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CPE – Stage 2 Evaluation Report

June 2023

Canolfan Arbenigedd Ffotoneg
Centre for Photonics Expertise

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Date of document: June 2023

Version: Final

Client: Prof. Caroline Gray OBE, CPE Director

Acknowledgements

We would like to thank the many individuals who gave their time to assist with the evaluation, all of whom were important in the writing of this report. This evaluation would not have been possible without all of these contributions.

List of abbreviations

Aberystwyth University	AU
Bangor University	BU
Business Development Managers	BDM
Centre for Photonics Expertise	CPE
Collaborative Research Project	CRP
Cross-Cutting Theme	CCT
Entrepreneurial Women in Renewable Energy	EWiRE
Equality Impact Assessments	EIA
Equal Opportunities	EO
European Regional Development Fund	ERDF
Full Time Equivalent	FTE
Gender Mainstreaming	GM
Higher Education Institution	HEI
Industry Innovation Partnership	i3P
Knowledge Economy Skills Scholarships	KESS
Key Performance Indicator	KPI
Public Sector Equality Duty	PSED
Research and Development	R&D
Research, Development and Innovation	RD&I
Research Technology Organisations	RTO
Small and medium-sized enterprises	SME
Social Exclusion	SE
Science, technology, engineering, and mathematics	STEM
Tackling Poverty	TP
Technology Readiness Level	TRL
University of South Wales	USW
Wales European Funding Office	WEFO
West Wales and the Valleys	WWV
Wrexham Glyndŵr University	WGU

Contents page

Contents

Table of tables

Table of figures

Executive Summary

Introduction

The Centre for Photonics Expertise (CPE) was a four-year ERDF-funded operation which brought together photonics expertise from Wrexham Glyndŵr University, the University of South Wales, Bangor University, and Aberystwyth University. The operation comprised two main components: the delivery of collaborative research projects to support businesses in developing photonics-based solutions that would address their challenges, and capital investment in photonics technologies to further develop the photonics capabilities of the HE partners.

Wavehill were commissioned, in April 2020, to evaluate the above-mentioned operation, which came to a close at the end of 2022. This report sets out the findings from our evaluation.

Main findings

Our evaluation of the CPE found a very successfully delivered operation which has more than delivered what it set out to do and provides the foundation for a formalised photonics cluster in Wales in line with the Welsh Government's strategic objectives.

Achievements

The CPE has supported 63 businesses through CRPs, and the main achievements can be summarised as follows:

- The CPE has delivered commendably in terms of its Key Performance Indicators, surpassing, or coming within 10 per cent of, the targets for the number of businesses engaged, investment leveraged in RD&I, and the development of new innovations.
- There is significant variability in the types of businesses supported regarding their size, sector, and geographic coverage across the WWV region, thus demonstrating how photonics technology can be applied across the economy.
- Most businesses were seeking support to develop new products or processes, and felt they had neither the knowledge and expertise to conduct the innovation nor the facilities, technology, and capacity, thus meaning that they required assistance from the CPE.
- There was a high degree of variability in the types of projects supported with regard to TRLs, scale and support intensity.

- Half of the supported businesses reported they had achieved everything they wanted, whilst an additional 23 per cent reported that they had partially completed what they wanted, or their projects were ongoing.

- The CPE has clearly generated innovation outcomes for businesses, with 72 per cent formulating ideas for new products, services, or processes, whilst 58 per cent managed to develop those innovations through the CPE. In total, 79 per cent reported that their projects would not have occurred without support from the operation.

- The operation has increased the awareness and understanding of photonics capabilities amongst supported businesses and increased their interest in conducting further activity, whilst there also appears to have been a modest impact on the encouraging of businesses to invest more in RD&I.

- Furthermore, there is strong evidence to suggest that the operation has made an important difference in changing attitudes and raising awareness of the benefits of higher education institutions (HEIs) and industry collaborations amongst supported businesses.

- In hard economic terms, many businesses reported outcomes pertaining to efficiencies (39 per cent) and productivity gains (22 per cent).

- The immediate impact on turnover has been modest, with an estimated return of just £153,000 for the 63 businesses supported. This is perhaps unsurprising given the latent impacts associated with RD&I activity. Indeed, further exploration of the potential impact for supported businesses estimated that the support could generate around £2.4m in increased economic returns over the next 12 months.

- The impact on employment appears to have been more immediate, with our analysis suggesting that the operation has created, or safeguarded, around 41 FTE positions in total.

- The operation has also generated positive environmental impacts through a combination of increasing the efficiency of businesses' processes, reducing their energy usage and waste (or support to re-use waste products), and the development of products and support for businesses whose operations focus on safeguarding the environment.

These key findings and points demonstrate that the operation did support a suitable group of businesses and enabled the vast majority to achieve positive outcomes which would not have occurred without the intervention. Whilst we have only just begun to see hard outcomes with regard to economic returns, these are likely to increase further, with most businesses managing to develop new and improved products, processes and services which will likely yield benefits for years to come. Taking into consideration the broader impacts around establishing the photonics infrastructure and understanding, the increasing interest

in collaborative RD&I activity, and the environmental impacts, the evidence suggests that the operation is in a good position to generate a positive return on investment.

Delivery model

Perhaps the main legacy and impact of the CPE is the experience of delivering the operation and the learning gained from that process. Members of the delivery team were unanimously satisfied with the delivery model; indeed, several highlighted it as a significant achievement that should be used as a blueprint for future interventions and other activities delivered by their institutions. This is corroborated by feedback from the supported businesses, which were overwhelmingly positive about their experience. The key components and strengths of the delivery model can be summarised as follows:

- The partnership model has been very effective, with strong complementarity in the expertise and capabilities of respective HEIs, thereby enabling the operation to provide a rounded support offer. The open and amicable nature of the partnership, with clear roles and responsibilities, acted as a key enabler in its success.

- The partnership model was underpinned by effective governance structures and management processes. This involved regular and appropriate forums for operational and strategic decision-making (including weekly meetings to discuss the allocation of new projects and updates on existing projects) which provided an effective mechanism through which to identify the most appropriate academic lead.

- Additionally, the business engagement process proved effective, with BDMs playing a crucial role in generating leads and identifying business needs that could be addressed by the operation.

- There was a clear template for establishing and delivering the CRPs, using tools such as the project scope form and collaboration agreement.

- The success of the operation has also been underpinned by its underlying principles, namely the focus on practical projects based on businesses' needs and having a streamlined process to ensure that projects could be delivered as quickly as possible.

There are key lessons outlined above – pertaining to the enablers of success – which should be incorporated into any future delivery. That is not to say that the operation has been without its challenges. Indeed, several issues and areas for improvement were highlighted during our evaluation, as follows:

- The bureaucratic requirements of running an ERDF project appear to have affected the speed of delivery, despite the efforts to streamline processes as much as possible. Most notably, the process of collecting timesheet and salary data was a frustration for some businesses.

- Another frustration was that every project had the same requirements in terms of process and evidence, irrespective of the scale of support given. This felt disproportionate for some of the smaller-scale projects, e.g. the advisory support projects.

- Resources have been another significant barrier, principally with regard to the BDM role, which was not helped by staff turnover. One potential weakness is the number of projects which were put forward for consideration. Having greater resources within the BDM compartment would have enabled the operation to develop a larger pipeline and thus be more selective in the projects supported. It is important to note that the COVID-19 pandemic will have likely affected the number of projects submitted due to the impact on networking and the closure of university facilities.

- The stakeholder engagement aspect appears to have been fairly limited. This will also have been affected by the COVID-19 pandemic.

These lessons will be equally important when designing future interventions.

Cross-cutting themes

There is substantial evidence of the operation's contribution towards the CCT objectives, with a particularly strong record on Supporting Women into STEM and Sustainable Development. There is a clear link with the Tackling Poverty CCT, given the impact on generating growth and employment opportunities. The CPE also ensured that good practices around themes such as equal opportunities, accessibility and the Welsh language were incorporated into delivery, although there was perhaps less activity in promoting opportunities within those spheres in comparison to Supporting Women into STEM.

In summary, the operation has certainly met the bare minimum requirements with regard to delivery against the seven CCTs and, in some cases, has gone well above those requirements. Accordingly, the operation should be commended for this particular aspect of delivery.

Next steps

The rationale for delivering the CPE is as important as ever. It is based on the premise that there are strong photonics-related expertise and capabilities in Wales, which are primarily held within academic institutions, and would benefit the nation if they were to be made available to industry. The CPE has provided a valuable mechanism through which industry can benefit from the said expertise, underpinned by an effective partnership and principles and processes which can work alongside industry. The centre has shown the benefits and potential impacts of doing so, the effectiveness of the delivery model, and that there is demand for the support. Accordingly, there is a clear case for continuing the CPE operation going forwards.

The focus, to date, has been on delivering the operation in line with the requirements of the ERDF funding. The operation will now need to identify a model that can sustain it for years to come and will require financial backing to trial that model as part of a beta-phase roll-out. There is also an opportunity to expand the delivery to maximise its reach and impact potential, as well as to fully utilise the expertise that exists in Wales. Principally, this would involve incorporating all eight HEIs into the next operation and making that operation available throughout Wales, thereby expanding the critical mass of expertise and the potential customer base. It has also been suggested that the remit of the operation be expanded in order to address other factors that limit the potential for photonics utilisation in Wales.

Recommendations

In light of these findings, the following recommendations are made.

Recommendation 1: The operation should continue to seek investment for a 'beta phase', which would include testing models for commercial income generation, perhaps as part of a Fraunhofer-type model. Options include developing a paid-for service for CRP involvement or a membership structure.

Recommendation 2: The delivery model successfully used by the CPE should form the basis for future delivery. This includes ensuring that the activity is challenge-led, utilises a BDM function to make it more accessible, incorporates the same spirit of collaboration and non-partisan decision-making, and utilises similar management and governance processes.

Recommendation 3: Future schemes may wish to remove some of the administrative barriers associated with the ERDF programme, notably the timesheets and salary data, so as to accelerate the process. It is important to note, of course, that this related to requirements associated with the ERDF funding and was not within the CPE team's control.

Recommendation 4: If possible, future schemes may also wish to allocate a greater proportion of resources to the BDM function in order to maximise the reach and income potential.

Recommendation 5: Linked to this, the operation should seek to be more selective in its approach in order to target support only at projects with the highest impact potential.

Recommendation 6: The geographic coverage of the operation should be expanded to cover the whole of Wales, with all eight HEIs involved in delivery and all Welsh-domiciled businesses able to access the support. This would maximise the expertise provided through the operation and increase the potential of developing a sustainable model via expanding the client base.

Recommendation 7: A multi-stranded support offer should be considered for future iterations of the operation, the main focus of which would be to continue delivering the CPE-type CRPs. However, the operation could also include a less intensive strand, potentially in the form of an advisory service, which would be less burdensome for businesses. At the other end, the operation should develop a new strand with ringfenced funding for larger-scale projects to expand on the best CRPs in order to maximise the impact potential.

Recommendation 8: The team could also consider the possibility of incorporating a broader remit into future delivery, which would include expanding the outreach aspect to school-age and upwards, representing a fourth strand to the support. This would help to address the issues of skills shortages and the need for photonics capabilities to progress at the same pace as technological developments.

1. Introduction

Wavehill were commissioned, in April 2020, to undertake a two-stage evaluation of the Centre for Photonics Expertise (CPE) operation. The CPE operation was originally a three-year project funded through the Research and Innovation priority within the European Regional Development Fund (ERDF) programme for West Wales and the Valleys (WWV); the operation started on 1st December 2018, and was due to end by 30th November 2021. It was then awarded a six-month no-cost extension to allow for the utilisation of underspent funds and savings as a result of COVID-19 and delays during the mobilisation period. The CPE team were then notified of an opportunity to access re-committed underspend from other ERDF operations, leading to the awarding of an additional £1.6m of spending and a further extension until December 2022. In total, the operation has been delivered at a cost of £7,340,134, consisting of £4,828,273 in ERDF funding and supplemented by £2,511,859 from the operation's promoters and partners (i.e. the four HE partners delivering the operation and supported enterprises).

The EU Structural Fund covers a range of activities, including research and innovation, business (SME) competitiveness, connectivity, energy and urban development. The CPE operation is funded under Specific Objective 1.2 of the ERDF Programme for WWV.

1.1 Introducing the CPE operation

The CPE operation brings together photonics expertise from Wrexham Glyndŵr University (WGU), the University of South Wales (USW), Bangor University (BU), and Aberystwyth University (AU). Operational management is provided by Glyndŵr University through the OpTIC Technology Centre, St Asaph.

The WWV ERDF Programme Specific Objective 1.2, under which the CPE operation is funded, has the aim of *'increasing the successful translation of research and innovation processes into new and improved commercial products, processes and services, in particular, through improved technology transfer from HEIs'*. The objective's associated result indicator is '*Average share of total turnover from product innovation and novel innovation: new to market, new to business and significantly improved*'. In support of this specific objective, the CPE operation is built on the premise that a 'platform' of complementary technologies and expertise (i.e. photonics), which have already become established in the partner universities and associated clusters, can be mobilised and applied to achieve innovation across many sectors.

Photonics is a key enabling technology with significant potential to make Welsh companies more competitive through the introduction of new products and processes. Photonics expertise available from the partnership involved in the CPE operation covers, amongst others, the use of sensors, lasers, optical surface metrology and calibration, optical design and fabrication, optoelectronic systems, and optical thin film coating.

The CPE operation business plan sets out a rationale for public investment in the operation based on the global status of photonics as a key enabling technology with considerable market potential for the implementation of photonics technologies and applications. The said plan is based on the premise that there is significant potential for using photonics to make Welsh companies more competitive and to introduce new products and processes. However, companies are not necessarily fully aware of new technological developments that can enhance their products and processes. Accordingly, part of the aim behind the business plan was to raise awareness of photonics technologies, the opportunities for utilisation, and potential benefits for the above-mentioned Welsh companies; all of these objectives sat alongside the goal of promoting collaboration between industry and academia, thereby ensuring that the expertise which exists within the HE sector can be applied in industry to the benefit of the economy.

There are two main support strands to the operation. First and foremost, there are the CRPs between HEI partners and businesses to develop photonics-based solutions. The second strand is the capital investment in photonics technologies, such as the investment in a Vacuum Coating Plant and associated equipment for thin film coating processes, or the investment in laser capability in BU. Underpinning the CRP strand was a well-developed business engagement process, which began with BDMs who were appointed to identify and reach out to businesses to discuss potential projects. The said strand was also underpinned by effective management processes within the academic team, the members of which met frequently to discuss the potential projects identified by the BDMs, undertook further exploration of their validity, and would then assign the most suitable academic lead for the business and their project.

A detailed overview of the operation and how it works is outlined in the Stage 1 Evaluation Report, which was finalised in November 2020. The report included a detailed account of the context, policy fit and rationale for the operation; exploration of the operation design, including the innovation process underpinning the operation, management aspects, resources, and the participant journey; and a review of the aims of the operation, including the Key Performance Indicators (KPIs) and other outcomes and outputs identified during the scoping stage. Importantly, the Stage 1 Report includes a Theory of Change model which provides a summary of the operation's rationale, its end goal, and the chain of activities, outputs and outcomes intended to achieve those goals. This can be seen in Appendix 1.

1.2 Evaluation aims and approach

The evaluation comprises five objectives, as follows:

1. Deliver the operation effectively and help to ensure the sustainability and legacy of the operation.
2. Capture and assess evidence on the operation's activities and outcomes in a robust and timely manner.
3. Assess the operation's wider and longer-term impacts – both quantitative and qualitative.

4. Capture any learning from the operation for dissemination – in Wales and beyond.
5. Provide evidence that will demonstrate the wider relevance of the operation and inform the wider innovation ecosystem and community of the benefits realised by the CPE operation.

Specifically, the following evaluation goals were established during the Stage 1 Report:

- Confirm whether the operation is making effective progress towards the goals of its stakeholders, including the Wales European Funding Office (WEFO) (see Chapter 2).
- Assess how effective the operation has been in engaging, at strategic and operational levels, with key partners, stakeholders, existing and potential supported businesses, and the wider community (see Section 3.2).
- Assess the extent to which the operation is making progress towards WEFO indicators (see Chapter 2).
- Assess how effective the operation has been in delivering against its cross-cutting themes ambitions and WBFG priorities (see Chapter 4)
- Identify what opportunities exist to develop new activities, and the engagements with stakeholders that are required to permit/resource such activity (see Chapter 5).
- Assess whether, and how, the operation may have achieved legacy and sustainability, and what actions may be advisable to further support this (see Chapter 5).
- Identify any learnings which could be used to optimise the performance of any future similar or legacy interventions (see Chapter 3).
- Assess how cost-effective the operation has been and its value for money (see Section 2.3.3).

Several research activities were undertaken to inform this report, utilising a mixed method approach consisting of literature and document reviews, a review of data monitoring processes, and stakeholder and partner interviews.

Two survey 'waves' were undertaken to capture feedback from the business participants, with 26 businesses surveyed in the period spanning March to April 2022 (Wave 1) and a further 19 during the period spanning August to October (Wave 2). Wave 1 targeted 38 businesses which had completed at least one project, whilst Wave 2 targeted all remaining contacts irrespective of whether they had completed their projects or not. Collectively, the 45 businesses surveyed represent a 71 per cent response rate (63 businesses in total). Those businesses took part in 63 projects between them, meaning our survey sample covers 70 per cent of the projects supported by the operation. This provides a strong evidence base for the report, with the survey capturing quantitative and qualitative data to generate insights into businesses' profile and background, their satisfaction with the support, and the outcomes generated.

Further, we also conducted follow-up interviews with 23 of the 26 businesses that completed the survey during the first wave. This provided an opportunity to capture more qualitative data on the outcomes generated for those businesses, including economic and environmental impacts.

In addition, we conducted 15 in-depth telephone interviews with delivery team members comprising academics, BDMs, and management personnel across the four organisations, thereby ensuring that we had an appropriate mix of perspectives across all stakeholders and types of delivery personnel.

External stakeholder perspectives were also obtained through eight in-depth stakeholder interviews with Welsh Government personnel (to obtain the funder perspective) as well as with other organisations and programmes involved in providing support in this area, such as ASTUTE and the Life Sciences Hub.

Supplementing this research fieldwork was an analysis of the management information, which included important data on outputs, spending, and delivery against the cross-cutting themes (CCTs).

Finally, six case studies have been developed to provide a 'deep-dive' exploration of the projects developed and their impact on businesses. These studies were based on interviews with the businesses, the academic leads, and materials developed by the operation team on the projects. The case studies can be seen in Appendix 2.

1.3 This report

All information generated through these activities has been analysed to inform the current report. We have structured the report to address the key evaluation questions, as follows:

- Chapter 2 provides a detailed description of the outcomes and impacts, by exploring achievement against delivery targets alongside a broader consideration of impact (including specific sections looking into the economic and environmental impacts).
- Chapter 3 has a more process evaluation focus, exploring the main strengths and weaknesses of, as well as the effectiveness of, the various delivery components, thus providing important lessons for future delivery.
- Chapter 4 outlines the contribution made towards the seven CCTs.
- Chapter 5 considers the legacy of the operation and sets out potential next steps.
- Chapter 6 concludes the report with a series of recommendations.

2. Operation's achievements

This section focuses on the outcomes from the operation, including an assessment of performance against the official performance indicators, before evaluating the broader impacts for supported businesses and for the WWV region.

