analysis of monitoring data over time, assuming that the pre-Challenge data represents the best counterfactual for what would have happened without the Challenge. This analysis takes relevant non-Challenge trends into account in a qualitative manner but does not attempt to quantitatively or statistically isolate the impact of the Challenge.

Evidence sources informing the evaluation

Process evaluation

We gathered and analysed four main sources of data for the process evaluation:

- A **contact survey** of PEMD organisations that have engaged with the Challenge;
- **In-depth interviews** with those responsible for the delivery of the Challenge (delivery group interviews);
- **Workshops** with PEMD organisations and academics; and
- **Monitoring data** collected by the Challenge/DER-IC.

This section provides an overview of each data source.

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 Challenge. It contained both process and impact questions. The survey was conducted with organisations, both from industry and

academia, which had engaged with the Challenge through applying to competitions, applying to the DER-IC or through other Challenge activities, such as knowledge sharing. Slightly different scripts were used for each of these groups.

The fieldwork took place between 3 October and 4 November 2022. An online link to the survey was sent out to contacts, followed by three email reminders to encourage participation. To maximise response rates, telephone chasing was also used to encourage participation by those for whom telephone numbers were available. The full, de-duplicated sample for the survey consisted of 226 individuals. A total of 69 respondents completed the latest iteration of the survey (17 by telephone and 52 online). Table 8 below shows the response rates against the different types of engagement with the Challenge. This is shown both for the baseline survey and the process and interim impact iteration of the survey. Overall, the response rate for this survey was slightly higher than for the baseline survey, particularly among successful funding applicants.

Table 8: Response rate by main engagement with the Challenge

	Baseline		Process and interim impact	
	Completed interviews	**Response rate**	**Completed interviews**	**Response rate**
Successful application for funding	32	31%	54	78%
Unsuccessful application for funding	4	19%	4	6%
Engage with presenters	7	18%	4	6%
Letters of support	7	13%	6	9%
Advisory group	7	88%	1	1%
Total	**57**	**25%**	**69**	**31%**

Source: BMG

It is important to note that some limitations to the achieved sample should be borne in mind when interpreting the data. In particular, the majority of the responses in the survey came from individuals who had been successful in their application to the Challenge for funding (54 of the total 69 interviews). The relatively small number of completed interviews by individuals who had been unsuccessful in their applications for funding (4), who had engaged with presenters (4), who had offered letters of support (6) and Advisory Group members (1) means that analysis by these sub-groups is not possible. As a result, the reported primary survey results are aggregated across the different types of engagement but should be considered most 'representative' of the CR&D strand of the Challenge (given that most respondents were successful applicants).

The relatively low number of responses in the survey overall means that comparisons between 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, the survey results were compared to the baseline survey conducted between September 2021 and February 2022 to help with understanding any changes in perceptions. The different composition of the samples should be borne in mind when interpreting the findings. In addition, where any survey results reported do not sum to 100%, this is due to rounding. All percentages are shown rounded to the nearest whole percentage.

More information about the survey methodology can be found in Annex B.

Delivery group interviews

In-depth interviews are particularly useful in eliciting a large amount of qualitative information from each individual. The interviews with key delivery leads at UKRI across the Challenge and the DER-IC aimed to help the evaluators understand how the processes of the Challenge were implemented, any issues that were encountered and any remedial action that was taken. Delivery leads are individuals employed by UKRI who are involved with delivering one or more of the workstreams of the Challenge or the DER-IC (competitions, DER-IC, skills, and knowledge transfer activities). The perspective of the delivery leads also provided context to help with analysis of feedback from external stakeholders and beneficiaries through the contact survey and industry and academic workshops.

The interviews, led by BMG, were conducted over video calls which lasted 45 to 60 minutes. This facilitated rapport building and provided an opportunity for delivery leads to reflect on processes and lessons learned. The fieldwork took place in June and July 2022. In total, 12 individuals took part in the interviews. Respondents represented the different strands of the Challenge and included some interviews with DER-wide delivery leads involved in more than one strand. This is why the number of interviews per strand in the table below does not add up to the total number of interviews (12).

Table 9: Delivery group interviews by strand of the Challenge

Strand	Completed interviews
Competitions	5
DER-IC	4
Skills gaps	2
Knowledge transfer	3
Total	12

Source: BMG

The interviews were semi-structured, following a 'skeleton' topic guide that set out the topic areas to be covered. Broad areas included:

- Can you provide us with an overview of how the strand's activities were structured originally and how they are being delivered?
- How efficiently are the strand's activities being delivered? Could this process be improved? If so, how?
- To what extent do you consider the strand to have reached its intended audience? Are any potential audiences underrepresented or not fully represented in knowledge transfer activities? Which ones? Why?
- To what extent is the design and delivery of the strand supporting the Challenge to achieve its objectives?
- How effectively have the different strands of the Challenge worked together so far?
- Do you think that the Challenge's funding and resources were appropriately split between activities and strands? Why?

- In terms of the Challenge governance structure, do you think that decisions were made at the right level and in a timely manner?
- Have you encountered any issues or problems in the delivery of any of the Challenge's activities that were not foreseen at the start of the programme?
- What is the process for monitoring the strand's projects and activities and ensuring they deliver on their outcomes? How is the monitoring data quality assured to ensure it is robust?

The semi-structured nature of the interviews allowed the evaluators to delve into the key metrics, but also meant that any unexpected topics or points of interest could be explored. This also enabled evaluators to modify their questions to suit the specific individual being interviewed and, therefore, gather the most relevant information.

The interviews were recorded and evaluated in a framework against relevant evaluation themes. Framework analysis was used to analyse the findings from the interviews. The evaluators organised statements by indexing qualitative evidence according to the thematic framework. This enabled the evaluators to interpret the key findings and evidence in each theme and identify additional evidence that complemented other data sources.

Industry and academic workshops

Workshops are useful for collecting information from a group of stakeholders on their attitudes, perceptions and experiences in a way that allows participants to build and reflect on each other's contributions. This iterative process allows views to be validated, and it is particularly useful for exploring and testing themes identified through quantitative research.

Two workshops were conducted as part of the process evaluation: one with academic beneficiaries of the various strands of Challenge delivery and another with PEMD industry beneficiaries. The workshop with industry beneficiaries consisted of six participants, while the workshop with academic beneficiaries consisted of five participants. Participants were selected to reflect the broad range of academic and industry stakeholders of the Challenge.

To maximise attendance, workshop participants were given the option of taking part either in person or online. All respondents who opted in preferred to take part remotely.

The workshops were structured around the process evaluation themes and questions described in Section 3. They were used to explore themes from the survey in further detail and to fill gaps where it was not possible to collect data for metrics from the quantitative survey. The facilitators framed questions to focus on the processes and activities of the Challenge rather than on the impact of these activities. The workshops were semi-structured, following a 'skeleton' topic guide that set out the topic areas to be covered. Some of the questions asked at the workshops included:

- How much do you think the competitions align to industrial needs?
- How efficient do you think the applications process is? Why do you say that?
- Did you form any partnerships or consortia as part of your applications? Was there anything in the competitions process that supported you in forming partnerships? How did it support you?

- How have you found the monitoring process? Is there anything you would change about the monitoring process?
- How well do you think the Challenge has engaged the industry? Are there any parts of the PEMD sector that you don't think have been engaged as well as others? If so, which areas?
- How easy has it been to understand what the Challenge is doing and what the opportunities for you are?
- How well known do you think the DER-IC and their aims are in the PEMD sector? Are there any areas of the PEMD sector that you don't think the DER-IC are relevant to? Why?
- How well do you think the DER-IC align with industry needs? Are they meeting a demand? Is there more that they could be doing to support industry?

Evidence from the workshops were analysed using framework analysis, as described above. The framework analysis combined evidence from the workshops with that from the surveys and delivery group interviews where appropriate.

Monitoring data

Management accounting data on the expenditure of the Challenge was analysed to draw descriptive conclusions on whether budgeting objectives are being achieved. In addition, management data from the DER-IC was also drawn on to describe utilisation of the DER-IC sites.

Interim impact evaluation

To undertake the contribution analysis outlined above, the methods deployed in the interim impact evaluation were:

1. Three types of in-depth case studies:
    a. An **activity-based case study** focusing on the activities of the DER-IC, and the Midlands DER-IC site in particular. This case study was formed through eight separate interviews with different stakeholders, both from within the DER-IC and from firms who work with its colleagues.
    b. Two **project-based case studies** which describe the technical, commercial and social impacts of the projects and explore any policy spillovers. They were developed from interviews and email exchange with stakeholders from the organisations participating directly in each project, supplemented by desk-based research into the nearby PEMD ecosystem.
    c. A **thematic case study** which took a step back from the immediate Challenge-funded activities and explored the impact of the Challenge on the wider PEMD supply chain and UK economy, based on primary research with academic institutions, PEMD firms, trade associations and policy audiences
2. Analysis of **survey data** collected as part of the process and interim impact survey described earlier in this section. This was predominantly a process evaluation survey, but we included ten impact questions;
3. Analysis of **monitoring data** that was shared directly by the Challenge and through Innovate UK KTN.

Senior representatives from the Challenge and UKRI also reviewed and provided feedback on a draft version of this report. More details on the methods can be found in the following subsections, and in Annexes D and E for the fieldwork materials used.

Activity-based case study

For this case study, we focused on the activities of one of the DER-IC sites. We chose the Midlands DER-IC site for two reasons:

a. **Equipment.** The majority of the funds allocated to the DER-IC was for the purchase of capital equipment, and this is expected to be a significant contribution by the DER-IC to the PEMD sector going forwards. Due to long lead times, the equipment is yet to be installed in a number of the sites, but the Midlands DER-IC site and South West & Wales DER-IC site have had pieces of equipment installed, and firms have already been able to use them. Given that the equipment is expected to form a fundamental part of the DER-IC's offering going forwards, we wanted to look at one of the two sites where firms had interacted with the equipment.

b. **Connectivity.** As discussed in more detail in Annex A, the DER-IC sites are divided thematically based on the technology they specialise in. South West & Wales looks at materials, the Midlands looks at machines, and the North East and Scotland both look at drives (lower power in the former and higher power in the latter). Given the interconnectedness between machines and drives, the North East and Scotland sites therefore interact with the Midlands DER-IC site to a greater extent than South West & Wales.

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. The purpose of these interviews was to understand the set-up and activities of the DER-IC as a whole and the Midlands DER-IC site specifically, as well as to gauge the internal view of the DER-IC's impact.

As the purpose of the case study was to look at the impact of the DER-IC on the PEMD sector, interviewing firms that had interacted with the DER-IC made up a core part of this case study. The purpose of these interviews was to understand how the firm 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 effects in the future. We interviewed colleagues at four different firms:

- Agile Manufacturing Power Systems (AMPS) – a start-up consultancy that produces in-depth designs for manufacturing of electric motors for a range of different original equipment manufacturers (OEMs). AMPS has interacted heavily with the University of Nottingham.
- Electrical Cooling Solutions (ECS) – a start-up engineering consultancy in the area of electrical drives with considerable experience in providing thermal solutions to electrical machines and power converters. ECS has interacted heavily with the University of Nottingham.
- McLaren Applied – a well-known manufacturer of electric motors and power electronics that has worked with the Midlands DER-IC site (specifically the University of Warwick Engineering Department) on the ESCAPE project, which hopes to secure a complete supply chain of next-generation silicon carbide power electronics. McLaren has also worked with the South West & Wales DER-IC site on the ESCAPE project and the North East DER-IC site on the SCIENZE project.
- Ricardo – a global engineering consultancy that has worked closely with the Warwick Manufacturing Group (WMG) as part of the Alumotor project to develop a supply chain around an innovative electric motor design.

Project-based case studies

We selected two Challenge-funded projects from the portfolio of 38 competition winners using a multi-criteria approach. Key criteria were:

- Size of Challenge project;
- Maturity of project;
- Number of organisations;
- Range of types of participating organisation (university research team, start-up or Catapult, SME, blue chip);
- Scale of application;
- Core to PEMD; and
- Number of relevant themes.

Primarily, the goal was to select two projects that were:

- Closely aligned to the ambition of the Challenge;
- Had been granted significant funding; and
- Had been operating for sufficient time for results to be available.

Having prioritised these elements, there were a few other factors that came into the decision:

1. The selection process assigned higher weighting to projects with a larger number of participating organisations and to those with greater diversity in the types of organisation, enabling the evaluation team to assess how the Challenge is facilitating collaboration across the PEMD ecosystem.
2. We preferred applications that were of large scale (in terms of target revenue), reasoning that these required more focus on development of the manufacturing route to achieve an economy of scale. For niche applications, manufactured cost tends to be less of a focus and manufacturing processes less specialised.
3. We also required the two projects to focus on different areas of PE (power electronics), M (machines) and D (drives) and preferably different sectors.
4. Finally, we tried to identify projects that would be relevant to a large number of the evaluation themes, but this last criterion proved harder to meet.

Thematic case study

Research for the thematic case study included a mix of:

- Panel discussions with external experts;
- Interviews of individuals; and
- Desk-based study.

The research aimed to identify changes in UK PEMD supply chains since 2019 when the Challenge was launched, and then to assess the degree to which these changes could be attributed to activities of the Challenge programme. The expert contributors to the thematic case study were drawn from a broad mix of

types of organisation involved with the PEMD ecosystem but not directly involved with the Challenge itself. We aimed to recruit experts across a span of industry, government and educational establishments, particularly those who had been involved in PEMD for a significant chapter of their career.

We originally planned to focus on a subset of the evaluation themes – those relating to skills development and environmental and policy spillovers. However, in the course of interviewing contributors, it became clear that they also wanted to offer perspectives on the wider set of evaluation questions. We decided to consider all of their evidence and report against the full set of evaluation themes.

Survey data

As mentioned earlier in this section, to prevent respondent survey fatigue, fewer impact evaluation questions were used for the process and interim impact survey than are outlined in the Evaluation Framework Report,. We therefore included impact evaluation questions only for the metrics that we thought were likely to be 'leading indicators' – a concept described further in Section 4. This isolated metrics where change is most likely to be seen, despite the early nature of the Challenge's activities. Our chosen list of impact evaluation metrics for the process and interim impact survey are shown in Table 10.

Beyond this, the survey used for the interim impact evaluation is the same survey used for the process evaluation outlined earlier in this section. The details of the approach to survey development and sample and survey limitations will therefore not be repeated here.

Table 10 Contact survey impact-related questions

Theme	Questions
Theme 1	■ Has your organisation conducted any first of a kind PEMD pilots in the UK in the previous financial year? ■ And does your organisation expect to conduct any first of a kind PEMD pilots in the UK in the next financial year? ■ At the start of your engagement with the Driving the Electric Revolution Challenge, what level of development was the manufacturing process at in terms of Manufacturing Readiness Level (MRL)? ■ And what level do you expect the manufacturing process to reach at the end of period covered by the Driving the Electric Revolution funding?
Theme 4	■ If your application for funding had been declined, would you have taken the project forward in any form? / After your application for funding was declined, did you take the project forward in any form? ■ Have you received any other public grants or private investment as a result of your engagement with Driving the Electric Revolution Challenge? ■ Do you expect to secure any further public grants or private investment as a result of your engagement with the Driving the Electric Revolution Challenge? ■ How much private finance has your organisation received as a result of your engagement with the Driving the Electric Revolution Challenge? ■ How much public funding has your organisation received as a result of your engagement with the Driving the Electric Revolution Challenge? ■ In your most recent financial year, how much did your company spend on research, development and demonstration activities?

Theme	Questions
	■ How, if at all, did your UK RD&D spend change compared to the year before? ■ You said that your UK RD&D spend increased. What was the source of this increased spend? ■ How much of an impact, if at all, did the Driving the Electric Revolution Challenge have on how much your company spent on research, development and demonstration activities?
Theme 5	■ How many of the following types of partners are you currently collaborating with on PEMD projects? (baseline report) ■ You said you are collaborating with companies outside of the PEMD sector. Which sectors are these companies in? ■ And how successful would you say these collaborations are? ■ How much do you think the Driving the Electric Revolution (DER) Challenge has impacted collaboration in general? ■ 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. □ The Challenge has been able to reach organisations from different sectors □ The Challenge has been able to reach organisations of different sizes □ The Challenge has been able to reach different types of organisations, such as businesses and academia □ The Challenge has been able to reach organisations focusing on different stages of the PEMD supply chain.
Theme 6	■ Has the Driving the Electric Revolution Challenge had an impact on the number of employees you have hired in the past 2 years? ■ And which of the following best describes how you expect your business to change over the next few years? ■ How has your growth projection been impacted as a result of your engagement with the Driving the Electric Revolution Challenge?
Theme 7	■ Where is the headquarter of your organisation and where does the majority of your work take place? ■ And what regions, other than the UK, does your organisation do work in? ■ What region in the UK is your headquarters in? ■ And where does the majority of your organisation's work in the PEMD sector take place in the UK?
DER-IC case study	■ Did you know that the DER-IC's four sites were available to use before today? ■ And have you made use or are you planning to make use of the DER-IC sites? ■ To what extent do you agree or disagree with the following statements about the DER-IC? □ The DER-IC sites offer valuable facilities for organisations across the PEMD sector □ The DER-IC sites address the design and testing needs of the PEMD supply chain □ The DER-IC sites address the design and testing needs of my organisation. ■ Which of the following best describes how effective you think the open access, contract-based model of the DER-IC is in meeting current industry needs? ■ And to what extent do you agree or disagree with the following statements about the DER-IC's knowledge transfer activities?

Theme	Questions
	□ The knowledge transfer activities have engaged a wide range of organisations across the PEMD sector □ The knowledge transfer activities have engaged a wide range of organisations across other sectors □ The knowledge transfer activities were delivered effectively and efficiently.

Source: Frontier Economics

Monitoring data

The interim impact evaluation involved an analysis of monitoring data collected internally by the Challenge and Innovate UK KTN. This data provides evidence for evaluation themes 4 and 5 and contributes to the baseline collected for evaluation theme 7. We therefore give a brief explanation of both types of monitoring data:

1. **Challenge ED&I data (Theme 7):** Challenge internal data designed to monitor the impact of activities on equality, diversity and inclusion (ED&I) measures. These specific measures relate to competition winners and therefore come from the competitions in 2019, 2020 and 2021.[3] Given that these competitions were early on in the Challenge's activities and that ED&I measures tend to be slow moving, we do not expect the data from the later competitions to have been impacted by Challenge activities. This data will therefore contribute to the baselining of these metrics.[4]
2. **Challenge investment data (Theme 4):** Challenge internal data to monitor the impact of activities on co-investment. This is monitored over time, and along with other UKRI Challenges, is split into four different categories: pledged, accompanying, aligned and follow-on.
3. **Innovate UK KTN data (Theme 5):** Innovate UK KTN collects data on the number of PEMD contacts over time and the level of engagement of those contacts over time. This can be used respectively as a proxy for the size of the PEMD ecosystem and for the engagement of members within it. While this is not a direct measure of the specific collaboration within this ecosystem, it can serve as descriptive evidence on the development of the PEMD ecosystem.

Developing the contribution analysis

Evidence from the different evaluation metrics and methods was analysed and mapped against the seven impact evaluation themes. The Frontier, BMG and E4tech teams conducted a review of the findings for each of the evaluation themes. Where multiple sources of evidence were found for specific themes (particularly where the messages from different sources about the impact of the Challenge were potentially contradictory), we discussed our view on the overall findings and strength of the evidence for that indicator to support a shared and agreed contribution narrative.

[3] These competitions are: Accelerated supply chain development strand 1 (September 2019); Accelerated supply chain development strand 2 (September 2019); Catalysing green innovation – advancing PEMD supply chain (Summer 2020); Business led innovation in response to global disruption (following the COVID-19 pandemic) (early summer 2020); Supply chains for Net Zero (June 2021).

[4] Unless the challenge runs additional competitions in the future, we will not be able to collect identical metrics for the final impact evaluation to see the change over time. Alternative measures will therefore need to be used for the final evaluation.

An initial draft of the narrative was written and presented at a meeting attended by representatives from the Challenge and UKRI. The presentation was based on the initial contribution narrative for each evaluation theme along with the key supporting evidence. Feedback and comments were taken from those attending the meeting. The consortium teams reviewed this feedback and used it to revise the initial draft report and contribution narrative.

3 Process evaluation findings

This section discusses the findings for each of the evaluation themes in turn, including recommendations where relevant.

Theme 1 – Management and governance of the Challenge

This theme focuses on the overall governance and programme management of the Challenge, including communication, risk management and financial accountability.

Programme coordination

This metric was analysed using evidence from the delivery group interviews. Delivery leads were asked how effectively they thought the different workstreams of the Challenge worked together. The workstreams were defined as CR&D competitions, DER-IC, skills gaps and knowledge transfer activities.

In general, there seemed to be consensus that there was coordination between workstreams, mostly due to the fact that leads at workstreams communicated with each other or sometimes because the same people worked across different streams. Some examples of cross-programme coordination were provided by interviewees:

"I know that coordination happens between the Industrialisation Centre Chair and the Challenge Director." DER-IC colleague

"The Industrialisation Centre in Scotland had a session within the Engage With sessions." DER-IC colleague

"In terms of CR&D, Industrialisation Centres, knowledge transfer I think there's reasonable communication between all of the strands and I think they all complement and overlap each other fairly well." Delivery lead (UKRI)

"I think they worked pretty well together. […] I think because it involves the same actors […] that applies as a positive when it comes to connecting various things." Delivery lead (UKRI)

Even if coordination and communications between workstreams happened, one of the delivery leads at UKRI mentioned that there was not necessarily a formal process for communication between certain streams to take place, with communication mostly happening organically:

"For me they [workstreams] worked very well together but it's possible this is because I was the one phoning them all up and also I had an understanding of where it was going and what everyone was doing, but there was no formal process – especially with DER-IC – on doing that, that's possibly happened organically but I would highlight I'm not sure we're supposed to have a direct link with the DER-IC. Our comms team and the DER-IC's share comms on a weekly basis because it benefits the whole PEMD and the DER-IC [sites] phone us directly to ask us to promote their events but this is an informal phone call system." Delivery lead (UKRI)

Nonetheless, some missed opportunities for coordination between workstreams were identified by interviewees who took part in the delivery lead interviews, notably in relation to skills gaps in general and between CR&D competitions and the DER-IC.[5]

"We [at one of the Industrialisation Centre sites] were thinking of applying to the skills competitions. We didn't do it in the end due to confusion as to whether we should do it and whether that was within the remit of Industrialisation Centres. The Universities already deliver CPD when companies come and request it so I'm not sure why that's not flagged to the wider Challenge." DER-IC colleague

"Funding from Challenge has already been committed [for competitions] so funding to use the equipment of the Industrialisation Centres will not come from the Challenge. We'll have to look elsewhere e.g. APC, ATI and other Innovate UK funding streams. That's quite disappointing I think for everybody and including the Challenge team themselves." DER-IC colleague

"The only strand I've had very little to do with and sight of is skills." Delivery lead (UKRI)

Management of funding and resources

This metric was analysed using evidence from the delivery group interviews.

Interviewees who took part in delivery interviews were asked to reflect on the extent to which the programme had used its resources efficiently and effectively. While most felt that funding and resources had been appropriately split between activities and workstreams, there was more mixed feedback in relation to this metric.

Firstly, some would have liked to have seen more funding and resource for skills gap activities, given their importance for ensuring that there is a skilled workforce to develop the PEMD supply chain, while acknowledging that this was constrained by the original business case:

"The amount we have to put to skills is probably not enough. It was not set out as a core pillar [of the programme] at the beginning though." Delivery lead (UKRI)

"More money needs to be invested in skills, not just £25,000 here and there." DER-IC colleague

"In terms of resource allocation, skills was made a low priority at the start of the Challenge – over last year it was given a much greater priority and more resource." Delivery lead (UKRI)

Nonetheless, the fact that there was some funding allocated to skills was seen as a positive. Interviewees also mentioned that skills was not an area that Innovate UK had tended to focus on historically and, therefore, having skills as a workstream within the Challenge was a welcome development.

[5] Management data from the DER-IC shows that as of the start of February 2023 five out of 19 projects were funded by the Challenge.

More generally, interviewees felt that while the funding was broadly appropriately split among workstreams, the overall funding amount for the Challenge was insufficient. This comment was echoed by industry and academia (i.e. competition winners who took part in the process workshops).

"It's just essentially the overall level of funding, £80m, is insufficient to address everything. If you look at Faraday, that's some over £250m and its main focus was the automotive sector and it did have quite a large research element to it which the Challenge hasn't. The Challenge focuses on manufacturing technology and developing supply chain capability but it's across every sector that needs electrification technologies and it had a third of the funding Faraday had so it's very unbalanced in my view." Delivery lead (UKRI)

"The main issue with this Challenge is that you want to rebuild the supply chain. £80 million is not going to touch the sides of it." Academic workshop participant

Budget management

This metric was analysed using evidence from the delivery group interviews and accounting data provided by UKRI.

This metric explores whether the Challenge is meeting its budgetary expectations, without unforeseen issues or additional costs.

Delivery leads agreed that the budget was being used as initially planned:

"I think the original plan and how it's been used has been very consistent through the Challenge." Delivery lead

"It's all being used as initially planned with very few and minor changes to that initial plan. The amounts of money for each component haven't changed but how we do it and the timings have been more flexible particularly with COVID." Delivery lead (UKRI)

None of the interviewees were able to identify activities that had incurred additional costs that had not been anticipated. The only issue mentioned in relation to budget was around a very small minority of competition winners who had not been able to deliver the activities they had intended to, in which case the Challenge had ensured that it got back the funding it had granted to these companies.

This feedback was corroborated by the accounting data provided by UKRI. This showed that overall spending was in line with planned budgets. There were some differences in when funds had been spent compared with the original budget; this was to allow flexibility and to accommodate delays caused by the COVID-19 pandemic. In the 2020/21 financial year, an additional £3 million was allocated to the DER-IC as an opportunity had been identified to purchase additional equipment to fill an important gap in the supply chain. These additional funds were provided from an underspend in the 2019/20 financial year in the CR&D budget.

Decision-making

This metric was analysed using evidence from the delivery group interviews.

Delivery leads were asked to consider whether decisions regarding the Challenge were made at the right level and in a timely manner. This helped us to understand whether the Challenge's governance structure was appropriate in order to maximise impact.

There was agreement among interviewees that the Challenge followed standard Innovate UK procedures for making decisions, which generally worked well and allowed the Challenge to justify how and why decisions were made. However, some views suggested that this process could sometimes slow down CR&D competitions and potentially put applicants off as it could be somewhat inflexible:

"The competition process is quite arduous and I think it needs to be to cover ourselves from people thinking the system is biased or unfair so you need to have that level of governance and justification and documentation and rationale provided throughout it. And that's fine when you're looking at £5m or above competitions, but when we've done smaller completions for projects of £25-50k and the total pot of money may be a quarter of a million pounds, this process is the only process we've got. It takes a lot of time from us but it also potentially puts applicants off." Delivery lead (UKRI)

"Innovate UK have to go through a process from project authorisations to the launch, to allocation of internal staff to launch documentations, scope documentation, … They then have to engage with us [KTN] to book slots for dissemination activities … so from conception to delivery of the money to end users, it can be 6-9 months or maybe longer and if you're running a project that's 1-2 years, it can end up being 3.5 years before you actually see the short-term impact and that's too long." Delivery lead (UKRI)

One of the participants in the academic workshop also raised concern about having the same process for smaller and larger competitions and this potentially putting people of smaller-scale competitions.

"SMEs are, I think, getting very tired of Innovate UK. It's a huge amount of effort." Academic workshop participant

Risk management

This metric was analysed using evidence from the delivery group interviews.

This indicator focuses on the effectiveness of the due diligence process: that is, whether failures occurred and, if so, whether the due diligence could have identified and/or mitigated the failure.

Although interviewees did not identify any project failures, they had encountered some difficulties in relation to COVID-19. These had particularly impacted the DER-IC sites as COVID-19 had led to longer timescales for procurement of equipment as well as higher prices for equipment. These difficulties were being overcome with longer timelines and prioritisation of equipment:

"Covid hit meaning that the cost of kit went up between 20 and 40% so we had to make a decision and had to end up losing 2-3 key pieces of capability. […] Everybody faced delays because companies hadn't been working." DER-IC colleague

Effectiveness of engagement with stakeholders

This metric is divided into three indicators:

- The Challenge's ability to engage with a range of stakeholders in addition to competition participants;

- The effectiveness of the Challenge's communications with project participants; and
- The Challenge's ability to increase equality, diversity and inclusion across the sector.

These indicators were analysed using evidence from the delivery group interviews, industry and academic workshops, and the contact survey.

Ability to engage with a range of stakeholders

Survey respondents were asked the extent to which they thought the Challenge had been able to reach different types of organisations, including industry and academia, organisations of different sizes and sectors, and organisations focusing on different stages of the PEMD supply chain. The results for this question are shown in Figure 5. Overall, over seven in ten agreed with these statements and fewer than one in ten disagreed.

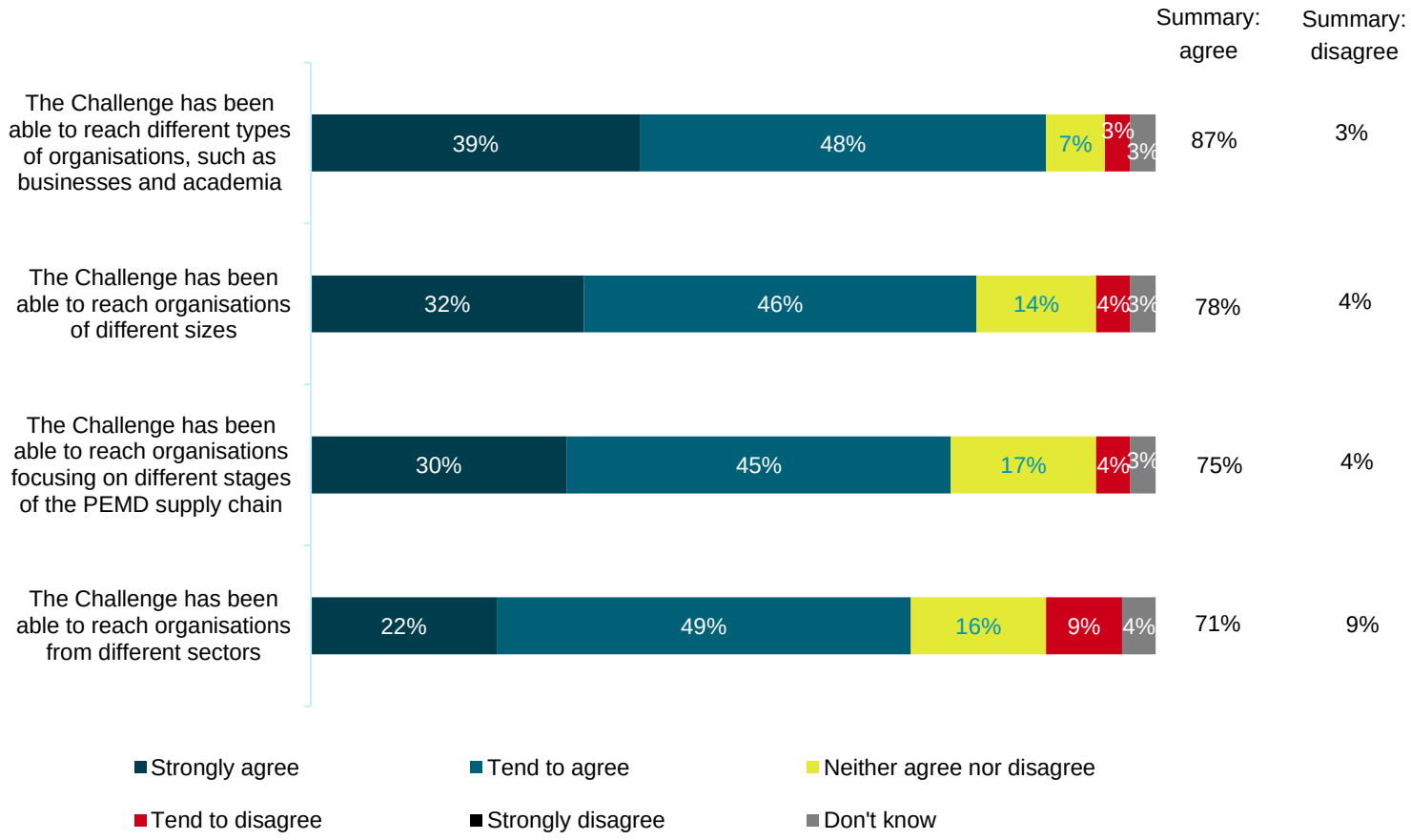
Close to nine in ten (87%) agreed that the Challenge had been able to reach different types of organisations, such as businesses and academia. Only 3% disagreed with this. The remainder were either neutral (7%) or did not know (3%).

Additionally, just under eight in ten (78%) agreed that the Challenge had been successful in reaching organisations of different sizes, while just 4% disagreed. The remainder were either neutral (14%) or did not know (3%). Of the nine large PEMD companies that responded to the survey, all but one agreed that the Challenge had been able to reach organisations of different sizes, and none disagreed. The SMEs in the survey appeared slightly less likely to be positive, with 16 of the 22 SMEs agreeing with this statement.

When it came to reaching organisations focusing on different stages of the PEMD supply chain, three in four (75%) respondents agreed that the Challenge had been able to reach these, while 4% disagreed. Close to two in ten (17%) were neutral and the remaining 3% did not know.

A similar proportion (71%) agreed that the Challenge had been successful in reaching organisations from different sectors. However, around one in ten (9%) disagreed with this. The remainder were neutral (16%) or did not know (4%).

Figure 5 Ability to reach different types of organisations



Source: *Contact survey. D3. To what extent do you agree or disagree with the following statements?*
Note: *Base: all respondents – process and interim impact survey (69).*

The delivery lead interviews also explored the extent to which the Challenge had been able to reach different sectors.

Interviewees felt that a lot of effort was put into trying to reach as diverse a group as possible, but that this was always going to be a challenge given the nature of the industry and how widespread PEMD was within other sectors. While the Challenge had developed working relationships with a wide range of industry bodies across different sectors, some sectors were seen as less likely to engage with the Challenge as they were at the early stages of their 'electrification journeys' generally or because of their low levels of engagement in electrification within the UK. Some examples were given of specific sectors, such as marine, rail and offshore renewables, that were specifically targeted because of these reasons,.

"We don't see as many applications as we'd like from the maritime industry, the rail industry, the off-shore renewables industry because possibly there aren't companies doing this R&D in the UK and they're waiting for the technology to develop for automotive before they start to take those on." Delivery lead (UKRI)

"We've not had any success in getting a project [at our DER-IC site] from the rail industry because of the way the industry works and the way they fund things. They work internationally, you don't get many companies developing things in the UK." DER-IC colleague

"The off-shore renewable side, that's a tough one because the supply chain currently is not in the UK." Delivery lead (UKRI)

Effectiveness of communications with project participants

Survey respondents were then asked to rate a range of communication channels in terms of how informative they thought each of those were. They were asked to rate them on a scale of 1 to 5, where 1 was not at all informative and 5 was very informative. The valid responses are shown in Figure 6.

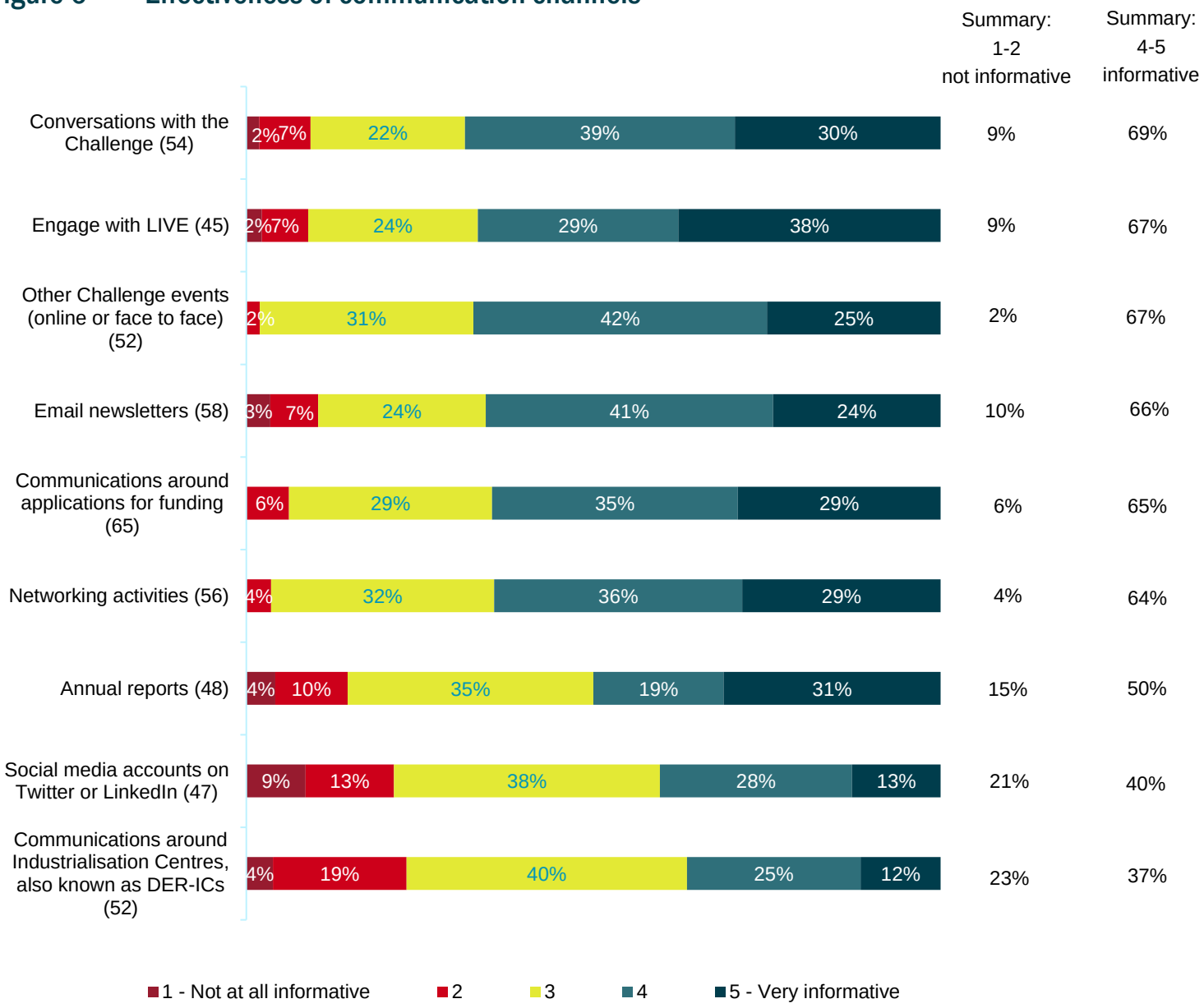
Conversations with the Challenge was the type of communication rated most highly, with just under seven in ten (69%) respondents considering these to be informative (rating of 4 or 5). This was followed by 'Engage with…LIVE' events and other Challenge events (online or face to face) (67% rated both of these as 4 or 5). 'Engage with…LIVE' events had the highest 'very informative' score of all the communications listed (38%).

Other highly rated communications included email newsletters (66% rated these as 4 or 5)[6], communications around applications for funding (65% rated these as 4 or 5) and networking activities (64% rated these as 4 or 5). One in ten, or fewer, rated these communications as not informative (rating of 1 or 2).

Further to this, half (50%) rated annual reports as informative (rating of 4 or 5), while 15% believed the opposite (rating of 1 or 2). Nonetheless, the highest not informative scores were given to social media accounts on Twitter and LinkedIn (21% gave a rating of 1 or 2 – not informative – and 40% gave a rating of 4 or 5 – informative) and communications around the DER-IC (23% gave a rating of 1 or 2 and 37% gave a rating of 4 or 5). In relation to the DER-IC, delivery lead interviews revealed that COVID-19 had led to delays in the procurement of equipment and at the time of qualitative fieldwork the DER-IC sites were still at a set-up stage and not fully operational, which may explain why communications about the DER-IC were not yet prominent.

[6] Where aggregated figures may seem to differ slightly from the summation of individual figures, this is due to rounding.

Figure 6 Effectiveness of communication channels



Source: *Contact survey. D4. How informative did you find the following communications from the Driving the Electric Revolution Challenge?*
Note: *Base: valid responses in parentheses – process and interim impact survey.*
Where total figures may seem to differ slightly from the summation of the individual figures, this is due to rounding.

The industry and academic workshops echoed the finding that, generally, the Challenge communications were seen to be effective and engaging. The 'Engage with' sessions were a clear example of this, with workshop participants having attended these both live and online. There was agreement that, while both online and face-to-face sessions were valuable, face-to-face sessions worked better for networking with other organisations. However, respondents also valued the ability to join these sessions online without having to travel. Being able to ask questions and the fact that the recording of sessions could be downloaded after they were held were also seen as real benefits for knowledge sharing within organisations.

"The Engage ones were really valuable and not just for the project, but as [company name] is a fairly large company and it can be hard to disseminate the information just within the company so me sending out links to

those Engage events is really useful because then people could just catch up online when people have time and make their own connections without having to be physically [there]." Industry workshop participant

"The Q&A sessions were managed really well, with anonymous questions. They [Challenge] did their best. I think what they lack is that if they're not face-to-face, the networking never really works in terms of the early consortium building or providing broader opportunities to present yourself to the network. But some of the recorded ones were quite good, I think, in terms of getting to meet people." Academic workshop participant

Ability to increase equality, diversity and inclusion across the sector

The delivery lead interviews explored the Challenge's initiatives to promote (ED&I) of underrepresented talent, including women, ethnic minorities, etc.

While interviewees did not mention specific EDI targets, there was agreement that efforts had been made to embed ED&I into the Challenge's activities, particularly around CR&D and skills competitions. These included having courses designed with skills competition funding that could be accessed by disabled people and targeting individuals from disadvantaged backgrounds, encouraging a diversity of presenters at 'Engage with' sessions and having ED&I questions at CR&D competition interviews:

"There's lots that we've done in the Challenge on ED&I and, if you look at skills competitions projects, all of them have got ED&I baked into what they're doing. For example, there's one project that's in a very deprived part of Manchester reaching out into that community and pulling through people who may want to get into this PEMD in terms of their careers. Some of the courses [developed with skills funding] have been designed so that, whatever your level of physical ability, you could still access virtual courses. We were clear on our processes that we would only fund skills projects that had ED&I backed in." Delivery lead (UKRI)

"We put a request for the Engage With sessions asking companies to consider ED&I, including having young people presenting and requesting companies to present what their own ED&I future projection was." Delivery lead (UKRI)

"We have ED&I questions at [CR&D] competition interviews because we're trying to increase the diversity of people getting into PEMD." Delivery lead (UKRI)

Additionally, Innovate UK KTN ran a series of webinars – one in 2020 and four between September 2021 and February 2022 – focused on the importance of ED&I at the workplace. These workshops provided a platform for organisations to showcase their approaches to:

- Tackling ED&I within the PEMD sector;
- Encouraging ED&I in research and industry; and
- Incorporating inclusive language and leadership.

The figures for attendance and engagement with these ED&I events between 2021 and 2022 are shown in Table 11 below.

Table 11: EDI event attendance

Date of webinar	Registration	Attendance	Questions asked
September 2021	48	28	2
October 2021	61	21	5
November 2021	63	26	7
February 2022	74	24	-
Total	**172**	**75**	**14**

Source: Innovate UK KTN monitoring data

Attendance figures were lower than 30 individuals per event, suggesting that more could have been done to publicise these events and attract attention to them. Nonetheless, the workshops conducted as part of the process evaluation revealed that the minority who attended these events regarded them as positive.

"We also attended the equality, diversity and inclusion workshops; and I think there were some more workshops proposed for SMEs as well about developing business. I think this is really what was really great. That's not something we had seen before, Innovate UK having these extra activities because we had won a grant from a special call. That was something new that in many ways I really appreciated." Academic workshop participant

Additionally, the delivery lead interviewees working at the DER-IC sites said that they did not have targets for ED&I. However, their parent organisations (universities and Catapults) had targets on diversity and inclusion, and the DER-IC sites followed their parent organisations in this respect.

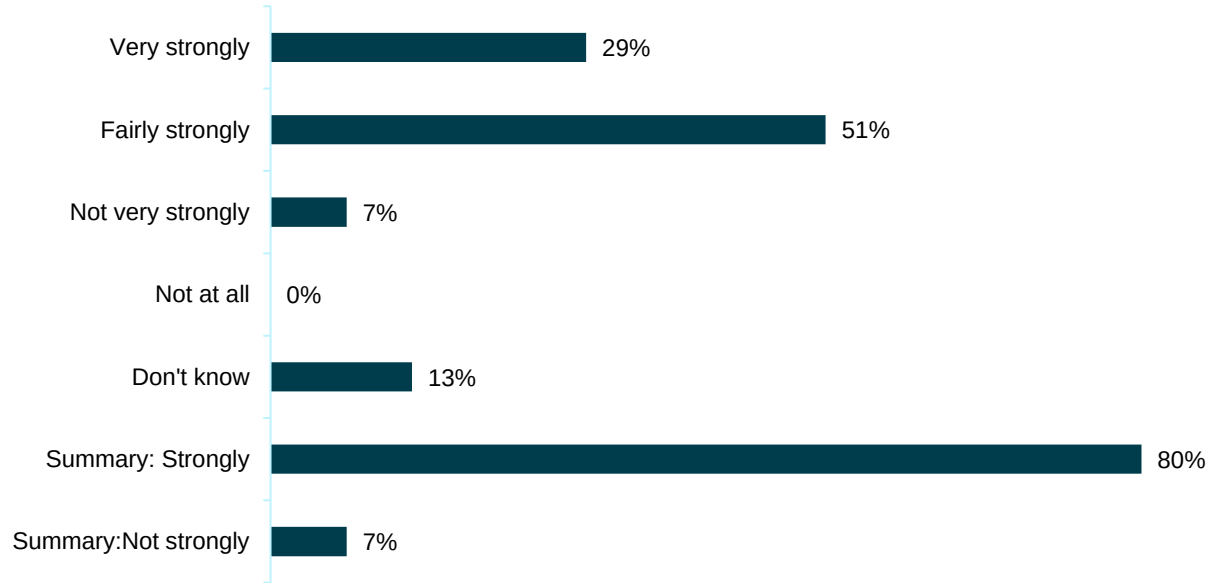
Alignment with other government initiatives in the UK

This metric examines the extent to which the Challenge aligns with other government initiatives in the UK, such as net zero and levelling up across UK regions.

This metric was analysed using evidence from the delivery group interviews, the survey, and the industry and academic workshops.

Survey respondents were asked the extent to which they thought the Challenge aligned with other government initiatives in the UK (Figure 7). Overall, eight in ten (80%) believed that the Challenge aligned strongly with other government initiatives, with just under a third (29%) stating that the Challenge aligned very strongly with other government initiatives and around half (51%) saying that the alignment was fairly strong. Just 7% stated that the Challenge did not align very strongly with other government initiatives in the UK and no respondents said that there was no alignment at all. The remainder (13%) did not know.

Figure 7 Perception of the Challenge's alignment with other government initiatives in the UK



Source: *Contact survey. K2. How well do you think the Driving the Electric Revolution Challenge aligns with other government initiatives in the UK?*
Note: *Base: all respondents – process and interim impact survey (69).*

Survey respondents who had a view as to whether the Challenge aligned with other government initiatives (47 respondents) were then asked what government initiatives they thought about when answering the question shown in Figure 7. The Advanced Propulsion Centre (APC) was the initiative most commonly mentioned by respondents (14), followed by the net zero target (11), the Faraday Battery Challenge (9), and the Aerospace Technology Institute (ATI) (8). A minority of respondents also mentioned the High Value Manufacturing Catapult (2), the Clean Maritime Demonstration Competition (CMDC) (3), and the Engineering and Physical Sciences Research Council (EPSRC) (3). Some also mentioned clean energy/agriculture and electrification in general (8).

Among delivery leads and academic workshop participants, there was consensus that the Challenge aligned with net zero:

"Everything we do is focused towards net zero and the electrification of transport, of energy, of industry to reduce emissions. PEMD is an absolutely key technology in ensuring the UK gets to net zero." Delivery lead (UKRI)

"I think it aligns extremely well with the overall net zero agenda. So I think that's fine." Academic workshop participant

However, industry workshop participants struggled to articulate what government initiatives the Challenge aligned with given its cross-sector nature.

"This seems fairly common sense but the Challenge remit isn't specific to any sector. […] I guess driving the electric revolution, well, the electric revolution itself is a new paradigm. So it's difficult to not include many different sectors. And so it's difficult to articulate how it fits with specific government initiatives, but it's good that it isn't sector specific." Industry workshop participant

Additionally, while delivery leads agreed that the Challenge pre-dated the levelling-up agenda, there was agreement that the Challenge aligned with this policy given the spread of competition winners across the UK and the lack of concentration of activity in the South East (for more information about this, refer to Figure 43 in Annex C).

