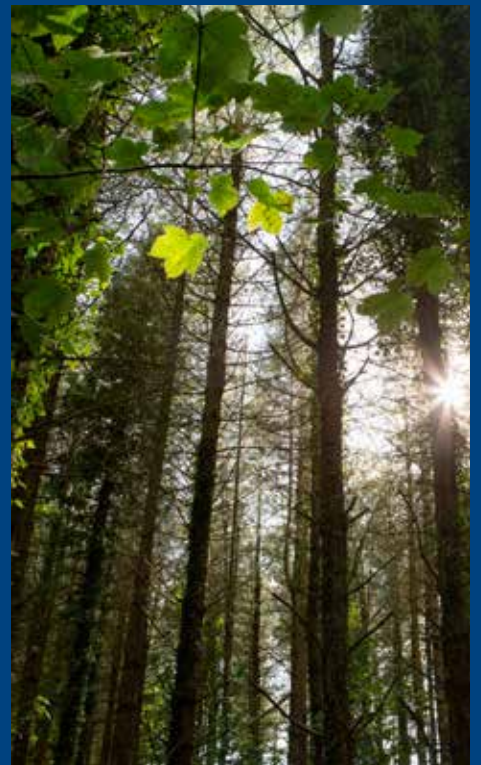


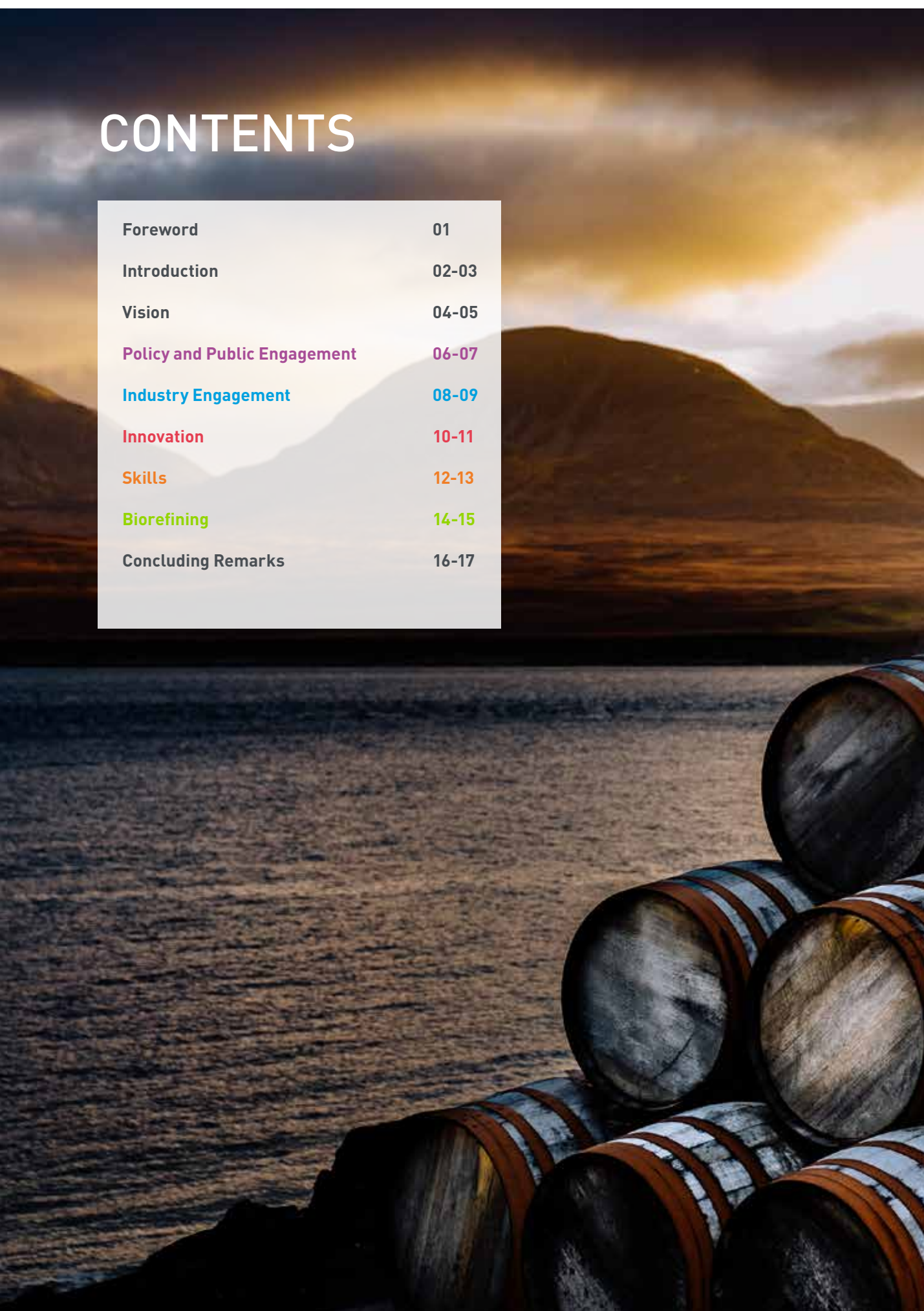
National Plan for Industrial Biotechnology