2.1 Delivery against Key Performance Indicators

In addition to the revised budget following the project extension, the CPE team were also required to increase their performance targets. The operation comprised seven formal ERDF-related KPIs that had been agreed with the WEFO. These provided the key metrics for judging the operation's performance in delivering against the Research and Innovation priority within the ERDF programme. Two of the aforementioned KPIs are intended to ascertain whether the operation has delivered the elementary outputs concerning the number of enterprises engaged and the number of partners co-operating in a research project. Another KPI focuses on the success in leveraging investment from the private sector through that industry engagement in research and development (R&D) projects. Two other KPIs concern the key outcome metrics for identifying the operation's success in delivering on its innovation remit, with an assessment of the number of enterprises supported in introducing new-to-firm or new-to-market products, or new-to-firm processes. The two final KPIs pertain to economic-related outcomes resulting from the operation, namely the increase in employment and the supporting of the establishment of a new enterprise

Table 2.1 over page shows the changes made to the target for each of these KPIs and the actual achievements attained based on the final claim submitted. The table illustrates that four of the seven KPIs saw the revised targets increase in line with the increased budget and timescale. Two of the targets remained unchanged – the number of enterprises receiving non-financial support was unchanged due to the fact that the indicator had not been recorded correctly prior to the end of Q10, and thus it was agreed that the operation team would only record achievement for post-Q10 projects and the target was deemed appropriate for that. The increase in employment KPI was the only one to see a reduction. This is because it had been a substantial challenge for the operation to achieve the said KPI, since the beginning, due to a combination of the challenges experienced during the pandemic, the low Technology Readiness Level (TRL) of many projects, and the fact that the timeframe from CPE intervention to an employment increase at a company was found to be much longer than originally anticipated.[1] The pandemic significantly altered the economic context in which beneficiaries were operating, with many having to switch focus from growth to survival. The CPE delivery highlighted that the context of the pandemic made it particularly difficult to achieve the employment targets. Indeed, all of this had the effect of making it extremely difficult to evidence increases in employment that could be attributed to the CPE. It is worth noting that employment-related outcomes have also been captured through the external evaluation, including exploration of future potential, which is perhaps

[1] Source: Business Plan Addendum document submitted to the WEFO in February 2022

a more suitable assessment of impact given the nature of innovation-related projects (particularly at the early TRL stage), where it does take time for outcomes to materialise.

Looking at the achievement figures, we see that four of the revised KPI targets were met or exceeded, whilst another target was close to being met. The above demonstrates that the operation has been successful in engaging partners in the CRPs (10 per cent above target) and securing investment from those businesses (exceeded target marginally), whilst there has also been success in translating this activity into key innovation outcomes for businesses, since the target of introducing new products or processes to the market was also exceeded. This measure records the more innovative outcomes (i.e. they are innovations which did not exist on the market prior to the CPE intervention) and is consistent with the CPE's general focus on the lower TRLs. Equally, this may also explain why the operation is slightly below its target for the overall number of new products/processes introduced (i.e. including innovations that were new to firm only), with more focus on the slightly more complex, embryonic projects than was potentially envisioned. At the same time, the operation can be commended for almost reaching its target for new-to-firm innovations (96 per cent achieved).

The KPI for number of enterprises supported has been met. Equally, it is important to remember that this has only been recorded for post-Q10 projects, and so the true number will be much higher. The only other underperforming KPI is the jobs created target (just 60 per cent achieved), which has not been met for the reasons explained above. Finally, no data was shared on new enterprises supported.

Table 2.1: Achievement against KPI targets

Indicator	Original Target	Revised Target	Achieved	% Achieved
Number of partners co-operating in a research project	120	175	193	110%
Number of enterprises receiving non-financial support	60	60	60	100%
Private investment matching public support in innovation or R&D projects	£325,000	£395,000	£397,408	101%
Number of enterprises supported to introduce new-to-firm products/processes	40	56	54	96%
Number of enterprises supported to introduce new-to-market products/processes	20	31	34	110%
Employment increase in supported enterprises	16	5	3	60%
New enterprises supported	1	1	N/A	N/A

Source: Management information shared by the CPE operation

Overall, these achievement figures are a positive account of the operation's success with regard to the amount of activity undertaken, as evidenced by the number of partners engaged and investment leveraged, as well as the translation of those outputs into innovation outcomes. This is, however, a fairly narrow assessment of what has been achieved. It is important to capture the broader outcomes generated for businesses and for the sector. We do this in the remainder of the chapter, based on detailed feedback from the businesses themselves alongside the perspectives of the delivery team and external stakeholders.

2.2 Business outcomes

2.2.1 Overview of results achieved

Businesses responding to our survey were split 50/50 when asked whether they had fully achieved what they initially set out to through the CPE project (22 responded 'Yes' and 22 'No'). Elaborating on this, the businesses responding 'Yes' to the question explained how they were able to develop their new products or processes or test their ideas. Other businesses highlighted that the CPE project had provided an effective first step and basis for further research and development, with some explaining they had won additional grant funding from other providers as a result. The quotes provided below are examples of the responses received from the businesses.

> "Since completing the project we have purchased the laser required to perform the markings. The next step is to commercialise the system."

> "The initial findings from the CPE project formed a partnership with Bangor University and another company. We have now received an Innovate UK grant."

> "We were looking to see which of three materials to use and we found the one we wanted and got on and used it."

Four businesses responding 'No' to the question explained that their project was ongoing and it was therefore too early to say. Of the other 18 responding 'No', six reported that they had partially achieved their aims. For example, one reported that they had achieved approximately 80 per cent of their goals, and most of their goals were ambitious. Reflecting on what had been accomplished, they were very pleased with the result, despite not achieving everything which they had set out to. This reflects a crucial point within R&D, i.e. that successfully demonstrating what does not work is just as important, as one business noted: *"sometimes the roads not taken are as important as the roads taken."*

Others indicated that they required more support but it had not been available; for example, one business declared that they had succeeded with their first project but were not able to get a second one through, whilst others said they needed more time or further input from the CPE team after the project had come to an end. Another simply stated that they did not have the time to utilise the learning: *"We've reached a point that we can make the sensor but haven't done it yet"*.

Similarly, a further eight respondents explained that they had not been able to complete the research that was needed because they had run out of time or budget, or the equipment/facilities had not been available at the time. Others felt that the operation had not been able to deliver what was promised, e.g. some highlighted that a prototype they were promised never materialised, or at least not to the standard expected.

There is a clear difference in the response to this question between businesses responding during Waves 1 and 2 of the survey, with 60 per cent (15/25) of the former (i.e. those which had completed at least one project) stating that they did fully achieve what they wanted, and just 37 per cent (7/19) of the latter (i.e. businesses contacted during the period spanning August to October whose projects may have been ongoing) reporting the same. This would suggest that there is a lag-issue and that a larger proportion of businesses are likely to consider their project aims as having been fully achieved after more time has elapsed.

As we have already alluded to, the impact of the pandemic cannot be ignored here. Indeed, 20 per cent of beneficiaries highlighted how the inability to carry out in-person work hindered their project progress and the outcomes they could achieve, e.g.:

> "Enormously affected in terms of when we could have staff in and keeping them all apart. A large portion of what we do is hands on equipment so it just made it more difficult."

Additionally, around a third (32 per cent) highlighted time delays and other constraints associated with the pandemic, e.g. "Covid was a huge problem throughout industry and academia so time constraints (were a barrier)", whilst others highlighted how the closure of laboratories affected delivery.

In summary, whilst the responses to the question were fairly mixed, they were generally positive, with half saying they had achieved everything they wanted, and an additional 23 per cent declaring they had partially completed what they wanted or the projects were ongoing. The remaining 12 respondents (27 per cent) had not achieved what they wanted, some not at all, and that was mostly because they needed more time or resources (with the pandemic likely to have had a substantial impact) or simply due to the fact that the project outcome was different to what they had expected or were anticipating.

Summary of case study findings

The case studies in Appendix 2 provide a detailed insight into the experiences and outcomes generated for the six businesses. They demonstrate a good mix of different experiences with examples from each academic partner, including some examples of collaborations between several different academic partners and the industrial organisation. They illustrate how some projects were able to apply new technologies and develop new products, leading to positive economic and environmental results, whilst others were able to tests things and determine solutions that were not the right fit for their business but which were also valuable outcomes.

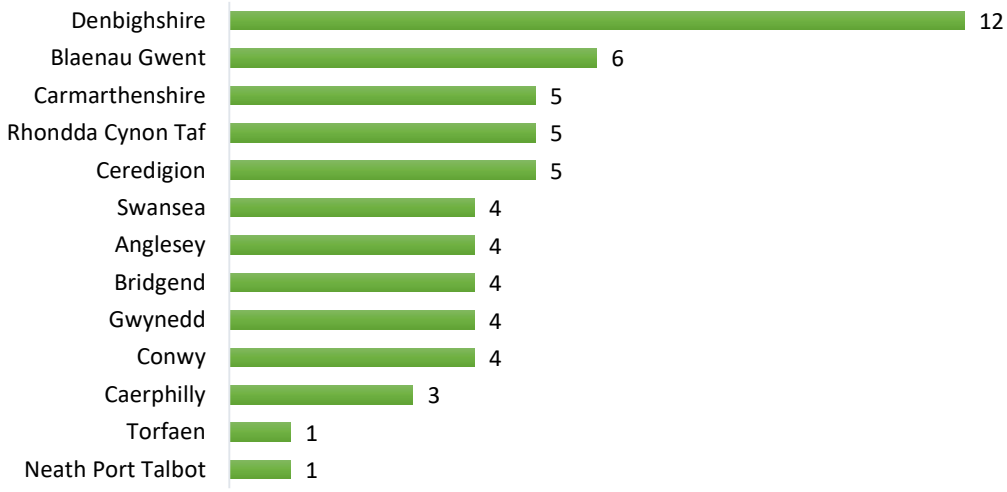
Diamond Centre Wales was involved in four projects and had a very positive experience with the operation, which has already led to new employment opportunities and has significant potential for economic impact. This is an example of early TRL projects which gave rise to the early development of products with the potential to have significant value, and which can be applied in multiple sectors. As a result, the above-mentioned business has secured a grant from Innovate UK to further develop these products, and is seeking to establish two subsidiary companies to take advantage of the commercial opportunities. The case study also demonstrates a significant impact on the cutting of costs, where the business was able to acquire a new system through the operation at a fraction of the cost which it would have had to pay to other providers.

The experiences of Enviro 365, Smart Storm Limited, and Robertson Geo demonstrate how the operation has provided an immediate economic return for those businesses due to the new products and/or more efficient processes developed. However, whilst Transcend Packaging and AVoptics were very positive about their experience of working with the academic leads, they eventually determined that the solutions being explored were not suitable for their businesses. However, they felt that the projects were needed to explore those options, and opined that it had been a worthwhile experience, giving them the knowledge, awareness, and confidence required to further explore photonics-related solutions in future. They were very positive about the partnership working aspect and expressed an intention to continue working alongside the universities in future.

2.2.2 Profile of businesses supported

The operation supported a range of different businesses, covering a multitude of contrasting sectors and business sizes. It had a wide reach within the WWV region to which it was limited, as demonstrated by Figure 2.1 over page, with engagement secured from at least one business from 13 of the 15 local authorities within the region. This demonstrates the success of the engagement approach in reaching out to businesses across the region, and illustrates the benefit of utilising the networks of four different HEIs located across Wales (WGU covering the north east, BU the north west, AU mid and south west, and USW covering the valleys region), alongside having two geographically-based BDMs (covering the north and south). The congregation of businesses in Denbighshire, close to where WGU is situated, reflects the importance of WGU's role in engaging businesses as the lead body.

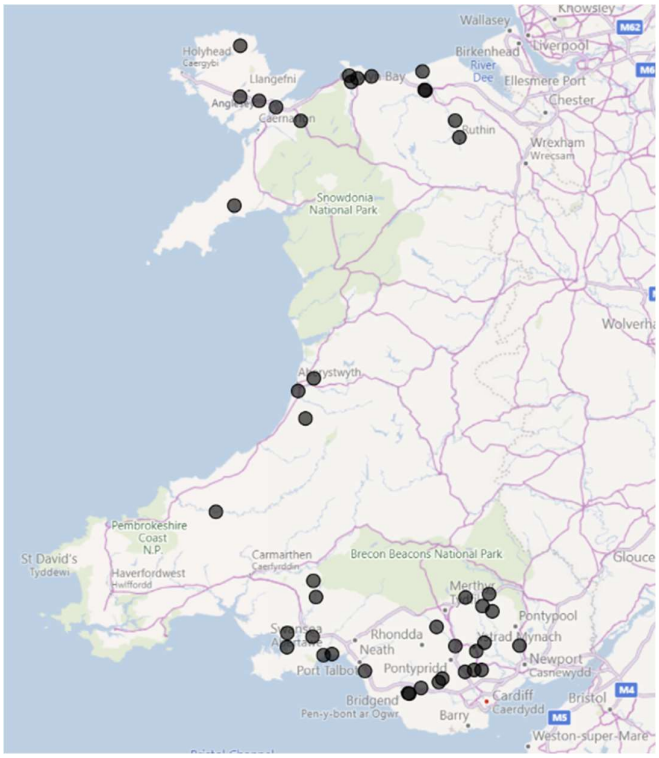
Figure 2.1: Geographic location (based on local authority data) of supported businesses



Source: Management information shared by the CPE operation

A more granular illustration of the location of businesses supported is presented in Figure 2.2 below, which again demonstrates the success of the engagement approach in the north and the valleys region in particular, although there is less success in the most south and mid-western parts of Wales.

Figure 2.2: Geographic location (based on local post code data) of supported businesses



Source: Management information shared by the CPE operation

The survey data shows a mix of different size groups, with 64 per cent falling into the microenterprise definition of employing fewer than 10 staff, whilst 10 per cent (4 businesses) were large (i.e. more than 250 staff).[2] This demonstrates that the operation has engaged larger than average businesses, with the StatsWales website illustrating that microenterprises make up 95 per cent of the Welsh economy, and large businesses make up just 0.6 per cent.

The management information contains interesting data on the sectoral composition of supported businesses, revealing that half (28/56) operate within the manufacturing sector. The other half contains 10 businesses (18 per cent) operating within the professional, scientific and technical activities – these include consultancies (e.g. engineering, agricultural, or environmental), diagnostics businesses etc. A further four businesses (7 per cent) are categorised within research and experimental development (e.g. within biotechnology), followed by three in mining and quarrying. The remaining businesses cover a wide breadth of sectors, from transport and construction, to agriculture, retail, health and communications.

This demonstrates the variance within the types of businesses supported and how photonics technology can be applied across the economy. It also shows how the operation has undertaken a mixed approach with regard to the innovativeness of businesses supported, from engaging with some businesses operating directly within R&D, to others with little familiarisation with the process. Part of the broader ambition behind the operation was to raise the profile of photonics and encourage greater R&D activity (in photonics specifically). Thus, it is important to consider which types of businesses have been engaged.

Further data was collected on this in the survey, where businesses were asked about the nature of their R&D activity prior to engaging with the operation. The results show that 77 per cent (34/44) of businesses had invested in research, development and innovation (RD&I) prior to the support, while 63 per cent had already received RD&I support from the public sector. Most (68 per cent; 30/44) had also collaborated with a HEI prior to the support. Accordingly, most supported businesses do appear to have been well-accustomed to undertaking RD&I prior to the support, thereby limiting the potential impact with regard to encouraging greater RD&I activity within the economy.

At the same time, the data shows that the operation has enabled around a quarter of the supported businesses to engage in RD&I for the first time. Further, the introduction to photonics technologies specifically appears to have been more significant, with just 40 per cent of supported businesses reporting they had used photonics technology to develop new processes, products or services prior to the support. Further survey data suggests that around half of businesses were not familiar with the different photonics technologies and their potential applications prior to the support, whilst just 46 per cent felt they had the

[2] The remaining 26% were small businesses, i.e. employing 10-49 staff members

expertise to utilise photonics technology, and just 34 per cent felt they had the equipment/facilities needed to utilise photonics on their own.

There are interesting differences between the two survey 'waves' that were conducted, where 50 per cent of Wave 1 respondents had used photonics prior to the support vs just 26 per cent from Wave 2. Additionally, more of the Wave 1 cohort had collaborated with HE (76 per cent vs 58 per cent in Wave 2), alongside receiving RD&I support from the public sector (71 per cent vs 53 per cent) and investing in RD&I (85 per cent vs 67 per cent). Wave 1 was based on businesses which had completed projects in early 2022, whilst Wave 2 was based on businesses which had not completed a project at that time, and thus we can assume that the Wave 1 subsample will generally have engaged with the operation sooner. This potentially suggests that the operation started by engaging the low-hanging fruit (i.e. businesses which the operation had previously engaged with and knew) before broadening the engagement approach and reaching businesses less familiar to them and less accustomed to the fields of photonics and RD&I more broadly. It is the latter cohort which provides the higher potential impact around encouraging greater RD&I and photonics technologies in Wales.

Motivations for support

Understanding businesses' reasons for accessing the support also provides important insights into whether the operation has engaged with the right types of businesses. When asked about the specific goals they hoped to achieve through the CPE, most of the businesses surveyed referenced new or improved products or processes (42 per cent each), whilst a further 33 per cent highlighted a need to undertake a proof of concept study. This demonstrates the breadth of different TRL projects that were supported.

When asked about what prevented them from carrying out the innovation before getting involved with the CPE, the vast majority felt they had neither the knowledge and expertise to conduct the innovation (89 per cent) nor the facilities and technology (75 per cent), whilst most also cited a lack of capacity (57 per cent). This would suggest that there was a high level of need for the support and high additionality, i.e. that the innovation would not have taken place without the support, and is a positive reflection on the selection process.

We were also interested in understanding the significance of the projects to the businesses. These were relatively small projects, typically at a value of less than £10,000, and thus we were wanted to understand whether they were considered an important part of businesses' development. Overall, businesses did appear to consider these as important projects, with 50 per cent reporting that they were hoping the project would generate a 'high' level of improvement for their business' efficiency and/or opportunity to generate additional income, whilst 32 per cent were hoping for, or anticipating, a 'moderate' level of improvement. Just 11 per cent (5/44) of businesses were anticipating that the project would generate a low level of improvement or were not expecting any improvements at all. According to the CPE business plan, the selection of CRPs had to take into account the scope for long-term benefits and ensure that projects with high impact potential were approved and that there would be no private sector overlap or displacement. This data suggests that the operation has generally succeeded in delivering on the above-mentioned remit.

Profile of projects supported

The delivery team explained that there had been a high degree of variability in the types of projects supported, ranging from low TRLs, such as feasibility studies, to higher TRLs, such as technical demonstrations or commercialisation. Some were very small projects focused on desk research and offering advice on suitable equipment or components for businesses to use, designing specifications for materials, or simply looking at health and safety considerations; conversely, others were more extensive and required, for example, the development of prototypes. They varied in terms of scale, support intensity and the time required. They also varied in terms of subject area, e.g. whether the subject was to do with process lines, quality control, products, or other innovations. Some were more on the margins of photonics, but later in the product development process the need for a photonics application became clearer, e.g. looking at tiles made from recycled glass. Some projects were more technical and niche, whilst others were less complex. There was also much focus on integrating photonics into new products and processes, i.e. using photonics techniques to help them evaluate their products, e.g. UV light, infra-red laser. According to one of the academics:

> "It was about supplying the solutions that were needed and keeping true to what the companies wanted. It could have been a simple paper study to recommend the best 3D printer option, or it might have been a fairly complex material study or something much more science-orientated. The main thing was to deliver the solution the business needed – it was truly solutions-driven."

The level of innovation did vary. For example, the Diamond Centre Wales projects (see case study) focused on a completely novel approach, whilst other projects focused more on applying existing solutions – that were available on the market – to address their needs. A mixed response was received on this from the academic partners, with some suggesting that the projects had been much more applied and closer to market than they were used to, whilst another described the innovation within the projects as being *"more incremental than disruptive… not ground-breaking innovation"*. Other academics, however, reported that most of their projects did focus on novel solutions. Further, the Business Plan Addendum document submitted to the WEFO in February 2022 suggests that projects, on average, have been within the TRL levels of 3-5, which is on the more novel side of the spectrum.