Theme 2 – Design and delivery of the Challenge competitions

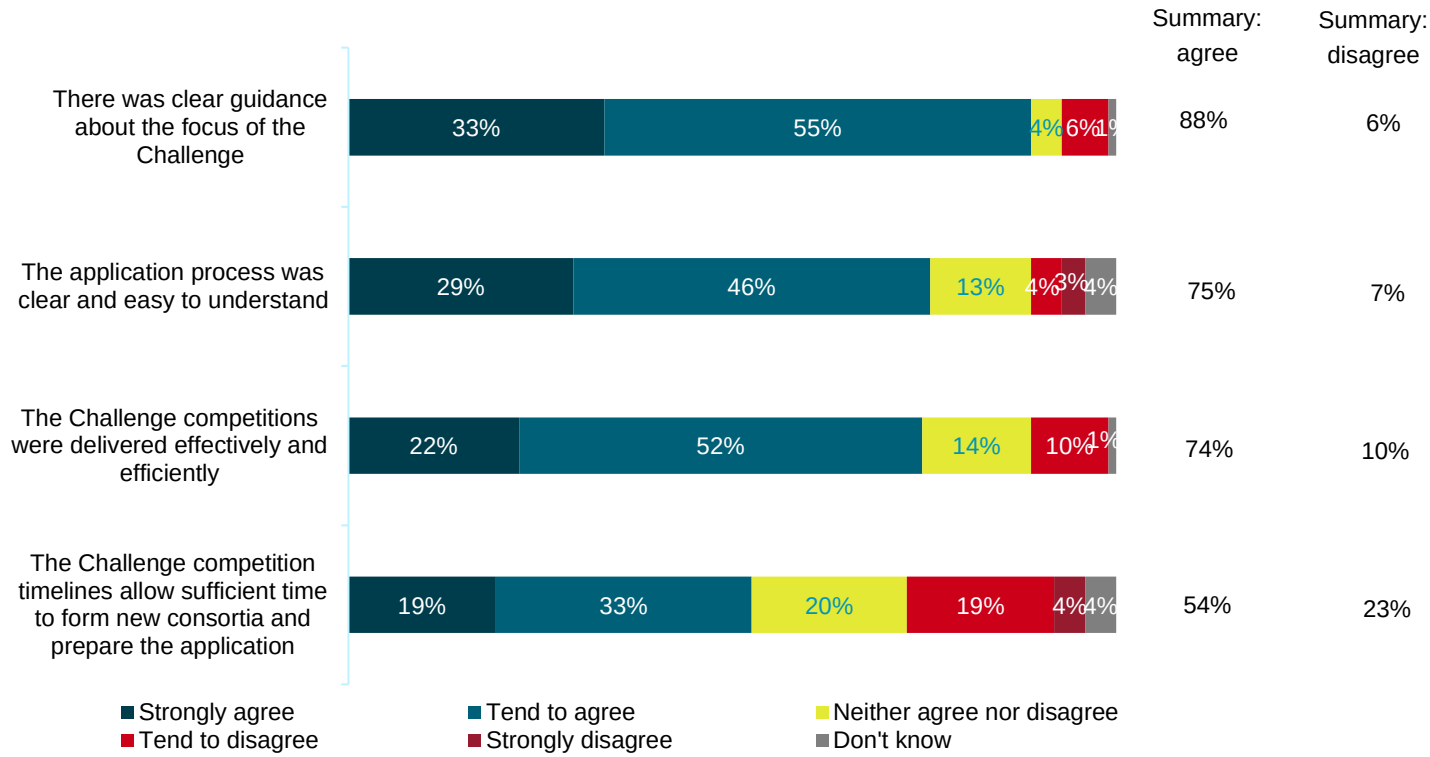
This theme focuses on the design and implementation of the competition activities, with an emphasis on the engagement process and the extent to which the competitions were aligned to industrial needs.

Overall views of design and delivery of competitions

Survey respondents were asked about their overall views of the Challenge's competitions. Figure 8 shows that nearly nine in ten (88%) agreed that there was clear guidance about the focus of the Challenge and three in four (75%) agreed that the application process was clear and easy to understand. A similar proportion agreed that the competitions were delivered effectively and efficiently (74%). One in ten or fewer disagreed with these statements. However, disagreement scores were higher with regard to the Challenge competition timelines allowing sufficient time to form new consortia and prepare the application (23% disagreed and 54% agreed).

Academics and large PEMD companies appeared to be more likely to disagree that the Challenge competition timelines allowed sufficient time to form new consortia and prepare the application (almost half of each group disagreed compared with almost a quarter of the overall sample). However, this should be treated as indicative only due to the relatively low base sizes for each sub-group (Academics 17, large PEMD companies 9).

Figure 8 Views of competitions



Source: *Contact survey. K1. Thinking about the Driving the Electric Revolution Challenge competitions, including the application process, how much do you agree or disagree with the following statements?*

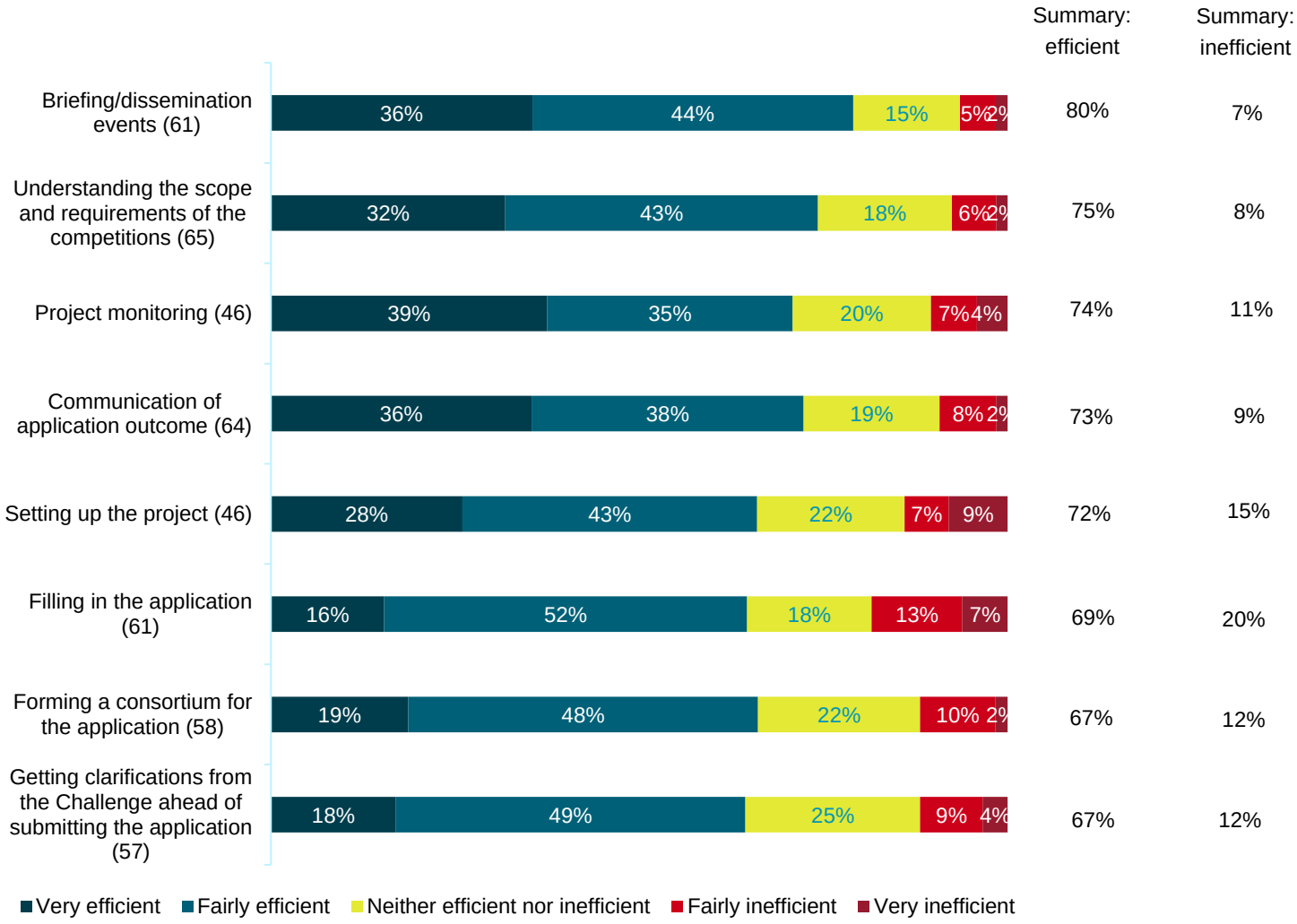
Note: *Base: all respondents – process and interim impact survey (69).*

All survey respondents were then asked how efficient or inefficient they found each stage of the application process, with successful applicants also being questioned about the process of setting up projects and project monitoring (see Figure 9). In relation to the application process, three in four (75%) considered the processes of understanding the scope and requirements of the competitions to be efficient while four in five (80%) said so about briefing/dissemination events. Fewer than one in ten saw these two processes as inefficient (8% and 7% respectively). However, positive scores were lower when it came to the process of forming a consortium for the application and getting clarifications from the Challenge ahead of submitting the application (67% respectively said these were efficient and 12% said the opposite)[7]. Nonetheless, the highest negative score related to filling in the application, with one in five (20%) regarding this as inefficient (and 69% regarding it as efficient).

Just under three in four (73%) regarded the process of communicating application outcomes as efficient. The views of project set-up and monitoring were largely positive, with just under three in four saying that these processes were efficient (72% and 74% respectively).

[7] Where aggregated figures may seem to differ slightly from the summation of individual figures, this is due to rounding.

Figure 9 Views of the application and delivery process



Source: Contact survey. T1. How efficient or inefficient did you find each of the below Driving the Electric Revolution Challenge processes?
Note: Base: valid responses in parentheses – process and interim impact survey.
Where total figures may seem to differ slightly from the summation of the individual figures, this is due to rounding.

The industry and academic workshops reflected some of the findings in the quantitative survey in relation to the structure and delivery of competitions. There was feedback that the briefing sessions were being used for a different purpose to what was intended by the Challenge. The timescales for submitting proposals (sometimes 3-4 weeks after the briefing sessions, according to workshop participants) meant that consortia very much felt like they needed to already be in a consortium by this point and to already have a very strong idea of their plans for a project. The 3-4 weeks were then used to simply write the proposal in the desired format, rather than come up with new ideas or collaborations. The briefing sessions were seen to be most useful as a way of finding out what other competitions would be live further down the line, rather than being very useful for the actual competition they were for. They were also considered useful for networking for future competitions.

"The turnaround time is extremely small and a constraint as we need heavy involvement of industries. It actually takes them more time to get internal approval to allocate resources, to agree on the project scope to work with

academia. So getting that industrial approval consent is time consuming. And it's very hard to get this whole cycle completed with the current timing allocated by Innovate." Academic workshop participant

"Large [companies] have difficulties to get approvals really quickly, which creates issues when the timelines are really short for approving." Academic workshop participant

"Generally, people go to these events with some idea of what they want to do and some idea of who they're going be working with, who they'd like to work with." Industry workshop participant

"We tend to go to most of the information events and so on for different calls and different spheres, not just DER. And it's really not about that particular call. It's a talk to the innovation lead to find out when the next call is happening." Industry workshop participant

These findings suggest that the delivery of competitions could have gone further in encouraging collaboration by allowing sufficient time to form consortia. As noted earlier, there was an appetite for fast-track competition processes where feasible, most likely for lower value competitions. Taken together these findings suggest that timescales should be tailored to the size and complexity of each competition (for example, larger competitions where consortia are more likely to be required will need longer timelines for bids to be developed) and that it is the decision-making process where applicants would like to see reductions for some competitions rather than the proposal development stage.

Table 12 below shows the timelines for the Challenge's competitions. While for most competitions, six or more weeks were allowed between the briefing sessions and the competition's close date, for some the timelines were shorter, which gives an indication about the competitions that workshop participants may have been referring to when commenting on timelines.

Table 12 Competition timelines

Competition ID	Competition name	Open date	Close date	Briefing date(s)	Time elapsed between briefing and competition close date
405	Driving The Electric Revolution: Accelerated Supply Chain Development, Strand 1	29/07/2019	25/09/2019	■ 30/07/2019 ■ 08/08/2019	■ 8 weeks and 1 day ■ 6 weeks and 6 days
406	Driving The Electric Revolution: Accelerated Supply Chain Development, Strand 2	29/07/2019	25/09/2019	■ 15/08/2019 ■ 20/08/2019	■ 6 weeks ■ 5 weeks and 2 days
43784	MABEL – Optimising through Life Cost of Industrial Gas Processing	25/07/2019	16/10/2019	30/07/2019	11 weeks and 2 days
483	Driving The Electric Revolution: Building Regional Centres of Excellence	23/10/2019	11/12/2019	29/10/2019	6 weeks and 1 day

Competition ID	Competition name	Open date	Close date	Briefing date(s)	Time elapsed between briefing and competition close date
648	Catalysing Green Innovation: Strand 1, Advancing PEMD Supply Chain	16/06/2020	29/07/2020	15/06/2020	6 weeks and 3 days
652	Catalysing Green Innovation: Strand 2: Securing the Future of ZEV	17/06/2020	30/07/2020	22/06/2020	5 weeks and 4 days
861	Driving the Electric Revolution: Supply Chains for Net Zero	08/03/2021	30/06/2021	09/03/2021	16 weeks and 2 days
1065	Driving the Electric Revolution – PEMD Skills Hub	15/11/2021	15/12/2021	16/11/2021	4 weeks and 2 days
969	Driving the Electric Revolution – Building Talent for the Future	09/08/2021	15/09/2021	10/08/2021	5 weeks and 2 days
1088	Driving the Electric Revolution – Building Talent for the Future 2: EoI	10/02/2022	03/02/2022	12/01/2022	3 weeks and 2 days
1125	Driving the Electric Revolution: Building Talent for the Future 2 – Full stage	11/03/2022	27/04/2022	07/03/2022	7 weeks and 3 days
1126	Driving the Electric Revolution: Building Talent for the Future 2	11/03/2022	27/04/2022	07/03/2022	7 weeks and 3 days

Source: Challenge management data

The overall application process was seen as efficient, with those who took part in workshops agreeing with this. Participants agreed that the application process followed the standard Innovate UK format, which they were familiar with. However, some feedback was provided by a minority of workshop participants. Firstly, academic participants felt that some of the information required in the application in relation to universities' finances was not necessarily relevant at the application stage and this was something that could be asked of them at project inception so as to make the application process more efficient. There was also a feeling among participants that the requirements for the application interviews could be made clearer in advance – for example, one participant felt that they were second guessing their preparation for the interview and said they had not been made aware that all consortium members needed to be present for the interview.

"In our experience there was a gap between the submission and then going to the panel. There was very short turnaround and the requirements of the panel discussion itself weren't very clear in terms of what questions [we were going to be asked] or what the exact purpose was. So it meant there was a lot of preparation or a lot of comments like second guessing what the preparation might be and yeah, we ended up almost regurgitating a lot of the original application." Industry workshop participant

Issues around the interview process were also brought up by two of the delivery leads involved in this process:

"There was a change of questions between the application and the interview […] applicants need to be given reasonable notice of what they're going to be asked and I don't think that was always the case." Delivery lead (UKRI)

"Making sure panel guidance is more robust because we found, in [one] interview, one of the panellists was scoring quite differently to the others. In the assessor written stage we remove outliers, but at interviews scores are anonymous so we don't necessarily know who it is." Delivery lead (UKRI)

These findings suggest that the guidance given to both applicants and assessors ahead of interviews could be more systematic. While it was explained that assessors had a meeting before the interview to discuss the scoring matrix, there was a feeling that this and associated guidance needed to be more robust to avoid having outliers (i.e. assessors who score very differently from others). This is important for consistency and credibility as a couple of academic participants in the workshop questioned whether some of the assessors were experts in the area, which could be avoided with a consistent approach to scoring and feedback.

"Sometimes the feedback we get following the peer review … These are not consistent and it often makes me question whether the proposal was read by an expert in that area or not." Academic workshop participant

Alignment of competitions to industrial needs

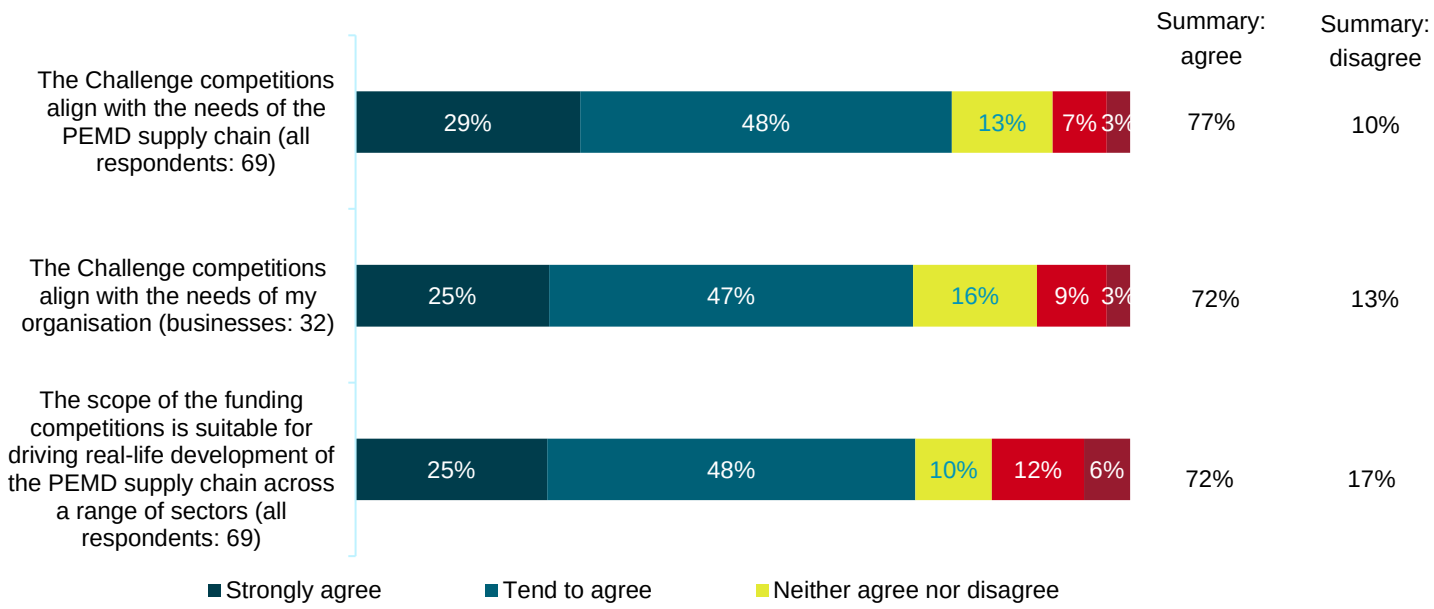
This metric was analysed using evidence from the contact survey, the industry workshop and delivery lead interviews.

The contact survey explored perceptions of the competitions' alignment with industry needs, as shown in Figure 10. While over seven in ten (72%) agreed that the scope of the funding competitions was suitable for driving real-life development of the PEMD supply chain across a range of sectors, disagreement with this statement was slightly higher than for the other two statements discussed above (17% disagreed).[8] Over three in four (77%) agreed that the competitions aligned with the needs of the PEMD supply chain and one in ten (10%) disagreed, with a similar proportion being neutral (13%).

Around seven in ten (72%) agreed that the competitions aligned with the needs of their organisation, a slightly lower proportion than those agreeing that the competitions aligned with the needs of the PEMD supply chain (77%), although this difference is not statistically significant. Thirteen percent disagreed that the competitions aligned with the needs of their organisation. The remaining 16% were neutral.

[8] Where aggregated figures may seem to differ slightly from the summation of individual figures, this is due to rounding.

Figure 10 Alignment of competitions with industrial needs



Source: *Contact survey. K1. Thinking about the Driving the Electric Revolution Challenge competitions, including the application process, how much do you agree or disagree with the following statements?*

Note: *Base sizes in parentheses – process and interim impact survey.*

Where total figures may seem to differ slightly from the summation of the individual figures, this is due to rounding.

The industry workshops corroborated the view that the Challenge competitions align with industrial needs. The competitions were seen as valuable for enabling CR&D at a deeper level than would otherwise take place, as well as for enabling collaboration between different parts of the supply chain. Further views on collaboration are part of theme 5 of the interim impact evaluation in Section 4.

"For us, it's definitely allowed us to do what we wanted to do much, much quicker and in much more detail, for sure." Industry workshop participant

"It's the opportunity to work collaboratively with local companies that are in the same environment, albeit in different parts of the supply chain." Industry workshop participant

Delivery leads at the Challenge explained that work was undertaken by the Challenge ahead of competitions to understand industry needs, which included consulting trade bodies and the Advisory Group (made up of industry representatives). The Advisory Group was considered a novel element for understanding industry needs compared to other Innovate UK Challenges and activities.

"Extensive work is done ahead of competitions to understand what competitions we strategically want to do or what competitions industry needs. We work with our Advisory Group and other trade organisations to understand what projects or areas or organisations need funding." Delivery lead (UKRI)

"I don't think we've ever used the Advisory Group as a right bottom up [before at Innovate UK]. They've been very useful as the voice of industry." Delivery lead (UKRI)

Success in engaging a range of stakeholders in competitions

This metric covers the following indicators:

- Success in engaging a wide range of sectors in competitions;
- Success in encouraging collaboration between businesses and academics;
- Success in encouraging collaboration between small and large companies; and
- Success of competitions in attracting relevant target audience.

These indicators were analysed using evidence from the contact survey, delivery lead interviews, and industry and academics workshops.

While Figure 5 explored the Challenge's ability to reach different types of organisations via a range of communication channels, Figure 11 focuses on the Challenge's ability to encourage collaboration across different types of organisations through competitions specifically.

Eight in ten (81%) survey respondents agreed that the Challenge was structured in a way that facilitated collaboration between businesses and academics, while one in ten (10%) disagreed with this. However, there was some indication that academics were less positive, with twelve of the seventeen academics in the survey agreeing with this statement and four disagreeing.

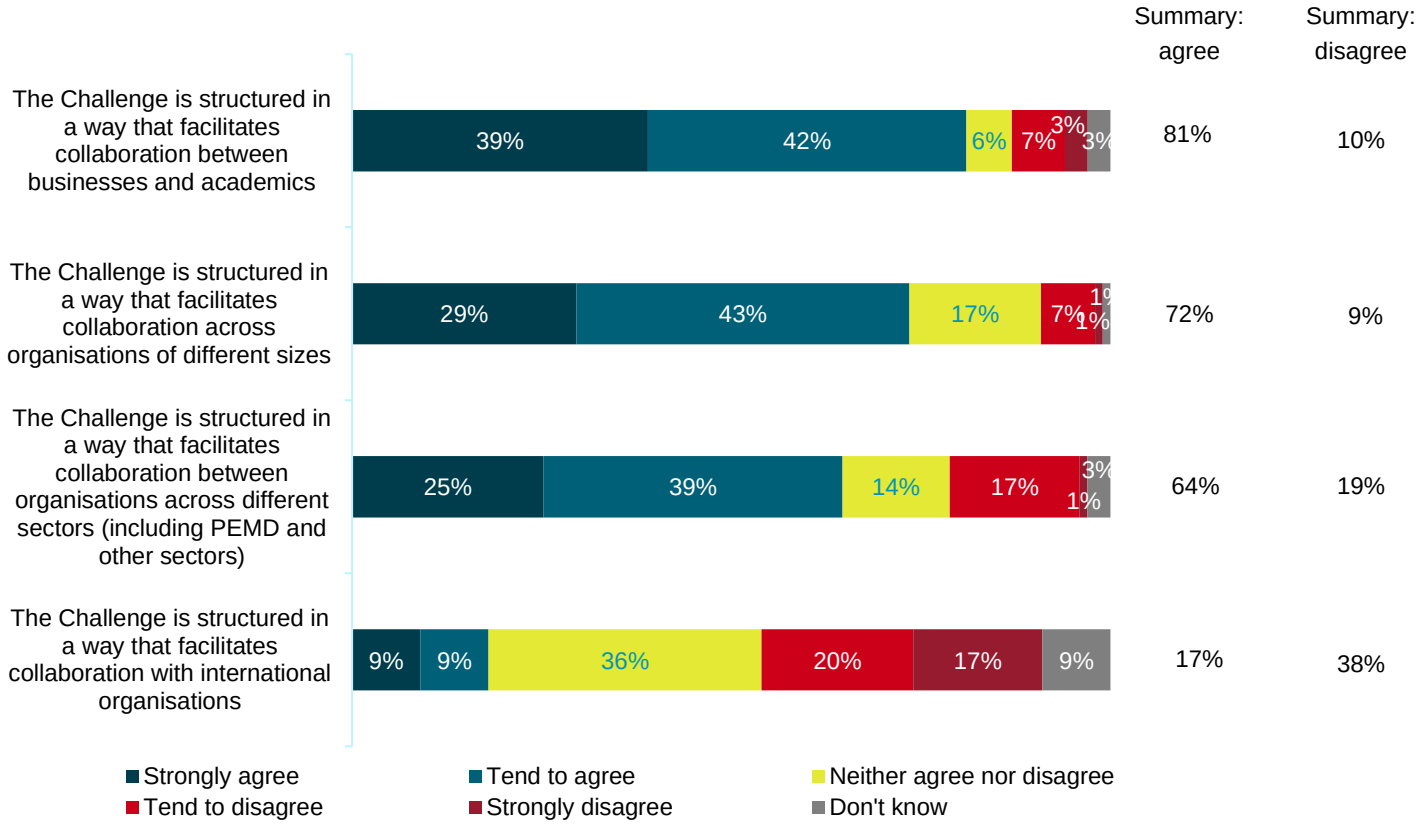
Moving on to collaboration across organisations of different sizes, seven in ten (72%) agreed that the Challenge facilitated collaboration between organisations of different sizes and just under one in ten (9%) disagreed. Close to two in ten (17%) were neutral and 1% did not know.

When it came to collaboration between organisations from different sectors (including PEMD and other sectors), just under two in three (64%) respondents agreed that the Challenge was structured in a way that facilitated collaboration between organisations across different sectors. Just under one in five (19%) disagreed with this and a similar proportion were neutral (14%), while 3% did not know.[9]

In contrast to the results discussed so far, fewer than one in five (17%) agreed that the Challenge was structured in a way that facilitated collaboration with international organisations, while around two in five (38%) disagreed. One in three (36%) were neutral and 9% did not know. While this reflects the fact that competitions were targeting UK-based companies, these results suggest that further efforts could be made by the Challenge to encourage collaboration between UK and international organisations.

[9] Where aggregated figures may seem to differ slightly from the summation of individual figures, this is due to rounding.

Figure 11 Ability to reach different types of organisations via competitions



Source: *Contact survey. K1. Thinking about the Driving the Electric Revolution Challenge competitions, including the application process, how much do you agree or disagree with the following statements?*

Note: *Base: all respondents – process and interim impact survey (69).*

Where total figures may seem to differ slightly from the summation of the individual figures, this is due to rounding.

The industry and academic workshops as well as the delivery lead interviews provided additional insights into the Challenge's ability to engage a range of stakeholders in competitions. In terms of engaging companies of different sizes, the academics who took part in workshops found that the short timeframe between briefing events and submission of bids made it harder to onboard SMEs and/or companies that had less experience in engaging with public funding.

"Some of them are very actively bidding and very successful, which is not the case with many other SMEs. So they need to be a bit more educated about these opportunities [competitions] and obviously as academia we are doing that to some extent, we are dragging them in. But I think more can be done from the Challenge side to encourage them and make them aware of the benefits of working with academia and obviously, you know, this is a collective effort." Academic workshop participant

"Helping them understand the system and be successful in the first application is part of the things we've been doing in one of the projects and it's been really a valuable. But I think if we had not thought about having this person paid by the project to support them, we would have been into real difficulties and I'm afraid we are missing out on supporting some of these SMEs because we don't have the bandwidth to support all the ones that would need support." Academic workshop participant

Academics felt that additional support could be provided by Innovate UK to help SMEs in submitting bids and learning how to be successful in their applications:

"For smaller companies, they almost feel like they're trying to answer an exam question and then they're told they failed at the end rather than having a second attempt or being told how to improve it somehow. I think it's about explaining to companies and really supporting them to build up their argument rather than just expecting them to do this really good submission where they understand completely what they're meant to be doing at the first instance." Academic workshop participant

It is worth noting, however, that help with applications is already provided to companies by Innovate UK KTN. This assistance consists of sessions to help with proposal writing and the formation of consortia. We recommend that this support is further publicised to SMEs directly as well as to academic organisations (for signposting) as the results above suggest that knowledge about the support available for proposal writing may be limited.

In relation to attracting companies from sectors other than PEMD, industry workshop participants felt that the Challenge had been successful in doing this although, as noted earlier in this section, there was a perception among delivery leads of difficulties in attracting companies from sectors such as rail, marine and offshore renewables. This is related to these industries' electrification journeys rather than a lack of effort from the Challenge to engage with these. Conversely, automotive was seen as a very engaged sector as this sector is committed to electrification and to having targets on this by 2030.

Furthermore, workshop participants tended to agree that competitions encouraged them to form consortia which included business and academic partners. When contemplating the competitions' scope, participants felt that 'it made sense' to seek a mix of academic and business partners.

"To get funding, it seems the consortium needs to be reasonably big and it usually involves private and academic [organisations] so a fairly broad spectrum." Industry workshop participant

"I think that it was a logic step because of the type of calls, that we need manufacturing. That was an opportunity for us to actually work with process companies […]. I think that was key for the call. So I think we did what we were supposed to do, bringing new companies in to work with us." Academic workshop participant

Management data on the range of competition winners by sector and type of organisation has been included in the interim impact evaluation section (see Section 4).

Theme 3 – Design and delivery of the DER-IC and knowledge transfer activities

This theme focuses on how the design and implementation of the DER-IC and knowledge transfer activities has supported engagement and knowledge exchange with a wide variety of organisations.

Utilisation of the DER-IC

This metric was analysed using evidence from the contact survey, the industry workshop and DER-IC management data.

Awareness of the DER-IC was explored via the quantitative survey (Figure 12).

At the time of the survey in October-November 2022, just under two in three (65%) said that they were aware that the DER-IC's four sites were available to use, while one in three (33%) were unaware. The remaining 1% did not know.

SMEs appeared to be less likely to be aware of the DER-IC than average (45% were not aware and 55% were aware). This result, however, should be treated as indicative only given the low base size for this sub-group (22).

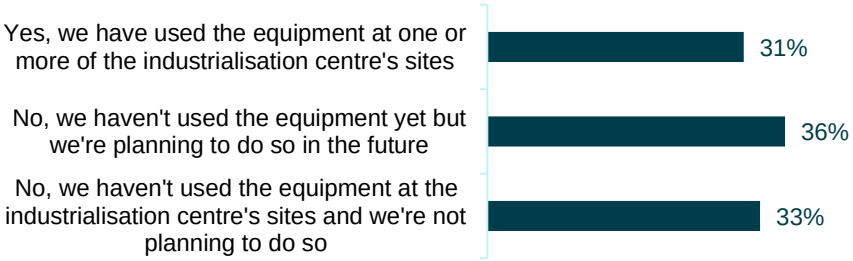
Figure 12 DER-IC awareness

Source: *Contact survey. F1. Did you know that the Driving the Electric Revolution Industrialisation Centre's four sites were available to use before today?*
Note: *Base: all respondents – process and interim impact survey (69).*

Survey respondents who said that they were aware of the DER-IC were then asked whether they had already used the facilities at the DER-IC sites or whether they were planning to do so in the future (Figure 13).

Close to one in three (31%) of those who were aware of the DER-IC stated that they had used the equipment at one or more of the DER-IC sites. The remainder (69%) had not yet made use of the equipment at the DER-IC sites. However, 36% had plans to do so in the future, while 33% were not planning to do so.

Figure 13 Use of the DER-IC sites



Source: *Contact survey. F2. And have you made use or are you planning to make use of the DER-IC sites?*
Note: *Base: where aware of DER-IC – process and interim impact survey (45).*

The academic and industry workshops corroborated that there are mixed levels of awareness of the DER-IC, with industry participants being largely unaware and academics being more likely to be aware as the DER-IC sites were attached to academic institutions or Catapults.

"We did have a couple of calls, but a long time ago. I think I wasn't really able to get a handle on what it was that they did really. I couldn't find anything that I could articulate that they could do for us, but that was probably

a couple of years ago now. So I mean, perhaps it's time for another conversation." Industry workshop participant

Innovate UK KTN events were an important channel for industry to hear about the DER-IC. One of the industry participants had strong plans to use the DER-IC equipment for one of their funded projects as well as doing so on a commercial basis, with conversations for this being underway but no activity having taken place in this regard by the time of the workshop fieldwork.

"We're definitely using one of them as part of our projects. So it's making use of that and in a wider field, we're starting to try to engage with some of the other Industrialisation Centres on some more commercial relations, not grant funded projects, to try and leverage that." Industry workshop participant

Delivery leads at the Challenge explained that procurement of equipment for the DER-IC had been impacted by COVID-19, which had led to longer timelines for procurement. This had delayed implementation of this workstream and, therefore, it was felt that it was too early to establish the extent to which the DER-IC sites would be utilised by industry and what types of companies and sectors would be more likely to make use of these facilities. Nonetheless, some expected automotive to make use of the centres more than other sectors given the speed of their transition to electrification.

"I think it's early days. I don't think [the Industrialisation Centres] are quite ready to start assisting yet." Industry workshop participant

Academic partners who took part in the workshops and were either involved with or had oversight of the DER-IC's activities explained that work to promote the centres was already underway even if the equipment was still being installed in most sites at the time of the fieldwork:

"From my side of the fence, they're trying very hard to push themselves out there to all the trade conferences that they can find." Academic workshop participant

"We have a series of seminars coming up […] where we'll take people in the facilities and show them the equipment and hopefully from that we'll get lots of people using the facilities." Academic workshop participant

In terms of promotion of the centres, delivery leads and academic workshop participants said that DER-IC business development managers would play a key role in promoting the centre sites and the equipment available and in bringing in companies and projects to use these. For the DER-IC site in Scotland, one of the leads involved with this explained that there was a manufacturing advisory service in Scotland, which stemmed from the Scottish Government, and they expected the DER-IC site in Scotland to get promoted through that.

In spite of these promotion activities, most industry workshop participants lacked knowledge specifically in relation to the design and testing facilities available and the utilisation models of the DER-IC. While some communication about the DER-IC had already been sent out, this had been done before the sites were fully operational and, as such, most industry workshop participants said that more communications were needed now that the DER-IC sites were starting to become operational. A list of the equipment available at each site would be helpful for understanding the opportunities available as would be a launch event so that industry and the institutions in charge of running the DER-IC sties could get together and discuss opportunities for

utilisation. Insights from delivery leads revealed that there were two main DER-IC utilisation models available to industry which would need to be publicised to increase knowledge among potential users:

a. Via publicly funded collaborative competitions; or
b. On a commercial basis, where the industrial partner retains the IP and the potential commercial leadership through it not being part of a public activity

Moreover, as the equipment becomes available and ready to use, it will be important to ensure that industry is supported in using the equipment from a skills perspective. Given that the equipment is likely to be very specialised and novel, companies are likely to need support from the DER-IC sites on how to use this:

"Semiconductor tools is a very specialised engineering discipline that you do need the expertise in. So I guess when we are engaging with the centres what we'll ask is 'can you do this for us?' rather than 'can we have access to your tool and go and use your tool [ourselves]?'." Industry workshop participant

Management data from the DER-IC sites shows that, by the start of February 2023, a total of 19 projects were utilising the DER-IC sites. The values of projects range from £25,000 to £15 million. The majority of projects so far (17 out of the 19 projects) are funded publicly, mostly by UKRI (including five projects that have received funding from the Challenge). The data suggests that only two of the 19 projects have been funded on a commercial basis. The number of partners per project varies from one to 12, with the average number of partners per project being five.

Alignment of DER-IC with industry needs

This metric was analysed using evidence from the contact survey and the industry workshop. Questions relating to perceptions of this alignment in the survey were only asked of those who said they were aware of the DER-IC.

The survey examined the extent to which the DER-IC aligned to the needs of the industry. As Figure 14 shows, seven in ten (71%) agreed that the DER-IC sites offered valuable facilities for organisations across the PEMD sector. One in ten disagreed with this (11%) and a similar proportion were neutral (13%) or did not know (4%).[10]

Six in ten (60%) agreed that the DER-IC sites addressed the design and testing needs of the PEMD supply chain, while around one in four (24%) were neutral. Just under one in ten disagreed with this statement (9%) and a similar proportion did not know (7%). This was also reflected in the activity-based case study. DER-IC colleagues stated that prior to holding the competition for equipment, the DER-IC had gone through a diligent process to identify the gaps faced by university and research & technology organisations (RTO) in the PEMD supply chain.

Respondents were also asked whether the DER-IC sites addressed the design and testing needs of their organisations. Just under half (49%) agreed with this, while around one in five (18%) actively disagreed. The remainder were either neutral (22%) or did not know (11%). This is counter to the evidence gathered in the

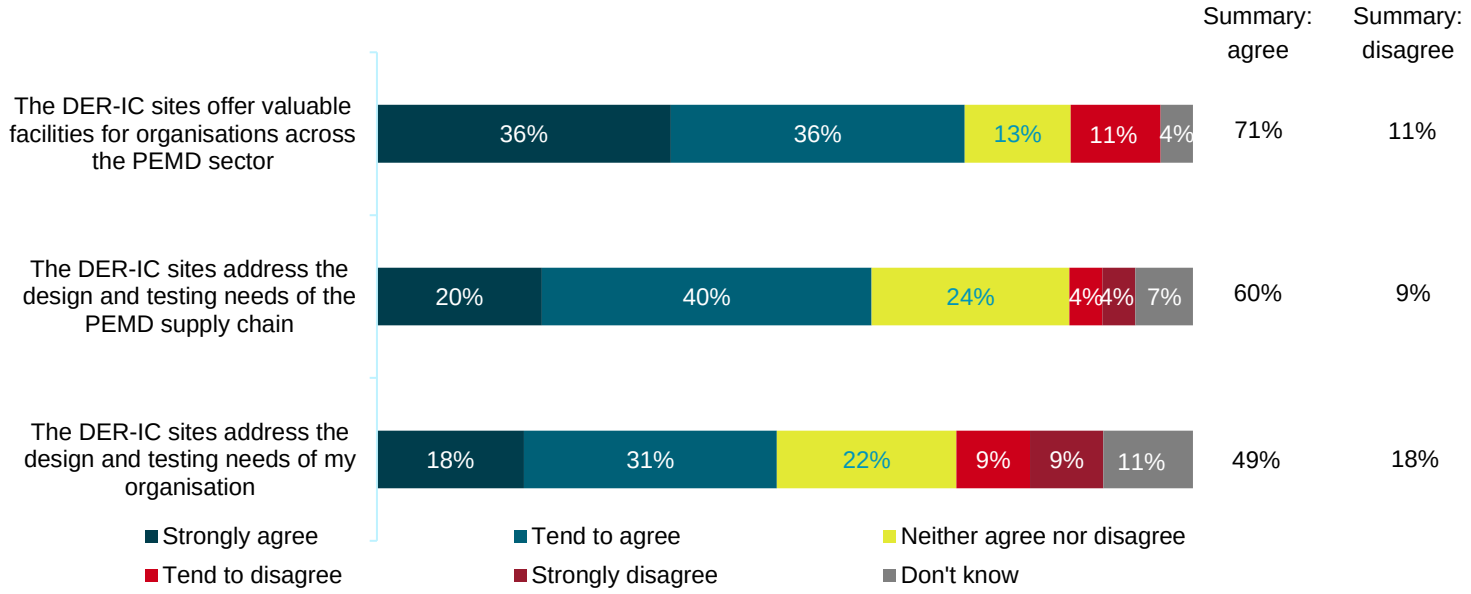
[10] Where aggregated figures may seem to differ slightly from the summation of individual figures, this is due to rounding.

case study – more detail in Section 4 – where firms interviewed said they found the DER-IC equipment very useful.

"The university of Nottingham has always had impressive equipment for research, but now [due to the DER-IC] they have 4/5 major manufacturing products that are quite amazing." SME

The relatively small sample sizes for both the case study and survey mean that this discrepancy is not surprising.

Figure 14 Views of the DER-IC

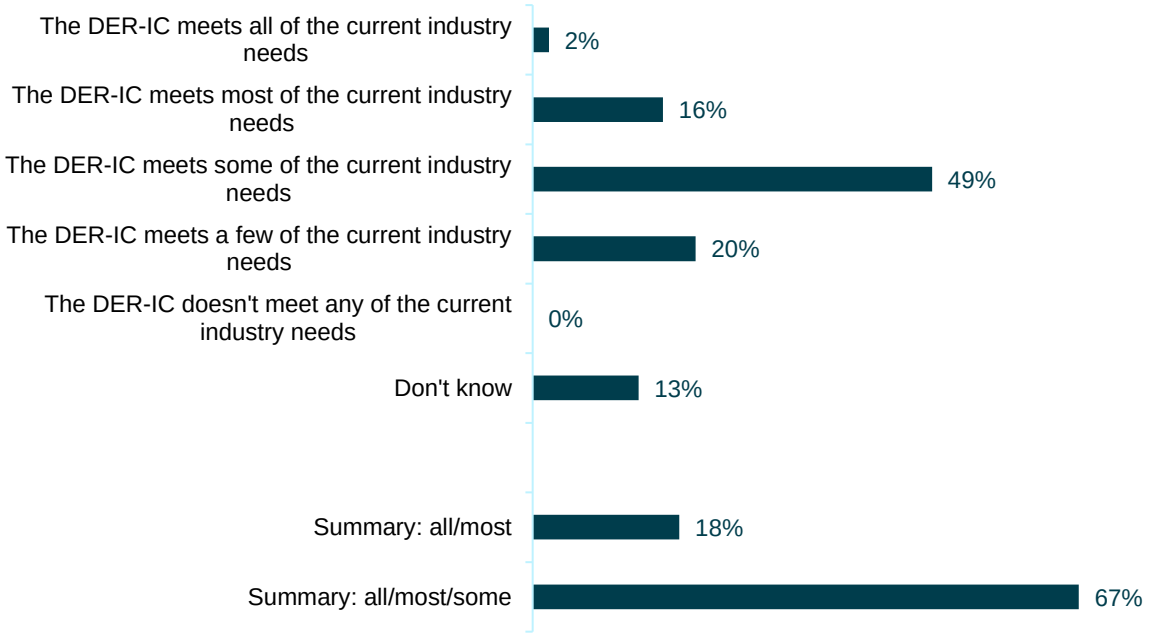


Source: Contact survey. F3. To what extent do you agree or disagree with the following statements about the DER-IC?
Note: Base: where aware of DER-IC – process and interim impact survey (45).
Where total figures may seem to differ slightly from the summation of the individual figures, this is due to rounding.

Figure 15 shows the extent to which survey respondents considered that the DER-IC met current industry needs. Overall, just under one in five (18%) thought that the DER-IC met all or most industry needs, which comprises 2% who believed that the DER-IC met all current industry needs and 16% who stated that it met most industry needs. Around half (49%) said that the DER-IC met some industry needs and a further 20% stated that it met a few. No respondents said that the DER-IC did not meet any industry needs. The remaining 13% did not know.

Businesses were less likely than academics and other type of organisations to agree that the DER-IC met at least some industry needs (57% cf. 75% of academics and other type of organisations, and 67% total). These differences to the overall result should be treated as indicative only given the low base sizes by sub-group.

Figure 15 Extent to which DER-IC meets industry needs



Source: *Contact survey. F3A. Which of the following best describes how effective you think the open-access, contract-based model of the 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.*

Note: *Base: where aware of DER-IC – process and interim impact survey (45).*

The DER-IC was generally seen to be a really positive activity among both industry and academic workshop participants, with the potential to align well with industrial needs, but delays in procuring and setting up equipment had meant that this objective had not yet been realised.

"You've got complementary capability with the different centres, that's useful. Depending on which end of the supply chain you're involved in […], you know which centre you're going to go to. I think if you look at the way that it's being set up, I think it makes a lot of sense the way it's been done. They've got the right experts at the right areas with the right equipment […] I'm sure there'll be a lot of up-take once this is ready to go." Industry workshop participant

Extent to which the DER-IC supports the Challenge to achieve its objectives

This metric was analysed using evidence from the delivery lead interviews and the industry workshop.

Given that the four centre sites were at early stages at the time of fieldwork and not yet fully operational, it is too early to say exactly how well the DER-IC sites support the Challenge's objectives. Nonetheless, delivery leads involved in this workstream felt that the DER-IC would play an important role in helping the Challenge to meet its objectives, notably in relation to engagement with industry and PEMD supply chain development across different sectors:

"[The DER-IC sites are supporting the Challenge to achieve its objectives] a massive amount on the project and supply chain engagement in terms of the equipment that we have. We're trying to grow the supply chain and

help enhance products to market and then the second aspect is the engagement that we have with industry." DER-IC colleague

"Our specific equipment is quite usefully applicable to all levels of the supply chain – also it's got a lot of cross sector impact or usability." DER-IC colleague

"I'm assuming their objectives are almost the same as ours around Net Zero [Overall Challenge and DER-IC objectives]." DER-IC colleague

While it was too early for most participants who took part in the industry workshop to comment on this theme, the minority of participants who had an opinion agreed with delivery leads that the centres would provide useful design and testing capabilities across the PEMD supply chain (see verbatim on the previous page).

However, one of the delivery leads felt that the fact that most CR&D funding had been granted before the DER-IC sites were available to use (due to procurement delays related to COVID-19) meant that this workstream would not be as effective in supporting the Challenge to meet its objectives, at least while the Challenge was operating. It is too early to tell whether other public funding and the commercial route to use the DER-IC will compensate for this, and whether utilisation of the DER-IC will meet expectations once the Challenge is no longer in operation.

Extent to which the knowledge transfer activities support the Challenge to achieve its objectives

This metric was analysed using evidence from the contact survey, the delivery lead interviews and the industry workshop.

For the purpose of this metric, knowledge transfer activities are described as activities carried out by the Challenge and the Innovate UK KTN to spread awareness of the Challenge, its aims and the projects it supports. Some of the most prominent knowledge transfer activities include:

- Innovate UK KTN promoting competitions via an email group set up specifically to focus on PEMD;
- Competitions promoted via events and on the Innovate UK KTN and UKRI websites;
- Scoping workshops ahead of competitions for the Challenge to exchange knowledge with industry to ensure competitions meet industry needs;
- 'Engage with' online sessions – 57 of these webinars were conducted over two years following the same format (a 30-minute presentation by a company to introduce itself and its technology and how others could collaborate with it, followed by a 30-minute Q&A from participants grouped and asked by the Challenge). These sessions were targeted at engineers rather than CEOs. Participants who wanted to talk to the company that was presenting to discuss collaboration could either go through the Challenge or contact the presenter directly. These sessions were recorded so that those who could not attend could still access the recording and ask to collaborate with the presenter if they wished to do so. In total, 3,057 people attended these webinars, with 565 questions asked at the Q&As and 125 introductions to presenters requested;
- 'Engage With…LIVE' – a face-to-face session held in Sheffield following the format described above was held to culminate two years' worth of webinars. More than 275 people attended and more than 50

companies showcased their involvement in the PEMD sector. 'Engage with' sessions stopped from September 2021 when the funding for all competitions had been allocated;

- Challenge newsletters; and
- Innovate UK KTN providing information about the Driving the Electric Revolution Challenge to a targeted network of PEMD-focused unique individuals.

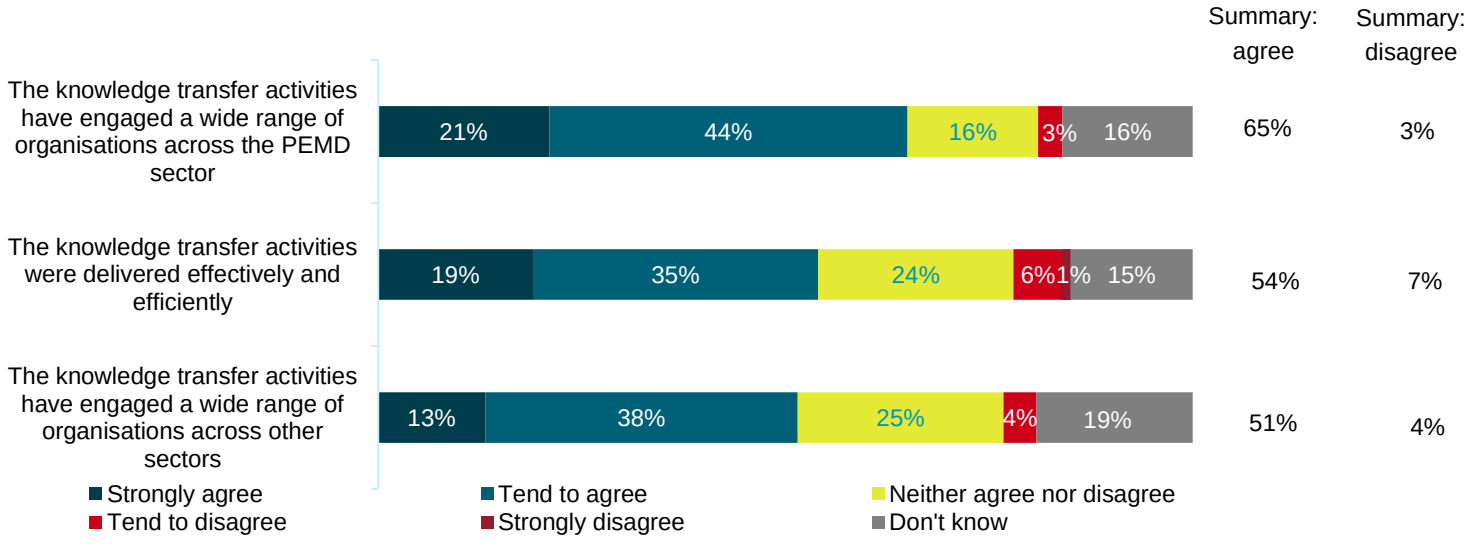
The survey delved into perceptions of the Challenge's knowledge transfer activities.

