

THE STATE OF UK BIOREFINING IN 2025

Progress, Performance and
Pathways for Growth



Biomass
Biorefinery
Network

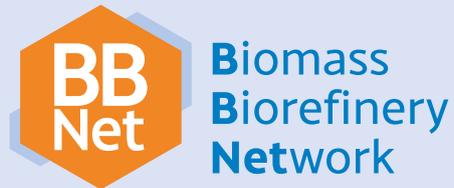


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CONTENTS

Definitions	6
1. Executive summary	8
2. Introduction	12
3. Methodology	14
3.1 Project scope	15
3.2 Project tasks	16
4. Industrial biotechnology in the UK – how did we get here?	18
4.1 Introduction	18
4.2 The UK’s science and innovation landscape	18
4.3 UK Biorefining policy and regulatory landscape	24
4.4 UK biorefining in an international context	29
4.5 Section summary	32
5. Industrial biotechnology today – current status in the UK	34
5.1 Introduction	34
5.2 Regional bioeconomy clusters	38
5.3 Biorefining success stories	40
5.4 Barriers to further growth	42
5.5 Section summary	51
6. The future of biorefining in the UK – where do we go from here?	53
6.1 Introduction	53
6.2 Scope and definitions	53
6.3 Achieving cost parity with fossil counterparts	55
6.4 The future of biorefining beyond the UK	57
6.5 Section summary	59
7. Biorefining sector needs for future growth in the UK	60
7.1 Introduction	60
7.2 Key recommendations	61
7.3 Stakeholder specific recommendations	62
8. Conclusions	71
8.1 Scope and definitions	71
8.2 Key findings: opportunities and challenges	72
8.3 Key recommendations	73
9. Annexes	75
9.1 Biorefining landscape review (Alder BioInsights)	
9.2 Stakeholder perspectives (Frey Consulting)	
9.3 Economic analysis (Perspective Economics)	

FIGURES

Figure 1: Visual illustration of how the biorefining sector relates to the bioeconomy, industrial biotechnology (IB) and engineering biology (EB).	13
Figure 2: Project methodology consisting of four discrete tasks; landscape review, stakeholder engagement, economic analysis and reporting.	14
Figure 3: Fragmentation of Government departments and their key strategies/focus areas relating to IB.	29
Figure 4: Segmentation of bioeconomy companies operating in the UK.	35
Figure 5: Historical bio-based company incorporations in the UK.	35
Figure 6: SME revenue growth (2014 to 2024) in the UK.	36
Figure 7: Fundraising by in-scope IB companies (2014 to 2024).	37
Figure 8: Total fundraising by in-scope companies by sector.	37
Figure 9: Size and type of IB companies operating in the UK (2025).	38
Figure 10: The main challenges to the adoption of biorefining in the UK, according to UK stakeholders surveyed.	43
Figure 11: Barriers to biorefining in the UK in terms of feedstock mobilisation, stakeholder view.	45
Figure 12: Stakeholder perceptions on access to scale up infrastructure.	46
Figure 13: Biorefining barriers to cost and profitability in the UK, according to UK stakeholders surveyed.	47
Figure 14: When ensuring fair trade, stakeholders were asked: which are barriers to biorefining in the UK?	49
Figure 15: Future growth scenarios.	54
Figure 16: Stakeholders were asked: How can the UK differentiate itself from other countries?	59
Figure 17: Visual illustration of how the biorefining sector relates to the broader bioeconomy and the industrial biotechnology and engineering biology technology areas.	60
Figure 18: Stakeholder views on the future of biorefining in the UK.	62

TABLES

Table 1: Summary of key recommendations for industry, funders and Government stakeholders.	11
Table 2: Main funding mechanisms used to support BBSRC's IB portfolio between 2010/11 to 2020/21.	23
Table 3: Examples of other countries' best practice to support biorefining internationally.	32
Table 4: Key challenges associated with bio-based products achieving cost parity with fossil-based alternatives.	56
Table 5: Short-, medium- and long-term recommendations for industry stakeholders.	65
Table 6: Short-, medium- and long-term recommendations for funders.	68
Table 7: Short-, medium- and long-term recommendations for government.	70
Table 8: Summary of key recommendations for industry, funders and Government stakeholders.	73

DEFINITIONS

Acronyms and abbreviations

- ABE** – Acetone–Butanol–Ethanol (fermentation process)
- BBB** – British Business Bank (public finance body referenced for FOAK linkages)
- BBIA** – Biobased and Biodegradable Industries Association
- BBJU** – BioBased Industries Joint Undertaking (Previous EU publicprivate partnership, replaced by CBE–JU)
- BBNet** – Biomass Biorefinery Network (Phase II NIBB)
- BBSRC** – Biotechnology and Biological Sciences Research Council (UKRI)
- BDC** – Biorenewables Development Centre (York)
- BEACON** – Biorefining initiative in Wales (openaccess centre)
- BECCS** – Bioenergy with Carbon Capture and Storage
- BEIS** – Department for Business, Energy and Industrial Strategy (a historic UK Government department, no longer operational)
- BERR** – Department for Business, Enterprise and Regulatory Reform (a historic UK Government department, no longer operational)
- BIS** – Department for Business, Innovation and Skills (a historic UK Government department, no longer operational)
- CBEJU** – Circular BioBased Europe Joint Undertaking (EU publicprivate partnerships)
- CBAM** – Carbon Border Adjustment Mechanism (EU trade instrument affecting carbon intensity)
- CPI** – Centre for Process Innovation
- DBT** – Department for Business and Trade (UK Government department, operational at the time of this report’s publication)
- DESNZ** – Department for Energy Security and Net Zero (UK Government department, operational at the time of this report’s publication)
- DSIT** – Department for Science Innovation and Technology (UK Government department, operational at the time of this report’s publication)
- EB** – Engineering Biology
- EPSRC** – Engineering and Physical Sciences Research Council (a part of UKRI)
- FOAK** – Firstofakind (demonstration/commercial scale projects)
- GVA** – Gross value added (economic metric)
- IB** – Industrial biotechnology
- IB Catalyst** – Joint BBSRC/EPSRC/Innovate UK programme (2014–2018) funding IB R&D from feasibility to experimental development

IBIGT – Industrial Biotechnology Innovation & Growth Team (UK Government initiative)

IBioIC – Industrial Biotechnology Innovation Centre (Scotland)

IBLF – Industrial Biotechnology Leadership Forum

IRA (US) – Inflation Reduction Act (US climate and clean tech incentives)

Key terms

BBNet (Biomass Biorefinery Network) – A Phase II NIBB focused on developing improved processes that convert nonfood biomass into sustainable fuels, chemicals, and materials, spanning bioprocessing, biocatalysis, fermentation, and integrated chemical conversion.

Bioeconomy – The part of the economy that uses biological resources, biological processes, and biotechnology to produce sustainable goods and services. It creates the market pull for biorefining and provides the overarching environment in which bio-based sectors can thrive.

Biorefining – The conversion of renewable biological resources (e.g., plants, agricultural residues, food waste, and microorganisms) into fuels, chemicals, materials, and other valuable products. In practice, it is the biobased analogue of a petroleum refinery, with industrial biotechnology as the key enabling process technology.

Engineering biology (EB) – A research/technology area (closely linked to synthetic biology) that designs and engineers biological systems and organisms for novel functions and products. EB is positioned inside IB as an important technology area used to manufacture new products and solutions.

Industrial biotechnology (IB) – The application of biological systems (microorganisms, enzymes, cells) to produce and process materials, chemicals, and energy, enabling more sustainable manufacturing. In this report, IB sits within the bioeconomy and serves as the process backbone of biorefining.

Networks in Industrial Biotechnology and Bioenergy (NIBB) – UKRI-funded collaborative research communities that foster academia–industry–policy partnerships and accelerate translation from research to industrial application. Phase I (2014–2019) and Phase II (2019–2024/26) supported targeted thematic networks including BBNet.

1. EXECUTIVE SUMMARY

This report, commissioned by the Biomass Biorefinery Network (BBNet), assesses the evolution, current status and future prospects of the UK biorefining sector. It draws on a decade of published literature (2014–2024), stakeholder engagement conducted in 2025, and economic analysis to identify barriers, opportunities and strategic interventions required to unlock growth and global competitiveness of the UK's biorefining sector.

For the purposes of this study, biorefining is framed in line with the interests and remit of BBNet, with a particular emphasis on IB as the core enabling process technology. This encompasses approaches such as fermentation and biocatalysis, as well as the integration of these biological methods with complementary disciplines to drive innovation and value creation. Although included within the wider definition of biorefining, it is important to note that for the purposes of this report, thermal and thermochemical processing of biomass (including methods such as pyrolysis and gasification) fall outside the scope of this study.

Over the last decade, the UK's biorefining sector has evolved from a nascent research-driven field into a critical component of the nation's bioeconomy. Public investment, notably through BBSRC's £413 million commitment and initiatives such as the IB Catalyst and NIBB networks, has delivered significant returns in intellectual property, spin-outs and collaborative research. These efforts have positioned the UK as a global leader in industrial biotechnology research and innovation, with strong academic capabilities and regional clusters driving progress, such as Scotland and Yorkshire.

However, despite these achievements, the sector faces systemic challenges that threaten its ability to scale and compete internationally. Economic analysis and stakeholder engagement reveal that revenue growth and company formation peaked in 2021 and have since declined, accompanied by a cooling of investor confidence and reduced fundraising activity. These trends underscore structural weaknesses in the UK's innovation-to-commercialisation pipeline, particularly in scale-up infrastructure, feedstock mobilisation and regulatory clarity. Without targeted intervention, the sector risks a contraction of ~5% in revenue and employment, forfeiting an estimated £0.5 billion in total SME revenues and associated climate benefits over the next five years.

Biorefining is a key component of the UK's transition to a net zero economy. By converting renewable and waste feedstocks into fuels, chemicals and materials, biorefining offers a pathway to decarbonise hard-to-abate sectors such as chemicals, plastics and advanced materials. Biorefining also strengthens national resilience by reducing reliance on imported fossil resources and creating skilled employment in high-value manufacturing.

The UK's key competitive strengths lie in:

- **Academic excellence and innovation ecosystems** – providing a strong foundation for discovery and collaboration.
- **Integration with engineering biology and digital technologies** – capitalising on world-leading expertise in synthetic biology, AI and automation.
- **Waste and residue valorisation** – leveraging robust waste management systems and circular economy policies.
- **Potential for progressive sustainability standards and regulatory reform** – enabling differentiation in global markets.



These advantages, however, will only translate into global leadership if structural barriers are addressed and long-term policy certainty is established.

Throughout the course of this project, stakeholder engagement identified five dominant barriers, facing the sector:

- **Cost and profitability** – bio-based products remain more expensive than fossil alternatives due to high energy costs, downstream processing complexity and process inefficiencies.
- **Market confidence** – absence of binding targets, procurement mandates, and clear standards undermines demand signals and investor confidence.
- **Feedstock mobilisation** – limited visibility of national biomass resources, high prices, seasonal variability, and competition from sectors such as sustainable aviation fuel constrain supply.
- **Innovation and scale-up support** – while early-stage research is well-funded, access to pilot and demonstration facilities declines sharply beyond TRL 6, creating a “valley of death” for commercialisation.
- **Regulatory fragmentation and trade challenges** – outdated frameworks, lengthy approval processes, and lack of harmonised sustainability standards impede market entry and global competitiveness.

These barriers are not new, with many first highlighted in the IB2025 report over a decade ago.¹

¹ IB 2025 Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy: A report to government by the Industrial Biotechnology Innovation and Growth Team. 2010.

Their persistence therefore reflects a critical need for systemic reform and coordinated action across government, industry, and research and innovation funders.

Global competitors are accelerating biorefining deployment through bold strategies and large-scale investment. For example, the US Inflation Reduction Act and the EU's Circular Bio-Based Europe Joint Undertaking exemplify integrated approaches combining fiscal incentives, infrastructure funding, and regulatory clarity.^{2,3} These measures have catalysed billions in private investment, created guaranteed markets and supported flagship commercial scale biorefineries.

In contrast, the UK's fragmented policy landscape and limited scale-up funding risks driving domestic innovations abroad, which is a trend already evident with companies such as Lixea and Azotic Technologies relocating commercial operations to the EU and US respectively. Without decisive intervention, the UK faces erosion of its competitive position within the IB space and risks losing the economic and environmental benefits that biorefining can offer.

Based on the views and insights collected from stakeholders in 2025, this report points to three possible high-impact interventions:

- **Investment in scale-up infrastructure** – establish shared pilot and demonstration facilities, linked through a national network, to de-risk commercialisation and accelerate technology deployment.
- **Feedstock mobilisation** – develop a national biomass map, secure long-term supply agreements and invest in feedstock innovation to ensure affordable, sustainable inputs.
- **Government coordination and policy certainty** – create a dedicated biorefining body to align strategies across departments, streamline regulations and leverage public procurement to stimulate demand.

These measures could unlock up to 18% growth in revenue and employment by 2030, compared to a potential decline projected under the status quo. The opportunity cost of inaction was estimated as being £0.5 billion in lost SME revenues by 2030, reinforcing the urgency and need for intervention.

In order to realise the biorefining sector's full potential, coordinated action is therefore required across all key stakeholder groups.

- **Industry** – should look to prioritise UK-based supply chains, adopt standards and engage in collaborative research initiatives to build resilience and market confidence.
- **Funders** – should provide targeted support for scale-up, regional clusters and IB Catalyst-style programmes to sustain innovation pipelines.
- **Government** – should deliver regulatory reform, include industrial biotechnology activities within existing UK funding for engineering biology (committed as part of the Industrial Strategy), and establish a “bioeconomy delivery body” to monitor progress and drive accountability for sectoral development.

2 US DoE. Inflation Reduction Act of 2022. 2022. URL: <https://www.energy.gov/lpo/inflation-reduction-act-2022>.

3 Circular Bio-based Europe Joint Undertaking. URL: <https://www.cbe.europa.eu/>.

Table 1: Summary of key recommendations for industry, funders and Government stakeholders.

	INDUSTRY	SHORT-TERM	MEDIUM-TERM	LONGER-TERM
INDUSTRY	Bioeconomy	Cooperation between industry players to map the UK's IB and EB infrastructure and assets. Potentially led by industry body.	Large corporates should increase levels of investment in innovation and commercial activities.	Leverage current industry standards to promote best practice, efficiency, and compliance.
	Biorefining	Invest in the creation and reinforcement of UK supply chains.	Participate in new collaborative research initiatives.	Maintain strong engagement with trade bodies.
	IB sector	Work with industry associations to raise the profile of investment opportunities.	Trade bodies should work with DBT to develop new industry initiatives.	Support the regeneration of regional industry clusters.
FUNDERS	Bioeconomy	Provide ongoing financial support to companies across the bioeconomy.	Support local initiatives that strengthen regional capabilities and foster collaborations.	Support project scale-up by funding larger-scale initiatives.
	Biorefining	Funding and support for EB should also include the wider biorefining sector.	Offer targeted funding to help SMEs access existing infrastructure.	Offer targeted support for biomass innovation programs.
	IB sector	Support existing networks and communities (e.g., NIBB).	Ensure backing for IB Catalyst-style programs.	Encourage systematic sharing from unsuccessful projects in the IB sector.
GOVERNMENT	Bioeconomy	Use and development of standards and metrology.	Prioritise the use of bio-based products in public procurement.	Develop a National Bioeconomy Plan.
	Biorefining	Review of waste classifications for use as feedstocks.	Identify and close gaps in biomass mapping for feedstock mobilisation through open access government resources (e.g., Defra statistics).	Link demonstration and first-of-a-kind (FOAK) project funding to financial support.
	IB sector	Ensure IB initiatives are fully incorporated within EB funding programs.	Identify opportunities for IB innovation across all IS-8 sectors.	Direct some EB investment toward long-term IB projects.

The UK stands at a crossroads. It possesses world-class research, strong regional capabilities and proven commercial successes. Yet, without bold and coordinated action, these strengths risk being overshadowed by structural weaknesses and international competition. Biorefining is not only an industrial opportunity, but also a strategic imperative for achieving net zero, enhancing economic resilience, and securing global leadership in sustainable manufacturing.

By investing in infrastructure, mobilising feedstocks and delivering coherent policy frameworks, the UK can unlock the full potential of its bioeconomy, creating green jobs, driving innovation and positioning itself as a global leader in the transition to a low-carbon future.

2. INTRODUCTION

The use of fossil fuels in global manufacturing is a major driver of greenhouse gas (GHG) emissions, air pollution and resource depletion – contributing significantly to climate change and damage to the Earth’s natural environment. According to the IEA, industrial manufacturing is directly responsible for roughly 25% of global CO₂ emissions, with roughly 9 gigatonnes generated in 2022. This makes it the second-largest CO₂ emitting sector globally after power generation.⁴

As set out in the Climate Change Act 2008 (2050 Target Amendment) Order 2019,⁵ the UK is now legally required to reach net zero GHG emissions by 2050. Therefore, progress must be made to significantly reduce UK dependence on fossil fuels across all sectors, including energy production, fuel production and materials manufacturing, to ensure that emissions are reduced in line with national targets. But while several alternatives to fossil fuel use already exist for energy and fuel applications (e.g., wind power, solar power, electric vehicles etc.), there are limited options for the replacement of fossil-derived carbon in manufacturing.

Biorefining refers to the use of renewable biological resources (such as plants, agricultural residues, food waste and microorganisms etc.) to produce a range of valuable products (e.g., biofuels, bioenergy, polymers, materials, chemicals, food and feed). To date, biorefining represents the only viable and scalable means of replacing fossil-derived carbon across chemical and material manufacturing sectors.⁶

Biorefining is a fundamental component of the broader bioeconomy concept – the part of the economy that uses biological resources, biological processes and biotechnology to produce sustainable goods and services. It can be thought of as the bio-based equivalent of a conventional petroleum refinery, but instead of using crude oil as the primary feedstock, biorefining uses renewable biological resources. Biorefining draws on the application of industrial biotechnology (IB), which serves as a key enabling technology within the biorefining sector. Engineering biology (EB) also lies within industrial biotechnology as an important research/technology area that utilises engineered organisms to manufacture novel products and offer innovative solutions to global problems. The relationship between the bioeconomy, biorefining, industrial biotechnology and engineering biology is illustrated in Figure 1.

The UK’s bioeconomy is positioned as one of the strongest outside of the USA and China, having contributed roughly £153 billion in gross value added (GVA) to the UK economy in 2022 and supporting approximately 4 million jobs nationwide.⁷

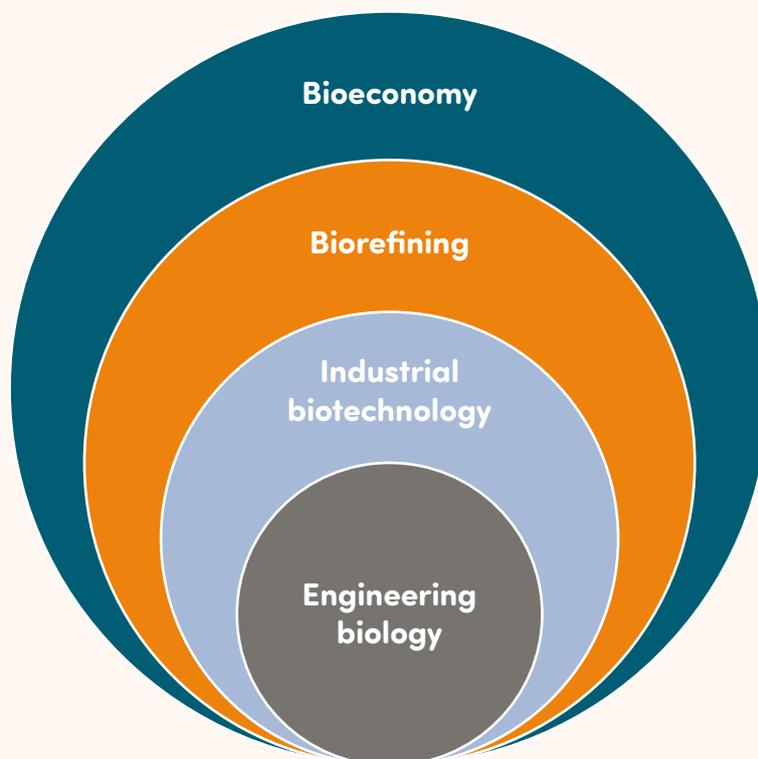
4 IEA, Industry Overview. URL: <https://www.iea.org/energy-system/industry>

5 Climate Change Act 2008 (2050 Target Amendment) Order 2019. URL: <https://www.legislation.gov.uk/ukdsi/2019/978011187654>

6 Innovate UK, Sustainable Carbon Ambition for the UK Chemicals Industry. 2024. URL: <https://iuk-business-connect.org.uk/wp-content/uploads/2024/08/IUK-Sustainable-Carbon-Report.pdf>

7 BBSRC, Building the Bioeconomy, 2022. URL: <https://webarchive.nationalarchives.gov.uk/ukgwa/20250701131000/https://www.ukri.org/publications/building-the-bioeconomy-presentation-and-posters/>

Figure 1: Visual illustration of how the biorefining sector relates to the bioeconomy, industrial biotechnology (IB) and engineering biology (EB).



- The industrial **bioeconomy** provides the market pull for biorefining. It encompasses the overarching economic environment for biorefining to thrive.
- **Biorefining** is a core activity within the bioeconomy.
- **Industrial biotechnology** (IB) serves as key enabling process technology within biorefining.
- **Engineering biology** (EB) is an important research/technology area within industrial biotechnology.

Furthermore, following the publication of “The UK’s Modern Industrial Strategy 2025” in June 2025, future support for biorefining was signalled through the government’s commitment to invest £380 million in engineering biology.⁸

The UK is now at a critical juncture, with a unique opportunity to position itself as a global leader in biorefining. By transforming renewable and waste feedstocks into high-value fuels, chemicals, and materials, biorefining offers a pathway to reduce reliance on fossil resources while enhancing national resilience, driving sustainable economic growth, and leveraging the UK’s strengths in innovation, agriculture, engineering biology, and industrial biotechnology.

This report explores developments in the UK’s biorefining landscape over the past decade – from the inception of the Networks in Industrial Biotechnology and Bioenergy (NIBB), through to the present day. It draws on literature, economic data analysis and stakeholder engagement to determine the current status and value of biorefining in the UK. The report identifies key barriers impacting on growth and outlines the range of possible opportunities attainable if the sector’s developmental needs can be met.

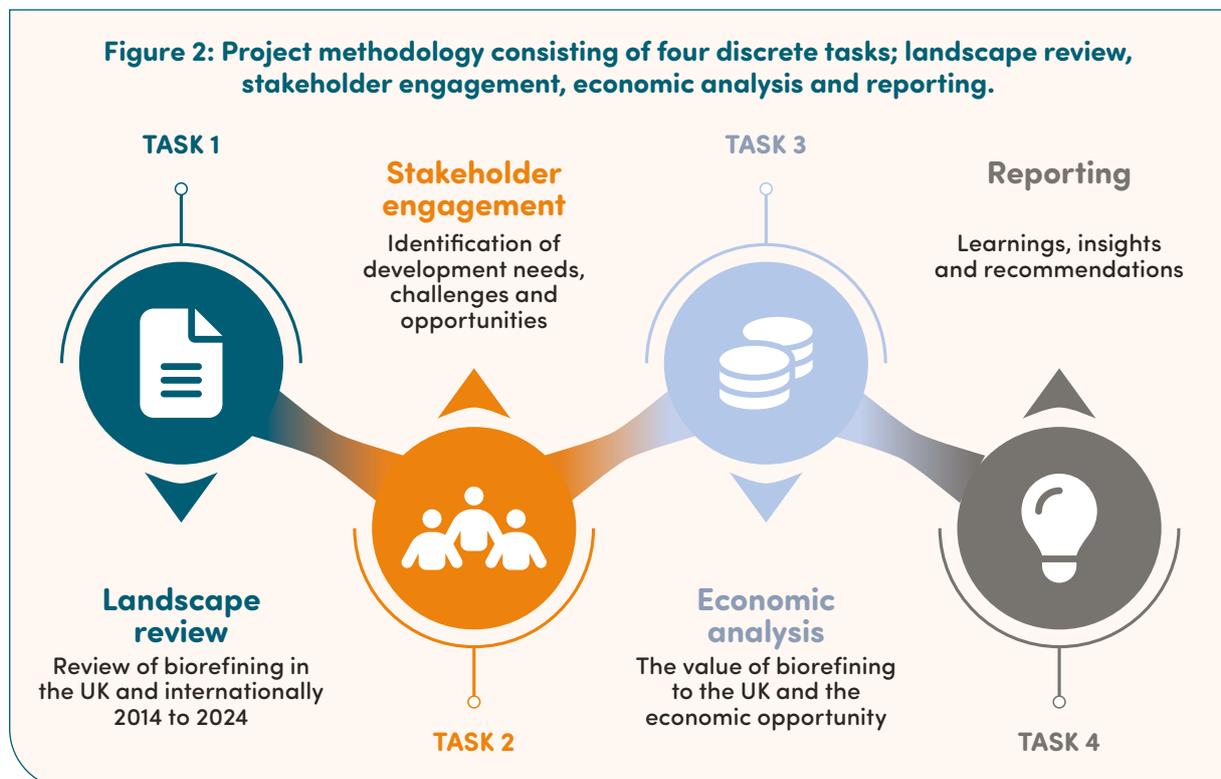
⁸ UK Government. The UK’s Modern Industrial Strategy. 2025. URL: https://assets.publishing.service.gov.uk/media/68595e56db8e139f95652dc6/industrial_strategy_policy_paper.pdf

3. METHODOLOGY

This report was commissioned by the Biomass Biorefinery Network (BBNet)⁹ to coincide with the end of the Network's coordination activities in January 2026. The report's primary aim is to identify key priorities to promote UK biorefinery growth, including the development of recommendations to be adopted by key biorefining stakeholder groups to ensure that the sector's full potential can be realised.

The project draws on a combination of research methods, delivered as per the four tasks outlined below and illustrated in Figure 2:

- **Task 1: Landscape review (2014–2024)** – mapping of developments across the UK's biorefining sector over the past decade. Led by Alder BioInsights.
- **Task 2: Stakeholder engagement** – gathering of insights from industry, academia, policy, and investment stakeholders. Led by FREY.
- **Task 3: Economic analysis (2014–2024, with projections to 2035)** – assessing past performance and the sector's future potential. Led by Perspective Economics.
- **Task 4: Analysis and synthesis report** – integrating all findings into a comprehensive report and presenting a set of key recommendations for the sector. Led by Alder BioInsights.



⁹ A Phase II NIBB which brings together and builds on the work of previous Phase I NIBB, such as LBNNet (Lignocellulosic Biorefinery Network), P2P (Plants to Products Network) and FoodWasteNet.

This study brings together insights from across industry, academia, policy and investment to examine progress made in the UK's biorefining sector to date. It outlines the UK's current biorefining position and presents the opportunities and challenges facing the sector going forward. The findings of this report aim to inform and influence the future of UK biorefining by highlighting emerging trends, barriers to adoption, and areas where targeted policy support and investment could unlock the sector's full potential.