There has been a significant focus on both product and process innovation within the projects supported, although perhaps more on the former. Indeed, 78 per cent of businesses responding to our survey indicated that they were interested in developing a specific product or service, with fewer (although still a majority) saying they were interested in developing a new process.

2.2.3 Innovation

The CPE has clearly generated innovation outcomes for businesses, which was the general thrust of the entire operation. This is confirmed in the beneficiary survey, with 72 per cent of businesses reporting that they have been able to formulate ideas for potential new products, services, or processes, whilst 58 per cent have developed a new product, service or process, and the same proportion have improved existing products/services/processes.

> "It's basically moved us forward by resolving the technical issues that we had with our laser marking technology so that we should now be able to go ahead and complete the development of a new product and launch that into the medical market."

> "It's allowed us to look into new areas for the business, areas where we wouldn't have the expertise as we're a medical device company so most of our knowledge base is in immunology rather than photonics and electronics."

Alongside these tangible outcomes, the vast majority of businesses reported softer outcomes, with 81 per cent indicating that the innovation has improved their understanding of the practical application of photonics. Even in cases where businesses had not received the direct benefits they were looking for, many felt that it had opened a new avenue for them to explore when searching for solutions in future.

> "It did lead to new ideas. Unfortunately, because we didn't achieve what we'd like to achieve through the project, we didn't get the kind of product benefits that we hoped for, but it has led to a few more ideas."

> "We've taken this as a premise to look at other low cost tech that may produce an acceptable output based on what we are trying to achieve."

There is some evidence to suggest that the operation has led to a greater investment in R&D. Indeed, we asked a question regarding this issue in the survey, with most businesses (57 per cent) reporting that they are investing more in RD&I as a result of the CPE support, at least to some extent, although only 19 per cent reported that they were investing more 'To a great extent'.[3] Further, 27 businesses were able to provide estimates on their RD&I budget pre and post support, with the data revealing that 48 per cent spent more post support (just 11 per cent reported lower spending, whilst 41 per cent reported the same level). On average, businesses reported that they spent around £16,000 more post support, which is equivalent to a 30 per cent increase in spending. However, this may partly reflect the general growth within the businesses. Indeed, when comparing RD&I spend pre and post support as a proportion of the businesses' turnover, the increase is much more marginal, at just 1 per cent on average. This would suggest that the operation has had a modest impact on encouraging businesses to invest more in RD&I.

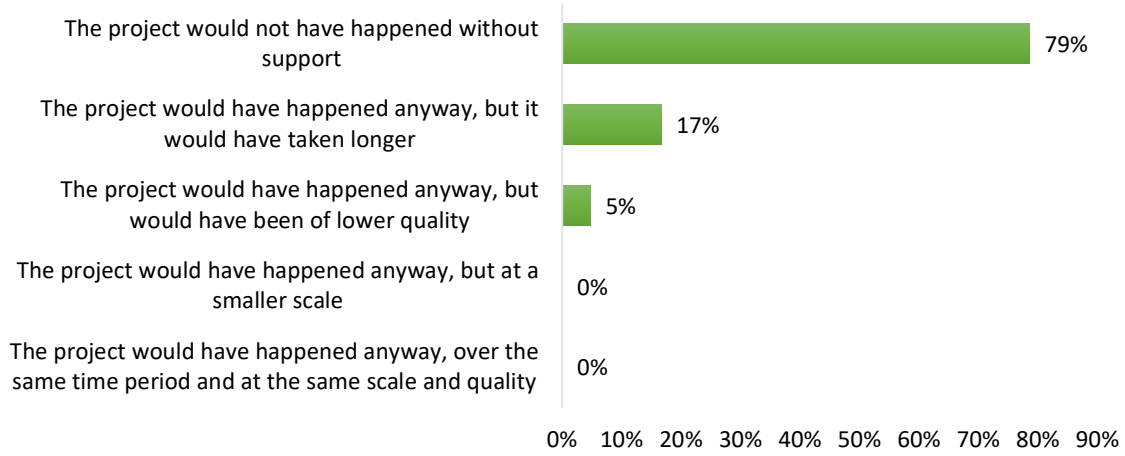
Nevertheless, there are some examples where the impact has been more significant, e.g. Diamond Centre Wales have set up an R&D department within their business as a result of the support (see case study). It was also highlighted, in discussions with delivery team members, that some businesses have become more focused on utilising studentships and PHDs to support their R&D activity, including examples of businesses looking to develop internship programmes.

2.2.4 Additionality

The survey included a question designed to understand the counterfactual position, i.e. the level of activity and outcomes that would have occurred had the support not been available. This enables us to understand the additionality of the support, i.e. the net impact achieved or the impact occurring over and above what would have occurred anyway. The results demonstrate a high level of additionality, whereby 79 per cent of respondents (33/42) believe they would not have undertaken the activity at all without the support from the CPE, whilst the remaining 21 per cent indicated that they would have taken longer to undertake the activity or that it would have been of lower quality. No businesses believe that they would have been able to undertake their project on the same scale or deliver the same quality and time frame without support from the operation (see Figure 2.3 over page).

[3] 19% responded 'To a great extent', 38% responded 'To some extent', and 43% responded 'Not at all'.

Figure 2.3: Beneficiary Survey: 'Thinking about your CPE project, would you have undertaken this activity without the support from the CPE team?'



Source: Beneficiary survey (n=42)

This is consistent with earlier findings which showed that businesses did not have the knowledge, expertise, capacity, and/or resources to undertake the activity on their own; indeed, most had never utilised photonics technology prior to the support and lacked understanding of it. This is also consistent with feedback received from the CPE delivery team, who felt that businesses would not have been able to access this specific type of expertise (e.g. reverse engineering capability) from other provisions. Generally, they felt that the vast majority of projects would not have occurred without the CPE support.

> "If CPE didn't exist and the SMEs go alone it would be tricky… They would have to hire professionals and need a lot of resource and time. What CPE does is removing the constraints and challenges."

> "Most wouldn't have happened. Lots required specialised expertise… niche knowledge in e.g. using diamonds as a device... It (the CPE operation) was a lot cheaper than external consultancy which would charge two or three times more."

Even in cases where businesses did hold the expertise in-house (a small proportion of businesses supported), the delivery team felt that resources such as the Coating Plant provided crucial capacity for them to undertake RD&I that would not have been possible otherwise with their own facilities and equipment used in production.

2.2.5 Delivery team and stakeholder perspectives

The CPE delivery team were confident that the operation has delivered important outcomes for supported businesses, whilst also noting that it would have potentially achieved much more were it not for the pandemic. At the most basic level, the operation's achievements consisted of developing solutions to their challenges and providing businesses with the results they needed to make decisions about their next steps, thereby enabling them to further their business. In that sense, delivery team members reported that the projects were a very good basis as a decision-making tool for future development, whilst also providing important validation on their products and processes:

> "Some projects helped companies to make very important investment decisions needed to scale up e.g. by adding a new process to their production line, while others needed to develop niche tech to improve their business, or make a process more innovative, or more safe for public use."

> "It helped enterprises decide which direction to go in. Many of them were seeking a feasibility study / testing the waters on what's possible – also testing their products and their applications to support future development."

The delivery team believe that the projects have generated 'hard outcomes' for businesses with regard to improving their margins and efficiency, generating new market opportunities, and thereby increasing turnover and employment. One academic described how several businesses were able to increase their resilience by becoming more independent in the supply chain.

However, perhaps the main outcomes reported by delivery team members pertained to developing the basis for larger/follow-up research projects and the research grants which several businesses were able to access as a result. Academics highlighted how the businesses were able to go to funders and demonstrate how they had *"made groundwork, that the project has legs and momentum"*; indeed, this gave them a much better case for investment. One academic highlighted how they have been able to publish research papers together with some of the businesses.

> "Some projects helped companies apply for further funding to unlock more grants. It's been particularly useful for those seeking funding at proof-of-concept or feasibility stage, and then helping them build on that to apply for further grants to support product and process development."

Equally, whilst there were some examples of projects progressing into larger exercises following the awarding of funding from other providers, the CPE had no internal mechanism through which to fund large-scale projects directly and thereby had to rely on external providers. This potentially represents a gap in the operation's delivery model.

2.3 Broader impacts

2.3.1 Attitudes towards photonics and collaborative R&D

The survey evidence strongly suggests that the operation has managed to introduce photonics technology to businesses as an option going forward. Prior to the support, 60 per cent of supported businesses had never used photonics, and just 50 per cent indicated that they had a good understanding and awareness of different photonics technologies. However, post support, 77 per cent of businesses reported that they will seek to use photonics technologies in future. In fact, 48 per cent (21/44) indicated that they had already identified further business needs that photonics and higher education collaboration could resolve.

> "We've been in discussion with them, further work on developing our technologies."

> "We looked at laser marking with Bangor through the CPE project and now we've had that experience, we're looking at potentially using lasers for different applications in the business."

Equally, businesses reported that there would still be challenges around conducting photonics-related RD&I themselves: 74 per cent reported that the lack of facilities and technology would be an issue, and 71 per cent cited gaps in knowledge and expertise, whilst 69 per cent cited challenges around capacity. As delivery team members have highlighted, photonics is generally a very specialised and niche area within RD&I, and therefore it would be unrealistic to expect businesses which do not directly operate in that space to be able to undertake these innovations themselves, thereby demonstrating the ongoing need for support for any future photonics-related innovations.

Delivery team members also highlighted the operation's impact in this respect, reporting that there were several examples where businesses had developed an understanding of the possibilities for change, and that previously there was an awareness gap around how photonics solutions could support their business.

> "Lots of the companies didn't know about laser uses before they approached us for support. Most of them have no idea that lasers can do so many different things. They get an opportunity to have a tour of the lab and do a quick demo, and this has been very effective at getting companies interested in learning more about uses of lasers for their business."

Several stakeholders made similar comments, noting how spreading the message about photonics and its potential impact is perhaps the most important impact. Others commented that *"photonics is something not many people have heard of – they need to innovate and they don't know this is out there*" and that *"companies who had no idea what they could use photonics for now have their eyes opened."*

Additionally, delivery team members highlighted that there has been a broader campaign which has not been limited to supported businesses. For instance, members of the wider business community have been actively engaged with many delivery team members, highlighting how they have demonstrated at industry exhibitions and business shows, and held open days, using portable laser systems and other equipment to demonstrate to local companies: *"We try our best to communicate how these technologies can solve many problems."*

What is more, the team demonstrated at the National Eisteddfod, again demonstrating capabilities such as laser engraving, so as to educate the public. One stakeholder highlighted how photonics is becoming increasingly prominent at a policy level, citing a reference to it in the innovation strategy, and suggested that operations such as the CPE have helped to promote the agenda. Thus, although it is not something which can be measured, the operation will likely have had some impact on raising awareness, understanding and promoting photonics capabilities.

RD&I and collaboration

We have already discussed examples where businesses have invested more in RD&I as a result of their experience with the CPE operation, and this looks set to continue, with 60 per cent reporting that they intend to invest more in RD&I and 78 per cent planning to enquire about receiving further support from the public sector for RD&I activity (this is up from 63 per cent reporting that they had received RD&I support prior to engagement).

There is also strong evidence to suggest that the operation has increased interest in collaborating with HEIs. Indeed, 80 per cent of our survey respondents stated that they would seek to work more often with HEIs on collaborative projects in future. Additionally, one of the most common responses when we asked an open question about the broader impacts from the operation was that it had opened their eyes about what academia can offer and strengthened their networking ties with universities.

> "It was very nice to work with universities. I suppose businesses as a whole tend not to want to go down that process because it's generally expected to be a very slow process, but certainly the team showed it wasn't. It was a very quick process and they were very efficient with what they were doing and very knowledgeable. It helps us to understand better how collaboration can help with commercialisation of prototypes and even concepts."

Delivery team members firmly believe that the operation has made an important difference in changing attitudes and raising awareness of the benefits of HEI and industry collaboration; one went as far as to describe it as *"one of the greatest achievements of the project"*. Members of the team explained how the operation had brought industry and academia closer together – that they had developed trusting relationships with industry partners, and changed opinions:

> "Some of the businesses never really worked with universities or had negative experiences, so this has been a good project to build trust."

2.3.2 Photonics infrastructure

Alongside the CRPs, around £2m of capital investment has been spent through the operation to develop the photonics infrastructure in Wales, with around half of that figure used to develop the Vacuum Coating Plant, alongside investments made by each partner to purchase equipment and develop new facilities (e.g. a photonics lab was set up at the USW). Whilst the main rationale for the investment was to ensure that partners had the capabilities required to deliver the CRPs, it has also generated infrastructural improvements to the photonics offer in Wales, which will have a sustained impact. Indeed, the Business Plan Addendum document submitted to the WEFO in February 2022 described how the investment would *"enhance each partner's R&D capability to utilise them after the CPE operation is closed and ensures CPE legacy to last for years to come by continuing the successful model under other funding schemes and eventually a self-sustained operation."*[4]

All such plans for capital investment were successfully implemented, including the installation and launch of the Vacuum Coating Plant at the OpTIC Technology Centre in St Asaph, which provided a new photonics capability not just to Wales, but to the UK as a whole, as described by the CPE Manager:

> "The new vacuum coating research facility provides a unique-to-the-UK, state-of-the-art, production-scale dedicated research facility to allow Welsh businesses to develop the next generation of thin film coatings to provide new products and processes to market."

Delivery team members highlighted the benefit of having a dedicated workspace for their photonics-related R&D, whilst they expected the plant to have "*huge benefits for companies across Wales"*, explaining that it creates capacity as well as capability. Whilst other businesses working in the said field may have the same thin film coating capability, this is the only plant which is dedicated to R&D; other facilities are utilised for production. Although the facilities and equipment have only been used for the operation activities to date, the intention is to make them available for collaborative research programmes going forward.

[4] Source: Business Plan Addendum document submitted to the WEFO in February 2022

However, many expressed concerns around the loss of funding and the impact that would have on ensuring that businesses can continue to benefit from these improved capabilities.

> "Those capital investments will struggle to have an impact without resource to support it because universities are struggling in terms of resource as it is."

Alongside the capital items purchased, some delivery team members highlighted how the operation in itself, and the success of the partnership, have also contributed towards developing photonics in Wales by establishing working relationships and models for collaboration; they further stated that the operation represents an early attempt at establishing a photonics cluster in Wales. Asked specifically about this, all partners felt that the operation has had at least some impact with regard to encouraging greater collaboration between HE partners and improving the photonics infrastructure in Wales. This has already led to discussions on further collaboration around Masters courses and, when funding opportunities are identified, partners will know how to fill gaps in expertise through collaboration: "*It will lead to stronger bids, the fact that we know each other, trust each other and know that we can work together*". Another partner described how the bonds between the four organisations had been *"immensely strengthened."*

Some academics also highlighted how they were able to develop their own expertise through the experience:

> "Before starting CPE, we had expertise in laser marking with one laser system. We now have three or four different systems. Our expertise and strengths have grown in different areas. Industry have transferred some ideas to us too e.g. through working with the steel sector and their challenges, it's been an important learning exercise."

External stakeholders certainly believe that the operation has had an impact on improving the photonics offer in Wales, building on what was already a strong tradition of photonics technologies, most definitely in the north east.

In conclusion, substantial improvements have been made to the photonics capabilities and infrastructure in Wales that industry could potentially utilise for years to come, thereby boosting the economy. Equally, however, it will be difficult for businesses to receive those benefits without an operation in place to facilitate the activity. Delivery partners reported that there will be ongoing collaboration on individual projects regardless, but continued funding support is required to provide support at scale. We cover this in greater detail in Chapter 5.

2.3.3 An assessment of the economic impact

There is some early evidence of the economic impact generated by the operation, although the COVID-19 pandemic will likely have had a substantial impact on beneficiaries' ability to grow. That said, survey data reveals that 39 per cent of beneficiaries (17/44) reported that the support has enabled their business to operate more efficiently, and 22 per cent (4/18) cited improvements to productivity – both of which can be linked to providing positive economic returns to those businesses. The businesses citing efficiencies described how they had developed new processes that were faster (e.g. see Smart Storm case study), whilst others described how they were able to undertake activities in-house that had to be outsourced previously. In total, 17 per cent of the businesses responding to the follow-up survey (4/23) reported that the project had led to a reduction in their costs. Additionally, there are some examples of local supply chain impacts, with around a quarter of businesses (26 per cent; 11/42) reporting that they had increased their spend in the local supply chain as a result of the CPE-related growth experienced by their business.

Increase in turnover

Turnover data was obtained from businesses pre and post support in order to ascertain any direct, immediate economic impact experienced by businesses. An assessment of this data shows modest immediate impacts. When asked, 46 per cent of businesses (19/41) indicated an increase in turnover, a further 41 per cent (17/42) signalled that there had been no change, and just 12 per cent (5 responses) reported a decrease. Where an increase had been reported, we asked whether they would attribute any of that change to the support received from CPE, and 15 respondents provided an answer to that question. Slightly over half (53 per cent; 8/15) indicated that the CPE had no impact, whilst 20 per cent (3/15) reported a modest impact of 0 to 20 per cent. The remaining 27 per cent signalled that a higher proportion could be attributed to the CPE, with one each selecting 21 to 40 per cent, 41 to 60 per cent, 61 to 80 per cent, and 81 to 100 per cent. By applying these figures to the reported increase in turnover, we can calculate that the CPE resulted in an increase of £90,050 in turnover for those 15 businesses. If we apply the average reported across the whole sample to all businesses supported (63), we can calculate that the support led to an increase in turnover of £153,328.

There are two crucial caveats that need to be considered. First, this is a rather crude estimate of the economic impact, based on the traditional methods outlined by central government in HM Magenta Book. It does not account for the 'safeguarding' of turnover amongst businesses which had recorded less or the same turnover compared to the year before the support was received (i.e. some of those businesses may feel that their turnover would be even less without the support). For example, one business recording no change in their turnover explained how the support had enabled them to cut costs:

> "It's given us more of an insight into slate most definitely. It's taken away a lot of the challenges. It's going to cost us a lot less money than we thought because we can use waste instead of getting the quarry to give us the good quality slate that goes on the roof."

We did obtain some data on this; businesses that had not experienced an increase in turnover were asked whether they thought their turnover would have been any different without the support. The response suggests that the 'safeguarding turnover' element might be limited to a small number of examples, with 10/13 respondents saying that the CPE had no impact on their turnover. However, we can speculate that the immediate impact on businesses' turnover is likely to be somewhat higher than calculated above.

Second, the modest immediate economic impact is perhaps unsurprising given that early innovation, which accounted for a large proportion of CPE projects, is known to take time to translate into hard data, as explained by one of the external stakeholders:

> "That is the nature of R&D, you won't have a result immediately. The projects will be just getting to grips with embedding innovations into the day to day and working out how the technology can be used to grow the business. Give it 12 months and you will see more results. You won't see things growing instantly after the project… it can take a long time."

Some of the businesses also explained that it could take some time to see any economic returns on the investment:

> "Realistically, given that it's going to take until about the end of the financial year to get this new product developed and then get it to market, I would hope to see some sales generated from this new product from about the beginning of the next financial year in April 2023 and for the sales of those products to increase year on year. So we are still in the stage of assessing what we expect those sales are going to be next year."

The modest immediate economic impact should not, therefore, detract from the operation's potential for economic impact. Indeed, there is strong evidence in the survey to suggest that the operation is likely to have a far stronger economic impact for supported businesses going forward. In total, 81 per cent (34/41) of respondents expected their turnover to increase in the next three years. A follow-up question was then asked to ascertain whether the CPE operation had contributed to respondents' confidence in growing their business, with most (61 per cent; 27/44) reporting that it had, at least to some extent.[5]

Explaining their rationale for this, nine businesses cited how the operation enabled them to develop new or improved products, or to validate existing products to move to commercialisation, thereby generating income opportunities. Linked to this, four businesses explained the impact on increasing their market penetration or opening new markets; six businesses highlighted the knowledge they had gained and, linked to this, four explained how they were able to improve their processes, which they predicted will contribute towards growth.