It is worth noting that these lower levels of agreement among businesses were not because of higher levels of disagreement but because businesses were more likely to have a neutral opinion.

shows, that just under two in three (65%) agreed that the knowledge transfer activities had engaged a wide range of organisations across the PEMD sector, while only 3% disagreed. The remainder were either neutral (16%) or did not know (16%). Around half (54%) said that the knowledge transfer activities had been delivered effectively and efficiently. A similar proportion (51%) agreed that the knowledge transfer activities had engaged a wide range of organisations across other sectors. While fewer than one in ten disagreed with these statements (7% and 4% respectively), these results suggest that more could be done to deliver knowledge transfer activities effectively and efficiently and to engage organisations across non-PEMD sectors.

Businesses were less likely than academics and other types of organisations to agree that the knowledge transfer activities had engaged a wide range of organisations across the PEMD (52% cf. 76%) and other sectors (35% cf. 65%), and that the knowledge transfer activities had been delivered effectively and efficiently (39% cf. 68%). It is worth noting that these lower levels of agreement among businesses were not because of higher levels of disagreement but because businesses were more likely to have a neutral opinion.

Figure 16 Perceptions of knowledge transfer activities



Source: *Contact survey. F4. And to what extent do you agree or disagree with the following statements about the Driving the Electric Revolution Challenge's knowledge transfer activities? By knowledge transfer, we mean the activities carried out by the Challenge and the KTN to spread awareness of the Challenge, its aims and the projects it supports?*

Note: *Base: all respondents – process and interim impact survey (69).*

Insights from the industry workshop revealed that knowledge transfer activities were seen as valuable for promoting what the Challenge was doing and making companies aware of the opportunities available to them. For example, Innovate UK KTN emails were useful for learning about upcoming competitions and for learning about the DER-IC, while the 'Engage with' sessions were seen as valuable networking opportunities. As mentioned earlier in this section, 'Engage with…LIVE' events and other Challenge events (online or face to face) were highly rated by those who completed the survey (67% respectively rated these as informative) and by industry workshop participants. These findings suggest that knowledge transfer activities are contributing to the Challenge's objectives, even though more could be done to promote the DER-IC, as explained in the previous theme.

"[We found out about the Challenge competitions] through our commercial work and trying to join the dots there. And then later when the calls were developed, with the KTN mailing lists, etcetera, then [attending] those briefings on the future calls." Industry workshop participant

The Innovate UK KTN sees itself as playing a key role in promoting the Challenge's activities and supporting it in achieving its objectives. According to one of the delivery leads interviewed from this workstream, UKRI did not have the capacity to send out the emails and update its website as quickly as Innovate UK KTN did, and UKRI did not have the existing networks to address specific sectors.

Theme 4 – Design and delivery of the Challenge skills gap activities

This theme focuses on how the design and implementation of the skills gap activities supported the achievement of project objectives and met the needs of the sector.

Alignment of skills gap activities with industrial needs

This metric was analysed using evidence from the delivery group interviews.

Prior to opening the skills competitions calls in early 2022 (Building Talent for the Future 1 and Building Talent for the Future 2), two activities were undertaken to understand industry needs in relation to skills. The Challenge engaged with industry bodies, and a training needs analysis piece was commissioned. However, according to one of the delivery leads, this training needs analysis did not fully deliver the desired insights because of a lack of roadmaps in some sectors. Nonetheless, from engaging with industry, delivery leads believed that skills gap activities were aligned to industry needs:

"If you speak to the PEMD community, the one thing everyone is struggling with is recruiting skilled people or they are trying to upskill their own people to meet their industry needs." Delivery lead

"There's a skills gap in PEMD globally so skills activities tap into that." Delivery lead

Given the somewhat muted results from the training needs analysis, skills competitions were designed in a way that forced applicants to identify industry needs and to have backing on the gap identified by industry.

"Because at stage one the needs analysis didn't fully identify needs in areas due to a lack of roadmaps, competitions applicants were asked to identify a need in those areas and have letters of support from industry

to prove that the outreach that they were doing or the courses they were developing or delivering were aligned to industry needs." Delivery lead

Despite this requirement for skills competition projects to align with industry needs, the fragmented project-by-project nature way of addressing skills gaps leaves unanswered questions as to whether the skills gap activities are fully addressing the industry's skills needs across sectors and in sufficient depth. Nonetheless, there was an expectation by the Challenge from the start that the £6 million of funding allocated to skills was not going to address PEMD skills shortages in full, with the focus instead being on funding specific activities that can demonstrate impact.

"What we don't know yet is if what we're doing is broad enough to meet cross-sector skills needs but also deep enough to give the deep knowledge that people and industry need." Delivery lead (UKRI)

"The only bit that I would question is the skills piece. It should have been a national skills provision rather than a lot of small competitions." DER-IC colleague

As discussed earlier in this section, while the fact that the Challenge was covering skills was seen as a positive and a new area for Innovate UK, it was felt that the budget allocated to this (around 8% of the overall Challenge's budget) was probably not enough to have a tangible impact on skills within the PEMD sector. It should be noted that the funding allocated to skills in the Challenge could be used to provide an indication of what activities might work for improving skills. While this amount can no longer be altered for this Challenge as the spending has already been agreed, we recommend that Innovate UK considers the ways in which skills may be approached for future initiatives, including how much funding should be allocated to this area relative to other areas such as CR&D, or whether separate initiatives dedicated to skills exclusively might be needed.

Extent to which the skills gap activities support the Challenge to achieve its objectives

This metric was analysed using evidence from the delivery group interviews as well as the industry and academic workshops.

Skills gap activities were seen as integral in supporting the Challenge to achieve its objectives given that a skilled workforce is a pre-requisite to the development of the PEMD supply chain.

"The objective of the Challenge is when people are making investment decisions in board rooms, when they are thinking where should I put my money for PEMD, the UK is in that conversation being a globally recognised place for investment for PEMD. And one of the things that's considered at that level is 'is there a skilled workforce available or am I going to have to bring people in or retrain?' And skills activities feed into this. There's such a massive skills gap globally. If you can't find the people, then everything else falls apart."
Delivery lead

Skills gap activities were also said to be important for the Challenge to ensure that people had the required skills to use the DER-IC's equipment:

"[Skills gap activities are] an integral part [of the Challenge] because otherwise even if you have the DER-IC no-one would be able to operate the equipment." Delivery lead

However, DER-IC colleagues identified missed opportunities for linking the skills gap and the DER-IC workstreams. Specifically, they suggested that expertise within the DER-IC sites could have been drawn on for delivering skills training to companies as some of the universities involved in this had already been delivering training to companies upon request prior to the Challenge.

"Skills are not part of what IC sites are doing and that's an issue/mistake. Actually, most of my time [at the DER-IC] is spent discussing skills over and above anything else. In [region], we have 30,000 shortage [of skilled staff] each year for the next three years." DER-IC colleague

"We [at one of the Industrialisation Centre sites] were thinking of applying to the skills competitions. We didn't do it in the end due to confusion as to whether we should do it and whether that was within the remit of Industrialisation Centres. The Universities already deliver CPD when companies come and request it so I'm not sure why that's not flagged to the wider Challenge." DER-IC colleague[11]

These findings suggest that while skills gap activities are seen as a key part of the Challenge, given their central role in ensuring that the PEMD supply chain can be developed, more could be done to ensure that skills gap activities support the Challenge in achieving its objectives. There could be better coordination between the DER-IC and the skills gap activities to address skills shortages via training and ensure that people are trained to use the DER-IC's equipment.

Theme 5 – Delivery and outcome monitoring

This theme focuses on how delivery and outcomes are monitored, and the effectiveness of these processes.

Effectiveness of the delivery monitoring process

This metric was analysed using evidence from the delivery group interviews as well as the contact survey and the industry and academic workshops.

This metric focuses on the extent to which the delivery monitoring process enables the team to respond to delivery and performance issues effectively and efficiently.

Survey respondents who were involved in delivering CR&D projects (54) had favourable views of the monitoring process, with just under three in four (74%) saying that this process was efficient and just around one in ten stating the opposite (11%).

Views of the monitoring process were also explored via the industry and academic workshops. Participants felt that there was some variability in monitoring processes, depending on the monitoring officer and their knowledge of the sector as well as their preferred style of monitoring. There was seen to be an element of 'luck' in terms of the monitoring officer assigned to a project, with some thought to make things harder while others made it easier. However, most felt they had been 'lucky' in the monitoring officer who had been assigned to them.

[11] These interviews took place between June and July 2022. We understand from the Challenge that all DER-IC sites ended up submitting applications for skills competitions by the time these closed.

"We had a very good experience working with the project monitoring officer. They were quite enthusiastic about the project, the work that we were delivering and they were also equally critical in terms of what they would love to see and so it was a very productive and, at the same time, constructive engagement with the project officer, which is not often the case with all Innovate [UK] funded programmes where monitoring officers could take on a more dominating role rather than a supportive role." Academic workshop participant

"The strictness of some of the MOs varies. Some are very pedantic and very by the book, and other ones are far more flexible and far more helpful, giving advice and indicating 'this would be a good idea if we have this ready for the next meeting' and such or 'yeah it looks like everything's going well, but you could do this better', as opposed to some people who would just go 'it's not my job to give advice'. I suppose that's just people. People view their roles slightly differently. I have heard some horror stories but I have to say that for both the projects that we've led we we've had two separate MOs, both really experienced and understanding." Industry workshop participant

Nonetheless, the involvement of the innovation leads in monitoring activities was seen to be a real positive, and something that was not seen so consistently across other UKRI funding. The project consortia felt that they were being listened to and that the Challenge was really invested in them and could sometimes help with technical aspects by linking people from different projects.

"What was quite useful for us from the quarterly meetings is actually to have the person from Innovate as well in the meeting, because actually there's quite a lot of issues that get resolved when you have both somebody from Innovate and the monitoring officer. [The innovation lead] is going to all these projects that are running in parallel actually sometimes they are quite similar things going on from project to project and they can actually give us some contacts." Academic workshop participant

"I thought one of the most useful things about the entire project was the innovation lead showed up to all of our quarterly meetings. And I really appreciate [the innovation lead] actually taking the time to show up because him with a very experienced monitoring officer was absolutely invaluable, I have to say, at navigating Innovate processes, but also thinking of suggestions for how to promote the technology within the PEMD sphere in the UK, which for us was very important because we're new to that." Industry workshop participant

Similarly, while it was pointed out that some monitoring officers did not usually get involved in technical aspects of the project, when this involvement took place, it was generally seen as a positive by project teams:

"The experience is really, really positive in terms of someone who's engaged, trying to make additional connections, pointing out other things that are useful, coming up with technical suggestions […] It's been pretty valuable." Academic workshop participant

Project management and accountability of partners when it comes to delivery were considered to be the main benefits of the monitoring process:

"I think, especially in terms of the academic part, it's sometimes useful to hold industrial partners accountable to what they said they were going to do in the project." Academic workshop participant

"I think quarterly review meetings means that you get together and you try and keep the project on schedule and on track." Industry workshop participant

Delivery leads at the Challenge also considered the delivery monitoring process to be effective, with the vast majority of projects progressing as expected or issues being spotted in a timely manner. A minority of projects had been terminated due either to companies' finances or the scope of the project not being feasible. There is also a process in place for the Challenge to stop funding to companies during projects in line with Innovate UK processes against the terms of the grant.

While these findings suggest that the processes in place help the Challenge to stop projects that are not progressing as expected in an efficient manner (i.e. with little to no time or resources wasted), the process of changing projects to enable progress is not as straightforward. Industry workshop participants stated that it could take six to eight weeks, if not longer, for a project change request (PCR) to be approved by the Challenge. This suggests that time is wasted in terms of project progress while waiting for the outcomes of PCRs. More details about this are included in the 'suggested improvements' subsection at the end of this theme.

Effectiveness of the outcome monitoring process

This metric was analysed using evidence from the delivery group interviews and the industry and academic workshops.

This metric focuses on the extent to which outcome monitoring enables the Challenge to understand if the programme is on track to deliver impacts.

From the point of view of delivery leads involved in competitions, most projects were either meeting or exceeding their expectations. Although some projects had been found not to be delivering on their outcomes, this was considered to be normal given the inherent uncertainty of CR&D activities:

"Not all projects deliver on their outcomes but that's because some projects have a level of uncertainty in their potential for delivery. That's fundamental research. Sometimes it shows that you can't do something and that's still a good outcome because you put that learning to a side and then start looking at alternatives to reach those goals." Delivery lead (UKRI)

After quarterly meetings, monitoring officers produce a report about each project for the Challenge with scores out of five against a range of areas, including activities undertaken against the timeline, technical development, and management of team, budget, resources and risks. A 'red-amber-green' (RAG) status is then derived from this indicating the project's risk level and the likelihood of it being successful or not. The Challenge then reviews this and takes action if and when needed to ensure projects deliver on their outcomes. Actions can include stopping funding certain projects, which is possible due to the monitoring cycle being aligned to the release of funding on a quarterly basis:

"If anything comes out of that [quarterly meetings and RAG status], we then say 'if you carry on doing X, we're going to stop you in a few months' time'. If a project is very clearly not doing what they said they were going to do or it's not going to have the impact they said it was going to have." Delivery lead (UKRI)

Apart from competitions, outcomes for other workstreams are also monitored. The DER-IC sites produce quarterly reports on performance against a series of key performance indicators (KPIs) that they send to their parent organisation. KPIs for the DER-IC include income targets; expected income over a funding period; financial targets; engagement KPIs; marketing and business development activity; marketing and

dissemination targets, i.e. events organised or attended; utilisation of equipment; number of industrial partners; impact around case studies; and follow-on investment related to usage of the grant-funded equipment by industry that then results in industry investing in production capacity in PEMD technology.

For knowledge transfer activities, the numbers of attendees at 'Engage with' sessions are monitored, as are the number of questions asked at each session and requests for company introductions from attendees.

As mentioned earlier in this section, industry and academic workshop participants also found the quarterly review meetings useful for keeping their projects on track and ensuring that they delivered against outcomes. The inputs of monitoring officers and innovation leads were seen as particularly valuable to ensure that projects delivered on their technical outcomes.

Robustness of monitoring data

This metric was analysed using evidence from the delivery group interviews.

When it came to project monitoring, the robustness of the monitoring data was checked at two levels. Firstly, monitoring officers did ad hoc quality assurance by having visibility of how projects were progressing and by asking for project plans or more information when needed. Secondly, delivery leads explained that no decisions were made about projects based on the quarterly reports from monitoring officers alone and that the Challenge had oversight of this project monitoring process as innovation leads attended quarterly meetings.

However, some issues were identified in relation to the project monitoring process. One of the delivery leads involved in monitoring said that there was no specific process at Innovate UK for monitoring officers to quality check project monitoring data. On the other hand, it seemed that part of the process of ensuring that robust monitoring data was provided by the monitoring officers to the Challenge was based on trust, which could result in compromised reliability of monitoring data:

"We use trusted monitoring officers. Within Innovate there's a pool of monitoring officers." Delivery lead

"We've stopped using a couple of monitoring officers because we didn't think they were either running meetings very well or reporting back very well, or indeed communicating either with the project team or the Challenge team very well." Delivery lead (UKRI)

In terms of the robustness of the data provided for the DER-IC sites' KPI reports, delivery leads involved in this workstream explained that the parent organisation of the DER-IC site (i.e. a university or Catapult) had a right of audit of the data which fed into KPI reporting. Additionally, the DER-IC's finances were subject to independent finance reports relating to claims, as per usual UKRI standard processes.

For knowledge transfer activities, the Challenge did not rely only on attendance statistics as feedback sessions were conducted after events. However, concerns were raised about the validity of this feedback:

"We don't hear much negative feedback and I don't know if that's because we're not asking things in the right way or because people don't want to be negative." Delivery lead (UKRI)

Suggested improvements to the monitoring process

This metric was analysed using evidence from the delivery group interviews and the industry and academic workshops.

While the monitoring process was regarded as widely positive, as discussed in the previous subsections, some improvements were identified by industry and academic workshop participants and delivery lead interviewees.

From the perspective of project participants, the PCR system was seen as an impediment to project progress given the long timelines for the Challenge to approve these. Participants agreed that providing outcomes for these requests should be made more straightforward as most projects will need to submit these requests at some point because CR&D usually entails adapting the project according to emerging findings. There was some feedback that the change of the system to Industrial and Financial Systems (IFS) had increased the difficulty of this process as it was perceived as difficult to navigate.

"As projects go through the quarters, generally you can see that you may have started off on the wrong track and you need to be pragmatic as you go through a project and there's no room for pragmatism in some cases without a PCR, which takes forever." Industry workshop participant

"The time it takes [for a PCR to get approved] means you've essentially got to assume it's going to get approved anyway. You've got to carry on because it will take six or eight weeks or something before you get an updated grant offer letter." Industry workshop participant

Given monitoring officers' detailed knowledge of projects and close contact with the project team, project participants wanted them to have more authority in relation to approval of PCRs in order to speed up the process.

Moreover, there was a feeling, from the experience of industry and academic workshop participants, that monitoring officers interpreted their roles differently and that the interpretations varied from monitoring officer to monitoring officer. For example, some monitoring officers assumed a more supportive role and others a more policing role, and some were more willing to get involved in technical discussions than others. Related to this, a delivery lead interviewee who was involved in the monitoring process explained that there was no specific guidance from Innovate UK for monitoring officers on how to quality check the data collected from projects for the purpose of monitoring. These findings suggest that clearer guidance for monitoring officers on the expectations of their role would be beneficial to ensure consistency.

From the point of view of monitoring officers, the clarity of information recorded on projects on Innovate UK's systems could be improved, as it was currently perceived to be fragmented, showing information for individual parties rather than aggregated across all projects' parties.

"I can't see how much all parties are spending and forecast. It only shows individual parties and it's hard to piece them back together again. It was adapted from a customer management tool, not a project management system or a database even." Delivery lead

Conclusions and recommendations

The purpose of the process evaluation was to identify the factors that have helped or hindered the effectiveness of the Challenge while providing actionable feedback to allow the Challenge to refine processes in real time and/or to feed into future initiatives. Key insights and recommendations are summarised below for each of the process evaluation themes. Overall, the Challenge was perceived to be running successfully and processes were felt to be effective, with some suggestions for improvements outlined below.

In relation to theme 1 (management and governance of the Challenge), while communication across strands usually happened, it was flagged that there was no formal process for coordination across workstreams to take place. Additionally, most delivery leads felt that there could be better coordination between skills gap activities and other workstreams. It was also felt that the fact that the Challenge's competition funding had been allocated before the DER-IC sites were fully operational was a missed opportunity. These findings suggest that **more formal processes for coordination among workstreams would be beneficial** in order to maximise the impact of each workstream and, consequently, of the Challenge as a whole.

Furthermore, there was consensus among Challenge delivery leads that the Challenge's funding and resources were being managed and distributed according to the initial business case. This was generally considered to be fair. While there was a desire to see additional funding for skills gaps activities, this was not possible within the approved business case for the Challenge.

There was also feedback in relation to decision-making. Most agreed that the process for competitions followed the standard Innovate UK process, which was seen as effective in ensuring that decisions were made transparently and in a non-biased way. However, this process could take a long time from conception of the competition calls to allocation of funding (6-9 months) and could potentially put applicants off lower value competitions. We therefore recommend that **Innovate UK looks into developing a fast-track process for lower value competitions** (e.g. up to £50,000 per project). For this, it will be important to maintain a balance between speeding up the funding allocation process and conducting certain checks to ensure that the funding is being allocated properly. This would involve having faster processes for competitions when it comes to doing financial and other checks, rather than providing applicants with less time to apply for competitions. We understand from the Challenge that these faster check processes have already been implemented for other Challenge competitions, such as the competitions launched by UKRI as a response to the COVID-19 pandemic, where checks were carried out within three months to fund projects with a value of under £50,000.

Additionally, while most of the Challenge's communications channels were considered to be effective in engaging with stakeholders, **social media communications and communications around the DER-IC sites were seen as the least informative, which suggests that improvements could be made to these to increase their effectiveness**.

Moving on to theme 2 (design and delivery of competitions), while a majority of survey participants agreed that the focus of competitions was clear and that the application process was easy to understand, there was some disagreement in relation to the scope of funding competitions being suitable for driving real-life development of the PEMD supply chain and in relation to competition timelines allowing sufficient time to form consortia and prepare the application (17% and 23% actively disagreed with these statements

respectively). In relation to the latter statement, industry and academic workshop participants said that the time between briefing sessions and deadline for submission of proposals could be too short at times (e.g. 3-4 weeks) to allow them to form consortia with organisations they had not collaborated with beforehand. While briefing events were seen as useful for networking and finding out about future competitions, we recommend that **sufficient time (at least two months) is allowed for competition applicants to form consortia** as it can take time for companies to get internal approval in relation to IP.

In terms of the scope of funding to deliver real-life development of the PEMD supply chain, delivery leads at the Challenge and applicants felt that the overall funding allocated to the Challenge (£80 million) was insufficient for delivering on this objective (i.e. delivering real-life development of the PEMD supply chain).

Moreover, there was feedback both from applicants and delivery leads in relation to application interviews. Applicants felt that it would have been helpful to have more information in advance about the questions that would be covered in the interview to assist with preparation, and some did not know in advance that it was a requirement for all consortium members to attend the interview. The lack of clarity around interview questions was echoed by one of the Challenge delivery leads, while another Challenge delivery lead explained that they had experienced some assessors scoring consortia at the interviews quite differently from others. These findings suggest that **further guidance is needed to ensure the interview process is robust**. Applicants should be made aware of requirements in relation to attendance of consortium members and, where possible, advance information on interview questions could be provided. Also, assessors will need more guidance on the scoring matrix so that they can apply this consistently.

Nonetheless, stakeholders considered the competitions to be aligned with industry needs, with over three in four (77%) survey participants agreeing that the competitions aligned with the needs of the PEMD supply chain. This reflected the Challenge's work ahead of competitions to understand industry needs, which involved engaging with industry bodies and the advisory board (which was made up of industry representatives). We recommend that this **industry engagement via industry bodies and an advisory board made up of industry representatives is kept as a process for this Challenge and future Innovate UK initiatives** in order to ensure alignment with industry needs.

When it comes to engaging stakeholders in competitions, the findings from the academic workshop participants indicate that **more efforts could be made by the Challenge to engage SMEs in competitions**. The academics who took part in the process workshops considered that the Challenge could give SMEs more support with applications, as smaller organisations were less likely to be familiar with applying for public funding. We recommend that the **Challenge engages with SMEs and academics to publicise the support that is already being offered by the Innovate UK KTN in this regard**.

Findings from theme 3 (design and delivery of the DER-IC and knowledge transfer activities) revealed that knowledge of the DER-IC was limited among stakeholders, with a third of survey participants saying that they were not aware of this. This was probably due to COVID-19 related delays in procuring the equipment for the DER-IC sites. However, now that the DER-IC sites are becoming operational, we recommend that the **DER-IC sends communications about its sites and facilities to industry (including the Challenge's competition winners) so that they are aware of the opportunities available in relation to design and testing**. This information should include an overview of the DER-IC utilisation model and the equipment

available. Given that the Challenge funding has already been allocated, it would also be useful to let industry know about **other sources of public funding that they could apply to going forward to use the DER-IC**.

Despite the low levels of knowledge, there was an early indication that the DER-IC sites are seen as valuable facilities by industry, with a majority of survey participants agreeing that the DER-IC sites addressed the design and testing needs of the PEMD supply chain (60%).

In relation to knowledge transfer activities, the 'Engage with' sessions (both online and face-to-face formats) were highly valued by stakeholders for networking and collaborating with others. While the Challenge has stopped delivering this now that the funding for competitions has been allocated, we **recommend that this 'Engage with' format is used in future initiatives to encourage collaboration and knowledge sharing among industry**.

Moving on to theme 4 (design and delivery of skills gap activities), while stakeholders were required to identify skills gaps and have back up from industry on this when applying for skills competitions, this led to skills gap activities being seen as fragmented, as this design did not allow the Challenge to know whether these activities were broad and deep enough to address the skills shortages in PEMD. Moreover, some Challenge delivery leads felt that there was insufficient funding for this workstream compared to others, which diminished the ability of this workstream to meet industry needs. This was seen as a shortcoming given how central skills are to the Challenge and the overarching objective of building the PEMD supply chain. While this amount of funding allocated to skills for the Challenge can no longer be changed as the spending has already been assigned, we recommend that Innovate UK **considers the ways in which skills can be approached for future initiatives**, including how much funding should be allocated to this area relative to other areas such as CR&D, or whether separate initiatives exclusively dedicated to skills might be needed. It is worth noting that most skills required for PEMD are not unique to PEMD, as PEMD skills align with electronic systems, electrical and electronic engineering, physics etc. This suggests that wider initiatives focused exclusively on skills may be needed to address skills gaps in PEMD as well as in other sectors.

There was also feedback from DER-IC colleagues that the skills gap activities could be better integrated with other workstreams, particularly the DER-IC. Skills are very important for operating the equipment at the DER-IC and universities engaged with the DER-IC are already delivering training on PEMD to companies on an ad hoc basis. We recommend that the **Challenge explores ways of better coordinating these workstreams to allow for knowledge sharing and to maximise impacts**.

In relation to the final process theme, theme 5 (delivery and outcome monitoring), there was consensus among industry and academic workshop participants that the monitoring process was helpful in keeping the project on track. The fact that innovation leads were present in quarterly meetings was considered to be a real positive, as they were able to help consortia find solutions to problems and provide contacts from other projects to address technical aspects. We recommend that the **Challenge keeps involving innovation leads for this Challenge as well as future initiatives as it makes stakeholders feel valued**.

In spite of these positive views, some improvements to the monitoring process were identified. Firstly, the systems used for project monitoring could be made more efficient. There was feedback from a monitoring officer that the system did not allow them to see aggregated information for a project as it showed information for each of the project parties instead. There was also feedback from industry that the system was hard to navigate, particularly since the move to IFS. For example, the process of submitting PCRs was seen as

complicated. Additionally, it was mentioned that getting outcomes on PCRs took a long time (6 to 8 weeks) and so could cause delays in projects. We recommend **quicker turnarounds for PCRs**, to avoid delays. As industry workshop participants suggested, this could be achieved by **giving monitoring officers greater authority for approving these requests** as they are more likely to be familiar with the project and understand the need for the request.

Academic and industry stakeholders felt that monitoring officers interpreted their roles differently, with some being more supportive and some more demanding, and some being willing to get involved in technical aspects of projects while others were not. Delivery leads also mentioned that although the Challenge tended to use trusted monitoring officers who had been used previously, on a couple of occasions the Challenge had stopped using some monitoring officers due to issues with reporting or communicating with the project team or the Challenge team itself. These findings suggest that **more guidance on the role and expectations of monitoring officers** could be provided by the Challenge to ensure consistency in the monitoring process.

Overall, most processes were found to be in place and followed appropriately. However, some improvements could be made, as identified in this section, to ensure that the Challenge's processes are as efficient as possible, which in turn will allow the Challenge to deliver on its impacts.

4 Interim impact evaluation

The Evaluation Framework Report outlined the metrics that should be used for a final impact evaluation of the Challenge. In reviewing this framework, we identified that not all these metrics would be relevant for this interim impact evaluation as the Challenge is still at a relatively early stage in its activities. We therefore begin this section by outlining the metrics that we examined for this report. Our review focused on two points:

- **Scope:** We reduced the metrics that we looked at from the full range of metrics outlined in the Evaluation Framework Report to a subset of 'leading indicators'.
- **Data source:** In some instances where the Evaluation Framework Report states that secondary data should be used to evaluate a metric, we used case studies instead. This was partly because we did not expect to see an impact in these metrics at the aggregate level – measured by secondary data – but we might expect to see an impact at the individual firm level, which we pick up in qualitative analysis.

Leading indicators

The leading indicators were selected using two criteria:

- Metrics that looked at shorter-term outcomes, such that changes in these metrics were more likely to be observed at this stage; and
- Metrics that were expected to be correlated with longer-term effects, such that changes in these metrics were expected to be a good indicator of future changes in outcomes and impacts.

In line with the theory-based approach, we viewed broadly positive changes across the group of leading indicators as evidence that the Challenge was on track.

We note two further points on our use of leading indicators:

- Limiting the focus of the interim impact evaluation to leading indicators does not mean that the consortium ignored any evidence related to later stage outcomes and impacts. Where we identified relevant evidence relating to these, this is reflected in our assessment. However, analysing them was not our main focus.
- The interim impact evaluation does not involve a repeat of the secondary data metrics from the baseline report. We think this would be disproportionate given that only a limited amount of time has passed, especially as we think observable changes in aggregate metrics are unlikely at this stage.[12]

Contact survey

The contact survey for the process and interim impact phase predominantly focused on the process evaluation. To prevent survey fatigue – and to keep the number of questions reasonably limited – we asked 30 questions focused on the interim impact evaluation, which were selected against the list of leading indicators.[13] The final impact evaluation will involve a further contact survey which will ask a more extensive

[12] Table 32 in Annex E demonstrates that the majority of impact metrics have been covered either as part of the baseline or the interim impact evaluation.

[13] This does not mean that 30 impact metrics were covered in the contact survey, as multiple questions are needed for each metric.

set of impact questions. We now go on to present summative findings for the interim impact evaluation, organised by the themes set out in Section 2.

Theme 1 – Has the Challenge accelerated innovation and commercialisation of PEMD technologies?

Key messages

While the interim impact evaluation did not track the MRL quantitatively, the case studies show **promising signs of the Challenge accelerating innovation and the commercialisation** of PEMD technologies. The **competition winners we engaged were able to increase the MRL** and accelerate the commercialisation of their products within the UK. The survey results also provide evidence of the Challenge's positive impact, with 17 out of 54 **firms expecting to be at MRL of 7 and above at the end of their engagement with the Challenge**, compared to only one reporting those MRL levels at the beginning of their engagement. Firms we engaged that had utilised the DER-IC's facilities had been able to **test manufacturing techniques and processes for innovative products** while waiting for long lead times on their own equipment, which accelerated the commercialisation of the technology. However, there was a concern from academic and policy stakeholder that commercialisation was not developing equally across all sectors, because the Challenge's investment was weighted too heavily towards some sectors.

This theme focuses on whether the **Challenge has been able to advance the innovation and commercialisation of PEMD technologies** in the UK by accelerating the growth of the UK PEMD supply chain and thereby increasing the contribution of the industry to the economy. The specific metric relating to this theme is summarised in Table 13.

This metric focuses on the impact of the Challenge on **MRL** for PEMD companies and competition winners. The Evaluation Framework Report included two additional metrics:

1. Challenge monitoring data to track project MRL. It has since been understood that the Challenge will not be collecting this data on a systematic basis, and therefore it cannot be used for monitoring purposes. However, MRLs are looked at in the project-based and activity-based case studies and may be included in the contact survey for the final impact evaluation.
2. Survey responses on the number of pilots. This was asked about in the process and interim impact survey, but it did not receive enough responses to be reported here. It will also be included in the final impact survey and we hope it will be reported in the final impact evaluation.

At this stage of the evaluation, the focus is on evidence relating to the activities conducted by the Challenge that are relevant to the theme and the perceptions of stakeholders on the impact of those activities. Evidence for this evaluation theme comes from:

a. Two project-based case studies of competition winners;
b. One activity-based case study of the Midlands DER-IC site;
c. One thematic-based case study; and
d. Analysis of data from process and interim impact contact survey.

We begin by presenting the activities undertaken by the Challenge relating to this theme, and then summarise how the Challenge has helped advance innovation and commercialisation through CR&D competitions and the equipment available at the DER-IC.

Table 13 Interim impact evaluation metrics – Evaluation theme 1

Evaluation metrics	Data sources	Methodology
a) Manufacturing readiness level (MRL) of competition winners	Case studies	■ Framework analysis of case study interviews with PEMD companies ■ Stated impact of Driving the Electric Revolution on MRL

Source: Frontier Economics

Activities undertaken by the Challenge

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

a. Providing over £30 million in CR&D funding to around 100 firms. These are firms that are at the beginning of developing new technologies and those that already have a proof of concept but need help to advance the MRL, **enabling innovation and commercialisation**.
b. Funding the DER-IC (£33 million), which has provided open access to equipment that fills gaps in the UK's current manufacturing capabilities and allows firms to test and explore ways of **improving their manufacturing techniques.**

The Challenge funding has assisted competition winners in advancing the MRL and the commercialisation of novel technology

The in-depth analysis of the project-based case studies provides practical evidence of the Challenge's role in assisting firms with developing manufacturing processes and commercialising novel technology. One Challenge-funded case study project consists of developing a software tool for the design of motor-generators with hairpin windings. The hairpin design has potential to **improve the manufacturability and performance of motors**. Manufacturers and designers can increase MRLs by using the tool to test various methods for minimising motor size and deploying new, better-performing motors. The software will therefore accelerate the commercialisation of energy-efficient designs that could have significant environmental benefits. Quantifying increases in MRLs is difficult, however, as the companies involved in the project have taken the work in house.

The findings from the first complete prototype and ongoing demonstration projects show promising signs in terms or commercialisation, and there is potential to develop a new motor design from initial concept to manufacture within six months. As a result of the project, the University of Nottingham – a partner in the project – successfully secured €147,000 as part of the H2020 DORNA programme to develop high-reliability electric traction drives and £40 million of funding for a new facility to research state-of-the-art power electronics. Moreover, two of the consortium members, GKN and University of Nottingham, have partnered with the University of Newcastle to fund a new Advanced Research Centre which aims to use the tool directly

as a platform to support future projects, expanding the tool's utility. The centre is supported by £3.5 million of funding from the Melrose Skills Fund.

The other Challenge-funded case study project is developing a novel die attachment process for next-generation power electronics. The Challenge funding allowed the consortium to **increase the MRL of the technology to level 9**. Where possible, the consortium working on the project aims to deploy the components and raw material needed from UK manufacturers specifically, therefore commercialising the technology within the UK. The preference for UK suppliers was partly inspired by the Challenge and was driven by the consortium's own goal to develop a reliable UK-based supply chain following disruptive events such as the COVID-19 pandemic, blockage of the Suez Canal and US-China trade tensions. Once commercialised, the technology can be deployed in a range of sectors, including military security bodies, telecommunications, aerospace and power grid, and it has received significant interest from the automotive sector.

Two business stakeholders in the thematic case study specifically mentioned that the **Challenge had played a fundamental role in the development of key industry projects.** One example was funding offshore wind projects, such that they are now commercially sustainable without the need for public funding.

"We know there's been at least two funded offshore wind projects; one of them is actually now at the point where they're continuing their research development program without the need for public funding, which is a real success story. So the support from the Challenge has moved them away from needing to approach Innovate UK for further funding" – Leader of accelerator

The equipment provided by the DER-IC has enabled firms to test manufacturing approaches, enabling the commercialisation of PEMD technologies

The Challenge has invested in equipment for the DER-IC that fills some of the gaps in the UK's current manufacturing capabilities and capacity. This enables industry to **test manufacturing techniques, which will enable the commercialisation of PEMD technologies**. Findings from the activity-based case study show that the equipment at the Midlands DER-IC site is being used by firms in all stages of their development journey. Start-ups and spin-outs learn how to design for manufacture, while larger and more mature companies look to pilot new products and processes before buying their own equipment.

A large manufacturer – part of a larger consortium project – pointed to its novel project as evidence of this. The project is developing a supply chain around an innovative design for an electric motor. This means that the project is not only creating the design for the novel motor and its manufacturing process but is also paving the way for the commercialisation of the technology. The equipment at the Midlands DER-IC site assisted the consortium in two ways:

1. The consortium has used the Winding Centre of Excellence – established as part of the Midlands DER-IC site – to learn about the type of machinery and processes that need to be acquired, without incurring the (significant) upfront costs of purchasing the machinery. The grant given to Warwick for this equipment cost nearly £1 million.
2. The consortium has also been able to consistently refine the manufacturing processes while awaiting a long lead time for its own equipment. This means that once their equipment arrives, the consortium will

already know how best to use the equipment, **significantly cutting down the time to manufacture and accelerating commercialisation**.

In the absence of the Midlands DER-IC site, the consortium would have bid for a project that was less ambitious in scope. The Midlands DER-IC site gave the consortium **reassurance that the required experts and equipment would be available to them throughout their project.** The current collaboration has given the consortium confidence not just in the Midlands DER-IC site but in the entire DER-IC initiative. It is consequently looking to other types of engagement with other DER-IC partners, including in Newcastle or Nottingham, for the manufacturing of inverters.

An SME we interviewed specialises in providing engineering consulting services to design the specifications for new PEMD-related technology. As this SME is a consultancy, it would not be looking to directly purchase equipment. However, being able to use the DER-IC's equipment allows it to trial and validate its design stimulations on real-life test data, providing a better service to its clients and allowing new PEMD technology to be developed faster. Being able to include a testing element in its bids has allowed this SME to bid for more ambitious and innovative projects. Without access to the Midlands DER-IC site equipment, it would not be able to do this, because it would not itself have invested in equipment.

However, there was a concern from stakeholders that the balance of Challenge activities between sectors may not be right as all sectors need support to commercialise PEMD. Stakeholders from academic and policy backgrounds felt that the Challenge portfolio was weighted towards the transport sector, with fewer projects being focused on the power sector. In particular, they specified the need for grid diagnostics and control systems and PEMD for wind power, especially given the need to increase the supply of electrical power as a key route for emissions reduction.

These individual examples can be supported by broader survey evidence

Results from the survey show that the **majority of successful applicants expected to be at a higher MRL at the end of their engagement with the Challenge**. Only one survey respondent reported being at MRL 7 or above at the start of their engagement with the Challenge (Figure 35 in Annex B), while 17 out of 54 successful applicants expected to be at MRL 7 or above at the end of their engagement with the Challenge (Figure 36 in Annex B).

Theme 2 – Has the Challenge increased the productivity of the UK PEMD supply chain?

Key messages

Productivity impacts, particularly at sectoral levels, are inherently long term. It is unlikely that we should expect to observe widespread impact even as part of the final evaluation in 2024. As it is not a leading indicator, we did not focus on productivity impacts as part of this interim evaluation.

Evidence from the project-based and activity-based case studies is consistent with these examples leading to future productivity benefits, but these have not yet been observed.

Evaluation theme 2 focuses on whether the Challenge's activities have so far increased the productivity of firms in the UK PEMD supply chain. For the purposes of this report, we define productivity to be firms either

producing more output with the same amount of inputs or producing the same output with fewer inputs. This includes both design and manufacturing productivity and could therefore be thought of as 'total productivity'.

We **do not expect total productivity increases to be a leading indicator** and therefore we do not examine the evaluation metrics for this theme (firm- and sector-level measures of productivity, input costs and wages) in the interim impact evaluation directly. Instead, at this stage, we present some indicative early evidence from the case studies. A fuller treatment of the productivity impacts will be examined directly in the final impact evaluation.

The project-based and activity-based case studies describe projects that are currently underway and where there are **expected future benefits in terms of increased efficiency and productivity**. Examples include:

a. A large OEM running a consortium project with the Midlands DER-IC site to test a new manufacturing process for inverters that would allow them to be produced more cheaply and efficiently;
b. A UK electronics manufacturer developing a new power electronics technology that provides higher efficiency and reliability compared with alternative die attachment methods;
c. A software designer using Challenge funding to facilitate the design and manufacturing of a new type of motor which increases energy efficiency and reduces use of scarce and expensive materials.

However, these projects are still ongoing or have only recently finished and therefore have **not had time to impact the total productivity of firms in any significant way**. It would therefore not be accurate to present these as productivity increases that can already be observed, but nor would it be sensible to suggest that this evidence is an early warning indicator that the Challenge is having no impact on productivity.

Theme 3 – Has the Challenge contributed to growing PEMD knowledge and skills in the UK?

Key messages

The Challenge is growing PEMD knowledge and skills in the UK through both the dedicated skills activities and the wider CR&D projects. Despite these, there has **not been a significant shift in stakeholders' perceptions** of skills shortages as a significant barrier to the expansion of the PEMD supply chain. However, we would **not expect a shift to take place yet**, given that the Challenge's skills activities are still in early days. However, we believe it is reasonable to expect the Challenge's activities to have a **positive impact on this perception in the future**. These activities centre around providing funding for knowledge and skills activities through skills competitions and knowledge transfer from the DER-IC both through collaborative projects and training firms to use the open-access equipment provided.

Evaluation theme 3 relates to the Challenge's ambition to increase the PEMD knowledge and skills base in the UK. The specific metrics relating to this theme are summarised in Table 14 below. These metrics focus on stakeholders' views on the current skills shortage in the PEMD sector, and the activities undertaken by the Challenge to address the issue. In the Evaluation Framework Report, this metric was to be collected as part of a contact survey. Given the limited impact questions in the process and interim impact contact survey,

for the interim impact evaluation this metric was addressed through the case studies instead. For the final impact evaluation, this metric will be addressed through both the phase 4 contact survey and the case studies.

Our in-depth case study analysis provides some evidence on the **perception of skills as a barrier and the Challenge's support of skills and training across the PEMD supply chain until now**. However, it is important to note that the dedicated skill-related activities are still in early days compared with its CR&D activities. Hence this evaluation theme will be assessed more completely in the final impact evaluation in 2024, particularly as the Skill Hub becomes operational and the effects of the Building Talent for the Future competition materialise.

Evidence from this theme comes from:

- Two project-based case studies of competition winners;
- One activity-based case study of the Midlands DER-IC site; and
- One thematic case study looking into policy and skills.

We begin by presenting the activities undertaken by the Challenge relating to this theme. We then present the perceptions of skills as a barrier, before outlining in more detail the activities that the Challenge has already undertaken to date that may contribute towards removing this barrier in the future.

Table 14 Interim impact evaluation metrics – Evaluation theme 3

Evaluation metrics	Data sources	Methodology
a) Perception of skills as a barrier to expanding the PEMD supply chain	Case studies	Stated impact of the Challenge on skills gap

Source: *Frontier Economics*

Note: *In the Evaluation Framework Report this metric was to be collect via a contact survey, but it is being collected through project case studies for the purpose of the interim impact evaluation.*

Activities undertaken by the Challenge

The Challenge has conducted a range of supporting activities to facilitate knowledge exchange and enhance the UK skill-set, including:

- Dedicating £6 million to support skills and training provision for school leavers to experienced engineers. The Challenge is funding competitions for various skills projects, including smaller-scale projects – for example, building interactive learning tools on specific engineering topics – as well as developing the Skills Hub.
- Funding the DER-IC which have:
  - Shared their knowledge and expertise with collaborators in several projects, which is then retained within firms and likely builds future skills capabilities; and
  - Offered the PEMD workforce the opportunity to work with new manufacturing equipment and provided training on the use of this equipment.

To date the 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

Stakeholders still see the shortage of skills as a significant barrier to the growth of the PEMD sector, but this is to be expected at this stage

Across the case studies, there was a **consensus among stakeholders that there was currently a significant shortage of relevant skills** in the PEMD sector that could prevent it from growing. Business stakeholders in the thematic case study were concerned about the UK's **lack of experienced engineers**, who are necessary to take PEMD technologies through the MRL journey. Interviewees from the project-based case studies stated that most of their new engineers were recruited from outside of the UK, making it particularly difficult for the firms that do not have the resources to provide visa sponsorships.

"Engineers with 15 years+ of experience are like unicorns – not rare, but mythical." Electronics manufacturer

One Midlands DER-IC site stakeholder argued that the shortage of skills within the PEMD sector was an issue that was severely understated by the UK government. There is demand for approximately 13,500 level 4-7 engineering jobs in the North East alone, and the total number of graduates in electrical engineering is about 1,100 per year. In 2017, EngineeringUK projected an engineering graduate supply shortfall of at least 20,000 annually based on demand (and likely higher, depending on assumptions).[14] Academic stakeholders perceived the shortage of engineers to be a deeply rooted issue within the UK, stemming from the subjects studied at school and university. They therefore argued that that there was a requirement for government intervention to boost graduates in STEM subjects.

In the baseline survey, over three-quarters of businesses surveyed believed there to be a skills shortage in the PEMD sector, with about half believing there were **significantly fewer people with the relevant skills than the industry currently needed**. The case study consensus being consistent with the findings from the baseline survey demonstrates that **the perception of skills as a barrier has not changed**. However, we would not expect the actions of the Challenge alone to remove this barrier, and **we would not expect its actions to have had any significant effect at this stage**. In the following sections, we outline the Challenge's activities in more detail and the mechanisms by which the Challenge could reasonably reduce the perceptions of skills as a barrier to PEMD sector growth. While we can say it is **reasonable to expect these activities to improve knowledge and skills** in the sector compared to if there were no Challenge activities, we cannot say that these activities will definitely have an effect, nor how great an effect they could potentially have relative to other drivers of narrowing skills gaps in the sector.

The Challenge has funded skills competitions which have led to training programmes across the sector

The Challenge has provided £6 million of funding for skills-related projects which have developed high quality training programmes, from vocational to postgraduate, with the aim of producing a more skilled workforce. It is too early for these projects to have had an impact on the perception of skills, but it would be reasonable to

[14] https://www.engineeringuk.com/media/1355/enguk-report-2017.pdf

expect that these projects could help to reduce this barrier in future. While this value of funding may seem small compared to the total funding for CR&D projects, the Challenge has been constrained by the initial bid in terms of the amount of funding that can be allocated directly to skills activities. It should be noted, however, that this value is still larger than the direct funding for skills activities in other similar Challenges.

The various case studies provide practical examples of the programmes that have been developed through Challenge funding of industry projects. One of the competition winners stated that the Challenge had co-awarded a grant for a training programme that has facilitated the **launch of the Advanced Propulsion System teaching module at the University of Nottingham**, which has replaced the Internal Combustion Engine module previously offered, hence increasing PEMD-specific training. About 140 undergraduate students are expected to attend the new module each year. In the case of another skills competition winner, the Challenge had funded an in-house training module for its graduate engineers.

SMEs interviewed in the activity-based case study had ongoing projects with the Midlands DER-IC site aimed at **developing high quality training programmes for a variety of skill levels within the PEMD sector**. Specifically, the Midlands DER-IC site partnered with an SME – focused on the design of electric motors – on a Challenge skills project, creating an interactive panel around the manufacture of bespoke designs that do not exist in the public domain. The Midlands DER-IC site has also collaborated on a DER-funded project with another engineering consulting firm that works on designing drives, motors and power converters. Before their partnership, the consulting firm provided training to other SMEs and smaller audiences. Through partnering with the Midlands DER-IC site and drawing on the University of Nottingham's extensive training and education experience, the SME is currently offering live training to much larger groups. The Midlands DER-IC site's testing facilities have also enabled a more hands-on element to this training, compared to the usual theoretical and classroom-based teaching, which it hopes will be beneficial in terms of the transfer of practical skills.

The DER-IC have shared technical expertise on collaborative projects and have provided training for firms to use their equipment

The DER-IC have undertaken knowledge sharing activities, both by working with firms directly on projects and by providing training for firms that use their equipment. Again, it is too early for these activities to have had an impact on the perception of skills as a barrier to PEMD growth – especially considering reported delays in procuring equipment due to COVID-19 – but it is reasonable to expect that these activities could reduce that barrier in future.

Two large manufacturing firms interviewed stated that the **Midlands DER-IC site had shared its knowledge and expertise with its project partners as part of funded projects**. One of the manufacturing firms stated that it had used the machine design experience, skills and facility of WMG – an academic institution that is part of the Midlands DER-IC site – to supplement its own. This had been facilitated through various meetings with WMG where they explained some of the design philosophies for automotive motors which the firm had previously not been aware of. Such examples demonstrating the transfer of skills and knowledge provide evidence of the Challenge's role in **upskilling the relevant workforce through the DER-IC, which will be retained within firms**. Another example is the Warwick School of Engineering (also part of the Midlands DER-IC site), which has provided R&D support to a large manufacturer on a project that aims to secure a complete supply chain for the next generation of silicon carbide power electronics in the UK.

As well as providing skills on collaborative projects, the Midlands DER-IC site **provides training on the use of the cutting edge equipment** located at its facilities, while also giving the UK workforce the opportunity to work with new manufacturing equipment. Firms interviewed agreed that the DER-IC provided a lot of support in using the facilities, including health and safety training as well as technician support in terms of setting up and operating the equipment.

Theme 4 – Has the Challenge increased the value of investment in UK PEMD companies?