3.1 Project scope

For the purposes of this report, biomass biorefining is defined as the development and application of innovative biological processes that transform renewable biomass resources into sustainable fuels, food ingredients, chemicals, and materials. This definition reflects the growing recognition of biorefining as a cornerstone of the modern bioeconomy, offering a viable pathway to reduce dependence on fossil-based resources while delivering environmental, economic and societal benefits. In the context of this project, biorefining is framed in line with the interests and remit of BBNet, with a particular emphasis on industrial biotechnology as the core enabling process technology. This encompasses approaches such as fermentation and biocatalysis, as well as the integration of these biological methods with complementary disciplines to drive innovation and value creation.

Although included within the wider definition of biorefining, it is important to note that for the purposes of this report thermal and thermochemical processing of biomass (including methods such as pyrolysis and gasification) fall outside the scope of this study. While these approaches represent significant areas of activity within the wider biorefining sector and bioeconomy, the focus in this report remains on biologically driven solutions, consistent with BBNet's mission and strategic priorities – as defined by the remit of the funding received from the BBSRC.

It is acknowledged that such a defined scope potentially limits the initiatives, challenges and opportunities that this report can explore within the wider biorefining sector. It means that:

- the claims made in this report about existing and planned research and commercial facilities/activities reflect only part of the progress that has been made and is ongoing in the sector;
- the recommendations in this report focus on progressing UK biotechnology for biorefining, and may not necessarily benefit other areas of biorefining, or even integrated biorefineries;
- the report presents a set of recommendations for the biorefining sector that should be considered alongside other technological approaches that have not been addressed in this report.

Areas such as competition for feedstocks, opportunities for performance improvement and process integration have therefore not been addressed. The limitations of this are that sector wide progress and challenges are not covered, nor is the prioritisation and availability of feedstocks within the wider biorefining sector. Furthermore, to focus on biotechnological feedstocks for products without looking at the use of biomass for energy and physical chemistry for products, constrains this report's ability to draw holistic conclusions on the potential for UK development, and on what standards, mechanisms, facilities and policies are needed to support these.

Throughout this report, the scope has been applied carefully and transparently to ensure clarity for readers. A narrow IB-focused definition of biorefining, aligned with BBNet's research remit, was used for activities including the stakeholder survey, interviews, and the majority of the economic analysis, where company classifications and revenue estimates reflect only IB-related biorefining activities. In contrast, a broader definition of biorefining and the wider bioeconomy was applied when reviewing national and international policy landscapes, historical context, and strategic developments, where biological, thermochemical and hybrid biorefinery pathways are often considered together. These distinctions are signposted throughout the report to help readers understand where findings reflect the BBNet-specific scope, and where insights from the broader biorefining sector are used to contextualise opportunities, challenges, and future growth potential.

While the scope of this report is intentionally focused on IB within biorefining, it offers a balanced and reliable view of general sector progress, as well as challenges and future potential. It achieves this by drawing together three complementary strands of analysis:

- an extensive literature and policy review,
- a rigorous economic assessment of sector performance, and
- wide ranging insights gathered through structured stakeholder engagement.

By triangulating these independent data sources, the report provides readers with a clear, evidence-based understanding of the UK's biorefining landscape. The methods employed here ensure that the findings remain both robust and broadly informative. Readers should therefore be confident that the conclusions and recommendations presented are grounded in empirical data, validated perspectives from industry and academia, and the professional experience of the project team.

3.2 Project tasks

TASK 1: Landscape review

The aim of this task was to provide a landscape description of the biorefining industry in the UK, from the inception of the NIBB (nominally the year 2014 but drawing on relevant literature published between 2012 and 2016) through to 2024.

Specific areas of focus included the science and innovation landscape (research and innovation facilitation programmes), the policy context stimulating biorefining, and the prevailing regulatory environment. The task reviewed how the UK's RD&I landscape evolved over the past decade, highlighting key investments in facilities and capabilities, where facilities have been lost, and how projects and collaboration had been used to facilitate and coordinate scale-up activities.

The landscape review focused on the UK but also described UK activity in an international context. The review also highlighted how a focus on regional/place-based RD&I ecosystems can stimulate biorefining research and commercial development e.g. the impact of Scotland's bioeconomy strategy.

The Task 1 report, "Biorefining Landscape Review", produced by Alder BioInsights, collates all evidence identified during this first task. This report can be found in **Annex I**.

TASK 2: Stakeholder engagement

Stakeholder engagement formed a central element of this project, providing critical insights into the evolution of the UK biorefining sector and the wider bioeconomy over the lifetime of the BBSRC NIBBs, and into the future. The engagement was designed to capture a broad range of perspectives – from academia, industry, policy, funding, regulation and investment – and to build a deeper understanding of how research, technology development, scale-up and commercial activities have progressed, as well as the opportunities and challenges that remain.

This engagement complemented the literature findings from the landscape review and quantitative findings from the economic analysis, ensuring that the project's outputs were informed by real-world experiences and validated against the views of those directly involved in biorefining. To achieve these aims, the project adopted a structured, two-tiered approach to stakeholder engagement:

- An **online survey of BNet members and other key stakeholders**, designed to capture developments in biorefining activities between 2014 and 2024 and to identify key barriers, achievements and future needs.

- **Follow-up one-to-one interviews** with a subset of survey respondents, undertaken to explore findings in greater depth and to capture nuanced perspectives on scale-up challenges, international comparisons and lessons for the future of UK Biorefining.

The outputs of both the survey and the interviews are combined and highlighted in this report.

More on “Stakeholder Perspectives”, including information on the types of stakeholders interviewed by Frey Consulting, can be found in [Annex II](#).

TASK 3: Economic analysis

The economic analysis task analysed secondary data on UK biorefining and biorefineries to assess economic trends including: changes in revenue, employment, GVA (gross value added), research activity and private investment over the 2014 to 2024 period. It established an agreed baseline of biorefinery activity and provided insights into overarching trends and key events.

Analysis on the impact of scale-up activities included brief descriptions of the rationale for accessing scale-up support outside of the UK (e.g. favourable policy, scale-up incentives, scale of market, access to talent, access to raw materials). Where companies chose to scale-up abroad, data on international employment was gathered from LinkedIn and used (together with evidence regarding the counterfactual scenario) to estimate potentially lost employment and GVA to the UK.

The analysis determined estimates of the potential future value of biorefining in the UK under a range of ambitions, including business-as-usual and various investment scenarios. The parameters and assumptions for this assessment were defined and agreed with BBNet, prior to issuing of the survey in Task 2, and to ensure the task was in-line with the scope of the project.

The Task 3 report, “Economic Analysis”, produced by Perspective Economics, collates all economic evidence generated during this project. This report can be found in [Annex III](#).

TASK 4: Reporting

This final task draws together the information collected in Tasks 1–3 and synthesises it into a report that outlines the key research findings, highlights opportunities for further development, and presents recommendations for future actions. While the scope of this report is limited to IB, the implementation of these recommendations across the entire biorefining sector is advised.

4. INDUSTRIAL BIOTECHNOLOGY IN THE UK – HOW DID WE GET HERE?

4.1 Introduction

The UK's biorefining sector¹⁰ has developed considerably over the past decade due to collaborative efforts made by key stakeholder groups, such as the UK Government, innovation and research funding bodies (e.g., BBSRC, Innovate UK), industry bodies and businesses.

This chapter examines how key stakeholder groups have contributed to the development of the modern IB industry, highlighting actions across the science and innovation landscape (including research and innovation support programmes), the policy framework, and the regulatory environment shaping the growth of the UK biorefining sector. It also considers UK biorefining sector growth over the past decade compared to key international geographies. A full version of the literature review and the PESTLE analysis that informed this chapter is provided in **Annex I**.

4.2 The UK's science and innovation landscape

The UK's biorefining sector has become a key contributor to the national economy, driven in large part by the findings and recommendations of the Industrial Biotechnology Innovation and Growth Team (IB-IGT) in 2007. The IB-IGT was a UK Government initiative led by the Department for Business, Innovation and Skills (BIS).¹¹ Its purpose was to work with industry to explore and address challenges to innovation and growth in the industrial biotechnology (IB) sector.¹² The IB-IGT played a key role in shaping policy and strategy for the UK's wider bioeconomy and was heavily involved in promoting the sector through public engagement and stakeholder collaboration.

In 2010, the IB-IGT published "IB2025", a horizon-scanning and road-mapping report on 'Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy'.¹³ The report projected that the UK's IB market could grow to between £4-12 billion by 2025, driven particularly by high-value, low-volume chemical production.

Market analysis published by the University of Cambridge's Institute for Manufacturing estimated that modern industrial biotechnology firms based in the UK generated a combined annual turnover of roughly £5 billion in 2023.¹⁴ Whereas economic analysis carried out on behalf of this project (see section 6 of this report) indicated that in 2024, companies operating within

10 A broader definition of UK biorefining and the wider bioeconomy was applied when reviewing national and international policy landscapes and strategic developments, where biological, thermochemical and hybrid biorefinery pathways are often considered together.

11 The UK's business department evolved from DTI (Department of Trade and Industry) to BERR (Department for Business, Enterprise and Regulatory Reform) in 2007, BIS (Department for Business, Innovation and Skills) in 2009, BEIS (Department for Business, Energy and Industrial Strategy) in 2016, and was split in 2023 into DBT (Department for Business and Trade), DESNZ (Department for Energy Security and Net Zero), and DSIT (Department for Science, Innovation and Technology).

12 Industrial biotechnology refers to the use of biological systems, such as microorganisms, enzymes, and cells to produce and process materials, chemicals, and energy in a sustainable way. It is a key part of the bioeconomy, offering alternatives to fossil-based manufacturing and contributing to net zero and clean growth goals.

13 IB 2025 Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy: A report to government by the Industrial Biotechnology Innovation and Growth Team. 2010.

14 Institute for Manufacturing, Life sciences beyond human health: modern industrial biotechnology in the UK. 2023. URL: https://www.ifm.eng.cam.ac.uk/uploads/Industrial_Biotech_-_Report_vPUBLICATION_240323.pdf

the scope of BBNet IB-related activities generated approximately £12.5 billion in revenue.¹⁵ While this differentiation in market sizes can be attributed to varying scopes concerning the companies reviewed by each study, these data points do indicate that IB sector growth has generally aligned with IB-IGT expectations, with the present market currently estimated to be in the region of £5–12.5 billion.

In the foreword to the “IB2025” report the Department of Business Enterprise & Regulatory Reform’s (BERR) then Secretary of State at the time stated that:

“IB will be one of the strongest driving forces behind the world’s low-carbon revolution. Offering businesses the capability to develop and use less carbon intensive products and processes, whilst also reducing costs and opening-up new, emerging, and established markets.”

The IB-IGT report laid out over 20 strategic recommendations designed to help the UK become a global leader in IB. These recommendations can be grouped into five key themes, each addressing critical barriers and opportunities relating to the sector. They included:

- 1. Policy and strategic coordination** – Recommendations included the development of a national strategy for IB; the integration of IB into wider UK industrial and environmental policy; the establishment of cross-government coordination for IB development; and the alignment of IB with sustainability and net zero goals.
- 2. Research, innovation and commercialisation** – Increase funding for IB R&D, especially in synthetic biology and bioprocessing; support interdisciplinary research across biology, chemistry, and engineering; promote translational research to bridge the gap between academia and industry; and facilitate the commercialisation of IB innovations.
- 3. Skills, education and workforce development** – Create targeted training programmes for IB-related skills; integrate IB into university and vocational curricula; support industry placements, internships, and apprenticeships; and build capacity in regulatory and technical expertise.
- 4. Infrastructure, investment and market creation** – Invest in pilot-scale and demonstration facilities across the country; improve access to venture capital and innovation funding; support regional IB clusters and innovation hubs; and encourage public procurement of bio-based products.
- 5. Regulation, public engagement and communication** – Streamline regulatory pathways for IB products; harmonise standards across the EU and globally; launch a national campaign to raise awareness of IB; and engage stakeholders in dialogue around ethics, sustainability, and innovation.

These recommendations directly influenced initiatives such as the Networks in Industrial Biotechnology and Bioenergy (NIBB), the IB Leadership Forum (IBLF), the IB Catalyst and the UK’s Industrial Biotechnology Strategy.¹⁶ The UK Government responded favourably to the 2010 report by supporting cutting-edge research to create a favourable operating environment for IB, by investing in open-access demonstrator facilities, and through funding for collaborative networks and partnerships.

The IB-IGT helped to materialise a vision for the UK’s IB sector and the bioeconomy as a whole. The IB-IGT played a critical strategic role in helping the UK’s IB sector mature from fragmented R&D to market-ready industrial applications. Their work highlighted the projected size of the IB market and led to the implementation of development levers to provide an invaluable steer for future policy, investment and collaborative efforts.

¹⁵ Economic analysis carried out by Perspective Economics.

¹⁶ UKRI. Report reveals impact of industrial biotechnology investments. URL: <https://www.ukri.org/news/report-reveals-impact-of-industrial-biotechnology-investments/>

4.2.1 Industrial Biotechnology Leadership Forum (IBLF)

The Industrial Biotechnology Leadership Forum (IBLF)¹⁷ is a UK-government-backed initiative whose aim is to provide strategic coordination and leadership for the UK's industrial biotechnology (IB) sector.

The IBLF was formed following recommendations set out in the IB-IGT "IB2025" 2010 report. The principal aims of the IBLF were to unite industry, academia, and government to help drive the UK's bioeconomy; to promote industrial biotechnology as a key enabler of clean growth and sustainability; and to coordinate strategic planning, policy alignment and investment to unlock IB's potential. The overarching goal of the IBLF was to help the UK realise the £4-12 billion IB market potential as set out in the "IB2025" report. A 2023 exercise estimated the IB market value at roughly £4.7 billion.¹⁸

The IBLF contributed to several UK strategies and reports aimed at advancing industrial biotechnology and the bioeconomy, including:

- National Industrial Biotechnology Strategy to 2030 (published in 2018)¹⁹
- Strategic Roadmap for Standards and Regulations (published in 2021)²⁰
- Growing the Bioeconomy: A national Strategy to 2030 (published in 2018)²¹

Another key output of the IBLF was the 2015 report "*Journey of Industrial Biotechnology: The Opportunity for Growth*" intended as a follow up to the 2010 IB-IGT "IB2025" report. The 2015 report assessed the UK's progress in terms of IB development over the previous five years and highlighted both key achievements and ongoing challenges facing the sector.²²

The IBLF report showcased companies such as Biocatalysts Ltd., who demonstrated reduction in enzyme development timelines from months to weeks through positive academic collaboration, and funding from Innovate UK, BBSRC and other bodies. The establishment of pilot and demonstration facilities were also celebrated as having supported the scale-up of a wide range of IB technologies, contributing to developments in the sector.

Despite notable progress having been made since the 2010 "IB2025" report, the IBLF update identified several key challenges that continued to hinder the IB sector in the UK in 2015, including:

- **Commercialisation bottlenecks** – The transition from laboratory research to market deployment remained slow, with many promising technologies stalling at the pilot or demonstration stage due to insufficient scale-up infrastructure and limited investment. SMEs and start-ups face additional challenges in securing finance, particularly for capital-intensive IB projects. These issues remain relevant, according to stakeholder engagement carried out as part of this project, as commercialisation bottlenecks are understood to remain a key challenge today.

17 UKRI, Industrial Biotechnology Leadership Forum. URL: <https://iuk-business-connect.org.uk/programme/industrial-biotechnology-leadership-forum/>

18 Institute for Manufacturing, Life sciences beyond human health: modern industrial biotechnology in the UK. 2023. URL: https://www.ifm.eng.cam.ac.uk/uploads/Industrial_Biotech_-_Report_vPUBLICATION_240323.pdf

19 Industrial Biotechnology Leadership Forum, Growing the UK Industrial Biotechnology Base. URL: <https://www.bioindustry.org/static/uploaded/d390c237-04b3-4f2d-be5e776124b3640e.pdf>

20 BSI, Industrial biotechnology, Strategic roadmap for standards and regulations, <https://static1.squarespace.com/static/68adbc3e3a06800fc02f97dd/t/68e51c24d05ed141c67a35f8/1759845412290/BSI-industrial-biotechnology-strategic-roadmap-for-standards-and-regulations-FINAL.pdf>

21 HM Government, Department for Business, Energy and Industrial Strategy. Growing the Bioeconomy. URL: https://assets.publishing.service.gov.uk/media/61a60c91d3bf7f055b2934cf/181205_BEIS_Growing_the_Bioeconomy__Web_SP_.pdf

22 Industrial Biotechnology Leadership Forum, Journey of Industrial Biotechnology: The Opportunity for Growth. 2015. URL: <https://iuk-business-connect.org.uk/perspectives/the-journey-of-industrial-biotechnology-the-opportunity-for-growth/>

- **Technical and process limitations** – Such as bioprocessing inefficiencies, feedstock challenges, and water usage concerns continued to threaten the development of IB in the UK. Stakeholder engagement carried out as part of this project outlined that feedstock challenges remained a key concern in 2025, in addition to the cost and scalability of new processes. These barriers are discussed further in section 6.3 of this report.
- **Market and policy uncertainty** – Volatility in energy markets and policy inconsistency i.e., a lack of long-term, stable policy frameworks made it difficult for businesses to plan and invest confidently in IB technologies. Stakeholder engagement carried out on behalf of this project demonstrated that UK policy and the prevailing market environment continues to hinder IB development to date.
- **Skills and knowledge gaps** – Shortage of interdisciplinary expertise – a need for more professionals trained across biology, chemistry and engineering to support IB innovation. The 2015 report found that there was generally a slow transfer of knowledge from academic research into industrial applications. This remains a critical challenge in 2025 due to a rapidly evolving technology landscape, meaning skills and training are essential to stay up to date with new scientific and technical developments. These barriers are discussed further in section 6.3 of this report.

The challenges outlined above, taken from the IBLF's 2015 report on the "Journey of Industrial Biotechnology", demonstrate that despite the positive progress and achievements having been made across the sector, in 2015 there was still work to be done by the government, industry and research bodies to realise the full potential of the IB sector. The report further reinforced the need for consistent policy, regulatory support, and public engagement to successfully support further sector development.

4.2.2 Networks in Industrial Biotechnology and Bioenergy (NIBB)

Another notable outcome of the 2010 IB-IGT "IB2025" report, was the formation of the Networks in Industrial Biotechnology and Bioenergy (NIBB).

NIBB were collaborative research communities funded by the Biotechnology and Biological Sciences Research Council (BBSRC) with additional support from the Engineering and Physical Sciences Research Council (EPSRC). Their mission was to foster partnerships among academia, industry, policymakers and NGOs, and to accelerate the translation of biotechnological research into industrial and environmental applications. The NIBB were funded across two distinct phases from 2014 to 2024. Phase I was funded from 2014–2019; and Phase II funded from 2019–2024.²³

The BBSRC initially committed £18 million in investment (with EPSRC support) to fund 13 Phase I NIBB. These 13 networks independently focussed on different areas relevant to industrial biotechnology and the wider bioeconomy e.g., anaerobic digestion (AD), biocatalysts, bioprocessing, chemical production, lignocellulosic biomass, waste and by-product utilisation, bioengineering, and microalgae.²⁴ Key outcomes and impacts of the Phase I NIBB initiative included:²⁵

- 277 businesses contributed funding to collaborative projects.
- >40 spin-out companies created.

²³ The COVID pandemic temporarily curtailed some programmes and as a result several NIBB extended activities into 2025 and 2026.

²⁴ The 13 Phase I NIBB were: Anaerobic Digestion Network (ADNet), Network in Biocatalyst Discovery, Development and Scale-Up (Biocatnet), Bioprocessing Network (BioProNET), Chemicals from C1 Gas Network (C1NET), Crossing biological membranes (CBMNet), Food Processing Waste and By-Products Utilisation Network (FoodWasteNet), High Value Chemicals from Plants Network (HVCfP), Glycoscience Tools for Biotechnology and Bioenergy (IBCarb), Lignocellulosic Biorefinery Network (LBNNet), The elements of Biotechnology and Bioenergy (Metals in Biology), Natural Products Discovery and Bioengineering Network (NPRONET), A Network of Integrated Technologies: Plants to Products (P2P), Unlocking the IB potential of microalgae (PHYCONET).

²⁵ BBSRC, Evaluation of the effectiveness and impact of BBSRC's Investments in Industrial Biotechnology. 2024. URL: <https://www.ukri.org/wp-content/uploads/2024/09/240924-BBSRC-12066-BBSRC-Industrial-Biotechnology-report-FINAL.pdf>

- The NIBB contributed to 31% of BBSRC-attributable IP, and 34% of BBSRC-attributable spin-outs, despite representing only 11% of BBSRC's total funding.
- 11% of NIBB publications had industry co-authors (vs. 4% BBSRC average).
- 33% of businesses reported increased turn over or expected growth due to NIBB engagement.
- 67% of businesses increased R&D investment in IB after participating in the NIBB initiative.
- 68% of projects funded by the BBSRC NIBB involved at least one industry partner, these projects leveraged 39% of funding (cash or in-kind) from industry, alongside the funding provided by BBSRC.
- The BBSRC NIBB leveraged £98 million in additional funding from a mixture of public and private funders.
- Over £92 million of this leveraged funding supported new research grants. £4.6 million supported early career researchers (ECRs) and students.
- The BBSRC NIBB initiative had a good level of international engagement. 16% of members were from outside of the UK, with 553 members based in Europe and 492 based elsewhere.

Following the success of the Phase I networks, the BBSRC (supported by EPSRC) awarded an additional £11 million to fund 6 new NIBB, which focused on priority areas within IB and the bioeconomy. These Phase II NIBB intended to continue the original mission of promoting research translation and fostering communities of IB specialists, across industry and academia. The 6 Phase II NIBB were:

- BNet (Biomass Biorefinery Network)
- Algae-UK (Algal Biotechnology Network)
- Carbon Recycling Network
- E3B (Elements of Bioremediation, Biomanufacturing & Bioenergy)
- EBN (Environmental Biotechnology Network)
- HVB (High Value Biorenewables Network)

The NIBB played an essential role in the growth of the IB sector and the wider bioeconomy over the past decade, serving as innovation hubs for the transformation of research into viable and impactful industrial biotech applications. Through the promotion of academic-industry partnerships and the funding of pilot-scale testing, the NIBB have helped to reduce the so called "valley of death" for science and innovation across the IB sector. Furthermore, one of the most beneficial aspects of the NIBB is that they have helped to create pockets of specialised communities and provided a support structure for researchers, startups and established companies alike. This need for a supportive and specialised community across the IB sector remains important today.

4.2.3 IB Catalyst

The 2010 IB-IGT "IB2025" report recommended increased strategic public investment in industrial biotechnology research. This ultimately led to the formation of the Industrial Biotechnology (IB) Catalyst in 2014.

The IB Catalyst was a £76 million funding initiative jointly delivered by Innovate UK (formerly the Technology Strategy Board), BBSRC and EPSRC. It delivered three rounds of funding from 2014 to 2017, supporting IB projects across three distinct stages: 1) feasibility studies; 2) industrial research; and 3) experimental development. Funding calls were targeted at projects across five key challenge areas, including:

- Production of fine and speciality chemicals and natural products (e.g. fragrances, flavours, pharmaceutical intermediates)
- Production of commodity, platform and intermediate chemicals and materials (e.g. plastics, resins, silks)
- Production of liquid and gaseous biofuels

- Production of peptides and proteins (e.g. enzymes, antibiotics, recombinant biologics)
- Novel or improved upstream or downstream processes to reduce costs or improve efficiency in industrial biotechnology applications

The IB Catalyst ran from 2014 to 2018 and was designed to bridge the gap between early-stage research and commercialisation. The overarching aim was to support collaborative R&D between academia and industry, help the UK become a global leader in the bioeconomy, and stimulate economic growth, job creation, and sustainability through industrial biotechnology.

In total, the IB Catalyst funded 82 projects across the five key challenge areas, with the scheme recognised for producing high-quality, internationally competitive research. It has been reported that 16% of journal articles published off the back of IB Catalyst funded projects were ranked within the top 10% of citation impact globally. Generally, publications linked to the IB Catalyst had a higher citation impact than those originating from other G7 countries within the same field.²⁶

The IB Catalyst programme demonstrated that adaptive funding strategies to sustain long-term commercial translation, covering specialty chemicals and bio-based materials were effective enablers of IB. As such, the IB Catalyst's legacy includes a strengthened pipeline of IB innovation and proof-of-concepts (PoC) across multiple value chains.

The IB Catalyst programme, along with the NIBB, have played a pivotal role in enabling commercialisation and the formation of spin-out companies, helping to translate research into market-ready industrial biotech solutions. Table 2 demonstrates that a considerable amount of investment was committed to the science and innovation IB landscape in the years between 2010/11 and 2020/21. With the help of investments made in this sector over the past decade, the prevailing UK IB market is now reportedly worth an estimated £5-12.5 billion. As such, it is critical that more investment continues to be committed to the sector going forward to ensure that growth can continue.

Table 2: Main funding mechanisms used to support BBSRC's IB portfolio between 2010/11 to 2020/21.

FUNDING MECHANISM	TOTAL SPEND	LIFESPAN	DESCRIPTION
RESPONSIVE MODE	£129.6 million	2010/11–2020/21	BBSRC's standard research grant application scheme, open for applications at any time.
STRATEGIC INSTITUTE INVESTMENTS	£49.1 million	2010/11–2020/21	Strategic funding awarded to the BBSRC strategically supported institutes.
FELLOWSHIPS	£8.9 million	2010/11–2020/21	Various types of fellowship awards were operated by BBSRC/UKRI. Fellowship grants are to support early and mid-career scientists transitioning to an independent research career.
BIOPROCESSING RESEARCH INDUSTRY CLUB (BRIC)	£13.8 million	2006–2011	Research club launched in partnership with EPSRC and industry. Jointly managed by BBSRC and the Health Tech and Medicines KTN. 18 company members contributed to funding and steering of the club.
INTEGRATED BIOREFINING RESEARCH AND TECHNOLOGY CLUB (IBTI)	£5.9 million	2008–2016	Research and technology club launched in partnership with EPSRC and the Bioscience Knowledge Transfer Network (KTN). 9 company members contributed to funding research and directed activities of the club.

²⁶ BBSRC, Evaluation of the effectiveness and impact of BBSRC's Investments in Industrial Biotechnology. 2024. URL: <https://www.ukri.org/wp-content/uploads/2024/09/240924-BBSRC-12066-BBSRC-Industrial-Biotechnology-report-FINAL.pdf>

FUNDING MECHANISM	TOTAL SPEND	LIFESPAN	DESCRIPTION
NETWORKS IN INDUSTRIAL BIOTECHNOLOGY AND BIOENERGY (NIBB)	£21.2 million	2014–2019	Network funding across BBSRC’s IB remit to establish communities.
IB CATALYST	£39.8 million	2014–2016	Joint venture with Innovate UK and EPSRC, set up to accelerate the commercialisation of IB derived products and processes.
ERA-IB AND ERA-IB-2	£5.8 million	2016–2022	Funded via the European Commission’s Framework Programme. Joint initiatives to foster the exchange of IB knowledge across borders.
ERA COBIOTECH	£3.4 million	2016–2022	Joint research initiative funded via Horizon 2020, bundling three predecessor ERA-Networks in IB.