Moreover, businesses were able to cite specific examples to support their claims on future potential impact. One business highlighted that the support had enabled them to *"onboard a large potential client that should hopefully lead to future work"*. Additionally, five businesses highlighted how they had secured grant funding[6] that will provide income to their businesses going forward. One of those businesses explained that the said funding provided them with secure income for the next three years, whilst another highlighted that they had secured £10m in grant funding through Innovate UK.

[5] 39% replied 'To no extent'; 39% replied 'To some extent'; and 23% replied 'To a great extent'.
[6] Two businesses cited Innovate UK funding.

The follow-up survey also contained a question on businesses' turnover expectations/aims in the next financial year, revealing that 61 per cent (14/23) were expecting an increase and just 4 per cent (1/23) were expecting a decrease (the remaining 35 per cent expected the same level of turnover). Of those expecting an increase, 46 per cent (6/13) attributed at least some of that to their CPE projects, including three respondents who attributed more than 20 per cent of the expected increase in turnover to the CPE (see Table 2.2 below). If we apply this data to their expected turnover, we can estimate a total return of £926,000 within the follow-up survey sample. This is equivalent to a return of £38,583 per business. Furthermore, if we apply this average to all businesses supported (63), we can calculate that the support will lead to an additional increase in turnover of £2,430,750 over the next 12 months.

Table 2.2: Beneficiary Survey: 'What proportion of this annual increase in turnover, if any, would you attribute to the changes brought about by the CPE operation?'

	Response	%
None	7	54%
Up to 20%	3	23%
20 to 50%	2	15%
More than 50%	1	8%

Source: Beneficiary survey – businesses reporting expectations of an increase in turnover (n=15)

These figures do rely on broad estimates and assumptions and should therefore be treated with caution. Nevertheless, we can conclude that there have been modest immediate economic returns resulting from the support provided, with the potential for far higher impacts in forthcoming years which could realistically provide a positive return on the circa £7.3m invested in the operation. Given the nature of RD&I operations such as these, it is also fair to assume that there will be longer-term economic impacts that will not occur until some years after the end of the operation, particularly in the cases where the projects have already developed into larger research projects with additional grant funding obtained. For example, it is possible that the £10m grant obtained by one business from Innovate UK would not have occurred without the operation, and that in itself demonstrates a positive return on investment. It is also worth noting that these estimates are only based on the positive returns for direct beneficiaries. They do not account for the unknown economic impact resulting from the capital investment component of the operation and some of the broader outcomes around increasing RD&I activity and photonics-related activity for years to come.

ERDF Result Indicator

This data can be used to assess the performance of the operation against the result indicator associated with Specific Objective 1.2 of the ERDF Programme, namely *'Average share of total turnover from product innovation and novel innovation: new to market, new to business and significantly improved'*. We can assume that the increases in turnover attributed to the CPE are related to product and novel innovation, which we would take to include process innovation, given that is the entire focus of the operation. Our analysis reveals that, on average, the product and novel innovation conducted as a result of the CPE

was responsible for 2.9 per cent of beneficiaries' total turnover. When looking at the estimates provided for the next 12 months, our analysis suggests that businesses, on average, expect the CPE product and novel innovation to be responsible for 8.2 per cent of their turnover.

Increase in employment

The survey data reveals a marginal change in employment when businesses were asked for the number of people they employed before the support and in the latest financial year; indeed, the figure rose from 1,957 full-time equivalent (FTE)[7] staff before the support to 1,983 afterwards. This represents an increase of 26 FTE positions, or 0.6 per business. Overall, 38 per cent (16/42) reported an increase, 52 per cent reported no change, and 10 per cent reported a decrease in employment. This is again indicative of the difficult trading environment created by the COVID-19 pandemic, which will have stifled growth, thereby affecting the operation's ability to demonstrate immediate economic returns.

A similar approach was then used to identify the net impact on employment growth resulting from the CPE, i.e. where an increase was reported, we asked whether they would attribute any of that to the operation. Half of respondents (8/16) said that the operation had no impact on their increased employment, a quarter (4/16) attributed a marginal increase (0 to 20 per cent), one attributed 21 to 40 per cent, and the remaining three respondents attributed a large proportion of the increase (81 per cent to 100 per cent) to CPE-related impacts. If we apply these proportions to the additional FTEs reported by the businesses following the support, it results in 9.7 new FTEs that can be attributed to the operation within the sample. If we gross this up to include all businesses supported (whether surveyed or not) by applying the average increase to the total number of businesses supported (63), it generates an estimate of the support creating 14.6 new jobs (almost half of the aforementioned impact was reported by one business – Diamond Centre Wales (see case study in Appendix 2)). This is higher than the figure reported to the WEFO (just three were reported to the WEFO – see Table 2.1 above) and is close to the original target (16). These jobs are likely to include the six fully-funded KESS[8] studentships that are linked to the CPE projects, as reported by the delivery team.

In addition to creating new employment, businesses were asked whether they believe the operation has had any effect in terms of safeguarding roles that already existed. In total, 30 per cent (13/43) stated that they believe it has had at least some effect in that regard, with the 13 businesses indicating that it has safeguarded 17.5 jobs between them. If we apply the average jobs safeguarded across the entire sample (0.42) to all businesses supported (63), this suggests that the operation has safeguarded 26.3 jobs. The aforementioned figure is consistent with a comment made by one of the external stakeholders, who strongly felt that

[7] We asked for their number of full time and part time employees before and after the support. These were converted into FTE position for the purposes of measuring change, with part-time positions assumed to be 0.5.

[8] Knowledge Economy Skills Scholarships

the operation should be capturing data on jobs safeguarded and that this would be an earlier and more important indicator of success.

Combined, all of the above-mentioned data would suggest that the operation has led to around 41 FTE positions within supported businesses which would not exist today had they not received the support. That said, it is important to stress that these figures should be seen as broad estimates given that the approach relies on self-attribution, which is not the most robust approach to estimating net impact.[9] Nevertheless, we can be confident that the impact on employment is substantially higher than that reported to the WEFO.

Looking ahead, 60 per cent (25/42) of businesses were anticipating an increase in their employment over the next 12 months. On average, businesses expected to take on around three new employees each and around half (47 per cent; 8/17) indicated this is partly linked to their CPE project. Overall, respondents expected to create 0.3 FTE positions each, on average, over the next 12 months, which can be attributed to the support. By applying this to all businesses supported, we estimate that the operation has the potential to create around 18.6 new FTE positions. Beyond this, there is far greater potential for the operation to create more employment if subsequent research proves successful, e.g. Diamond Centre Wales reported that around 1,000 roles would be created should they be successful in progressing with the commercial opportunities that came out of their CPE projects (see case study).

2.3.4 An assessment of the environmental impact

There are some examples of the operation's environmental impact, as demonstrated through the case studies. For example, Diamond Centre Wales were encouraged to develop their green infrastructure, Transcend Packaging's project had the potential to reduce waste product material and processing time (although the company decided not to proceed with the new process), Smart Storm's project helped with the reduction of industrial waste streams, and Enviro 365 were supported in developing a solution that would better manage the risks posed by oil spills.

There are indirect environmental benefits linked to the fact that 39 per cent of beneficiaries reported that they are able to operate more efficiently as a result of the support, whilst the support given to businesses working directly in the environmental protection space (such as Enviro 365) has a clear link to generating environmental benefits. Moreover, 22 per cent of respondents to the follow-up survey (4/18) reported that there have been environmental benefits such as savings in energy, GHG emissions, and waste resulting from their projects.

[9] A more robust approach would have involved the use of a comparison group so that comparisons could be made in the employment and turnover between those receiving support and those that had not received support. However, this was not possible due to resource limitations and a lack of suitable businesses for a directly comparable group.

What is more, the operation's CCT management information tracked activity delivered against the Sustainable Development CCT. In it there were listed 33 examples of projects that contributed towards this theme, the vast majority of which concerned direct or indirect environmental impacts. This contained a mix of improvements made to businesses' own processes so that they could operate more sustainably; it also included projects that aimed to develop or improve products and services which would have a positive effect on the environment (see Section 4.7 for further information).

Respondents to the follow-up survey were subsequently asked an open question about any environmental impacts resulting from their projects. In response, just over half (13/23) indicated no impact, 30 per cent (7/23) reported a positive impact, and a further 9 per cent (2 respondents) indicated there was potential for positive impacts, whilst one suggested an adverse impact as they were using more energy as a result of the project. Of the seven reporting positive impacts, two stated that they have been able to reduce their energy usage, two declared that they have reduced their use of chemicals, and one each stated that they have reduced waste, re-used a waste product, and developed a product that can help protect the environment.

> "The processes that we are using are very energy hungry and the processes that we are developing would reduce the cycle time, so I guess it's not as a direct outcome of the project but it's a consequence of it."

3. Lessons on delivery performance

The current chapter explores the operation's delivery performance and, crucially, identifies the main lessons that should be taken from the experience. This includes an assessment of the most effective aspects that should feature in future interventions, the least effective aspects, and areas for improvement; at the same time, there is an outlining of overall satisfaction levels and an assessment of the extent to which the operation has been delivered as intended.

3.1 Satisfaction with the delivery performance

It is clear from our research that the operation has been well received by each key stakeholder group. Indeed, 75 per cent (33/44) of businesses responding to our survey reported that they were 'very satisfied' with the support, whilst a further 9 per cent were 'somewhat satisfied'. Just 7 per cent (3/44) provided a negative response, saying they were 'somewhat dissatisfied'.[10]

The delivery personnel were unanimously positive. They were particularly pleased about the benefits generated for businesses and the variation of businesses engaged. Others compared it to other ERDF-funded operations they had been involved with, describing this as the best-run example, whilst yet another praised the *"smooth"* nature of delivery. Further, the operation can be particularly commended for the way it managed the challenges caused by the COVID-19 pandemic, where the team showed flexibility in moving to desk-based arrangements and shared resources (such as laboratory space) with the HEIs opening at different times.

External stakeholders participating in our evaluation, who felt sufficiently close to the operation or were familiar with some of the business experiences, were also very positive in their overall assessment of delivery performance, noting the dynamic nature of the operation and buy-in from industry, whilst also stating that they had not heard anything detrimental about it.

3.1.1 Main strengths

There were clear, common themes which emerged during discussion with delivery team members regarding the main strengths of the operation and their rationale for providing such a positive response, with most referring to the strength of the partnership (9 of 13 interviewees referred to this). Most (7 respondents) also referred to the effectiveness of the processes developed to manage the operation, whilst six cited the capabilities and complementarity of photonics expertise across the partnership.

[10] The remaining 9% (4/44) selected 'Neither satisfied nor dissatisfied', whilst none selected the 'Very dissatisfied' option.

Delivery team members described how collaboration between HEIs is often difficult because of the competitive nature of the sector. However, the internal working between universities was clearly effective and not overly competitive, even when deciding how to allocate projects. It was described as a fairly informal approach where partners worked seamlessly together and provided a united front to industry, which would access support from the most appropriate provider without tension. Indeed, three interviewees noted how it was quite rare for competing universities to work in this way.

This is partly linked to the processes developed for the operation, which appears to be a key factor behind the success. Interviewees described how the operation contained a clear, effective, end-to-end process for them to follow, starting with the initial engagement (often with a BDM) to scope the requirements and verify businesses' eligibility for support. There was then an effective internal process designed to identify the most appropriate academic lead, with all potential projects discussed openly during the operation's weekly meetings. The responsibility for business engagement would then be taken up by the academic lead, utilising tools such as Project Scope Forms and Collaboration Agreements, which were agreed across the partnership and streamlined. Having such templates was said to have been crucial in making the process as quick and painless as possible. Indeed, two interviewees highlighted the speed of the operation as a strength, explaining it was closer to the speed to which industrial partners are accustomed.

> "This (satisfaction with delivery) is due to the effective structure and model. Having the permanent support on the admin side and BDMs has helped… It means that we are ready to pounce when new projects come in. As a lead academic, I have 10% time attributed to this but it's unpredictable when this time might be needed, so having the post docs working full time means we can respond quickly when things come up."

> "The flexibility and responsiveness in working with companies (have been the main strengths). Often, academic collaboration with industry can be slow, but having the T&Cs already worked out with universities before we go to businesses has really helped."

As a result, the team were able to get some projects started in as little as a week, particularly for the smaller businesses – the larger ones could be more complex due to their legal teams engaging in the process.

The expertise within each HEI and the complementarity of that expertise across the partnership have been essential ingredients in the operation's delivery performance. Interviewees highlighted how the team had different strengths and, when brought together, these strengths created a critical mass of knowledge and capabilities that businesses could access across different areas of photonics technology, be it meteorology, lasers, material characterisation, optoelectronic devices, etc.

> "Each partner had a specific area of expertise e.g. laser-related projects would go to Bangor. It seemed to work really well. Some projects were delivered with two academic partners where a blend of skills were required."

The effectiveness of the processes around matching businesses with the most appropriate provider was crucial in maximising the value of having such a diverse team. Additionally, running across several of these factors, four respondents highlighted the effectiveness of the leadership and internal communications as one of the key strengths.

Other key strengths included the overarching approach and principles of the operation, which were very much practically focused and challenge-led (3 cited this). They were clear that the projects were not about conducting research for the sake of it, and they were careful not to *"reinvent the wheel"*, i.e. the first step would be to look for existing solutions on the market and only if nothing suitable was available would they develop novel innovations. Some of the external stakeholders also highlighted this as a key strength, and, linked to the previous point, singled out the importance of having 'industrialists' leading the team and former industrialists working directly on project delivery.

Two interviewees emphasised the importance of the BDM role, which has clearly been a crucial element of delivery by allowing academics to focus on delivery and by communicating with businesses in a style they understand. Finally, another interviewee thought that the geographic reach of the operation was another important factor.

These sentiments are corroborated by feedback from external stakeholders who also spoke about the partnership approach, capabilities, and industry-focused design of the operation.

> "I have never seen an example where different universities are so willing to talk so openly and collaborate so effectively. They tend to be one academic department that lead and a bunfight for outputs. What I really liked is that the BDMs have an open discussion with the four partners about the best fit. It's not just the one that shouts the loudest, it's the best fit for the company and the right solution."

3.1.2 Areas for improvement

The main challenges and potential areas for improvement can be broadly categorised into four main groups: the speed of delivery, the scale of delivery, external challenges, and communications with businesses.

Whilst the delivery team felt they had streamlined processes as effectively as possible, the bureaucratic requirements of running an ERDF project still appear to have affected the speed of delivery. Seven of the 13 delivery team members referred to the 'paperwork' and administrative requirements as some of the main weaknesses and areas that could be improved, whilst four referred specifically to the speed of support. Interviewees explained that, whilst many of the processes had worked well, there would also be bottlenecks created by the laborious process of collecting timesheet data from businesses and other administrative requirements. The responsibility for doing so was delegated to one staff member, partly due to ensuring optimal GDPR compliance by creating one point of contact. However, this created capacity issues, and some of the progress with businesses would occasionally *"grind to a halt"* as a result of these administrative requirements. This appears to have affected the quality of the business engagement experience in some cases. Indeed, when asked about potential improvements to the support, six of the 43 responses to the business survey highlighted a desire to reduce the administration requirements.

> "Admin and bureaucracy have to be totally aware of the speed of products because if it's not done it can kill projects."

> "Filling them (timesheets) in is a nightmare. Every other project you put a standard rate in for the salary, for these ones you need to put in the exact salary of the person working on it, I can't see other people's salaries so it makes it a nightmare to try and fill it in and on top of that the spreadsheets don't work properly, the links don't work so it takes a lot of time."

Accordingly, one delivery team member suggested that there should be greater resources in future operations to support businesses in tackling those administrative challenges. Equally, some of these issues are linked to ERDF funding requirements and could, therefore, be averted in future operations.

Future interventions may wish to consider adjusting the process requirements according to the scale of the projects at hand. For instance, some of the smaller projects were described as simple advisory support, e.g. where businesses wanted reassurance that they were investing in the most appropriate equipment. Having to complete the different administrative steps, such as the collaboration agreements, timesheets, etc., is potentially disproportionate for such small-scale projects, as described by one of the delivery team members when detailing the administrative requirements for businesses:

> "Where projects came more advisory and feasibility based, the paperwork could feel mismatched, so there could be branches - low vs high TRL where you can just go in to provide advice without additional paperwork for the smaller ones. As soon as we stepped into multiple months, it felt appropriate."

Delivery team members highlighted that ERDF-related constraints had also affected other aspects of delivery, including the ability to make changes to resource allocation during delivery:

> "The paperwork, rules and lack of flexibility with spending… we can't spend outside the boxes that were ticked at the beginning. Just moving quickly to purchase equipment… we have three months of revenue funding left for staff salary but their work has come to an end – we can't use that on other things. We spend an incredible amount of time trying to get on top of this – it is not efficient."

Six businesses also referred to the timescale of the projects more broadly, with some simply noting they would like the projects to be delivered quicker (e.g. with faster communication), whilst three noted they would have preferred larger or longer projects to have more time to complete their targets, or the availability of further funding to implement findings.

There have also been capacity constraints in other aspects of delivery, principally with regard to the BDM role, where there had been some staff turnover resulting in the operation only having access to one BDM at different points in delivery. The face-to-face work and initial engagement by the BDMs was seen as a crucial part of the process to identify potential projects and establish relationships with businesses. Thus, losing some of those resources will have affected the lead-generation process and potentially the quantity and quality of projects supported due to not having *"enough irons in the fire"*, as one delivery staff member described it.

A further six businesses indicated that communications with the CPE team could have been better, with some providing examples whereby communications with the team had broken down and one highlighted how their experience had deteriorated after their BDM contact had moved on, reflecting the importance of the BDM role as a conduit:

> "When we started off we had [Name of BDM] as a communicator between both the company and the academics. Sometimes it's a little bit hard especially for me for being not academic to be able to understand technology. I know what I want it to do, but unless my chief technical officer was there to explain it in more detail… so [Name of BDM] helped with that but when [Name of BDM] left we were given another person but

that person hasn't really been in touch with us… that liaison after [Name of BDM] left dropped."

We understand that several researchers and one administrative team member also left their roles at different points, thereby contributing to further capacity challenges. The *"noncontinuity"* within the team was also picked up by one of the external stakeholders who had worked closely with the project, although the stakeholder praised the project for the way in which those challenges were managed: *"it could have knackered the project but it didn't"*. Delivery team members did concede that losing *"some good team members across the institutions"* had led to losing some *"momentum, knowledge and expertise towards the end as people leave and can't be replaced"*.

When asked about the main areas for improvement, three delivery team members and one of the external stakeholders reported that making the support available throughout Wales, i.e. not limited to the WWV region, would be a significant improvement.

One delivery team member suggested that the scope of support should be expanded to provide training and knowledge transfer activity. It was also suggested that a future operation could deliver more activity around the wider awareness-raising of photonics technologies, e.g. by demonstrating the potential careers within photonics to younger generations and engaging industrial partners in the process.

Finally, most of our survey's business respondents (24/44) felt that external factors such as COVID-19 and Brexit affected the support received from the CPE operation, with 14 explaining that these factors had added time delays or constraints, meaning the projects took longer to complete, e.g. researchers were not able to access their labs for a period and there were also issues around access to staff within the businesses. Further, nine stated that they missed out on not being able to meet in-person, whilst five felt that these external issues had affected communications.

In summary, whilst there have been some challenges in delivery, the vast majority of businesses have been very satisfied with their experience. Indeed, when asked about potential areas for improvement, 37 per cent of businesses (16/43) reported that they could not think of any. Equally, several interesting suggestions were made with regard to potential improvements of future delivery.