Key messages

The Challenge appears to have been **very successful in catalysing co-investment**, reaching approximately £195 million in 2022 and **exceeding its original target** for the lifetime of the project (2021-2025). Although approximately **half of the co-investment has not yet been realised**, the Challenge seems on track to achieve this. Aligned co-investment – co-investment closely related to Challenge-funded projects – makes up a significant amount of the total co-investment levels, although follow-on co-investment is also expected to pick up, with some competition winners already securing additional follow-on funding. This can also be seen in the survey results, with **over half of respondents expecting to secure further funding** as a result of their engagement with the Challenge. Approximately 60% of respondents also mentioned that the Challenge had had a positive impact on their organisation's RD&D spend.

Evaluation theme 4 relates to the Challenge's aim to increase the value of investment in UK PEMD companies to ultimately improve the supply chain and facilitate exports. Table 15 describes the metrics, data sources and methods for this theme. The metrics focus on assessing the Challenge's impact on co-investment, its role in assisting firms in securing both private and public investment, and its effect on firms' R&D spending.

Evidence for this evaluation theme comes from:

- Analysis of Challenge monitoring data;
- Two project-based case studies of competition winners;
- One activity-based case study of the Midlands DER-IC site;
- One thematic-based case study on policy and skills;
- Analysis of data from the process and interim impact contact survey.

This section first provides an overview of the activities undertaken by the Challenge to date and then summarises the evidence for each of the two main activities.

Table 15 Interim impact evaluation metrics – Evaluation theme 4

Evaluation metrics	Data	Methodology
a) Value of co-investment	DER Monitoring Data	Descriptive analysis of monitoring data, by competition, by co-investment category
	Contact survey	Stated impact of the Challenge on ease of securing investment

Evaluation metrics	Data	Methodology
b) Perceptions of ease of securing investment; follow-on funding		Stated impact of the Challenge on securing or expecting to secure follow-on funding
	Project-based and activity-based case studies	Framework analysis of stated impact of Driving the Electric Revolution
c) Value of public sector investment in PEMD companies	Contact survey	Stated impact of Challenge on public sector investment
	Project-based and activity-based case studies	Framework analysis of stated impact of Driving the Electric Revolution
d) Value of R&D spending by UK/overseas PEMD companies	Contact survey	Stated impact of Challenge on RD&D spending
	Project-based and activity-based case studies	Framework analysis of stated impact of Challenge

Source: Frontier Economics

Activities undertaken by the Challenge

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

- The Challenge has funded around 100 CR&D projects amounting to over £30 million being invested by the Challenge.
- The Challenge has funded the DER-IC (£33 million) which has:
  - Signposted firms to relevant funding opportunities;
  - Collaborated with firms on projects; and
  - Allowed firms to use equipment.

The Challenge, in collaboration with the DER-IC, has been able to catalyse co-investment levels that exceed its initial targets for the lifetime of the project

The Challenge maintains a record of the amount of co-investment associated with each competition and project and collects information on other co-investment. The Challenge has four specific categories in measuring co-investment:

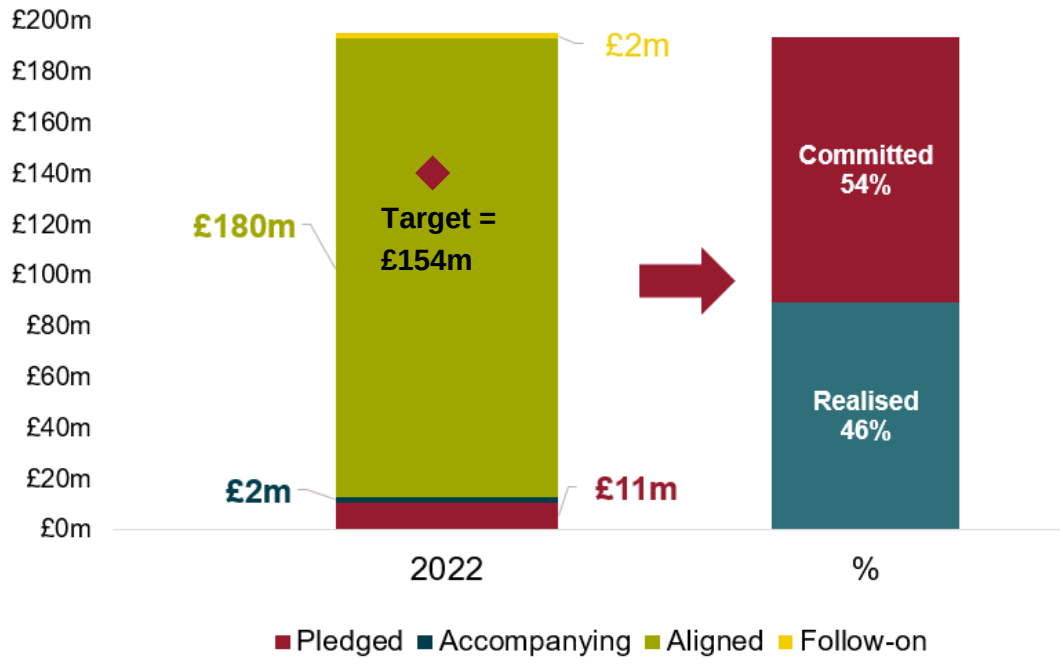
- **Pledged** and **accompanying** co-investment, which relate to the investment that consortia declare to spend on a Challenge-funded R&D project. Pledged co-investment is the initial co-investment companies make, some level of which is mandatory to receive Challenge funding. Accompanying co-investment represents any additional spending beyond the initial scope, for example because of cost overruns;
- **Aligned** co-investment, which relates to investment in a technology or project which is closely related to the Challenge-funded project; and
- **Follow-on** investment, which relates to investment to take to market or exploit outcomes from Challenge-funded R&D projects.

Annex C provides a more detailed overview of the various types and values of co-investments provided in the Challenge monitoring data.

At the start of the Challenge, total funding was expected to be approximately £234 million over the period from 2019 to 2025. UKRI provided £80 million to fund the Challenge, and the remaining £154 million was expected to be catalysed as co-investment by industry (a roughly 2:1 ratio of private to public investment). Monitoring data shows that the Challenge has already been successful in securing co-investment levels that exceed its original target. Cumulative co-investment levels up to 2022 stood at £195.2 million, **exceeding the initial target for the lifetime of the Challenge**. This led to the Challenge revising its forecast upwards by 40%, to the current target of £256 million. This would represent more than a 3:1 ratio of private to public investment if realised.

Given the scale of the co-investment target compared with the funding received by the Challenge, it was expected that a **significant part of co-investment would need to come from aligned and follow-on** categories, because it was unlikely that pledged and accompanying co-investments alone would make up the scale of expected leveraged private investment. Monitoring data bears this out in Figure 17: aligned investment currently stands at £180 million, while pledged and accompanying co-investment total £12.7 million. Follow-on investment is £2.3 million. We would expect greater levels of follow-on co-investment at the final impact evaluation as follow-on investment can only occur after projects have finished.

Figure 17 Co-investment levels by category (2022)



Source: Frontier analysis of Challenge monitoring data

It is important to note that these total figures represent the sum of the investment that has been **committed** upfront, as well as the investment that has already been spent on a project (**realised**). At this stage, £105 million of the total co-investment levels is committed and £90 million has been realised. The Challenge would need almost all of today's co-investment to be realised to reach the original target of £154 million laid

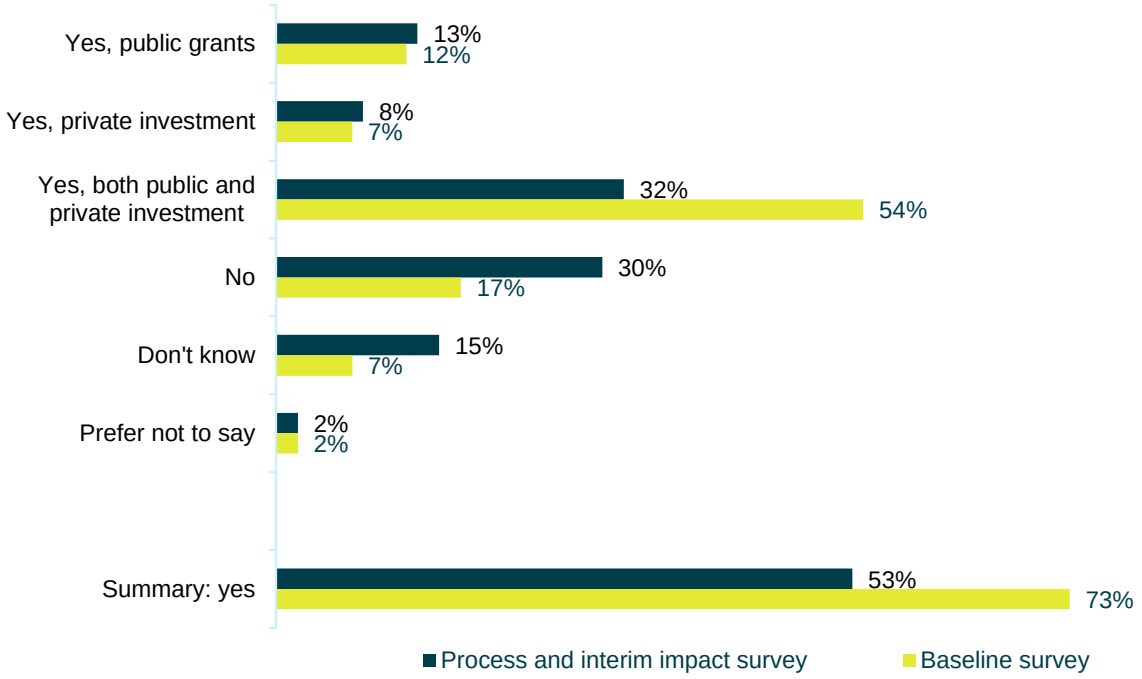
out in initial documentation, but it is on track to achieve this. Therefore the Challenge has so far been successful in securing expected funding inputs and the amount of co-investment is a positive indication of the wider PEMD industry's ability to advance the development of PEMD technologies.

The Challenge has partly achieved this investment through directly funding CR&D projects, which have allowed firms to secure further public grants and private investment

The qualitative data gathered by the in-depth case study analysis and the survey provides evidence of the Challenge's positive impact on increasing investment in PEMD companies through the funding it has directly given as part of CR&D competitions. Evidence from the project-based case studies states that the Challenge has increased investor interest and confidence in PEMD projects.

1. **Challenge funding has increased investor interest leading to more public investment:** By match-funding projects and developing specific technology, the Challenge has immediately catalysed pledged co-investment and has raised investors' interest in the specific prototypes developed. As an example, one competition winner on the DER Hairpin project stated that the Challenge's funding – which led development of a software tool for the design of motor-generators with hairpin windings – contributed to securing further EU funding to develop the next-generation motors using the tool. The co-investment in this project included £1 million of pledged co-investment and a further €147,000 from the EU and £3.5 million from the Melrose Skills Fund in follow-on co-investment.
2. **Challenge funding has boosted confidence to encourage private investment:** By providing public investment, the Challenge has provided the infrastructure to promote more private investment. One set of competition winners from the GaNSiC project stated that prior to the Challenge, they had not been able to raise the investment required for their project due to generally low investor confidence in the UK PEMD supply chain. The funding provided by the Challenge assisted the competition winner in securing more follow-on funding for other projects, including a further £1.4 million capital investment for a follow-on project supported by the APC, BMW and other project partners, @FutureBEV.
3. **Over half of survey respondents expected to secure further funding as a result of their engagement with the Challenge** (Figure 18). Around half of survey respondents expected to receive funding through engagement with the Challenge. Out of the 60 respondent, 27 expected to receive further public grants and 24 expected further private investment. In fact over a third of successful applicants said they had already received funding since their interaction with the Challenge. Expectations about future funding have declined from the baseline survey – around half of respondents expected to receive future funding compared to almost three-quarters in the baseline survey – although sample sizes are not large enough for us to be sure the difference is statistically significant.

Figure 18 Expectations to receive funds through engagement with the Challenge



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 Challenge?*

Note: *Base: successful applicants or have engaged with the DER-IC – process and interim impact (60), baseline (41).*

Investment has also increased because of the DER-IC, through a number of its activities

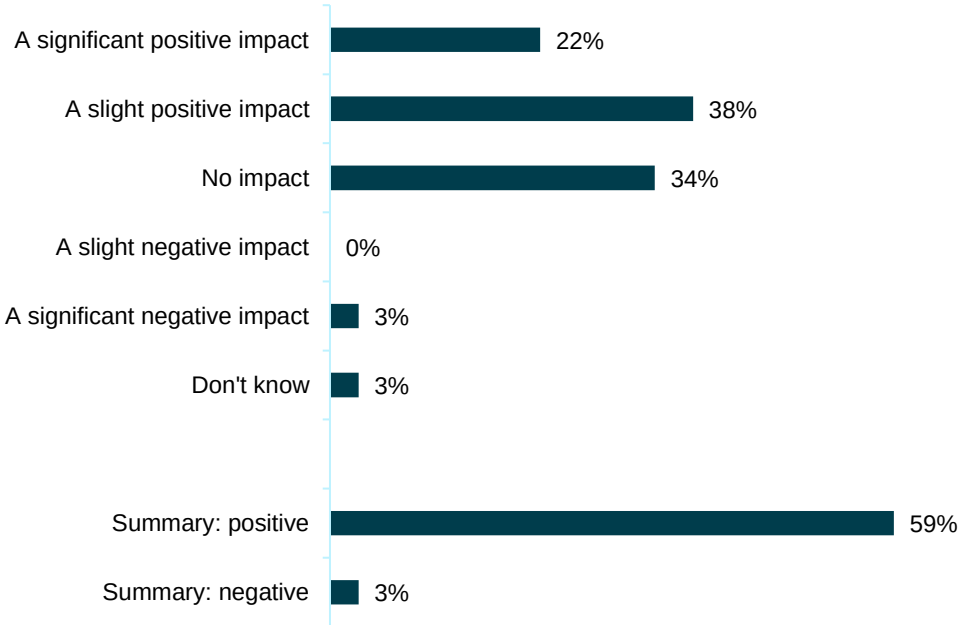
1. **Collaborating with the DER-IC on projects has led to increased investment for firms:** Firms interviewed – both SMEs and larger organisations – stated that the Midlands DER-IC site had assisted them in tapping into new investment. In the case of one of the SME partners, collaborating with the Midlands DER-IC site on a small skills-related Challenge project of £25,000 had allowed them to demonstrate their capabilities, consequently linking up with much bigger companies than they were previously able to. Since the beginning of their collaboration with the Midlands DER-IC site, the SME had been able to apply for three other projects, with a combined total value of approximately £10 million. The view of the stakeholder we interviewed was that this would not have happened without the partnership with the Nottingham part of the DER-IC. Another interviewee – representing a large manufacturing company – stated that partnering with a reputable organisation such as the Midlands DER-IC site had contributed to a more successful outcome regarding winning project bids.
2. **The DER-IC have pointed firms towards funding opportunities:** Representatives from the Midlands DER-IC site stated that, while industry partners were not always aware of the best funding route for their activities, the DER-IC had the time, resources and connections (with funding bodies) to keep track of funding opportunities and share them with firms. In the case of another large manufacturing company, the DER-IC's proactiveness in signposting new funding opportunities had encouraged them to develop a new strategic project with the Midlands DER-IC site, which had not previously been in their pipeline, that they were currently bidding for.

3. **By providing use of equipment, the DER-IC have increased investment:** Through providing access to equipment and testing facilities, the DER-IC provide UK manufacturers with the ability to test products and processes with minimised risk and upfront investment. This increases the value of these firms to potential investors. While there were significant delays in procuring the equipment due to COVID-19, the Midlands DER-IC site's equipment has already enabled larger firms to test and explore ways of improving their manufacturing techniques and processes. This enables firms to ultimately advance their MRL and commercialisation, making them increasingly attractive to investors. SME stakeholders interviewed stated that using the DER-IC's equipment and testing facilities had already enabled them to secure funding for novel projects by including a testing element in their application bids, which they would have been unable to do without making significant investments themselves.

According to survey results, most respondents thought the Challenge's activities had had a positive impact on RD&D spend

Business respondents were asked how much their organisations had spent on RD&D activities in the most recent financial year. The results show that, of those who could answer the question, there was a roughly even spread of respondents across all categories from £100,000 to £10 million, with fewer spending above or below that (Figure 38 in Annex B). Business respondents were then asked to state the impact they thought the Challenge had had on the amount their company had spent on RD&D activities in the most recent financial year. Figure 19 shows that over half of respondents thought that the **Challenge had had a positive impact on their organisation's RD&D spend** – with seven out of 32 respondents reporting a significant positive impact and a further 12 reporting a slightly positive impact. This compares to 11 respondents who said that the Challenge had had no impact.

Figure 19 Impact of the Challenge on RD&D spend



Source: Contact survey. E3A. How much of an impact, if at all, did the Driving the Electric Revolution Challenge have on how much your company spent on research, development and demonstration activities in your most recent financial year?

Note: *Base: businesses – process and interim impact (32).* Where *total figures may seem to differ slightly from the summation of the individual figures, this is due to rounding*.

Theme 5 – Has the Challenge helped foster a collaborative PEMD ecosystem?

Key messages

The Challenge has run CR&D competitions, established the DER-IC and shared general communications with their contacts to foster collaboration in the UK PEMD ecosystem.

Data from Innovate UK KTN demonstrates that the Challenge has **increased its reach** over time, unsurprisingly spiking around the time of larger competitions. Engagement of the stakeholders in that ecosystem – in terms of registering and attending Challenge events as well as page views – has been **maintained over time** in absolute terms, but this has not grown with the increase in the Challenge's ecosystem, except when there have been competitions.

Through its activities, the Challenge has **increased the number of current collaborations**, with the potential for these to become sustained and increase the overall collaboration within the ecosystem in the future. This increased **collaboration is between a range of actors** – large organisations, SMEs, academics – and is **not limited to a particular technology or sector**. According to the survey results, respondents are collaborating with academics and SMEs the most, with 80% of respondents stating that the collaborations were successful. The Challenge's positive impact on collaboration was also evident in every in-depth case study interview, which included a range of organisations in terms of size, sector and technology of interest.

Evaluation theme 5 focuses on whether the Challenge's activities have so far helped to foster a collaborative PEMD ecosystem. The specific evaluation metrics relating to this theme are summarised in Table 16. The metrics emphasise the importance of collaboration across different actors in the PEMD ecosystem, including large companies, SMEs and academics, and collaboration across technology areas.

At this stage of the evaluation, the focus is on evidence relating to the activities conducted by the Challenge relevant to the theme and perceptions from stakeholders about the scale and additionality of any collaboration benefits realised. Evidence for this evaluation theme comes from:

- Analysis of Innovate UK KTN's monitoring data;
- Two project-based case studies of competition winners;
- One activity-based case study of the Midlands DER-IC site;
- Analysis of data from the process and interim impact contact survey.

We begin by presenting the activities undertaken by the Challenge relating to this theme and then summarise the evidence for each metric based on the different data sources.

The Evaluation Framework Report indicated that monitoring data from Innovate UK KTN could directly measure the level of collaboration in the PEMD ecosystem. Innovate UK KTN has only recently started collecting that data. We therefore hope that it will be available to analyse for the final impact evaluation but it was not ready for the interim impact evaluation. Instead, we agreed with the Challenge that Innovate UK KTN data should be used to measure the reach of the Challenge and the engagement of the stakeholders within that ecosystem.

Table 16 Interim impact evaluation metrics – Evaluation theme 5

EVALUATION METRIC	DATA SOURCE	METHODOLOGY
a) Number of members of Innovate UK KTN PEMD ecosystem and engagement of those members	Innovate UK KTN monitoring data	■ Trend analysis
b) Number and strength of collaborations between PEMD companies in different sectors	Contact survey	■ Stated impact of Driving the Electric Revolution on number and strength of collaborations; includes qualitative responses
	Project-based and activity-based case studies	■ Framework analysis of stated impact of Driving the Electric Revolution on number and strength of collaborations (multiple sectors, spillovers) in specific case studies
c) Number and strength of collaborations between PEMD companies and academics (ISCF3)	Contact survey	■ Stated impact of Driving the Electric Revolution on number and strength of collaborations; includes qualitative response
	Project-based and activity-based case studies	■ Framework analysis of stated impact of Driving the Electric Revolution on number and strength of collaborations in specific case studies
d) Number and strength of collaborations between large PEMD companies and SMEs	Contact survey	■ Stated impact of Driving the Electric Revolution on number and strength of collaborations; includes qualitative responses
	Project-based and activity-based case studies	■ Framework analysis of stated impact of Driving the Electric Revolution on number and strength of collaborations in specific case studies
e) Number and strength of collaborations between PEMD companies producing different technologies	Contact survey	■ Stated impact of Driving the Electric Revolution on level of collaboration across technologies; includes qualitative responses
	Project-based and activity-based case studies	■ Framework analysis of stated impact of Driving the Electric Revolution on number and strength of collaborations in specific case studies

Source: Frontier Economics

Activities undertaken by the Challenge

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

- The **competitions**, which require collaborative research by winners, aim to foster immediate collaboration with the intention of building relationships between individuals and organisations that lead to follow-on collaboration in the future. There have been five CR&D competitions that have so far funded 191 participants in 139 projects. Of these projects, 43% have a power electronics element, 49% have a machines element and 30% have a drives element.
- The establishment of the **DER-IC**, which has created 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. The competition for the DER-IC was held in October 2019, and the DER-IC were set-up the following year. The DER-IC have 30 employees, including technical and support staff, and £4.5 million of DER-IC funding is used to pay these members of staff for various activities, including facilitating collaboration.

- 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 KTN – such as the 'Engage with …' series – as well as regular newsletters.

The Challenge has increased the size of the PEMD ecosystem that is engaged with the Challenge through the Innovate UK KTN, although levels of engagement through events have not grown as much

Evidence from Innovate UK KTN's 'DER Community' contact database shows that there has been a **significant increase in the reach of the Challenge** since it began its activities, **centring around its competitions**. This can be seen in Figure 20 below, which shows the cumulative number of contacts in the 'DER Community' database every month between July 2019 and March 2022. Most of this growth came in the first two years, with increases to the database of over 100 new contacts per month on average, and it has slowed since summer 2021. The two sharp increases in growth in May to June 2020 and February to April 2021 that can be seen in Figure 20 align with the Catalysing Green Innovations S1 and Supply Chains for Net Zero competition events respectively. However, it is not possible to discern from this evidence alone how much of this growth comes from the size of the PEMD ecosystem growing or from the Challenge having increased its reach within the PEMD ecosystem.

As well as the Challenge's network growing, it is likely that the wider PEMD supply chain in the UK is growing. There is no strict sectoral definition of PEMD, and therefore there is no external metric that can be used to estimate how many individuals or organisations operate within the PEMD supply chain. However, if we look at potentially comparable sectors – such as solar generation in Germany – it is possible to see significant growth in the last five years, with annual installed capacity increasing from under 2GWp to over 5GWp.[15]

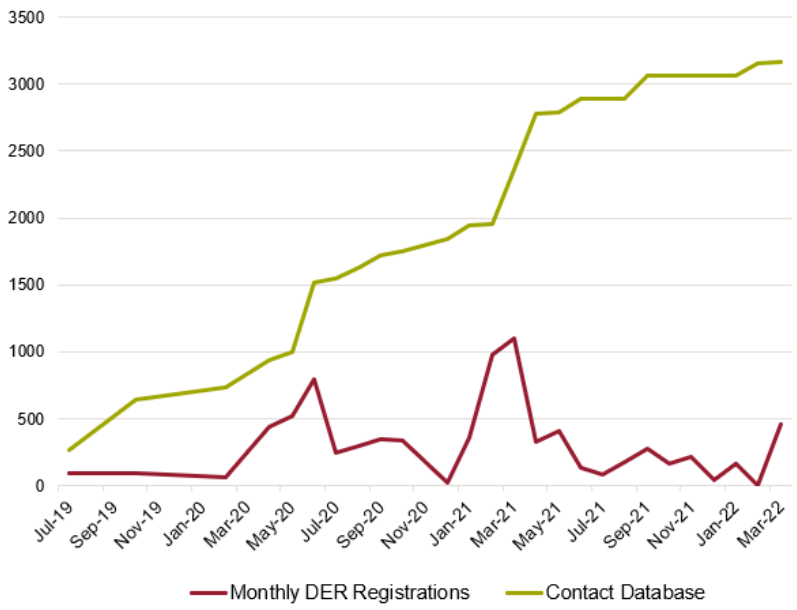
Engagement in terms of the total number of registrations for attendance at Challenge events every month is represented in the second line of Figure 20, which varies over time with twin peaks matching the two competitions. This variation over time is driven both by variation in the number of events and variation in the number of registrations per event. There are up to seven separate events per month across the period, with most months having between two and four events. Registrations per event also vary significantly from 20 or 30 to over 200. Apart from the two peaks around the Catalysing Green Innovations S1 and Supply Chains for Net Zero competitions, **engagement with Challenge events has stayed reasonably flat** over time in absolute terms.

Other metrics of engagement – such as event attendance and Challenge page views on the Innovate UK KTN website – follow a similar trend to registrations. While attendance at Challenge events is smaller than registrations – on average 40% smaller – event attendance also peaks at the time of the same two competitions. In June 2020 and March 2021, Challenge event attendance reaches almost five times its

[15] https://www.cleanenergywire.org/factsheets/solar-power-germany-output-business-perspectives

monthly average. Attendance is also relatively flat outside of those times, mirroring what we see in terms of registrations, with an average of 128 Challenge event attendances every month.

Figure 20 Total 'DER Community' contacts in Innovate UK KTN database and monthly Challenge event registrations



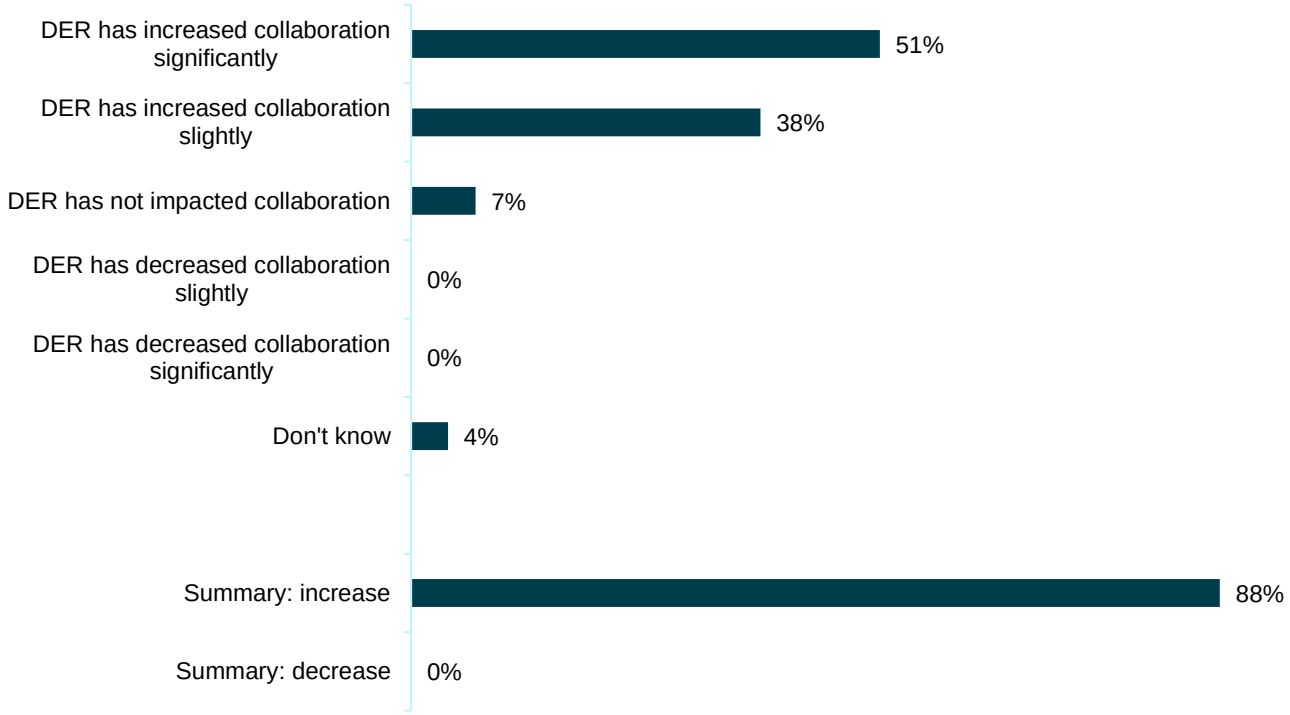
Source: Frontier Economics analysis using Innovate UK KTN data.

This data implies that the PEMD ecosystem engaged with the Challenge is growing and that competitions, in particular, are effective ways to increase membership and catalyse engagement, but that outside of these times engagement is more modest.

The Challenge has increased the number of collaborations within the PEMD ecosystem

Survey respondents were asked to reflect on the extent to which they thought the Challenge had impacted collaboration in general (see Figure 21). **Nearly all of the respondent – 61 out of 69 – were of the opinion that the Challenge had increased collaboration**, and more than half felt that the Challenge had increased collaboration significantly. Only five respondents believed that the Challenge had had no impact on increasing collaboration.

Figure 21 Impact of the Challenge on collaborations



Source: *Contact survey. D3A. How much do you think the Driving the Electric Revolution (DER) Challenge has impacted collaboration in general?*

Note: *Base: all respondents – process and interim impact (69).*
Where total figures may seem to differ slightly from the summation of the individual figures, this is due to rounding.

Evidence from the in-depth case study analysis also demonstrates a number of examples of the Challenge positively affecting the number of collaborations taking place in the PEMD ecosystem, and the wider benefits that the collaborations bring. Competition winners across both project-based case studies felt that the collaboration on their projects had been very beneficial in terms of knowledge exchange and capability building. Several project winners we engaged with commented that the collaborations would not have happened without having the CR&D projects to bid for. **Competition winners thought their current collaboration would likely lead to further collaborations** by strengthening complementary connections and leading to cross-referrals of new business leads. However, stakeholders did raise the trade-off between enabling collaboration and determining IP, which will be inherent as part of the CR&D projects and any follow-on collaborations. We note that the Challenge can direct participants to find collaboration agreements but they do not provide templates for management of IP.

Representatives at the Midlands DER-IC site stated that the **number of projects they had coming up had increased five-fold** compared to before the DER-IC had been established, and that many of these companies had not approached them before. However, a number of stakeholders interviewed across the activity-based case study and the process evaluation workshops felt that the DER-IC had a low profile amongst industry players outside of the Challenge and that more could be done to advertise its facilities and expertise.

"… there's a lot of people that don't know what they [the DER-IC] are doing." Industry interviewee from thematic case study

There was a consensus amongst all firms in the activity-based case study that **working with the DER-IC had led to new collaborations** for them, sometimes establishing a consortium with multiple new collaborators met through the Midlands DER-IC site. This seemed particularly important for SMEs, which had a smaller contact base before working with the Midlands DER-IC site.

One set of competition winners shared the view of the DER-IC and its partners that the Challenge was helping to facilitate collaboration, beyond directly funding CR&D. The competition winner said that the Challenge had facilitated communications in the UK PEMD sector such that companies involved in the **sector were now more aware of one another**, helping to facilitate collaboration.

"[an] innovation cluster is gaining momentum in the UK." SME project winner

This competition winner stated that they were now in talks with every single automotive player in the UK, demonstrating the growing connections within the sector.

The Challenge has fostered collaborations between a variety of actors in the PEMD ecosystem

Survey evidence finds that the Challenge's activities have led to collaborations between a variety of actors – including large operators, SMEs, and academics – and that these collaborations have generally been very successful. These collaborations have also been across sectors and using different technologies. Table 17 shows the average number of collaborations within each type of organisation and the proportion that are collaborating with at least one partner from each group. Table 18 shows the number of people collaborating with each type of organisation, as well as how many reported the collaborations as being successful or unsuccessful. Researchers and SMEs were the most common groups that respondents were collaborating with, and the vast majority – 36 out of 44 – rated these collaborations as 'successful'.

Table 17 Collaborations on PEMD sector projects

	Average collaborations	% collaborating with this group
Researchers	5.0	64%
Small or medium PEMD companies in the same sector	5.9	48%
Small or medium PEMD companies in different sectors	4.9	42%
Small or medium PEMD companies that produce different technologies	4.7	42%
Large PEMD companies in the same sector	2.7	42%
End-users	7.4	38%
Large PEMD companies in different sectors	3.1	35%
Companies outside of the PEMD sector	5.7	30%
Others	1.2	3%

Source: Contact survey. D1. How many of the following types of partners are you currently collaborating with on PEMD projects?
Note: Base: all survey respondents who gave a response (51).

Table 18 Success of collaborations on PEMD sector projects

	n. collaborating with this group	% successful	% unsuccessful
Researchers	44	82%	7%
Small or medium PEMD companies in the same sector	33	82%	3%
Small or medium PEMD companies in different sectors	29	76%	3%
Large PEMD companies in the same sector	29	69%	7%
Small or medium PEMD companies that produce different technologies	29	66%	7%
End-users	26	73%	4%
Large PEMD companies in different sectors	24	71%	4%
Large PEMD companies that produce different technologies	21	67%	5%
Companies outside of the PEMD sector	21	62%	5%

Source: *Contact survey. D2. And how successful would you say these collaborations are? Please think about each different type of company you are currently collaborating with.*

Note: *Base: shown in table.*

The Challenge has facilitated a closer link between industry partners and academics

In line with survey results, competition winners also mentioned the **collaboration between industry and academics**, citing the Advanced Research Centre co-located in Newcastle and Nottingham Universities as a current example of project collaborations that can enable further knowledge sharing. A project-specific technology platform was given as a future example of fostering industry-academic collaboration because the life-cycle assessment this platform facilitates is expected to attract significant interest from both groups. We asked for their impressions of the Challenge's additionality to this project, but they were unable to comment.

Representatives at the Midlands DER-IC site were being asked to join as academic collaborators on projects. This was both because the Midlands DER-IC site is becoming a hub to connect different firms together – and is therefore visible when these collaborations are formed – and because some firms that work with the DER-IC felt that it improves their funding applications to have the DER-IC onboard.

Colleagues at the Midlands DER-IC site, including the University of Nottingham, were being **approached by new sectors**; some colleagues had previously specialised in aerospace and were being approached by automotive companies for their expertise and use of equipment.

The Challenge plays an important role in connecting firms of different sizes, and this has been particularly beneficial for SMEs

Both competition winners and individuals related to the DER-IC across the case studies agreed that the Challenge had facilitated the **collaboration of firms of different sizes**. A representative from one competition-winning consortium said that involving multiple complementary consortium members in their CR&D project had allowed them to view their previous work from a 'completely different angle' – in this case

by bringing together a small-scale software developer and a global machine manufacturing company. The survey results (Table 17) show that most of these collaborations are taking place with SMEs, rather than larger firms. The average number of collaborations with SME PEMD companies in the same sector is 5.9, and 48% of survey respondents are collaborating with this group, making this the second most common group for survey respondents to be collaborating with.

Moreover, the survey data shows that there are lots of successful collaborations with SMEs in different technologies and using different technologies. Most survey respondents (82%) who were collaborating with researchers and SME companies in different sectors rated these collaborations as 'successful'. This is supported by the fact that the firms interviewed across the range of case studies were from a variety of sectors and used a diverse range of technologies, and the increase in collaboration occurring with all of the interviewees across the case studies suggests that the **uptick in collaboration is not limited to one particular sector or technology**.

Theme 6 – Did the Challenge lead to an expansion of UK PEMD manufacturing capacity?

Key messages

Through funding CR&D projects for competition winners, which has led to development of new processes and novel technology, the Challenge has had a **positive impact on growth projections and the number of employees** in some of the firms we engaged. The survey results confirm this, with the vast majority of firms stating that the Challenge had had positive impacts on their growth projections and over half of survey respondents saying that the Challenge had already led to them increasing the number of their employees. The open-access equipment hosted by the DER-IC has provided a risk- and cost-minimised opportunity for firms to test products, **improve their manufacturing processes and identify the equipment they need** to improve manufacturing capacity. However, at this stage of the evaluation, there is not enough evidence to conclude whether the Challenge's activities have had widespread effects on expanding manufacturing capacity across the PEMD supply chain.

Evaluation theme 6 focuses on whether the Challenge has expanded the UK PEMD manufacturing capacity to ultimately increase the size of the PEMD supply chain and its contribution to the economy. The specific evaluation metrics relating to this theme are summarised in Table 19 below. The metrics cover the Challenge's potential impacts on the number of employees and growth projections as well as activities undertaken to improve UK manufacturing capacity.

At this stage of the evaluation, the focus is on evidence relating to the activities conducted by the Challenge that are relevant to the theme and perceptions from stakeholders about the impact of the Challenge on growth projections and number of employees. Evidence for this evaluation theme comes from:

a. Two project-based case studies of competition winners;
b. One activity-based case study of the Midlands DER-IC site; and
c. Analysis of data from the process and interim impact contact survey.

We begin by presenting the activities undertaken by the Challenge relating to this theme. We then summarise the survey evidence on projections and the case study evidence of the effect of the CR&D funding and the DER-IC on employees and growth projections.

Table 19 Interim impact evaluation metrics – Evaluation theme 6

EVALUATION METRIC	DATA SOURCE	METHODOLOGY
a) Number of employees	Project-based case studies	Framework analysis of stated impact of Driving the Electric Revolution Stated impact of Driving the Electric Revolution on employment, by region/technology
b) Growth projections of leading UK-based PEMD actors	Contact survey	Stated impact of Driving the Electric Revolution on growth projections

Source: Frontier Economics

Activities undertaken by the Challenge

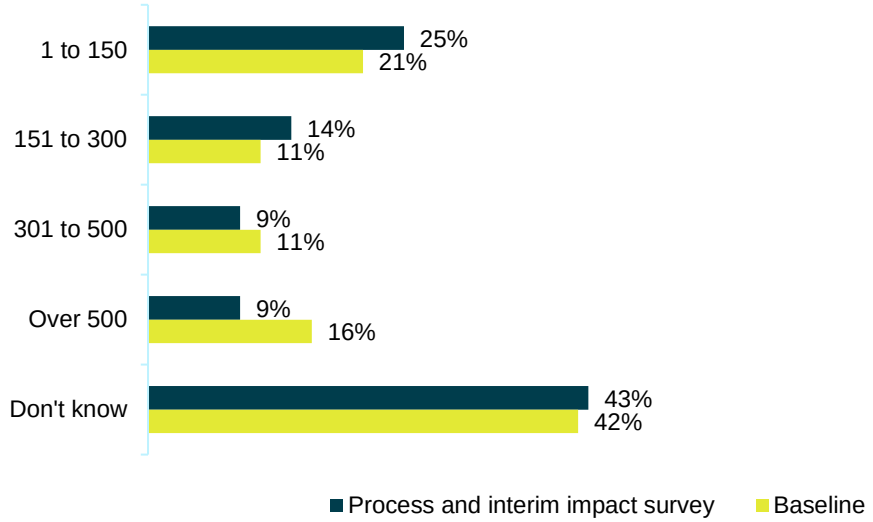
The Challenge's activities that have focused on increasing manufacturing capacity include:

- Funding CR&D projects that advance the MRL of the UK PEMD supply chain and enhance firms' manufacturing capacity.
- Funding the DER-IC, which have:
  - provided open-access testing facilities and equipment, which could enable firms to trial equipment and then increase their manufacturing capacity (although these have been delayed due to COVID-19); and
  - secured funding for firms by collaborating with them, therefore boosting growth projections.

Although the PEMD supply chain is not perceived as a defined sector, the survey evidence suggests that stakeholders expect the supply chain to grow and the Challenge has had a positive impact on their growth projections

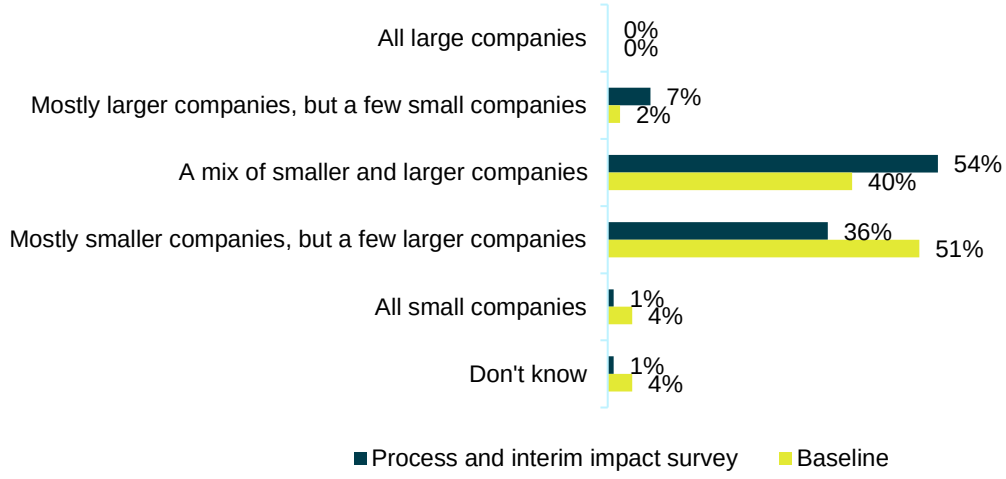
Survey respondents were asked to estimate roughly how many companies in the UK were currently involved in the PEMD supply chain, as shown in Figure 22. The survey questionnaire defined the PEMD sector as any organisation that is involved in the research, manufacture or supply chain of power electronics, electric machines or drives. Interestingly, a significant proportion – 30 out of 69 respondents – could not estimate the number of companies in the sector. Of those who could give an estimation, the estimates varied considerably. This suggests that stakeholders do not have a clear perception of the size of the supply chain. This is likely because PEMD is not a clearly defined sector but is a mix of technologies used across a variety of sectors. When asked about the perceived current structure of the PEMD supply chain, about half of respondents believed that it was a mixture of smaller and larger companies, and about a third stated that there were mostly smaller companies with few larger ones (Figure 23).

Figure 22 Estimation of UK PEMD supply chain companies



Source: Contact survey. B4. Roughly how many companies involved in the PEMD supply chain do you think there are currently in the UK?
Note: Base: all respondents – process and interim impact (69) and baseline (57).

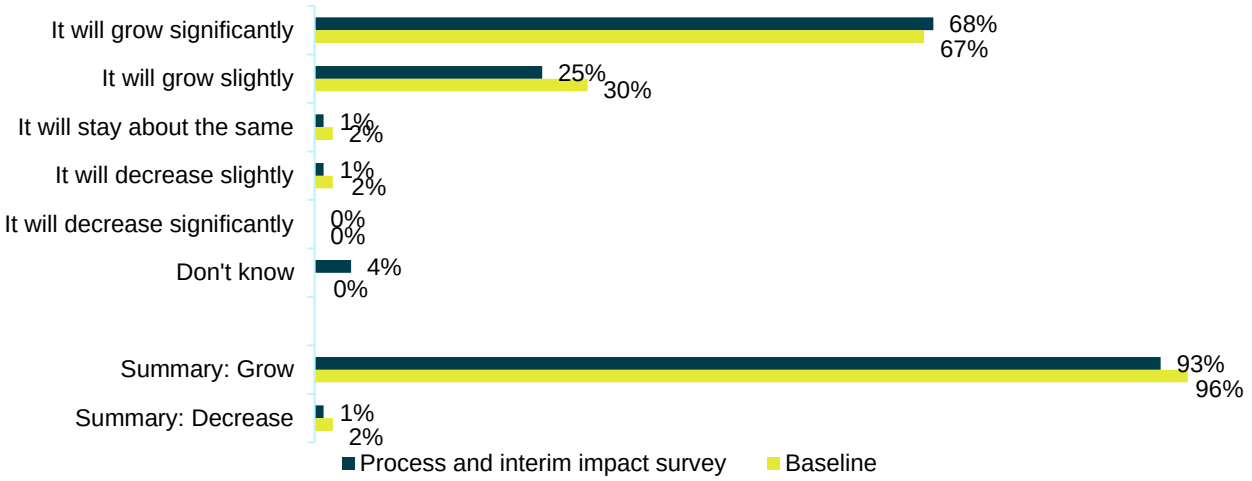
Figure 23 Perception of current structure of UK PEMD supply chain



Source: Contact survey. B5. Which of the following best describes the current UK PEMD supply chain?
Note: Base: all respondents – process and interim impact (69) and baseline (57).

In order to assess growth projections, survey respondents were first asked to describe how they expected the UK PEMD supply chain as a whole to change over the next few years. Figure 24 shows that nearly all survey respondents – 64 out of 69 – expected the sector to grow, with two-thirds expecting it to grow significantly, and a further quarter expecting it to grow slightly.

Figure 24 Expected change in UK PEMD sector over the next few years

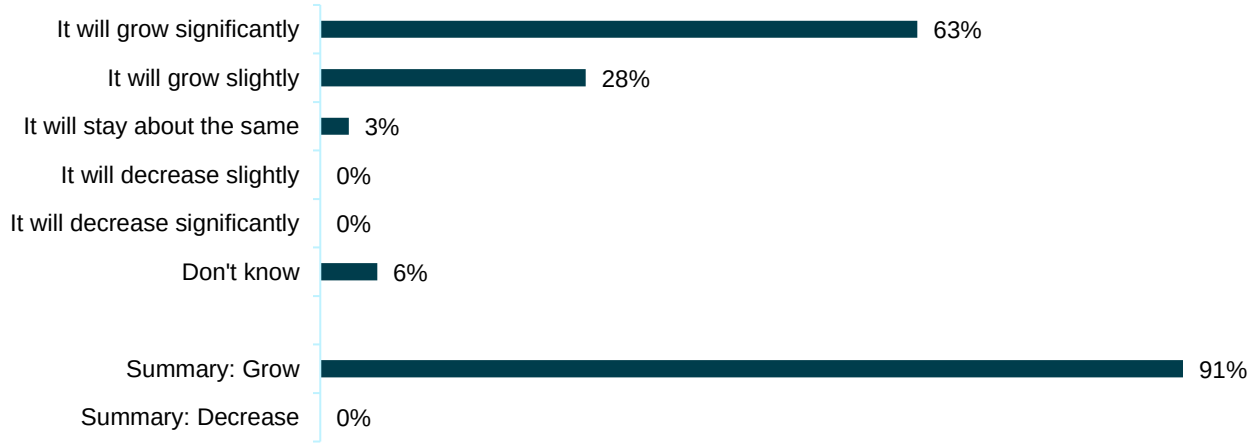


Source: *Contact survey. B6. And which of the following best describes how you expect the UK PEMD sector to change over the next few years?*

Note: *Base: all respondents – process and interim impact (69) and baseline (57).*
Where total figures may seem to differ slightly from the summation of the individual figures, this is due to rounding.

After reflecting on the UK PEMD sector as a whole, the survey asked business respondents to estimate how they thought their business would change over the next few years. As Figure 25 shows, perceptions about the growth of individual businesses were similar to perceptions about the UK PEMD sector as a whole. The **vast majority of business respondents expected their business to grow**, with 20 out of 32 respondents expecting it to grow significantly.

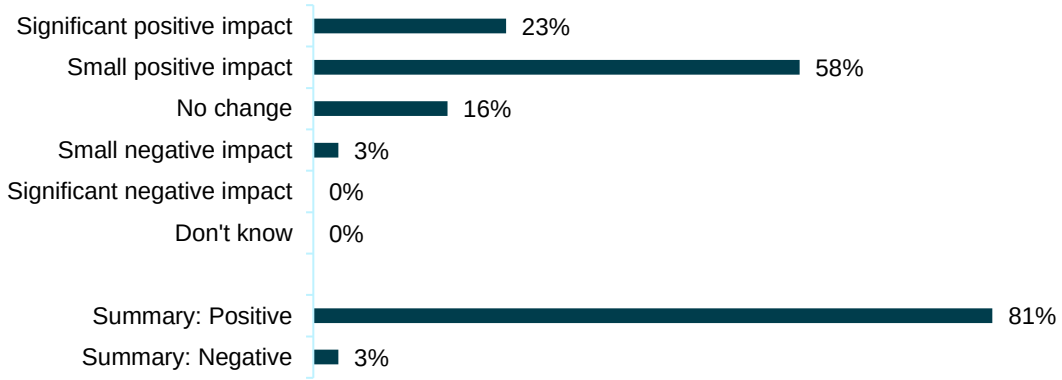
Figure 25 Expected change in respondents' organisation over the next few years



Source: *Contact survey. B6A. And which of the following best describes how you expect your business to change over the next few years?*
Note: *Base: businesses – process and interim impact (32).*

Business respondents who said that their business would change over the next few years were then asked to state the impact of their engagement with the Challenge on their growth projections. As Figure 26 illustrates, **the vast majority of respondents believed that the Challenge had had a positive impact on their growth projections** – 25 out of 31 respondents. This included just under a quarter who said that they expected the Challenge to have a significant positive impact on the growth of their business and more than half who expected the Challenge to have a small positive impact on their organisation's growth.