4.3 UK Biorefining policy and regulatory landscape

In 2015, the UK Government published “Building a high value bioeconomy”. The report placed emphasis on the opportunities available from utilising biological waste streams. The report described the UK’s bioeconomy landscape in 2015, the key sector stakeholders, and the main gaps in knowledge and information that may be preventing further sector development.²⁷

To address these knowledge gaps, action was taken to collect economic data and issue a call for evidence (CfE).²⁸ The data and information gathered during this CfE underpinned two flagship strategy documents relating to the bioeconomy, both published in 2018. The first, published by the IBLF, described a National Industrial Biotechnology Strategy to 2030.²⁹ It laid out a roadmap of actions required to grow the UK’s IB sector. The second, published by the UK Government, was a policy document, “Growing the Bioeconomy: A National Strategy to 2030”. The strategy outlined the Government’s view of the bioeconomy, how it related to other national strategies, and the actions needed in order to realise its potential.³⁰

4.3.1 National Industrial Biotechnology Strategy to 2030

The National Industrial Biotechnology Strategy (NIBS) to 2030, published in 2018 and co-authored by the IBLF, CBMNet (Crossing Biological Membranes Network) and BIOCATNET (Biocatalysis Network),³¹ presented a sector-led long-term vision for positioning the UK as a global leader in clean growth through IB. The sector-led strategy aimed to embed IB at the heart of the UK Government’s Industrial Strategy and Bioeconomy Strategy, driving innovation, sustainability, and economic prosperity. The NIBS strategy was structured around seven key themes, each with targeted actions:³²

27 HM Government, Building a high value bioeconomy, URL: https://assets.publishing.service.gov.uk/media/5a7f7c9ce5274a2e8ab4c78e/BIS-15-146_Bioeconomy_report_-_opportunities_from_waste.pdf

28 UK Government, UK Bioeconomy: call for evidence. URL: <https://www.gov.uk/government/calls-for-evidence/uk-bioeconomy-call-for-evidence>

29 Industrial Biotechnology Leadership Forum, Growing the UK Industrial Biotechnology Base. URL: <https://www.bioindustry.org/static/uploaded/d390c237-04b3-4f2d-be5e776124b3640e.pdf>

30 HM Government, Department for Business, Energy and Industrial Strategy. Growing the Bioeconomy. URL: https://assets.publishing.service.gov.uk/media/61a60c91d3bf7f055b2934cf/181205_BEIS_Growing_the_Bioeconomy__Web_SP_.pdf

31 Two of the UK’s BBSRC Phase I Networks in Industrial Biotechnology and Bioenergy (NIBB).

32 Industrial Biotechnology Leadership Forum, Growing the UK Industrial Biotechnology Base. URL: <https://www.bioindustry.org/static/uploaded/d390c237-04b3-4f2d-be5e776124b3640e.pdf>

1. **External environment** – Establish a consistent, long-term policy landscape to support IB. Align government departments and regulatory bodies to reduce fragmentation.
2. **Funding and access to finance** – Create a supportive financial ecosystem for IB SMEs. Improve access to public and private investment for scale-up and innovation.
3. **Infrastructure and regional footprint** – Develop regional hubs and open-access biorefinery centres. Ensure IB contributes to clean growth across all UK regions.
4. **Trade, investment and commercialisation** – Position the UK as a global hub for IB innovation and commercialisation. Promote exports of bio-based products and attract inward investment.
5. **Regulations and standards** – Ensure UK frameworks are robust yet innovation-friendly. Support risk-aware innovation and international harmonisation.
6. **Skills** – Foster interdisciplinary skills across biology, chemistry and engineering. Promote IB as an attractive career path and support workforce development.
7. **Communication** – Build a unified IB community voice. Engage the public and stakeholders in Responsible Research and Innovation (RRI).

The “National Industrial Biotechnology Strategy” pointed to IB as a key enabler of clean growth, net zero ambitions, and circular economy objectives, calling for improving access to finance, scale-up infrastructure and regional innovation hubs; and encouraged unified messaging alongside improved public understanding of the benefits of IB. However, as indicated by the stakeholder engagement carried out in 2025 for the current project (findings presented in section 6 of this report, with more detail in [Annex II](#)), more work is required to realise the aims of each of the key themes outlined above.

4.3.2 Growing the Bioeconomy: A National Strategy to 2030

In 2018, the UK Government published a Bioeconomy Strategy, formally titled “Growing the Bioeconomy: A National Strategy to 2030”.³³ The key aims of this strategy were to boost clean growth through a reduced reliance on fossil resources and the promotion of low-carbon, biobased alternatives. It outlined aims to; drive innovation through support for R&D in bioscience, biotechnology and synthetic biology; encourage the commercialisation of biobased products; support the creation of economic value by growing the bioeconomy’s contribution to GDP, job creation and regional development. Another key aim was to coordinate national efforts by aligning government, industry and academic objectives, and provide a unified framework for policy and investment.

The Government’s Bioeconomy Strategy identified several key challenges associated with the sector which needed to be addressed to drive the industry forward. These included fragmentation across sectors and regions, scale-up barriers for SMEs and innovators, skills shortages in biotechnology and bioengineering, regulatory complexity and lack of clarity, limited public awareness and engagement, and competition for biomass between food, energy, and materials. Most of these challenges had previously been identified on a number of occasions, including in the IB-IGT “IB2025” report in 2010.

Key outcomes of this 2018 strategy included: the expression of a clear national vision to position the UK as a global leader in bio-based innovation, manufacturing and exports; improved integration of IB with broader government strategies (e.g., Clean Growth Strategy, Industrial Strategy, Life Sciences Strategy); and recognising the role of open-access biorefinery centres that went on to become the focal points for commercialisation and scale-up of bio-based technologies.

33 HM Government, Department for Business, Energy and Industrial Strategy. Growing the Bioeconomy. URL:https://assets.publishing.service.gov.uk/media/61a60c91d3bf7f055b2934cf/181205_BEIS_Growing_the_Bioeconomy__Web_SP_.pdf

The Bioeconomy Strategy also highlighted the bioeconomy's contribution to the wider UK economy as being £220 billion GVA (gross value added)³⁴ and supporting over 5 million jobs.³⁵ The 2018 strategy set the ambition to double the size of the UK's bioeconomy by 2030, outlining considerable potential for growth in this sector.

The 2018 Bioeconomy Strategy helped pave the way for the 2023 "National Vision for Engineering Biology", that committed £2 billion over 10 years to engineering biology R&D and infrastructure.³⁶ The Bioeconomy Strategy also contributed to the UK Government's Life Sciences Sector Plan,³⁷ which included £2 billion investment (a commitment spread over 10 years), support for Genomics England, UK Biobank and AI-ready health data platforms, and a focus on biotech scale-up and vaccine manufacturing capacity.

Mirroring the Bioeconomy Strategy's emphasis on regional capability, BioPilots UK launched in October 2016, formed as a strategic alliance between five open-access biorefining centres across the UK, to address the barriers associated with technology scale-up. The centres provided pilot-scale equipment, process development expertise and technological support for SMEs and researchers. The five centres included:³⁸

- Biorenewables Development Centre (BDC) (York)
- Centre for Process Innovation (CPI) (Redcar)
- Industrial Biotechnology Innovation Centre (IBiolC) (Scotland)
- BEACON (Wales)
- The Biorefinery Centre (Norwich)

The Bioeconomy strategy was withdrawn in 2021, with its principles absorbed into broader frameworks such as the 2023 UK Innovation Strategy³⁹ and 2021 Net Zero Strategy.⁴⁰ While these two strategy documents do not focus explicitly on the bioeconomy and industrial biotechnology, they do recognise the significant potential for reducing emissions in sectors such as chemicals, textiles and plastics, by replacing fossil-based inputs with bio-based alternatives.

4.3.3 Biomass policy statement and strategy

In November 2021, the UK Government published the "Biomass Policy Statement"⁴¹ which outlined the government's strategic view on the role of biomass in achieving net zero emissions by 2050. The UK Government strategic view was later expanded upon in the 2023 "Biomass Strategy". The 2021 statement and the 2023 strategy aimed to guide how biomass should be used across energy sectors (e.g., electricity, heat, transport, industry) and non-energy applications to support decarbonisation in the UK.

34 An economic metric that measures the value of goods and services produced in an area, industry or sector, minus the cost of inputs and raw materials. In other words, it shows the contribution of a sector to the economy.

35 Chemical Industry Association, Harnessing the Bioeconomy for Industrial Transformation. 2025. URL: <https://www.cia.org.uk/sustainability/harnessing-the-bioeconomy-for-industrial-transformation/1427.article>

36 UK Government, DSIT. National Vision for Engineering Biology. 2023. URL: <https://www.gov.uk/government/publications/national-vision-for-engineering-biology/national-vision-for-engineering-biology>

37 UK Government. Life sciences sector plan. 2025. URL: <https://www.gov.uk/government/publications/life-sciences-sector-plan/life-sciences-sector-plan>

38 Bangor University. Launch of BioPilots UK: a network of open access biorefining centres. URL: <https://research.bangor.ac.uk/en/activities/launch-of-biopilots-uk-a-network-of-open-access-biorefining-centr/>

39 UK Government. UK Innovation Strategy. 2023. URL: <https://www.gov.uk/government/publications/uk-innovation-strategy-leading-the-future-by-creating-it/uk-innovation-strategy-leading-the-future-by-creating-it-accessible-webpage>

40 UK Government. Net Zero Strategy: Build Back Greener. 2021. URL: <https://www.gov.uk/government/publications/net-zero-strategy>

41 UK Government, BEIS. Biomass Policy Statement. 2021. URL: <https://assets.publishing.service.gov.uk/media/6183a2f4d3bf7f55fd843da1/biomass-policy-statement.pdf>

The Biomass Strategy⁴² was published by the Department for Energy Security and Net Zero in 2023, with the aim of clarifying the role of biomass in achieving the UK's net zero emissions target by 2050, updating and expanding on the 2021 Biomass Policy Statement. The Biomass Strategy outlined that biomass could be used to respond to global energy challenges, including the Ukraine conflict, climate change, and energy security concerns, and aimed to define the strategic role of biomass across energy and non-energy sectors.

Many of the key challenges highlighted in the 2023 Biomass Strategy mirrored concerns previously raised by the sector, such as sustainable feedstock supply i.e. ensuring sufficient, affordable and sustainable biomass feedstocks from both domestic and international sources; and food security i.e., balancing biomass cultivation with the UK's commitment to maintain food production levels. Other challenges identified in the strategy included managing emissions from biomass combustion and its impact on public health. Furthermore, the strategy highlighted challenges in predicting biomass supply and demand beyond 2035 due to complex market and environmental variables.

The Biomass Strategy set out that biomass use should be prioritised in sectors where it delivers the greatest environmental and economic benefit, supporting innovation and scale-up of domestic biomass feedstocks and enabling negative emissions through technologies such as BECCS (bioenergy carbon capture and storage). The Biomass Strategy proposed a tiered approach to biomass use in the form of short-, medium-, and long-term goals:

- **Short-term (2020s)** – Continue support for biomass in power, heat, and transport.
- **Medium-term (to 2035)** – Shift towards BECCS and reduce unabated biomass use.
- **Long-term (to 2050)** – Focus on hard-to-decarbonise sectors and negative emissions technologies.

The Biomass Strategy positioned biomass as being a critical enabler of net zero, especially in applications such as renewable electricity, biomethane generation and gas grid greening, industrial decarbonisation, low-carbon hydrogen production and non-energy uses (e.g. bio-based materials). It outlined the need for a common sustainability framework across sectors and reinforced the UK's position as a global leader in biomass sustainability standards. Aligning with the Government's views in the Biomass Strategy, £30 million was also awarded to innovative projects under the Biomass Feedstocks Innovation Programme.⁴³

4.3.4 The UK's Modern Industrial Strategy

The UK Government's "Modern Industrial Strategy"⁴⁴ published in June 2025 is the most recent of national strategies central to the UK's bioeconomy and biorefinery landscape.

The 2025 Industrial Strategy signalled the UK Government's intentions and priorities for driving economic growth, innovation and a sustainable future for the UK. It sets clear priorities on the strategic direction for innovation, particularly in science, technology and infrastructure. It identified the need for cross-sector collaboration, especially between academia, industry and government. Furthermore, a key aspect of the strategy is to ensure alignment with net zero and sustainability goals.

42 UK Government, DESNZ. Biomass Strategy. 2023. URL: <https://assets.publishing.service.gov.uk/media/64dc8d3960d123000d32c602/biomass-strategy-2023.pdf>

43 UK Government, Biomass Feedstocks Innovation Programme. 2022. URL: <https://www.gov.uk/government/publications/apply-for-the-biomass-feedstocks-innovation-programme>

44 UK Government. The UK's Modern Industrial Strategy. 2025. URL: https://assets.publishing.service.gov.uk/media/68595e56db8e139f95652dc6/industrial_strategy_policy_paper.pdf

The Government, as part of this strategy, committed to invest £380 million in engineering biology (EB).⁴⁵ Figure 1 demonstrates that EB is a key component of IB and the wider biorefining sector. However, the Industrial Strategy did not confirm this alignment of EB with IB. The current project identified the definitional incorporation of IB within EB funding programmes as being a critical need for the sector at present, following the announcement of EB funding and a current lack of clarity surrounding what is to be eligible for support. Industry would therefore benefit from prompt UK Government confirmation that IB initiatives are to be incorporated within EB funding programs.

4.3.5 Translating strategy into policy

A number of strategies relating to IB and biorefining have been published over the past decade, with key strategies discussed above. Others include:

- Industrial Biotechnology: Strategic Roadmap for Standards and Regulations⁴⁶
- UK Innovation Strategy⁴⁷
- Net Zero Strategy: Build Back Greener⁴⁸
- Delivering a 'Net Zero' National Health Service⁴⁹
- National Vision for Engineering Biology⁵⁰

Despite the succession of strategies outlined above, the general feedback from stakeholder engagement conducted in 2025 for the current project suggests that a positive appetite for IB related developments has not effectively translated research and innovation into widespread commercial reality. One reason for this lies in the fact that the IB sector, and the bioeconomy more generally, encompasses a wide range of different market and regulatory specialisms, and that there is currently a lack of joined up action across government departments, public funding bodies, regulatory agencies and industrial value chains which has led to slow progress in this area.⁵¹

Figure 3 demonstrates the multiplicity of government departments that deal with different IB related topics. Their priorities and focus areas with regards to biomass use are not necessarily aligned. This diversity in priority and focus presents barriers in terms of the development of whole value chains and the wider UK economy in mind. Furthermore, fragmented government action, across different departments, ultimately leads to a lack of departmental responsibility for the Government's input to IB sector development. As such, better alignment between Government and IB industry areas is essential to ensure that the overarching strategies (summarised in this report) can be developed and implemented more effectively into subsequent UK policy.

45 UK Government. Press Release. 2025. URL: <https://www.gov.uk/government/news/tech-innovators-backed-to-set-up-and-scale-up-in-britain-through-industrial-strategy>

46 BSI, Industrial biotechnology, Strategic roadmap for standards and regulations, URL: <https://static1.squarespace.com/static/68adbc3e3a06800fc02f97dd/t/68e51c24d05ed141c67a35f8/1759845412290/BSI-industrial-biotechnology-strategic-roadmap-for-standards-and-regulations-FINAL.pdf>

47 UK Government, BEIS. UK Innovation Strategy. 2021. URL: <https://assets.publishing.service.gov.uk/media/61110f2fd3bf7f04402446a8/uk-innovation-strategy.pdf>

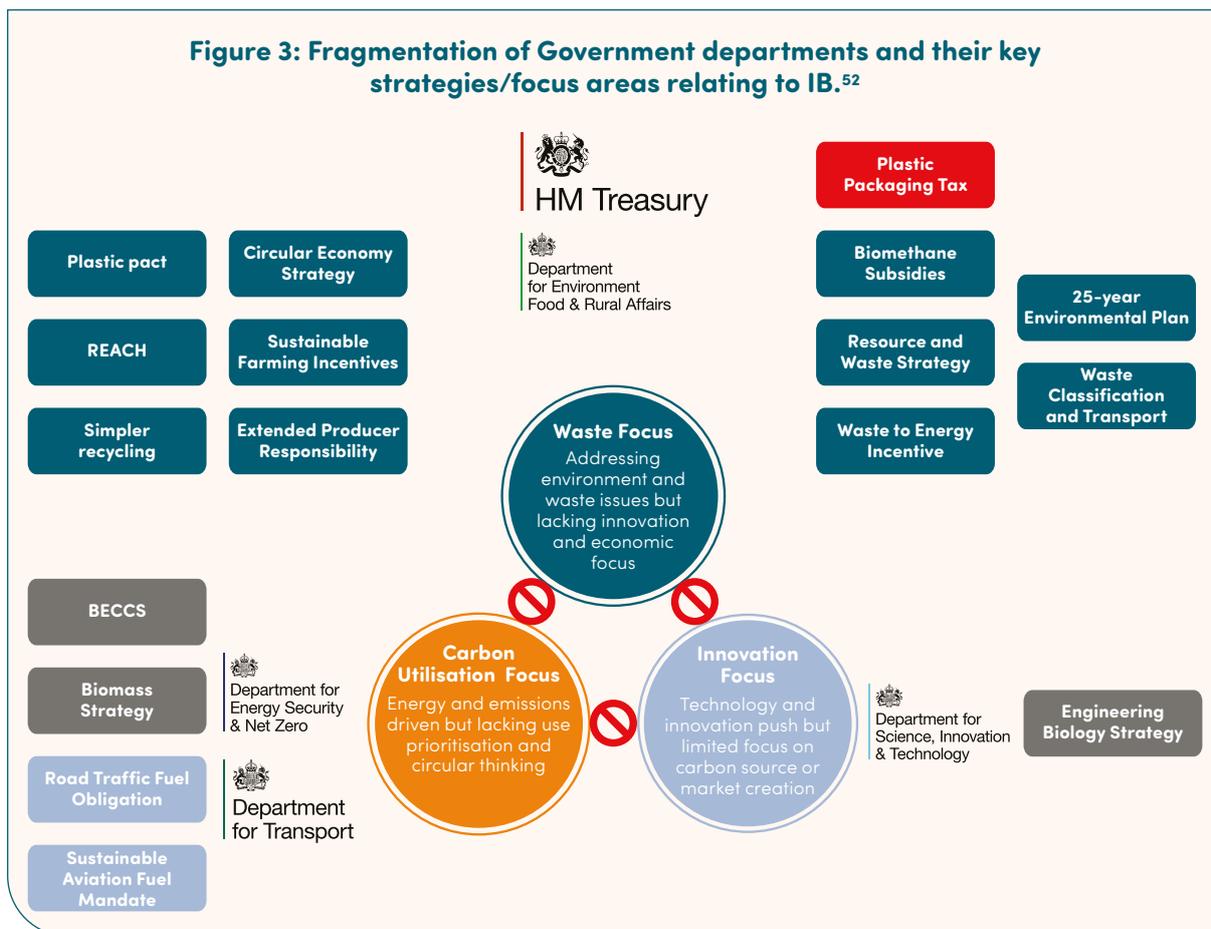
48 UK Government. Net Zero Strategy: Build Back Greener. 2021. URL: <https://www.gov.uk/government/publications/net-zero-strategy>

49 NHS, Delivering a 'Net Zero' National Health Service. URL: <https://www.england.nhs.uk/greenernhs/wp-content/uploads/sites/51/2020/10/delivering-a-net-zero-national-health-service.pdf>

50 UK Government. DSIT. National Vision for Engineering Biology. 2023. URL: https://assets.publishing.service.gov.uk/media/656de8030f12ef07a53e01ac/national_vision_for_engineering_biology.pdf

51 BB-REG-NET, Addressing the UK's polysemous bioeconomy. URL: https://bb-reg-net.org.uk/wp-content/uploads/2025/03/BBREGNET_Addressing-the-UKs-polysemous-bioeconomy-_A-call-for-policy-cohesion.pdf

Figure 3: Fragmentation of Government departments and their key strategies/focus areas relating to IB.⁵²



4.4 UK biorefining in an international context

Over the past decade, biorefining has also undergone significant developments across major economies outside of the UK. The following section describes actions taken internationally to develop biorefining landscapes beyond the UK, and what impacts these actions have had. This section intends to provide brief examples of biorefining developments taking place globally. The section is not an exhaustive list, and other notable examples exist that have not been highlighted here.

4.4.1 United States

Biorefining development in the United States over the past decade has been rapid, characterised by a diversification of biorefining capacity. The introduction of the Inflation Reduction Act (IRA)⁵³ in 2022 marked a major inflection point in the US, as it provided long-term fiscal incentives for the development and subsequent use of low-carbon fuels. To date, the IRA has dedicated roughly \$400 billion to energy security and climate initiatives including biofuels, clean fuels, carbon capture and related clean energy infrastructure.⁵⁴ In addition to the combined social and economic benefits that this presents, the scheme is anticipated to reduce emissions in the US by 33–40% by 2030 (approximately 1.15Gt CO₂e avoided) compared to 2005 levels.⁵⁵

52 BB-REG-NET, Growing the UK's Modern Industrial Bioeconomy. 2025. URL: <https://bb-reg-net.org.uk/wp-content/uploads/2025/12/BB-REG-NET-WHITE-PAPER.pdf>

53 US DoE. Inflation Reduction Act of 2022. 2022. URL: <https://www.energy.gov/lpo/inflation-reduction-act-2022>

54 BARR. The Inflation Reduction Act: Fuels focus. 2022. URL: <https://www.barr.com/insights/the-inflation-reduction-act-fuels-focus/>

55 US Congress. Inflation Reduction Act of 2022 (IRA): Provisions Related to Climate Change. 2022. URL: <https://www.congress.gov/crs-product/R47262>

Furthermore, over the past decade scientific and technological developments in the US have been supported by a suite of federal innovation programmes. For example, the U.S. Department of Energy's (DOE's) Bioenergy Technologies Office (BETO) maintained substantial annual funding for research into lignocellulosic conversion, fermentation-based biochemicals, algae systems and waste-derived fuels.⁵⁶ BETO's Scale-Up Programme further helped several technologies move from laboratory research to pilot and demonstration scales.⁵⁷ In parallel, the DOE's Industrial Demonstrations Program initiated major grants for low-carbon biomanufacturing,⁵⁸ while the U.S. Department of Agriculture continued to support commercial biorefineries through initiatives such as the Biomass Research and Development Initiative and loan guarantee schemes.⁵⁹

The US BioPreferred Program, established under the US Farm Bill and managed by the USDA, also promotes the use of bio-based products.⁶⁰ Its mission is to reduce fossil fuel dependence, support rural economies and advance environmental sustainability.

These combined efforts have resulted in a broad expansion of US biorefining capacity over the past 10 years. Biofuel production increased to roughly 24 billion gallons per year in 2024, while renewable diesel and emerging advanced biofuels also reached an estimated 4.3 billion gallons per year in the same period.⁶¹ Furthermore, as a result of the BioPreferred Program, bio-based products contribute \$470 billion to the U.S. economy and supports 4.6 million jobs. This reduces petroleum use by an estimated 400 million gallons annually, cutting CO₂ emissions and supporting climate goals.⁶²

Due to the favourable environment created for biorefining in the US, a number of UK-based IB related companies have experienced success in this geography. A notable example, Azotic Technologies, is a spin-out from the University of Nottingham. Their flagship product, Envita® (sold as Encera® internationally), leverages a proprietary strain of bacteria to enable systemic nitrogen fixation in non-leguminous crops. This lets plants fix atmospheric nitrogen inside their own cells and thus reduces reliance on synthetic fertilizers.⁶³ Azotic worked with the UK's CPI to advance their technology from TRL 4 to TRL 8, developing industrial-scale manufacturing processes and producing multi-tonne batches to support both field trials and commercial release.⁶⁴ After six years of research and field trials carried out across 11 states in the US, Envita debuted commercially in North America in November 2018. Initial trials showed 5–20% yield improvements in corn, even at unchanged nitrogen application levels.⁶⁵

This case study highlights that while research and development was carried out in the UK, technology commercialisation was achieved in the US. This is a message that was also echoed throughout the stakeholder engagement component of the current project. Stakeholders noted that while R&D support was highly effective for companies operating at low TRLs, as scales and commercial developments increased, a lack of appropriate infrastructure and support decreased. As such, better access to infrastructure and commercialisation support should be considered a critical need for the sector going forward.

56 US DoE. Bioenergy Technologies Office Funding Opportunities. URL: <https://www.energy.gov/eere/bioenergy/bioenergy-technologies-office-funding-opportunities>

57 US DoE, Bioenergy Technologies Office Scale-Up and Conversion Topic Areas. URL: <https://www.energy.gov/eere/bioenergy/bioenergy-technologies-office-scale-and-conversion-topic-areas>

58 US DoE, Industrial Demonstrations Program. URL: <https://www.energy.gov/oced/industrial-demonstrations-program-0>

59 US DoE, Alternative Fuels Data Centre. Biomass Research and Development Initiative. URL: <https://afdc.energy.gov/laws/378>

60 USDA. BioPreferred program. URL: <https://www.biopreferred.gov/BioPreferred/>

61 US EIA, 2024. URL: <https://www.eia.gov/todayinenergy/detail.php?id=63465>

62 USDA, USDA Releases Economic Impact Analysis of the U.S. Bio-based Products Industry. 2021. URL: <https://www.usda.gov/about-usda/news/press-releases/2021/07/29/usda-releases-economic-impact-analysis-us-bio-based-products-industry>

63 Azotic. URL: <https://www.azotic.com/>

64 CPI. Azotic Technologies. URL: <https://www.uk-cpi.com/case-studies/azotic-technologies>

65 Azotic. URL: <https://www.azotic.com/>

4.4.2 European Union

The European Union also experienced considerable development in its biorefining sector over the past decade due to a combination of stringent climate policies, substantial research funding, and cross-border industrial collaboration. Between 2015 and 2025, the EU implemented some of the world's most comprehensive regulatory frameworks for renewable and low-carbon fuels. For example, the Renewable Energy Directive II (RED II), adopted in 2018, and its successor RED III in 2023, established binding requirements for renewable energy in transport and introduced specific mandates for advanced biofuels. At the same time, this legislation constrained the use of crop-based biofuels, reinforcing a shift toward waste- and residue-based feedstocks, in a push to promote the use of sustainably derived biomass for consumption across the economy.⁶⁶

Furthermore, the Fit for 55 package,⁶⁷ introduced in 2021, added further momentum to the EU's biorefining sector. While ReFuelEU Aviation⁶⁸ created a long-term demand signal for sustainable aviation fuels, and FuelEU Maritime⁶⁹ incentivised renewable marine fuels across the shipping sector.