Driving Progress to 2025



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FOREWORD



Scotland's Economic Strategy prioritises boosting investment and innovation to create a strong, vibrant and sustainable economy. Industrial Biotechnology underpins innovation across a range of sectors to boost prosperity through 'green' growth and has the potential to be transformational when considering this aim.

I am proud that Scotland is a world leader in the circular economy. Industrial Biotechnology can help us maintain this by providing a means to manufacture chemicals, pharmaceuticals, consumer products, and many other materials, that uses innovative processes and sustainable raw materials with a reduced carbon footprint – supporting our transition to a low-carbon future.

In 2013, Scotland launched the National Plan for Industrial Biotechnology which set out ambitious targets of a £900m turnover and over 200 companies active in industrial biotechnology by 2025. Since setting out these targets we have seen great success with the industry growing from 43 to over 100 companies, and a compound annual growth rate of 10% to over £340m per annum.

The Industrial Biotechnology Innovation Centre (IBioIC) was established in 2014 and has quickly been recognised as a European centre of excellence for industry-led research, having supported 48 industry/academia collaborative projects in Scottish universities. IBioIC has developed bespoke training and development programmes to ensure the current and future industry has the necessary skilled workforce to continue to innovate in Scotland: over 50 PhDs and 90 MScs have already been awarded. I am pleased that IBioIC has received funding for a further 5 years to continue supporting this rapidly growing industry.

I believe that the industrial biotechnology sector in Scotland will continue to make a strong contribution to our economy, and can do so whilst also reducing our impact on the environment. The targets set out in this document may indeed be ambitious. But ambition is the first step to success.

Ivan McKee, MSP

Minister for Trade, Investment and Innovation

INTRODUCTION

The growth of our bioeconomy is crucial to reduce Scotland's dependency on carbon intensive feedstocks and to make our manufacturing sector more sustainable which sits firmly within the vision outlined by the Scottish Government's Climate and Energy Change Plans.

The National Plan for Industrial Biotechnology (IB) set out to transform the competitiveness and sustainability of multiple sectors in Scotland by:

- Industrial Engagement - Increasing awareness of biotechnology as a transformation tool
- Biorefining - Increasing industry adoption of biotechnology to generate increased turnover
- Skills – Delivering the skilled workforce needed to meet the needs of this emerging technology
- Innovation - Facilitating collaborations, partnerships and investment to drive innovation

Since launch, great progress has been made across all themes, as summarised opposite. The following pages set out the next steps required to continue this exciting journey for each of these themes. It has been recognised that to deliver success the support of the wider public is necessary, and to get this support the awareness of IB as a technology for good needs to be addressed, therefore an additional theme has been added to the National Plan:

- Public Awareness - Creating a positive environment for the establishment of a Bioeconomy

The themes set out above closely align with the UK Bioeconomy Strategy published in December 2018. It sets out the blueprint in 15 actions for transforming the UK economy through the power of bioscience and biotechnology with the ambition to double the size of the UK bio-economy by 2030 to £440 billion. The actions focus around five key themes of Ideas, People, Infrastructure, Business Environment and Places, and it commits the government to continuing to support the research and innovation landscape, skill the work-force, invest in infrastructure, develop supportive policies and regulatory landscape and create a governance group to oversee the delivery of this strategy.

KEY ACHIEVEMENTS

Inputs

£50m
invested in innovation and
over £25m
private investment raised



Activities

Established IBioIC

48 Industry led projects
in Scottish Universities

2 open access scale-up
equipment centres established

Biorefinery Roadmap published

Impacts

Number of companies
increased by over 100%
from 43 in 2012 to 111 in 2017

sales increased by
£168m from 2012 to 2017
from £189m in 2012 to
£357m in 2017

and an additional
170 jobs
have been created

Outcomes

Investment in biorefineries

New skilled graduates –
52 PhDs and 94 MScs

Bioresource Mapping
Tool launched

IBioIC annual conference
established and is the
largest in IB in the UK

VISION

Our Vision is to achieve a mature bioeconomy in Scotland by 2025, this will be accomplished by increasing the number of companies active in IB to over 200 and increasing IB related turnover to £900m.