Figure 26 Impact of the Challenge on growth projections

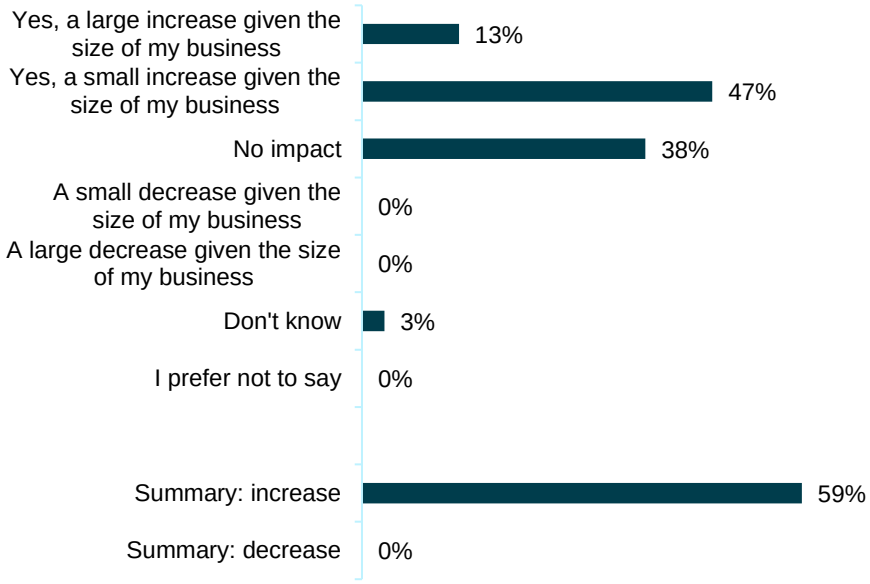


Source: *Contact survey. B6B. How has your growth projection been impacted as a result of your engagement with the Driving the Electric Revolution Challenge?*

Note: *Base: businesses who believe their business will change over the next few years – process and interim impact (31).*

The survey further explored the impact of the Challenge on the number of employees hired in the past year. This question was only asked of business respondents, and the majority of respondents – 22 out of 32 – were firms with fewer than 249 employees (as can be seen in Figure 40 of Annex B). **Over half of business respondents – 19 out of 32 – said that the Challenge had led to an increase in the number of employees they had hired** in the past financial year (Figure 27). This comprises four who said the Challenge had led to a large increase and fifteen who said the Challenge had led to a small increase. No firms said the Challenge had had a negative effect on the size of their business.

Figure 27 Impact of the Challenge on number of employees hired in the past financial year



Source: *Contact survey. A7C. Has the Driving the Electric Revolution Challenge had an impact on the number of employees you have hired in the past financial year?*

Note: *Base: businesses – Phase 3 (32). Where total figures may seem to differ slightly from the summation of the individual figures, this is due to rounding.*

Case study evidence supports the survey details by providing a more detailed view of the changes in some firms

By funding CR&D projects, evidence from our case studies suggests that the **Challenge has had a positive impact on the growth projection and number of employees** of some of the funded firms we engaged as part of our case studies.

For instance, on one case study project the Challenge has brought together relevant consortium members and has funded 80% of the project to develop a new die attachment process for next-generation power electronics. Evidence suggests the Challenge has contributed to key benefits for this project. A stakeholder representing one of the consortium members stated that the combination of the current favourable global environment and the support of national programmes including the **Challenge was translating into 25% revenue growth for 2021** and the company was expecting a further 50% increase in revenue in 2022. Since its involvement with the Challenge, its employee numbers had increased by over 25%, with 11 new candidates expected to be recruited as of July 2022. The firm's **manufacturing facility was also set to increase significantly**, from 2,200ft^2 to 46,000ft^2, with direct-dispense responsible for half of this growth. Annex A provides more details on the project.

Another consortium member specified that since the beginning of the project, the consortium had **increased its number of project managers**, both at junior and senior levels, and the number of skilled semiconductor engineers. The firm had recruited nine graduates, who had received specific training, and it was looking to hire 12 more (as of July 2022). Partly through the financial support of the Challenge, the organisation had developed a strong in-house training module for its graduate engineers which had the potential to **attract more talent** by providing an opportunity to work on new, state-of-the-art equipment.

The DER-IC have enabled firms to test their manufacturing processes and identify the equipment they need, and they have helped in securing more funding, which in some cases has transpired to higher growth projections

Firms were not always certain of what equipment and capabilities were needed for manufacturing. The open-access equipment hosted by the DER-IC was a risk- and cost-minimised way of testing products and processes and this ultimately **allowed firms to identify the equipment that was needed.** While there were delays in procuring this equipment due to COVID-19, positive benefits had already been experienced by stakeholders.

"The University of Nottingham has always had impressive equipment for research, but now they have 4/5 major manufacturing products that are quite amazing. We have used one to trial manufacturing stages." SME

These are some helpful examples of the benefits of both the CR&D funding and the DER-IC, but there is not currently enough evidence to say that this impact on growth projections or employment is systematic across multiple firms in the sector.

These represent clear (individual) examples of where the Challenge has increased UK PEMD manufacturing capacity. However, at this stage of the evaluation, there is not enough evidence to conclude whether the Challenge's activities have had widespread effects on expanding manufacturing capacity across the PEMD supply chain. We would not expect this to be the case at this time, and therefore the lack of systematic evidence should not be seen as an early warning sign that the Challenge will not achieve the goals set out in the Evaluation Framework Report.

Theme 7 – Did the Challenge drive environmental, societal and policy benefits?

Key messages

This theme covers positive spillovers around environmental, societal and policy benefits. We do not discuss every possible spillover that the Challenge could potentially impact but look at some significant elements that fit into each of the three buckets:

- **Environmental:** Environmental impacts are not a leading indicator and, therefore, there was not much information that stakeholders could provide on the Challenge's impact so far. However, information collected in the thematic case study provided a more detailed qualitative perspective on the current position.
- **Societal:** ED&I monitoring data was not available at the time of writing, and thematic stakeholders could not identify any impact that the Challenge had had so far had on gender balances.
- **Policy:** Monitoring data on the distribution of winning companies implies that the Challenge is supporting levelling up.

Evaluation theme 7 focuses on whether the Challenge's activities help to drive environmental, social and policy benefits. The specific evaluation metrics relating to this theme are summarised in Table 20. The metrics cover the Challenge's potential impacts on the environment, workforce diversity and levelling up.

At this stage of the evaluation, the focus is on evidence relating to perceptions from stakeholders about the scale and additionality of any policy spillover benefits realised (which inform qualitative baselining and early evidence of impact) and comparisons with evidence from the baseline report. Evidence is taken from:

- Analysis of monitoring data from the Challenge;
- One thematic case study looking into policy and skills;
- Two project-based case studies of competition winners; and
- Analysis of data from the process and interim impact contact survey.

Table 20 Interim impact evaluation metrics – Evaluation theme 7

EVALUATION METRIC	DATA SOURCE	METHODOLOGY
a) Perceptions of impact on sustainability of UK products and components	Project-based and thematic case studies	Framework analysis of sustainability perceptions
b) Perceptions of impact on environmental policy and market regulations	Project-based and thematic case studies	Framework analysis of environmental policy and market regulation/ standards
c) Workforce diversity	DER monitoring data	Descriptive analysis of count and value of competition winners by gender and age of lead company representative
d) Distribution of winning companies	DER monitoring data	Descriptive analysis of count and value of competition winners by region
e) Distribution of PEMD companies	Contact survey	Stated impact of Driving the Electric Revolution on the regional distribution of PEMD companies in the UK

Source: Frontier Economics

The thematic case study allowed a more detailed qualitative baseline but could not yet provide insights on the Challenge's impact on environmental policy in the UK

Environmental impacts are not a leading indicator. Therefore it is unsurprising that case studies for the interim impact evaluation could not yet find evidence for the Challenge's impact on environmental policy and sustainability. The lack of this evidence should therefore not be seen as an early warning sign.

However, what the thematic case study was able to do at this stage was provide a more detailed qualitative perspective on the current position and difficulties that the Challenge is facing when it comes to impacting environmental policy. There was a general view among stakeholders involved in the thematic case study that a number of barriers were making it difficult for the Challenge to have a significant impact on environmental policy. These related to the lack of a high-level government industrial strategy:

- Four industry and public body professionals held the view that UK government policies which directly target the semiconductor sector are few and fragmented, despite the fact that these will be essential for creating a decarbonised future.

> *"Although there is attention to semiconductors form all aspects of society, there's no common policy framework addressing them."* University professor

- **Poor coordination** across government departments also means that work is being supplicated and not progressing as efficiently as it could. For examples, BEIS and DCMS both launched separate inquiries into similar issues in the semiconductor space rather than launching an inquiry jointly or in a coordinated way.
- The long time taken for the UK government to respond to the proposed purchase of Newport Wafer Fab by Nexperia is representative of **slow decision-making** in government. This is possibly because there is no clear framework or strategy, but the delay increases the uncertainty of UK investors.

However, there is a concern that the Challenge will not be able to fulfil its potential because currently the **Challenge is not well known** outside of its immediate circle and it is **spread too thinly** for the investment to be able to capitalise on the opportunities available. This concern comes from three different stakeholders interviewed as part of the thematic case study, from both academia and industry:

- For the Challenge to have a direct impact on wider environmental policy and standards, it needs to be influential enough within the PEMD supply chain that those outside of the sector take note. However, an industry stakeholder did not feel that the Challenge was well known within the PEMD sector, let alone outside it.
- Two different stakeholders felt that, while the Challenge was doing significant work to influence policy working with various departments in UK government, it was spread across too many areas with a relatively modest investment to be able to have a substantial impact in any particular area. This meant that it is barely able to scratch the surface of some of these issues, in order to have impacts on environmental policy and standards more broadly.

> *"DER being spread across so many sectors is a drawback to the Challenge."* Leader of an accelerator

> *"They're trying to spread it across too many things and it's a relatively modest investment, it's just scratching the surface."* Leader of an accelerator

We cannot comment on workforce diversity at this time without ED&I monitoring data available

The Evaluation Framework Report outlines that we should use ED&I monitoring data from the Challenge to look at the distribution of competition funding across age and gender. However, the monitoring was not available at the time of writing, and therefore this could not be used to provide evidence on this societal spillover. While we asked thematic stakeholders for their views, they could not identify any impact that the Challenge had so far had on gender balances.

Monitoring data suggests the Challenge is supporting levelling up

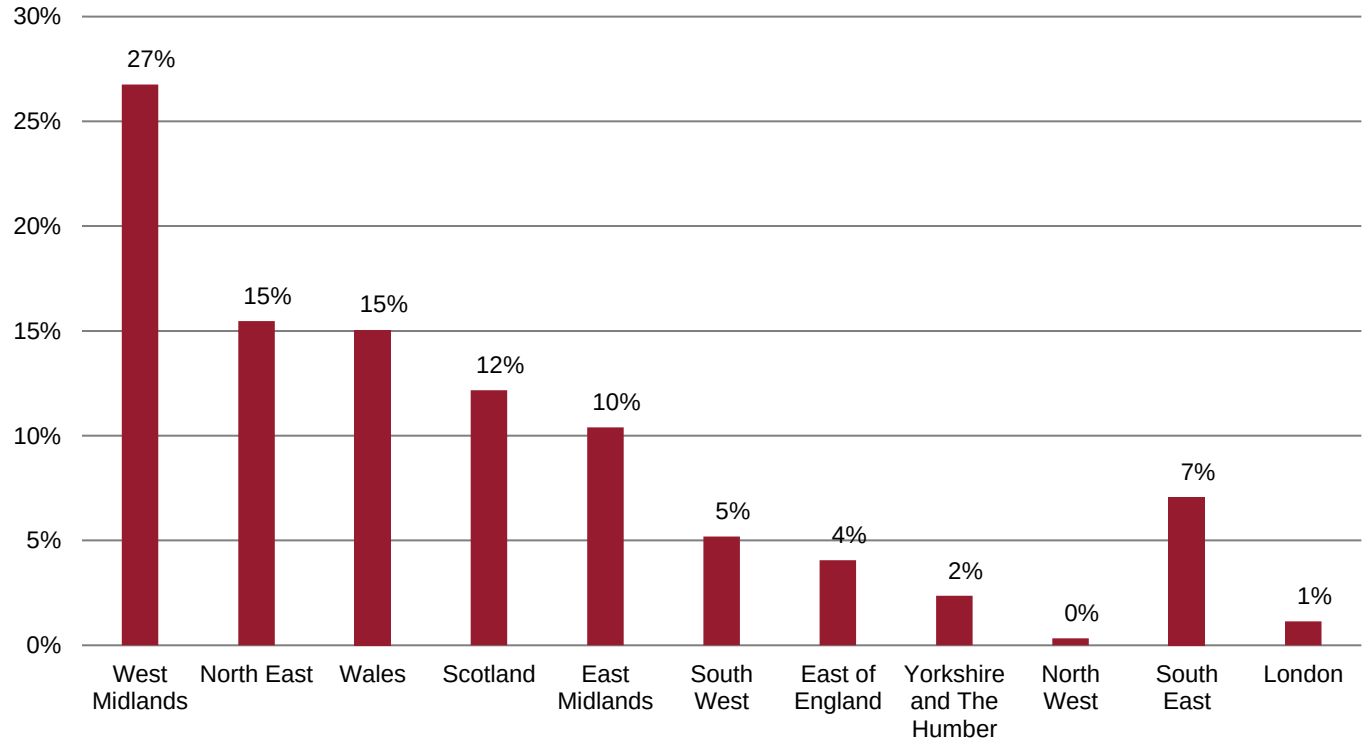
The monitoring data from the Challenge represents the best current evidence relating to the regional distribution of funding.

The Challenge monitoring data on competitions includes funding given to competition winners for the CR&D, DER-IC and skills competitions. While this is not necessarily a measure of the regional distribution of the Challenge's impact, it is used as a proxy at this time because it is too soon for the regional impact of the Challenge's activities to be measured.

Based on monitoring data, we see that **only 10% of all investment (by value) has gone to London and the South East** and that the vast majority of projects funded by the Challenge have been located in other regions. In this way, the Challenge is providing positive policy spillovers to the levelling-up agenda by investing money in areas of the UK that have previously not received as much investment.

Figure 28 below shows the distribution of funding to all regions. The remaining 90% of funding outside London and the South East is not evenly spread, although levelling-up objectives do not imply even funding across the UK outside those regions. The Midlands is a locus for automotive development and would likely have PEMD applications under 1MW. In comparison, heavy industry and power tend to be centred in Merseyside (North West) and the Humber regions and would likely have applications above 1MW. The Midlands has received 37% of Challenge funding (27% to the West Midlands and 10% to the East Midlands) while Yorkshire and the North West have received a combined around 2%. This may display an overrepresentation of applications under 1MW or in the automotive sector, and an underrepresentation of larger scale applications and those in heavy industry and power. More allocation to applications in industrial heat and power would likely see a larger number or projects in these regions, where there is a stronger focus on industrial heat and power. It is important to note that any over or underrepresentation could come from the distribution of bids that the Challenge has received, as well as from the Challenge's choice of winners.

Figure 28 Percentage of Challenge investment excluding London & South East



Source: *Frontier analysis of Challenge monitoring data*

Note: *The summation of the individual bars is below 100% due to rounding, there is not a missing region.*

Conclusions

Overall, the Challenge seems to be doing well and **appears to be on track** to meet future outcomes and impacts, **without any significant early warning signs**. It would appear that the Challenge is making a positive contribution towards increasing the scale of the PEMD supply chain in the UK, although it is too early to say how significant this contribution will be.

Given that the approach used to evaluate the Challenge is a thematic contribution analysis, it is important to think about all themes when providing a holistic view and not to focus too heavily on a subsection. A summary by theme is given below:

1. **Theme 1:** While it has not been possible to quantitatively track MRL, the case studies imply that the Challenge is helping firms to accelerate the MRL of their projects and commercialise new technologies. However, this may not be equal across all sectors.
2. **Theme 2:** Productivity has not been looked at directly as part of the interim impact evaluation, as it is unlikely to be a leading indicator. Case study projects could reasonably improve total productivity in the future, but it is too early for them to have led to these benefits already.

3. **Theme 3:** The early nature of the Challenge's direct skills-related activities means that perceptions of skills as a barrier to PEMD sector growth are so far unchanged. However, the Challenge is undertaking activities that could reasonably be expected to have a positive impact on the skills barrier in the future.
4. **Theme 4:** The Challenge is running ahead of target in terms of encouraging co-investment, raising the new target by 40%. This co-investment is mainly aligned, although greater volumes of follow-on co-investment are expected to appear in the future. This will require high proportions of committed investment to be realised, but the Challenge seems on track. It has catalysed this co-investment by making it easier for firms to secure public and private follow-on investment and by encouraging firms to increase their own RD&D spending.
5. **Theme 5:** The Challenge has expanded its reach, although the engagement of this ecosystem has not increased at the same rate. The Challenge has encouraged additional collaboration between a variety of actors, especially academics and SMEs, and this collaboration is even covering different sectors and technologies.
6. **Theme 6:** The Challenge has expanded the manufacturing capacity of some of the firms we engaged, increasing forecasts and the size of the workforce. However, there is not enough evidence at this stage to say that this effect has been widespread or systematic.
7. **Theme 7:** The Challenge has not yet had an impact on environmental policy, although this would not be expected in such a short space of time. Societal benefits in terms of workforce diversity will be covered in the final impact evaluation. The Challenge has supported levelling up by giving only a small proportion of investment to London and the South East, with 90% going to other regions.

For the Challenge to be able to maintain this momentum and do its best to ensure that its activities have a positive and significant impact on the UK PEMD supply chain, it will need to:

- Use its network to support the DER-IC in their efforts to publicise the opportunities they have on offer so that firms are aware of the DER-IC and take up the equipment and services they provide;
- Boost efforts in PEMD sectors that have received less support so far, perhaps by moving the focus from well-covered areas (such as automotive) towards less well-covered areas (including industrial heat and power);
- Continue promoting the connection and interaction of the PEMD ecosystem through Challenge-led engagement in support of collaboration between companies within it;
- Consider options to further tackle the issue of skills, which has consistently been seen as a significant barrier to PEMD growth and development; and
- Continue to help the UK government to develop a clear high-level industrial strategy for the development of a UK PEMD supply chain by tying investment and development efforts together.

Annex A Case studies for the interim impact evaluation

Introduction to case studies of competition winners

We developed two case studies of projects that have received Challenge funding to understand the extent to which:

- The projects have achieved technical, commercial, environmental policy or social impacts; and
- These impacts can be attributed to the Challenge's competition-based activities and outputs.

The case studies focus on the following types of impact, which we refer to as evaluation themes (the same themes are framed as questions in the evaluation framework):

- Accelerated innovation and commercialisation;
- Increased productivity;
- Increased value of investment;
- Fostering a collaborative PEMD ecosystem;
- Increased manufacturing capacity; and
- Environmental, societal and policy spillovers

Out of 52 Challenge-funded projects, for study, we selected 'DER Hairpin –Accelerating the UK E-Machine Preformed Winding Supply Chain' and 'GaNSiC Direct-Dispense' using the following criteria:

- Size of the project;
- Number and type of participating organisations;
- Scale of application;
- PEMD focus; and
- Number of relevant impact evaluation themes.

The projects target different aspects of the PEMD space:

1. 'DER Hairpin − Accelerating the UK E-Machine Preformed Winding Supply Chain' advances an innovative approach to accelerate the commercialisation of new electric machine and motor designs.
2. 'GaNSiC Direct-Dispense' is an innovation in power electronics that is expected to lead to an expansion of UK power electronics manufacturing capacity.

Project-based case study 1 – DER Hairpin

Technology and project description

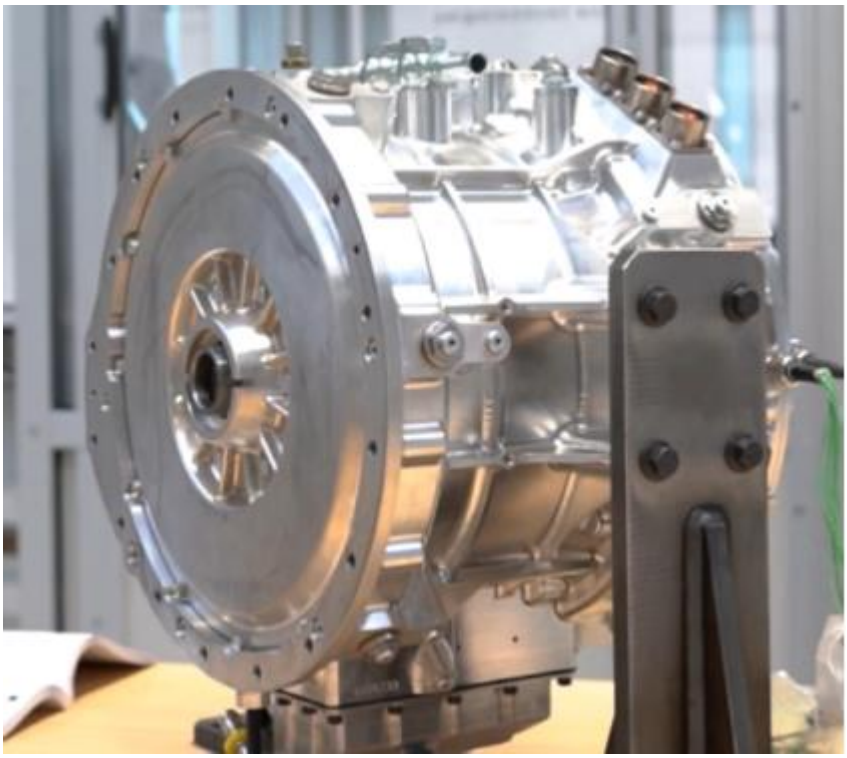
Increased electrification of end-user applications is critical for meeting the UK government target of net zero emissions by 2050. It will require greater use of electric motors as primary movers across all sectors. It is

necessary to reduce the manufactured cost and to increase the energy efficiency of existing motor designs to ensure that the net zero transition is affordable.

'DER Hairpin' focused on the development of a software tool for the design of motor-generators with preformed windings. Conventional motors, particularly those of low power (kW), use random windings. Hairpin windings are solid flat wire conductors and hence can achieve higher fill factor and reduced thermal resistance in the slot, leading to the potential for higher efficiency and torque density. The improvement can only be achieved by optimising the motor design for the specific application, either with a model or by empirical trial and error. The software tool incorporates a multi-physics simulation to calculate the thermal, electrical and mechanical performance for motor windings of any topology. It accelerates the design cycle, enabling rapid commercialisation of motors with higher power densities and efficiencies and providing significant competitive advantage for its users.

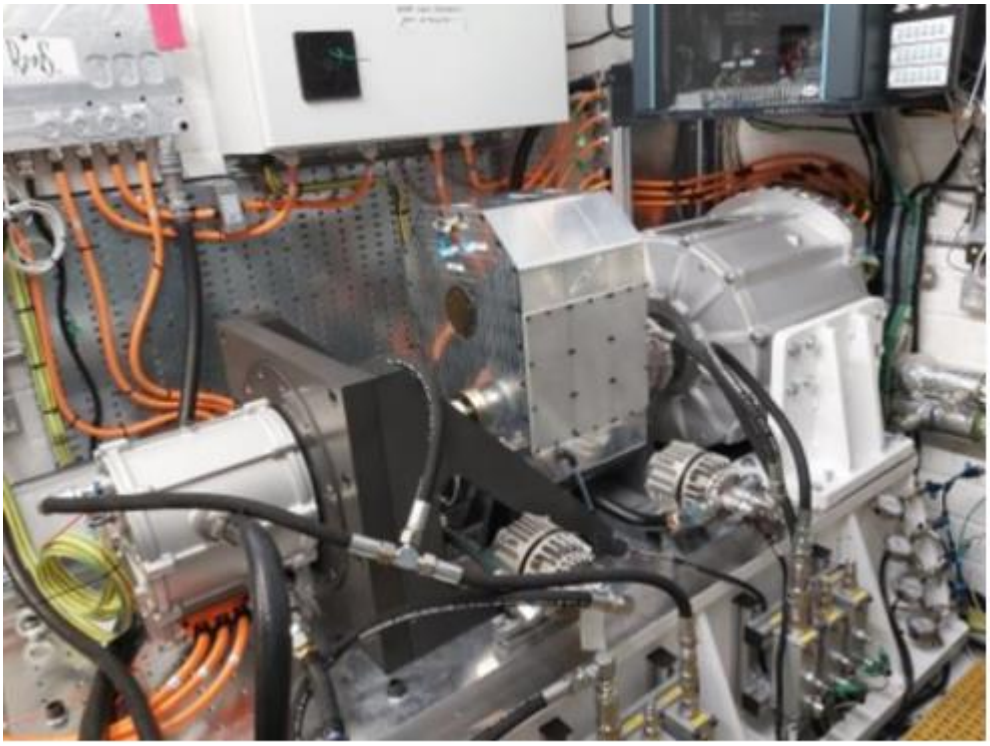
In addition, the tool will allow motor designers and manufacturers to develop designs which avoid use of high-strength permanent magnets and the rare earth elements they contain. Rare earth elements have been the subject of recent trade wars; volatility in the price and availability of raw materials disrupts supply chains and limits their capacity.

Figure 29 Prototype motor with hairpin windings used to validate multi-physics design model



Source: Cummins

Figure 30 Prototype motor on high-speed rig test



Source: GKN

In the course of the project, the consortium successfully demonstrated a combined hardware and software prototype: the results from the software tool were validated experimentally across a variety of winding types including copper and hybrid materials (aluminium and copper).

In the consortium group, Cummins provided the motor hardware for the prototype and its manufacturing know-how; GKN Automotive supported the design for manufacture, build and test of the passenger car electric motor; Motor Design Ltd. (MDL) brought software development skills; Belcan Motors provided new concepts for production and managed the approval and integration of the prototype production process; and the University of Nottingham contributed its knowledge of the fundamental technology and science and provided a home for the new process equipment.

The project received about £830,000 in DER funding, which corresponds to 46% of the total project costs, and was conducted between April 2020 and June 2021.

Cummins provided an additional £500,000 for hardware and labour. GKN Automotive spent an additional £463,000 during the project and a further £58,000 since project end developing the UK supply base. It estimates that it has spent approximately 4,100 people-hours since project end, continuing the testing development and disseminating the technology into other new motor designs. The activities financed through the Challenge are shown in Table 21 below:

Table 21 Approximate breakdown of types of activity funded by Challenge

Activity	% DER funding (nearest 5%)	
	Cummins	GKN
Construction of prototype	30	15
Purchase & commissioning of equipment	0	30
Product development (hardware or software)	30	35
Experimentation and testing	40	20

Source: GKN, Cummins

Accelerated innovation and commercialisation of PEMD technologies

Scale of the application

The project solution has significant scaling potential, particularly in the heavy-goods vehicle sector.

The technology developed in this project has broad applicability and therefore has a potentially very high impact if adopted. The scale of deployment will vary across sector and will likely be larger in heavy-duty versus light-duty vehicles.

In the heavy-duty transport segment, the project consortium envisions a market penetration of 10,000 units per year. To achieve such a high uptake, other challenges must still be overcome. For example:

- The tool creates designs with increased flux density, but other fundamental technical challenges must be addressed in order to provide sufficient power (350-400kW) at low weight (<900kg).
- The value proposition of the tool must be further developed in order to motivate uptake.

In the light vehicle segment, cost, space and efficiency of motor systems are the key criteria that define the attractiveness of innovations.

The current trend is that motor operating speed is rapidly increasing, from 10-15krpm to 15-20krpm, which is likely to be achieved towards the end of the decade – note that 1krpm is one thousand revolutions per minute. At higher speeds, motors based on hairpin windings have higher Joule losses arising from skin and proximity effects than those based on random windings, but their overall power density remains greater. The balance of these counteracting effects varies with application. In short, the limited efficiency benefits of hairpin-wound motors at higher speeds may focus use of the software design tool on the heavy-duty vehicle segment.

Validation of the technology

The Challenge provided clear validation of the tool, which is now being deployed in other projects

Validation of the technology is a critical step in the route to market and requires the comparison of theoretical predictions from models with physical results. During the project, predictions from MDL's multi-physics design software were validated experimentally by measurement of the performance of physical prototypes that were manufactured using an automated winding pilot station paid for by the Challenge.

Route to market

The demonstrated technology system is set to be deployed at full scale

The software tool is enabling Cummins to optimise the designs of its electric machines and is providing flexibility to its production lines. Cummins faces a market that is evolving quickly. The speed to market provided by the tool gives an immediate competitive advantage, allowing Cummins to fully harness its research and manufacturing capabilities.

Building on the lessons learned from the Challenge prototype, project stakeholders expect to develop a new motor design from initial concept to manufacture within six months, reducing the previous development timescale by 25-75%; the automotive OEM SAIC (Shanghai Automotive Industry Corporation) reported as much as three years for an early hairpin design16. Enabled by innovations such as DER Hairpin, the automotive industry expects that the manufacturing cycle for an electric motor will be significantly faster than for the internal combustion engines they will replace; for a new diesel engine platform, meeting current regulations on emissions it is three to seven years.[17,18,19]

Commercialisation through partnering and licensing models

From the experience of the evaluation team, the project consortium could opt for two main scaling routes:

- Developing a manufacturing capability in which the software is embedded – establishing strategic partnerships is likely to be essential to develop a flexible production line; or
- Licensing route – selling the software design tool as a standalone solution and profiting from a percentage of the sales in order to provide the customers with more flexibility to develop their own configurations.

Since the Challenge project, MDL has been acquired by US company Ansys (amount not disclosed). As part of its announcement of the acquisition, Ansys recognised MDL's capability in multi-physics electric machine design, a capability that was developed further through involvement in the Challenge.

Growing PEMD knowledge and skills base

The Challenge has enabled the consortium members to develop an in-house training component

Hairpin windings create a new design paradigm over conventional randomly wound motors. Training helps to accelerate deployment by ensuring that current motor designers can quickly upskill. A company spun out from the University of Nottingham to commercialise advanced hairpin designs benefitted from a DER training grant co-awarded with the technical development project. In turn, the same training programme has been

[16] https://news.mgmotor.eu/why-1-percent-efficiency-improvement-means-so-much/

[17] https://www.seetao.com/details/174433.html

[18] https://doi.org/10.1533/9780857090836.1.3

[19] Private communication with automotive engineer.

incorporated into the Advanced Propulsion System teaching module at the University which will replace the Internal Combustion Engine module; about 140 undergraduate students are expected to attend each year.

Other consortium members have also been asked to provide training to corporate engineering and design teams based on the learning from the DER project.

> *"It's all tied together … when you build up credibility with one team, then they'll forward you on to another team that needs reskilling."* MDL

Such reskilling is beginning to gather pace across the UK, beyond the DER projects. MDL had an optimistic view:

> *"There is some reskilling happening […] many OEMs being focused on electrification."* MDL

Fostering a collaborative PEMD ecosystem

Collaborations between the consortium members

The collaborations between the consortium members are mutually beneficial

The project provided the opportunity to view the design of motors from a completely different angle: it strengthened the relationship between diverse and complementary consortium members: MDL, Cummins, GKN, Belcan and the University of Nottingham together span design, manufacturing and product testing.

Potential collaborations beyond the consortium members

There is a significant opportunity for knowledge exchange

The technology system provides a strong platform for future multidisciplinary research. For example, it could facilitate life-cycle assessment (LCA) of different motor designs and the identification of 'pinch points' for embedded carbon. LCA assesses the greenhouse gas emissions created by the production, the use and the recycling of the motor. The LCA capability is expected to attract substantial future interest from academia and industry.

Increased value of investment in UK PEMD companies

The Challenge has led to further investment in the technology system from both internal and external stakeholders

The Challenge has enabled the development of the technology prototype and has therefore contributed to raising investors' attention towards the software tool. In H1 2022, Cummins acquired electric propulsion businesses Meritor and Siemens Commercial Vehicles.[20] Cummins R&D expects that the acquisitions will motivate greater internal funding for the development of hairpin designs. It reports that DER Hairpin and the wider Challenge programme have been a significant enabling factor in the company's decision to increase

[20] https://www.freightwaves.com/news/meritor-buying-siemens-electric-propulsion-business

the scale of its R&D activities in the UK, e.g. through the Cummins Innovation Centre[21] and a new site at Silverstone.

As a result of the Challenge programme, the University of Nottingham successfully applied for EU funding to develop next-generation motors using the tool and for further commercial development of the tool. For example, the H2020 DORNA programme[22] includes a grant of €147,000 to the University of Nottingham for development of high-reliability electric traction drives.

The University of Nottingham has raised £40 million of funding for a new facility to research state-of-the-art power electronics and machines.[23] Sponsors include D2N2 and the Wolfson Institute. Although not a direct cause, the Challenge has been a supporting factor in raising the funds for the facility.

"The creation of our new Power Electronics and Machines Centre is truly game-changing when it comes to the future of transportation electrification, including the aviation and automotive sectors." Professor Sam Kingman, Pro-Vice-Chancellor for Faculty of Engineering

Consortium members, GKN Automotive and University of Nottingham, along with the University of Newcastle, have founded the GKN Automotive Advanced Research Centre,[24] which develops future innovations in power electronics and motor drives and will use the tool to support future projects, expanding the tool's utility. GKN Automotive's £3.5 million of investment in the Advanced Research Centre is partly supported through the Melrose Skills Fund. The Melrose Skills Fund is a £10 million fund allocated over five years to develop and promote engineering skills in the UK. The ongoing collaboration at the Advanced Research Centre has enabled wider sharing of the lessons learned from DER Hairpin.

Environmental impact and policy spillovers

Increased productivity of the UK PEMD supply chain

The Challenge has facilitated the development of a software tool that can continuously raise the level of innovation in motor designs and that can accelerate the deployment of new, better-performing motors

Using the tool, designers can assess options for minimising motor size. Meritor, a recent Cummins acquisition, is focused on the small, high power density market and expects to significantly benefit from its use of the tool: the creation of highly compact designs requires the multi-physics optimisation (thermal, electrical and mechanical) that the software tool uniquely provides.

The tool will also enable assessment of design directions that have potential to strongly boost manufacturing productivity, such as continuous hairpin and radially inserted hairpin designs.

Use of the tool accelerates the commercialisation of material- and energy-efficient designs that will help to reduce greenhouse gas emissions, targeting key metrics such as cycles/kWh and losses per mile. Automotive

[21] https://www.nottingham.ac.uk/research/groups/cummins-innovation-centre/index.aspx

[22] https://cordis.europa.eu/project/id/872001

[23] https://www.nottingham.ac.uk/news/40-million-facility-at-the-university-of-nottingham-to-drive-a-revolution-in-green-electric-transport-and-power-conversion-of-the-future

[24] https://www.nottingham.ac.uk/news/university-of-nottingham-collaborates-on-new-research-centre-to-accelerate-the-uks-electrified-future

OEM SAIC reports an efficiency improvement of 1%[25] by use of motors with hairpin windings versus those that are randomly wound. Although a small number, 1% applies to the very large amount of electrical power used by motors − the International Energy Agency (IEA) estimateds that motors accounte for ~50%[26] of global electricity consumption (28,000 TWh in 2021[27]). If 30% of these motors deploy hairpin windings, there is a global energy saving of 42 TWh over the energy required for the most efficient designs of randomly wound motors. The electrical energy saving leads to an emissions reduction of 18Mt of CO_2/yr, assuming carbon intensity of electricity of 430 tCO_2/GWh. 18Mt is a conservative estimate which does not account for growth in demand for motors and the energy and material saving for the rest of the vehicle achieved through reduction of motor weight.

The counterfactual without the Challenge

The Challenge brought together the diverse capabilities of the consortium members, providing them with a low-risk context in which to demonstrate the full prototype

All the consortium members were in close agreement that the DER programme had played a critical role in allowing MDL to validate its design software on hardware. Validation required a combination of the skills available in each of the participating companies design, manufacturing and application engineering. Without the Challenge project, more money and time would have been required on separate software and hardware iterations. Each new design would require separate experiments, creating a long-term drag on the pace of commercial development.

Project-based case study 2 – GaNSiC Direct-Dispense

Technology and project description

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 semiconductors 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 project has 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.

[25] https://news.mgmotor.eu/why-1-percent-efficiency-improvement-means-so-much/

[26] https://www.globalefficiencyintel.com/new-blog/2017/infographic-energy-industrial-motor-systems

[27] https://ourworldindata.org/electricity-mix

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 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,[28] which cannot be achieved through traditional printing methods[29] – a problem that the Challenge project aimed to resolve.

The Challenge project developed a novel process using an ink-jet to dispense silver sinter paste directly on circuit boards, 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.[30]

The Challenge project brought together Custom Interconnect Ltd (CIL), responsible for developing the ink-jetting dispensing technique, and 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 £207,000 in DER funding and CIL supplied an additional £45,000. CIL received 70% of the total project funds and CSAC received 30%. The project was of nine months' duration, starting in November 2020.

The CIL activities financed through the Challenge are shown in Table 22.

Table 22 Approximate breakdown of types of activity funded by the Challenge

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

Source: CIL

[28] https://ieeexplore.ieee.org/document/5890856

[29] https://ieeexplore.ieee.org/document/5730658

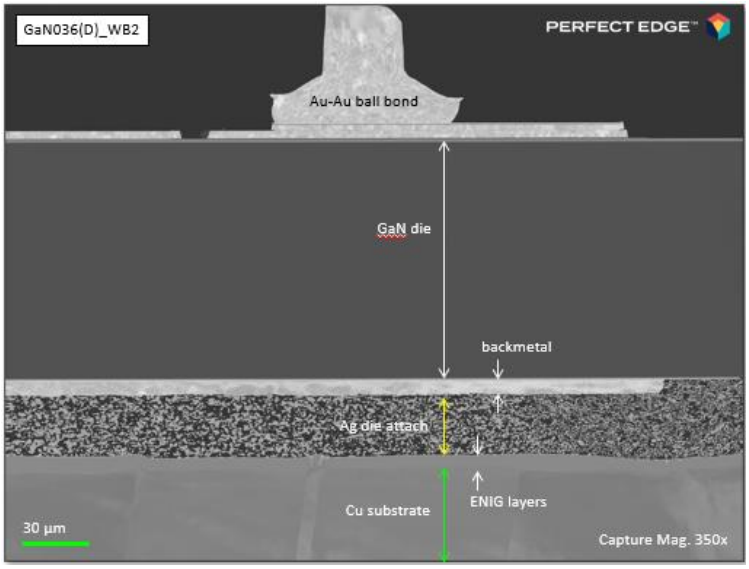
[30] Heraeus Electronics_Sinter Materials

The case study was developed based on interviews with three representatives from the consortium and a desk-based review of direct-dispensing technology and power electronics die attachment.

Project outcome

CIL and CSAC view GaNSiC Direct-Dispense as a complete success: it validated a process to 'dispense' pressure-less silver sinter onto GaN devices and high-pressure and low-pressure silver sinter onto SiC devices. It confirmed that CSAM (confocal scanning acoustic microscopy) is the only effective inspection method and should be combined with periodic sampling for SEM (scanning electron microscopy) measurement of sectioned devices (destructive testing). The new attachment and testing process will allow future SiC dies to have bondable/solderable/sinterable top-level source contact pads, reducing device heating and enabling new device geometries.

Figure 31 SEM of device cross section showing top and bottom sintered contacts



Source: CIL

Manufacturing capacity of the PEMD supply chain

The GaNSiC Direct-Dispense has many potential applications across different end-use sectors

The decarbonisation of the global economy requires increased electrification of end-use applications, which in turn is driving increased demand for power electronics. Market research specialist Yolé reports a global market for SiC power electronics of $0.6 billion (2021) growing to $3.2 billion (2025) at a compound annual growth rate (CAGR) of 30%, with automotive applications taking ~50% share.[31] The 2025 market for GaN is forecast to be about 10% of the market for SiC. Yolé forecasts that SiC/GaN devices will reach 15% of the total power device market in 2025.

[31] https://www.yolegroup.com/strategy-insights/reshaping-the-landscape-of-the-power-electronics-industry-the-game-is-on/?cn-reloaded=1&cn-reloaded=1

Very approximately, the die attachment has a share of between 1% and 2% of the total manufactured cost for the device.[32] If it continues to scale successfully, by 2025, GaNSiC Direct-Dispense can access a global opportunity of the order of $3.5 million to $7 million. The opportunity for GaNSiC Direct-Dispense to become established as the standard solution is now during the early growth phase of the market.

Following the DER programme, Direct-Dispense has been deployed in several new projects

CIL achieved 25% revenue growth in 2021 and is aiming for a further 50% increase in revenues in 2022. Direct-dispense manufacturing has now been deployed in seven customer projects. CIL's manufacturing facility is set to increase from 2,200ft^2 to 46,000ft^2 with direct-dispense responsible for half this growth in capacity[33]. The equipment fit-out for this facility will initially be £6 million, with a further £6 million in 12 months' time. Project stakeholders reported that, critically, the Challenge had allowed the direct-dispense technology to be proven at scale, providing the validation needed to attract new customers and to expand manufacturing capacity.

> *"None of the scale improvements would have been achieved without the DER challenge."* CIL

The DER funding enabled CIL to:

- Attract essential capital investment for other projects (e.g. for the @FutureBEV project);
- Establish essential collaborations throughout the UK PEMD space; and
- Attract customers from many different sectors.

Project stakeholders reported that demand for direct-dispense technology is growing from a broad range of sectors, with the largest share from automotive. There has also been large demand from military and UK security bodies as well as from companies involved in telecommunications, aerospace, energy and power grids. For example, CIL and CSAC have partnered with BMW to use direct-dispense for the manufacture of BMW electric vehicle (EV) drives, integrating three direct-dispense silver sinters per layer. BMW leads the market in the high standards it sets for the performance and reliability of semiconductors integrated in EV drive applications. The partnership with BMW is an indication of the high quality of bonding now achieved by direct-dispense.

CIL is also in discussion with UK-based tier-1 defence packaging companies which are currently relying on imported equipment for die attachment.

Growing PEMD knowledge and skills base

The DER programme enabled CIL and CSAC to recruit new staff and develop training programmes, against a backdrop of a chronic UK-wide skills shortage

Experts from the evaluation team reported that, over the past two to three decades, the UK has not been able to compete with the low cost of semiconductor production in Asian countries. Consequently,

[32] Estimate by Custom Interconnect Ltd.

[33] https://www.cil-uk.co.uk/news/cil-invests-9m-and-expands-with-a-new-semiconductor-packaging-power-device-and-pcba-manufacturing-facility-in-andover-uk/

semiconductor manufacturing capacity has progressively fallen in the UK and, with it, the need to train semiconductor engineers, either through apprenticeships or university courses. However, there are signs that the trend is reversing, driven by the need to boost supply chain reliability and meet increasing demand for semiconductors. The counter trend is also supported by the growth in demand of power electronics where currently China and Taiwan have a weaker position relative to Europe and USA. The repatriation of semiconductor manufacture to the UK will require expansion of the UK semiconductor skills and knowledge base, particularly for power electronics.

CIL and CSAC recognise the challenge of building a strong recruitment pipeline in the UK and share concerns that other countries are moving more quickly. However, there is progress: CIL and CSAC have seen additions to their workforce and increasing interest in their training programmes, which can be partly attributed to their involvement in the Challenge and partly to the growing market for power electronics. The opportunity to gain experience of state-of-the-art semiconductor manufacturing processes such as direct-dispense is an attractive draw for participants.

CIL's headcount increased from 132 to 167 over the period between November 2020, the start of its involvement in the Challenge, and July 2022. Over this period its engineering department grew from eight engineers to 32 engineers; ten of the 24 new engineers are newly qualified graduates. CIL has ten more engineer vacancies to fill and is recruiting approximately three new hires per month. By March 2023, as CIL enters the production phase of some projects related to direct-dispense, the headcount is expected to increase to over 200; by March 2024, CIL will employ 300 people in total.

> *"Approx half the increase in staff from 132 persons to the planned 300 persons are as a direct result of project GaNSiC Direct-Dispense and follow-on projects such as @FutureBEV (BMW), PE2M and EleVAIT (JLR) and hopefully Future Drive."* GKN

CSAC has increased the number of project managers, both at junior and senior levels (for more in-depth projects). The number of skilled semiconductor engineers has also increased − by a surprisingly high number given the strength of global competition for these skills. It has recruited nine graduates, who have received specific training, and is looking to hire 12 more (as of July 2022).

CSAC has developed a strong in-house training module for its graduate engineers, which was partly enabled by the Challenge. Over the course of the direct-dispense project work, CSAC has trained two engineers, enabling the replication and development of direct-dispensing projects in the future. CSAC reports two main benefits from the training module:

- Attraction of more talent by providing an opportunity to work on new, state-of-the-art equipment; and
- Retention of staff − CSAC views retention as a more successful route to building its capability than seeking to bring in experienced hires, mid-career.

Despite the recent progress, there are still many vacancies to fill in CIL and CSAC:

> *"Engineers with 15 years+ of experience are like unicorns – not rare, but mythical."* CIL

Investment in PEMD companies

The Challenge helped to increase investors' support for use of direct-dispense for next-generation power semiconductors

Before the Challenge, CIL was not able to raise the finance needed for the ink-jet dispensing facility. There was low investor confidence in UK PEMD supply chains: big OEMs were not willing to make large capital investments without public support.

The UKRI funding has de-risked direct-dispense manufacturing and has raised interest from customers and investors alike, thereby attracting the private finance needed for further scale-up

The grant funding from the Challenge helped CIL to attract a further £1.4 million of capital investment for a follow-on project supported by the APC, BMW and other project partner @FutureBEV. The total project value is £3.2 million, of which CIL has privately funded £1.8 million. CIL is in talks with multiple potential customers for the module developed in @FutureBEV. They seek to use the module in commercial-scale applications, which will require the additional capacity provided by the new 46,000ft^2 facility.

Other follow-on projects using direct-dispense technology include:

- PE2M[34]
- EleVAIT (JLR (Jaguar Land Rover) and other project partners)
- Future Drive (at bid stage) (GKN and other project partners)

These commercial projects are under strict non-disclosure agreements, so levels of investment cannot be disclosed. Project GaNSiC Direct-Dispense has provided the fundamental process know-how needed for @FutureBEV, PE2M, EleVAIT and, potentially, Future Drive. The know-how is required for production of most commercially funded SiC power devices at CIL.

The GaNSiC Direct-Dispense consortium uses, whenever possible, UK-made components and aims to catalyse the development of a UK-based supply chain

CIL is working whenever possible with UK suppliers for the provision of printed circuit boards (PCBs), sub-trays and other materials. This preference was partly inspired by the Challenge, but mostly driven by the company's own goal to develop a reliable supply chain following disruptive events such as the COVID pandemic, blockage of the Suez Canal and US-China trade tensions.

Collaboration across the PEMD ecosystem

The DER programme has enabled the project consortium members to benefit from their joint knowledge base and establish market-leading roles within the UK PEMD space

[34] https://www.cil-uk.co.uk/news/project-pe2m/

Project stakeholders reported that, over the course of the Challenge, CSAC had developed its technical knowledge, e.g. in the area of gallium nitride. The already close relationship between CIL and CSAC strengthened further, e.g. through cross-referral of new business leads.

After the project, CIL and CSAC witnessed wider benefits brought by the Challenge to UK PEMD supply chains. DER has facilitated marketing and communications across the UK market, increased mutual awareness of companies involved in PEMD and enhanced the diversity of customers and projects. According to CIL, an innovation cluster is gaining momentum in the UK on the back of the Challenge support. Within this cluster, players can engage in mutually beneficial conversations to enhance the joint knowledge base. For example, CSAC is now seen as an attractive partner for applications of gallium nitride in the communication sector.

CIL is currently in talks with every automotive player in the UK, which is evidence of the collaborative environment that the Challenge has engendered.

"Before GaNSiC Direct-Dispense, they [UK automotive players] wouldn't have touched us." CIL

What progress would direct-dispense have made without the Challenge (counterfactual)?

The Challenge allowed the direct-dispense technology to be developed and qualified for use in commercial-scale application

DER provided the critical funding for the capital equipment needed to overcome a key development hurdle. Of course, CIL and CSAC recognised the potential and were actively pursuing other sources of development finance. It is likely that they would eventually have been successful, but this transformational technology would have taken longer to commercialise and would have generated less benefit for UK business and society.

Activity-based case study

Purpose of the case study

The activity-based case study focuses on one of the regional DER-IC sites to explore the effects – both those seen to date and those anticipated in the future – on organisations that have engaged with it. Crucially, the case study explores what firms would have done in the absence of the DER-IC, i.e. the counterfactual scenario.

The DER-IC site chosen for the case study is the Midlands DER-IC site, as the activities undertaken here are indicative of the work being done across each of the four DER-IC sites and the Midlands DER-IC site is one of two DER-IC sites that already have pieces of equipment in place. This was confirmed by senior representatives within the Challenge and the DER-IC itself.

The case study provides a rich understanding of the impact of the DER-IC on the ground by conducting qualitative research through a series of interviews with both DER-IC colleagues and firms engaged. Specifically, four Midlands DER-IC site colleagues were interviewed along with four firms, chosen by the

Midlands DER-IC site, which capture a range of firm sizes in various stages of the supply chain, as shown in Table 23 below.

The case study is structured as follows:

- An overview of the DER-IC set-up;
- A deep-dive into the Midlands DER-IC site and how it is structured;
- The activities of the Midlands DER-IC site in connecting firms;
- The role of the Midlands DER-IC site in signposting firms to funding opportunities;
- The current and future role of the DER-IC in the provision of skills; and
- The equipment received by the Midlands DER-IC site and its impact.