Innovation funding has become a defining strength of the EU's bioeconomy. For example, the multi-billion-euro Horizon 2020 and Horizon Europe programmes supported research and demonstration projects related to biorefining, synthetic biology, and advanced materials.⁷⁰ The Bio-Based Industries Joint Undertaking (BBI-JU), which later evolved into the Circular Bio-Based Europe Joint Undertaking (CBE-JU), helped to finance several flagship commercial-scale biorefineries.⁷¹ The EU Innovation Fund provided additional support for large-scale SAF and advanced biofuel demonstration plants.⁷²

These EU actions produced substantial impacts. By 2021, bioenergy accounted for about 59% of all renewable energy consumed in the EU. Transport biofuel consumption reached approximately 16.5 million tonnes of oil equivalent, an increase of almost 40% compared with 2013.⁷³

The favourable environment for the support of biorefining and bio-based technologies encouraged by the EU has enabled UK companies to move out from the laboratory and demonstrate their novel processes at scale. For example, Lixea, founded in 2017 as an Imperial College London spin-out, develops innovative biomass-fractionation technologies using patented ionic liquids. The company's flagship Dendronic® process converts low-value wood and agricultural residues into purified cellulose, lignin, and biochemicals, offering a sustainable alternative to petrochemicals and tackling waste biomass streams.⁷⁴

While this technology was researched and developed in the UK, scale up was supported by the EU, with the company's pilot plant based in Bäckhammar, Sweden. Operational since 2021, this plant processes ~20 kg/batch of diverse biomass, for the production of product-grade cellulose, lignin, formic acid and furfural. It was built with support from the EU's EIC Accelerator Pilot (2020–2022), securing grants (€2.3 million and €2 million) for optimisation and pilot operations.⁷⁵

66 European Commission. Renewable Energy Directive. URL: https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en

67 European Commission, Fit for 55: Delivering on the proposals. URL: https://commission.europa.eu/topics/climate-action/delivering-european-green-deal/fit-55-delivering-proposals_en

68 European Commission. ReFuelEU aviation. URL: https://transport.ec.europa.eu/transport-modes/air/environment/refueeu-aviation_en

69 European Commission, Decarbonising maritime transport – FuelEU Maritime. URL: https://transport.ec.europa.eu/transport-modes/maritime/decarbonising-maritime-transport-fueeu-maritime_en

70 European Commission, Horizon Europe. URL: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

71 Circular Bio-based Europe Joint Undertaking. URL: <https://www.cbe.europa.eu/>

72 European Commission, Innovation Fund Projects. URL: https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund/innovation-fund-projects_en

73 European Commission. Bioenergy report outlines progress being made across the EU. 2023. URL: https://energy.ec.europa.eu/news/bioenergy-report-outlines-progress-being-made-across-eu-2023-10-27_en

74 Lixea. URL: <https://www.lixea.co/>

75 Expand Fibre. URL: <https://www.expandfibre.com/news/item/expandfibre-ecosystem-member-lixea-develops-a-revolutionary-technology-for-valorising-waste-streams-into-functional-materials>

4.4.3 Others

Other notable examples of best practice adopted internationally to support biorefining are highlighted in Table 3.

Table 3: Examples of other countries' best practice to support biorefining internationally.

COUNTRY	BEST PRACTICE
BRAZIL	Brazil has decades of ethanol blending mandates and one of the most efficient sugarcane-based bioindustries. Its system benefits from high yields, low fossil inputs, and cogeneration from bagasse residues. ⁷⁶ With policies like RenovaBio, Brazil is now expanding into biochemicals and aviation fuels. ⁷⁷
INDIA	India's progress is slower but supported by subsidies and large biomass availability. ⁷⁸
CANADA	Canada benefits from supportive policy and strong infrastructure, especially in fuels and chemicals. ⁷⁹
NORWAY	Norway: strong facilities but limited commercial rollout. ⁸⁰
AUSTRALIA	Australia: active VC funding and CSIRO-led innovation. ⁸¹
JAPAN AND SOUTH KOREA	Japan and South Korea: emerging, with Japan strong in advanced tech. ⁸²
THAILAND	Thailand: regional biofuel leader with strong biomass base. ⁸³

4.5 Section summary

In summary, the past decade has seen the UK's industrial biotechnology (IB) and biorefining sector grow significantly. This has been driven by coordinated action from government, research funders, industry and academia. Central to this progress was the Industrial Biotechnology Innovation & Growth Team (IB-IGT), established in 2007, which set out a long-term vision for the sector through its influential IB2025 report. This report projected a UK IB market worth £4–12 billion by 2025 – a figure which has been broadly realised, with the sector valued at approximately £4.7 billion by 2023.⁸⁴

76 Grandis et al. Scientific Research on Bioethanol in Brazil: History and Prospects for Sustainable Biofuel. Sustainability 2024, 16(10), 4167; <https://doi.org/10.3390/su16104167>.

77 BrazilianNR. Understanding Brazil's RenovaBio: A Sustainable Biofuels Policy. URL: <https://braziliannr.com/2024/03/28/understanding-brazils-renovabio-a-sustainable-biofuels-policy/>

78 Economic Times. India's biofuel sector transitioning from promise to partial implementation: Report. 2025. URL: <https://energy.economicstimes.indiatimes.com/news/oil-and-gas/indias-biofuel-sector-transitioning-from-promise-to-partial-implementation-report/121841815>

79 IEA Bioenergy. Biofuels production and development in Canada. 2025. URL: <https://www.ieabioenergy.com/blog/publications/biofuels-production-and-development-in-canada/>

80 IEA Bioenergy. Implementation of bioenergy in Norway – 2024 update. URL: https://www.ieabioenergy.com/wp-content/uploads/2024/12/CountryReport2024_Norway_final-.pdf

81 CSIRO, Biotechnology. URL: <https://www.csiro.au/en/research/production/biotechnology?start=0&count=12>

82 Japanese Cabinet Office. Bioeconomy Strategy. URL: https://www8.cao.go.jp/cstp/english/bio/bio_economy_en.pdf

83 Dialogue Earth, Thailand's ethanol revolution: Can biofuels deliver on climate goals? URL: <https://dialogue.earth/en/climate/thailands-ethanol-revolution-can-biofuels-deliver-on-climate-goals/>

84 Institute for Manufacturing, Life sciences beyond human health: modern industrial biotechnology in the UK. 2023. URL: https://www.ifm.eng.cam.ac.uk/uploads/Industrial_Biotech_-_Report_vPUBLICATION_240323.pdf

The IB2025 recommendations led to major structural developments, including:

- The **Industrial Biotechnology Leadership Forum (IBLF)**, which provided strategic coordination and helped shape national IB and bioeconomy strategies.
- The **Networks in Industrial Biotechnology and Bioenergy (NIBB)**, which created collaborative communities linking academia and industry, generated spin-outs, leveraged significant private funding and reduced barriers to commercialisation.
- The **IB Catalyst**, a £76 million joint funding programme supporting IB innovation from feasibility through to experimental development, producing high-impact research and proof-of-concept technologies.

Between 2010 and 2021, substantial public investment flowed into IB through multiple funding mechanisms, demonstrating strong value for money relative to the sector's current market size.

Alongside scientific investments UK policies also evolved. Key milestones included:

- **Building a High Value Bioeconomy (2015)** and the **Bioeconomy Strategy (2018)**, which set ambitions to double the bioeconomy by 2030 and highlighted IB's contribution to clean growth.
- The **National Industrial Biotechnology Strategy to 2030**, which outlined actions across policy alignment, funding, infrastructure, skills, regulation, and public engagement.
- The **Biomass Strategy (2023)**, which clarified the role of biomass in achieving net zero and prioritised its use where environmental and economic benefits are greatest.
- The **Modern Industrial Strategy (2025)**, which committed £380 million to engineering biology – an important enabler of IB – although clearer integration with IB policy is still needed by the sector.

Despite numerous strategies having been developed over the past 10 years, this section has highlighted the issue of fragmented policy implementation across government departments. This has resulted in ineffective translation of strategy into successful commercial outcomes.

Furthermore, a number of persistent barriers also remain. Stakeholder engagement in 2025 carried out for the present report suggest that barriers identified in 2010 remain unchanged since the initial IB-IGT "IB2025" report published in 2010. These include:

- Commercialisation bottlenecks, particularly access to affordable scale-up infrastructure.
- Policy and market uncertainty, discouraging long-term investment.
- Feedstock sustainability and cost issues.
- Skills shortages across interdisciplinary IB expertise.

Stakeholder evidence further suggests that many of these challenges continue to impact on companies looking to innovate in this sector, resulting in some choosing to scale up abroad rather than domestically (e.g., Lixea and Azotic). Thus, without addressing the issues flagged throughout this section, the UK risks falling behind in the global bioeconomy and losing the opportunity to secure both economic and environmental benefits from a thriving biorefining sector.

5. INDUSTRIAL BIOTECHNOLOGY TODAY – CURRENT STATUS IN THE UK

5.1 Introduction

This chapter sets out a view of the current state of biorefining in the UK, based on a combination of the literature review, economic analysis and insights garnered from a survey of BBNet members and other industrial biorefining stakeholders. The full literature review is set out in **Annex I**, the stakeholder survey methodology and findings are described in more detail in **Annex II**, and the economic analysis is provided in **Annex III**. The resultant insights are considered by the project team, based on their professional experience, to be transferrable to the wider definition of biorefining, and it has been clearly stated where this is not the case.

To assess the current economic impact of IB in the UK, a longlist of ~2,500 companies potentially involved in IB was compiled from 14 separate sources.⁸⁵ Analysis and classification of descriptive information regarding these companies produced a refined shortlist of roughly 1,200 companies that are understood to be operating within the project's scope of IB activities. Analysis of these 'in-scope' companies shows that they operate right across the value chain, and across every region of the UK. Most of these companies operate within one of five main segments (Figure 4):

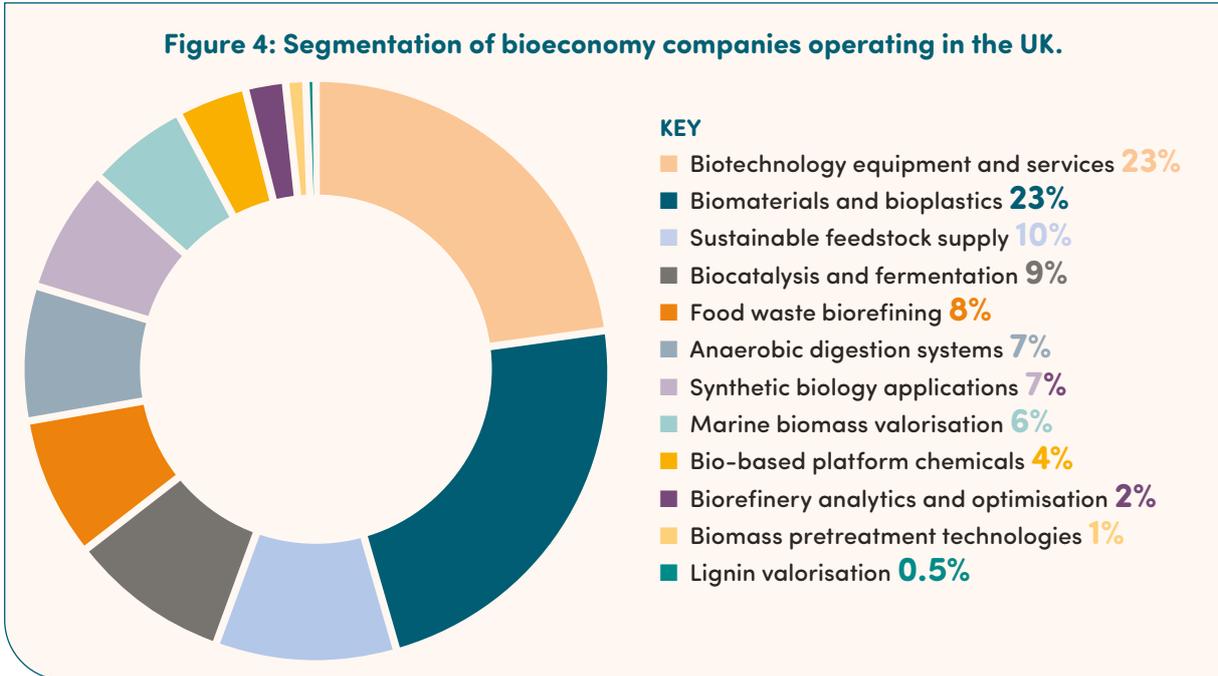
- biotechnology equipment and services (22%),
- biomaterials and bio-based plastics (22%),
- sustainable feedstock supply (15%),
- biocatalysis and fermentation (9%),
- food waste biorefining (9%).

In 2024, these companies generated approximately £12.5 billion in revenues and contributed £5.1 billion in gross value added to the UK economy. The sector employs 20,300 people across the UK, representing a significant source of skilled employment in advanced manufacturing and biotechnology.⁸⁶

85 Bio-renewables Development Centre, in-house datasets produced to inform recent studies into biochemicals and biomaterials, Companies House, Beauhurst, Bureau van Dijk, BBNet data, Innovate UK project data, the Centre for Process Innovation, UKRI Gateway to Research, Bio-based Britain, Stakeholder Engagement, IBiolC, KTN Award Winners, BBIA.

86 Economic analysis provided by Perspective Economics.

Figure 4: Segmentation of bioeconomy companies operating in the UK.



Following the initiatives introduced across the science and innovation landscape, as well as increased support for the IB sector through the development of industrial strategies, the commercial landscape of the bioeconomy grew steadily over the past decade (Figure 5). Between 2008 and 2020, there was a steady increase in new company incorporations, which indicates a growth in commercial opportunities and entrepreneurial confidence in bio-based solutions. New company incorporations reached a peak in 2021, but they have since seen a notable decline. While the low number recorded in 2024 may be partly attributable to a lag in company data records, the broader trend suggests a potential cooling of entrepreneurial activity across the IB sector in recent years.

Figure 5: Historical bio-based company incorporations in the UK.

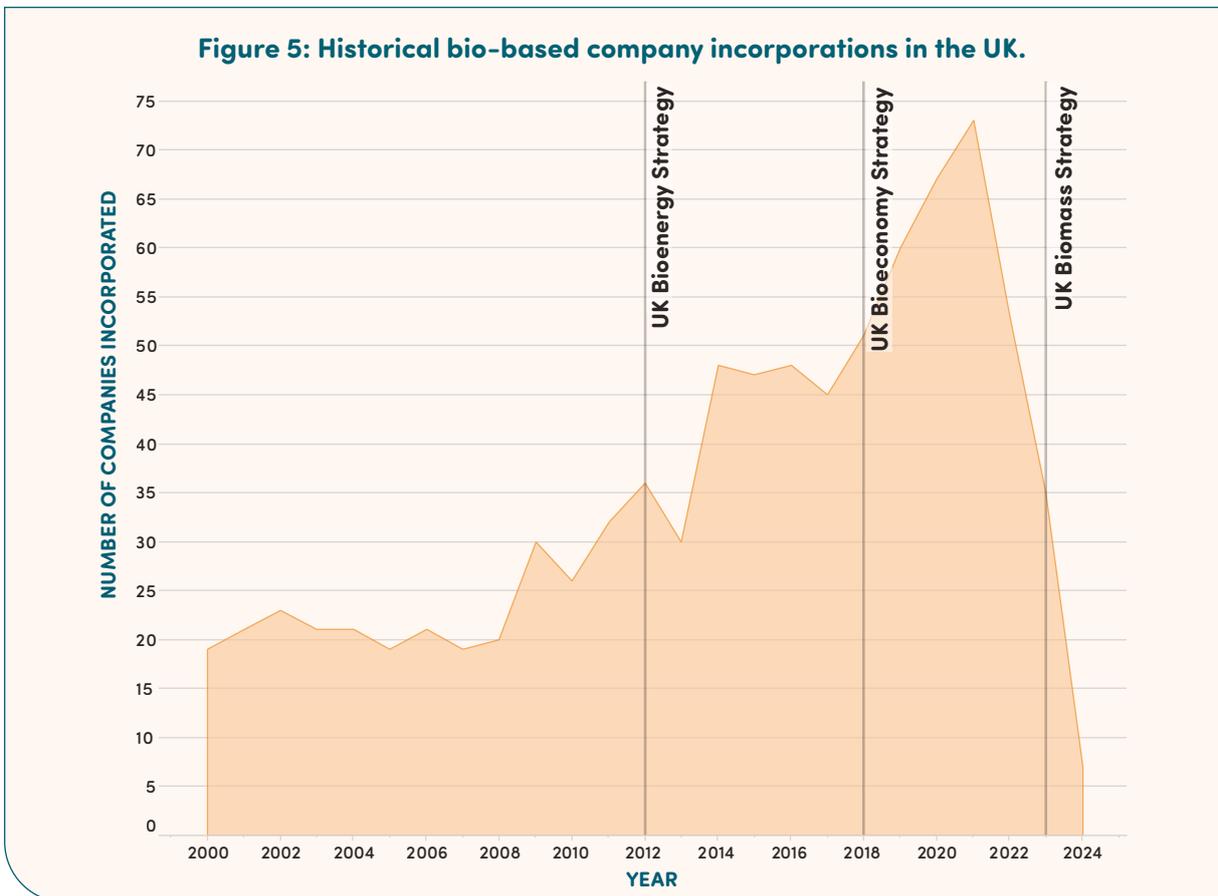
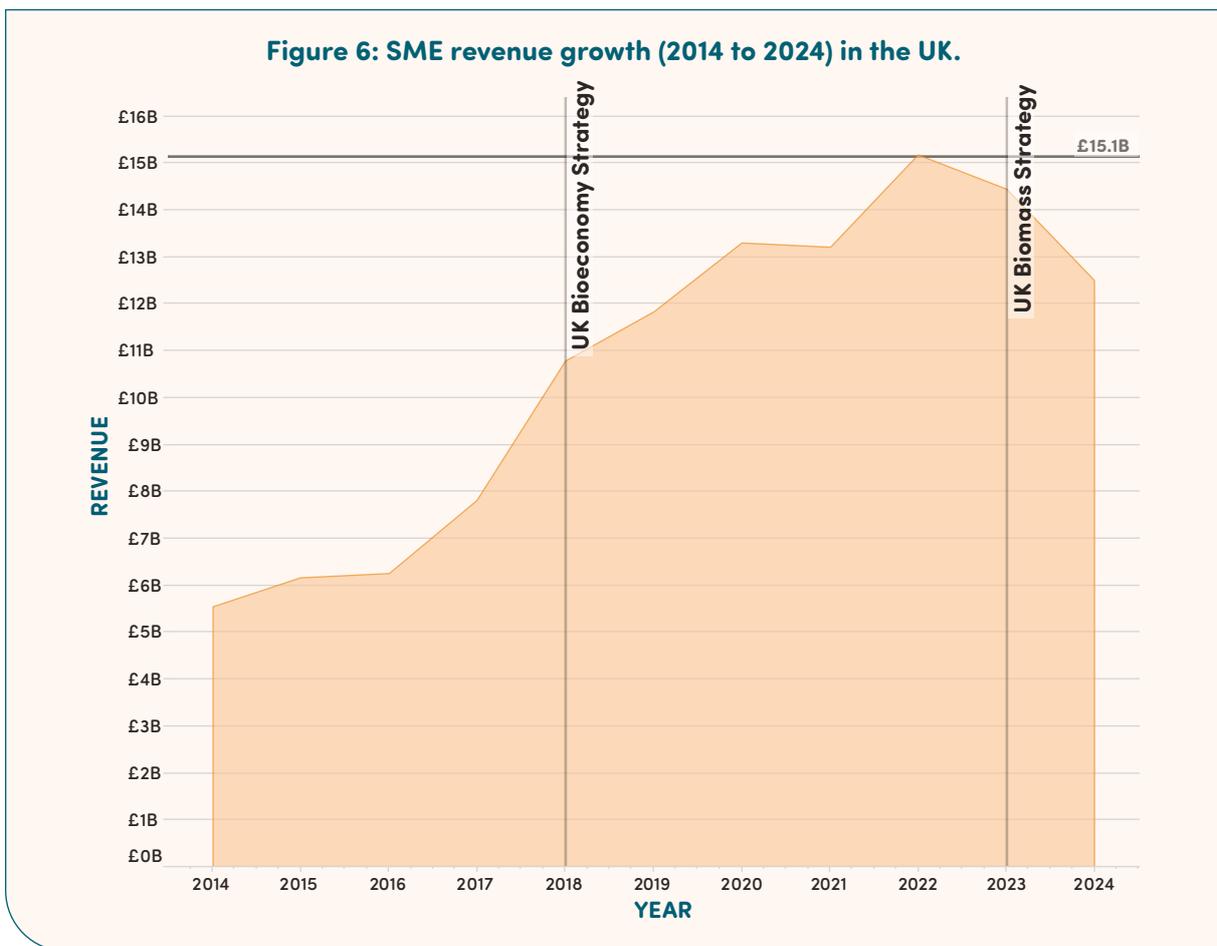


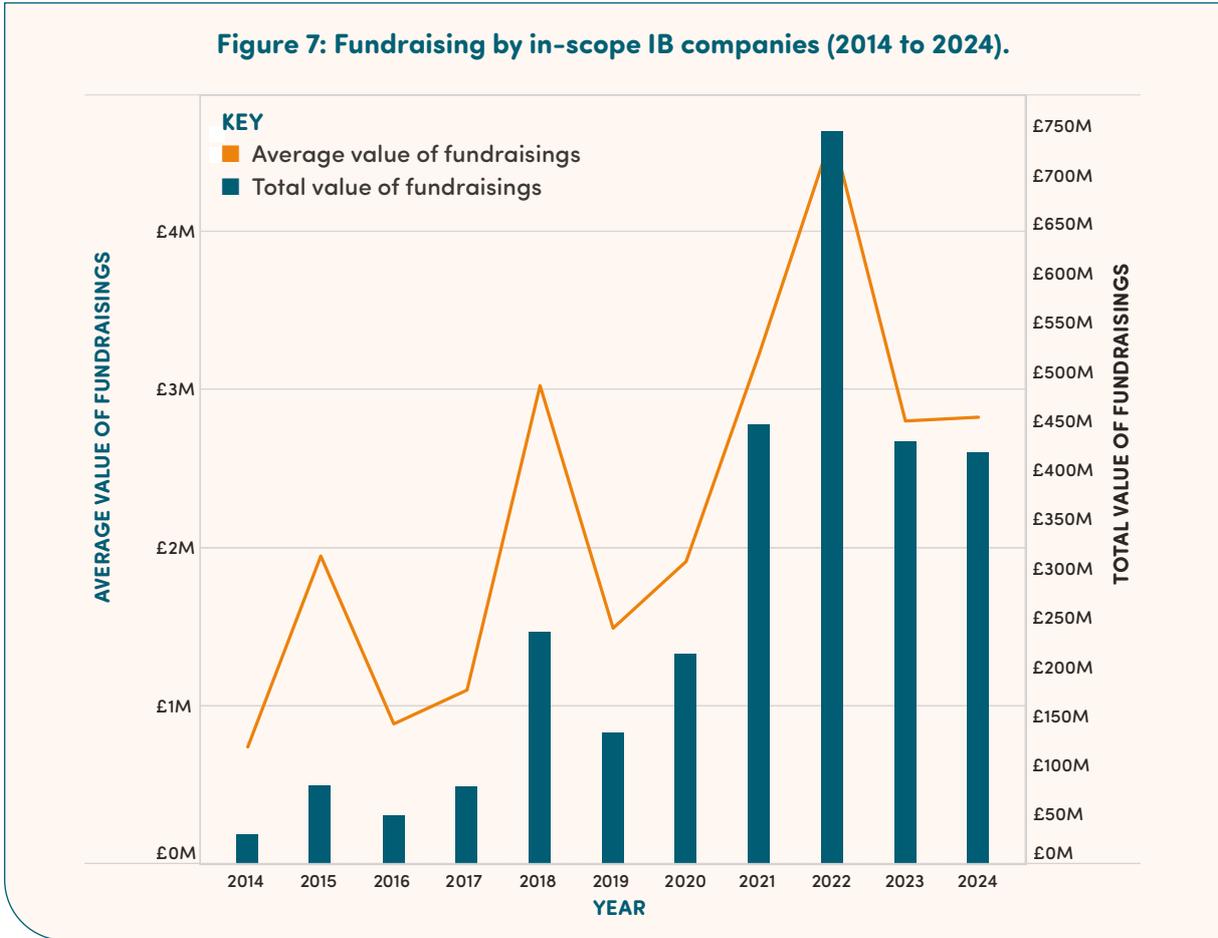
Figure 5 demonstrates that small and medium sized enterprises (SMEs) operating within the scope of IB activities demonstrated strong revenue growth between 2014 and 2022, potentially reflecting maturing IB market opportunities and greater commercial traction, to a peak of just over £15bn. However, this positive trajectory reversed following 2022. Large companies also experienced similar growth patterns, with revenues growing steadily between 2014 and 2022 before flatlining between 2022 and 2023. In 2024, large company revenues declined by approximately 10%, representing a substantial contraction in the sector’s economic output. These parallel trends across companies of different sizes indicates systemic challenges rather than firm-specific difficulties. While wider data on UK GDP also indicates slower economic growth since 2022, challenges appear to be more pronounced among the companies included in this analysis.⁸⁷ Potential contributing factors may include increased competition from international markets, regulatory uncertainties, or challenges associated with scaling bio-based solutions.



Companies operating within the scope of IB activity also secured 1,260 substantive levels of private funding, totalling £3.2 billion since 2007. Figure 6 below shows that, since 2014, both the number and value of fundraising activities showed an upward trajectory until 2022, indicating growing investor confidence in bio-based technologies and expanding capital requirements. However, this positive momentum shifted markedly in 2023, when both the total value of fundraising and the average value per fundraising declined. These metrics remained flat in 2024, suggesting a sustained cooling of investor enthusiasm. This trend is particularly concerning given the capital-intensive nature of scaling bio-based businesses to commercial production.

⁸⁷ Analysis of annual ONS data on UK GDP shows that the compound annual growth rate between 2014 and 2022 was 1.6%. The compound annual growth rate between 2022 and 2024 was less than half that figure, at 0.7%.

Figure 7: Fundraising by in-scope IB companies (2014 to 2024).



Analysis by segment reveals that biomaterials and bio-based plastic companies secured the highest total fundraising value at £707 million, reflecting both commercial potential and the substantial capital required to develop alternative materials at scale (Figure 8). Synthetic biology companies have achieved the highest average value per fundraise at £8.2 million, suggesting that whilst these ventures may be fewer, they attract substantial investment commitments when they do raise capital, likely reflecting the transformative potential and intellectual property value associated with synthetic biology applications.

Figure 8: Total fundraising by in-scope companies by sector.

Biomaterials Total: £707M Per fundraise: £2.7M	Anaerobic digestion systems Total: £277M Per fundraise: £3.2M	Biocatalysis and fermentation Total: £249M Per fundraise: £2.5M
Biotechnical equipment and services Total: £662M Per fundraise: £2.5M	Food waste biorefining Total: £158M Per fundraise: £1.8M	Marine biomass valorisation Total: £157M Per fundraise: £2.5M
Synthetic biology applications Total: £642M Per fundraise: £8.2M	Bio-based platform chemicals Total: £153M Per fundraise: £3.4M	Other Total: £105M Per fundraise: £4.4M
	Advanced biofuels Total: £119M Per fundraise: £3.0M	

In terms of size, small and medium-sized enterprises (SMEs) make up roughly 93% of all businesses operating throughout the bioeconomy (n~1,100), according to 2025 analysis. The distribution of companies by size varies considerably across segments (Figure 9).