3.1.3 Delivery against original conception

Generally, delivery team members felt that there had been no significant deviations from the original concept, with the operation largely delivered as intended. The CRPs have been *"short and sharp"*, as originally conceived, and the operation has been able to stay true to the core principles (e.g. providing industry-led, solution-based projects operating at a suitable speed for industrial partners); moreover, the team have also generally been able to make the capital investments that were intended.

> "It has gone as expected. In fact, we have achieved a fair bit more than we said we were going to… we have been able to support so many more businesses than we could before this. We did have several routes to collaborate with industry through internal resources, however it was a longer process… this has taken it from a process of months or years to one of just a few weeks."

Three of the 13 delivery team members did indicate that there had been some changes during the course of the operation that saw it *"evolve"* and improve with the delivery becoming smoother. One highlighted that there had been an increase in the number of projects involving more than one academic partner towards the end, due to the increased collaboration between HEIs. Another suggested that there had been a deliberate change of focus towards smaller-scale projects, often feasibility studies, towards the end in order to ensure that the targets could be achieved. Yet another mentioned that there had been a pivot in the businesses targeted, with the operation unable to engage semiconductor businesses as originally intended, as they generally fell outside the WWV region. This resulted in the targeting of broader manufacturing businesses, perhaps more than initially intended, thus leading to a greater diversity of businesses, whilst it also *"sparked a broader range of relationships"*. The team member explained that, whilst working with these 'non-traditional' photonics businesses did provide some benefits, it may also have affected the hard impacts generated, as collaboration with the large semiconductors had a higher impact potential. Additionally, such collaboration would have generated more value from the thin film coating plant, which is particularly beneficial to the semiconductor sub-sector.

Overall, despite these slight deviations and changes in momentum, the operation does appear to have been able to deliver what it set out to. It was able to continue, albeit at a slower pace, during the pandemic, and has met the majority of its target indicators.

Extension

The extension to the CPE operation coincided with a 26 per cent increase in the budget. This included a 23 per cent increase in staff costs to extend delivery staff's contracts, thereby allowing the operation to continue delivering the CRPs during the extended period. Additionally, the extension saw a 29 per cent increase in non-staff costs, which primarily involved further capital investments (see 'Accommodation' in Table 3.1 over page). These investments were designed to provide scope and capability for further support of enterprises in areas that had already been identified through early CRP work. AU invested in a Thermo Scientific FTIR spectrometer as a complementary instrument to their existing diagnostic and material characterisation. This was used to support three projects in their pipeline. BU invested in High-Power High-Repetition Rate Ultrafast as a result of their efforts in addressing certain industrial challenges in companies they supported through the CPE

and the fact that none of the existing lasers could meet those requirements. USW invested in a Metal 3D Printer and a Linear Terahertz Imaging System to support collaboration within the CPE and to also sustain and strengthen the position of USW–industry collaboration going forward. Finally, WGU invested in a large-capacity 5-axis CNC grinding machine to enhance and complement the capabilities at the OpTIC Technology Centre in St Asaph, including the tin-film coating plant.

Table 3.1: Comparison between the original and revised budget

Expenditure areas	Original Business Plan	Revised Budget	Change
Staff Costs			
Researchers	1,082,712	1,384,526	28%
Project Delivery Staff	387,903	471,893	22%
Project Management	567,013	650,068	15%
Academics	438,381	555,059	27%
Project Delivery Staff (In-kind from Private Sector)	325,000	395,000	22%
TOTAL STAFF	**2,801,009**	**3,456,546**	**23%**
Non-Staff Costs			
Professional service	22,500	39,596	76%
Accommodation	1,434,750	2,130,427	48%
Marketing promotion	60,000	58,675	-2%
ICT	78,334	61,033	-22%
Administration	193,691	143,361	-26%
Human resources	28,530	21,015	-26%
Travel transport	90,000	40,456	-55%
Simplified cost options – 25% of Eligible Direct Costs	1,095,954	1,389,027	27%
TOTAL NON-STAFF	**3,003,759**	**3,883,590**	**29%**
TOTAL EXPENDITURE INC STAFF COSTS	**5,804,768**	**7,340,134**	26%

Source: Management information shared by the CPE operation

3.2 Engagement with stakeholders and alignment with other operations

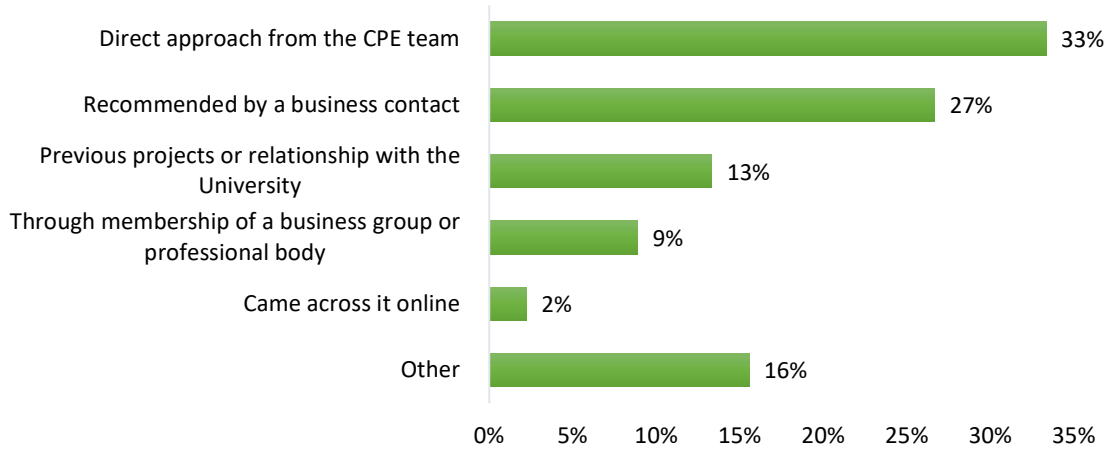
One of the key evaluation aims was to assess how effective the operation has been in engaging at strategic and operational levels with key partners, stakeholders, businesses and the wider community. We have already discussed this to some extent at earlier points in the report, but we address it directly here.

3.2.1 Business engagement

The business engagement approach was summarised in the previous section, drawing on the BDMs to undertake the initial engagement and create a pipeline of potential projects, before undergoing the project scoping, collaboration, and handover to the academic partners. Projects that could produce new-to-market products and processes were prioritised, although the operation could also deliver follow-on projects with existing businesses, where appropriate.

Businesses became aware of the operation through three main routes. A third were made directly aware by the CPE team (i.e. primarily the BDM outreach activity). Around a quarter found out about the support through other businesses, and 13 per cent stated that they had previous relationships with the university. Additionally, all but one of those selecting 'Other' explained that they had been made aware by a contact at the university. Consistent with previous findings, the data shows that a higher proportion of Wave 1 respondents were aware of the support as a result of an existing relationship (19 per cent vs just 5 per cent of Wave 2). This again demonstrates how the operation initially engaged with businesses known to them, often already operating within photonics, before reaching out to the wider economy.

Figure 3.1: Beneficiary Survey: 'How did you first hear about the CPE project?'



Source: Beneficiary Survey (n=45)

Generally, delivery team members felt they had succeeded in supporting an appropriate set of businesses, noting the diversity of sectors engaged with, and their familiarity with, photonics, as well as the opportunity to work with smaller businesses which have traditionally been harder to engage. This was attributed to the impact of the BDMs, with delivery team members explaining how they were able to entice 'non-traditional' businesses through avoiding technical discussions:

"If they were to go to a company and ask whether they had a photonic-related issue, it would be a short discussion. So they had a different approach, they just asked about their challenges in general, and then follow up by asking have they considered using lasers, new coatings etc. to address the issue. You then get a different response from businesses. So having the BDMs has opened doors for us… We have managed to reach beyond the usual suspects."

"Some companies knew about photonics at a high-level, some didn't really know anything at all. The ones that didn't know in the beginning, knew about the wide field in general by the time they finished, they had a solid knowledge."

We understand that some of the BDMs had a background within photonics technology, and therefore had some intuition on how businesses could benefit from the technology, which was highlighted as a key enabler in their effectiveness in bringing forward suitable projects to the wider team. There was some disagreement within the comments regarding the approach, with some stressing the importance of ensuring that the initial engagement was non-technical and stating that having network-building skills was the most important trait for BDMs. Conversely, two interviewees stressed the importance of ensuring that academic leads could engage in the initial discussions alongside the BDMs to provide the technical input where needed. The difference in approaches also involved some highlighting the importance of simply listening to businesses' needs and challenges, and others emphasising the importance of communicating what the operation could deliver. These differences can be seen in the quotations provided below.

"The BDMs did a great job in understanding the brief. They had a very non-technical approach – a listening approach. We didn't want people going to business owners to say how fantastic we were. It was about just listening to how they were looking to make their own improvements, so it's not blinded by the science at the outset."

> "I did have a disagreement at the very beginning on the grounds that we wanted academics sat in front of companies talking about solutions and that's how you get fruitful interactions. The BDM initially went out on their own. This was a bit of an issue… it probably needed the technical knowledge at that initial contact."

The balance of opinion on these two points was to support the former approach (i.e. a listening/non-technical approach), although the optimal strategy is likely to include a combination of both, i.e. BDMs who facilitate non-technical discussions but also have the technical knowhow to suggest potential solutions and explain what the operation can deliver.

Four delivery team members suggested that the operation could have done with more BDMs to carry out further outreach work and thus create a larger pipeline of businesses and potential projects, thereby enabling the operation to be more selective in supporting projects with the highest impact potential. Indeed, our analysis of the pipeline data reveals that, whilst only around 20 per cent of all businesses that had been identified were supported (63 of 318), the reasons for not proceeding with projects were, in almost every case, to do with ineligibility (e.g. outside the WWV region) or the fact that the business had become unresponsive. We have not identified any examples where the CPE team decided against engaging with a business because the project was deemed to have insufficient impact potential. The analysis suggests that all eligible projects, where the operation secured businesses engagement, did go ahead into delivery, which indicates a lack of selectivity in the approach. This is consistent with comments made by the delivery team, with one member stating: *"generally speaking we helped every company we could support"*. Indeed, they would signpost to other provisions where it was felt that there was no suitable photonics solution. The delivery team member went on to state that:

> "We set out to support as many businesses as possible. We didn't want to be selective, because what makes one project better than another? You don't know until you have done the project what the value is, and it's difficult to judge the value of supporting specific businesses. So we didn't want to be in a position of cherry-picking projects."

This does seem to run in contrast with the approach described in the initial business plan, where the following was stated:

> "The selection of CRPs will take into account the scope for long term benefits and the best results in terms of economic impact in WWV."[11]

However, another delivery team member described the need to support projects that had scope for long-term benefits as a "*key consideration"*. Indeed, the initial step identified businesses and projects that offered *"genuine solutions"* which were not necessarily about growth and commercialisation – it could be having an impact on their processes and understanding.

Delivery team members felt that subsequent engagement with businesses after the initial scoping process had also been effective, explaining that the template developed worked very well. They were able to set realistic expectations from the outset and would often hold regular meetings with industry partners. The team were adaptable and could provide a bespoke approach to businesses requiring different engagement styles. For example, some businesses only wanted to speak to the academic staff, whilst others would only communicate with the BDMs.

The vast majority of businesses responding to our survey were positive about the different aspects of engagement with the CPE, as can be seen in Figure 3.2 over page, where more than eight in ten agreed, or strongly agreed, with every statement. Whilst the initial application and scoping aspects received the least positive feedback, 86 per cent and 91 per cent still provided a positive response to those two aspects, respectively, noting that the application process was easy and agreeing that the scope of the project was straightforward. The ongoing business engagement aspects received an even more positive reaction, with businesses satisfied with the communication and organisation of the support. They were most pleased with the knowledge and expertise provided by the academic partners, with almost half strongly agreeing with that statement, which is by far the most positive response.

[11] CPE Business Plan Main - V 1.18

Figure 3.2: Beneficiary Survey: 'Overall, to what extent do you agree with the following statements?'

Source: Beneficiary Survey (n=44)

3.2.2 Engaging key stakeholders

The CPE operation has worked alongside key stakeholders, to some extent, in an attempt to ensure that the support for businesses is as coordinated as possible. It has worked alongside other Welsh Government-funded operations and networks (e.g. ASTUTE, MADE, Accelerate, Knowledge Transfer Network, FSB, South Wales Chamber) to ensure appropriate cross-referrals. For instance, Figure 3.1 reveals that 9 per cent of supported businesses became aware of the support through other networks, whilst the CPE management information further reveals that 50 businesses which the CPE engaged with were referred to other provisions, including 14 that were referred to ASTUTE.

The team confirmed that there has been some discussion and engagement with other provisions where there is some crossover (e.g. ASTUTE and Accelerate both offer RD&I support in the same region, although their offers are broader than photonics and they are typically larger projects), so as to limit duplication and ensure complementarity. They have held joint events with ASTUTE to promote the operations in a coordinated fashion. They have also worked alongside the Welsh Government's internal team of innovation specialists who operate across Wales and advise businesses on all aspects of RD&I. Perhaps most significantly, they have worked with other key innovation support providers throughout the UK, including the Knowledge Transfer Network, whose remit is to accelerate innovation, including through Innovate UK grants. Several CPE projects have led to successful applications for much larger grant funding from the KTN, and thus the relationship has provided businesses with an opportunity to further develop their RD&I projects in some cases. Finally, the CPE's Executive Board contained external representation, with representatives from the Welsh Optoelectronics Forum, industrial advisers, and other key stakeholders providing industry insights and insight into the wider innovation ecosystem.

It is clear from discussions held with the external stakeholders that the operation is well-regarded, that it sits in a space which no other provision directly caters for (the USP being the niche focus on photonics and the scale and speed of delivery), and that there have been examples of collaboration. Equally, stakeholders generally reported that they had not worked extensively with the operation, and thus the engagement with external stakeholders does not seem to have been a significant focus of delivery.

In conclusion, the collaboration with other stakeholders appears to have served its purpose in ensuring an awareness of the operation across key providers and establishing cross-referral mechanisms, gaining some expert input into the oversight of delivery (through representation on the Executive Board) and some collaboration to provide an opportunity for businesses to scale-up their projects through other providers. Equally, it is also clear that collaboration with external stakeholders has been fairly limited. It may have been possible to do more in this area by, for example, providing a better continuum of support for businesses to upscale their projects, as most of the smaller-scale projects did not proceed to larger grant funding.

3.3 Management process

As we have already noted, the administrative and management processes developed around the operation appear to have been one of the main strengths, with clear roles and responsibilities, streamlined forms, and regular internal meetings through appropriate operational and strategic-focused forums. Delivery team members praised the clarity of the process and the template developed for a consistent approach for each project. There was a clear role for the BDM to carry out the initial engagement work, an effective process to decide which institution should lead on the project through weekly internal meetings, and clear processes in place to agree on the scope of the work, time commitments from the academic and industrial partners, and agreed outputs, all of which was formalised in collaboration agreements.

> "This has worked well – they know who the lead institution has been, who is leading on each work package, and agree the CRP roles and responsibilities. It is very clear. This has allowed them to complete projects effectively."

> "It has helped having an agreed process and a consistent collaboration agreement. These processes have worked well and could be applied to other projects in other parts of the University."

The initial implementation period was longer than expected, with several iterations of the collaboration agreement, scoping forms etc. developed. However, the time spent on that exercise certainly appears to have been worthwhile, with delivery team members indicating that it has been critical to their success, noting the importance of having clear timescales and expectations at the beginning, coupled with consistent updates and engagement, thereby ensuring that the business partners generally had a satisfactory experience which aligned with their expectations. These sentiments are supported by the feedback from the supported businesses, with Figure 3.2 above showing a high level of satisfaction with these processes. Additionally, some of the case studies provide detailed examples of the operation's effectiveness in managing the participant journey (see Robertson Geo case study).

3.3.1 Partnership working

The CPE partnership provided the reach and breadth of geographic and subject matter coverage for companies in the WWV region – something which no single HEI could provide. Importantly, businesses were not confined to receiving support from the HE partner within the closest geographic proximity of their operation. Through this partnership approach, they could tap into a larger network and access the most appropriate expertise for their subject matter.

The discussion with delivery team members on the partnership working aspect was almost unanimously positive, with interviewees describing how they had created an effective team ethos where they were working for the CPE as opposed to their individual universities. Despite having their own individual targets, we have not seen any evidence of disagreements over project allocation. Indeed, delivery team members confirmed that the process was conducted openly and amicably in a non-competitive spirit, with the interests of the participating business the only factor driving decisions. Interviewees also pointed to the collaborative projects involving multiple academic partners (e.g. see Diamond Centre Wales and Enviro 365 case study examples) as evidence of the cross-fertilisation of support.

This effective partnership working has been underpinned by the complementarity of the skills-mix across the partnership, making the process of designating projects much easier and creating clear opportunities for joint working. The said working has also been underpinned by the effective management processes, such as the weekly operational meetings to discuss each project.

> "We started out with a framework of weekly online meetings for the whole team where we would run through all the projects etc. We kept that going throughout, so when Covid hit… it was a seamless transition...The initial online meetings really helped to cement things. Other projects meet once a quarter, but

we did it online all together, discussing technical challenges. We did have smaller groups brainstorming specific things, but the fact all the comms was done online meant we could do it frequently and efficiently."

3.3.2 Governance structures

The operation was led by WGU, and all delivery partners generally thought they had managed it well, with interviewees commenting on the quality of the individuals involved and the effectiveness of the administration processes, although two interviewees reported that they would prefer a more decentralised management approach in future partnership operations.

All agreed that the various governance structures had been effective, from the weekly operational meetings which had helped in terms of project allocation, management, relieving bottlenecks and sharing challenges, to the quarterly operational management meetings, executive board meetings and WEFO progress reviews. All had a different purpose, with clearly-defined roles and remits for the different groups. This multi-layered governance structure appears to have provided effective strategic oversight combined with a good mechanism for making operational decisions.

3.4 Delivery of the CRPs

We have already discussed the profile of projects supported (see Section 2.2.2 above); however, we also asked about the effectiveness of project delivery and collected feedback on the design aspects.

All delivery partners were satisfied with the delivery of the CRPs, again noting the importance of the processes and template developed to facilitate delivery. Generally, it was reported that there had not been significant delays, albeit with some exceptions. The team were able to establish a good rapport with industrial partners for the most part, although some businesses were less contactable depending on how busy they were and how much they prioritised their project. Another delivery team member commented there had been a *"healthy mix of making new designs and evaluating/testing existing products"*.

Whilst there was some variability in terms of the engagement levels from businesses, the process of formally agreeing hourly commitments as part of the match-funding has been an effective way of ensuring that projects were generally jointly delivered in a true collaborative spirit.

Delivery team members spoke about how the CPE approach contrasted with other interventions they had been involved in, noting that the CRPs were generally smaller and much quicker, were challenge-based, industry-focused, and were built on trusting personal relationships and mutual understanding, good communication, and a clear shared vision and goals.

> "It works a bit better to not go too many months at a time on projects and keeping the goals short term where six months is the high-end. It means they're much more focused on final objectives; we know there's limited time and it creates a high pace of work. It contrasts with [name of another operation] which felt like longer duration, bigger projects, and the project management could suffer."

One of the external stakeholders made a similar comment, stating that other operations which focus on larger, more intensive, and slower projects *"have their place"* but often provide solutions that *"never see the light of day"*. According to the stakeholder, the CPE was the opposite of that, with its industry-focus and emphasis on quick solutions.

A further delivery team member commented that there is a need for both types of intervention – the short and sharp projects, and the more in-depth, research-heavy projects. Accordingly, it was suggested that a future iteration of the CPE may wish to create a mechanism to develop more in-depth projects with a small number of organisations.