Table 23 Stakeholder interviewed

Type of stakeholder	Role	Description of firm
DER-IC colleague	DER-IC Chair	NA
DER-IC colleague	Chief operating officer, Midlands DER-IC site	NA
DER-IC colleague	General Manager, DER-IC, University of Nottingham	NA
DER-IC colleague	CEO WMG High Value Manufacturing Catapult	NA
Firm - AMPS Electrical Limited	Chief technology officer	Agile Manufacturing Power Systems (AMPS) is a consultancy that offers 'design for manufacturing' for electric motors.
Firm - Electrical Cooling Solutions	Director and Founder	Electrical Cooling Solutions (ECS) is a thermal engineering consultancy specialising in the area of electrical drives.
Firm – McLaren Applied	Head of Electrification, McLaren Applied	McLaren Applied develops and delivers advanced engineering and technology solutions that enable organisations across various sectors.
Firm – Ricardo	Head of PEMD	Ricardo is a global engineering, environmental and strategic consultancy, operating across a range of market sectors.

Source: Frontier Economics

DER-IC set-up overview

The DER-IC operates as a nationwide network, with the ultimate goal of scaling up PEMD capabilities

The DER-IC operates as a nationwide network, providing businesses with the opportunity to scale up their PEMD capabilities, while allowing them to reduce their risk by sharing expertise, technical advice and facilities. The DER-IC network consists of over 30 academic institutions, Catapults and university associates. The DER-IC supports firms using a mixture of activities, with the ultimate goal of enabling the PEMD sector to move towards manufacturing in the UK and helping to deliver long-term net zero sustainable growth. The DER-IC's main activities include:

- Providing helpful connections for firms to speak to;
- Signposting firms towards funding opportunities;
- Purchasing and facilitating access to equipment; and
- Promoting training and skills activities.

The DER-IC has received funding of £33 million from the Challenge. The bulk of this funding (£28.5 million) is dedicated to investing in new equipment, with the remaining funding covering staff costs, marketing and other business activities. There are about 30 colleagues actively working at the DER-IC, consisting of chair Professor Matt Boyle, four chief operating officers (one for each DER-IC region), the technical staff (Chief Technology Officers, technicians, engineers) and support staff.

The DER-IC is broken down into four regional sites with thematic variation

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 (Table 24), and therefore the distinction between the regions of the DER-IC is principally based on a thematic separation rather than a geographical separation in terms of the locations being supported. The thematic separation allows different centres to build on each other's learnings and share knowledge without duplicating work or competing with each other. As the DER-IC is building on existing capabilities and facilities, firms interviewed were not always clear where the DER-IC in particular was offering assistance, and where the rest of the institutions were involved. This was particularly the case when collaborating with universities.

Table 24 The DER-IC locations

Driving the Electric Revolution-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
Scotland DER-IC site	The National Manufacturing Institute Scotland (NMIS) and the Power Networks Demonstration Centre (PNDC), Glasgow	High-power PEMD MW-scale machines & drives Prototype & scale-up MW-scale testing

Driving the Electric Revolution-IC	Location	Area of focus
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: Driving the Electric Revolution: An introduction

Each DER-IC site works with other organisations in its region. For instance, the University of Strathclyde works with seven Scottish organisations; Newcastle University works with seven northern organisations; Warwick and Nottingham universities bring twelve partners together and are also responsible for the coordination of the Catapult network; and Wales works with another two centres. There are an additional five organisations in the South West that intend to join the network and are working with CSAC.

The DER-IC reports intense collaboration

We asked case study participants about their perceptions of the level of collaboration between different DER-IC regions. Despite the DER-IC operating in these different sites, colleagues from the DER-IC stated that there was a lot of collaboration and the centres worked closely together.

"The DER-IC are essentially one body, but address different requirements across the country. There is a misconception that there is a lack of coordination between the centres. This is not true, the centres work very closely together." DER-IC colleague

The set-up of the DER-IC has allowed new connections to be established within the DER-IC itself. There is currently a shared database of contacts between the various DER-IC sites, regular knowledge exchange meetings and updates on the various networks, and the centres collaborate as partners on certain projects.

"At the Midlands meetings, we [different DER-IC organisations] exchange a lot of information. We look at sharing intelligence on upcoming funding calls and events. And one institute would usually do a more in-depth presentation so that the others get an understanding of their activities. So it's all about building the network and being aware of each other's strengths." DER-IC colleague

However, firms interviewed were less aware of how the different centres operate as a national framework and tended to have a close partnership with one DER-IC site at a time rather than dealing with multiple DER-IC sites on a given project.

"I wouldn't say there has been a lot of joining up between the DER-IC centres [in the case of our project], but this was not necessarily a failure but [rather] more how the project is set up." Large manufacturer

Participants interviewed in one of the process evaluation workshops were not certain of the DER-IC's activities. Even from speaking to firms that had worked with the Midlands DER-IC site, the value proposition of the DER-IC as a whole was not always clear. The DER-IC could therefore dedicate more resources to marketing its activities.

"I do struggle a bit in in terms of understanding what benefit we would get from working with the DER-IC. We need to know what they provide, what they are good at and how they can help us." Large manufacturer

The Midlands DER-IC site

Background of the Midlands DER-IC site

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.

The Midlands DER-IC site is one of two DER-IC that already have pieces of equipment in place, and the equipment has been in operation for a longer period than other DER-IC. In the case of the University of Warwick all new DER-IC funded equipment has been installed and commissioned. The pieces of equipment currently in the Midlands DER-IC site are:

- A High Frequency Coil Manufacturing and Magnetic Test Characterisation capability to develop and manufacture electrical machines which operate at higher frequencies – based at the University of Nottingham;
- A power electronics reliability and failure analysis facility focusing on improving reliability and robustness – at the University of Warwick; and
- A Winding Centre of Excellence facility for UK supply chain companies to manufacture discrete hairpin machines to production quality – based at WMG.

The nature of the specialisation of the Midlands site – which focuses on manufacturing techniques of machines and drives in small volumes, while the North East and Scotland work on scale-up – means that it has greater interactions with the other centres and has been active in connecting firms to different partners.

The Midlands DER-IC site's success in connecting firms

The Midlands DER-IC site has undertaken activities centred around raising the visibility of the PEMD sector, providing networking opportunities and connecting firms to relevant partners. This activity is linked to evaluation theme 5, which reflects the Challenge's ambition to foster collaboration and knowledge sharing between companies across the PEMD supply chain and in adjacent sectors. Findings show that the Midlands DER-IC site has had a positive impact on connecting industry experts and increasing the number of collaborations for PEMD companies of various sizes in different sectors.

The DER-IC has raised the profile of the PEMD sector

A key aim of the DER-IC network is to join up the capabilities already present across the UK and to grow the sector through connecting people in different areas of PEMD. The consortium connects firms to help resolve

their technical issues, either by linking them to colleagues within the DER-IC or to other academic and industry experts.

"There are probably 100 people with influence and expertise in PEMD across the UK. However, almost 10,000 people have the aspiration to enter the sector, and the DER-IC has been engaging with those 100 experts and ensuring [through them] the questions of the 10,000 people are answered as quickly as possible." DER-IC colleague

One of the Midlands DER-IC site colleagues interviewed stated that the centre had raised the profile of PEMD and of those working in the sector, so that new entrants to electrification will know who to ask for the required support.

"We [the DER-IC] receive an inquiry from a company and if we are not able to respond, we can put that question out to the rest of our partners. Our mission is to never send firms away disappointed, if we cannot help them we find an entity who can, or try and at least point them in the right direction." DER-IC colleague

The Midlands DER-IC site connects firms (both large firms and SMEs) to new entrants or organisations they have not collaborated with previously

Beyond this, the Midlands DER-IC site also uses its wide network to help connect businesses across the supply chain on various projects. Some firms approach the DER-IC after hearing about it or connecting with it during Challenge events. However, the majority of partners who approach the DER-IC, and those that the DER-IC approaches, already have a prior connection with the DER-IC. For instance, some of the firms that we engaged had previously worked with the universities that are now leading the DER-IC.

The connections facilitated by the DER-IC mostly involve connecting two organisations, although they sometimes support building larger consortia. Once the connection has been made, depending on the need of the firms, the DER-IC's involvement can continue further or the introduction can be the end of it.

The firms we interviewed, both SMEs and large firms, highlighted the network opportunities that the Midlands DER-IC site had provided. It had played an instrumental role in connecting Ricardo with the rest of its partners to form a consortium for the Alumotor project, as well as being a project partner itself. The Alumotor project is funded by the DER and involves building the UK's electric motor supply chain to deliver the next generation of sustainable electric motors. In the absence of the Midlands DER-IC site, Ricardo stated that it would not have connected with its current partners as it had not collaborated with them previously, and some were new entrants to the industry. Ricardo's current collaboration with the Midlands DER-IC site has given it the confidence to continue its work with other DER-IC centres, potentially exploring the manufacturing of an invertor with Newcastle in 2024.

"[Collaborating with the Midlands DER-IC site] has given us confidence not just with regards to WMG's expertise, but the wider initiative as well. So we will be looking at other types of engagements with the other DER-IC sites, including Nottingham and Newcastle." Large manufacturer

In the case of SMEs, associating with a well-known institution such as the Midlands DER-IC site can pave the way for establishing partnerships with larger corporations. Agile Manufacturing Power Systems (AMPS) initially partnered with the University of Nottingham as part of the Midlands DER-IC site initiative on a skills project with a value of £25,000, developing educational materials to bring exposure of PEMD to individuals through an interactive panel. Although the project was on a relatively small scale, establishing a connection

with the University of Nottingham has allowed AMPS to partner on future projects with much larger OEMs than they would have otherwise been able to. AMPS has since been able to apply for three other funded projects that have a combined total investment of about £10 million.

"Start-ups might not [directly] benefit from a small scale project, but you could show people that you are capable and your solution actually works, and for that you need either collaboration or funding. For us, this was all enabled through our project that we had with the University of Nottingham." SME

The Midlands DER-IC site has enhanced the interactions between industry and academia within the PEMD sector

Additionally, the Midlands DER-IC site has facilitated a greater interaction between industry and universities within the PEMD sector. Due to the Midlands DER-IC site's network and reputation, one SME interviewed stated that firms were more likely to approach academic institutions when they were part of the DER-IC. In other words, the DER-IC has added a more commercial element to universities, which were much more research focused previously and therefore firms faced more challenges when approaching academic institutions. As an example, the University of Nottingham is being approached by companies, both large well-known organisations and new entrants, that it would not otherwise have typically interacted with.

"There are companies that are now approaching us [Nottingham] post DER-IC that had never contacted us before. We have [historically] had a lot of expertise in the aerospace sector. But when we started promoting our activities in the DER-IC and the facility in place, we have received a lot more clients from the automotive sector which we did not [initially] expect. Our BD pipeline has grown by 5 times compared to when we did not have the DER-IC." DER-IC colleague

The Midlands DER-IC site's role in signposting funding

Alongside supporting connections, the Midlands DER-IC site helps to signpost firms towards other UK or EU grant-funded projects (e.g. the Aerospace Technology Institute (ATI), Advanced Propulsion Centre (APC,) other Innovate UK and UKRI projects). This corresponds to evaluation theme 4, which relates to increasing the value of investment in UK PEMD companies in order to grow the UK's supply chain and facilitate export. While the industry is not always aware of these opportunities, the Midlands DER-IC site has the time, resources and connections with funding bodies to share these prospects. It was generally agreed that the Midlands DER-IC site has been successful in assisting directing firms into funding opportunities in multiple ways.

First, firms are more likely to be successful in winning bids if they partner with a reputable organisation such as the Midlands DER-IC site. In the case of Ricardo, its partnership with an industry expert such as WMG was an important factor leading to its success in winning the bid for funding.

"[With respect to winning the funding] having a reputable academic partner such as WMG was very valuable and one that's aligned with industry is twice as valuable." Large manufacturer

Second, the Midlands DER-IC site actively signposts firms to funding opportunities for the projects in their pipeline. In the case of AMPS, the University of Nottingham was particularly helpful in sharing relevant funding opportunities, including funding to finance a pilot project. While the DER-IC holds some events to share funding opportunities, most of the signposting takes place in conversations between DER-IC stakeholders

and different firms. Some of the firms engaged stated that they would not have applied for some of the funding opportunities in the absence of the DER-IC.

" [The DER-IC showed us that there is an] opportunity here for us to apply for something together, and be an innovator [in a training project that] is industry led. We did not have all the skills necessary to do it on our own so we wouldn't have applied for that funding had it not been for the DER-IC [involvement]." SME

Third, through promoting new funding opportunities, the Midlands DER-IC site encourages firms to come up with new projects that are beneficial and contribute to the growth of the PEMD sector. For instance, McLaren Applied is now in conversation with the Midlands DER-IC site about developing a new strategic project that it did not initially have in mind because the DER-IC has signposted it to new funding opportunities.

The Midlands DER-IC site's skill-related activities

There was a consensus among those we interviewed that there is a significant current shortage of skills, engineers and technicians that could prevent the PEMD sector from growing. The Challenge has therefore placed the support and provision of skills as one of its strategic priorities. This activity relates to evaluation theme 3, which reflects the Challenge's ambition to increase the PEMD knowledge and skills base in the UK in order to facilitate the growth of the supply chain. Although the benefits of this specific activity could be assessed more accurately in the next evaluation phase in 2024, partners interviewed generally agreed that the DER-IC is helping UK skills by sharing technical expertise on projects and undertaking specific skills activities. However, there is potentially a need for further involvement due to the significant gap.

The Midlands DER-IC site contributes to projects by providing its technical expertise, which is then retained within firms

There are concrete examples of the Midlands DER-IC site providing its technical expertise by partnering with industry partners in their projects. In the case of the Alumotor project led by Ricardo, the Winding Centre of Excellence is providing its expertise with both the design and manufacturing process of the electric motor. This has been facilitated through various meetings with WMG where they explain some of the design philosophies for automotive motors which the firm were previously not aware of. The transfer of skills and knowledge in this project provides evidence of the DER-IC's role in upskilling the relevant workforce, which will be **retained within firms** throughout the project and the manufacturing process. Ricardo currently has a small team of engineers with expertise in electrification, and being able to draw on WMG's knowledge has helped it to progress more rapidly than it otherwise would have.

"We have used WMG's machine design experience, skills and facility to supplement our own, and that has been really successful. We have also had meetings with WMG where they explain some of the design philosophies for automotive motors which we were previously unaware of. This transfer of skills and knowledge will be retained as we go through the project and the manufacturing process." Large manufacturer

Another example of such a collaboration is the ESCAPE project, led by McLaren Applied with 12 other partners, including Warwick School of Engineering (WSoE), which sits within the Midlands DER-IC site. The project aims to secure a complete supply chain for the next generation of silicon carbide power electronics in the UK, and WSoE has been providing R&D support for two workstreams within the project: the SiC device fabrication and the component manufacture. WSoE has also recruited additional researchers and experts to support the project.

Being able to rely on the Midlands DER-IC site's expertise has encouraged firms to be more ambitious in their project bids, which may help build future skills capabilities

Being able to rely on the Midlands DER-IC site as a partner has encouraged companies to take up novel projects, even if they did not initially possess the required expertise and capabilities to do so. In the case of Electrical Cooling Solutions (ECS), it has started a project with a large OEM to redesign one of its electric motors. The project requires a unique skill-set in terms of design which ECS did not previously have, so it would not have bid for the project without the Midlands DER-IC site's partnership. The Midlands DER-IC site is assisting with the design and innovation aspect of the motor by using its previous expertise and know-how and applying it on a commercial level.

"The company [large OEM] came to us with a big project involving the redesign of one of their electric motors. On our own we wouldn't have been able to do so. So we went to [the Midlands] DER-IC and said that we're able to tackle 20% of the project, but would need help for the other 80%. With [the Midlands] DER-IC's partnership, we put a collective bid in for a nine month project worth £500k and we are now starting it." SME

The Midlands DER-IC site promotes tutorials and skills activities within the sector

Additionally, the Midlands DER-IC site has been collaborating with industry partners to promote pilot training programmes and skills activities, from vocational to postgraduate, within the sector. As well as the AMPS interactive training panel already mentioned, ECS is collaborating with the University of Nottingham to develop training material for larger groups of organisations and individuals, whereas previously ECS had only provided training to smaller audiences. Through partnering with the Midlands DER-IC site and relying on the University of Nottingham's extensive training experience, ECS is currently offering live training to much larger groups than it would have previously. Being able to use the DER-IC's testing facilities to carry out demonstrations has offered a more practical and hands-on element to the training than theoretical classroom-based teaching would do.

"[The Midlands DER-IC site showed us that there is an] opportunity here for us to apply for something, and be an innovator [in a training project that] is industry led. We did not have all the skills necessary to do it so we wouldn't have applied for had it not been for the [Midlands] DER-IC's [involvement]. We have also been able to use their facilities and do demonstrations as well. So rather than theoretical or classroom based teaching, we offer a more hands on element that was provided by the [Midlands] DER-IC." SME

The Midlands DER-IC site also provides training for the use of its equipment – further explored in Section 4. To help assist industry in using the equipment, the Midlands DER-IC site has expert staff on hand to provide technical, health and safety training to the staff that would be involved in operating it.

Some stakeholders felt that the DER-IC could play a more important role in the provision of skills within the PEMD sector

While the DER-IC has carried out these skills-related activities, interviewees from the DER-IC generally agreed that it would need to play a more active role in terms of the provision of skills within the industry, although this was not necessarily echoed in the interviews with firms. This is particularly important as the DER-IC does not have the required funding or capabilities to facilitate the growth of the sector on its own and would need to train other partners. According to a DER-IC stakeholder, the shortage of skills within the PEMD sector is an issue that is severely understated by both the government and the Challenge.

"Post-Covid especially, a lot of people do not have the quantum skillset required. 13,500 Level 4-7 jobs are needed in the North East alone in 3 years' time, and the total number of graduates in electrical engineering each year in the UK is about 1,100." DER-IC colleague

The DER-IC was felt to be well placed to identify and address the skills gaps within the sector. This is partly due to the needs expressed by industry when faced with the manufacturing challenges and partly due to the work the centres have had to do to attract and retain engineers. The Challenge can therefore utilise the centres to help develop the skills network. Additionally, the DER-IC's close relationship with academic organisations can enable them to address the issue in a more fundamental manner.

"In the future, the skills piece will be significant, as firms are saying this is a significant gap in the supply chain. This cannot be just about a skills hub, but rather needs to be about promoting STEM in schools." DER-IC colleague

The impact of the Midlands DER-IC site's equipment

The Midlands DER-IC site offers open access to its facilities and equipment, giving industry the opportunity to access equipment regardless of whether they are a competition-funding recipient. This is relevant to evaluation theme 6, reflecting the aim of the Challenge to expand the UK PEMD manufacturing capacity. It also relates to evaluation themes 2 and 3 increasing the productivity of the supply chain and contributing to knowledge and skills.

Long lead times for the installation of equipment due to COVID-19

The procurement stage for allocating the £28.5 million of DER funding to different pieces of equipment started in 2021, and the DER-IC ran a competition to award equipment to different bidders. This competition ran for one month and was open to the various DER-IC but also to other organisations to bid for. The competition was therefore independently assessed by Innovate UK KTN, as the DER-IC partners themselves were bidders. Prior to the competition, the organisations within the DER-IC held workshops to identify gaps in the UK's current capability, the strength of network partners and the equipment they were inclined to compete/bid for, to avoid competition in equipment overlap. The competition awarded nine grants for nine suites of equipment and these were split quite evenly between competition winners.

Due to COVID-19 and other supply chain issues, there have been delays and long lead times on the delivery and installation of equipment. For instance, for the University of Nottingham, the lead time for installing the equipment doubled to 18-24 months compared with the original expectation of 8-12 months.

Access to equipment has encouraged SMEs to innovate and expand their activities, and has enabled larger organisations to improve their manufacturing techniques with minimised risks and costs

Equipment and test facilities are accessible to companies within the PEMD supply chains. Start-ups and spin-outs tend to employ the equipment to learn how to design for manufacture, while larger and more mature companies are looking to pilot new products and improve manufacturing processes. Access to the equipment has enabled SMEs to innovate and expand their activities by taking part in novel projects. Partners interviewed stated that using the equipment and testing facilities that were commercially available to them by the DER-IC had encouraged them to bid for projects including a testing element in their application, which they would have been unable to do without making significant investments themselves.

Despite being a consultancy and not having its own testing facilities, ECS is currently making use of the DER-IC's equipment on two applied projects. First, it is collaborating with the University of Nottingham on consultancy work and utilising the equipment to validate its design simulations on real-life test data. Second, the Midlands DER-IC site is providing the equipment and testing facility for the project between ECS and a large OEM company, as outlined in Section 4.

"The DER-IC's equipment has been very helpful because we don't have any hardware or any test equipment ourselves. So we are able to bid for projects and include a testing element, knowing that we can go to the university and use their testing facilities that are commercially available to us without spending any money." SME

AMPS is another example of an SME that would not be able to purchase equipment itself. Having access to Nottingham's equipment means it can provide a better service for its clients by trialling their designs.

"I think what they have done [regarding equipment] is amazing because the DER funding is an accelerator and enabler. So any company of any size can have an innovative idea and instead of investing millions of pounds in equipment to test something, they can test it in a place like Nottingham University with minimal costs. They can trial it, and if everything works great, then they will be able to scale it." SME

Although some equipment had existed across the centres prior to the DER-IC, firms engaged argued that the offering of equipment had significantly improved due to the funding provided by the Challenge. Additionally, some firms were not aware of whether they could access similar facilities elsewhere.

"I don't know where we would have gone to use this equipment, partly because I don't know where offers that sort of range of equipment available to us at the DER-IC. It's definitely something we have not been offered before." SME

The Midlands DER-IC site's equipment has also enabled larger firms to test and explore ways of improving their manufacturing techniques. The UK Alumotor consortium – led by Ricardo – is currently using the equipment at the Winding Centre of Excellence at Warwick University to consistently refine the manufacturing processes while awaiting long lead times for their own equipment. This means that, once their equipment arrives, the consortium will already have knowledge about how best to use it, significantly cutting down the time to manufacture. It has also given Ricardo the opportunity to assess the type of machinery and processes that it would need to purchase in the future, without incurring significant costs.

"Without the involvement of WMG and the [Midlands] DER-IC (which is using cutting edge, impressive manufacturing gear) we would perhaps [have] bid for a project less ambitious in scope, rather than one that is currently effectively developing a supply chain and manufacturing design. [This is because] we would need to de-risk some of the aspects [that] the [Midlands] DER-IC is now supporting us with, including the advanced manufacturing processes." Large manufacturer

For organisations to take advantage of this opportunity, some interviewees mentioned that there was a need to raise awareness and provide more transparency on what equipment the DER-IC currently has in place. It would be particularly beneficial to have a list of the equipment that various centres offer and to hold launch events where industry partners could visit the different centres, view their equipment and engage with the relevant partners.

In conclusion, the equipment provided by the DER-IC was perceived as extremely beneficial by the industry partners interviewed. The Midlands DER-IC site's equipment has enhanced the UK's manufacturing productivity by giving firms the opportunity to test products and purposes with reduced risks and costs and ultimately to advance their MRL and commercialisation.

"The primary difference that the DER-IC network has made is that it has given firms the confidence to step into manufacturing … as it provides them with the knowledge that the manufacturing scale up capability (in terms of people and equipment) will be there once it is needed." Large manufacturer

Thematic case study

Introduction

The thematic case study is part of a wider evaluation of the impact of the Driving the Electric Revolution Challenge and was developed based on primary research with academic institutions, PEMD firms, trade associations and policy audiences. The thematic study takes a step back from the immediate Challenge-funded activities and explores the impact of the Challenge on the wider PEMD supply chain and UK economy. The original intent was to focus on evaluation themes 1, 3 and 7:

- Has the Challenge accelerated innovation and commercialisation of PEMD technologies?
- Has the Challenge increased the productivity of the UK PEMD supply chain?
- Has the Challenge contributed to growing PEMD knowledge and skills in the UK?
- Has the Challenge increased the value of investment in UK PEMD companies?
- Has the Challenge helped foster a collaborative PEMD ecosystem?
- Did the Challenge lead to an expansion of UK PEMD manufacturing capacity?
- Did the Challenge drive societal, environmental and policy spillovers?

However, in the course of interviewing stakeholders, it became clear that they also wanted to offer perspectives on the wider set of evaluation questions. We therefore considered all of this evidence in the reporting.

The research included a mix of panel discussions with external experts, interviews of individuals and desk-based study. The research aimed to identify changes in UK PEMD supply chains since 2019, when the Challenge was launched, and then to assess the degree to which these changes might be attributed to activities of the Challenge programme. The baseline for the UK PEMD supply chain is detailed in an earlier report[35] which describes the main technologies, supply chain activities and major players.

The research for this thematic case study was conducted about three years after the launch of the Challenge. It covered all themes except theme 2, reasoning that it was too early to assess productivity. The themes overlap but have important distinctions which were made clear to the external experts participating in the study. For example, successful commercialisation (theme 1) may not lead to expansion of UK manufacturing capacity (theme 6) if downstream development partners use or develop facilities abroad; or an increase in

[35] Reference to baseline report.

UK PEMD skills (theme 3) can generate more societal spillover (theme 7) if it comes through retraining and skills upgrade rather than through foreign hires.

As an introduction, there is a useful distinction between the evaluation themes accelerating commercialisation and expanding manufacturing capacity

In the evaluation study, we seek to separate the effect of the Challenge from larger forces affecting UK PEMD supply chains. For example, the Challenge seeks to expand PEMD manufacturing capability which is partly enabled by access to raw materials, access to non-emitting sources of energy and access to markets, all factors outside the scope of the Challenge. Within scope are skills, knowledge, investment and an innovative ecosystem.

Specific conclusions or insights from the evaluation team are marked as such and aim to reflect the balance of contributors' views or highlight aspects that are particularly salient to the evaluation themes. In some cases, the evaluation team drew on its wider experience of the PEMD sector, e.g. from its facilitation of the APC's technology developer accelerator programme (TDAP). In these cases we always cite 'the evaluation team'.

Contributors

We selected external contributors who were closely conversant with the supply chains and industries within which the Challenge resides but who were not involved directly with it. Contributors were recruited from industry, academe, trade bodies and government on the understanding that all contributions would be anonymous. We do not disclose specific roles or names of people and organisations, but we do indicate the types of source for each item of evidence or opinion. Where possible, we indicate the level of certainty and the number of contributors that supported each view.

From an original list of 53 candidates, we invited 43 who were chosen to provide a diverse mix of job roles, industrial sectors, PE (power electronics), M (machines) and D (drive) disciplines, and organisation types. Thirteen people chose to participate and ten declined, two because of scheduling issues and eight because they believed they would not be able to contribute. A further 20 failed to respond at all despite receiving at least three reminders. The take-up was a little lower than expected and may have been because people have some difficulty in connecting PE, M and D technologies to specific sectors.

The organisations, roles and expertise of the participants are summarised in Table 25.

Table 25 Thematic case study contributors

Organisation	Job title	Sector	PEMD focus
Large corporation	Engineering	Power	PE, D
Government	Stakeholder engagement	Transport, Power	PE, D
Trade association	Commercial	Power, Transport, Buildings, Health	
Trade association	Commercial	Power, Transport, Buildings, Health, Agriculture, Digital	PE, D
University	Academic	Transport (mostly aviation)	PE, M

Organisation	Job title	Sector	PEMD focus
Trade association	Commercial	Electronic	PE
Trade association	Commercial	Electronic	PE
SME	Engineering	Transport, Power, Industrial equipment	PE, M
University	Academic	Power (shifting to offshore wind)	PE
Accelerator	Commercial	Power (mostly offshore wind)	PE, M, D
University	Academic	Transport	PE
SME	Commercial	Electrical, Electronic, Industrial equipment	PE

Source: ERM

Accelerated innovation and commercialisation

The innovation funnel

Innovation is often described as a funnel, at the front end of which are early-stage concepts that are yet to be reduced to practice and, at the back end, mature applications at a material scale. To assess the impact of the Challenge for accelerated innovation and commercialisation, we need to first understand where in the innovation funnel we should be looking. On its website,[36] UKRI states this clearly: DER funds will be 'invested in collaborative, industry-led innovation projects that will help businesses grow strategically important UK PEMD supply chains and develop manufacturing capability'. The focus on supply chains and manufacturing capability implies a MRL of 2-8 using the framework developed by the UK Automotive Council and UK government.[37] We note that, while the UKRI publishes a scale for technology readiness level (TRL),[38] it does not have one for MRL, which might have been helpful in the context of DER given its focus on manufacturing capability.

Those interviewed were widely of a view that the Challenge funds were supporting the development of technologies in the middle stages of the innovation funnel. However, there were mixed views amongst interviewees on where in the funnel the Challenge aimed to achieve its impact.

The DER is directed at next-generation PEMD supply. One of the trade association leaders strongly stated that, for the Challenge to achieve significant impact, the new technologies and capabilities it has initiated would need continued support after completion of the Challenge programme. Several business leaders echoed this view: the Challenge should be seen as part of long-term industrial strategy with ongoing government funding and policy measures to support it. Given this feedback, the evaluation team suggested that ongoing Challenge communication could provide more information on what will happen after project completion, particularly for successful projects, helping participants and potential investors to plan for success.

> *"Projects are like seeds, they need watering and they need growing."* Leader of trade association

[36] https://www.ukri.org/what-we-offer/our-main-funds/industrial-strategy-challenge-fund/future-of-mobility/driving-the-electric-revolution-challenge/

[37] https://apcuk.co.uk/app/uploads/2021/09/Automotive-Technology-and-Manufacturing-Readiness-Levels.pdf

[38] https://beta.ukri.org/councils/stfc/guidance-for-applicants/check-if-youre-eligible-for-funding/eligibility-of-technology-readiness-levels-trl

In summary, DER accelerates innovation through a part of the funnel. It is fair for government to expect that industry should fund late-stage innovation, but it will only do so if the policy environment is stable and supportive.

Sector focus

The Challenge is designed to focus on commercialisation of technologies for PEMD, with the premise that these are required in applications in many sectors – the Challenge website cites the energy, industrial and transport sectors.[39] The broad sector reach was commented on by two interviewees. They asked whether the Challenge could be expected to deliver against the reach given its level of funding and pointed to a risk that programme resources are spread too thinly. Their argument was that, although PEMD technologies are pervasive, significant customisation activities are needed within each sector to enable commercialisation.

A strong recurring theme in panel discussions was whether programme resources are spread too thinly. We address it here but it also applies to later themes such as skills development and building manufacturing capacity. From the perspective of the evaluation team, the criticism seems partly fair: the Challenge aims to span a broad business, technology and application space and a wide section of the innovation funnel.

On the other hand, the evaluation team could not envisage a better framing of the Challenge: If it had focused wholly on power electronics (cf. Faraday Challenge), would there have been enough UK-based applicants? If it had focused solely on machines or drives, then would it have run into the problem discussed later that power electronics is essential, a *sine qua non*? If it had focused wholly on automotive or transport sectors, would it have failed to capitalise on the pervasive nature of PEMD?

One industry professional we consulted commented that the language on the Challenge website showed some bias towards transport.

"DER being spread across so many sectors is a drawback to the Challenge, as well as the name that alludes to transport applications." Leader of accelerator

Two interviewees commented on a lack of projects in the energy sector.

"When I looked at the projects that the challenge was covering, not many of them resonated with me in terms of the applications that we've got within the power Industry" … "but I guess that's because some of the innovation and the technology will naturally cross." Industry technical expert

The evaluation team analysed the portfolio of Challenge projects awarded and concluded that it is somewhat weighted toward the transport sector, with fewer projects that could benefit the power sector: 68% of projects by number are related to the transport sector – of the 68%, over a third apply to more than one sector; 21% of projects are related to the power sector. The importance of the power sector for the UK economy and decarbonisation is exemplified by the UK government's ambitious targets for development of offshore UK

[39] https://www.der-ic.org.uk/sectors

wind power.[40] There is a need for MW generators and drives for wind turbines[41] and diagnostics and control systems for power transmission lines.[42]

A consequence of the transport bias is that the Challenge portfolio is weighted toward 100s kW-scale applications with fewer at 1MW and above. Forty-five percent of the Challenge projects are focused on lower than 1MW-scale applications; 21% on MW+ scale; and 35% are indeterminate or not applicable. Based on the weighting, the evaluation team argues that the Challenge is accelerating commercialisation more strongly in the 1-100s kW power segment than in the MW+ segment.

Flexibility

One innovation professional commented that programme flexibility is key to accelerate commercialisation: resources must be allocated according to where the greatest development hurdle lies. Often, new hurdles are discovered as development progresses. Through the provision of DER-IC, the Challenge is structurally in a good position to enable flexibility of resourcing.

Stakeholders seemed to support the conceptual design of the DER-IC but could not provide evidence either way to assess how they are working in practice, e.g. in broadening access to resource, facilitating collaboration and allowing programme flexibility. A comment consistently heard from companies outside the Challenge was that the DER-IC have quite a low profile.

"The DER-IC are not really known among industry players, unless you have worked with them or sold them equipment." Industry commercial expert

Growing PEMD knowledge and skills base

Experienced engineers

A large majority of those interviewed reported having difficulty finding the experienced engineers (ten years' experience) needed for growth of the UK PEMD supply chain and that over recent years the shortage has become more acute. Corporate interviewees stated that they were currently recruiting most of their engineers from abroad.

"Most engineers at the moment are not UK citizens, but from Asia and India. The percentage of PhD engineering students from the UK ten years ago I'd say [was about] 70%, if you took it now it will be 0%." Industry technical expert

"When we're recruiting engineers, PhD or otherwise, or semiconductor physicists, I would say 9 out of 10 of are not UK based, so we're really experienced at doing visas." Industry technical expert

[40] https://www.great.gov.uk/international/content/investment/sectors/offshore-wind/

[41] https://ietresearch.onlinelibrary.wiley.com/doi/full/10.1049/rpg2.12114

[42] https://www.smart-energy.com/news/42-technology-smart-grid-tech/

"We need to think about social mobility and how we can grow talent and capability because we see less people coming through university, particularly with electrical engineering qualifications." Industry technical leader

Although most contributors to the evaluation study could not see any sign of the skills shortage easing, one pointed to a positive sign of change: EPSRC Centres for Doctoral Training and student competitions (e.g. for Formula E) are increasing the numbers of students enrolling on engineering courses.

A trade association leader commented that growth requires both training and retention. Access to state-of-the-art equipment in DER-IC helps retain skills in the UK – engineers can demonstrate that they have been working at the leading edge.

Another university interviewee commented that a shortage of engineers arises through choice of subjects taken at school before university. They were not aware of any Challenge outreach activities to schools.

"The status of engineers is appalling in this country and it's one of the reasons that we don't get a good enough supply chain." University professor

Overall, interview participants could not identify any specific impact on the PEMD skills base due to the Challenge. However, they widely considered that the existence of the Challenge projects and DER-IC are strongly supportive of growth in UK skills.

Gender balance

One interviewee thought the Challenge could do more to increase the attractiveness of engineering and power electronics to women − as a route for growth in the overall skills base. A Chinese professor reported that UK universities attract fewer female engineers than their Chinese counterparts, leading to a profession with a strong gender bias. The gender imbalance is reflected in university applications for engineering courses.

The evaluation team noted that this observation was borne out by the gender balance of university and industry professionals that contributed to the evaluation study; the gender balance of the Challenge team itself is also quite poor.

The evaluation team reviewed a detailed study by Engineering UK on women in engineering,[43] which in contrast to the view of the interviewees reports an uptick in the percentage of women electrical and electronic engineers between 2010 and 2021. However, this study does not break out numbers participating in university studies or the specific discipline of power electronics.

The negative outlook of interviewees is also somewhat countered by the recent analysis of UCAS data by employment lawyer Richard Nelson LLP[44] which showed an increase of 96 per cent in female undergraduate applications to engineering courses over the last decade. However, despite this increase there is still a 4:1 imbalance remaining.

[43] https://www.engineeringuk.com/media/318036/women-in-engineering-report-extended-analysis-engineeringuk-march-2022.pdf

[44] https://www.richardnelsonllp.co.uk/university-applications-course-largest-gender-disparity/

In summary, although the Challenge is strongly sensitive to the principles of ED&I, none of the participants in the thematic case study could identify any impact (positive or negative) on gender balance caused directly by the Challenge. A second component of ED&I – racial diversity – is increased by the practice of recruiting PEMD talent from abroad to meet the increasing demand for skills, which arises partly from the Challenge's work to grow the UK PEMD supply chain.

Retraining

A university professor and trade industry professional pointed to the need to retrain, potentially in PEMD, people whose skills will become obsolete in the course of the transition to net zero. Within this, they included formal courses as well as informal on-the-job training. They were not aware of the DER activities to upskill industry professionals and to educate and inspire interns and school students through:

- The PEMD Skills Hub[45] (total budget of £1 million); and
- The building talent for the future competition[46] (total budget of £250,000).

> *"53% of welding jobs in the UK will be lost due to automation. We're providing power into those automation industries. How do we transition these industrial areas into electronics?"* Leader of trade association

From the perspective of the evaluation team, retraining is very much in the cross-hairs of the Challenge. However, we do not have much evidence yet of the impact that Challenge activities are making towards retraining. The training modules were launched late in the Challenge timeline because of delays caused by the pandemic and it is likely too soon to see their impact.

We note that the training needed to contribute to PEMD design and manufacture is lengthy, particularly for power electronics. In a net zero economy, other skills and industries, e.g. domestic heat pump installation, are likely to be more easily accessible for people who are retraining.

One leader of an industry association suggested that the DER funding for training would be more effective if it was more concentrated.

> *"The money is spread wide over a lot of small placements rather than as a large investment and we need to look at transitioning with maybe a big training centre almost university-size to train people from the legacy industries into the new industries."* Leader of trade association

The evaluation team reviewed the geographic location of Challenge projects and found a greater number outside London and the South East – the North East, West Midlands and Wales account for over 50% of project funding. The DER-IC are also outside the South East, located in Scotland, the North East, the Midlands and the South West & Wales.[47] These regions have a larger share of industries and skills that risk becoming obsolete in the transition to net zero. By locating projects and DER-IC in these regions, the Challenge indirectly contributes to retraining (and levelling up).

[45] https://www.ukri.org/opportunity/driving-the-electric-revolution-pemd-skills-hub/

[46] https://www.ukri.org/opportunity/driving-the-electric-revolution-building-talent-for-the-future/

[47] https://ktn-uk.org/events/engage-with-driving-the-electric-revolution-industrialisation-centre/

Skills transfer

Many of the professionals consulted in this study recognised that university-industry projects provide an opportunity for skills transfer – there are several in the Challenge portfolio. However, several also noted that historically 'projects have tended to disappear down the academic route', i.e. fundamental technology and science tend to be favoured over deployment.

From the experience of the evaluation team, the drift to an 'academic route' is a problem arising from the traditional university-industry collaboration model which is based on post doctorate research or PhDs. It arises because academics are assessed by their contribution of new ideas to their field of study, not against successful deployment of a technology. Challenge projects use a different collaboration model targeted at increased MRL, not number of publications. Through the Challenge model, industry developers gain access to leading-edge academic thinking to help address hard technical problems. Academics gain access to real-world data and problems to stimulate future research.

Fostering a collaborative PEMD ecosystem

A university professor advised that, although the Challenge is doing well in understanding the key challenges of PE, M and D, it lacks a system-level approach, observing that the best solution for a specific application may not be the optimal choice from an overall system perspective.

"From the system-level perspective, indeed, the best system may not necessarily be the best inverter or the best motor for a specific application. There needs to be a system level optimization, no funded project under DER at the moment is looking at this." University professor

From the experience of the evaluation team, this comment is calling for a level of optimization that can only be achieved through real-world practice, not through theoretical models. For example, from a commercial standpoint, many supply chains are webs of interaction, not a simple linear sequence; from a technical standpoint, PEMD includes a hierarchy of systems interacting at the material, component, circuit, drive, machine, application and sector-level. The UKRI would probably have wasted its budget attempting to unpick these complex commercial and technical systems.

A contributor from a university and one from a trade association questioned whether the Challenge programme's IP strategy would hinder collaboration between PEMD organisations, within Challenge projects and at the DER-IC.

"One of the problems that I haven't seen the challenge answer yet is how we can incentivize UK industry to work together on this" … "without some way in which companies can monetize their intellectual property, they're unlikely to want to share it with another potential competitor." Business leader

"Sharing of best practice, I think that's what's missing." Industry commercial expert

From the evaluation team's experience of designing and coordinating innovation projects, ownership of IP is a common concern that tends to be raised by collaborating parties. The UKRI has provided clear templates for management of IP and probably cannot go any further to alleviate this concern.

Increased value of investment in UK PEMD companies

Under this evaluation theme, we consider both the amount of investment and the return on it. Neither is easy to obtain: as PEMD is not a sector, investment in PEMD companies is not specifically tracked in reports to investors. Panellists were able to comment on the amount of investment but not the value derived from it.

One interviewee stated that the funding for the Challenge appeared small (£80 million) compared with the investment in the semiconductor sector made by Germany and the USA ($10 billion). They argued that the imbalance made it harder to attract corporate investment in UK semiconductor manufacturing; corporate investors get higher 'leverage' outside the UK. There is strong evidence for this statement: The European Chips Act promises €43 billion in public investments up to 2030.[48] Germany is expected to be the largest beneficiary as the country that hosts the majority of manufacturing facilities, but no investment amount has been specifically allocated to it. In the USA, The CHIPS Act[49] directs $280 billion in spending over the next ten years,[50] of which $200 billion is for scientific R&D and commercialisation; $53 billion is for semiconductor manufacturing, R&D, and workforce development; and $24 billion is for tax credits for chip production. The Act also includes a $3 billion allocation to programmes aimed at leading-edge technology and wireless supply chains.

A business leader in the UK semiconductor industry claimed that government support had changed little in the past years while the governments of other countries, e.g. Germany and USA, appeared to be investing strongly to make sure they had access to power electronics components. However, they also noted that the UK still has some world-leading semiconductor companies.

Another interviewee commented that many billions of pounds of investment would be needed to impact the UK manufacturing capacity power electronics components and drew comparison with the funding needed to establish ‘gigafactories’ for battery manufacture.

Expansion of UK PEMD manufacturing capacity

The market dynamic

Interviewees from universities and business observed that the Challenge is running during a period of rapid market growth and a scramble for scale; it fits the *zeitgeist* well. A university professor and business leader stated that automotive OEMs have an immediate commercial need for large-scale PEMD supply, which is not available. They elaborated to say there is still demand for more conventional silicon-insulated gate bipolar transistors (IGBT) rather than just leading-edge SiC switching devices. Their comments are consistent with the widely reported backlog in orders for EVs in the UK market.[51,52]

[48] https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-chips-act_en

[49] https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/

[50] https://www.mckinsey.com/industries/public-and-social-sector/our-insights/the-chips-and-science-act-heres-whats-in-it

[51] https://cpb-eu-w2.wpmucdn.com/blogs.bristol.ac.uk/dist/8/611/files/2021/08/price.pdf

[52] https://www.cenex-lcv.co.uk/storage/seminar-programme/sessions/presentations/stephen_lambert_mclaren_applied_1663838562.pdf

"Everybody's fighting for access to these new technologies and everybody's trying to get volumes up to push price down." Industry technical expert

"Car manufacturers, especially those in Western companies have not built-up proper supply chains with the manufacturers of these devices. So they just go around the market and buy components at the cheapest prices they can … in the large volume automotive markets, it's all about cost." University professor

The evaluation team would not expect the Challenge to impact the automotive sector's immediate supply shortage: the Challenge is focused on the early-stage to mid-stage commercialisation of promising new technologies rather than the late-stage scale-up needed to meet the high volumes and low costs required by mass automotive OEMs. The DER-IC, for example, provide access only to pilot-scale manufacturing processes; their objective is to accelerate the learning needed to achieve full-scale production. In the next two sections, we present more detailed comments from participants on manufacturing capacity, firstly in power electronics and then in machines and drives. Note that manufacturing facilities in the final stage of the supply chain involve integration of all three, PE, M and D.

Manufacturing capacity for power electronics

Several interviewees noted that the UK is starting from a trailing position with fewer PEMD companies than competing countries such as Germany.

"In Germany, for example, you can go and speak to the people, industry, manufacturing about these things and you can form a strong relationship with them. In the UK, however, you don't have those industrial partners to go and talk to, or at least not in the same numbers anyway." University professor

None were able to point to evidence that the Challenge is increasing the number of UK companies. In the view of the evaluation team, it is too soon for the Challenge funding to cause growth in numbers; several years are needed. On the other hand, in the three years since the Challenge was launched there have been examples of robust organic growth, e.g. as reported by Custom Interconnect Ltd (see earlier case study).

There was some doubt about whether manufacturing capacity expansion in power electronics was practically possible: four of the university and business professionals we consulted stated that the UK has a strong R&D programme but it lacks the key building blocks to develop power electronics manufacturing capability.

"We can do those things here. We're great at the moment and we have some incredible design skills and work going on in those research areas. What's missing is the high-level strategy that creates the large volume supply chain." Industry technical expert

"The demand is so big that even in this country alone, we'd need 10 large fabs to supply the demand." University professor

"Once you have that core competence and core manufacturing process capability, there's not a big difference between making devices with different technical specifications." Industry technical leader

From the experience of the evaluation team, some blocks might indeed be lacking, although there is ongoing effort to provide them. These include access to raw materials[53] and non-emitting sources of energy, and, potentially, access to markets,[54] depending on the trajectory of UK relationships with the EU. UK energy strategy[55] is in some flux as a result of the Europe-wide energy crisis caused by the war in the Ukraine. However, the UK government's strong commitment to developing offshore wind power should help to support future semiconductor manufacturing facilities and their energy-intensive processes.

There were different views amongst interviewees on whether the UK had the background knowledge base and skills needed to establish high-volume semiconductor manufacture: one business interviewee stated that the skills are present now, another that they would take decades to build.

Next-generation power electronics will see increasing application of silicon carbide and gallium nitride devices, with the first currently achieving the larger share of applications and revenue − the Challenge spans both types. One industry professional commented that the UK is developing a stronger supply chain for gallium nitride than for silicon carbide. The evaluation team noted that, given the earlier stage of market development, there is more opportunity in gallium nitride for new entrants based in the UK as less investment is needed to compete at world scale.

A university researcher and trade association professional summarised by saying that the Challenge is doing the right things to expand capacity, and doing them well, but for power electronics the Challenge is at the wrong scale and at risk of being spread too thinly.

"They're trying to spread it across too many things and it's a relatively modest investment, it's just scratching the surface" … " and what we're seeing here is a real opportunity if we can leverage greater industry and government investment to drive and accelerate these things further." Leader of accelerator

Manufacturing capacity for electric machines and drives

Interviewees commented that DER faces a significant challenge in growing manufacturing capacity for machines and drives, but a smaller one than for power electronics: the UK supply chain is starting at a very low base and it lacks skills and capacity. Some evidence for this view comes from the TDAP accelerator programme sponsored by the Advanced Propulsion Centre. TDAP is now in its sixth year and is complementary to DER with a focus on accelerating development of transport technologies, primarily automotive. The list of all companies that have participated in TDAP[56] has a larger number of SMEs in machines and drives than in power electronics.

"The main challenge we have at the moment is there's no significant UK content or manufacturing capability for DER to build upon." Leader of accelerator

[53] https://www.makeuk.org/-/media/eef/files/reports/make-uk-inspired-energy-net-zero-roadmap-2022.pdf

[54] https://www.gov.uk/government/publications/export-strategy-made-in-the-uk-sold-to-the-world/made-in-the-uk-sold-to-the-world-web-version

[55] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1069969/british-energy-security-strategy-web-accessible.pdf

[56] https://www.apcuk.co.uk/funded-projects

"For people coming up with innovative designs and techniques, there isn't necessarily the manufacturing base in order to expand." Business leader

One business interviewee noted growing capabilities at 1-100s kW-scale in North East England, including motors, drives and their applications. They did not confirm whether the growth could be traced directly to the Challenge. However, the evaluation team noted that 11% of the Challenge projects had participants in this region. The same interviewee cited lower capacity at 1MW and higher scales.

*"We have growing UK competence in small machines, small drive syste*ms*, very well suited to automotive. But we don't have any significant capacity at MW and multi MW scale."* Business leader

The evaluation team expected that the weighting of the Challenge project portfolio towards 1-100's kW-scale was a reflection of the pre-Challenge skills base. It seems likely that the number and quality of bids for Challenge funds reflected the nation's underlying skills. The Challenge team could have awarded funding preferentially to projects in areas where there were skills gaps, but this would have first required viable bids – a chicken and egg paradox. Furthermore, it would have been a difficult funding strategy to implement without knowledge of where there were gaps to bridge and a clear overarching industrial strategy.

Development of a resilient PEMD supply chain

A key enabler for expansion of manufacturing capacity is developing the resilience of PEMD supply, i.e. ensuring that PEMD supply will not be greatly impaired by adverse changes in the physical, commercial and political environment. Since the Challenge was launched, the UK has seen increasing disruption of UK PEMD supply chains caused by the COVID-19 pandemic and by increasing polarisation of trade arising from the Ukraine war and US-China trade tensions. The impact of the Challenge on resilience is an important sub-theme.