- The largest share of large companies operating across the UK's bioeconomy is involved in chemicals and food waste biorefining.
- While synthetic biology and biorefinery optimisation segments comprises the greatest shares of smaller companies operating across the bioeconomy.

Figure 9: Size and type of IB companies operating in the UK (2025).⁸⁸

	MICRO	SMALL	MEDIUM	LARGE
Advanced biofuels	27.50%	37.50%	27.50%	7.50%
Anaerobic digestion systems	24.40%	54.70%	12.80%	8.10%
Bio-based platform chemicals	20.00%	31.10%	35.60%	13.30%
Biocatalysis and fermentation	31.70%	48.50%	11.90%	7.90%
Biomass pretreatment technologies	30.80%	61.50%	7.70%	
Biomaterials	34.20%	43.10%	15.80%	6.90%
Biorefinery analytics and optimisation	41.70%	58.30%		
Biorefinery process integration	46.70%	40.00%	6.70%	6.70%
Biotechnology equipment and services	28.10%	50.00%	15.80%	6.20%
Food waste biorefining	29.20%	44.90%	14.60%	11.20%
Sustainable feedstock and processing	33.70%	44.40%	15.20%	6.70%
Synthetic biology applications	24.40%	67.90%	5.10%	2.60%

5.2 Regional bioeconomy clusters

Bioeconomy related companies provide economic benefits right across the UK, with notable clusters outside of London – in Yorkshire and the Humber, the North West and the North East of England, as well as in Scotland (see **Annex III**). This geographic distribution highlights the breadth of economic opportunity created by BBNet-relevant businesses.

The evidence suggests that regional support is an effective mechanism for driving bioeconomy growth, as funding can be tailored to the region's capabilities (e.g., whiskey by-products in Scotland, and farming strengths in Yorkshire). This also encourages SMEs working within supported regions to innovate with local feedstock and infrastructure, leading to more sustainable, place-based solutions. In these regions, universities can work with local businesses to co-develop technologies, with regional authorities acting as conveners and funders. Furthermore, open-access centres (e.g., CPI, BDC) can provide lab and pilot-scale facilities.

⁸⁸ Economic analysis carried out by Perspective Economics – see **Annex III** for details.

CASE STUDY 5.2.1: Scotland's bioeconomy



A key example of regional investment to create a thriving bioeconomy hub can be seen in Scotland. Scotland's drive to build its bio-based capacity is integrated into its economic policymaking, making bio-based production more likely to scale. For example, the "National Plan for Industrial Biotechnology" (2013) is now incorporated into the nation's "**National Strategy for Economic Transformation**" (2022), a 10-year plan to develop Scotland's economic potential.

Scotland is building a thriving bioeconomy centred around high-value biotech to leverage the research outputs of its world-renowned universities and highly skilled workforce. The main axis of implementation are the 300 organisation members of **Scotland's Industrial Biotechnology Innovation Centre (IBiolC)**, many of which are headquartered in Scotland. The innovation centre is split between two locations; the **FlexBio site, hosted at Heriot-Watt University in Edinburgh**, which focuses on de-risking the scale-up of biotech production, and **RapidBio, hosted at the University of Strathclyde in Glasgow**, which focuses on microbial media improvement through process scale-down, cell-line selection. Scotland also has a Bioeconomy Cluster Builder (BCB) that supports Scottish micro-companies and SMEs looking to develop products or services that use biotechnology.

Scotland is moving towards **linking traditional food sectors with industrial bio-based production**. For example, Scotland's whisky industry generates waste by-products that can have multiple uses across different sectors, including biogas with new value chains being tested under a collaboration between the Scotch Whisky Association and IBiolC. Scottish companies have been exploiting **crossovers between agriculture and industry**, by producing high-value products from vegetables and food waste i.e., CelluComp, a key example of a company working in this sector that already operates commercially in the region – the company extracts and refines root vegetable fibres to make high value functional additives for paints, coatings, inks and personal care products.

Grangemouth, located on the Firth of Forth, is one of Scotland's most significant industrial hubs. Historically, it has been home to INEOS and Petroineos, chemical and petrochemical industries, and the Port of Grangemouth. However, the site is undergoing a major transition due to the planned closure of the Petroineos refinery in 2025, which threatens roughly 400 jobs. This shift represents a broader strategy to decarbonize the region and repurpose the site for sustainable industrial activities.

The **Grangemouth Industrial Cluster** is now being reimagined through a Just Transition Plan, aiming to support affected workers and communities, attract new investment, and develop low-carbon manufacturing and energy projects. **Project Willow** was a £1.5 million feasibility study jointly funded by the UK and Scottish Governments, designed to explore low-carbon alternatives for the Grangemouth site. This study evaluated 300 technologies, selecting nine promising projects, and outlined that £3.5 billion in private investment would be needed to realise their base case scenario. The study indicated that the site could create up to 800 new jobs and add £700 million to the economy by 2040. One of nine promising projects identified was the ABE fermentation process, that converts by-products and waste from industries such as food, drink and agriculture into bio acetone, bio butanol, and bio ethanol (ABE). Scottish biotechnology company Celtic Renewables operate a flagship processing plant in Grangemouth which is branded as Scotland's first biorefinery. The refinery was commissioned in 2024 with the first shipments of commercial product made in November 2024.

5.3 Biorefining success stories

A report published by BBSRC titled “Evaluation of the effectiveness and impact of BBSRC’s investments in Industrial Biotechnology” outlined where key investments were made over a ten-year period (2010/11 to 2020/21) in industrial biotechnology related initiatives.⁸⁹ The review was conducted by an independent expert panel and assessed 568 grants with active spend during the review period. It revealed that the total investment in IB over this period was roughly **£413 million, including £42.4 million in co-funding** from EPSRC and Innovate UK.

The report found that BBSRC’s investments in IB had contributed to an excellent level of IP generation and covered a range of potential applications. Furthermore, BBSRC’s IB investments had made positive contributions to the establishment of spin-out companies. For example, 9% of grants with start dates between 2013 and 2017 reported a spin out arising from their grant. In total, IB investment had contributed to the establishment of 44 spin-out companies with incorporation years between 2010 and 2021. The majority of spinouts formed by BBSRC funded IB researchers were still active at the time of evaluation (2022).

CASE STUDY 5.3.1: Unilever



Unilever is a key example of an existing UK corporation who are actively transitioning towards a bio-based business model as part of its broader sustainability strategy. This shift is driven by the need to reduce greenhouse gas emissions, improve supply chain resilience and meet consumer demand for environmentally responsible products.

Unilever’s bio-based transition goals are based on:

- Reaching net zero emissions across the value chain by 2039
- 100% sustainable sourcing of key crops by 2030
- Implementation of regenerative agriculture on 1 million hectares by 2030
- Reduction of Scope 3 emissions by 39% by 2030, with raw materials accounting for ~52% of total emissions

Examples of Unilever products and initiatives include:

- **Quix Dishwashing Liquid** – in partnership with Evonik, represents the first commercial launch of a biosurfactant-based cleaning product by Unilever.
- **Geno Partnership** – \$120 million joint venture with Genomatica to develop the use of fermentation-derived fatty alcohols to replace palm oil in surfactants. This has the potential to reduce the carbon footprint of palm-derived ingredients by up to 50%.
- **REN Clean Skincare** – production of fermented bisabolol as a bio-based ingredient for the replacement of wild-harvested chamomile extract, reducing pressure on natural ecosystems.
- **Plant-based foods** – in partnership with Algenuity for brands like Magnum, Hellmann’s and the Vegetarian Butcher. Producing microalgae-derived proteins for climate-friendly, vegan products.

89 BBSRC. Evaluating BBSRC investments in industrial biotechnology research. 2024. URL: <https://www.ukri.org/publications/evaluating-bbsrc-investments-in-industrial-biotechnology-research/>

CASE STUDY 5.3.2: Celtic Renewables



Celtic Renewables is spin out company founded in 2011 at **Edinburgh Napier University**. It was born from a research project aimed at finding sustainable alternatives to fossil fuels using biogenic carbon resources. The company addresses a major challenge facing the biofuels sector – competing with petrochemical processes, which are often cheaper due to the cost of raw materials, meaning that there is a need for cost-effective, sustainable feedstocks.

Scotland's whisky industry produces vast amounts of draff (sugar-rich barley kernels) and pot ale (a yeast-based liquid remaining after distillation). These are considered relatively low-value, carbon-rich by-products of the whisky production process. Celtic Renewables developed a novel process to convert these into biobutanol, a sustainable biofuel that can directly replace petrol in vehicles, requires no engine modification, and offers a low-carbon alternative to fossil fuels.

Celtic Renewables uses a modernised version of the Acetone-Butanol-Ethanol (ABE) fermentation process. It converts whisky residues into high-value chemicals, producing biobutanol, bioacetone, and bioethanol. These chemicals can be used in cleaning products, cosmetics and pharmaceuticals, as well as fuels. Celtic Renewables has raised over £60 million in funding from a mix of public and private sources. Key milestones include:

- 2020–2024: Multiple equity crowdfunding rounds via Crowdcube, raising over £8.8 million from more than 5,700 investors.
- Scottish Enterprise contributed approximately £20 million, a third of the total investment for the Grangemouth biorefinery.
- Earlier rounds included grants from the Department of Energy and Climate Change (DECC) and venture capital backing from UK innovation funds.

In late 2021, Celtic Renewables completed the construction of their flagship Grangemouth Facility, with commercial operations beginning in 2024. The facility has the capacity to process 100,000 litre fermentations for the production of bio-based acetone, biobutanol and bioethanol. The **carbon savings** associated with these products are an **estimated 65% compared to petrochemical equivalents**, equating to nearly 3 tonnes of CO₂ saved per tonne of product produced. Celtic Renewables is planning the development of 3–4 larger scale biorefineries over the next 4–5 years, demonstrating positive growth in the industry.

CASE STUDY 6.3.3:

Holiferm



Holiferm is a pioneering UK-based biotechnology company driving innovation in sustainable biosurfactants. Founded in 2018 in Manchester, Holiferm aims to replace petrochemical surfactants with biodegradable, non-toxic biosurfactants using fermentation-based processes. Their patented gravity separation technology enables continuous fermentation, making production more efficient and scalable. This process is understood to use **50% less energy** than conventional processes, meaning that Holiferm products can save up to 3 tonnes of CO₂ per tonne of biosurfactant produced compared to petrochemical alternatives.

Holiferm produces sophorolipid biosurfactants in high-foaming (HF) and low-foaming (LF) variants, marketed under brands like:

- Holisurf
- HoneySurf
- AgriSurf
- GranuSurf

Key applications for Holiferm products include in personal care (shampoos, cleansers and baby products), home care (dishwashing liquids, laundry detergents), industrial cleaning, and in agriculture (soil health, biocontrol, nutrient delivery).

The company raised over \$38 million across multiple rounds of funding, with support from the Clean Growth Fund, Rhapsody Venture Partners, Icos Capital and Greater Manchester Combined Authority. It now employs roughly 70 employees, and in February 2023 it opened its first commercial processing facility in the Wirral, UK. The initial capacity of this commercial plan was 1,100 tonnes per year, but it has since increased to 1,600 tonnes per year. It is further expected that by the end of 2025, the facility will be able to process 3,500 tonnes per year, and, eventually, it is planned that the site will be able to scale up to 15,000 tonnes per year.

5.4 Barriers to further growth

Despite the UK's notable biorefining success stories, the economic evidence presented earlier in this chapter indicates that the UK's biorefining sector is experiencing a decline in terms of number of companies incorporated, employment numbers and revenue. It is therefore evident that the sector still faces significant challenges.

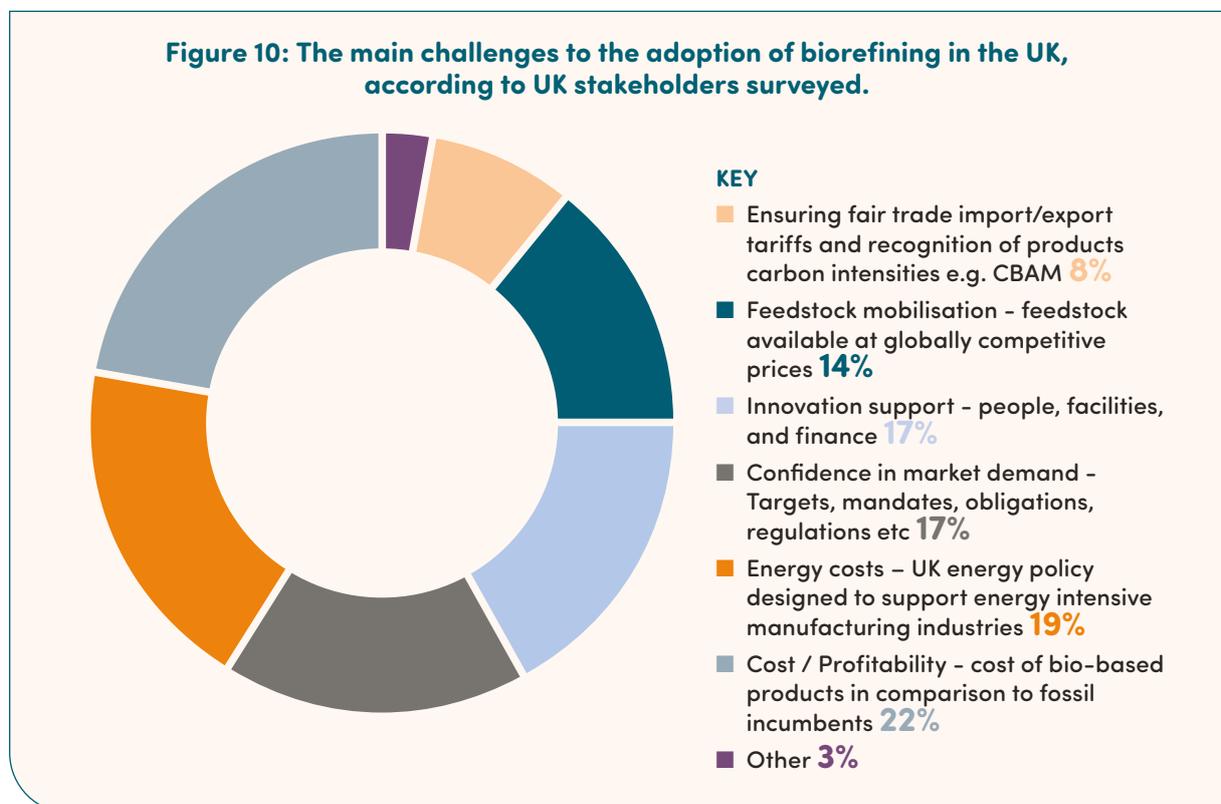
In order to investigate the key barriers to further growth in the biorefining sector, stakeholder views on sector challenges were collected via survey and interviews. In total 76 individuals responded to an online survey sent to BBNET members and other key stakeholders, from 70 different organisations. 45% of respondents were from academia, roughly 35% were from industry, and the remaining 20% were from scale-up companies, Government, NGOs, and 'others' that do not fall into a defined category. The online survey was followed up by one-to-one interviews with a subset of IB sector respondents. Of these respondents, 41 individuals were interviewed from 39 organisations, including 16 from academia and 23 from industry. Further details on this research can be found in [Annex II](#).

When asked about the main challenges to the adoption of biorefining in the UK, a large number of stakeholders interviewed identified the cost and profitability of bio-based products in comparison to fossil-based counterparts, as well as overarching energy costs. When combined, these issues made up for one third of the challenges articulated by interviewees.

The main barriers to biorefining in the UK identified by stakeholders in 2025 were:

- **Cost and profitability:** The most significant barrier is the high cost of bio-based products compared to fossil incumbents. This indicates that economic competitiveness is the biggest challenge for scaling biorefining. Unless bio-based solutions can achieve cost parity market adoption will remain limited.
- **Market confidence and demand:** A lack of clear market signals – such as binding targets, mandates, regulations or obligations – creates uncertainty for investors and businesses. Without assured demand companies hesitate to invest in biorefining infrastructure.
- **Fair trade and carbon recognition:** Tariffs and mechanisms like the Carbon Border Adjustment Mechanism (CBAM)⁹⁰ could influence competitiveness. Recognition of the lower carbon intensity of bio-based products is necessary to level the playing field internationally.
- **Energy costs:** UK energy policies and the high costs associated with energy-intensive manufacturing are another major challenge. Since biorefining is energy-intensive, unfavorable energy pricing undermines competitiveness.
- **Feedstock mobilisation:** The availability of sustainable feedstock at globally competitive prices is another constraint. Ensuring secure, affordable and reliable access to raw materials is critical for the sector's growth.
- **Innovation support:** While innovation is happening, barriers exist in securing sufficient people, facilities and financing to accelerate progress. This reflects gaps in the broader innovation ecosystem, which are vital for scaling up new technologies.

Figure 10: The main challenges to the adoption of biorefining in the UK, according to UK stakeholders surveyed.

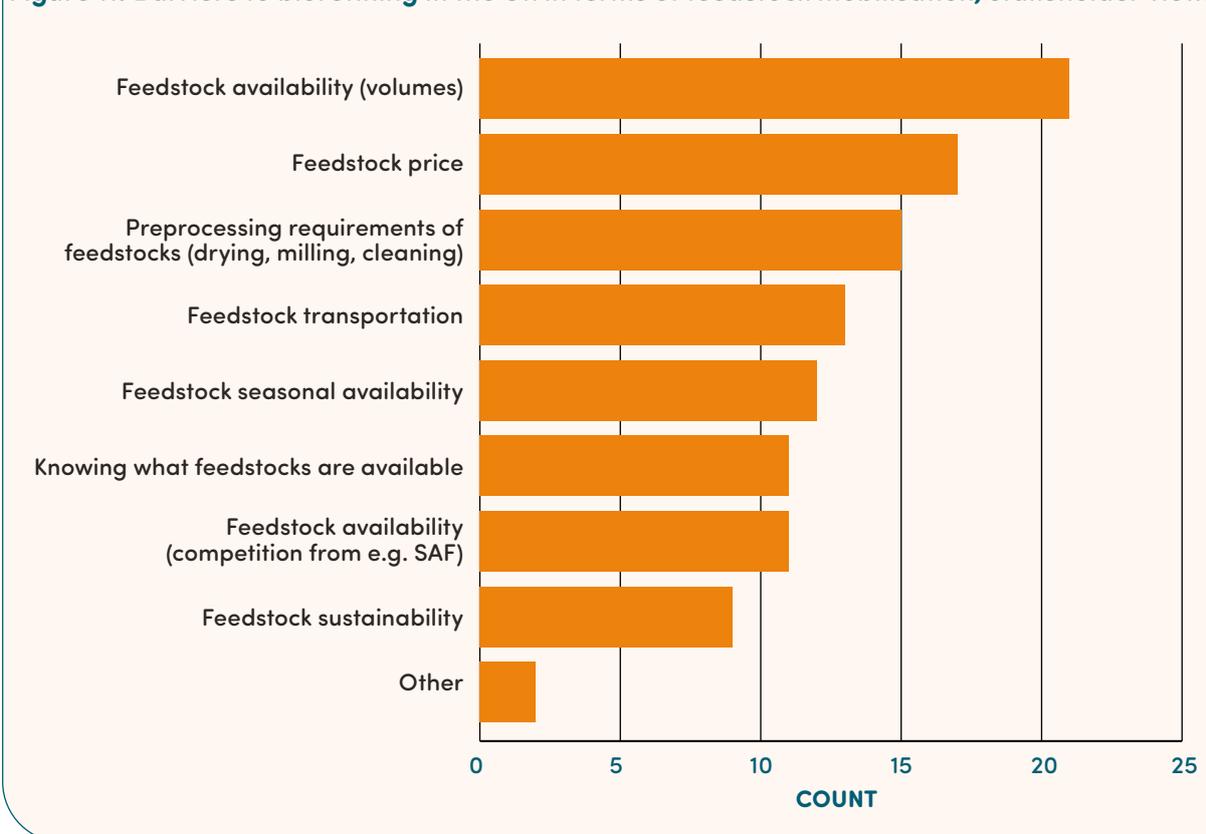


90 Carbon Border Adjustment Mechanism. URL: https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en

5.4.1 Feedstock mobilisation barriers

In terms of feedstock mobilisation barriers, stakeholders indicated that the availability of feedstock was a key concern for companies operating within the biorefining sector, alongside feedstock price, processing requirements, logistics and competition. The key barriers associated with feedstock mobilisation in the UK include:

- **Feedstock availability (volumes)** – The most frequently cited barrier. This reflects limited large-scale, consistent supply of suitable biomass or waste materials in the UK, driven by competition between sectors (e.g. energy, transport and chemicals) and regional disparities in resource availability. The generation of a feedstock map to outline where feedstock is available would help market access and is a recommended action for industry.
- **Feedstock price** – High costs are a major deterrent for biorefining investment. Limited domestic supply, fragmented markets and transportation costs often make bio-based feedstocks more expensive than fossil-based alternatives.
- **Preprocessing requirements (drying, milling, cleaning)** – Many potential feedstocks (e.g. agricultural residues, food waste) require costly and energy-intensive pre-processing before they can be used, reducing the overall economic viability of biomass utilisation.
- **Feedstock transportation** – Biomass is bulky and often produced far from processing sites, making logistics and transport costs significant. This issue is amplified by the lack of regional collection and aggregation infrastructure.
- **Feedstock seasonal availability** – Agricultural and forestry residues are produced cyclically, leading to supply fluctuations and storage challenges for biorefineries that require year-round operation.
- **Knowing what feedstocks are available** – Stakeholders report a lack of clear, up-to-date data on local and national feedstock sources, qualities, and quantities, which limits planning and investment confidence.
- **Feedstock availability (competition from e.g. SAF)** – Growing demand for bioresources from other sectors, particularly sustainable aviation fuels (SAF), increases competition and drives up prices, constraining supply for chemicals and materials production.
- **Feedstock sustainability** – Ensuring feedstocks meet sustainability standards (e.g. carbon footprint, land use, biodiversity) adds complexity and cost and can limit the types of materials that can be sourced.

Figure 11: Barriers to biorefining in the UK in terms of feedstock mobilisation, stakeholder view.

5.4.2 Innovation support barriers

In terms of innovation support, the main barriers reported by stakeholders included limited access to pilot and demonstration facilities, as well as a lack of long-term patient capital⁹¹ and investment security. This reflects the capital-intensive nature of biorefining, and the high-risk factors associated with scaling technologies from lab to commercial scale. In order to overcome these barriers, key actions for government and funders would be to provide focussed financial support for businesses and scale up infrastructure in the UK.

For example, a stakeholder interviewed as part of this project stated:

“Introducing a 2% reduction in corporation tax and fixed, lower energy prices for the first ten years of operation would provide vital support for new biorefinery enterprises. This measure is designed to encourage early-stage growth, strengthen investor confidence and establish a stable foundation for long-term industry development.”

COO, Biomanufacturing SME

Furthermore, fragmentation between research, industry and government support programmes, and difficulty securing public funding or grants were also frequently cited as innovation support barriers. These point to systemic issues in coordination and access to consistent support mechanisms. As such, a key recommendation here would be to focus on joined up support between different stakeholder groups (e.g., corporates, SMEs and start-ups, academia etc.), led by an overarching industry body, with the interests of the wider biorefining sector a key pivotal aim.

⁹¹ Referring to long-term investment capital that prioritizes sustainable growth and value creation over quick returns.

Moderate barriers to innovation support included a shortage of skilled workforce and specialist training, and limited venture capital interest in bio-based industries – both indicating human capital and investor confidence challenges. Less pressing barriers included insufficient collaboration between academia and industry, suggesting that partnerships exist but may not be fully leveraged to support commercialisation.

Overall, the stakeholder responses suggested that, while the UK has a strong research base, translating innovation into commercial biorefining success is hindered by funding gaps, investment insecurity and infrastructure limitations.

5.4.3 Access to scale up infrastructure barriers

When asked about barriers relating to scale up infrastructure in the UK, most stakeholders felt that access to scale up infrastructure at smaller scales was good. But as scale increases the accessibility of suitable infrastructure decreased. This indicates that at early-stage research and early-stage commercialisation support is good. But in working towards sector growth and supporting developments towards full commercialisation more investment to improve access to scale-up services is needed.

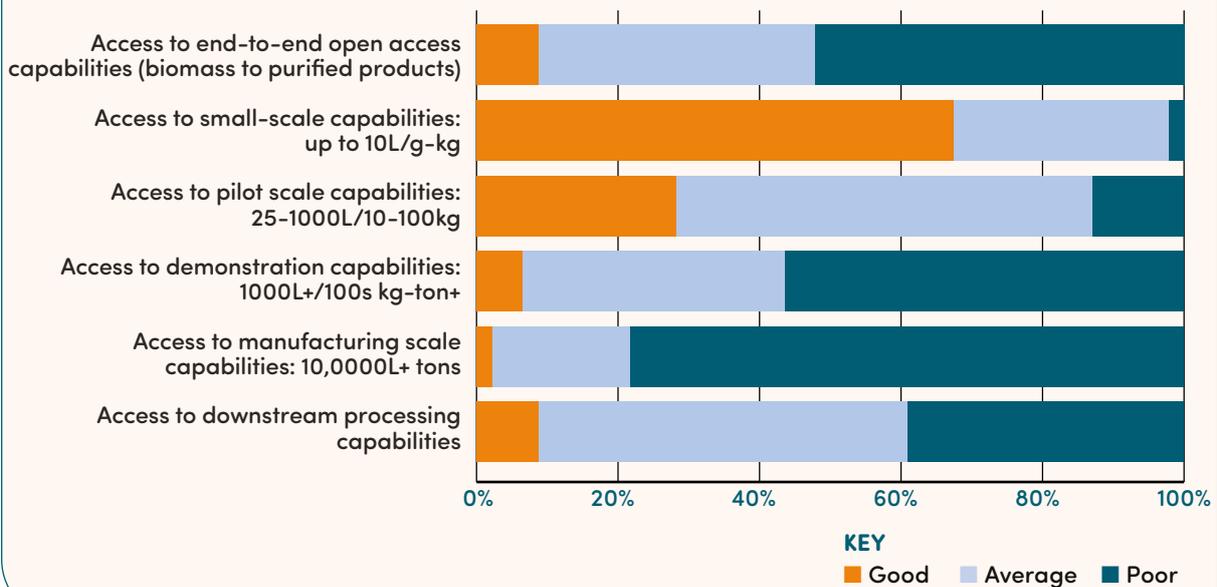
A stakeholder interviewed as part of this project stated that:

“Access to affordable, agile infrastructure is fundamental to unlocking the full potential of the bioeconomy. When companies can rapidly scale production, test new technologies and adapt to market needs, it not only accelerates innovation and growth, but it also strengthens investor confidence.

A supportive infrastructure ecosystem signals stability and readiness – encouraging long-term investment and positioning the UK as a global leader in sustainable industry transformation.”

Director, Venture Capital Company.

