IOP R&D blueprint survey: background briefing

Businesses: unlocking private investment

Physics delivers substantial economic benefits. In 2019, physics-based industries generated £229bn in gross value added (GVA), equivalent to 11% of UK GDP.[1] These industries employed 2.7 million full-time equivalent (FTE) employees – 10% of total UK employment – in productive, rewarding careers, with an average salary of £42,000 and labour productivity of £84,000.

As evidenced by the CBI Economics report 'Paradigm Shift'[2], commissioned by the IOP, business activities built on physics skills and expertise are associated with high levels of innovation. Across the UK, physics-based businesses are making innovation central to everything they do, actively investing in scientific discovery and technology, driven by the goal of developing new products or services and growing their businesses.

As a result, the most physics-reliant industries accounted for around a third of total business R&D expenditure in the UK in 2019. To reach the 2.4% target, these industries will need to increase R&D investment by 55%, from £8.9bn to £13.8bn, by 2027.

Nearly 60% of physics innovators expect their R&D/innovation spending to increase over the next five years relative to the previous five years. However, physics innovation is costly, risky and development times for physics technologies are typically much longer than for other technology areas. Businesses face significant challenges in supporting the direct and potential costs of innovation, and in accessing the necessary finance, skills, equipment and external expertise – areas where government support is needed to enhance capability and economic return. Physics innovators most commonly report significant cost pressures during the large-scale prototyping and production/scaling up stages, the latter also reflecting the phase when it is most difficult to secure funding.

To deliver the necessary uplift in R&D activity, physics-based businesses need the right conditions and support to overcome these challenges.

Scientific discovery: strengthening the research base

Almost every modern-day technology has its origins in fundamental physics discoveries. From building particle detectors, sensors of all types and advanced satellite platforms to better understand our planet and the universe, to using new materials and nanotechnology to drive engineering advances, or developing new cancer diagnostics and treatments to improve outcomes for patients, UK physics has been indispensable to many of the world's most impactful and successful innovations. The historic leadership that the UK has been able to demonstrate in physics will only be sustained if investment is at levels that match or exceed international comparator nations.

The R&D ecosystem is broad and complex. Funding for physics research from UKRI has increased substantially over the past decade, partly through establishment of the Industrial Strategy Challenge Fund and increases in funding for applied science. Support for mission and challenge-led innovation is increasingly important to UK physics, bringing together cross-disciplinary researchers and innovators to help solve some of our biggest challenges, such as achieving net zero. As a result, the apparent balance of funding for discovery, applied and experimental development research has shifted – between 2009 and 2019, the proportion of total R&D funding from civil government departments, the Research Councils and Innovate UK allocated to discovery research decreased from 42% to 31%.[3]

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[1] Centre for Economics and Business Research (2021). Physics and the Economy: Measuring the value of physics-based industries in the UK https://www.iop.org/strategy/productivity-programme/physics-and-economy#gref

[2] CBI Economics (2021). Paradigm Shift: Unlocking the power of physics innovation for a new industrial era https://www.iop.org/strategy/productivity-programme/innovation-survey#gref

[3] ONS (2021). Research and development expenditure by the UK government: 2019 https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/ukgovernmentexpenditureonscienceengineeringandtechnology/2019

UK universities play a significant role in delivering excellent discovery physics research (88% of physics outputs assessed in the 2014 Research Excellence Framework were rated as 'internationally excellent' or 'world leading', compared to 76% of outputs across all disciplines[4]) and in training the highly-skilled people needed to deliver the Government's science superpower vision. But research in the UK's universities is currently funded at levels below its full economic cost, with the total deficit for research activity in universities in England and Northern Ireland reaching more than £4 billion in 2019/20.[5]

All types of R&D, and all types of research institution, must receive the necessary support to maintain a strong supply of transformative ideas that fuel future innovation and secure the UK's scientific leadership.

People and skills: expanding the R&D workforce

A highly-skilled and adaptable workforce is central to the UK's future economic success and international leadership in the next technological revolution.

The number of R&D workers in the UK grew by 40% between 2009 and 2019 to reach 490,000 FTE.[6] This is equivalent to 1.4% of the total workforce, the highest proportion in recent decades, but smaller than in competitor nations such as South Korea, Germany and France.

Education and training in physics open doors to fulfilling careers across a range of critical industries in every part of the UK – around 1 in 20 jobs make use of physics-related knowledge and skills.[7] In addition to their broad utility across the economy, physics-related knowledge and skills have a critical role to play in fuelling technological innovation and addressing some of the most pressing challenges facing society, such as achieving the net zero emissions target.

However, skills shortages threaten to derail plans to increase investment in physics-based R&D/innovation, causing delays to projects, missed targets and missed opportunities. Two thirds of physics innovators reported suspending or delaying R&D in the past five years because of skills shortages, with these being particularly acute at the production/scaling up stage of the R&D/innovation pipeline.[2]

Demand for physics-related skills is growing and now in excess of pre-pandemic levels – this reflects their importance, but is likely to exacerbate existing skills shortages in the coming years. For the UK to fully seize the opportunities offered by increased investment in R&D, we need an equally dramatic increase in the scale and diversity of the R&D workforce. Additional support for physics education and training is needed to boost students' attainment and progression at school and to upskill those already in the workforce.

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[4] REF 2014 (2014). Unit of assessment summary data, UOA 9: Physics https://www.ref.ac.uk/2014/media/ref/results/AverageProfile_9_Physics.pdf
[5] Office for Students (2021). Annual TRAC 2019-20 https://www.officeforstudents.org.uk/publications/annual-trac-2019-20/
[6] OECD Main Science and Technology Indicators https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB
[7] Emsi Burning Glass (2021). Physics in Demand: The labour market for physics skills in the UK and Ireland https://www.iop.org/strategy/productivity-programme/workforce-skills-project