Only scenarios that describe a breakdown in global trade would require the whole PEMD supply chain to be repatriated to the UK and, even then, the nation would still rely on imports of key materials. It falls on BEIS to set a strategy for which activities in the supply chain should be based in the UK – 'where the UK has a right and/or need to play' – and then to implement the strategy through development of a consistent set of policy measures.

DER seems to have particularly focused on the development of PEMD supply chains for electrified transport. However, one business leader in the energy sector commented that the Challenge team appeared to have given less focus to the PEMD supply chain needed for development of grid infrastructure, e.g. high voltage switches, cables, digital control systems.

"Our procurement teams are thinking very carefully about what is our plan for build out of transmission networks, what materials we might need and how might we source them." Industry technical leader

High-strength magnets, a critical component for many electrical machines, require some materials that have few sources of supply. One industry participant noted that the Challenge was helping to address this scarcity by accelerating the development of technologies to recover scarce materials at end of life.

"UKRI contributed part of a £4.3 billion investment into a process for the recycling of neodymium from magnetic devices. At the moment they're extracting neodymium from hard disk drives. Investment by the DER program was very strategic and timely." Leader of trade association

Interviewees also commented on how the Challenge was helping to reduce the need for high-strength magnets and the critical materials they contain. For example, a Challenge-funded project has brought together Greenspur and the University of Warwick to develop magnet assembly manufacturing processes for a ferrite based permanent magnet generator, which if successfully commercialised will reduce the need for rare earth materials. A second project, Magnomatics Winder, seeks to improve resource efficiency and system reliability. It aims to develop the use of a magnetic gear for application in wind turbines, replacing conventional mechanical gears and the additional steel, lubricants and maintenance that they need. Following successful large-scale tests at the ORE Catapult and at Norvento, a major global OEM has taken an exclusive option to evaluate the technology for offshore wind greater than 5MW.[57]

"There's been at least two funded offshore wind projects; one of them is actually now at the point where they're continuing their research development programme without the need for public funding, which is a real success story. So the support from DER has moved them away from needing to approach Innovate UK for further funding." Leader of accelerator

In total, the Challenge portfolio has four projects developing motor designs that are likely to benefit from more resilient supply; they embody either low-cost magnetic materials or substitutes for copper.

Resilience is increased by recovery of materials at end of life, reducing the need for virgin materials which for PEMD products are mostly imported. Two trade association professionals stated that technologies to enable circular solutions are an area of strength in the UK and praised the work of UKRI and the Challenge to advance the country's position in this area. There is evidence for this statement: of the 38 projects in the Challenge 2021 report, three to four directly address circularity. Examples are the recovery of gallium from GaN semiconductors at end of life using ionic liquids and the development of virtual process development tools for assessment of life-cycle and embedded carbon, remanufacturing, refurbishment and recyclability.

One university professor commented that, to be effective, the UK PEMD supply chain must include the starting material, i.e. wafer production.

"We don't have a supply chain which includes materials, the starting material." University professor

A second academic argued that supply of power electronics is critical to the success of the rest of the UK PEMD supply chain, stating that power electronics is only 10% of the value but, without it, the other 90% cannot be realised. Several noted that with the use of wide bandgap devices the share of value attributable to power electronics is increasing.

From the experience of the evaluation team working with UK-based semiconductor device developers, the supply of power electronics is indeed critical, but the argument for onshoring power electronics manufacture is less clear. Leading manufacturers of wide bandgap devices are based in the USA, Germany, Switzerland and Japan, a diverse set of countries all of whom the UK has long-term, stable trading relationships with. On the other hand, there is a global shortage of wafer fab capacity: foreign manufacturers see strong demand from domestic markets and will require a significant premium to motivate export to the UK. We note that the sale of Newport Wafer Fab casts further uncertainty on future UK manufacturing capacity of wideband gap

[57] https://www.magnomatics.com/renewable-wind-energy

semiconductors. After several months' deliberation, the UK government has now decided to stop the purchase of NWF by Nexperian, but a new buyer has yet to be found.

The evaluation team noted that over 40% of the Challenge portfolio by funding supports development of next-generation power electronics, a share that would seem to be representative of their value.

Environmental and policy spillovers

Four industry and public body professionals held the view that UK government policies that directly target the semiconductor sector are few and fragmented; the sector receives low levels of attention relative to other industrial sectors.

> *"Semiconductors is not considered as an industry" … "Although there is attention to semiconductors from all aspects of society, there's no common policy framework addressing them."* University professor

They also stated that there is a lack of any high-level strategy to tie investment and development efforts together. Furthermore, they reported poor coordination between government departments; e.g. BEIS[58] and DCMS[59] launched separate inquiries on similar issues in the semiconductor space.

Two interviewees, one from a university and one from industry, complimented the Challenge on its hard work to support government efforts to fill the policy gap.

> *"We should recognize the significant work that Will and the team are doing in terms of trying to influence policy and working very hard with UK Gov and the various departments."* Business leader

The current lack of clear policy is further evidenced by the long time taken for the UK government to respond to the proposed purchase of Newport Wafer Fab by Nexperia, which has links to the Chinese Communist Party.[60] The decision-making process appears slow,[61] possibly because there is no clear framework or strategy on which it can call. The delay fuels uncertainty for UK players in the sector and their investors.

With this backdrop, it is unsurprising that none of the contributors to the thematic case study could report any policy spillover that could be attributed to the Challenge. Relevant policy affecting PEMD supply chains is advancing slowly, or not at all.

[58] https://committees.parliament.uk/committee/365/business-energy-and-industrial-strategy-committee/news/171064/inquiry-launched-into-the-semiconductor-industry-in-the-uk/

[59] https://committees.parliament.uk/writtenevidence/109609/pdf/

[60] https://committees.parliament.uk/committee/78/foreign-affairs-committee/news/166116/foreign-affairs-committee-publishes-government-response-to-sovereignty-for-sale-followup-to-the-acquisition-of-newport-wafer-fab/

[61] https://www.theregister.com/2022/10/04/newport_wafer_fab_decision_delayed_nexperia_china/

Other possible areas for policy spillover explored by the evaluation team were the new policies for EV charger networks[62] and decarbonisation of building heating,[63] both released in 2022. Both policies are directed toward emissions abatement and the achievement of the government's 2050 net zero target.

One government leader reported that the Challenge had not affected the development of EV charger standards.

"Charger standards are set as outcome-based standards, so they don't define choice of a particular technology – we've left that up to the charge point manufacturers." Government leader

As charger standards are customer- rather than technology-driven, the evaluation team would not expect the Challenge to have much effect.

In summary, the research conducted for the thematic case study revealed no evidence yet of policy spillovers from the Challenge. DER can only take a role in shaping policy relevant to PEMD if the UK government itself sets policy development in this area as a priority. Given the current slow pace of policy development, the evaluation team considers that it is too early to expect any spillover.

[62] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1065576/taking-charge-the-electric-vehicle-infrastructure-strategy.pdf

[63] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1044598/6.7408_BEIS_Clean_Heat_Heat__Buildings_Strategy_Stage_2_v5_WEB.pdf

Annex B Survey development and analysis

The purpose of this annex is to share the full results of the impact-related questions of the process and interim impact survey. We share the full survey results of impact-related questions. Specifically, we include results and accompanying text that are not included in the main body of the report (section 5) for each evaluation theme. We therefore do not include theme 5 in the annex as the survey results have been specified in body of the report. Themes 2 and 3 did not include impact-related questions in the survey and are also not included.

Survey overview

The survey aimed to provide an overview of the behaviours and perceptions of businesses and academics that have engaged with the Challenge. Fieldwork for the process and interim impact phase of the survey took place between 3 October and 4 November 2022. For the analysis of findings, comparisons are made to the baseline survey where relevant in order to understand whether there have been any changes over time. Fieldwork for the baseline survey took place between September 2021 and February 2022.

Sample methodology

For both iterations, the sample for the survey included:

- Those who had successfully applied for funding from the Challenge;
- Those who had not been successful in their application for funding from the Challenge, including those who had withdrawn their application;
- Those who had presented at the 'Engage with' webinars or the 'Engage with…LIVE' session hosted by the Challenge;
- Those who had provided initial 'letters of support' when the case for the Challenge was being made to the government; and
- Those who are part of the Advisory Group for the Driving the Electric Revolution Challenge.

Although there are likely to be organisations engaged in the PEMD sector in the UK that did not engage with the Challenge in any way, this was determined to be the fullest sample available as PEMD companies are not easily distinguished from sources such as company registration data due to the broad mix of sectors they could be registered as. This approach was agreed as the best method to balance available contacts with the resource needed to engage contacts in the survey. It was also agreed that only companies with a presence in the UK would be in scope as that is where the greatest impact of the Challenge is expected.

Contact details were shared by the Challenge for each round of competitions that had taken place so far, for the 'Engage with' presenters and for those who had provided 'letters of support'. These were then combined and de-duplicated so that any contacts who had applied to multiple competitions or had engaged with the Challenge in a number of ways were only included in the sample file once.

A census approach was used, with all contacts being invited to take part in the survey. Three reminders were sent to those who had not completed the survey to encourage them to take part. Further to this,

contacts who had not completed were invited to complete the survey by telephone (where telephone numbers were available). Contacts who had been successful in their application for funding but had not completed the survey were also approached by representatives from the Challenge to encourage them to take part.

Sample composition

The full, de-duplicated sample of the survey consisted of 226 individuals for the most recent iteration of the survey (227 for the baseline). Table 26 shows the main way in which each of these contacts had engaged with the Challenge. In total, 69 individuals completed the survey at the process and interim impact phase, which represents an overall response rate of 31%. This is higher than the response rate obtained at the baseline (57 responses, representing a 25% response rate). Response rates broken down by the main form of engagement with the Challenge are shown in Table 2627. These show that those who had not applied for funding were substantially less likely to respond to the survey at both iterations. The response rate among successful funding applicants is 78%, an improvement compared to the baseline (cf. 31%).

Table 26 Main engagement with the Challenge

	Baseline		Process and interim impact	
	Count of individuals	Percentage of individuals	Count of individuals	Percentage of individuals
Successful application for funding	102	45%	112	50%
Unsuccessful application for funding	21	9%	20	9%
Engage With presenters	40	18%	39	17%
Letters of support	56	25%	48	21%
Advisory group	8	4%	7	3%
Total	**227**	**100%**	**226**	**100%**

Source: BMG

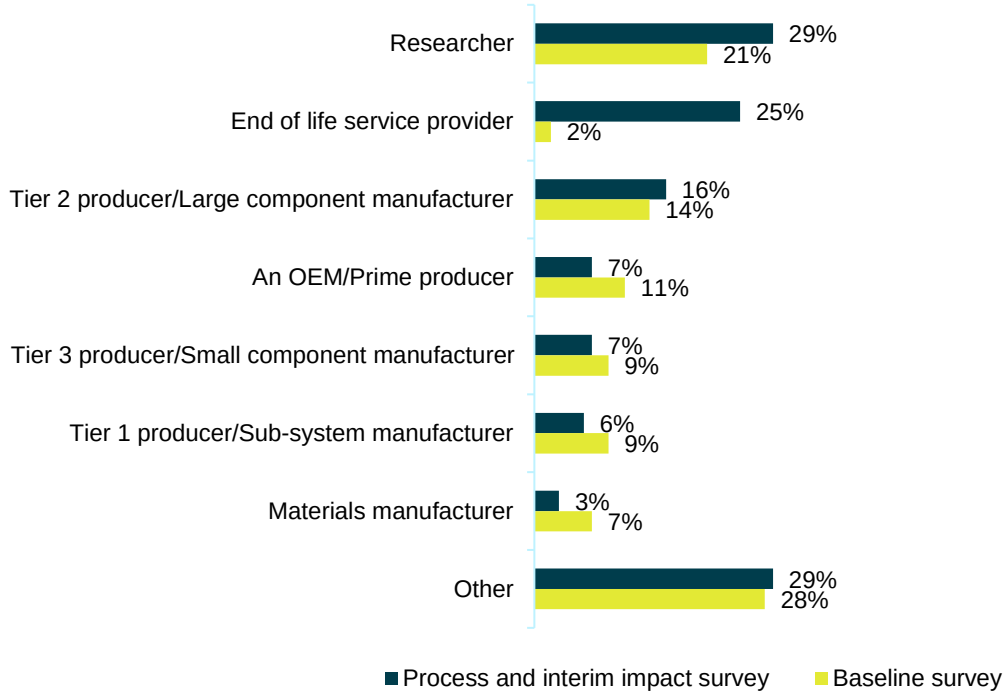
Table 27 Response rate by main engagement with the Challenge

	Baseline		Process and interim impact	
	Completed interviews	Response rate	Completed interviews	Response rate
Successful application for funding	32	31%	54	78%
Unsuccessful application for funding	4	19%	4	6%
Engage With presenters	7	18%	4	6%
Letters of support	7	13%	6	9%
Advisory group	7	88%	1	1%
Total	**57**	**25%**	**69**	**31%**

Source: BMG

Within the survey, respondents were asked to categorise their involvement in the PEMD sector. They were asked to select, from a list, the response that they thought best described their organisation in relation to the PEMD sector. Respondents were only able to select one response. Figure 32 shows how the individuals who completed the survey categorised their organisation. Just under three in ten (29%) classed themselves as a researcher. The next most common group was end of life service providers (25%), followed by tier 2 producers (16%). Some of the responses given in the 'other' category included industry bodies, Catapults and training providers.

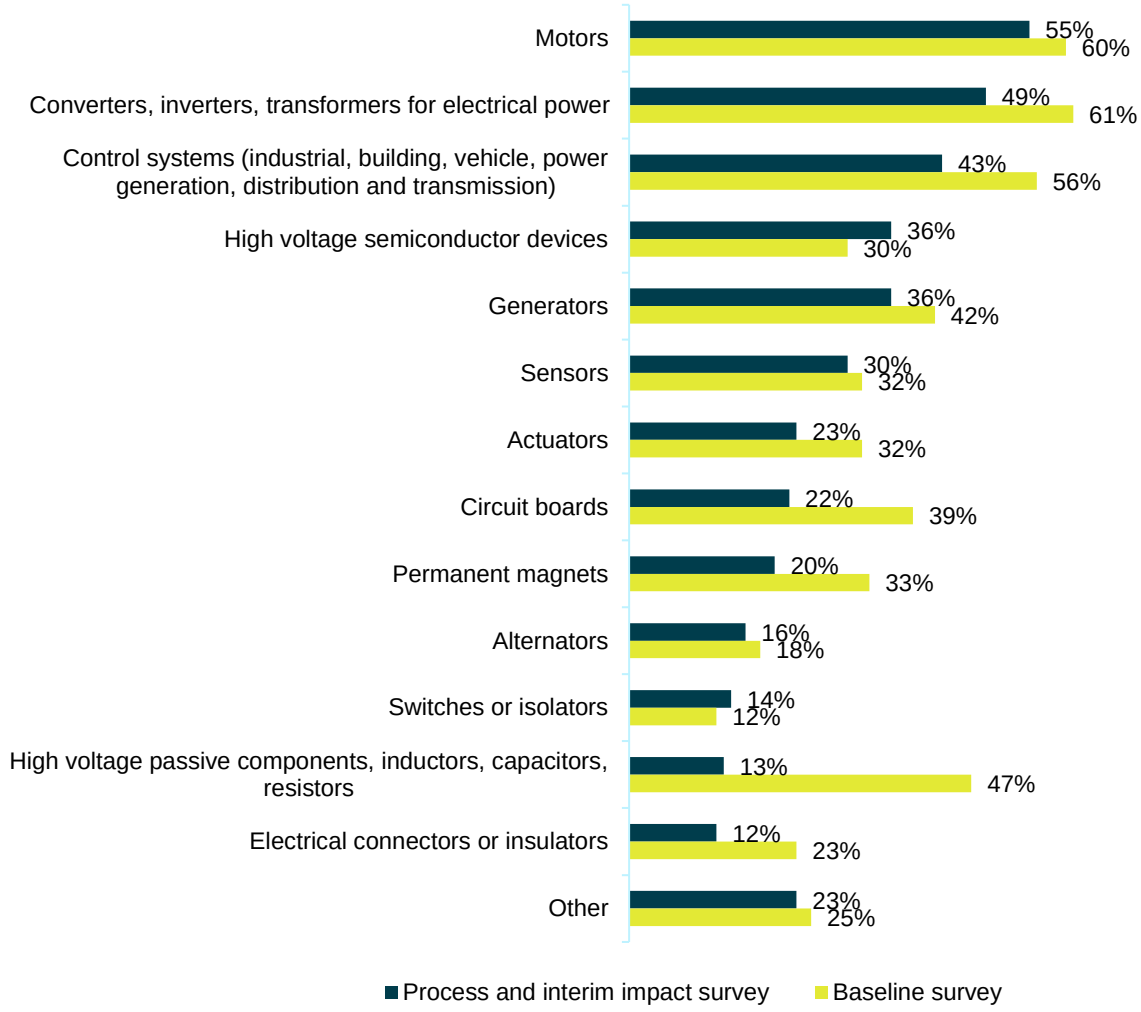
Figure 32 Involvement with PEMD sector



Source: Contact survey. A1. Which of the following best describes your organisation in relation to the PEMD sector?
Note: Base: all respondents – process and interim impact (69) and baseline (57).

Survey respondents were also asked which specific technologies their organisation focused on in relation to PEMD. Again, they were asked to select from a list of technologies but, in this case, they were able to select multiple types if their organisation was involved with more than one technology. The results are presented in Figure 33. The most common technology areas to be involved with are motors (55%) and converters, inverters, transformers for electrical power (49%). The next most common areas are control systems (43%), high voltage semiconductor devices (36%), generators (36%) and sensors (30%). All of the remaining areas were selected by less than 30% of respondents.

Figure 33 PEMD technology area



Source: *Contact survey. A4. Which of the following areas does your organisation or research group focus on in relation to the design and development of PEMD technologies?*

Note: *Base: all respondents – process and interim impact (69) and baseline (57).*

Survey methodology

A mixed-mode approach was used for the survey, encompassing both online and telephone interviews. This mixed-mode approach was employed to maximise response rates and to utilise the sample and resources available as much as possible.

Forty-one of the contacts provided did not include any telephone numbers. This group included all of the 'Engage with' and Advisory Group contacts, and a small number from the 'letters of support' group and 'successful applicants' group. As no telephone details were available for these contacts, they were only invited to complete the survey via email.

The online and telephone surveys had the same content and the only differences were small wording tweaks to ensure that the question text made sense to the respondent if it was read out by an interviewer over the phone or if it was read on a screen by a respondent completing the online survey.

The survey was designed around the evaluation framework and aimed to answer the research questions in the framework where other sources of primary or secondary information were not available.

While the survey collected a range of useful data and inputs from PEMD sector organisations, it should be noted that there are some limitations to the achieved sample for this baseline evaluation. Some questions were only asked of businesses as they referred to aspects such as turnover, other characteristics and research and development activity. As such, responses from these questions are based on 32 responses or fewer. While this number is large enough to indicate patterns at a total level, it is not sufficient to allow for sub-group analysis.

Survey questionnaire

Below are the types of question used and topics covered for the survey.

Background

- Which of the following best describes your organisation in relation to the PEMD sector?
- What proportion of your organisation's business is focussed on PEMD technologies?
- Which of these bands would best describe the proportion of your organisation's business that is focussed on PEMD technologies?
- What proportion of your organisation's business do you expect to be focussed on PEMD technologies in 3 years' time?
- Which of the following areas does your organisation or research group focus on in relation to the design and development of PEMD technologies?
- Which of the following best describes where your organisation's headquarters is?
- And what regions, other than the UK, does your organisation do work in?
- What region of the UK is your headquarters in?
- And where does the majority of your organisation's work in the PEMD sector take place in the UK?
- How many members of staff does your organisation currently employ in the UK?
- Has the Driving the Electric Revolution Challenge had an impact on the number of employees you have hired in the past 2 years?
- Which of the following bands would best describe your UK turnover for the previous financial year?
- In which of the following ways have you engaged with the Driving the Electric Revolution Challenge?

Perceptions on UK progress

- Overall, how would you rate the UK's current reputation as a centre for innovation in PEMD technology? Please use the same scale.
- 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.

- Has your organisation conducted any first of a kind PEMD pilots in the UK in the previous financial year? 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.
- And does your organisation expect to conduct any first of a kind PEMD pilots in the UK in the next financial year?
- Roughly how many companies involved in the PEMD supply chain do you think there are currently in the UK?
- Which of the following best describes the current UK PEMD supply chain?
- And which of the following best describe how you expect the UK PEMD sector to change over the next few years?
- And which of the following best describe how you expect your business to change over the next few years?
- How has your growth projection been impacted as a result of your engagement with the Driving the Electric Revolution Challenge?

Design and delivery of competitions

- How efficient or inefficient did you find each of the Driving the Electric Revolution Challenge processes?
- Thinking about the Driving the Electric Revolution Challenge competitions, including the application process, how much do you agree or disagree with the following statements? (Statements are related to whether the Challenge has facilitated collaboration between different organisations)
- How well do you think the Driving the Electric Revolution Challenge aligns with other government initiatives in the UK?
- Which UK government initiatives were you thinking of when you answered the previous question?
- If your application for funding had been declined, would you have taken the project forward in any form?
- At the start of your engagement with the Driving the Electric Revolution Challenge, what level of development was the manufacturing process at in terms of Manufacturing Readiness Level (MRL)?
- And what level do you expect the manufacturing process to reach at the end of period covered by the Driving the Electric Revolution funding?
- Have you received any public grants or private investment as a result of your engagement with Driving the Electric Revolution Challenge?
- Do you expect to secure any further public grants or private investment as a result of your engagement with the Driving the Electric Revolution Challenge?
- How much private finance has your organisation received as a result of your engagement with the Driving the Electric Revolution Challenge?
- How much public funding has your organisation received as a result of your engagement with the Driving the Electric Revolution Challenge?

Collaboration

- How many of the types of partners are you currently collaborating with on PEMD projects?

- And how successful would you say these collaborations are?
- How much do you think the Driving the Electric Revolution (DER) Challenge has impacted collaboration in general?
- How informative did you find the communications from the Driving the Electric Revolution Challenge?

Research, development and demonstration

- In your most recent financial year, how much did your company spend on research, development and demonstration activities?
- How, if at all, did your UK RD&D spend change compared to the year before?
- How much of an impact, if at all, did the Driving the Electric Revolution Challenge have on how much your company spent on research, development and demonstration activities?

DER-IC and knowledge transfer activities

- Did you know that the DER-IC's four sites were available to use before today?
- And have you made use or are you planning to make use of the DER-IC sites?
- Do the DER-IC sites offer valuable facilities for organisations across the PEMD sector?
- How effective do you think the open access, contract-based model of the DER-IC is in meeting current industry needs?
- To what extent do you agree or disagree with the following statements about the DER-IC's knowledge transfer activities? (Statements relate to whether knowledge transfer activities have engaged a wide range of organisations within and across the PEMD sector.)

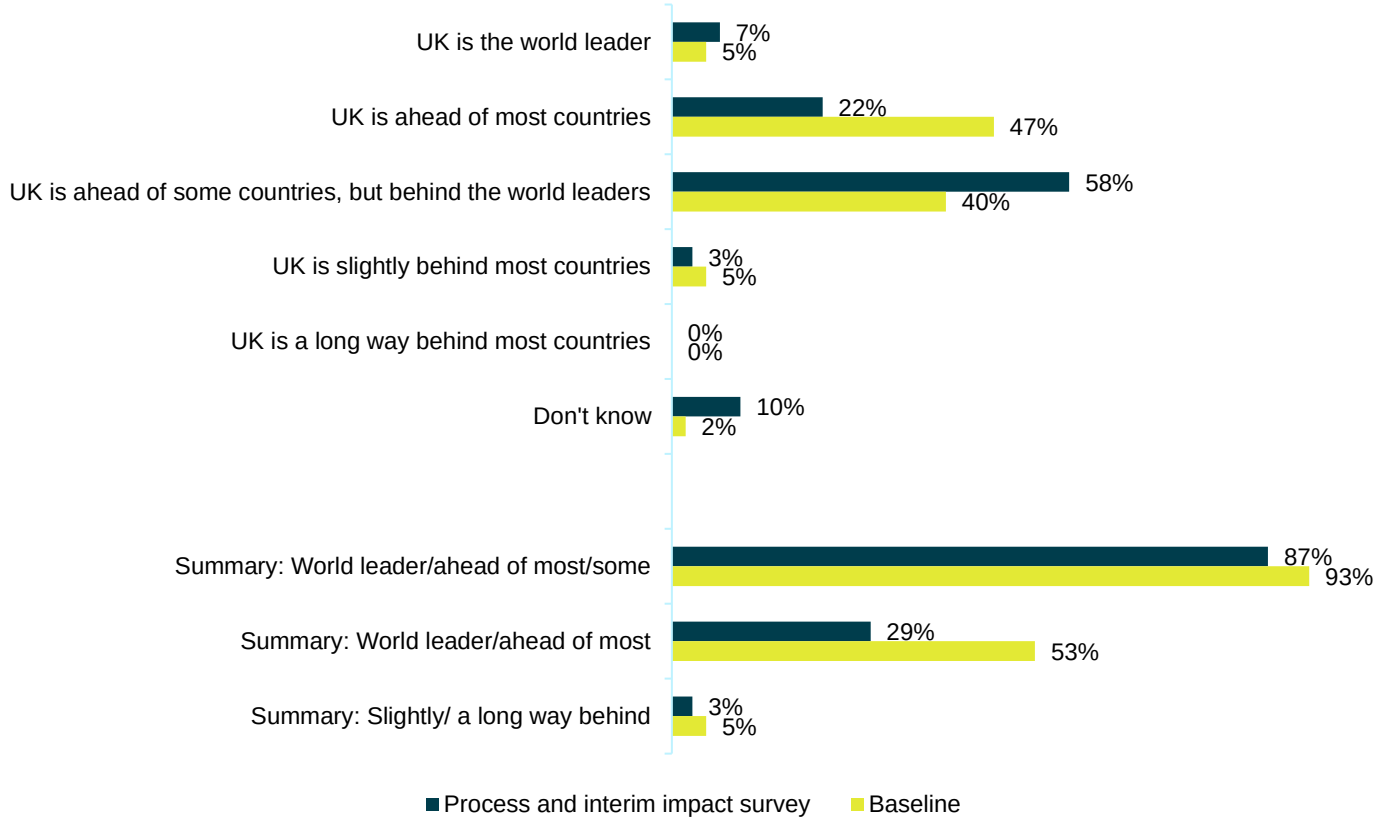
Survey results

Theme 1 – Has the Challenge accelerated innovation and commercialisation of PEMD technologies?

Most stakeholders do not see the UK as the world leader in terms of innovation in PEMD technology, but businesses are expecting more focus on PEMD compared to the baseline results

The Challenge aimed to promote the UK as a centre of innovation and excellence in PEMD manufacturing processes. In order to gauge stakeholders' perceptions of the UK's current position, survey respondents were asked whether they considered the UK to be a leader or ahead of most countries in terms of being a centre for innovation in PEMD technology. The evidence from the survey shows that 29% of survey respondents considered the UK to be the world leader and the majority of stakeholders (58%) considered the UK to be ahead of most countries but behind the world leaders (Figure 34). Compared to the baseline results, there was a decrease of 24 percentage points in those that considered the UK to be the world leader (29% cf. 53%), and this decrease was accompanied by an increase in those who believed that the UK was ahead of most countries but behind the world leaders (58% cf. 40%).

Figure 34 UK position compared to other countries as a centre for innovation in PEMD technology



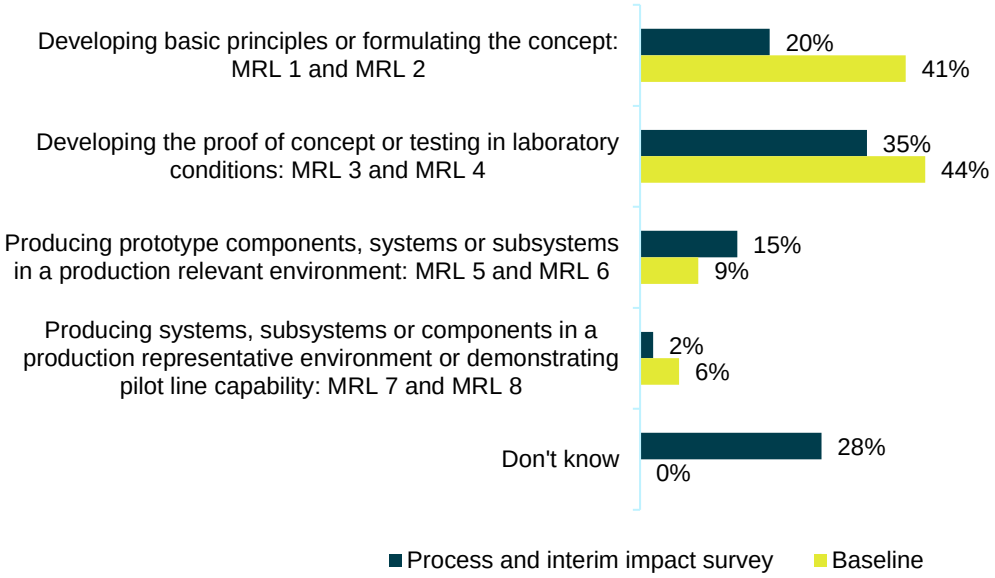
Source: *Contact survey. B2. Overall, how would you rate the UK's current reputation compared to other countries as a centre for innovation in PEMD technology?*

Note: *Base: all respondents – process and interim impact (69) and baseline (57).*

The Challenge has had a positive impact on increasing MRL levels for businesses

Figure 35 shows that most respondents were at MRL levels below 4 before their engagement with the Challenge began, while Figure 36 shows that the majority (63%) expected the manufacturing process to be at least MRL 5 or 6 at the end of their engagement with the Challenge.

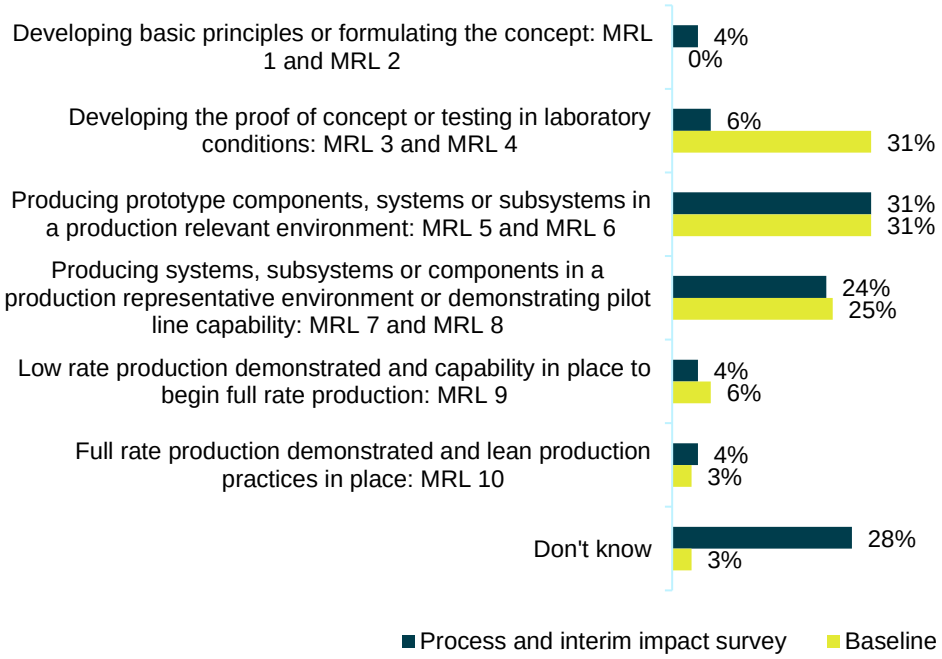
Figure 35 Stage of MRL development at the start of engagement with the Challenge



Source: *Contact survey. C4. At the start of your engagement with the Driving the Electric Revolution Challenge, what level of development was the manufacturing process at in terms of Manufacturing Readiness Level (MRL)?*

Note: *Base: successful applicants – process and interim impact (54) and baseline (32).*

Figure 36 Expected MRL at the end of Driving the Electric Revolution Challenge funding



Source: *Contact survey. C5. And what level do you expect the manufacturing process to reach at the end of period covered by the Driving the Electric Revolution Challenge funding?*

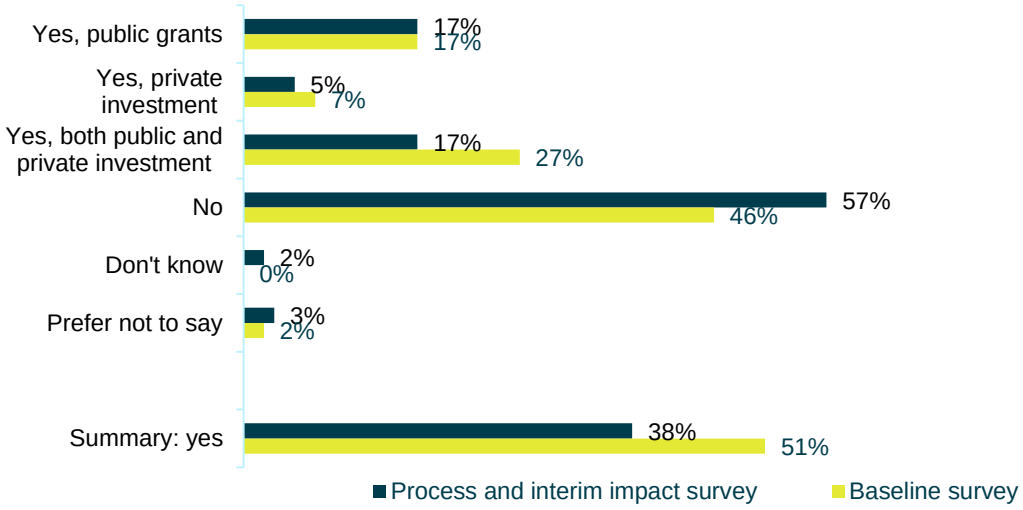
Note: *Base: successful applicants – process and interim impact (54) and baseline (32).*

Theme 4 – Has the Challenge increased the value of investment in UK PEMD companies?

A significant proportion of respondents have already received other public funds after interacting with the Challenge

According to the survey results, 38% of respondents who had been successful in their application for funding or who had engaged with the DER-IC, had received other funding as a result of their engagement (Figure 37). Of those who had received other funding, public funding was the most common. As outlined in section 5, 53% of survey respondents expected to receive further funding through engagement with the Challenge. Compared to the baseline, a lower proportion of respondents reported having received both public and private investment (17% cf. 27%).

Figure 37 Receipt of other private or public funds



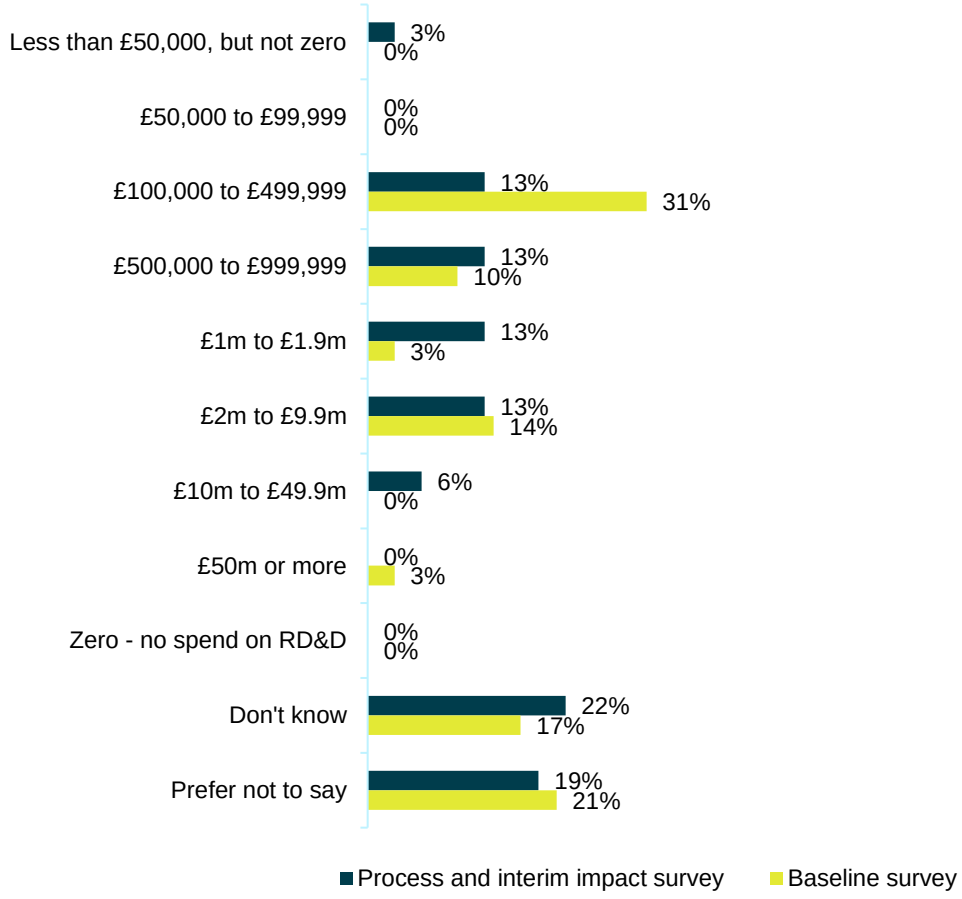
Source: *Contact survey. C6. Have you received any other/public grants or private investment as a result of your engagement with the Driving the Electric Revolution Challenge?*

Note: *Base: successful applicants or have engaged with the DER-IC – process and interim impact (60), baseline (41).*
Where total figures may seem to differ slightly from the summation of the individual figures, this is due to rounding.

Most of the businesses the Challenge has interacted with have spent between £100,000 and £2 million in RD&D

To provide some context on the Challenge's impact on RD&D spend, business respondents were asked how much they had spent on RD&D activities in the most recent financial year. Most respondents had spent between £100,000 and £2 million on RD&D. It is worth noting that sizeable proportions either did not know (22%) or preferred not to say (19%) (Figure 38).

Figure 38 Amount spent on research, development and demonstration activities in the most recent financial year

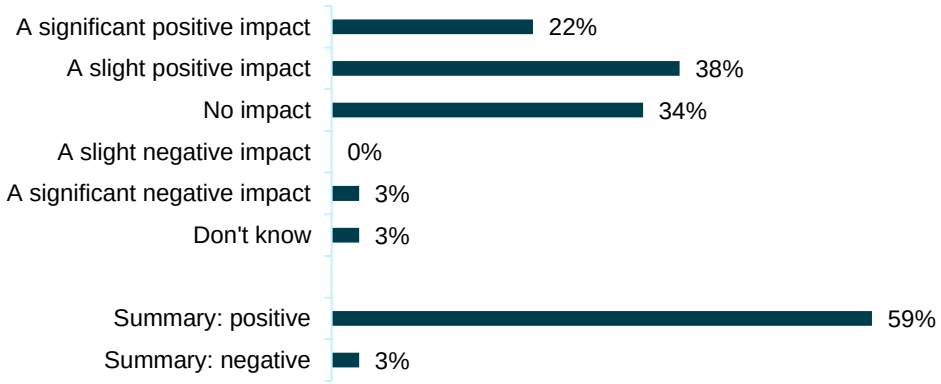


Source: *Contact survey. E1A/E1B. In your most recent financial year, how much did your company spend on research, development and demonstration activities? We are interested in all research, development and demonstration activities undertaken in the reporting period either for the business or for a customer. This should be the total cost of RD&D conducted by the business, regardless of the source of funds or their treatment.*

Note: *Base: all respondents – process and interim impact (69) and baseline (57).*

The interpretation of the survey results represented in Figure 39 has already been discussed in Section 4.4 above, and will not be repeated here.

Figure 39 Impact of the Challenge on RD&D spend



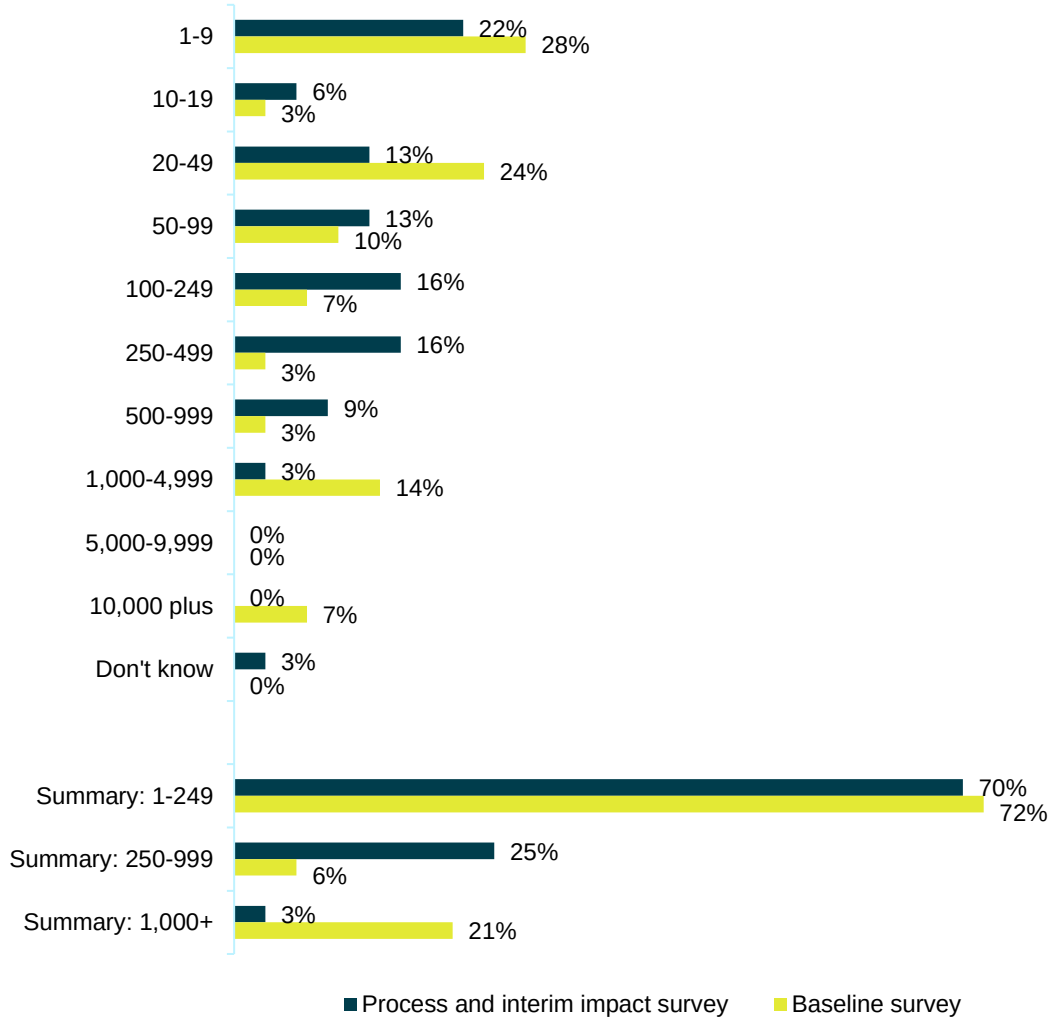
Source: *Contact survey. E1A/E1B. In your most recent financial year, how much did your company spend on research, development and demonstration activities? We are interested in all research, development and demonstration activities undertaken in the reporting period either for the business or for a customer. This should be the total cost of RD&D conducted by the business, regardless of the source of funds or their treatment.*

Note: *Base: businesses – Phase 3 (32).*

Theme 6 – Did the Challenge lead to an expansion of UK PEMD manufacturing capacity?

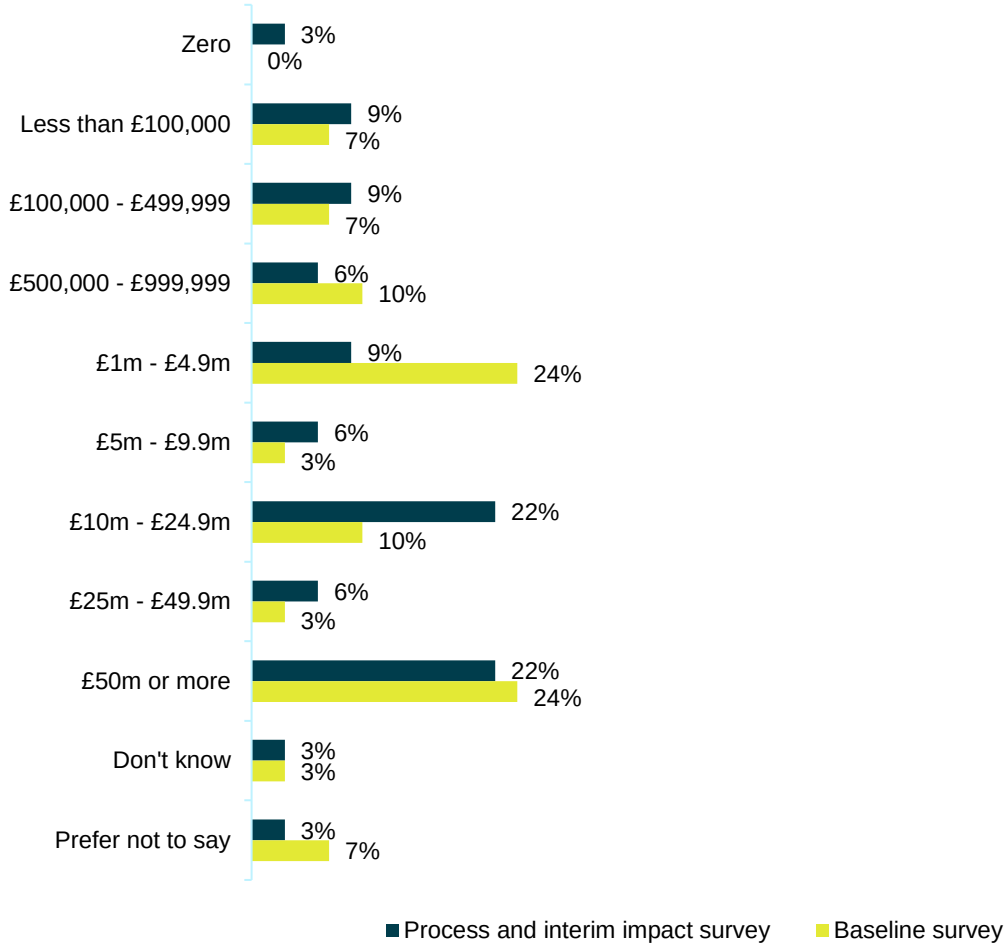
In order to gauge the impact of the Challenge on growth projections and number of employees, the survey asked respondents to report on their current business structure. The majority of businesses in the survey had between 1 and 249 full-time employees (Figure 40), and 27% had a UK turnover of less than £1 million in the previous financial year and 34% had a UK turnover of between £5 million and £50 million (Figure 41). This turnover included any non-PEMD operations as well as any PEMD operations. It is important to note that only 25% of surveyed businesses as part of the baseline reported that 100% of their organisation's business was focussed on PEMD technologies. Nearly a quarter (22%) reported that PEMD technologies accounted for 10% or less of their organisation's business. This was even higher amongst business respondents who had been successful in their DER funding application (27%). This suggests that the economic activity of businesses involved in the PEMD supply chain is often only partially related to PEMD.

Figure 40 Number of full-time employees



Source: Contact survey. A7A/A7B. Which of these bands would best describe the number of UK full-time equivalent employees at your organisation?
.Note: Base: businesses – process and interim impact (32) and baseline (29).

Figure 41 UK turnover in the last financial year



Source: *Contact survey. 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.*

Note: *Base: businesses – process and interim impact (32) and baseline (29).*

Theme 7 – Did the Challenge drive environmental, societal and policy benefits?

The survey results show that the Challenge has mostly targeted UK-based companies. As shown in Figure 42, nearly all business respondents who were successful in their application for Driving the Electric Revolution Challenge funding (82%) are headquartered in the UK. The most common regions to work in are the European Union, Asia and North America.

Survey respondents were then asked to specify the regions their headquarters were based in within the UK. Figure 43 shows that 36% of business respondents who had been successful in their application for funding had their headquarters in the South East and there was a similar split in the West Midlands and East Midlands (14%). The areas where these organisations said they undertook the majority of their work correlated heavily with where their headquarters were.