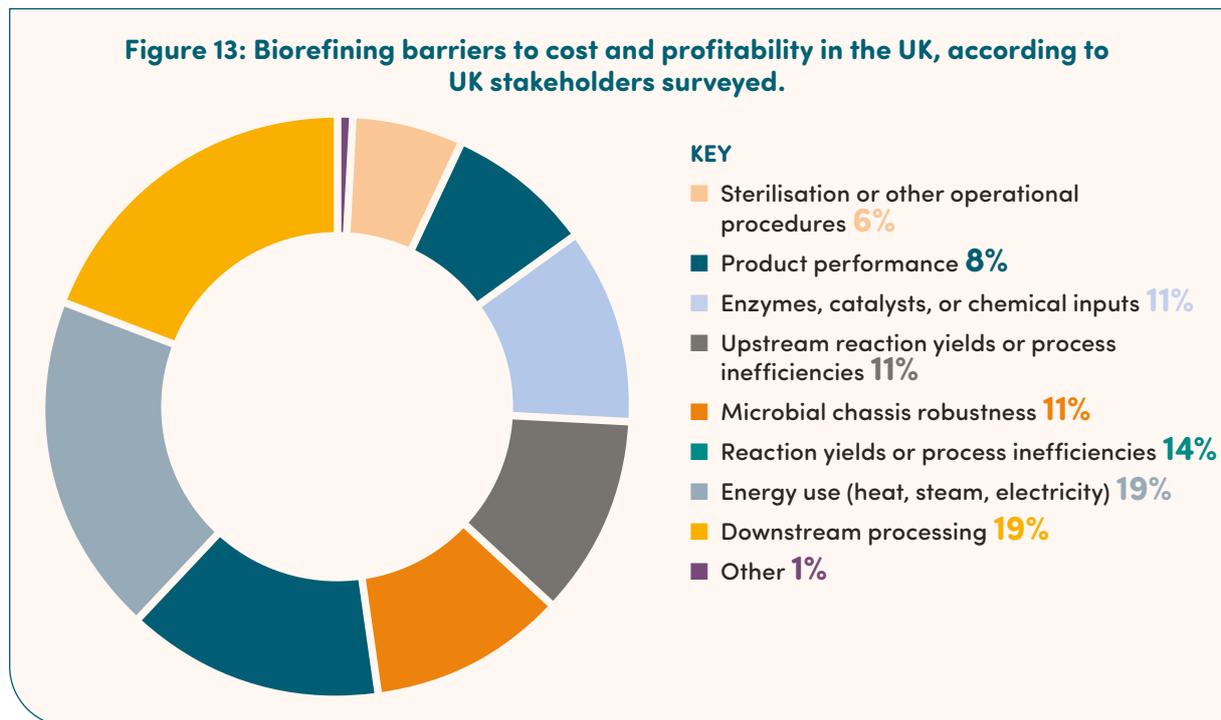
Figure 12: Stakeholder perceptions on access to scale up infrastructure.



5.4.4 Cost and profitability barriers

Regarding cost and profitability, the main barriers identified were downstream processing and energy use, followed by process inefficiencies and input-related challenges. Downstream processing and energy use (heat, steam, electricity) are the leading cost drivers as both require high energy inputs and complex equipment, making purification and operation expensive. Furthermore, reaction yields and process inefficiencies limit productivity and scalability, often due to suboptimal biological systems or variable feedstocks. Microbial chassis robustness issues reduce reliability under industrial conditions, while enzyme, catalyst, and input costs remain high due to limited supply and reuse options.

Upstream inefficiencies, such as costly biomass pretreatment, further add to production costs, and product performance and operational demands like sterilisation also contribute additional costs, especially when bio-based products underperform compared to petrochemical alternatives.



5.4.5 Market confidence barriers

When asked about confidence in market demand and what are considered as barriers to biorefining in the UK, the most notable stakeholder response was a lack of long-term government strategy and policy. Stakeholders considered that the key barriers related to market confidence were:

- Long-term government strategy and policy:** Identified as the most significant barrier, reflecting widespread uncertainty around consistent and supportive policy frameworks. The absence of clear, long-term strategies, incentives and funding mechanisms undermines investor confidence and limits commitment to biorefining projects.

A stakeholder interviewed as part of this project stated that:

“Long-term government strategy and policy continue to be the most significant barrier to the growth of biorefining in the UK. Widespread uncertainty over consistent regulatory frameworks, targeted incentives and reliable funding mechanisms undermines investor confidence, limits long-term planning and discourages commitment to new projects.

Without a clear, sustained and supportive policy environment, the UK risks falling behind in the global bioeconomy and losing the opportunity to secure both economic and environmental benefits from a thriving biorefining sector.”

CCO, SME

- **Market pull:** A lack of strong market demand from consumers and industry reduces incentives for investment and scale-up. Without clear market signals or procurement support, biorefining products struggle to compete with fossil-based alternatives.
- **Supply chain integration:** Challenges in linking feedstock suppliers, processing facilities and end-users hinder the development of efficient value chains. Limited coordination across sectors slows commercialisation and adds operational risk.
- **Standards and certification schemes:** The absence of clear and widely utilised standards for biorefining products generates uncertainty amongst buyers and investors. This gap constrains market acceptance and confidence.
- **End-of-life infrastructure and management:** Concerns persist around the disposal, recycling and broader circularity of biorefining products. Weak end-of-life systems limit the sector's sustainability potential and environmental credibility.
- **Industry organisation and trade representation:** A fragmented industry landscape with limited collective voice makes it more difficult to influence policy, coordinate action and attract investment at scale.
- **Consumer understanding:** Low public awareness of biorefining and its benefits restricts market uptake. Improved communication and education could strengthen consumer demand for bio-based products.
- **Environmental impact:** While less frequently cited, ongoing questions about genuine sustainability performance and lifecycle impacts highlight the need for transparent assessment and communication.

5.4.6 Fair trade barriers

In terms of ensuring fair trade, across the UK's bioeconomy, stakeholders noted “unfair” market competition from countries with lower production costs and less rigorous regulations, which was noted as being the biggest concern amongst the stakeholders surveyed (11 respondents, Figure 14). UK bio-based producers face higher costs due to strict environmental, labour and quality standards, while competitors abroad benefit from cheaper energy, lower wages, and looser regulations. This price gap allows imports (often with higher carbon footprints) to undercut UK products, discouraging investment and driving ‘carbon leakage’. Furthermore, stakeholders noted unequal access to international markets for UK producers as another key barrier. UK biorefineries face tariffs, regulatory barriers and a smaller home market compared to competitors in the EU, US and Asia. Post-Brexit uncertainty and limited bioeconomy incentives are believed to further weaken market competitiveness, especially in an international context.



Limited transparency in global supply chains was also noted as a barrier, as feedstocks for biorefining are often sourced globally, but opaque international supply chains make it difficult to verify sustainability or ethical standards. This undermines consumer trust and gives less transparent suppliers unfair cost advantages.

Furthermore, current trade and subsidy systems were flagged as barriers as they often provide preference to fossil-derived materials through tax breaks and legacy infrastructure. Bio-based products face higher costs and fewer incentives, distorting markets and limiting fair competition despite environmental benefits. Additionally, inconsistent definitions of ‘sustainability’ across countries complicates trade. UK producers may have to meet strict domestic criteria that aren’t recognised abroad, while imports from regions with weaker standards freely enter the UK market. Global alignment through ISO or trade agreements could create a level playing field.

5.4.7 Regulatory barriers

The UK Government’s Industrial Strategy sets a bold ambition: to make the UK a top three global hub for fast-growing technology businesses by 2035.

A central pillar of this vision is engineering biology, a sector pivotal to the £30 trillion global industrial bioeconomy. The UK Government has committed £2 billion over the next decade to this field, including £380 million for R&D and infrastructure.⁹² However, according to the stakeholders interviewed, the UK’s outdated and fragmented regulatory framework poses a significant threat to this ambition.⁹³

92 UK Government. The UK’s Modern Industrial Strategy. 2025. URL: https://assets.publishing.service.gov.uk/media/68595e56db8e139f95652dc6/industrial_strategy_policy_paper.pdf

93 BB-REG-NET, Unlocking Regulatory Pathways for Novel Bio-Based Chemicals and Materials in the UK. 2025. URL: https://bbia.org.uk/wp-content/uploads/2025/11/Regulatory-Pathways-for-Novel-Bio-Based-Chemicals-and-Materials-in-the-UK_NON-CONFIDENTIAL.pdf

One stakeholder stated that:

“The current regulatory framework not only slows innovation but discourages investment in a sector that could make the UK a leader in green chemistry. By treating sustainable breakthroughs as regulator risks rather than strategic opportunities, the system holds back progress towards a circular, low-carbon materials economy.”
CEO, SME

In combination, the economic data and stakeholder insight collected as part of this project highlights a stark message. Without reform, the UK risks losing its competitive edge in industrial biotechnology to global rivals who are already modernising their regulatory environments.

Three critical risks were identified:⁹⁴

- **Company exodus:** UK bio-based SMEs are relocating to countries with more supportive regulatory ecosystems, leading to a loss of jobs, IP, and taxpayer-funded innovation.
- **Investment drain and company failure:** Regulatory uncertainty and extended timelines are increasing perceived risk for investors, causing startups to fail or downscale and putting billions in public R&D at risk.
- **Delayed economic gains:** Every regulatory delay defers significant economic and environmental benefits, including green jobs, tax revenues and market leadership.

While the UK has world-leading research and early-stage innovation in bio-based technologies, companies face regulatory systems that are outdated, fragmented and not designed for the novel aspects of bio-based products. As a result commercialisation is slow, investment is deterred, and SMEs are disproportionately affected.

1. **No bio-based-specific regulatory frameworks** – UK regulations often fail to differentiate between fossil-based and bio-based products, applying the same rules despite their very different environmental and toxicological profiles. UK REACH offers no streamlined routes for low-toxicity, renewable alternatives. Food contact regulations do not yet accommodate biodegradable coatings, bio-based films, natural additives or emerging packaging materials.⁹⁵
2. **Fragmented oversight and lack of coordination** – Regulatory responsibilities are dispersed and overlapping. A product like a biodegradable lubricant may be regulated under REACH (chemical safety), Defra (environmental impact), and OPSS (consumer safety). For food-contact packaging made from seaweed, responsibilities may span FSA, OPSS, and Defra. The lack of coordination creates delays and confusion, especially for resource-constrained companies.
3. **Lack of clarity for novel materials** – New materials such as fibre-based packaging, algae-derived films and mycelium-based trays don't fit neatly into existing regulatory categories. Companies often get passed between agencies (HSE, FSA, OPSS, Defra) with no clear lead authority. The Engineering Biology Regulators Network is a good initiative but experience to date is not positive.⁹⁶

94 BB-REG-NET, Unlocking Regulatory Pathways for Novel Bio-Based Chemicals and Materials in the UK. 2025. URL: https://bbia.org.uk/wp-content/uploads/2025/11/Regulatory-Pathways-for-Novel-Bio_Based-Chemicals-and-Materials-in-the-UK_NON-CONFIDENTIAL.pdf

95 BB-REG-NET, Unlocking Regulatory Pathways for Novel Bio-Based Chemicals and Materials in the UK. 2025. URL: https://bbia.org.uk/wp-content/uploads/2025/11/Regulatory-Pathways-for-Novel-Bio_Based-Chemicals-and-Materials-in-the-UK_NON-CONFIDENTIAL.pdf

96 BB-REG-NET, Unlocking Regulatory Pathways for Novel Bio-Based Chemicals and Materials in the UK. 2025. URL: https://bbia.org.uk/wp-content/uploads/2025/11/Regulatory-Pathways-for-Novel-Bio_Based-Chemicals-and-Materials-in-the-UK_NON-CONFIDENTIAL.pdf

- 4. Lengthy, high-cost authorisation procedures** – Approval processes are complex, slow and costly – often requiring the same burden of proof as petrochemical substances despite their very different environmental and toxicological profiles. SMEs, in particular, face barriers in terms of both time and cost. Lack of risk proportionality creates unnecessary delays for low-risk innovations.

5.5 Section summary

In summary, biorefining is an important and growing component of the UK economy, supporting sustainable manufacturing, low-carbon technologies and advanced materials. Analysis of approximately 2,500 companies identified around 1,200 firms operating within the scope of IB, spanning the full value chain and distributed across all UK regions.

The sector is largely concentrated within five principal segments: biotechnology equipment and services (22%), biomaterials and bio-based plastic (22%), sustainable feedstock supply (15%), biocatalysis and fermentation (9%), and food waste biorefining (9%). In 2024, the sector generated approximately £12.5 billion in revenue, contributed £5.1 billion in gross value added (GVA) and employed around 20,300 people, largely in skilled scientific and manufacturing roles. Small and medium-sized enterprises (SMEs) dominate the sector, accounting for approximately 93% of all IB companies.

The UK IB sector experienced steady growth between 2008 and 2021, with increasing company formation reflecting rising commercial opportunities and confidence in bio-based solutions. However, since 2021 new company incorporations have declined, suggesting a cooling of entrepreneurial activity. Revenue growth across both SMEs and large firms was strong between 2014 and 2022, peaking at over £15 billion. However, this trend reversed after 2022, with revenues stagnating or declining. Furthermore, large companies recorded a ~10% fall in revenues in 2024, indicating sector-wide structural challenges rather than isolated firm-level issues.

Investment trends also mirror this pattern. Since 2007, IB companies have secured £3.2 billion across 1,260 private funding rounds. Fundraising activity increased steadily until 2022, reflecting strong investor confidence. However, both the value and average size of investments declined sharply in 2023 and remained flat in 2024. This is particularly concerning given the capital-intensive nature of biorefining and scale-up activities.

The UK bioeconomy benefits from strong regional clusters, which can demonstrate the value of place-based approaches that align local feedstocks, infrastructure, skills and research capabilities. For example, Scotland provides a leading example of effective regional coordination. Bioeconomy development in Scotland is embedded within national economic strategy and supported by institutions such as the Industrial Biotechnology Innovation Centre (IBiolC), which provides open-access facilities for scale-up and commercialisation. Scotland has also pioneered industrial transition at Grangemouth, aiming to repurpose a historically petrochemical site towards low-carbon manufacturing and biorefining, supported by public-private investment and a just transition framework.

Several UK companies demonstrate the commercial and environmental potential of industrial biotechnology:

- **Unilever** exemplifies how large corporates are integrating bio-based solutions into global supply chains, including biosurfactants, fermentation-derived ingredients, and alternative proteins, as part of its net zero and sustainable sourcing commitments (see case study 6.3.1).
- **Celtic Renewables**, a university spin-out, converts whisky by-products into bio-based fuels and chemicals using ABE fermentation. The company has raised over £60 million, commissioned Scotland's first commercial biorefinery in 2024 and delivers carbon savings of approximately 65% compared to petrochemical equivalents (see case study 6.3.2).

- **Holiferm**, founded in 2018, produces low-carbon biosurfactants using energy-efficient fermentation. The company has raised over \$38 million in funding, operates a commercial facility in the UK and is scaling production rapidly (see case study 6.3.3).

Initial public investment has been critical to the successes experienced across the sector to date. For example, between 2010 and 2021, BBSRC invested approximately £413 million in IB, contributing to strong intellectual property generation and the creation of 44 spin-out companies, most of which remain active.

Despite notable successes, stakeholders interviewed considered that the UK IB sector faces significant constraints that are limiting growth and commercialisation.

- **Cost and profitability** – The dominant barrier is the higher cost of bio-based products relative to fossil-based alternatives. Energy costs, downstream processing and process inefficiencies are major contributors, preventing many technologies from reaching cost parity.
- **Market confidence** – A lack of long-term government strategy, binding targets and market incentives undermines investor confidence. Weak market pull, limited standards and certification, and underdeveloped end-of-life infrastructure further constrain demand.
- **Feedstock mobilisation** – Biorefining is constrained by inconsistent availability of sustainable feedstocks at scale, high prices, seasonal supply, transport costs and growing competition from other sectors, such as sustainable aviation fuels. Limited transparency on national feedstock availability reduces planning and investment certainty.
- **Innovation and scale-up support** – While the UK has a strong research base, companies face a shortage of patient capital, limited access to large-scale demonstration facilities, fragmented support mechanisms and skills gaps. Access to infrastructure declines sharply beyond pilot scale.
- **Fair trade and regulation** – UK producers face higher costs due to stricter environmental and labour standards, while competing internationally with imports produced under looser regulations. Regulatory frameworks are widely viewed as outdated, fragmented, and poorly suited to bio-based products, leading to delays, high compliance costs, and a disproportionate impact on SMEs. Stakeholders report risks of company relocation, lost investment and delayed economic benefits as a result.

The UK industrial biotechnology sector combines world-leading research, strong regional capabilities and proven commercial success. However, recent economic and investment trends indicate a sector under increasing pressure. Without coordinated action to address policy certainty, regulatory reform, cost competitiveness, feedstock security and scale-up infrastructure, the UK risks losing its competitive position in the global bioeconomy. Targeted, long-term intervention is essential to unlock sustainable growth, green jobs, and economic value from industrial biotechnology.

6. THE FUTURE OF BIOREFINING IN THE UK – WHERE DO WE GO FROM HERE?

6.1 Introduction

This chapter presents a view of the future of biorefining in the UK, based on economic analysis combined with insights gathered from stakeholder survey responses to a set of questions posing possible future scenarios. Stakeholder survey methodology is set out in [Annex II](#). The economic analysis is set out in more detail in [Annex III](#).

6.2 Scope and definitions

For the purposes of this report, biomass biorefining is defined as the development and application of innovative biological processes that transform renewable biomass resources into sustainable fuels, food ingredients, chemicals, and materials. This definition reflects the growing recognition of biorefining as a cornerstone of the modern bioeconomy, offering a viable pathway to reduce dependence on fossil-based resources while delivering environmental, economic and societal benefits. In the context of this project, biorefining is framed in line with the interests and remit of BBNet, with a particular emphasis on industrial biotechnology as the core enabling process technology. This encompasses approaches such as fermentation and biocatalysis, as well as the integration of these biological methods with complementary disciplines to drive innovation and value creation. Although included within the wider definition of biorefining, it is important to note that for the purposes of this report thermal and thermochemical processing of biomass (including methods such as pyrolysis and gasification) fall outside the scope of this study. The project team considers that the scenarios and future outlook presented in this section are transferrable to the wider definition of biorefining.

After a decade of investment in UK biorefining, marked by strong revenue and employment growth, plus several notable successes, the UK's bio-based sector risks losing momentum. To understand how specific interventions could invigorate the biorefining sector, stakeholders were asked to consider the impact of four possible scenarios.

SCENARIO 1: INFRASTRUCTURE INVESTMENT

UK Government successfully establishes shared scale-up facilities and industrial clusters with co-location incentives, enabling companies to access pilot plants and demonstration facilities. Feedstock remains at market rates with limited coordination, and sector oversight stays fragmented across departments.

SCENARIO 2: FEEDSTOCK MOBILISATION

The UK secures long-term agreements for affordable feedstock through international partnerships and domestic feedstock mobilisation. However, businesses have to fund their own scale-up facilities, and government coordination remains limited with fragmented policies across departments.

SCENARIO 3: GOVERNMENT COORDINATION

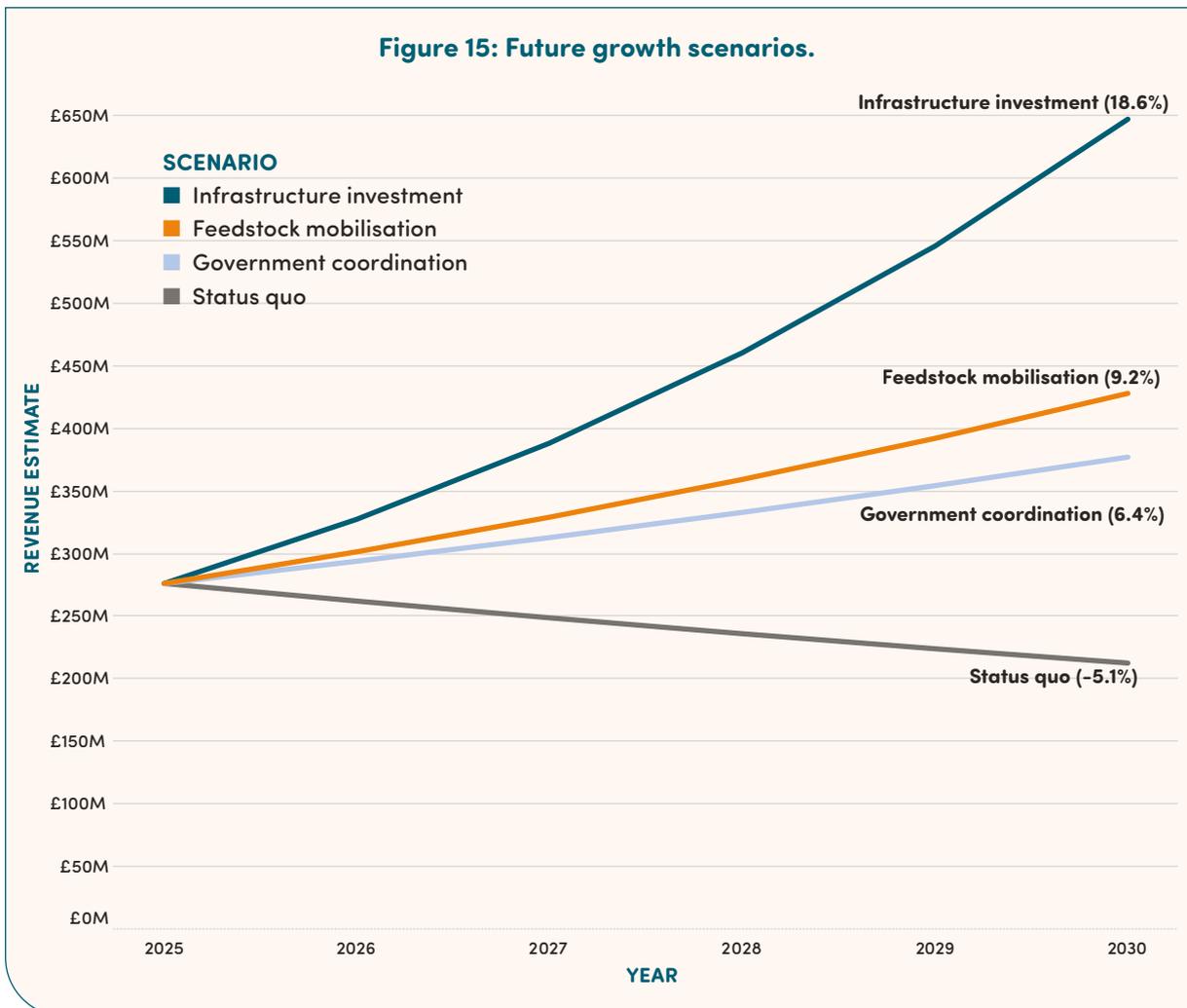
A dedicated biorefining body coordinates activity across departments, streamlines regulations, and aligns policies between devolved nations. However, feedstock costs remain high and public investment in scale-up infrastructure is limited.

SCENARIO 4: STATUS QUO

Government maintains current levels of biorefining support without significant expansion or reduction, with existing R&D programmes continuing at present funding levels. Familiar regulatory processes remain in place alongside modest private investment and existing skills ecosystem.

When asked to estimate the impact that different scenarios could be expected to have on revenue and employment in the next five years, responses from bio-based business representatives who took part in the online survey suggested that investment in scale up infrastructure would have the most positive impact on growth followed by feedstock mobilisation and government coordination. In contrast, survey respondents believed that, without intervention, revenue and employment could be expected to contract. In total 76 individuals responded to an online survey sent to BBNet members and other key stakeholders, from 70 different organisations.

The four scenarios described above are illustrated in Figure 15.



Survey responses offered clear guidance on the interventions most likely to catalyse growth. Investment in scale-up infrastructure was perceived to be the single most beneficial intervention, with respondents estimating that it could generate ~18% growth in the sector. This echoes additional stakeholder insight gathered throughout the project that points to a critical gap in the current ecosystem i.e., the UK has strengths in early-stage research and development, but the infrastructure required to demonstrate and scale biological processes to commercial production remains a barrier.

Feedstock mobilisation was estimated as contributing 9% growth in revenue and employment on average by 2030, and more effective government coordination was perceived as potentially adding 6% growth, reflecting the potential impact of coherent policy frameworks that span multiple government departments and align regulatory, innovation and industrial support mechanisms.

The gap between future revenue under the status quo and the highest impact scenarios amounts to a total of almost £0.5 billion in lost revenues to bio-based SMEs by 2030. This can be considered the opportunity cost of doing nothing.

Beyond the direct revenue impact, this lost activity would translate to forgone employment, reduced innovation, diminished competitive positioning and lost contributions to UK climate and sustainability objectives. Focused investments in scale-up infrastructure, feedstock systems and coordination mechanisms could yield notable economic returns.

6.3 Achieving cost parity with fossil counterparts

Reaching cost parity between bio-based and fossil-based industries will require a multifaceted approach that combines technological innovation, process integration, policy reform, and market-driven incentives. The challenge is not purely technical; it also depends on systemic coordination, scale and the creation of fair market conditions that account for environmental externalities. The key challenges associated with achieving cost parity are outlined below as evidenced by stakeholder engagement.⁹⁷

⁹⁷ Evidenced by stakeholder engagement via online survey. See [Annex II](#).

Table 4: Key challenges associated with bio-based products achieving cost parity with fossil-based alternatives.

	BARRIER
TECHNOLOGICAL AND PROCESS INNOVATION	Improved biological and catalytic efficiency: Development of robust microbial chassis, engineered enzymes and durable catalysts to increase yields, titres and conversion rates while reducing energy and raw material inputs. Enhanced metabolic and enzyme engineering, process intensification and co-product valorisation will drive higher productivity and lower operational costs.
	Advanced upstream and downstream processing: Feedstock pre-processing innovations – reducing the cost of collecting, separating and converting complex lignocellulosic materials (e.g., agricultural residues, wood waste) into standardised intermediates. Streamlined and continuous downstream processing (DSP) to match large-scale upstream productivity and reduce capital and energy intensity. Electrification of processes and adoption of AI-driven digital twins to optimise bioprocess design, integration and control for maximum efficiency.
	Flexible and continuous biorefineries: Implementation of flexible biorefinery systems capable of processing diverse, seasonal feedstocks using a mix of enzyme-based and environmentally friendly physical-chemical methods. Development of continuous production methods to ensure higher asset utilisation and lower unit production costs compared to batch processes.
FEEDSTOCK STRATEGY AND SUPPLY CHAIN INTEGRATION	Utilisation of low-cost, underutilised feedstocks: Exploiting local, low-value biomass and waste streams—including agricultural residues, forestry by-products and post-consumer waste plastics—can reduce raw material costs while promoting circularity. Securing feedstock supply year-round through integrated logistics and partnerships is critical for stable operations.
	Integration with existing industrial infrastructure: Co-locating biorefineries with existing industrial sites allows the use of waste heat, utilities and CO ₂ streams to reduce both cost and emissions.
	Retrofitting existing assets and linking biorefining processes with available infrastructure lowers capital requirements and accelerates scale-up.
SCALE-UP, DEMONSTRATION AND COLLABORATION	Access to scale-up facilities: Broader access to pilot and demonstration plants is essential for process optimisation and risk reduction before full-scale deployment. Linking UK biorefining scale-up centres through digital platforms could pool national expertise and infrastructure, enabling pre-validation of processes in silico.
	Academic-industry partnerships: Funding for collaborative R&D between academia and industry is crucial to translate laboratory successes into commercially viable technologies. Focused investment should target platform technologies and building block chemicals, avoiding direct competition with low-margin fossil commodities.
POLICY AND MARKET MEASURES	Creating a level playing field: Removing fossil fuel subsidies, adjusting tax and tariff structures and internalising carbon costs (e.g., through carbon taxation) will correct price distortions that currently disadvantage bio-based products. Transparent carbon accounting for bio and fossil feedstocks will highlight the true environmental costs and benefits of each.
	Incentivising bio-based markets: Public procurement policies should prioritise low-carbon and bio-based products, stimulating demand and de-risking early investments. Regulatory clarity on the use of genetically modified organisms (GMOs) and recognition of bio-based carbon value will support innovation and market growth.
	Driving fossil cost increase and bio market expansion: As fossil-based incumbents face stricter waste, carbon and pollution regulations, the relative competitiveness of bio-based products improves. Expanding high-value bio-based markets (specialty chemicals, materials, nutraceuticals) will enable profitable entry points before scaling to commodity sectors.
ENERGY AND SYSTEMS CONSIDERATIONS	Reducing energy costs – for example, through integration with SMR nuclear, fusion, or renewable sources – could have a significant impact on bio-based production economics.
	Integration of circularity principles and carbon capture within biorefineries can create negative-emission products, improving both environmental and financial performance.