4. Cross-cutting themes

A further key objective assigned for this evaluation was to assess how effective the operation has been in delivering against its CCT ambitions. All ESF-funded projects are required to demonstrate that they have met the following CCTs:

- Equal Opportunities and Gender Mainstreaming (including activities supporting Welsh language speakers).
- Sustainable Development.
- Tackling Poverty and Social Exclusion.

The performance of the operation in delivering against these CCTs has been measured through the following CCT case/project level indicators, which were agreed with the WEFO:

- Positive action measures – Women.
- Female participation in STEM.
- Activity supporting speakers of the Welsh language.
- Development of an Eco-Code.
- Local supply chain development.
- Resource efficiency measures.
- Develop/engage CCT Champions.

The CPE team developed a system to monitor the operation's performance against the broad CCT objectives and specific indicators through a tailored CPE CCT data monitoring spreadsheet. This was divided into the categories outlined below (which cover the different CCT indicators), outlining the objectives and presenting a comprehensive list of activities under each one.

- Equal Opportunities and Gender Mainstreaming.
- Supporting Women in STEM.
- Recruitment.
- Welsh language.
- Accessibility.
- Tackling Poverty and Social Exclusion.
- Sustainable Development.

The activities are outlined below alongside the evaluator's summary of delivery against each CCT.

4.1 Equal Opportunities and Gender Mainstreaming

The following five objectives were outlined for CPE delivery against the Equal Opportunities (EO) and Gender Mainstreaming (GM) CCTs:

1. The CPE to refer employers/enterprises/organisations to the SMART Innovation Future Proofing Toolkit should they require support to either 'adopt' or 'improve' an equality and diversity strategy, or carry out monitoring.
2. To develop a compliance matrix for EO&GM (in consultation with the SMART Innovations CCT team) which is to be shared with all Project Panels and BDMs as a guide and check list to ensure that CCT indicators are achieved and also used to create awareness in enterprises supported by the programme.
3. To ensure that all CPE partner HEIs' equal opportunities strategies and monitoring systems in place are up to date and cover areas such as flexible working, bullying and harassment, Welsh language policy, and staff training and development policy. It is also expected that the Equality Strategy at each HEI will be reviewed on a regular basis by their respective HR and QA departments.
4. To ask enterprises to provide any baseline equal opportunities strategy/information as part of CPE engagement, and refer them to the SMART Innovations team for advice on what they need to do to improve their position.
5. To develop tools for monitoring EO&GM activities and seek to implement or adapt tools developed by SMART Innovation teams, as well as other ERDF/ESF operations.

The operation's management information contains a list of 20 activities delivered against the EO & GM CCT. These are wide-ranging – some have been about embedding EO practices within the CPE way of working, whilst others have been about promoting EO and GM, or upskilling. These are summarised below:

- Two of the activities note the diversity within the CPE delivery team, including nine female staff members and seven members from ethnic minority groups, whilst another activity highlighted an example of a collaboration with another organisation to link in with the degree apprenticeship programme. Indeed, there are examples of businesses developing internship programmes and providing opportunities to undergraduates and postgraduates as a result of their CPE projects (six KESS studentships have been linked with CPE projects), thereby illustrating how the operation has supported youth employment.

- A further three activities describe the accessible nature of service delivery, where all materials are developed in a bilingual format and the service appears to be proactively[12] offered in Welsh with at least some Welsh speakers on the delivery team (although it is not noted how many team members can speak Welsh). This demonstrates that the operation has successfully delivered against the following CCT case/project level indicator: **'Activity supporting speakers of the Welsh language'**.

[12] The principle of the 'proactive offer' is related to asking service users explicitly about their language choice rather than relying on users to ask the question.

- Further, the paperwork contains questions eliciting gender and diversity data in the form of Yes/No questions, and a system established to refer employers – who do not have appropriate policies in place – to the Toolkit provided by the Welsh Government via the Business Wales portal. Finally, the promotional video developed by the team was constructed with equal gender and ethnicity representation in mind.

- Four activities highlight the various training undertaken by members of the delivery team to help support the accessibility of the service, from attending unconscious bias sessions, to autism awareness, and a general session on equality, diversity and inclusivity; moreover, the team organised an online 'Gender Neutral Language in STEM' presentation that many team members attended.

- Many activities focus on promoting gender mainstreaming, particularly by supporting women in STEM. Team members had attended a focus group on women working in STEM; one became a member of their university's SiSTEM social group, the aim of which was to increase informal networking opportunities for female members of staff in Computer Science and Electronic Engineering. This demonstrates that the operation has successfully delivered against the following CCT case/project level indicator: **'Female Participation in STEM.'**

- Linked to these promotional activities, several activities have focused on contributing towards existing celebrations of equal opportunities and diversity. For instance, the operation released video biographies of female delivery team members through its social media platforms on the International Day of Women and Girls in Science; CPE team members engaged with UNESCO's 'For Women in Science' online worldwide festival; an interview was conducted with one female team member on International Women's Day about her experiences during her career in STEM; and one team member joined a panel of female speakers as part of an International Women's Day webinar. Additionally, the operation publicised a Business News Wales article which contained details on the 'Getting Women Coding' initiative – encouraging women and girls to sign up to free training in the field of computer coding. These activities demonstrate that the operation has successfully delivered against the following CCT case/project level indicator: **'Positive action measures – Women.'**

- Further, the team introduced a referral mechanism through the Smart Innovation Gateway in Year 3 of the operation, which gave businesses insights into signing up to the CCT system, reviewed their EO&GM policies, etc.

Author's comments

It is clear from this evidence that the operation has been very active in their contribution towards the EO&GM CCT and has delivered against all three of the CCT case/project level indicators under this CCT, namely: 'Positive action measures – Women', 'Female participation in STEM', and 'Activity supporting speakers of the Welsh language'. It is unclear whether some of these activities, such as the examples of team members attending unconscious bias or autism awareness courses, were undertaken as a direct result of the CPE or as part of the universities' activities. With that said, however, other activities can be clearly attributed to the operation. For instance, the operation was able to use leading female personnel within the team as an opportunity to promote women in STEM.

With regard to the five objectives described at the outset, we note that the first has been fulfilled by encouraging employers to adopt EO & GM policies and referring businesses to the toolkit. The fifth objective has also been fulfilled, and forms the evidence base for the activities described above. We have not, however, received evidence of the second, third and fourth objectives being fulfilled.

4.2 Supporting Women in STEM

Whilst the Supporting Women in STEM theme can be seen as part of the wider EO & GM CCT theme, there was a separate and dedicated space for it within the CPE, with its own specific objectives, which are outlined below.

1. To follow gender equality policies as a high priority and align recruitment with the Welsh Government's 'Science for Wales' strategy where possible, so as to encourage women studying STEM subjects in Wales.
2. Gender equality in research and innovation as set out by the European Commission to be considered throughout the CPE operation and its recruitment process – i.e., through job adverts with emphasis on gender equality.
3. To maximise opportunities to support female participation and, where possible, actively seek to support female role models working on operations.
4. To consider gender balance when establishing research teams, boards and committees, and aim to achieve a minimum 40 per cent/60 per cent split.

A list of 31 activities was set out in the operation's CCT database, and many of those activities have already been outlined above. These again contain several points on the composition of the CPE delivery team, detailing the number of positions filled by female team members and the seniority of those positions (e.g. the operation's Director and one of AU's lead academics). Further, the operation actively sought to engage women-led businesses, e.g. the CPE BDMs worked alongside women's networks such as Network She, and even joined a female networking walking group in order to establish potential new company contacts. The database further notes that this generated several leads for the BDMs and that three of the supported businesses were female-led, although we do not know whether that was as a result of the BDM's proactive approach to engage such businesses.

As noted in the previous section, the operation undertook several outreach activities to promote opportunities for women in STEM. Delivery team members joined several networks, such as the Entrepreneurial Women in Renewable Energy (EWiRE) initiative, Women in Business bi-weekly networking sessions, the SiSTEM social group (as mentioned earlier), and KTN's "Women in Innovation" online events to encourage women to take advantage of the opportunities that exist within the sector. Additionally, delivery team members gave talks on women's experiences in STEM roles via presentations or online videos. They attended various webinars, such as the Technocamps online events, as part of their Network for Women Working in STEM. They contributed towards a Business Wales podcast on the matter and made additional contributions (e.g. video biographies, interviews, panel discussion) towards several International Women's Day and International Day of Women and Girls in Science events.

Author's comments

The evidence suggests that, whilst only three of the 63 supported businesses appear to have been female-led, the operation has actively sought to maximise leads amongst women-led businesses through engaging women-specific networks. The aforementioned directly addresses the third objective outlined under this CCT.

Additionally, the CPE appears to have delivered on the fourth objective, whereby nine of the initial 26-strong team were women, which is equivalent to 41 per cent of the team and meets the target of achieving a minimum 40 per cent/60 per cent split. There were, however, some changes in staff personnel throughout the operation, and we do not know whether that ratio was maintained. Further, the operation appears to have delivered on the first two objectives through its recruitment approach, although we have not had sight of the job adverts to understand the emphasis on gender equality. We also note that the operation has delivered against the relevant CCT case/project level indicator.

Overall, the evidence suggests that the operation has been a good exemplar of the opportunities for women in STEM given the number and seniority of female roles within the team. Importantly, the operation has sought to capitalise on that fact by sharing their experiences working on the project and their careers in general, so as to promote the possibilities for women and girls in STEM. Thus, there is substantial evidence to suggest that the operation has effectively delivered against the CCT of supporting women in STEM.

4.3 Recruitment

The following four objectives were outlined for the operation's recruitment CCT:

1. To ensure that all recruitment and job opportunities are made available to all qualified, including those with protected characteristics in line with the Equality Act 2010.
2. To build-in Welsh language considerations for all candidates, including the use of Welsh language as desirable, and providing Welsh application forms and bilingual job adverts.

3. To seek to broaden the diversity of their teams and those of the enterprises involved in the operation whilst also ensuring that external recruitment is supported if possible.
4. To follow the 'Positive About Disabled People' (two-tick symbol) system as part of recruitment procedures and policies to encourage applications from disabled people.

Against these objectives, the operation's CCT database shows that all job adverts included statements on equality, anti-slavery, and Welsh language provision. Adverts were also published in both Welsh and English, and all candidates were offered the opportunity to be interviewed in Welsh if they wished. There was also encouragement of applications from disabled people and those with protected characteristics. Further, any interviews for the recruitment of new staff were held remotely via virtual video conferencing, where required, since the COVID-19 restrictions had been introduced at that time.

Author's comments

The operation does appear to have largely delivered against this CCT, with consideration given to the Welsh language requirements of all candidates (second objective), and the operation sought to broaden the diversity of the team and supported businesses (objective 3) through their recruitment and business engagement approach (see previous section on the proactive approach to engage women-led businesses). We can assume that the operation did make recruitment and job opportunities available to all qualified, including those with protected characteristics (objective 1) and followed the 'Positive About Disabled People' system (objective 4), although there was no explicit reference to these points in the list of activities or evidence contained with the operation's management information.

4.4 Welsh Language

Two objectives were outlined for the CCT concerning the Welsh language:

1. To ensure that all printed material, websites and publicity aimed at the public are made available in bilingual formats (English/Welsh).
2. To make provision for Welsh language communication/interpretation for those who wish to communicate in Welsh.

There is a comprehensive list of activities and evidence against this CCT within the database, with 25 points in total. All printed material, websites and publicity aimed at the public do appear to have been made available in bilingual formats, including all job adverts (alongside an opportunity to be interviewed in Welsh), launch events (bilingual invites, agenda, and translation facility during events), and leaflets/promotional flyers, newsletters, business cards, websites, social media and press releases. Some of the delivery team members were also Welsh speakers – all at AU at the beginning were either fluent speakers or learners; 80 per cent of CPE staff at USW, and 20 per cent of staff at BU spoke basic Welsh (no figure was given for WGU). Additionally, several staff members have attended Welsh language sessions to develop their abilities to converse in Welsh, whilst the team introduced a "Welsh Word/Phrase of the Week" as an agenda item during the weekly team meetings and monthly Operational Managers meetings. Importantly, the management information notes

that ‘all parties are invited to engage with the CPE team through the medium of Welsh if desired’, including through CPE paperwork, which would suggest that supported businesses do receive a ‘proactive offer’ in relation to language choice.

What is more, the operation has undertaken some activity to promote the Welsh language. For instance, one staff member enlisted in their university’s programme of teaching Welsh to non-native speakers, whilst CPE acknowledged 'Diwrnod Shwmae Su'mae' and St David’s Day by sharing social media posts in Welsh.

Author’s comments

The operation certainly appears to have met and surpassed objectives concerning the Welsh language by ensuring that the service was available in Welsh to those who desired it. We note that the operation has delivered against the relevant CCT case/project level indicator, i.e. **‘Activity supporting speakers of the Welsh Language’**. There has also been some promotional activity.

4.5 Accessibility

Two objectives were noted for the accessibility CCT:

1. To adhere to the Public Sector Equality Duty (PSED) in Wales (arising from the Equality Act 2010) with the aim of contributing towards a fairer society.
2. To endeavour to undertake 'Equality Impact Assessments' (EIA) to help reduce inequality and mitigate potential adverse impacts.

The activity/evidence log provides seven points on the delivery against this CCT, noting how all team members had undertaken their own university’s training sessions to update their knowledge on matters relating to equality and diversity, whilst an online Digital Inclusion and Accessibility training session was also attended. Further, the thin-film coating facility’s suspended flooring at WGU’s OpTIC Centre met the needs of all staff and visitors, including those with any mobility restrictions. Other points relate to the provisions implemented to make the service accessible for Welsh speakers (as noted in the previous section).

Author’s comments

It is not possible to ascertain, from the activity/evidence log, whether the two objectives have been achieved, since there is no specific reference to adherence to the PSED and the undertaking of EIA. However, it is assumed that these were undertaken. We understand that the operation has met the overall need of creating an accessible service, although we have not seen any evidence of actual engagement with under-represented groups (other than gender), such as businesses led by people living with disabilities.

4.6 Tackling Poverty and Social Exclusion

Two specific objectives were agreed for the Tackling Poverty (TP) and Social Exclusion (SE) CCTs, as outlined below:

1. To help WWV region enterprises increase their competitiveness and growth by creating new employment opportunities and further tackling poverty, with positive impacts on the local economy resulting.
2. To inform and encourage beneficiaries to apply for any training or skills development opportunities available through ERDF/ESF so as to enhance workforce skills and tackle in-work poverty.

The first objective describes how the overarching goal of the CPE, i.e. to increase competitiveness and enhance economic growth, is intrinsically linked with the desire to tackle poverty. Indeed, the evidence outlined earlier in this report (see Section 2.3.3) demonstrates the impact which the operation has had in that regard, leading to job creation. This has included providing employment opportunities to young people (six studentships are linked to CPE projects), whilst the operation also worked with a local primary school to offer school pupils an opportunity to visit the OpTIC Centre to view the facilities and learn more about STEM careers. Further, and as already noted, the operation has actively sought to encourage those from non-traditional backgrounds into STEM, e.g. the contribution made to the 'Getting Women Coding' initiative.

What is more, the activity/evidence log notes how several of the projects directly address the TP&SE CCT. For instance, one project sought to reduce the frequency at which people access healthcare and to improve quality of life, whilst another explored how the flexibility of working provided by office pods can both reduce reliance on long distance commuting and improve accessibility to COVID-safe office spaces for people and businesses on low income.

Author's comments

There is a clear correlation between the fundamental thrust of the CPE operation and tackling poverty in particular; as such, the operation has clearly addressed the first objective noted above. Additionally, the operation appears to have delivered on the second objective by working alongside businesses to, for example, provide studentship opportunities, although there are no references within the activity/evidence log to support businesses in enhancing workforce skills and tackling in-work poverty.

4.7 Sustainable Development

Three objectives were outlined to address the Sustainable Development CCT, as follows:

1. To develop a project Eco-Code to raise environmental awareness and seek to adopt relevant aspects in the operation.
2. To develop and promote innovative technologies and processes, in line with the 'Low Carbon, Energy and Environment' vision, so as to help reduce the causes and effects of climate change.
3. To endeavour to support the development and promotion of sustainable local supply chains.

There has been significant activity against this CCT, as demonstrated by the 71 points recorded under the activity/evidence log on the operation's CCT database. First and foremost, the operation has clearly contributed towards the Sustainable Development goal through the types of projects and businesses supported. The database contained 33 examples of the support given to these projects that can be linked to positive outcomes with regard to Sustainable Development. These examples contained a mix of improvements made to businesses' own processes so that they could operate more sustainably; moreover, there were also projects which aimed to develop or improve products and services that would have a positive effect on the environment and people's well-being further afield. These projects are listed below.

- A project that sought to develop a sustainable packaging solution which is fully biodegradable and environmentally friendly.
- The development of a process to re-use waste as raw material for 3D printing.
- Support provided to a business to procure energy storage capability.
- A project that sought a durable method for sealing solar panels, thus contributing towards sustainable energy production.
- A project that sought to improve a business's industrial wastewater remediation process, thus contributing towards a clean environment.
- A process developed to reduce rejected samples within a business's production system, thereby reducing the waste produced.
- A project that developed products to improve animal welfare.
- A process developed to assist the growing of plants in a sustainable mode, therefore reducing energy demands.
- A project designed to improve an automated pothole detection system on roads.
- A project to develop an optical means to monitor parasite infection and hive health of honey bee colonies in an ethical & eco way, thereby supporting sustainable agriculture.
- A project which sought to support the principle of sustainable, natural flood management.
- A project which sought to improve the manufacturing process of recyclable paper straws and contribute towards a reduction in plastic.

- Two projects that developed techniques which had the potential to decrease the use of cleaning products and polluting chemicals.
- Development of a product to improve the germination rates and yield from vegetable seed, which may reduce waste in horticulture.
- Development of a technology to reduce the energy consumption of energy-intensive data processing tasks.
- A project that encouraged the use of solar panels.
- A project to improve a system that acts to prevent the leaking of potentially-harmful substances into the natural environment and the pollution of waterways.
- A project that looked at the efficiency of LED lighting for lighthouses.
- Improve a product which allows for better monitoring of foot health in people with diabetes – a condition which disproportionately affects people from poorer backgrounds.
- Development of a product that could provide a low-cost solution to the problem of managing a range of health conditions at reduced cost.
- Support given to a business that provides sustainable fashion items using materials sourced ethically in the UK.
- A project that sought to increase the efficiency of a lighting system for shrimps' well-being.
- A project to improve the design and storage conditions of medicinal capsules, which, it is hoped, will lead to a reduction of spoilage and waste.
- A project that developed office pods to reduce reliance on long distance commuting and improve accessibility to COVID-safe office spaces.
- Other points simply noted that the projects would provide supported businesses with process efficiencies/waste reduction.

In addition, many other points noted how the operation's processes were environmentally friendly. For instance, the operation sought to limit their travel-related carbon footprint as much as possible by using virtual platforms to hold cross-partner meetings, some meetings with industry partners (although these often needed to be in-person), supporting team members in working from home, and conducting job interviews online. Where travel was necessary, there are at least two examples where the team hired an electric car. What is more, the team used software packages to record and share information, thereby reducing paper-based working. The BU CPE team have procured second-hand equipment where possible, and all procurement has been in line with the university's Procurement Strategy, which incorporates sustainability objectives. This demonstrates the successful delivery of the following CCT case/project level indicator: **'Resource efficiency measures.'**

Several training activities have been undertaken to ensure that sustainable development is embedded within the operation's ways of working. This has included inviting a representative from the Future Generations Commissioner for Wales to attend a CPE CCT meeting to deliver a presentation on the Future Generations Act and its aims/objectives. The team also met with the Director of the Sustainability Lab at Bangor University, who delivered a CCT-focused presentation to offer advice and guidance on the recording of CCT

activity. Subsequently, team members attended a training seminar conducted by the Sustainability Lab to share best practice, ideas, and to further develop the team's culture of sustainability. Several team members have attended webinars, online training sessions and seminars. These have included seminars surrounding lasers and grant applications, which also focused on areas of sustainable development, and a second webinar on Low Carbon Laser Manufacturing. Another member attended online training on Life Cycle Assessment and hoped to apply this knowledge during the making of procurement decisions. The CPE conducted a site visit to Bangor Forest Garden to learn about sustainable methods of growing food and reducing human impact on the environment. Finally, at a practical level, the team undertook training on the use of OneDrive and Microsoft Teams to ensure they could reduce paper-based working.