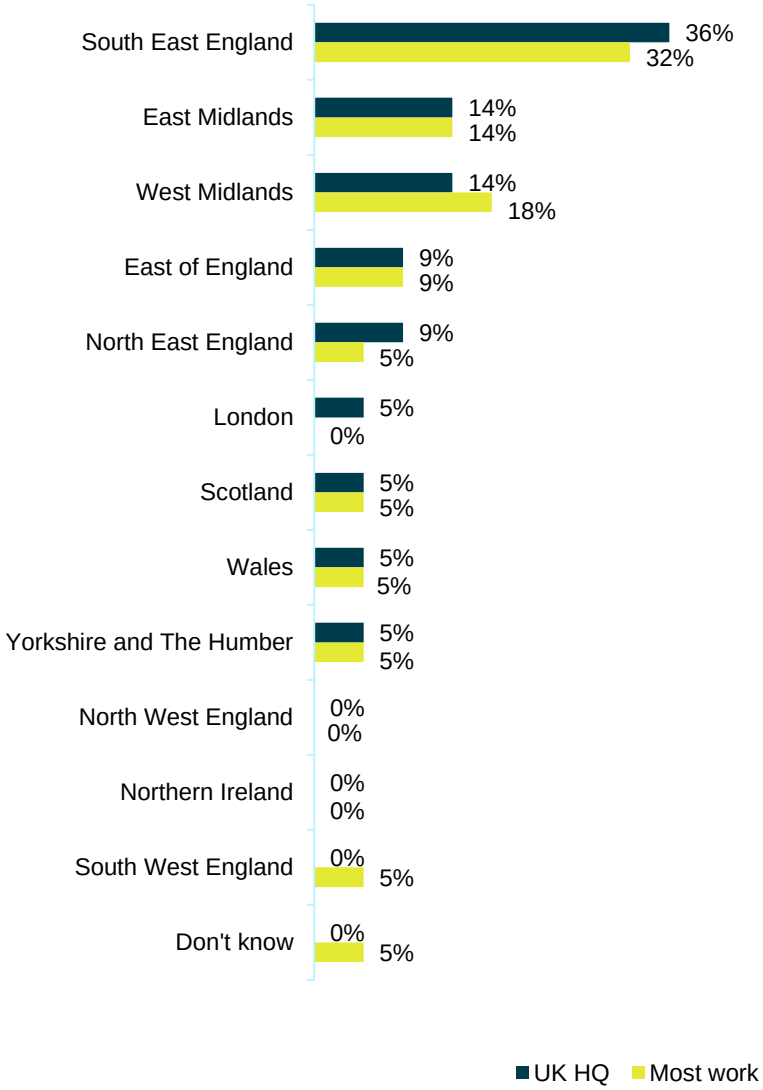
It is important to note that this does not contradict our results from the DER monitoring data, which show that only 11% of projects took place in the South East and the region only received 7% of the total Challenge funding. This is because results for this survey question were based on a small sample size of 22 business respondents, and therefore they are not completely representative of all competition winners. As outlined in the sources of the survey above, the discrepancy therefore is likely due to the respondents who took part in the survey, who seemed to be more skewed towards the South East.

Figure 42 Headquarters and international operations of winning companies

Source: *Contact survey. A5A. Which of the following best describes your organisation?*

Note: *Base: all businesses that were successful in their Driving the Electric Revolution Challenge application – process and interim impact (22), baseline (18).*

Figure 43 Location of HQ and area of most work for winning companies



Source: *Contact survey. A5C. What region of the UK is your UK headquarters in? A5D. And where does the majority of your organisation's work in the PEMD sector take place in the UK?*

Note: *Base: all businesses that were successful in their Driving the Electric Revolution Challenge application – process and interim impact (22).*

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Annex C Analysis of monitoring data

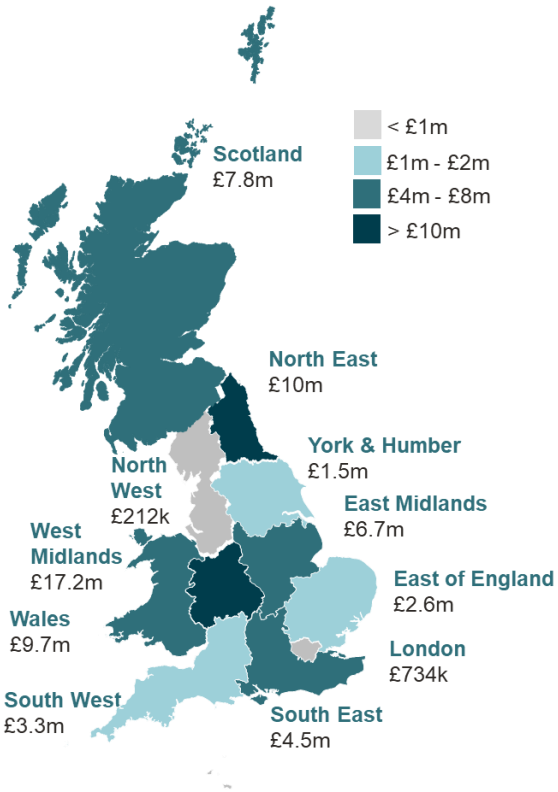
This Annex contains an in-depth account of the data and analysis underpinning the commentary on monitoring data given in Section 4.

Challenge ED&I (Theme 7)

The Challenge provided data on the count and value of competition winners by region for 2019-2021 from internal data designed to monitor the impact of activities on ED&I measures including levelling up. This data informs understanding of how the Challenge is investing in different regions. The raw dataset included £33 million received by the DER-IC, which was allocated in full to Newcastle University. We supplemented the data with figures provided by the head of the DER-IC on how the £28.5 million of this funding for capital expenditure was distributed across the regions. We further assume that the £4.5 million in operational expenditure was evenly distributed between the DER-IC regions. Total grants – including the funding to the DER-IC – amounted to £64.5 million, and there are 138 projects and 190 participants across the UK.

Figure 44 reflects the findings from Section 4 of our report that 90% of the Challenge's funding through competitions and the DER-IC has been given outside of London and the South East, and that more funding has been focussed on predominantly automotive regions – West Midlands (28%), North East (16%) and Wales (15%) – compared to other regions that could have a use for PEMD – Yorkshire (2%) and North West (<1%).

Figure 44 Grants received in each region



Source: Frontier Economics

Comparing the total investment received and the number of projects across the regions, we can see that on average more expensive projects have tended to be in the North East and Scotland, and cheaper projects in the North West and London.

Table 28 Competition funding by region

Region	Grant (£)	Projects	Participants	Average grant per project (£)
North East	£9,974,127	10	14	£997,413
North West	£212,806	3	3	£70,935
Yorkshire and the Humber	£1,520,948	10	10	£152,095
East Midlands	£6,706,495	20	27	£335,325
West Midlands	£17,251,429	24	41	£718,810
East of England	£2,614,153	13	17	£201,089
London	£734,799	7	8	£104,971
South East	£4,559,587	16	22	£284,974
South West	£3,350,522	9	11	£372,280
Wales	£9,709,754	17	27	£571,162
Scotland	£7,844,431	9	10	£871,603
Total	**£64,479,051**	**138**	**190**	**-**

Source: Frontier Economics

Challenge investment data (Theme 4)

The Challenge provided us with internal data that monitors co-investment. This is split into four categories:

- **Pledged co-investment (Type 1):** Investment that consortia declare and plan to spend on Challenge-funded R&D projects;
- **Accompanying co-investment (Type 2):** Extra public (non-UKRI) and non-public investment in R&D over and above that pledged in business cases or project plans but made in order to achieve the agreed objectives;
- **Aligned co-investment (Type 3):** Investment in a technology or R&D projects considered close to, and evidently prompted by, a Challenge-funded R&D project, for example investment that specifically mentions the Challenge and results from increased confidence in the technology area; and
- **Follow-on co-investment (Type 4):** Investment to take to market or exploit outcomes from Challenge-funded R&D projects. This often involves combining with other technology intellectual property to achieve a commercial project.

Table 29 captures the difference between total eligible project costs and the grant offered. It is calculated at the project level, according to latest system data for each quarter, and is projected over time from the start date of the project. All other co-investment values are aggregated annually at Challenge level and are

reported by project partners and recorded based on the date that the values are submitted. The data shows cumulative co-investment up to the latest year, so it is sufficient to focus on 2022 levels of co-investment. We note that this is gross investment data which does not attempt to capture any sense of counterfactual or additionality (i.e. how much of this investment would have been made absent the Challenge, whether in the same investment project or alternatives).

We note that the these four types of co-investment can be both committed and realised co-investment. Co-investment is recorded as committed as soon as the grant letter is signed. As partners start spending the funds for the projects, co-investment becomes realised.

As outlined in Section 4, the Challenge has exceeded its co-investment target and consequently adjusted its forecast up. To actually achieve these targets, committed co-investment would need to be realised, but the Challenge is on track. The next evaluation phase will be able to shed more light on whether total co-investment levels have been in line with the Challenge's expectations.

The split between co-investment categories is not even. The scale of desired co-investment in the original aims of the Challenge – £154 million compared with the £80 million of public investment – meant that the Challenge was unlikely to be able to achieve this level of co-investment through just pledged and accompanying co-investment. Hence aligned and follow-on investment were always expected to take on a significant role. The significant contribution of aligned co-investment compared to pledged and accompanying co-investment is therefore not a surprise, and more follow-on co-investment is expected in the future.

Table 29 Cumulative co-investment (2022) by type

Co-investment type	Committed (£ /%)	Realised (£ /%)	Total (£)
Pledged	£10.3m / 10%	£0.2m / 0%	£10.5m
Accompanying	£0.0m / 0%	£2.3m / 3%	£2.3m
Aligned	£95.0m / 90%	£85.1m / 95%	£180.1m
Follow-on	£0.0m / 0%	£2.3m / 3%	£2.3m
Total	**£105.3m / 100%**	**£89.9m / 100%**	**£195.2m**

Source: Frontier Economics

Innovate UK KTN Data (Theme 5)

Innovate UK Knowledge Transfer Network (KTN) collects data on the total number of contacts in its databases and the events they hold. These can be attributed to the Challenge, and therefore can be used as descriptive evidence on the size of the PEMD ecosystem that the Challenge interacts with and the level of engagement of its members. The data includes:

- The contact database of Innovate UK KTN: contains individual contacts related to the PEMD sector and serves as a proxy for the Challenge's reach.
- Three other datasets that proxy for measuring engagement:

- Competition events: This data records registration numbers, attendance, questions asked, and requests for introduction during competition events;
- ‘Engage with…’ events: This data records registration numbers, attendance, questions asked, and requests for introduction at webinars and events. The events include ED&I workshops which aim to raise awareness of ED&I issues within the community, as well as engagement events with specific organisations that are active within the PEMD sector; and
- Marketing data: A record of PEMD-related emails and newsletters sent and the opening rates, as well as DER website view statistics.

The trends in the contact database, registrations for events and attendances at events were discussed in more detail in Section 4 but appear to show that the Challenge has increased its reach over time while engagement has stayed reasonably constant.

- This variation over time is driven both by variation in the number of events and in the number of registrations per event. There were up to seven separate events per month across the period, with most months having between two and four events. Engagement can be seen to have picked up during competitions, and the types of competitions taking place seem to have been an important factor in driving engagement, as a higher number of competitions in each year does not necessarily associate with higher numbers of registrations (Table 30). For instance, the same number of competition events took place in 2021 and in 2022 (up until September), but there was a significantly higher level of engagement in 2021, both in terms of attendance and registration rates. ‘Supply Chains for Net Zero’ were the most attended competitions and contributed to 2021 being a particularly successful year.
- The ‘Engage with…’ webinars were initiated in April 2020 at the start of the COVID-19 pandemic to facilitate the continuation of meetings and engagements with organisations involved in PEMD. Since 2020, 57 ‘Engage with…’ events have taken place, with 3,057 people attending, and leading to 125 new introductions made by Innovate UK KTN between companies for future partnerships and collaboration. Registration for these events does not follow a clear trend and varies based on the event. Most events (45 out of 57) had fewer than 200 people registering for events, and 48 out of 57 had attendance rates of less than 90. Table 31 highlights some events which had particularly high rates of attendance and registration.
- Registration levels generally declined over 2021 but peaked for one event in March 2022 – the ‘Engage with…LIVE!’ event – which was particularly successful with 430 participants, double the second highest registered event recorded. ‘Engage with…LIVE!’ was initiated at the end of the COVID-19 lockdowns, with the aim of enabling leading companies and organisations involved in PEMD to meet, engage and network in person. The number of registrations for this event may demonstrate that in-person PEMD networking events could provide an effective platform to engage the community and may also reflect the desire among the community for a return to in-person events as the pandemic restrictions were eased.

Table 30 Innovate UK KTN data on competitions

Year	Number of competitions	Attendance	Registrations
2019	3	154	188
2020	12	996	1248
2021	8	1012	1576
2022	8	255	316

Source: Frontier Economics analysis of Innovate UK KTN data

Table 31 Innovate UK KTN 'Engage with…' events with high attendance

Date	Event	Attendance	Registrations
March 2022	Engage with...LIVE!	275	430
August 2020	Engaging a Diverse Workforce for the Future	140	209
January 2021	Engage with... McLaren Applied	138	224
April 2021	Engage with... YASA	99	226

Source: Frontier Economics analysis of Innovate UK KTN data

In terms of other elements of the Innovate UK KTN data that we looked at:

- From the marketing data, the average open rate of emails related to DER newsletter and briefing updates was 35% over a three-month period in 2020, and the average click rate (those opening the links provided in the email) was 15%. We do not have time series or benchmark data to compare these figures to.
- In terms of the statistics provided on the number of views of the DER programme website, there is a monthly average of 265 views between September 2020 and August 2022.

Annex D Materials for the process evaluation

Delivery lead interviews

Interviewer instructions

This topic guide is intended to be used in a flexible way. It is not meant to be read out word by word. You should follow up on any emerging theme that would be of value to the research objectives.

Introduction and briefing (3 minutes)

- Thanks for agreeing to take part.
- Researcher to introduce themselves & BMG, independent social research agency.
- Explain interviews form part of UKRI's process evaluation of the Challenge.
- UKRI will use the information we collect to understand how the processes of the Challenge were implemented, any issues that were encountered and any remedial action that was taken.
- We will not reveal the identity of those who take part in these interviews. However, UKRI may be able to identify you given the reduced number of delivery leads that we can talk to. If there's anything you say that you'd rather keep off the record, then please do let us know.
- These interviews will contribute to providing the research team with an understanding of how the different strands of the Challenge operate and we will use the content of these discussions to feed into the reports that we will deliver to UKRI, in combination with a wide range of primary and secondary information sources. This will form part of the process evaluation, which will be followed next year by a final impact evaluation.
- There are no right or wrong answers: it's just your views or opinions that count. What you don't know is as important as what you do know.
- We would like to audio-record the discussion for the purposes of accurately capturing all the information you share with us. The audio will be used for analysis purposes only and will not be shared with anyone outside of BMG Research. All recordings will be securely destroyed on completion of this study.

Provide opportunity for respondent to ask any questions. Seek permission to audio-record. Switch microphone on. Once switched on, confirm that the audio-recorder is on for the benefit of the tape.

Warm Up (5 minutes)

- Ask respondent to introduce themselves:
- First name
- DER strand involved with (competitions, industrialisation centres/knowledge transfer, skills gaps, DER-wide delivery lead)
- Role and responsibilities within DER

Design and Delivery (15 minutes)

COMPETITIONS [ASK IF RELEVANT STRAND]

- Can you provide us with an overview of how the competitions were structured originally and how they are being delivered?
- [SHOW PROCESS MAP and check whether the participant understands the process in the same way]
- How efficiently are the competitions being delivered? Could this process be improved? If so, how?
- How did you encourage applications from across the PEMD sector? Did this happen from the beginning or did remedial action take place to encourage greater participation from certain sectors?

DER-IC [ASK IF RELEVANT STRAND]

- Can you provide an overview of how DER-IC is structured and how it operates?
- To what extent do you consider the industrialisation centres to have reached their intended audience?
- Are any potential audiences underrepresented or not fully represented in DER-IC? Which ones? Why?
- To what extent is the design and delivery of the Industrialisation Centres supporting the Challenge to achieve its objectives?
- Thinking about the companies that use the industrialisation centres, what sectors tend to use the industrialisation centres the most? Or is it equally distributed across the PEMD sector?
- Are there sectors that could benefit from the industrialisation centres which aren't doing so at all or not to the same extent as other PEMD sectors? If so, which ones? Why is this?

KNOWLEDGE TRANSFER ACTIVITIES [ASK IF RELEVANT STRAND]

- Can you provide an overview of how the knowledge transfer activities are structured and how they operate?
- To what extent do you consider the knowledge transfer activities to have reached their intended audience?
- Are any potential audiences underrepresented or not fully represented in knowledge transfer activities? Which ones? Why?

- To what extent is the design and delivery of the Industrialisation Centres supporting the Challenge to achieve its objectives?

SKILLS GAP ACTIVITIES [ASK IF RELEVANT STRAND]

- Can you provide an overview of how skills gaps activities are structured and how they operate?
- To what extent is the intended design and delivery of the skills gap activities enabling the Challenge to achieve its objectives?
- Would these objectives be met without the skills gap activities? PROBE FULLY
- How do the skills gap activities address the needs of the sector and their supply chains?

Management and Governance of the Challenge (20 minutes)

- In your opinion, how effectively have the different strands of the Challenge worked together so far? *PROBE FULLY*
  - Can you give an example of ways in which [participant's strand] works or exchanges knowledge with the other strands of the programme? What are the benefits of this if any?
  - Do you think that the different strands of the programme could coordinate their work in a more effective way? How?
- Do you think that the Challenge's funding and resources were appropriately split between activities and strands? Why? *PROBE FULLY*
  - Was the funding allocated to any of the activities or strands disproportionately in your view? Why?
- Is the Challenge using its budget as expected?
  - Have any activities or projects incurred any additional costs that were not anticipated? IF YES: Why was this? How was this dealt with?
- In terms of the Challenge governance structure, do you think that decisions were made at the right level and in a timely manner?
- Have you encountered any issues or problems in the delivery of any of the Challenge's activities that were not foreseen at the start of the programme?
  - *IF YES:* Was this positive or negative?
  - *IF YES:* What was the impact of this?
  - *IF YES:* How was this dealt with?
- How many organisations are involved in activities/projects related to your strand? What type of organisations are these?
  - Are there any types of organisation or sectors that are not adequately represented in the Challenge?
  - Apart from target competition participants, how has the Challenge engaged with other stakeholders in the sector?
- What processes are in place to ensure organisations working in a given activity communicate with each other and deliver their project on time?

- Have there been any delays or communication issues? IF YES: How was this resolved?

- Were there any targets to attract underrepresented talent from the sector into the Challenge/strand? i.e. women, ethnic minorities, etc
  - *IF YES:* what were these targets? Were they met?
  - *IF NO:* do you feel that women and those from ethnic minority backgrounds are adequately represented in the Challenge/strand?
- Has the Challenge design and delivery facilitated levelling up across UK regions? By levelling up, we mean tackling economic disparities across different regions.
  - *IF YES:* How?
- To what extent does the challenge align with the Government's Net Zero carbon targets? How?
  - What about:
    - Grand Challenges
    - Sector Deals
    - 2.4% R&D expenditure target
    - Other Government initiatives relevant to the sector?

Delivery and outcome monitoring (10 minutes)

- Are the strand's projects/activities progressing as expected?
- Have any activities/projects been stopped or changed?
  - *IF YES:* Why?
  - *IF YES:* At what stage was it stopped/changed?
  - *IF YES:* Did this incur additional costs or require additional resources?
- What is the process for monitoring the strand's projects and activities and ensure they deliver on their outcomes?
  - Have any activities or projects so far been found to not be fully delivering on their outcomes?
  - How was this spotted?
  - Has any action been taken to rectify this?
- How is the monitoring data quality assured to ensure it is robust?
  - How does this process work in practice?
  - Who is involved in this process?
- Are there any improvements that can be made to delivery and outcome monitoring? If so, what are they?

Wrap Up (2 minutes)

- Is there anything else that you would like to say about the Challenge in general or your specific strand? Do you have any further comments or feedback?
- Thank and close

Academic and industry workshop topic guide

Introduction and briefing (5 minutes)

Introduction:

- Moderator to introduce themselves and BMG Research
- Thank them for agreeing to take part in the workshop
- Explain about the evaluation of the Challenge and what the process evaluation focusses on
- There are no right or wrong answers
- Please respect the thoughts and opinions of others. We won't be asking you to share any commercially sensitive information, we're interested in your experiences of the Challenge and its processes
- Pease do not talk over others; you will all get a chance to speak
- You don't have to answer any questions you feel uncomfortable answering
- We aren't experts in the PEMD field, so please be patient with us if we ask you to explain any technical points

Purpose of the discussion: BMG, along with Frontier Economics and E4Tech, have been commissioned to carry out an evaluation of the Driving the Electric Revolution Challenge. As part of this we're looking at the processes and set-up of the Challenge and whether there are any lessons that can be learned for future phases of the Challenge or for other similar initiatives. Other stages of our evaluation will focus on the impact of the Challenge and whether it has met its objectives.

Length: The workshop should take no more than 2 hours

Confidentiality: All information you provide will be treated confidentially, which means anything you tell us today will be completely anonymous, and no one will be able to trace the information back to you. We may use some of the things you say in our reports, but we won't reveal who said them and we'll ensure that it's not possible to work out who has said them from the quotes. This is in line with the Market Research Society Code of Conduct.

Recording: We would like to video-record the session for the purposes of accurately capturing all the information you share with us. The video will be used for analysis purposes only and will not be shared with anyone outside BMG Research.

Background and introduction (10 minutes)

- First, let's start with some introductions. Please could you tell us…
  - Your name
  - The organisation you work for
  - Which DER projects you have been involved with

Design and delivery of the DER competitions (30 minutes)

To start we'd like to take you back to the applications process for DER competitions. Just to remind everyone, there have been several rounds of competitions so far:

1. Accelerated supply chain development strand 1 – September 2019
2. Accelerated supply chain development strand 2 – September 2019
3. Catalysing green innovation – advancing PEMD supply chain – Summer 2020
4. Business led innovation in response to global disruption – Early Summer 2020
5. Supply chains for Net Zero – June 2021
6. Skills competitions – Early 2022 *[NOTE PARTICIPANTS ARE UNLIKELY TO HAVE BEEN INVOLVED IN THIS COMPETITION]*

- How did you first hear about the Challenge and the competitions?
- Are these channels that you would usually use?
- In your opinion, have the competitions reached the relevant organisations in the sector? Why/why not? What more could they have done to target the sector?
- How much do you think the competitions align to industrial needs? Were your projects things you were working towards already, or were they a new focus for your organisation?
- [INDUSTRY GROUP ONLY] Do the competitions align well with the needs of your supply chains? How/how not?
- Are there any areas you wish were covered by the competitions that weren't? What are these?
- How long did it take for your organisation to prepare your application or applications?
- Were there any aspects that took longer than you thought they would, or were more difficult? Did you have any issues? Probe for:
  - Engagement sessions
  - Finding relevant partners
  - Filling in the application
  - Submitting the application
  - Interview process
  - Being notified of the decision
- How efficient do you think the applications process is? Why do you say that?
- Did you form any partnerships or consortia as part of your applications?
- What types of organisations were these partnerships with? Probe for:
  - Academics and research *[INDUSTRY GROUP ONLY]*
  - Industrial partners
  - Non-sector companies
  - International companies

  - SMEs
  - Large companies
  - Companies in your supply chain *[INDUSTRY GROUP ONLY]*
- Had you worked with these partners before? If not, how did you decide who to approach and how did you approach them?
- Why did you choose the partners that you did? Did the conditions of the competitions encouraged you to seek partners that you otherwise wouldn't have?
- Was there anything in the competitions process that supported you in forming partnerships? How did it support you?

Delivery and outcome monitoring (15 minutes)

I'd now like to talk about the delivery and monitoring processes. This includes the quarterly meetings with your Monitoring Officer, kick off meetings and ongoing monitoring as well as close out reports if your project has reached that stage.

- How have you found the monitoring process?
- What benefits do you get out of the monitoring process? Probe for:
  - Help from the Monitoring Officer with challenges you're facing
  - Ability to determine if the project is running to schedule
  - Financial monitoring
  - Improvements to your processes or ways of doing things
- Have the quarterly meetings been helpful? If so, how?
- Has any of the monitoring changed the way that you've gone about delivering your project?
- Were any delivery or performance issues raised during monitoring? If so, how were these responded to?
- How useful has the monitoring process been in helping you to understand whether you are on track or not?
- Is there anything you would change about the monitoring process?

Management and governance of the Challenge (15 minutes)

I'd now like to talk a little bit about the engagement that the Challenge has done. This includes the Engage With sessions, events, emails and information that they have sent out.

- In what ways have you engaged with the Challenge? Probe for:
  - Engage With sessions – how frequently did they attend
  - Face to face events
  - Online events
  - Email communication
  - Briefing sessions

- Anything else?

- How well do you think the Challenge has engaged the industry? Are there any parts of the PEMD sector that you don't think have been engaged as well as others? If so, which areas?
- How effective you do think these wider engagement activities have been in helping the Challenge to meet its objectives?
- How easy has it been to understand what the Challenge is doing and what the opportunities for you are?
  - Was it clear when the competitions would take place and what they were looking for?
  - Were the overall objectives of the Challenge clear?
- How timely was communication from the Challenge? Probe for:
  - Notice of competitions and briefing events
  - Notice of deadlines
  - Notice of other Challenge activities
- How well do you think the Challenge aligns with other government initiatives, such as Net Zero?
  - Are the Challenge's aims complementary with other initiatives? If so, which ones?
  - How much do you think the Challenge have been interacting with other government initiatives? In what way?

Design and delivery of the DER-IC and knowledge transfer activities (20 minutes)

For the final part of the workshop, we'd like to talk about the DER industrialisation Centres.

- Are you all aware of the Industrialisation Centres and what they do? If not, give explanation.

There are 4 DER-IC's, North East, Scotland, Midlands and South West and Wales, but equipment is also available at other sites. They are designed to be 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.

- How did you become aware of the DER-IC? What channels was this through? Are these channels that you usually use?
- How well known do you think the DER-IC and their aims are in the PEMD sector? Are there any areas of the PEMD sector that you don't think the DER-IC are relevant to? Why?
- Have any of you used the DER-IC yet? Any plans to do so? Why/why not?
- How well do you think the DER-IC align with other Challenge activities?
- How do you think they help the Challenge meet its objectives?
- How well do you think the DER-IC align with industry needs? Are they meeting a demand? Is there more that they could be doing to support industry?

Wrap Up (5 minutes)

- Is there anything else you would like to add that we have not covered today?

- Thank and close

Survey

Screener

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 Challenge, or have had some form of engagement with the 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 Challenge, or have had some form of engagement with the 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 whilst 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 BUSINESSES [CODES 1-7 AT A1]

A3. And what proportion of your organisation's business do you expect to be focussed in PEMD technologies in 3 years' time?

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

IF BUSINESS [CODES 1-7 AT A1]

A5A. Which of the following best describes your organisation?

Please select all that apply

MULTICODE, READ OUT

a) Headquartered in the UK, and only do work in the UK EXCLUSIVE
b) Headquartered in the UK, but also do work in Europe
c) Headquartered in the UK, but also do work outside of Europe
d) Headquartered outside of the UK EXCLUSIVE
e) DO NOT READ OUT Don't know EXCLUSIVE
f) 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

a) 1-9
b) 10-19
c) 20-49
d) 50-99
e) 100-249
f) 250-499
g) 500-999
h) 1,000-4,999
i) 5,000-9,999
j) 10,000 plus
k) Don't know

IF BUSINESS [CODES 1-7 AT A1]

A7C. **Has the Driving the Electric Revolution Challenge had an impact on the number of employees you have hired in the past financial year?**

SINGLE CODE, READ OUT

a. Yes, a large increase given the size of my business
b. Yes, a small increase given the size of my business
c. No impact
d. A small decrease given the size of my business
e. A large decrease given the size of my business
f. Don't know
g. 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

ASK ALL

A9. In which of the following ways have you engaged with the Driving the Electric Revolution 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 Challenge
7. Social media accounts on Twitter or LinkedIn
8. Attended another Challenge event (online or face to face)
9. Conversations with the Challenge
10. Other (specify) BACKCODE ONLY
11. None of the above
12. Annual reports
13. Attended an external event (non-UKRI)

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 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

B4. Roughly how many companies involved in the PEMD supply chain do you think there are currently in the UK?

SINGLE CODE, NUMERIC, WHOLE NUMBERS ONLY, ALLOW DK, MIN 0, MAX 100,000

ASK ALL

B5. Which of the following best describes the current UK PEMD supply chain?

SINGLE CODE, READ OUT

a) All large companies
b) Mostly larger companies, but a few small companies
c) A mix of smaller and larger companies
d) Mostly smaller companies, but a few larger companies
e) All small companies
f) Don't know

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

ASK ALL

B6A. **And which of the following best describes how you expect your business to change over the next few years?**

SINGLE CODE, READ OUT

a. It will grow significantly
b. It will grow slightly
c. It will stay about the same
d. It will decrease slightly
e. It will decrease significantly
f. Don't know

ASK IF B6A=a, b, c, d, e

B6b. How has your growth projection been impacted as a result of your engagement with the Driving the Electric Revolution Challenge?

a. Significant positive impact
b. Small positive impact
c. No change
d. Small negative impact

e. Significant negative impact
f. Don't know

Design and delivery of competitions

READ OUT (ALSO SHOW FOR CAWI): The following questions ask about your views of the Driving the Electric Revolution competitions. As a reminder, there have been several rounds of competitions so far:

- Accelerated supply chain development strand 1 – September 2019
- Accelerated supply chain development strand 2 – September 2019
- Catalysing green innovation – advancing PEMD supply chain – Summer 2020
- Business led innovation in response to global disruption (following the COVID-19 pandemic) – Early Summer 2020
- Supply chains for Net Zero – June 2021
- Skills competitions – Early 2022

ASK ALL

T1. How efficient or inefficient did you find each of the below Driving the Electric Revolution Challenge processes?

SINGLE CODE PER ROW, READ OUT

a) Understanding the scope and requirements of the competitions
b) Briefing/dissemination events
c) Forming a consortium for the application
d) Getting clarifications from the Challenge ahead of submitting the application
e) Filling in the application
f) Communication of application outcome
g) Setting up the project SHOW ONLY IF APPLICATION STATUS=SUCCESSFUL OR MIXTURE OF SUCCESSFUL AND UNSUCCESFUL
h) Project monitoring SHOW ONLY IF APPLICATION STATUS=SUCCESSFUL OR MIXTURE OF SUCCESSFUL AND UNSUCCESFUL

SCALE

1. Very efficient
2. Fairly efficient
3. Neither efficient nor inefficient
4. Fairly inefficient
5. Very inefficient
6. Don't know
7. Not applicable

ASK ALL

K1. Thinking about the Driving the Electric Revolution Challenge competitions, including the application process, how much do you agree or disagree with the following statements?
By the application process we mean the whole process from when you started to dedicate time to the application. This may have included carrying out research into the requirement, contacting potential partners and clarifications from the Challenge before you began writing the application itself.

SINGLE CODE FOR EACH STATEMENT. REVERSE SCALE.

a) The Challenge is structured in a way that facilitates collaboration between businesses and academics
b) The Challenge is structured in a way that facilitates collaboration across organisations of different sizes

c) The Challenge is structured in a way that facilitates collaboration with international organisations
d) The Challenge is structured in a way that facilitates collaboration between organisations across different sectors (including PEMD and other sectors)
e) The Challenge competition timelines allow sufficient time to form new consortia and prepare the application
f) There was clear guidance about the focus of the Challenge
g) The application process was clear and easy to understand
h) The scope of the funding competitions is suitable for driving real-life development of the PEMD supply chain across a range of sectors
i) The Challenge competitions were delivered effectively and efficiently
j) The Challenge competitions align with the needs of the PEMD supply chain
k) The Challenge competitions align with the needs of my organisation SHOW IF A1=1-7

SCALE

1. Strongly agree
2. Tend to agree
3. Neither agree nor disagree
4. Tend to disagree
5. Strongly disagree
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 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) Challenge has impacted collaboration in general?

SINGLE CODE, READ OUT

1. DER has increased collaboration significantly
2. DER has increased collaboration slightly
3. DER has not impacted collaboration
4. DER has decreased collaboration slightly
5. DER has 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 Challenge has been able to reach organisations from different sectors
2. The Challenge has been able to reach organisations of different sizes
3. The Challenge has been able to reach different types of organisations, such as businesses and academia
4. The 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

ASK ALL

D4. How informative did you find the following communications from the Driving the Electric Revolution Challenge?

CAWI: Please select one answer per row

GRID SINGLE CODE PER ROW, RANDOMISE, READ OUT

1. 'Engage with' LIVE
2. Other Challenge events (online or face to face)
3. Communications around applications for funding
4. Communications around Industrialisation Centres, also known as DER-ICs
5. Email newsletters
6. Annual reports
7. Networking activities
8. Social media accounts on Twitter or LinkedIn
9. Conversations with the Challenge

SCALE

1. 1 – Not at all informative
2. 2
3. 3
4. 4
5. 5 – Very informative
6. Not applicable
7. Don't know
8. Prefer not to say

ASK ALL

K2. How well do you think the Driving the Electric Revolution Challenge aligns with other government initiatives in the UK?

SINGLE CODE, REVERSE SCALE

1. Very strongly
2. Fairly strongly
3. Not very strongly
4. Not at all
5. Don't know FIX

IF 1-4 AT K2

K3. Which UK government initiatives were you thinking of when you answered the previous question?

OPEN, ALLOW DK

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 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
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 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. And what level do you expect the manufacturing process to reach at the end of period covered by the Driving the Electric Revolution Challenge funding?
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 DER-IC)
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 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 DER-IC)

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 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 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 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 A1=1-7

E3A. **How much of an impact, if at all, did the Driving the Electric Revolution Challenge have on how much your company spent on research, development and demonstration activities in your most recent financial year?**

SINGLE CODE

1. A significant positive impact
2. A slight positive impact
3. No impact
4. A slight negative impact
5. A significant negative impact
6. Don't know

DER-IC and knowledge transfer activities

READ OUT/SHOW IF CAWI **This final 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

F1. Did you know that the Driving the Electric Revolution Industrialisation Centre's four sites were available to use before today?

SINGLE CODE, DO NOT READ OUT

1. Yes
2. No
3. Don't know

ASK IF F1=1

F2. And 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

ASK IF F1=1

F3. To what extent do you agree or disagree with the following statements about the Driving the Electric Revolution Industrialisation Centre (DER-IC)?

SINGLE CODE PER ROW, READ OUT

1. The DER-IC sites offer valuable facilities for organisations across the PEMD sector
2. The DER-IC sites address the design and testing needs of the PEMD supply chain
3. The DER-IC sites address the design and testing needs of my organisation

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

ASK IF F1=1

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 Challenge's knowledge transfer activities? By knowledge transfer, we mean the activities carried out by the Challenge and the KTN to spread awareness of the 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 organisations 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

Annex E Materials for the interim impact evaluation

Impact metrics across baseline and interim impact evaluation

As outlined in Section 4, not all impact metrics were used for the interim impact evaluation. However the majority of metrics appear in either the baseline or the interim impact evaluation, as demonstrated by Table 32. Cases where metrics were not covered in either phase were because:

- The 'university case study' is not included in the interim evaluation because outcomes are not yet likely to be observable. The university case study focuses more heavily on outcomes from skills activities, which to date the Challenge has not progressed as far. 'Industry case studies' refers to all four case studies that are included in the interim impact evaluation.[64] These case studies may include academic participants but are still not considered to be part of the 'university case study'.
- There are metrics that will form part of case studies in the final evaluation, but they are not leading indicators and hence not included in the interim evaluation and did not require baselining.
- The contact survey for this phase predominantly focuses on the process evaluation. To prevent survey fatigue – and to keep the number of questions reasonably limited – only ten questions focus on the interim impact evaluation. Given this, we chose not to survey a number of metrics in the interim impact evaluation that will appear in the final impact evaluation.
- Certain datasets – such as the Business Structure Database Microdata – are held in secure environments which do not generally approve requests to extract data that is not directly published. Baseline and post-baseline evidence of these will therefore be analysed at the time of the final impact evaluation, and therefore are not included in either the baseline or the interim impact evaluation.

The table also indicates where the data source for an evaluation metric differs in the interim impact evaluation from the final impact evaluation:

- * indicates that the data source has changed to contact survey for interim evaluation; and
- ** indicates that the data source has changed to case study for interim evaluation.

There are a few cases where the baseline was not carried out for a metric as part of the phase 2 baseline report. Where this is the case:

- † indicates that the data could not actually be used to monitor a change in the metric; and
- †† indicates that the baseline will take place as part of phase 3 rather than phase 2, and this centres around the thematic case study. The reasoning for this is explained in Section 4.

The purpose of this table is to summarise which metrics and data source both *are* and *are not* being included in the interim impact evaluation.

[64] This consists of two project-based case studies that look at competition winners, one activity-based case study which looks at the DER-IC, and a thematic case study focussed on policy and skills.

Table 32 Full list of final impact evaluation metrics: use in baseline and interim impact evaluation

THEME	EVALUATION METRIC	DATA SOURCE	BASELINE	INTERIM
1	a) Manufacturing readiness level (MRL) of competition winners	Contact survey	✓	
		Industry case studies		✓
	b) Patent filing	The European Patent Register	✓	*
	c) Number of first of a kind PEMD pilots	Contact survey	✓	✓
	d) Number of PEMD deals signed by university technology transfer offices	University case study		
	e) Share of PEMD activity in product test centres	University case study		
2	a) Labour force productivity	Annual Business Survey aggregates	✓	
	b) Total factor productivity	Annual Business Survey aggregates	✓	
		Contact survey		
		Industry case studies		
	c) Sector input costs	Contact survey		
		Industry case studies		
	d) Wages in PEMD companies	Annual Business Survey aggregates	✓	
3	a) Number of participants in relevant university courses	University case study		
	b) Number of relevant apprenticeship starts	Apprenticeship starts, by sector pathway, framework, and standard	✓	
	c) Perception of skills as a barrier to expanding the PEMD supply chain	Contact survey	✓	**
	d) Increase in awareness of PEMD career opportunities	KTN monitoring data		
4	a) Value of co-investment	DER monitoring data		✓
	b) Perceptions of ease of securing investment and follow-on funding	Contact survey	✓	✓
		Industry case studies		✓
	c) Value of public sector investment in PEMD companies	Industry case studies		✓
		Gateway to Research	✓	*

		UKRI Financial Transparency Data	✓	*
	d) Value of RD&D spending by UK/ overseas PEMD companies	Contact survey	✓	✓
		Industry case studies		✓
	e) Share of PEMD companies which are foreign owned	Business Structure Database microdata		
	f) UK operations of leading manufacturers of PEMD products	Industry case studies		
	g) Value of venture capital investment in PEMD companies	EIS1/SEIS1 forms data from IDBR survey and Companies House (depending on granularity of the data)		
5	a) Number of introductions made by KTN, by sector	KTN monitoring data		✓
	b) Number and strength of collaborations between PEMD companies in different sectors	Contact survey	✓	✓
		Industry case studies		✓
	c) Number and strength of collaborations between PEMD companies and academics	Contact survey	✓	✓
		Industry case studies		✓
		Gateway to Research	✓	
		UKRI Financial Transparency Data	✓	
	d) Number and strength of collaborations between large PEMD companies and SMEs	Contact survey	✓	✓
		Industry case studies		✓
		UKRI Financial Transparency Data	✓	
	e) Number and strength of collaborations between PEMD companies producing different technologies	Contact survey	✓	✓
		Industry case studies		✓
		UKRI Financial Transparency Data	†	
		Gateway to Research	†	
6	a) Value of turnover	Business Structure Database microdata		
		UK business: activity, size and location	✓	
		Contact survey	✓	
		Industry case studies		✓
	b) Number of employees	Business Structure Database microdata		

		UK business: activity, size and location	✓	
		Contact survey	✓	
		Industry case studies		✓
	c) Number of companies	UK business: activity, size and location	✓	
	d) Growth projections of leading UK-based PEMD actors	Annual company reports		**
		Contact survey	✓	✓
	e) Size of the sector	Industry case studies		✓
		Data from trade bodies	✓	
	f) Export volume	UN Comtrade	✓	
	g) Export value	UN Comtrade	✓	
	h) Import value	UN Comtrade	✓	
	i) Domestic capacity across supply chain	UN Comtrade	†	
		Industry case studies		
		Contact survey	✓	
7	a) Perceptions of increase in sustainability of UK product/component	Contact survey		
		Industry case studies		††
	b) Perceptions of impact on environmental policy and market regulations	Contact survey		
		Industry case studies		††
	c) Workforce diversity	DER monitoring data		††
	d) Distribution of winning companies	DER monitoring data		††
		Business Structure Database Microdata		
		Contact survey	✓	
		Industry case studies		††
	e) Distribution of PEMD companies	Contact survey	✓	
		Business Structure Database Microdata		
		UK business activity: activity, size, location	✓	

Source: *Frontier Economics*

Note: *The metrics here do not exactly match those from the evaluation framework, as in a few cases metrics needed to be dropped because the evidence sources were not as imagined. All of these changes have been approved by the Challenge. 'Industry case studies' refers to one (or multiple) of the case studies included in this report, project-based case studies, activity-based case study, and thematic case study. This reflects the language used in the Evaluation Framework Report.*

Topic guide – Project-based case studies

1. Has the Challenge accelerated innovation and commercialisation of PEMD technologies?
    a. What is the expected scale of the application?
    b. What is the number of motors that would benefit from this process?
    c. How many could be made in the UK?
    d. What progress has Accelerating the UK E-Machine Preformed Winding Supply Chain made toward achieving this scale?
    e. What pilot trials/prototypes has the challenge enabled?
    f. What is their status?
    g. How does this compare with full-scale implementation?
    h. What impact, if any, do you think the Challenge has had on the technological improvement of manufacturing processes of power electronics in the UK?
    i. What progress would have the project made without the Challenge (counterfactual)?
    j. How has the Challenge affected ease of recruitment of staff with PEMD skills?
    k. In addition to funding, what key enablers has the Challenge provided to accelerate the deployment of the developed technology, e.g. equipment, relationships?
    l. How are these enablers important to the project?
2. How has the 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 UK-based operations?
3. How has the 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?
4. What societal, environmental and policy spill-overs has the Challenge created?
    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 Challenge made on the productivity of the UK PEMD supply chain?
    e. How has the Challenge affected rate of innovation of PEMD technologies?
    f. How has the Challenge affected rate of commercialization?

Topic guide – Activity-based case study

Interviews with DER-IC colleagues

Introduction (3 mins)

- Introductions (brief)
- Explain purpose of interview (part of challenge evaluation, interim impact stage, 4 case studies)
- Recording
- Please say if there are bits that you don't want in the report
- Ask for a description of role

High-level understanding of the DER-IC site

1. Could you please explain how the regional split of the DER-IC operates in practice, and what its purpose is (compared to being one national organisation)?
2. Besides the funding given by the challenge, how does the DER-IC interact with the challenge? (Gives advice on competitions, creates consortia that bid into competitions, is part of consortia that bid into competitions)
3. Of the types of activities that the DER-IC has been involved with to date, what bucket of activities has had the greatest impact?
4. Looking forward, do you think it will be the same types of activities that have an impact going forwards, or will this change?
5. How do you think the challenge could make better use of the DER-IC?

Equipment

6. Our understanding is that the competitions for the equipment and the lead times of actually purchasing and installing the equipment were all quite long processes. Could you please give us a rough idea of timelines?
7. Before the challenge, were WMG and some of the other DER-IC partners already offering equipment for private companies to come in and use, or is this a new activity since the founding of the DER-IC?
8. Can you give us an example of a company that has come in and used a piece of equipment bought by either WMG or Nottingham University using challenge funding?
9. Where do firms who come and borrow equipment tend to be in their development?

Connecting firms

10. Our understanding from Matt is that the bulk of the DER-IC activities so far has been in connecting firms and building consortia. Would you say that is true for the Midlands DER-IC site?

11. Do these consortia tend to then apply for funding, or do they form private partnerships themselves?
12. Can you think of an example of firms you have connected in this way?
13. How has the challenge changed your ability to connect firms?

Specific firm interactions

14. 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. Do any particular firms come to mind that you would suggest we speak to?

Interviews with firms who have interacted with the DER-IC

Introduction (5 mins)

- Introductions (brief)
- Explain purpose of interview (part of challenge evaluation, interim impact stage, 4 case studies)
- Recording
- Please say if there are bits that you don't want in the report
- Ask for a description of role within company

Overview (25 mins)

1. In a few sentences, can you give me a brief introduction into what your company does?
2. How does PEMD technology interact with your other activities, and how important is it to your overall activities?
3. How long have you been working with WMG? What activities do they help you with?
4. Do you know what the DER-IC is, and how this fits into WMG?
5. Is it clear to you what parts of your activities with WMG are made possible by the DER-IC?
6. What interactions have you had with the DER-IC since 2019?
7. 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?
8. 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?

9. 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?
10. Apart from the points already mentioned, have you had any other interactions with the challenge?
11. In terms of the external support you have received from the DER-IC or the challenge overall, is there anything that could be improved? *(Either starting to undertake a new activity, or doing a current activity differently?)*

Impacts (15 mins)

12. Innovation
   a. What kind of external support have you received to help commercialise new technologies?
   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?
13. Productivity
   a. Has the DER-IC/WMG helped to improve your efficiency, or change your productivity by bringing down input costs? How/through what activities?
   b. Do you expect the DER-IC/WMG to continue to help in this way?
   c. How do you think your productivity would have changed without the DER-IC/WMG?
14. 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?
15. 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?

16. 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?

Topic guide – Thematic case study

1. Development priorities for electrification of the transport, industry, and power sectors in particular physical infrastructure and enabling policies
   a. How has the Challenge affected infrastructure and policy development?
2. UK supply chain capacity needed for development of the transport, industry, and power sectors
   a. How has the Challenge affected the productivity and capacity of the UK supply chain for power electronics, electric machines and drives (PEMD)?
3. What new or emergent technologies are required?
   a. How has the Challenge changed the rate of innovation and commercialisation of PEMD technologies?
4. What engineering skills will be most critical?
   a. How has the Challenge contributed to growing PEMD knowledge and skills in the UK?
5. Links to the Challenge work on accelerating deployment of next generation PEMD – Power Electronics (e.g. wide band gap semiconductor switches), Electric machines (e.g. ultra-high efficiency motors and generators) and Drives (interface of power rail to end use application)
   a. What effect has the Challenge had on the value of investment in UK PEMD companies?
   b. To what degree has the Challenge fostered a collaborative PEMD ecosystem?

Annex F Metrics that are used in the interim impact evaluation

Table 333 Full list of impact evaluation metrics used in the interim impact evaluation and their methodology

Theme	Evaluation Metric	Data Source	Methodology
1	a) Manufacturing readiness level (MRL) of competition winners	Industry case studies	Framework analysis of case study interviews with PEMD companies Stated impact of Driving the Electric Revolution on MRL
	c) Number of first of a kind PEMD pilots	Contact survey	Stated impact of Driving the Electric Revolution on number of pilots
3	c) Perception of skills as a barrier to expanding the PEMD supply chain	Industry case studies	Stated impact of the Challenge on skills gaps
4	a) Value of co-investment	DER monitoring data	Descriptive analysis of monitoring data, by competition, by co-investment category
	b) Perceptions of ease of securing investment; follow-on funding	Contact survey	Stated impact of the Challenge on ease of securing investment Stated impact of the Challenge on securing or expecting to secure follow-on funding
		Industry case studies	Framework analysis of stated impact of Driving the Electric Revolution
	c) Value of public sector investment in PEMD companies	Contact survey	Stated impact of Challenge on public sector investment
		Industry case studies	Framework analysis of stated impact of Driving the Electric Revolution
	d) Value of RD&D spending by UK/overseas PEMD companies	Contact survey	Stated impact of Challenge on RD&D spending
		Industry case studies	Framework analysis of stated impact of Challenge
5	a) Number of members of Innovate UK KTN PEMD ecosystem and engagement of those members	Innovate UK KTN monitoring data	Trend analysis
	b) Number and strength of collaborations between PEMD companies in different sectors	Contact survey	Stated impact of Driving the Electric Revolution on number and strength of collaborations; qualitative response
		Industry case studies	Framework analysis of stated impact of Driving the Electric Revolution on number and strength of collaborations (multiple sectors, spillovers)

	c) Number and strength of collaborations between PEMD companies and academics (ISCF3)	Contact survey	Stated impact of Driving the Electric Revolution on number and strength of collaborations; qualitative response
		Industry case studies	Framework analysis of stated impact of Driving the Electric Revolution on number and strength of collaborations
	d) Number and strength of collaborations between large PEMD companies and SMEs	Contact survey	Stated impact of Driving the Electric Revolution on number and strength of collaborations; qualitative response
		Industry case studies	Framework analysis of stated impact of Driving the Electric Revolution on number and strength of collaborations
	e) Number and strength of collaborations between PEMD companies producing different technologies	Contact survey	Stated impact of Driving the Electric Revolution on level of collaboration
		Industry case studies	Framework analysis of stated impact of Driving the Electric Revolution on number and strength of collaborations
6	b) Number of employees	Industry case studies	Framework analysis of stated impact of Driving the Electric Revolution Stated impact of Driving the Electric Revolution on employment, by region/technology
	d) Growth projections of leading UK-based PEMD actors	Contact survey	Stated impact of Driving the Electric Revolution on growth projections
7	a) Perceptions of increase in sustainability of UK product/component	Industry case studies	Framework analysis of sustainability perceptions
	b) Perceptions of impact on environmental policy and market regulations	Industry case studies	Framework analysis of environmental policy and market regulation/standards
	c) Workforce diversity	DER monitoring data	Descriptive analysis of count and value of competition winners by gender and age of lead company representative
	d) Distribution of winning companies	DER monitoring data	Descriptive analysis of count and value of competition winners by region

Source: Frontier Economics