A stakeholder interviewed as part of this project stated that:

“Achieving cost parity with fossil-based production won’t come from feedstocks alone – it depends on innovation across the entire bio-based value chain. Advances in fermentation technology, continuous bioprocessing, downstream processing and feedstock valorisation are essential to drive efficiency, lower costs and unlock the true potential of sustainable chemistry.”

VP, Large Corporate

6.4 The future of biorefining beyond the UK

Beyond the UK, international biorefining sectors are set to grow substantially in the future. Different regions have established specific targets and corresponding measures to achieve these ambitions, reflecting national priorities and resource endowments specific to certain geographies. A summary of biorefining in the US, EU, Brazil, India, Canada and others was presented in Section 5.4. The future of biorefining in these geographies is summarised below, in order to allow the UK to be compared with other locations.

For example, in the United States, the federal government has set an ambitious goal of producing 3 billion gallons of SAF each year by 2030 through its SAF Grand Challenge. Its long-term vision extend to meeting 100% of aviation fuel demand with SAF by 2050, whilst simultaneously reducing life-cycle greenhouse gas emissions of SAF by at least 50% relative to conventional jet fuel. Beyond aviation, the US seeks to expand low-carbon liquid fuels and the broader bioeconomy, emphasizing large-scale biomanufacturing and intensive use of biomass feedstocks. Achieving these goals is expected to create tens of thousands of jobs, with the Department of Energy projecting that over 70,000 jobs could be supported by the SAF value chain alone. The DOE has published a SAF roadmap outlining technical, regulatory and financial strategies, and the federal government is providing substantial loan guarantees for large-scale SAF projects, totalling nearly \$3 billion for select facilities. Additional economic incentives include tax credits for low-carbon fuels, and interagency monitoring that ensures that progress metrics, such as SAF capacity and emissions reductions, are tracked against targets.

In the European Union, biorefining ambitions are integrated within a broader strategy for creating a sustainable, circular bioeconomy. The EU Bioeconomy Strategy aims to expand bio-based industries while supporting climate neutrality by 2050, reducing dependence on fossil fuels and creating green jobs. Through the CBE JU, the EU is focusing on deploying innovative and sustainable solutions, including bio-based chemicals, materials and polymers, and on building first-of-a-kind industrial biorefineries that convert food waste or marginal land biomass into high-value products. The EU is also targeting increased SAF adoption in aviation under the ReFuelEU Aviation regulation, with blend mandates expected to rise in the coming decade. To further support these ambitions, the EU has committed substantial public-private funding through the CBE JU, amounting to approximately €2 billion, which intends to finance research, pilot projects and commercial-scale demonstration plants. The EU Bioeconomy Action Plan also lays out concrete measures, including strengthening bio-based sectors, establishing standards, mobilizing stakeholders, and ensuring sustainability and circularity. Complementary regulatory support comes from the European Green Deal, climate targets, and sector-specific directives that create a demand-pull for low-carbon fuels and bio-based products.

India’s biorefining strategy for the future centres on rapidly scaling bioenergy production to meet climate and energy goals while simultaneously supporting rural development and employment. The country aims to achieve twenty percent ethanol blending (E20) in petrol in the near-term and has set long-term plans for higher biofuel adoption, including a 5% biodiesel blending target by 2030. India is also targeting a 5% blending of compressed biogas in its transport and energy sectors by 2028, alongside the introduction of 2% jet fuel blending for international aviation by 2028. These goals are supported by a combination of policy measures, economic incentives,

and infrastructure programs. The National Policy on Biofuels establishes blending mandates, allows for feedstock diversification, including non-edible oils, used cooking oils and agricultural residues, and provides guidelines for biorefinery development. The SATAT programme, India's flagship biogas initiative, is facilitating the creation of a nationwide network of compressed biogas plants while ensuring a reliable supply of biomethane. To promote advanced technologies, India is implementing the Sustainable Integrated Biorefinery Mission in partnership with international collaborators, supporting research, development and demonstration of second-generation biofuels and bio-based products. In parallel, technical standards and logistics improvements are being introduced to ensure biomass collection efficiency and to prepare fuel distribution infrastructure for ethanol and CNG blending.

6.4.1 UK strengths compared to international geographies

What are the UK's strengths compared to international geographies? Stakeholders were asked in what areas could the UK differentiate itself from other countries. The results indicate several clear areas of perceived strength and opportunity for the UK's bioeconomy (Figure 16):

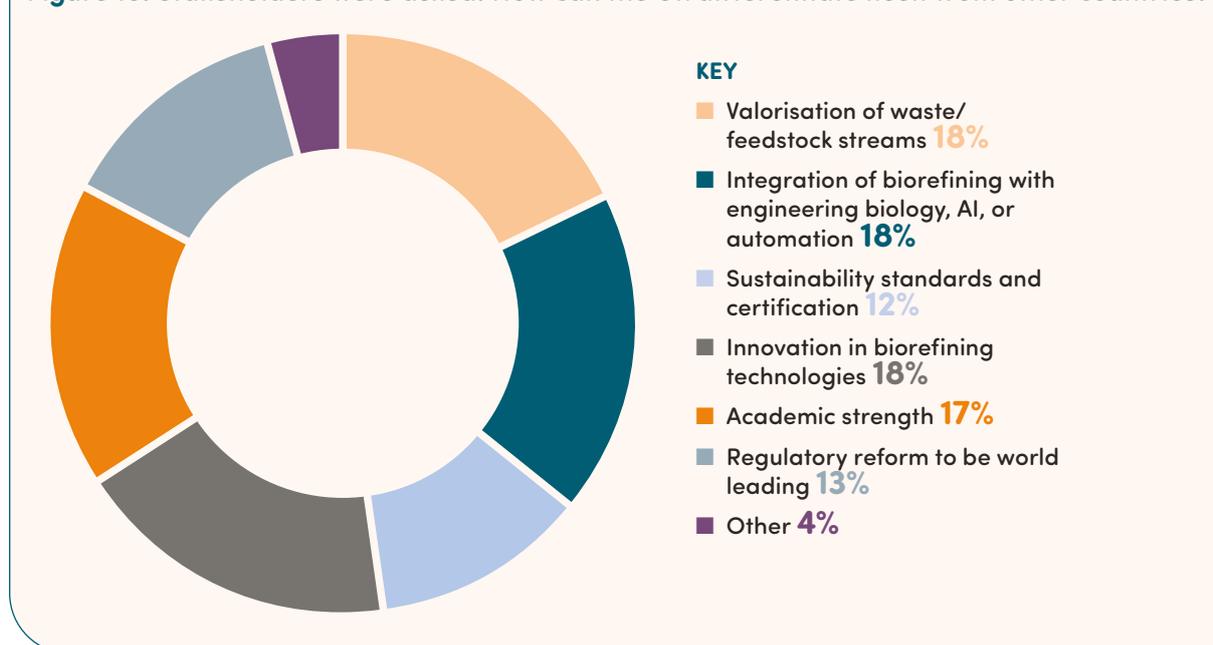
- **Valorisation of waste/feedstock streams (18%)** – Respondents see the UK's strong waste management systems, industrial symbiosis initiatives and circular economy policies as key enablers. The UK generates large volumes of diverse biogenic waste, and turning these into higher-value bio-based products could provide both environmental and economic advantage.

One stakeholder stated that:

“By leveraging second-generation biomass derived from waste, the UK has the opportunity to differentiate itself on the global stage. Instead of relying on conventional resources, it can transform agricultural residues, forestry by-products, and urban organic waste into high-value chemicals and sustainable materials. This approach not only addresses the challenge of waste management but positions the UK as a leader in circular bioeconomy innovation, turning what others see as refuse into strategic economic and environmental advantage.”

Professor of Green Chemistry, University.

- **Integration of biorefining with engineering biology, AI, or automation (18%)** – This reflects confidence in the UK's world-leading capabilities in synthetic biology, digital innovation and automation. Leveraging these strengths could make UK biorefineries more efficient, adaptive and globally competitive, enabling smarter process control and optimisation.
- **Innovation in biorefining technologies (18%)** – The UK's strong innovation ecosystem positions it well to lead in developing new processing technologies and integrated biorefinery models. This focus on innovation also reflects the need to overcome scale-up barriers that have historically constrained the sector.
- **Academic strength (17%)** – The UK's universities and research centres remain internationally recognised for excellence in biosciences, chemical engineering and materials research. This strong academic base provides a foundation for talent, collaboration and discovery-driven innovation across the biorefining value chain.
- **Sustainability standards and certification (13%)** – Respondents recognise growing global demand for traceability, verified sustainability claims and harmonised certification. The UK could differentiate itself by developing robust standards that build trust and facilitate international trade in sustainable bio-based products.
- **Regulatory reform to be world-leading (12%)** – There is awareness that clearer, more enabling regulation could accelerate investment and deployment. Respondents feel the UK has the chance to set progressive frameworks post-Brexit that align environmental, industrial and innovation goals – but also recognise that regulatory progress has been slower than desired.

Figure 16: Stakeholders were asked: How can the UK differentiate itself from other countries?

6.5 Section summary

After a decade of sustained investment and growth, the UK biorefining and wider bio-based sector is at an important juncture. While the sector has delivered strong revenues, skilled employment and internationally recognised success stories, recent evidence indicates mounting economic and structural pressures. Without targeted intervention, stakeholders anticipate a contraction of around 5% in revenue and employment over the next five years.

Survey evidence from bio-based businesses highlights that investment in scale-up infrastructure would deliver the greatest positive impact, with potential growth of up to 18%, followed by feedstock mobilisation (9%) and improved government coordination (6%). The gap between the status quo and the most ambitious intervention scenarios represents an estimated £0.5 billion in lost SME revenues by 2030, alongside forgone jobs, innovation and climate benefits.

However, achieving cost parity with fossil-based incumbents remains a central challenge. Addressing this challenge will require coordinated advances in process efficiency, feedstock strategy, energy integration and scale-up capability, supported by policy measures that create fair market conditions and recognise the carbon benefits of bio-based products. While the UK has strong research, innovation and waste valorisation capabilities, translation to commercial scale is constrained by high energy costs, fragmented infrastructure, limited patient capital and regulatory complexity.

International competitors, including the US, EU and India, are accelerating biorefining deployment through clear long-term strategies, mandates and large-scale public investment. In comparison, the UK's competitive strengths lie in waste and residue valorisation, engineering biology and digital integration, academic excellence, and the potential to establish world-leading sustainability standards and regulation.

Overall, the evidence suggests that the UK retains a strong foundation for leadership in biorefining, but decisive action is required to unlock growth, secure international competitiveness and realise the sector's contribution to economic resilience and net zero objectives. The next chapter outlines some key recommendations for such decisive action including strategic investment in scale-up infrastructure, coordinated feedstock systems and coherent policy and regulatory frameworks.

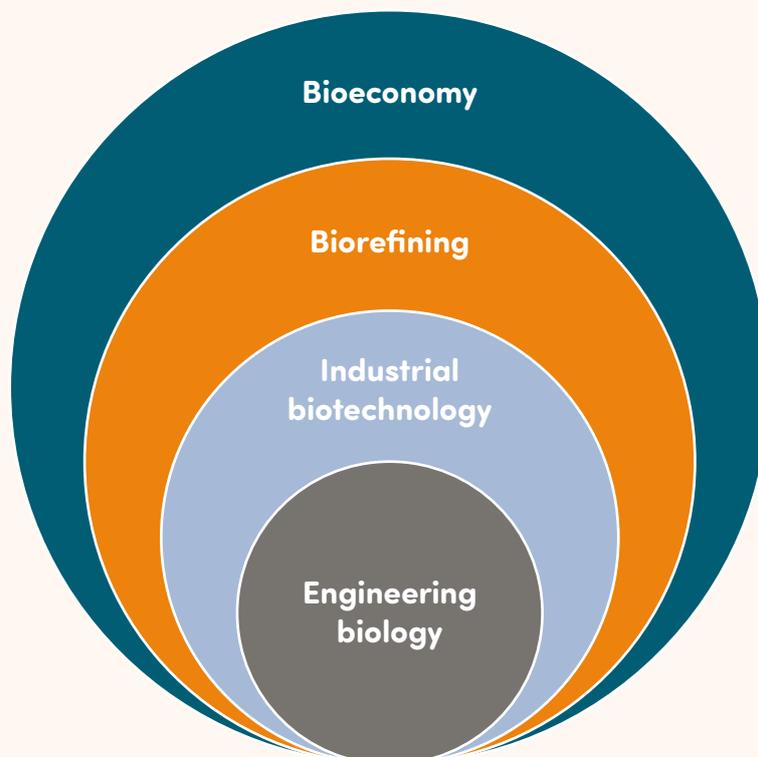
7. BIOREFINING SECTOR NEEDS FOR FUTURE GROWTH IN THE UK

7.1 Introduction

This chapter brings together key findings from the literature review (Chapter 4 and **Annex I**), stakeholder survey (Chapters 5 and 6 and **Annex II**) and economic analysis (Chapters 5 and 6 and **Annex III**) to present a set of recommendations that are considered key to the future of the biorefining sector and the factors needed to sustain its growth. Since the biorefining sector includes a diverse mix of stakeholders, recommendations in this report are directed toward the stakeholder groups best placed to implement them, i.e. businesses, science and innovation funders, and the UK Government.

As outlined in Chapter 1, the biorefining sector is a critical component of the wider bioeconomy. Industrial biotechnology is a key enabling technology within the biorefining space, and engineering biology is understood to fall within the remit of IB (Figure 17).

Figure 17: Visual illustration of how the biorefining sector relates to the broader bioeconomy and the industrial biotechnology and engineering biology technology areas.



The recommendations presented in this section consider the needs of the biorefining sector within the wider UK bioeconomy, whilst also drawing on IB as a key enabling technology within the biorefining sector. Biorefining cannot succeed in isolation, therefore to develop a flourishing sector, a successful bioeconomy and IB expertise is essential.

For the purposes of this study, the current report considers biomass biorefining as being defined as the development and application of innovative biological processes that transform renewable biomass resources into sustainable fuels, food ingredients, chemicals and materials. This definition reflects the growing recognition of biorefining as a cornerstone of the modern bioeconomy, offering a viable pathway to reduce dependence on fossil-based resources while delivering environmental, economic and societal benefits. In the context of this project, biorefining is framed in line with the interests and remit of BBNET, with a particular emphasis on industrial biotechnology as the core enabling process technology. This encompasses approaches such as fermentation and biocatalysis, as well as the integration of these biological methods with complementary disciplines to drive innovation and value creation.

7.2 Key recommendations

There are several overarching actions that should be adopted by all active stakeholders in the biorefining industry to contribute to sectoral growth. The recommendations in this section build on recommendations found in the reviewed historic literature and build on the stakeholder views gathered by survey and interview during the project. Additionally, the knowledge and insights gathered by the consultancy team in recent projects including the BB-REG-NET programme, have been used to inform the recommendations.⁹⁸

- **Alignment of industrial biotechnology with government target sectors** – The UK Government’s “Modern Industrial Strategy”, has identified 8 target sectors as key growth areas for the UK economy. The biotechnology industry should work with other industries and companies in these target sectors (e.g., clean energy industries, life sciences and advanced manufacturing) to ensure that industrial biotechnology demonstrates its applicability and commercial potential through cross-sectoral growth strategies.
- **Targeted research funding for IB** – While alignment with the UK’s broader national goals is important, it is also critical that targeted funding is encouraged to ensure that industrial biotechnology receives support to build and integrate its capabilities into supply chains.
- **Use UK’s industrial biotechnology capabilities to build global supply chains** – A key recommendation of the IB-IGT’s IB2025 report was for a coordinated approach to promotion of UK IB capability and infrastructure overseas. Many chemical and materials supply chains are already global, but it should be recognised that some capabilities need to be located in the UK for resilience reasons.
- **Skills and training for a developing IB sector** – Skills and training has consistently been an important goal for the IB sector, from the industry’s early development, through to the present day. Stakeholders consistently flagged skills and training as a critical need for an evolving sector. For example, a mixture of technical expertise across different IB areas, as well as interdisciplinary knowledge and business-oriented skills are necessary to support a successful IB sector.
- **Collaboration across stakeholder groups** – Effective collaboration is a fundamental part of growing a strong and harmonised biotechnology sector. Stakeholder engagement undertaken for this report outlined a need for effective collaboration both between different stakeholder groups within the biotechnology sector, and also with other sectors that operate within the supply chains that could benefit from the applications of biotechnology.

The recommendations outlined above should be acted on by all stakeholders active in the UK’s biorefining industry. Additionally, specific recommendations can be made for individual stakeholders to enable targeted actions across the sector. These recommendations are discussed below, considering the needs of the biorefining sector within the wider UK bioeconomy, whilst also drawing on IB as an enabling technology within the biorefining sector.

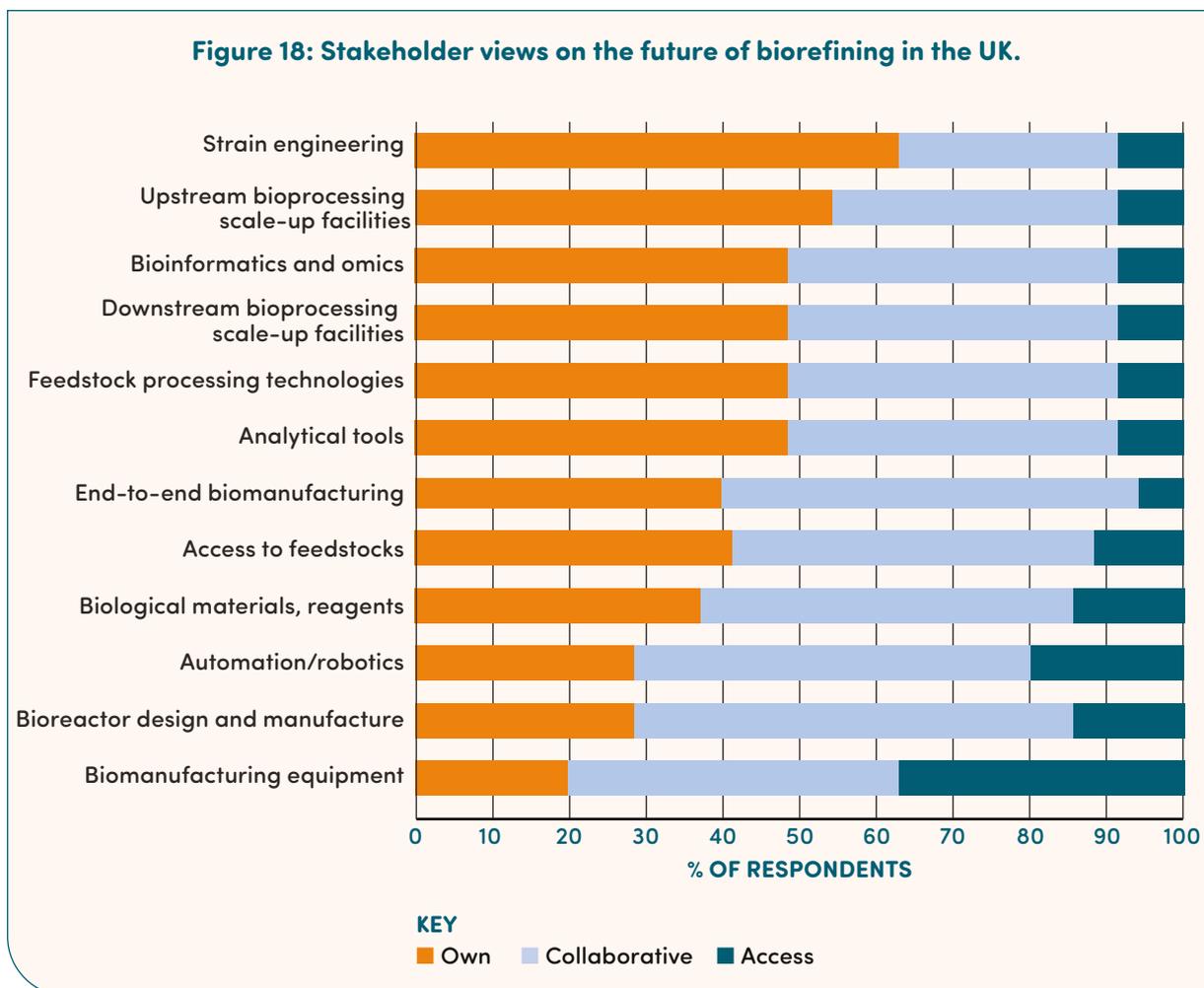
98 BB-REG-NET. URL: <https://bb-reg-net.org.uk/>

7.3 Stakeholder specific recommendations

7.3.1 Industry stakeholders

Industry stakeholders include commercial businesses operating within the biorefining sector, from start-ups and SMEs to large corporations. They form the backbone of a biorefining economy, validating innovation, developing bio-based products and processes, creating jobs, and ultimately generating economic value.

The importance of collaboration between businesses was a common theme that arose during stakeholder engagement. This was seen as being a critical need for the industry going forward. Figure 18 highlights different areas where stakeholders would preferentially operate on their own, collaboratively with other businesses, or by accessing infrastructure/facilities externally. It illustrates that, in most cases, collaboration between organisations is highly preferred.



Strategic partnerships between businesses can help to derisk technical and operational challenges. Collaborations across technology areas, as well as value chains, can result in combined knowledge and experience sharing, bringing together different perspectives on commercialising biorefinery processes (e.g. agri-food companies working in partnership with chemical companies, each bringing their own market knowledge and consumer reach to the collaboration).

Building and operating large biorefineries is challenging, both in terms of capital investment and operating costs. Many start-ups and university spin-outs in the biorefining sector are built by teams with scientific backgrounds and, despite considerable research and development

expertise, may lack experience of large-scale plant operations, such as process optimisation, regulatory compliance and supply chain management.⁹⁹

Business development through strategic partnerships with established corporations can be invaluable for start-ups seeking to commercialize new technologies. These partnerships provide access to important resources, such as technical expertise, research infrastructure and commercial opportunities using established distribution and sales channels. They also provide opportunities for knowledge transfer and joint problem-solving. By collaborating with experienced industry players, start-ups can accelerate their path to market, reduce financial and operational risks, and build credibility with investors and customers.

Industry recommendations to support the bioeconomy

- **Short-term:** Map **IB infrastructure** in the UK to support research efforts across the bioeconomy. Industry is aware of the infrastructure and capabilities available in the UK, but knowledge is spread across businesses in the sector. A tool mapping the infrastructure and capabilities could be used by all stakeholders to access and develop the facilities needed for growth. Such a tool would serve as a necessary precursor to closing gaps in UK IB infrastructure and would ultimately enable targeted support from funders and the government.
- **Medium-term:** Ensure **large corporates support SMEs through open innovation programmes**. This would be to share knowledge gained through years of corporate experience and product/technology development, as well as infrastructure and other technical capabilities. While this action would primarily benefit start-ups and small businesses across the bioeconomy, there would potentially be larger corporates and open innovation collaborations who would also benefit, as they will be at the forefront of new research and innovation, and helping to create new business-to-business partnerships once SME businesses begin to flourish.
- **Long-term:** Ensure that industry stakeholders adhere to **industry standards** as these exist to support the bio-based industries. The adoption of many standards¹⁰⁰ has historically been low, as they are neither a legal/regulatory requirement, nor beneficial financially. The benefits to industry of implementing standards for bio-based products and processes could be more actively encouraged. Although there may be more that government could do in terms of developing regulation to encourage market pull, it is ultimately up to industry stakeholders to understand and act on the opportunities that standards offer. Implementing standards can enhance consumer confidence, ensure a more unified perception of quality and encourage more consistent terminology across the industry.

Recommendations for industry to support biorefining

- **Short-term: Prioritise UK business ventures** i.e., building UK based supply chains for national resilience. Regardless of economic factors, businesses in the UK can choose to manufacture in the UK, source UK feedstocks and supply to UK markets. While government would ideally provide incentives to encourage this, ultimately industry is the stakeholder responsible for building UK specific supply chains. Examples of key bio-based products that could be produced in the UK to contribute to resilience include raw materials, chemical intermediates, biomethane, etc. This is a key recommendation of the withdrawn Bioeconomy Strategy,¹⁰¹ but remains critical today.

99 First Bight Ventures, The Industrial Biomanufacturing Graveyard, 2025.

100 BSI, Industrial biotechnology, Strategic roadmap for standards and regulations. URL: <https://static1.squarespace.com/static/68adbc3e3a06800fc02f97dd/t/68e51c24d05ed141c67a35f8/175984541290/BSI-industrial-biotechnology-strategic-roadmap-for-standards-and-regulations-FINAL.pdf>

101 HM Government, Department for Business, Energy and Industrial Strategy. Growing the Bioeconomy. URL: https://assets.publishing.service.gov.uk/media/61a60c91d3bf7f055b2934cf/181205_BEIS_Growing_the_Bioeconomy__Web_SP_.pdf

- **Medium-term:** Seek new collaborative research initiatives that deliver tangible advances in the development of **digital materials passports across sectors** including sustainable packaging and bio-based chemicals. As is the case for standards (above), digital passports could help to improve market confidence in bio-based products for consumers and demonstrate to government that biorefining is an effective and sustainable means of meeting policy aspirations e.g., net zero targets.
- **Long-term:** A coordinated effort is needed in order to drive biorefining efforts forward. **Trade bodies** active in the biorefining sector should **collaborate and regularly engage with business** and **act as the overarching voice for the sector**, rather than offering fragmented views of sector needs.