Further, some activity has been undertaken to promote sustainable development and the work which the operation has carried out in relation to it. Perhaps the main example of this is the Eco-Code that has been developed and placed on display within CPE office sites and added to the CPE website. Developing an Eco-Code is a specific CCT case/project level indicator that has been successfully delivered.

Additionally, the operation has engaged with several events to promote sustainable development. For instance, the team widely promoted and encouraged their network of contacts to attend a Photonics for Net Zero online event. They also attended an online event at BU, "Be part of the Waste Revolution", as part of Waste Awareness Week. Additionally, they attended an AU climate change event where CPE projects were mentioned, and one of the academic leads delivered a webinar on the physics of climate change to undergraduate students, using the CPE as a research and industry collaboration example.

Finally, although not captured in the operation's CCT database, there are some examples of wider local supply chain impacts, with around a quarter of businesses which responded to our survey reporting that they had increased their spend in the local supply chain as a result of CPE-related growth. Two examples have been provided by the CPE team to demonstrate the impact on local supply chain development:

- Global Laser – CPEWEFO--015: This project explored the enterprise's current use of three-dimensional (3D) printing and inhibitors and enablers in small-sized manufacturing and parts production. The project clearly demonstrated that 3D printing technology can be implemented in the manufacturing of a wide range of parts for the enterprise's products. Two types of 3D printing technologies, namely Fused Deposition Modelling (FDM) and Stereolithography (SLA), were used for different parts, and all advantages of each technology, as well as where it can be used, were addressed. Different types of materials for each technology were utilised, and the specifications of the thermomechanical properties of all tested materials were addressed. 3D models of the parts based on 2D drawings provided by the enterprise were then developed and optimised for 3D printing. Following this project, the enterprise was convinced to buy 3D printer(s) to re-design some of their components and products, and to make them using 3D printing technology.

- Formatt Hitech – CPEWEFO--181: This project investigated the feasibility of more locally produced glass-based NDFs (Neutral Density Filters) to replace a product which was produced to their specification by a supplier based in China. This enabled greater turnaround and flexibility of design changes, as well as improvements to develop new products.

The information provided above demonstrates that the operation has successfully delivered against the following case/project level indicator: **'Local Supply chain development'**.

Author's comments

There is substantial evidence to demonstrate effective delivery against the Sustainable Development CCT. This evidence has been obtained from four main occurrences; the most significant, by far, has been the impact from the projects themselves. As we noted earlier in the report, many of these projects have acted to reduce the carbon footprint by creating more efficient processes or reducing waste within the supported businesses. Additionally, several of the businesses work directly under the Sustainable Development umbrella, and thus the support given to improve their products and processes will have had an important indirect impact. Alongside project impacts, the CPE's own practices have sought to limit the carbon footprint, underpinned by the training associated with that, and the team have undertaken certain activities to promote sustainable development outside of the projects supported. Importantly, the aforementioned evidence demonstrates that the operation has successfully delivered the relevant case/project level indicators pertaining to this CCT, namely the development of an Eco-Code and the resource efficiency measures that have been deployed.

4.8 CCT champions

Finally, we note that the operation established a CCT Steering Group which consisted of representatives from each academic partner acting as CCT champions, whose role was to closely monitor and ensure delivery against the CCT objectives. Weekly CPE meetings included a CCT agenda item where the whole team would be involved in the discussion before assigning actions to the CCT Champions.

5. Legacy and next steps

The evidence presented within this report suggests that the CPE operation is likely to leave a strong legacy related to RD&I in Wales. We have already described how the operation has raised awareness of opportunities to utilise photonics technologies, led to some businesses committing more resources to RD&I, and impacted on businesses' attitudes towards collaborating with academia. According to one of the delivery team members:

> "I like to think that one of the legacies is that industry perceives academia differently… A good legacy would be that universities are more commonly seen as being here to help companies."

The operation has had a notable impact on the photonics infrastructure as a result of the more than £2m of capital investment in equipment and technologies. This CPE-enabled investment will be available for use through future programmes: *"it brings down the costs going forward – we already have them in place, we just need revenue support going forward now"*.

Additionally, there has already been some impact in hard economic terms, and the evidence suggests that the future potential for further economic gains is much greater. All of this is captured in Chapter 2.

Perhaps the main legacy, however, is the experience of delivering the operation itself and the lessons generated from it (see Chapter 3). This was certainly the view from the delivery team, with several interviewees highlighting the model developed and the process they had in place which, in their view, should provide a blueprint for future interventions.

> "We have developed a mechanism that works well to support businesses – a good blueprint that can be applied to other areas of the university. The system is well refined and the projects crop up across universities – so it's been important learning for academia supporting businesses. We've been through all the hoops and have a good system."

Different delivery team members spoke about the template developed for collaboration between HEIs and industry. They described the benefits of having the collaboration agreements in terms of ensuring clarity from the outset, having dedicated researchers whose sole focus is on the CRPs, and having the BDM resources to generate leads across universities as well as a partnership that operates in a non-partisan way, e.g. when allocating projects. Another delivery team member spoke about the legacy of developing the CPE as a brand and how they have existed as an entity rather than separate universities.

External stakeholders shared similar sentiments regarding the importance of capturing the learning generated during the last four years of delivery and of maintaining the partnership going forward. Both delivery team members and external stakeholders highlighted the risk of losing some of the potential legacy if the team, which has amassed valuable experience and expertise, were to be disbanded. Thus, there is a pressing need to secure additional funding to enable some form of continuity in delivery before all momentum is lost.

> "They will lose researchers and expertise (if no funding is secured). Then it's a long slog back up the hill to build back up capability, to get the trust back with industry – having to say to them we're taking a hiatus and we will be back in nine months."

The progress made by the CPE over the last four years demonstrates that the operation does satisfy a demand from industry and that there are substantial, potential impacts.

5.1 Expanding the CPE

With the changes imposed by Brexit, inevitably no further funding will be available from EU sources under the ERDF programme, and the CPE management team have been proactively exploring various funding opportunities to ensure CPE continuation. The innovation support landscape in Wales has been a cluttered marketplace, partly because of the European structural funds programmes, which means that several other operations are in a similar position.[13] One of the external stakeholders noted that there could be a void in the marketplace as a result of the end of EU funding.

[13] Several other RD&I operations have been delivered in Wales through funding from the ERDF, e.g. ASTUTE, Accelerate, CEMET, Supercomputing Wales, MEECE etc. Additionally, there are a myriad of other support provisions alongside the structural funds operations, including core support from the Welsh Government (e.g. SMART Innovation), the UK Government, Local Government, Innovate UK and the Catapult Network.

Against this backdrop, securing financial support from the Welsh Government is likely to be a very competitive endeavour, and the government have made no commitments to financially support the continuation of these operations at this point. Nevertheless, the operation received strong backing from external stakeholders as well as delivery team members during the discussions held as part of this evaluation. Indeed, one of the key external stakeholders felt that the CPE should be the main RD&I programme to be supported by the Welsh Government going forward, such is the high esteem it is held in.

There was also strong support for the idea of expanding the operation throughout Wales by engaging the other four HEIs not currently involved in delivery.[14] A recent research study commissioned by WGU found that academics across the eight HEIs in Wales are enthusiastic about a Wales-wide collaborative photonics cluster.[15] The research also sought to establish the extent of existing academic capabilities in photonics in Wales, finding that there were extensive and varied photonics capabilities across all eight universities, where each has different priorities and strengths. Further, the report notes that expanding the CPE to incorporate the strengths of all universities and the challenges of all industry organisations across Wales would deliver the vision of the Welsh Government's Innovation Strategy, which identified a need for an *"optics, photons and optoelectronics pan-Wales"* cluster.[16]

Ultimately, it will be for the Welsh Government to decide whether they can support the continuation of these operations and, if so, how many and which ones should be prioritised. There is certainly strong evidence in this report to support continued investment in the CPE.

Two other suggestions were made during our consultation with delivery team members and external stakeholders with regard to future expansion. First, a case was made for broadening the remit, which would include a community or schools education programme that could be delivered within or alongside the CPE. This would help raise the profile of photonics and create a better entry route for young people, thereby addressing skills shortages and helping to ensure that skills progression can keep pace with progress in technological processes and concepts. Second, it was suggested that a future iteration could include ringfenced funding for larger projects to build on the most appropriate CRPs. This would better enable progression through the TRLs to commercialisation, and increase the potential impact opportunity.

[14] These comprise Cardiff University, Cardiff Metropolitan University, Swansea University, and the University of Wales Trinity Saint David.
[15] Urban Foresight, *'Photonics based academic capabilities and capacity within Welsh universities'*, 2022.
[16] Welsh Government, 'Innovation Strategy for Wales', 2022.

5.1.1 Alternative funding sources

According to the research study commissioned by WGU, Research Technology Organisations (RTOs) such as the CPE can generate income, without turning to public funds, through three main routes:

1. Charging industry organisations for the opportunity to utilise the RTO's expertise, facilities and resources to complete an R&D activity on their behalf.
2. Implementing a membership model where industry organisations pay a fee to have access to a broad range of services and expertise.
3. Licensing IP or patents held by the RTO.

However, whilst a combination of these income sources may be possible in the medium to long term, it is unlikely that such a self-sufficient model would be feasible in the short term, particularly when considering the current economic climate. We explored this in the beneficiary survey, with mixed responses from businesses regarding their openness to paying for such a service in future. Just 11 per cent (5/44) reported that they would 'certainly' be willing to pay to be involved in CRPs in future, whilst a further 11 per cent reported they would 'likely' be willing to pay. This is balanced against a quarter of businesses (11/44) reporting that they would not consider paying for projects in future. Most other businesses (45 per cent of the total) reported that they would only 'consider' paying for projects in future and were not confident enough to select either of the first two options.[17] In summary, this demonstrates that there is some potential to generate income by making the CRPs a paid-for service, although this would need to be tested further. The idea of establishing a consortium of businesses with a membership model could also be explored, although public support would be needed to trial it or for universities to trial it at their own risk.

Delivery team members expressed their view that delivering the operation without public finance is not currently feasible. They suggested that the universities would not be in a position to fund the various aspects to run such an operation, including having dedicated academics, a BDM function, and the coordination of several small projects with many different businesses.

Whilst it may not be feasible for the HE partners to run the operation on the same scale on their own, one of the external stakeholders suggested that they should perhaps consider, if possible, continuing with some form of partnership and business engagement to avoid losing the CPE presence altogether.

[17] The remaining 7 per cent reported they were 'unsure'.

> "They could keep the network. They may not have specific funding but the universities might want to take it upon themselves to spend some business development time and have an email address going… There is still the logo, an email address, and some presence just to keep the brand going and use it when the funding does become available."

Unless Welsh Government funding does become available, the evidence suggests that the CPE will need financial support from other sources to continue. Potential options suggested during our consultation range from academic sources of funding (e.g. the Higher Education Council For Wales and the Wales Innovation Network) to UK-wide public finance options (e.g. through Innovate UK, UK Research and Innovation (UKRI), and the Industry Innovation Partnership (i3P)). These are, however, highly competitive funding bodies, and so securing the funding needed for CPE continuation will not be easily achieved.

The CPE's long-term vision is to develop the type of business model used successfully by the Fraunhofer Institutes and introduced in recent years in the UK as part of the Catapult network. The Catapult Centres were set up with funding from Innovate UK, and many continue to operate with substantial funding from Innovate UK utilising the following model:

- 1/3 core public funding (via Innovate UK and/or relevant Welsh Government funding).
- 1/3 industry-funded contracts (i.e. Contract Research at commercial market rates).
- 1/3 collaborative R&D-funded (projects part funded by industry and part publicly funded through research councils, Horizon 2020 and other sources).

In the medium- and short term, the operation will need revenue funding from grant sources at an estimated £1.1m per year to continue delivery on a similar scale.[18]

[18] This estimate is based on the resource requirements of the CPE initiative, assuming that any new initiative will build on the existing assets and reach that the centre has. Source: Urban Foresight analysis.

6. Conclusions and recommendations

6.1 Main findings

Our evaluation of the CPE has found a very successfully delivered operation which has more than achieved what it set out to and which provides the foundation for a formalised photonics cluster in Wales in line with the Welsh Government's strategic objectives. What is more, it is likely that the operation would have achieved further still had it not been for the COVID-19 pandemic.

6.1.1 Achievements

The CPE has supported 63 businesses through CRPs and the main achievements can be summarised as follows:

- The CPE has delivered commendably against its KPIs, surpassing or reaching within 10 per cent of the targets for the number of businesses engaged, investment leveraged in RD&I, and developing new innovations.
- There is significant variability in the types of businesses supported regarding their size, sector, and geographic coverage across the WWV region, demonstrating how photonics technology can be applied across the economy.
- Most businesses were seeking support to develop new products or processes and felt they had neither the knowledge and expertise to conduct the innovation nor the facilities, technology, and capacity, thus requiring support from the CPE.
- There was a high degree of variability in the types of projects supported with regard to TRLs, scale and support intensity.
- Half of supported businesses reported that they had achieved everything they wanted to, and an additional 23 per cent reported they had partially completed what they wanted or their projects were ongoing.
- The CPE has clearly generated innovation outcomes for businesses, with 72 per cent formulating ideas for new products, services, or processes, whilst 58 per cent managed to develop those innovations through the CPE. Moreover, 79 per cent reported that their projects would not have occurred without support from the operation.
- The operation has increased the awareness and understanding of photonics capabilities amongst supported businesses and increased their interest in conducting further activity, whilst there appears to have been a modest impact on encouraging businesses to invest more in RD&I.

- There is also strong evidence to suggest that the operation has made an important difference in changing attitudes and raising awareness of the benefits of HEIs and industry collaboration amongst supported businesses.
- In hard economic terms, many businesses reported outcomes with regard to efficiencies (39 per cent) and productivity gains (22 per cent).
- The immediate impact on turnover has been modest, with an estimated return of just £153,000 for the 63 businesses supported. This is perhaps unsurprising given the latent impacts associated with RD&I activity. Indeed, further exploration of the potential impact for supported businesses estimated that the support could generate around £2.4m in increased economic returns over the next 12 months.
- The impact on employment appears to have been more immediate, with our analysis suggesting that the operation has created or safeguarded around 41 FTE positions in total.
- The operation has also generated positive environmental impacts through a combination of increasing the efficiency of businesses' processes, reducing their energy usage and waste (or supporting the re-use of waste products), and the development of products and support for businesses which operated to safeguard the environment.

These key findings and points demonstrate that the operation did support a suitable group of businesses and enabled the vast majority to achieve positive outcomes which would not have occurred without the intervention. Whilst we have only just begun to see hard outcomes with regard to economic returns, these are likely to increase further, with most businesses managing to develop new and improved products, processes and services which will likely yield benefits for years to come. Taking into consideration the broader impacts around establishing the photonics infrastructure and understanding, increasing interest in collaborative RD&I activity, and the environmental impacts, the evidence suggests that the operation is in a good position to generate a positive return on investment.

6.1.2 Delivery model

Perhaps the main legacy and impact of the CPE is the experience of delivering the operation and the learning gained from that process. Members of the delivery team were unanimously satisfied with the delivery model; indeed, several highlighted it as a significant achievement that should be used as a blueprint for future interventions and other activities delivered by their institutions. This is corroborated by feedback from the supported businesses, which were overwhelmingly positive about their experience. The key components and strengths of the delivery model can be summarised as follows:

- The partnership model has been very effective, with strong complementarity in the expertise and capabilities of respective HEIs, thereby enabling the operation to provide a rounded support offer. The open and amicable nature of the partnership, with clear roles and responsibilities, acted as a key enabler in its success.

- The partnership model was underpinned by effective governance structures and management processes. This involved regular and appropriate forums for operational and strategic decision-making (including weekly meetings to discuss the allocation of new projects and updates on existing projects) which provided an effective mechanism through which to identify the most appropriate academic lead.
- Additionally, the business engagement process proved effective, with BDMs playing a crucial role in generating leads and identifying business needs that could be addressed by the operation.

- There was a clear template for establishing and delivering the CRPs, using tools such as the project scope form and collaboration agreement.

- The success of the operation has also been underpinned by its underlying principles, namely the focus on practical projects based on businesses' needs and having a streamlined process to ensure projects could be delivered as quickly as possible.

There are key lessons outlined above around the enablers of success that should be incorporated into any future delivery. That is not to say that the operation has been without its challenges. Indeed, several issues and areas for improvement were highlighted during our evaluation, as follows:

- The bureaucratic requirements of running an ERDF project appear to have affected the speed of delivery, despite the efforts to streamline processes as much as possible. Most notably, the process of collecting timesheet and salary data was a frustration for some businesses.

- Another frustration was that every project had the same process requirements and evidence requirements, irrespective of the scale of support given. This felt disproportionate for some of the smaller-scale projects, e.g. the advisory support projects.

- Resources have constituted another significant barrier, principally with regard to the BDM role, which was not helped by staff turnover. One potential weakness is the number of projects that were put forward for consideration. Having greater resources within the BDM compartment would have enabled the operation to develop a larger pipeline and thus be more selective in the projects supported. It is important to note that the COVID-19 pandemic will have likely affected the number of projects submitted due to the impact on networking and the closure of university facilities.

- The stakeholder engagement aspect appears to have been fairly limited. This will also have been affected by the COVID-19 pandemic.

These lessons will be equally important when designing future interventions.

6.1.3 Cross-cutting themes

There is substantial evidence of the operation's contribution towards the CCT objectives, with a particularly strong record on Supporting Women into STEM and Sustainable Development. There is a clear link with the Tackling Poverty CCT, given the impact on generating growth and employment opportunities. The CPE also ensured that good practices around themes such as equal opportunities, accessibility and Welsh language were incorporated into delivery, although there was perhaps less activity in promoting opportunities within those spheres in comparison to Supporting Women into STEM.

In summary, this aspect of the operation's performance is undoubtedly a success, with delivery against each of the CCT case/project level indicators. What is more, the operation has gone well above those requirements in many cases. Accordingly, the operation should be commended for this particular aspect of delivery.

6.1.4 Next steps

The rationale for delivering the CPE is as important as ever. It is based on the premise that there are strong photonics-related expertise and capabilities in Wales, which are primarily held within academic institutions, and would benefit the nation if they were to be made available to industry. The CPE has provided a valuable mechanism through which industry can benefit from that expertise, underpinned by an effective partnership and principles and processes to work alongside industry. The operation has shown the benefits and potential impacts of doing so, the effectiveness of the delivery model, and that there is demand for the support. Accordingly, there is a clear case for continuing the CPE operation going forward.

The focus, to date, has been on delivering the operation in line with the requirements of the ERDF funding. The operation will now need to identify a model that can sustain it for years to come and will need financial backing to trial that model as part of a beta-phase roll-out. There is also an opportunity to expand the delivery to maximise the operation's reach and impact potential, and to fully utilise the expertise that exists in Wales. Principally, this would involve incorporating all eight HEIs into the next operation and making it available throughout Wales, thereby expanding the critical mass of expertise and the potential customer base. It has also been suggested that the remit of the operation be expanded in order to address other factors that limit the potential for photonics utilisation in Wales.

6.2 Recommendations

In light of these findings, the following recommendations are made.

Recommendation 1: The operation should continue to seek investment for a 'beta phase', which would include testing models for commercial income generation, perhaps as part of a Fraunhofer-type model. Options include developing a paid-for service for CRP involvement or a membership structure.

Recommendation 2: The delivery model successfully used by the CPE should form the basis for future delivery. This includes ensuring that the activity is challenge-led, utilises a BDM function to make it more accessible, incorporates the same spirit of collaboration and non-partisan decision-making, and utilises similar management and governance processes.

Recommendation 3: Future schemes may wish to remove some of the administrative barriers associated with the ERDF programme, notably the timesheets and salary data, so as to accelerate the process. It is important to note, of course, that this related to requirements associated with the ERDF funding and was not within the CPE team's control.

Recommendation 4: If possible, future schemes may also wish to allocate a greater proportion of resources to the BDM function in order to maximise the reach and income potential.

Recommendation 5: Linked to this, the operation should seek to be more selective in its approach in order to target support only at projects with the highest impact potential.

Recommendation 6: The geographic coverage of the operation should be expanded to cover the whole of Wales, with all eight HEIs involved in delivery and all Welsh-domiciled businesses able to access the support. This would maximise the expertise provided through the operation and increase the potential of developing a sustainable model through expanding the client base.

Recommendation 7: A multi-stranded support offer should be considered for future iterations of the operation, the main focus of which would be to continue delivering the CPE-type CRPs. However, the operation could also include a less intensive strand, potentially in the form of an advisory service, which would be less burdensome for businesses. At the other end, the operation should develop a new strand with ringfenced funding for larger-scale projects to expand on the best CRPs in order to maximise the impact potential.

Recommendation 8: The team could also consider the possibility of incorporating a broader remit into future delivery, which would include expanding the outreach aspect to school-age upwards, representing a fourth strand of the support. This would help address the issues of skills shortages and the need for photonics capabilities to progress at the same pace as technological developments.

Appendix 1: A Theory of Change for the CPE Operation

Rationale/Need for the CPE Operation	Objectives of the CPE Operation
• Photonics technology is recognised as a key enabling technology. • There is expertise and experience and therefore significant potential for using photonics to set up collaborative research projects that will help to make Welsh companies more competitive and to introduce new products and processes. • Despite the considerable potential market for the implementation of photonics technologies and applications, companies are not necessarily fully aware of new technological developments that can enhance their products and processes. • There has also been a lack of cohesion within the photonics offer amongst HEIs. • Businesses experience barriers when it comes to fully extracting commercial opportunities from collaboration opportunities with the public research base. Thus, innovation activity in specific target sectors is necessary to focus efforts and to provide the best opportunity for successful engagement and intervention in the use of photonics expertise. • Businesses in Wales in general (including WW&V) have been less inclined to engage in, and access, innovation and collaboration support than their UK counterparts. • Improved innovation processes and improvements in managing innovation and knowledge transfers are needed to bring together SMEs, technology providers and universities, thus leading to collaboration, linkages and coordinated innovation activities across the West Wales & Valleys (WWV) region. • HE and industry traditionally work at different speeds and legal requirements can make the collaboration process too onerous for it to be worthwhile. More streamlined, agile and quicker approaches and processes are needed to fulfil the potential of HE/industry collaboration.	• Increase the awareness of the potential of photonics for business growth in West Wales and the Valleys and improve collaborative working between project partners. • Build on the current research expertise in the involved Welsh universities to effect improvement in new product/process development and embed knowledge directly into supported enterprises for their customers and business partners. • Harness academic strengths, building on these and putting in place mechanisms and collaborative research programmes which will ensure that photonic technology is embraced and adopted by industry, specifically in West Wales and the Valleys (WWV) • Create a world-class research environment that unifies the all-Wales photonics research capability to deliver cross-sector, industry-driven photonics solutions and develop a pipeline of innovation by piloting new products and services that complement existing products and services. • Bring about transformational and sustainable long-term economic growth through enhanced competitiveness and high value jobs in the Innovation Wales grand challenge areas of low carbon, energy and environment, and advanced engineering and materials.

Inputs	• Three-year project with a total cost of £5,804,767 – funded by the ERDF (£3,782,656) and by co-financing (£2,022,111) • Expertise relevant to the CPE will be drawn from: ◦ Wrexham Glyndŵr University, University of South Wales, Bangor University and Aberystwyth University ◦ The OpTIC Technology Centre, St Asaph ◦ Business engagement expertise from the BDMs • Operation management will be provided by Glyndŵr University: ◦ Governance will be delivered by a CPE Executive Board; the CPE OMT and Weekly Project Panels

Activities	ERDF outputs	Intermediate outcomes one	Intermediate outcomes two	Overall impacts
• The CPE will engage with micro, SME and large businesses to plan innovation projects and deliver innovations that will meet industry needs and identified opportunities. • Target sectors include low carbon, energy and environment, and advanced engineering and materials. • Specific activities planned include: ○ Business development visits to companies ○ Collaborative research & development projects ○ Demonstration days ○ Support to assist SMEs in the commercial application of photonics technologies • Investment in thin-film development and research facility. • Engagement & communication. • Monitoring & evaluation.	• **120 partners** co-operating in a research project. • **60 enterprises** receiving non-financial support. • **£325,000 of private investment** matching public support in innovation or R&D projects. • **40 enterprises** supported to introduce new-to-firm products/ processes. • **20 enterprises** supported to introduce new-to-market products/ processes. • **16 jobs created** in supported enterprises.	• CPE engagement & collaboration model is tested and enhanced. • Supported enterprises realise they have a problem which photonics & collaboration with HEIs can resolve. • HEIs develop more agile, quicker processes for industry collaboration. • Improved knowledge of relevance and applicability of photonics within target sectors across WW&V. • The CPE demonstrates the success of applying photonics technology and applications to target sectors in WW&V. • HEI partners learn more about each other and develop their combined skills further by virtue of collaborative working.	• Capital investment further enhances photonics capacities in Wales. • A pool of HEI expertise in photonics is working with enterprises across target sectors in WW&V. • Supported enterprises achieve tangible economic benefits – t/o; growth; efficiency; jobs. • Future commercialisation opportunities are identified. • REF impact case studies & academic research produced and published. • CPE contributes to delivery of regional growth. • Further collaborations between industry and HE is sustained, using new processes.	• Improved & new product/process development using photonics in WW&V enterprises. • Increases in employment in the target sectors and associated supply change benefits from using photonics applications in WW&V. • Institutional/researcher collaborations persist beyond the lifetime of the CPE project. • Foundation for future inward investments in the Welsh economy using phonics expertise. • Positive attitudes towards future RD&I and collaboration between SMEs, technology providers and HEIs in WW&V.

Assumptions	Barriers & risks
• There is demand amongst the WW&V SME community for the support available through the CPE. • The target sectors are the appropriate ones to target for innovation activities. • There are sufficient SMEs in West Wales and the Valleys that could benefit from photonics applications for the operation to reach its targets. • There is photonics-specific expertise available within the CPE operation partnership that will match the needs of target SMEs. • The project will successfully identify appropriate SMEs with which to work. • The CPE and its HEI partners will effectively engage with SMEs to ensure full collaboration, including exploratory and/or pilot projects that could lead to further future engagement or collaboration. • Partners will actively and enthusiastically co-operate closely with the CPE, with each other, and with wider stakeholders. • Sufficient progress will have been made by the end of the operation for a follow-on project to be justified. • Success will be demonstrated by the quality of the projects that come through and communicating this widely so that others can see and experience the benefits. • Teams of researchers brought together by the CPE will continue their network and research input beyond the CPE's lifetime.	• Delays in getting the appropriate staffing in place could affect project capacity going forward. • Short length of the operation's timespan may lead to early loss of delivery staff & momentum of the pipeline. • Partners and beneficiaries may find the burden of monitoring and reporting processes and procedures of collaborative working onerous. • The size and/or range of the CPE partnership across four HEIs may focus too much attention on coordination processes – too many meetings, for example. • SMEs may be challenged by their understanding of photonics technology and potential applications. • Slow implementation of Cap-ex equipment may impede the operation process. • Insufficient time may be available for CPE projects to achieve full potential outcomes and impacts. • COVID-19 may have an adverse effect on project progress and take-up, with limited investment available from SME partners. • Pressures on HEIs may undermine participation in CPE – resources, restructuring etc. **Enablers** • Regular and consistent cross-partner communications and efforts to support joint working preceded the CPE and continue to be managed successfully within the CPE. • Clear administration processes and joint working across partners will help to minimise bureaucratic delays and confusion. The technology barriers of understanding amongst SMEs will be overcome by focusing on business issues, needs and solutions. • Balancing short-term 'win' projects with longer-term capacity building projects should allow the CPE to achieve its contracted outputs and outcome whilst also preparing for longer-term impacts to be revealed. • A clear vision of a CPE2 operation will help avoid short termism and lack of commitment amongst partners and supported enterprises.

Appendix 2: Case Studies

Diamond Centre Wales

Diamond Centre Wales is a bespoke jewellery manufacturer based in South Wales, with an expert team of artists, designers, diamond graders and Goldsmiths who create over 1,000 bespoke pieces each year. They collaborated with Bangor University to develop technology around laser-engraved nano QR codes on diamonds to ensure traceability and provenance, whilst Aberystwyth University also provided support around developing a capability, they can use in-house to grade the products. According to the CEO:

> "If you want to grade a diamond, you'd have to go to a grading house, and that lab would be the same size as our ground floor and it would cost them… a minimum of £600,000 to kit out the lab. With this machine now, it can do all the grading, for all the colour stones… all of this has never been done before, and this machine will probably come out under £70,000 and will fit on your desk, so all that's down to [name of academic lead] and our ideas."

They were approached by the CPE team and asked to become involved in a collaborative project; however, the project developed from a need identified by the business. Alongside Bangor University, they conducted a feasibility study that scoped the lens technology needed to read the QR codes and engrave those codes. Whilst the business noted they had the expertise to utilise photonics technology with their team, they had neither the awareness of the technology nor the equipment to apply it to their work in practice.

> "The jewellery industry is doing reasonably well worldwide but there are huge gaps in the way of developing technology…we had ideas that internally we wanted to create which turned out to be world-beating."

Following the successful proof of concept, they are now further developing the technology called TUI (The Ultimate Identifier) through an arm of the business known as Seculux. According to the CEO:

> "Without Bangor University doing the CPE work and the super lens part of it, that would have been impossible."

They have since secured funding from Innovation Fund UK, and are continuing their partnership with Bangor University in order to further improve and scale up the technology and its applications, alongside a new partnership with the University of South Wales. They have also set up an R&D department within the business and are involving multiple HEIs and academics in this work.

The business has been able to create seven new full-time positions since receiving support, and attributed the vast majority of that (81 to 100 per cent) to the support received from the CPE. Additionally, the Managing Director stated that the impact of the CPE project will be immense, with the creation of up to 1,000 jobs, including high-skilled manufacturing jobs, product support roles, and further R&D.

Interest in their work is growing amongst large industry stakeholders, including the Ministry of Defence, the Royal Mint, and insurance companies, with the transferability of the technology across jewellery and metals meaning it has considerable applications and use in a variety of contexts. The CEO further highlighted that they are establishing two separate businesses – Seculux and Tivitec – within the arm of Diamond Centre Wales, which is expected to be a *"huge commercial avenue"*. Thus, whilst the project is yet to have generated an economic return for the business, the potential impact is clearly evident.

In addition to the considerable potential impact on turnover and employment from the project, the project has an additional environmental benefit following on from encouragement from the project team to consider the potential for developing their green infrastructure.

> "They have made us aware and pushed us in a way that we have become greener as a company. We are going to rent out the whole roof space for solar panelling which will cover lots of our bills and some going back to the grid."

Transcend Packaging

Transcend Packaging specialises in the manufacturing of sustainable packaging such as paper straws, cups, boxed packaging and cutlery, with major clients including McDonalds and Ribena. Located in Caerphilly, they were recommended to the CPE by a business contact and have been working in partnership with Bangor University.

Transcend Packaging approached CPE to address some of the challenges in their current blade-based paper straw-cutting process. CPE researchers experimented with several different lasers and techniques, with the aim being to cut the company's paper straws without burning or marking them, which would improve both quality and the speed of the process. This also has the additional environmental benefit of reducing waste product material and processing time. The project had a successful outcome, whereby a laser was identified that could be used to cleanly cut the straws. The business was very pleased with the support, noting that the CPE team were *"highly professional"*.

Whilst the business have yet to actively deploy the technology at scale, and have therefore not seen a significant impact on their production, the CEO did note that the project had been very informative and has led to broader impacts, such as the development of collaborative relationships with HEIs. The businesses were particularly pleased about being able to draw on academic skills and resources so as to push innovation. They had not previously considered the application of photonics to their work prior to working with academics from Bangor University.

> "From that perspective, I think it was quite instrumental. Sometimes having innovative ideas and being able to have the medium to test them out gives you a chance to make an assessment about whether that's the right direction of travel."

The project was also the catalyst for further internal development around additional products, specifically in the area of quality assurance and piloting of products that have not been tested at scale, such as opportunities to replace single-use plastic in the wider food service industry.

The work completed on the project will be crucial when it comes to addressing the recently announced Wales-specific single-use plastics directive, which extends producer responsibility obligations. It would also ensure that the packaging is compliant with EU legislation on packing waste, which would increase the company's export potential. The CEO noted that this will help drive employment sustainability and export potential for Welsh-based businesses.

AVoptics

AVoptics specialises in fibre optic, photonic, electrical and electronic solutions for harsh environments. Their products and services include cable assemblies, consultancy & design, field repair kits, and full integration test rigs. Following on from the COVID-19 pandemic, they developed a personal boundary marker that uses a laser to highlight a 2-metre radius around the wearer. AVoptics have used their capabilities in 3D printing to manufacture a non-reflective prototype component, and in collaboration with the CPE, were able to achieve a highly reflective coating on the surface.

As a business already working in the photonics industry, they already had a SMART-funded research project through the Welsh Government. They approached the CPE and Wrexham Glyndwr University, as they felt these institutions could help them achieve a better product and give them access to a wider range of facilities. They hoped to identify whether the materials they were using for 3D printing would be suitable for use in a vacuum coating chamber and to understand how they could make a more reflective and flat metal-coated plastic part.

"We now have a much stronger understanding of what was possible for our optical product concept and have already identified the follow-up opportunity to take advantage of the CPE's vacuum coating facility."

Further development work on this project is under consideration – the Welsh Government was impressed with their working prototype and has invited them to apply for further funding for this project, as well as another COVID-related product. Through the project, the business gained a better understanding of what the CPE does and how it can link in with other support.

"Welsh Government were pleased that not only did we complete the project that we'd used on their funding they were also pleased the CPE facility was being used by a local SME."

The Principle Research Engineer at the company stated that the collaboration had helped them define new ways of carrying out their technical work and corroborated some of the results from their own experiments. On conclusion of the project, they decided against pursuing the product further, but were positive about the process and the partnerships created through the CPE.

"It was quite technically tricky and it would have taken a lot more development to pursue it and we didn't really think that the commercial viability of that approach was necessarily worth it."

Enviro 365

Enviro365 provides an engineering consultancy service delivering environmental protection planning and support equipment. The company has been expanding its engineering services since its establishment in 2019, although the directors have extensive previous experience, with over 25 years in relevant industries. Being a small start-up in the environmental sector, the business noted that it can be daunting when looking for advice and help to progress basic ideas.

After coming across the CPE online, the Managing Director spoke to the CPE BDM, which assessed what the business wanted to achieve and put a partnership in place with the University of South Wales and Aberystwyth University.

They were seeking to develop a prototype alarm that sends out an SMS when there is an oil spill – a product identified by the business. The Managing Director noted that the partnership was not only quick to instigate, but provided a sounding board and technical capability to advance their basic idea to prototype stage for further funding.

"The team from Aberystwyth and South Wales Universities were superb and the quality of the support from CPE was amazing…We came up with a prototype that worked, we couldn't ask for better than that!".

The knock-on impact of the project has been considerable – it enabled the business to develop a product that can be used in conjunction with its core services, which has allowed them to develop another product which could provide its own business stream. The business subsequently secured a grant with HS2 to further innovate.

The business has since developed its R&D capabilities by sponsoring four Masters students to progress their prototype research. They have taken on an apprentice and sponsored two undergraduate and two postgraduate students working on their research projects; indeed, this will allow them to take the products to the next step of commercialisation and grow the business. The collaboration with the universities has added valuable weight to their projects. The business more than doubled their turnover since first engaging with the CPE, and attributed some of that growth to the operation:

> "Without CPE we wouldn't have had the benefits of working with the university and developing a brand new product. We rent a room now in Aber Innovation."

Smart Storm

Smart Storm Limited are leading waste water monitoring and treatment experts, offering solutions for the removal of fats, oils and grease from wastewater tanks and bespoke monitoring systems. They work frequently with the food and drink industry, in particular with brewers, food producers and edible oil refineries. Whilst the business had the expertise to utilise photonics technology, it needed the awareness of specific applications and the equipment to use photonics in practice.

Through the partnership they developed with Bangor University, they were seeking improvement in product efficiency. They were incredibly positive about the outcomes achieved through the collaboration and have had continuing dialogue with the project partners on the ongoing development work.

> "It's helped us develop a product that we wouldn't have had the technical skills or time to develop and what's come out of it has been immensely helpful. By laser burning our rubber belt, we found it was better at picking fat up and rejecting water on the belt than just the untreated belt. It picks more up so it's a more efficient method of recovering oil. It's helped us develop a product that picks more FUG (fats, oils and grease) up at lower concentrations or lower presence."

The academic partners described it as a *"very successful experiment"* which had doubled the process efficiency. Smart Storm's MD felt it had enabled them to increase market penetration, thereby contributing to the growth experienced by the business since engaging with the CPE.

The impacts of the project are multi-fold; as an environmental product, it improves reduction of industrial waste streams. The support also resulted in increased spend in the local supply chains due to the growing volume of sales.

Roberston Geo

Roberston Geo are a manufacturing company that became involved with the CPE after approaching Bangor University. Based in Conwy, they are market leaders in developing wireline logging techniques and technologies. As an end-user of their own technologies, the feedback loop from direct field experience also fosters a continuous improvement culture, which is what led them to seek specialist support from academics at Bangor through the CPE.

They were experiencing difficulties with a camera lens used during their work on-site and were seeking to develop a new camera lens which could operate at higher temperatures. They knew that they did not have the expertise or technology in-house to resolve the thermal issues, but they noted that, upon approaching the university, the academics were aware of the problem instantly and able to find a solution.

> "As things expanded and contracted, the actual lens system was going out of focus, which was a serious problem for us… They were able to discover that we could get something off the shelf with the same prescription using the Z Max software they use for their optic retracing… to have a product available which would work at the higher temperature specification which we required which otherwise we simply wouldn't have been able to do."

What started as a simple technology review developed into further projects around troubleshooting the business' telescopic gyroscope and exploring novel approaches to solve the issue. Collaboration with Bangor University was very successful, and the approach of the academics involved complemented that of Robertson Geo.

> “The teams that we've dealt with have controlled the meetings very well with tight agendas, which is really useful. Nobody wastes any time. We get to the crux of the matter pretty quickly…it's a very focused and targeted approach, which is the way we normally do things.”

The impact of the CPE project has been seen through additional sales and the increase in employees. This has led to an increase in turnover for the business, which has in turn allowed them to invest further in research and development. This all stems from being able to address a key service issue through the CPE support.

In addition to the impact of the research projects on their work, the Engineering and Development Manager was positive about the networking aspect of the CPE – in particular, knowing where the expertise lies as well as other businesses which need similar solutions in the industry. Following the success of the CPE collaboration, they launched two additional projects with them in order to investigate solutions to two other lens-related issues which they experience in their work. This also encouraged the business to embark on further collaboration with a different university outside of the CPE.

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