Industry recommendations to support industrial biotechnology

- **Short-term:** Encouraging the **mobilisation of investment funds** is critical for further growth in the sector. Investors and businesses should continue to come together, share information, network and explore investment opportunities. The current report found a recommendation in the 2010 IB-IGT report to be still valid.¹⁰² The IB-IGT report recommended that leadership/investor forums would be responsible for raising awareness in the private and public sectors regarding the capabilities and potential of IB, as well as leading on the long-term development and promotion of IB into new and existing supply chains.
- **Medium-term:** Being **open to innovation** and signalling a clear intention to academia and research that collaboration is desired and necessary to drive growth in IB. Trade bodies should work with the Department for Business and Trade to develop new initiatives that enable UK SMEs to get innovative products to international markets more quickly and more often.
- **Long-term: Support the regeneration of existing infrastructure clusters** (e.g., Grangemouth and Wilton) which would encourage IB sector growth by addressing gaps in resources, connectivity and expertise. Such regeneration of existing infrastructure would promote collaboration between companies, academia and government; allow for upgrading facilities and infrastructure; and facilitate access to funding and talent.

The specific recommendations for industry stakeholders summarised in this section can be summarised in Table 5 as follows:

¹⁰² IB 2025 Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy: A report to government by the Industrial Biotechnology Innovation and Growth Team. 2010.

Table 5: Short-, medium- and long-term recommendations for industry stakeholders.

INDUSTRY	SHORT-TERM	MEDIUM-TERM	LONGER-TERM
BIOECONOMY	Partner with UKRI to build a complete and accurate map of the UK's IB and EB infrastructure and assets , to highlight where knowledge gaps exist – whether in equipment, facilities, expertise, regional distribution, or data availability – and develop targeted interventions to close those gaps.	Large corporations should increase levels of investment in innovation and commercialisation activity , ¹⁰³ whether through in-house later-stage collaborative research, or investment in innovative SMEs that can accelerate growth and provide access to fresh ideas, emerging technologies and agile ways of working.	Leverage current industry standards to promote best practice, efficiency, and compliance. Actively shape future standards working with industry bodies, regulators and stakeholders to ensure that new methodologies, technologies and data requirements are aligned.
BIOREFINING	Invest in the creation and reinforcement of UK supply chains to boost national resilience, by supporting domestic producers, improving logistics infrastructure and encouraging regional collaboration to reduce dependency on fragile global supply networks.	Participate in new collaborative research initiatives that can deliver tangible advances in the development of digital materials passports ¹⁰⁴ across sectors including sustainable packaging and biochemicals.	Maintain strong engagement with trade bodies , to contribute to standard-setting, share best practices, access networking and funding opportunities, and ensure their voices are represented in policy discussions and industry initiatives. ¹⁰⁵
IB SECTOR	Work with industry associations to raise the profile of investment opportunities, bring together investor forums and create platforms where businesses, investors, and stakeholders can network, share insights and explore funding opportunities. ¹⁰⁶	Trade bodies should work with the Department for Business and Trade to develop new initiatives that enable UK SMEs to get innovative products to international markets more quickly, and more often.	Support the regeneration of regional industry clusters ¹⁰⁷ by addressing gaps in resources, connectivity and expertise. This includes promoting collaboration between companies, academia and government; upgrading facilities and infrastructure; and facilitating access to funding and talent.

103 UK Government. The UK's Modern Industrial Strategy. 2025. URL: https://assets.publishing.service.gov.uk/media/68595e56db8e139f95652dc6/industrial_strategy_policy_paper.pdf.

104 UK Government. The UK's Modern Industrial Strategy. 2025. URL: https://assets.publishing.service.gov.uk/media/68595e56db8e139f95652dc6/industrial_strategy_policy_paper.pdf.

105 UK Government. The UK's Modern Industrial Strategy. 2025. URL: https://assets.publishing.service.gov.uk/media/68595e56db8e139f95652dc6/industrial_strategy_policy_paper.pdf.

106 UK Government. The UK's Modern Industrial Strategy. 2025. URL: https://assets.publishing.service.gov.uk/media/68595e56db8e139f95652dc6/industrial_strategy_policy_paper.pdf.

107 UK Government. The UK's Modern Industrial Strategy. 2025. URL: https://assets.publishing.service.gov.uk/media/68595e56db8e139f95652dc6/industrial_strategy_policy_paper.pdf.

7.3.2 UK innovation funders

A report for BBSRC found that around £413 million, including £42.4 million in co-funding from EPSRC and Innovate UK, was invested in UK biorefining over a ten-year period (2010/11 to 2020/21).¹⁰⁸ But the House of Lords Science and Technology Committee recently pointed out that the public investment landscape for science and technology growth remains fragmented, overly complicated and small in scale.¹⁰⁹ The UK Government has stated that part of the role of public sector investment bodies such as Innovate UK, the British Business Bank (BBB) and the National Wealth Fund (NWF) is to support scale-up for science and technology companies and to crowd in private sector finance.¹¹⁰ To provide a clear pipeline of support, Innovate UK, the British Business Bank and the National Wealth Fund must therefore work closely together, aligning on priority research areas and companies, with direction set by the Industrial Strategy.

The House of Lords Science and Technology Committee further recommended that each of Innovate UK, the British Business Bank and the National Wealth Fund should track successful referrals (for example, from a successful Innovate grant to scale-up funding via the British Business Bank) as a key performance indicator. Each should simplify and scale up their offers and provide clear guidance.¹¹¹ The House of Lords Committee also suggested that to achieve a properly integrated, diversified and well-resourced public investment landscape, the various government lending and investing bodies could be consolidated, including Innovate UK. A more consolidated structure would allow the relevant bodies to act more strategically, benefit from diversification and risk aggregation, and provide pooled expertise and continuity of support, reducing the overall complexity the UK funding system.

Recommendations to funders to support the bioeconomy

- **Short-term:** Provide **ongoing financial support** to facilitate knowledge dissemination and help overcome policy barriers that hinder innovation and collaboration (e.g., BB-REG-NET).
- **Medium-term:** Stimulate the bioeconomy through the **support of regional initiatives** (e.g., BioYorkshire and Project Willow). Historically, reports outlined the need for regional clusters as focussed support; making use of local resources, geographies and infrastructure can result in more tailored and effective support than overarching nationwide support. This can boost local economies and promote the creation of jobs. There is evidence that support for local clusters (e.g., the Scottish bioeconomy) has generated good results in boosting the bioeconomy. In support of this, stakeholders interviewed for the current report identified this as an important intervention.
- **Long-term: Consider how the UK bioeconomy could be supported through public-private partnerships** such as Europe's CBE-JU. The creation of CBE-JU has led to a risk that the UK will lose innovative manufacturing opportunities to Europe, unless similar incentives are created to ensure that innovations developed in the UK are scaled up and commercialised here. This was flagged during the stakeholder interviews as the UK has no clear mechanism for funding the scale up of pilot or larger scale biorefining demonstrations. Lessons from public-private partnerships like CBE-JU could inform similar UK initiatives designed to deliver on the UK's Net Zero and Industrial Strategy objectives. Support in the UK should specifically aim to fund flagship plants as first of a kind commercial scale facility.

108 BBSRC. Evaluating BBSRC investments in industrial biotechnology research. 2024. URL: <https://www.ukri.org/publications/evaluating-bbsrc-investments-in-industrial-biotechnology-research/>

109 House of Lords, Science and Technology Committee, 2nd Report of Session 2024–2, Bleeding to death: the science and technology growth emergency. URL: <https://publications.parliament.uk/pa/ld5901/ldselect/ldsctech/192/192.pdf>

110 UK Government. The UK's Modern Industrial Strategy. 2025. URL: https://assets.publishing.service.gov.uk/media/68595e56db8e139f95652dc6/industrial_strategy_policy_paper.pdf

111 House of Lords, Science and Technology Committee, 2nd Report of Session 2024–2, Bleeding to death: the science and technology growth emergency. URL: <https://publications.parliament.uk/pa/ld5901/ldselect/ldsctech/192/192.pdf>

Funder recommendations to support biorefining

- **Short-term:** Historically, the IB-IGT recommended that the Government should improve access to demonstration funds by **broadening the remit of existing commercial-scale demonstration funds to ensure that IB is included within the scope of eligible technologies**.¹¹² Stakeholders surveyed for the current project confirmed that this remains a priority today, and flagged the need for EB infrastructure funding committed by the UK government to also cover funding for bio-based chemicals at a pilot/demo phase.
- **Medium-term:** Provide **financial support to enable SMEs to access scale-up support and infrastructure**. A key theme arising from the stakeholder engagement was that support typically exists for early-stage research and development, but as innovations develop, support becomes less visible and available. This recommendation originally stemmed from the IB-IGT recommendations that an IB fund (of £2.5–5 million per year for 3–5 years) should be established by the end of 2009 to allow industry, particularly SMEs, access to demonstration facilities.¹¹³ This however remains a priority.
- **Long-term:** Continue to **invest in feedstock innovation**, through developing new feedstocks, which are high yielding and functional (such as being drought tolerant). **Long-term funding**, in the form of a **biomass innovation programme**, i.e. continuing the research of the Biomass Connect programme, would help to significantly boost biorefining in the long-term by ensuring that feedstocks are readily accessible. This is a finding from stakeholder engagement for the current project where concern was expressed regarding the potential future supply of feedstocks.

Funder recommendations to support IB

- **Short-term:** Supporting **the communities and networks developed in IB over the past decade**, for example, a continuation of NIBB support would allow the continuation of the effective networking and collaboration demonstrated over the last 10 years. The NIBB, each with their own specific focus areas within the IB/EB space, allowed for specialists to come together, expand on knowledge and create a space for focussed support. The NIBB achieved huge success over the past 10 years,¹¹⁴ resulting in not only innovation support but the development of community in this space, which is seen as a critical factor in bringing together the right companies/persons/technologies/ideas to promote further growth. This recommendation was outlined in BBSRC's finance review report,¹¹⁵ and stakeholders interviewed also expressed these views.
- **Medium-term:** Implement **funding for IB in the form of an IB Catalyst-style programme**. The historical success of the IB catalyst provided funding support for projects in this area across a range of scales and project types. Funding of this nature can provide a pipeline of projects travelling from lower technology readiness to the point where pilot and demonstration trial could be undertaken. The ability of the IB Catalyst to provide the length of project funding required to bring technology to maturity which enables the formation of start-up or spin-out companies has also been demonstrated. This recommendation was originally made by the IB-IGT "IB2025" report,¹¹⁶ but stakeholders surveyed for the current project continued to express support for this initiative and have called for its return.

112 IB 2025 Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy: A report to government by the Industrial Biotechnology Innovation and Growth Team. 2010.

113 IB 2025 Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy: A report to government by the Industrial Biotechnology Innovation and Growth Team. 2010.

114 Biomass Biorefinery Network: Impact report. 2026. URL: <https://www.bbnet-nibb.co.uk/wp-content/uploads/2026/02/BBNet-Impact-report-2019-2026.pdf>

115 BBSRC. Evaluating BBSRC investments in industrial biotechnology research. 2024. URL: <https://www.ukri.org/publications/evaluating-bbsrc-investments-in-industrial-biotechnology-research/>

116 IB 2025 Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy: A report to government by the Industrial Biotechnology Innovation and Growth Team. 2010.

- **Long-term:** Encourage the systematic **sharing of unsuccessful projects** to prevent the duplication of research efforts and accelerate learning across the sector. This recommendation was identified through stakeholder engagement for the current project.

The specific recommendations for funders can be summarised in Table 6 as follows:

Table 6: Short-, medium- and long-term recommendations for funders.

FUNDERS	SHORT-TERM	MEDIUM-TERM	LONGER-TERM
BIOECONOMY	Provide ongoing financial support to facilitate knowledge dissemination and help overcome policy barriers that hinder innovation and collaboration.	Support local initiatives that strengthen regional capabilities, foster collaboration and address specific community or industry needs. This support can take the form of grants, mentoring, or infrastructure investment, helping smaller projects grow and have a broader impact.	Support project scale-up by funding larger-scale initiatives , taking inspiration from programs like the EU Circular Bio-based Europe Joint Undertaking (CBE-JU).
BIOREFINING	Funding and support for EB infrastructure should also include the wider biorefining sector and not be limited to narrow applications of the current EB definition.	Offer targeted funding to help SMEs access existing infrastructure , such as labs, pilot plants, or specialised equipment.	Offer targeted support for biomass innovation programs , including research, pilot projects and commercialisation initiatives.
IB SECTOR	Support existing networks and communities developed over past decade through continued support for NIBB.	Ensure backing for IB Catalyst-style programs that enable early-stage and high-potential industrial biotechnology projects to develop, commercialise and scale.	Encourage the systematic sharing from unsuccessful projects to prevent duplication of research efforts and accelerate learning across the sector.

7.3.3 UK Government

Recommendations to Government to support the bioeconomy

- **Short-term: Support and develop standards and metrology**, in alignment and partnership with industry. Defined terms and rules for bio-based product use and manufacturing will provide more transparency across the sector, encourage market pull and thus, help the sector to grow. At present, standards are not widely used across the sector, and while this is a responsibility of industry, there is also a role for Government.
- **Medium-term:** Help to support the wider bioeconomy through the **public procurement of bio-based products, especially in single use applications** e.g., NHS product procurement.
- **Long-term:** designate a **specialised team** to deal with the use of biomass as a resource in the form of a “Bioeconomy Delivery Council”. The aim of the responsible party would be to monitor the sector, including initiatives such as the development of a Biomass Hierarchy, a National Bioeconomy Plan and a Land Use Strategy, to be reviewed every five years. This unit or group should have ministerial oversight to provide accountability, lend a voice to the sector and allow for sector targeted actions to be delivered by the government. This recommendation was originally suggested by the IB-IGT which stated that “IB is considered as a value-creating demand factor when developing a strategy for managing sustainable land use in the context of intensification of demand for all purposes.” This recommendation was further highlighted as a need by 2025 stakeholders.

Government recommendations to support biorefining

- **Short-term:** Conduct a **review of waste regulations for the use of wastes as feedstocks**, including a thorough review of how wastes are classified when used as feedstocks in industrial processes. This should consider regulatory definitions, environmental impact, safety and technical suitability, with the aim of facilitating innovation, ensuring compliance and promoting sustainable resource use.
- **Medium-term: Maintain mapping and statistics around feedstock availability** to provide visibility, as well as confidence in feedstock supply for users well into the future. Stakeholders interviewed for this project identified biomass via a critical tool to enable feedstock mobilisation.
- **Long-term:** Provide **'demonstration and first of a kind' funding** for biorefining technologies through the British Bank and National Wealth Fund.

Government recommendations to support IB

- **Short-term:** Carry forward the unaddressed recommendation made by the IB-IGT,¹¹⁷ that any new business support schemes should be defined in a way that does not exclude or impede IB, and that existing funding schemes that may unintentionally exclude or marginalise IB be modified to remove this blockage. Stakeholders interviewed for this project outlined that the Government could provide confidence to the sector by **confirming that IB is fully integrated within the engineering biotechnology** funding committed as part of the Modern Industrial Strategy, which would in turn drive growth in the wider bio-based industries.
- **Medium-term:** Assess **the role of EB and IB as enabling technologies across all Industrial Strategy-8 (IS-8) sectors**. Such an assessment would create drive, clarity and incentives for EB/IB across all Industrial Strategy targets.
- **Long-term: Clarify that £380 million of EB investment will also encompass long-term IB projects**, providing the financial stability needed to advance ambitious research, scale-up technologies, and strengthen the UK's industrial biotechnology ecosystem.

The specific recommendations for Government can be summarised in Table 7 as follows:

¹¹⁷ IB 2025 Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy: A report to government by the Industrial Biotechnology Innovation and Growth Team. 2010.

Table 7: Short-, medium- and long-term recommendations for government.

GOVERNMENT	SHORT-TERM	MEDIUM-TERM	LONGER-TERM
BIOECONOMY	Partner with industry on use and development of standards and metrology to enhance product reliability, facilitate collaboration and reduce technical barriers.	Support sustainable innovation and drive demand for the bioeconomy through prioritising the use of bio-based products in public procurement , such as within the NHS.	Develop a National Bioeconomy Plan , reviewed every five years, and monitored by the cross-government Bioeconomy Delivery Council .
BIOREFINING	Review of waste classifications when used as feedstocks in industrial processes. This should consider regulatory definitions, environmental impact, safety, and technical suitability, with the aim of facilitating innovation, ensuring compliance, and promoting sustainable resource use.	Identify and close gaps in biomass mapping for feedstock mobilisation .	Accelerate commercialisation and reduce investment risk by linking demonstration and first-of-a-kind (FOAK) project funding to financial support from the British Business Bank and National Wealth Fund (NWF).
IB SECTOR	Promote alignment, efficiency and sector growth by ensuring that industrial biotechnology (IB) initiatives are fully incorporated within engineered biology (EB) funding programmes .	Identify opportunities for innovation, efficiency and sustainable growth by assessing the contribution and potential of engineered biology (EB) and industrial biotechnology (IB) across all eight IS-8 sectors .	Provide the financial stability needed to advance ambitious research, scale-up technologies and strengthen the UK's industrial biotechnology ecosystem by ensuring that the scope of the £2 billion of EB investment effectively includes IB projects .

8. CONCLUSIONS

Over the past decade, the UK's biorefining sector has evolved from a nascent research-driven field into an increasingly important component of the bioeconomy. Public investment, notably through BBSRC's £413 million commitment and initiatives such as the IB Catalyst and NIBB networks, has delivered significant returns in intellectual property, spin-outs and collaborative research. These efforts have positioned the UK as a global leader in industrial biotechnology research and innovation, with strong academic capabilities and regional clusters, such as Scotland and Yorkshire, driving progress.

However, despite these achievements, the sector faces systemic challenges that threaten its ability to scale and compete internationally. Economic analysis and stakeholder engagement reveal that revenue growth and company formation peaked in 2021 but have since declined, accompanied by a cooling of investor confidence and reduced fundraising activity. These trends underscore structural weaknesses in the UK's research-to-commercialisation pipeline, particularly in scale-up infrastructure, feedstock mobilisation and regulatory clarity. Without targeted intervention, the sector risks contraction of ~5% in revenue and employment over the next five years, forfeiting an estimated total of £0.5 billion in SME revenues and associated climate benefits.

8.1 Scope and definitions

For the purposes of this study, the current report considers biomass biorefining as being defined as the development and application of innovative biological processes that transform renewable biomass resources into sustainable fuels, food ingredients, chemicals and materials. This definition reflects the growing recognition of biorefining as a cornerstone of the modern bioeconomy, offering a viable pathway to reduce dependence on fossil-based resources while delivering environmental, economic, and societal benefits. In the context of this project, biorefining is framed in line with the interests and remit of BBNet, with a particular emphasis on industrial biotechnology as the core enabling process technology. This encompasses approaches such as fermentation and biocatalysis, as well as the integration of these biological methods with complementary disciplines to drive innovation and value creation.

Although included within the wider definition of biorefining, it is important to note that for the purposes of this report thermal and thermochemical processing of biomass (including methods such as pyrolysis and gasification) fall outside the scope of this study. While these approaches represent significant areas of activity within the wider biorefining sector and bioeconomy, the focus in this report remains on biologically driven solutions, consistent with BBNet's mission and strategic priorities – as defined by the remit of the funding received from the BBSRC.

It is acknowledged that such a defined scope potentially limits the initiatives, challenges and opportunities that this report can explore within the wider biorefining sector. It means that:

- the claims made in this report about existing and planned research and commercial facilities/activities reflect only part of the progress that has been made and is ongoing in the sector;
- the recommendations in this report focus on progressing UK biotechnology for biorefining, and may not necessarily benefit other areas of biorefining, or even integrated biorefineries;

- the report presents a set of recommendations for the biorefining sector that should be considered alongside other technological approaches, that have not been addressed in this report.

8.2 Key findings: opportunities and challenges

Biorefining is a key component of the UK's transition to a net zero economy. By converting renewable and waste feedstocks into fuels, chemicals and materials, biorefining offers a pathway to decarbonise hard-to-abate sectors, such as aviation, and to defossilise chemicals, plastics and other advanced materials. It also strengthens national resilience by reducing reliance on imported fossil resources and creating skilled employment in high-value manufacturing.

The UK's key competitive strengths lie in:

- **Academic excellence and innovation ecosystems** – providing a strong foundation for discovery and collaboration.
- **Integration with engineering biology and digital technologies** – capitalising on world-leading expertise in synthetic biology, AI and automation.
- **Waste and residue valorisation** – leveraging robust waste management systems and circular economy policies.
- **Potential for progressive sustainability standards and regulatory reform** – enabling differentiation in global markets.

These advantages, however, will only translate into global leadership if structural barriers are addressed and long-term policy certainty is established.

Throughout the course of this project, stakeholder engagement identified five dominant barriers, still currently facing the sector:

- **Cost and profitability** – Bio-based products remain more expensive than fossil incumbents due to high energy costs, downstream processing complexity and process inefficiencies.
- **Market confidence** – Absence of binding targets, procurement mandates and clear standards undermines demand signals and investor confidence.
- **Feedstock mobilisation** – Limited visibility of national biomass resources, high prices, seasonal variability and competition from sectors such as SAF constrain supply.
- **Innovation and scale-up support** – While early-stage research is well-funded, access to pilot and demonstration facilities declines sharply beyond TRL 6, creating a “valley of death” for commercialisation.
- **Regulatory fragmentation and trade challenges** – Outdated frameworks, lengthy approval processes and a lack of harmonised sustainability standards impede market entry and global competitiveness.

These barriers are not new with many first highlighted in the IB2025 report over a decade ago. However, their persistence reflects a critical need for systemic reform and coordinated action across government, industry and funders.

Global competitors are also accelerating biorefining deployment through bold strategies and large-scale investment. For example, the US Inflation Reduction Act and the EU's Circular Bio-Based Europe Joint Undertaking exemplify integrated approaches combining fiscal incentives, infrastructure funding and regulatory clarity. These measures have catalysed billions in private investment, created guaranteed markets and supported flagship commercial-scale biorefineries.

In contrast, the UK's fragmented policy landscape and limited scale-up funding risks driving domestic innovations abroad – a trend which is already evident in companies such as Lixea and Azotic Technologies who have relocated their scale operations to the EU and US respectively. Without decisive intervention, the UK faces further erosion of its competitive position in the IB space and risks loss of the economic and environmental benefits that biorefining can offer.

8.3 Key recommendations

Based on the views and insights collected from stakeholders, this report points to three possible high-impact interventions:

- **Investment in scale-up infrastructure** – Establish shared pilot and demonstration facilities, linked through a national network, to de-risk commercialisation and accelerate technology deployment.
- **Feedstock mobilisation** – Develop a national biomass map, secure long-term supply agreements, and invest in feedstock innovation to ensure affordable, sustainable inputs.
- **Government coordination and policy certainty** – Create a dedicated biorefining body to align strategies across departments, streamline regulations, and leverage public procurement to stimulate demand.

These measures could unlock up to 18% growth in revenue and employment by 2030, compared to a potential projected decline under the status quo. In order to realise the sector's full potential, coordinated action is therefore required across all key stakeholder groups.

- **Industry** – Should look to prioritise UK-based supply chains, adopt standards and engage in collaborative research initiatives to build resilience and market confidence.
- **Funders** – Should provide targeted support for scale-up, regional clusters and IB Catalyst-style programmes to sustain innovation pipelines.
- **Government** – Should deliver regulatory reform, integrate IB and EB within Industrial Strategy funding, and establish a bioeconomy delivery body to monitor progress and drive accountability.

Table 8: Summary of key recommendations for industry, funders and Government stakeholders.

	INDUSTRY	SHORT-TERM	MEDIUM-TERM	LONGER-TERM
INDUSTRY	Bioeconomy	Cooperation between industry players to map the UK's IB and EB infrastructure and assets. Potentially led by industry body.	Large corporates should increase levels of investment in innovation and commercial activities.	Leverage current industry standards to promote best practice, efficiency and compliance.
	Biorefining	Invest in the creation and reinforcement of UK supply chains.	Participate in new collaborative research initiatives.	Maintain strong engagement with trade bodies.
	IB sector	Work with industry associations to raise the profile of investment opportunities.	Trade bodies should work with DBT to develop new industry initiatives.	Support the regeneration of regional industry clusters.
FUNDERS	Bioeconomy	Provide ongoing financial support to companies across the bioeconomy.	Support local initiatives that strengthen regional capabilities and foster collaborations.	Support project scale-up by funding larger-scale initiatives.
	Biorefining	Funding and support for EB should also include the wider biorefining sector.	Offer targeted funding to help SMEs access existing infrastructure.	Offer targeted support for biomass innovation programmes.
	IB sector	Support existing networks and communities (e.g., NIBB).	Ensure backing for IB Catalyst-style programs.	Encourage systematic sharing from unsuccessful projects in the IB sector.

	INDUSTRY	SHORT-TERM	MEDIUM-TERM	LONGER-TERM
GOVERNMENT	Bioeconomy	Use and development of standards and metrology.	Prioritise the use of bio-based products in public procurement.	Develop a National Bioeconomy Plan.
	Biorefining	Review of waste classifications for use as feedstocks.	Identify and close gaps in biomass mapping for feedstock mobilisation.	Link demonstration and first-of-a-kind (FOAK) project funding to financial support.
	IB sector	Ensure IB initiatives are fully incorporated within EB funding programs.	Identify opportunities for IB innovation across all IS-8 sectors.	Direct some EB investment toward long-term IB projects.

The UK stands at a crossroads. It possesses world-class research, strong regional capabilities, and proven commercial successes. Yet, without bold and coordinated action, these strengths risk being overshadowed by structural weaknesses and international competition. Biorefining is not only an industrial opportunity, but also a strategic imperative for achieving net zero, enhancing economic resilience, and securing global leadership in sustainable manufacturing.

By investing in infrastructure, mobilising feedstocks, and delivering coherent policy frameworks, the UK can unlock the full potential of its bioeconomy, creating green jobs, driving innovation, and positioning itself as a global leader in the transition to a low-carbon future.

However, looking ahead, it is important to acknowledge that the scope of this report has been intentionally focused on IB-led biorefining, consistent with BBNets research remit. As a result, thermal and thermochemical pathways, wider biomass-to-energy systems, and wholesector feedstock prioritisation have not been assessed in detail in this report. Therefore, to build on the findings presented here, a set of recommended next steps should therefore include a broader, crosstechnology evaluation of UK biomass use, improved wholesystem feedstock mapping, and integrated analysis of how biological, thermochemical, and hybrid biorefining routes can collectively support the UK's netzero and industrial strategy goals. These actions would ensure that future policy and investment decisions are informed by a comprehensive, systemwide understanding of the UK's biorefining landscape.

9. ANNEXES

9.1 Biorefining landscape review (Alder BioInsights)

9.2 Stakeholder perspectives (Frey Consulting)

9.3 Economic analysis (Perspective Economics)

Disclaimer

While Alder BioInsights considers that the information and opinions given in this work are sound, all parties must rely on their own skill and judgement when making use of it. Alder BioInsights will not assume any liability to anyone for any loss or damage arising out of the provision of this report.

Alder BioInsights is a leading international consultancy with expertise on the conversion of biomass to bioenergy, biofuels and bio-based products.

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