Achieving critical mass will be essential to significantly reduce our reliance on fossil fuels. This will be realised using transformative biobased technologies.

Scotland's main strengths lie in our research excellence and highly skilled workforce. Innovation will continue to play an integral part to ensure the development of technology from lab scale through to commercial scale facilities.

To build on the successes that have already been achieved, it's significantly important that mechanisms are in place and readily available to support companies at every stage of their journey towards manufacturing. The themes outlined in this document will be critical to supporting this journey.







POLICY AND PUBLIC ENGAGEMENT

Biotechnology is a positive innovation for Scotland. It is replacing existing pharmaceuticals, chemicals and fuels with similar or better performing materials from sustainable, non-fossil based raw materials. This requires new raw material suppliers, processes and conversion technologies. By developing biotechnology with our existing natural, human, academic and infrastructure resources we reinforce Scotland as a progressive, sustainable, high value manufacturing nation.

Biotechnology is disruptive innovation that is transforming established and traditional industries into new ways of manufacturing and new supplier chains. The biorefining theme highlights these new chains, some are established and some are new. Recent legislative changes in the harvesting of kelp, which is an identified significant new raw material for extracting high value products, has highlighted the need for public awareness of the benefits that biotechnology can bring to local communities and broader society. Hence, this new theme will work towards improving public awareness of the bioeconomy.



Mission

- To drive greater public engagement with this transformative technology
- To encourage inclusive debate on the sort of manufacturing industry Scotland wants
- To increase the number of people taking up careers in biotechnology
- To smooth the regulatory environment for companies to navigate
- To ensure there are greater, more informed policies and legislation that encourage the development of the bioeconomy

Next Steps

The next steps to achieving the mission are as follows:

- To establish a work group with the necessary expertise responsible for promoting the bioeconomy
- To develop and deliver a communications strategy for the bioeconomy
- To identify best practice in communicating the benefits of the bioeconomy internationally
- To develop a forum for discussion and debate



Since its launch in 2014, IBioIC has been evangelising for greater awareness within industry, government and academia about the benefits that developing the bio-economy can bring. We are very keen to include the public in this discussion. This new theme for the National Plan will communicate these benefits to a much wider audience and bring many more diverse views into the mix. Our intention is to engage the imagination, creativity and aspirations of the public to outline the future they want and to help deliver this through a partnership with all stakeholders.”

Dame Anne Glover, Chair, IBioIC.



INDUSTRY ENGAGEMENT

Approximately 40 companies were originally identified as being active in biotechnology in Scotland, growth to date has come from both organic development of businesses already active in the Scottish bioeconomy, the creation of new entities and a strong value proposition to encourage international direct investment into Scotland.

A focus on business engagement is crucial to the ongoing growth of Scotland's bioeconomy. Skirted by a landscape of innovation centres and a connected academic community, unique natural resources including renewable energy, and a pre-existing infrastructure, companies are the engine which drives sectors forward, and should be at the heart of any strategic plan. The close collaboration between industry, academia, and government, known as the triple helix, is unbalanced without an environment which supports, encourages, and engages companies to innovate and expand.



Mission

- To target local companies where biotechnology processes might be usefully deployed, and continue to nurture the nascent Scottish bioeconomy
- To create a compelling case for inward investment
- To develop novel value chains

Existing and new value chains of interest include:

- Whisky co-products
- Marine biomass
- Municipal solid wastes and food processing by-products and wastes
- Agricultural biomass
- Forestry biomass
- Carbon dioxide

Next Steps

The next steps to achieving the mission are as follows:

- To continue to raise the profile of the bioeconomy, broadening engagement, encouraging wider adoption, and attracting non-traditional economic sectors to biotechnology activity.
- To develop marketing messages highlighting Scotland's strength in biotechnology, unique value chains and feedstocks, and outlining how Scotland will continue to fill existing gaps in the bioeconomy. These will be used at events to promote Scotland, which in turn will stimulate interest and adoption.
- To build a robust mechanism to support international inward investment enquiries to maximise the number of global companies attracted to Scotland.



Engaging with the Scottish Industrial Biotechnology community has provided great support for evaluating new concepts that will enable a more cost-effective production of our products as well as access to new talents in the form of MSc industry placements.”

Devro
www.devro.com



Benchmark believes that the industrial biotechnology network in Scotland offers significant opportunities to enhance its ability to achieve the objectives associated with its long-term vision. This includes access to the networking opportunities, bespoke R&D equipment, training, and project and PhD calls that the network offers, and we are enthusiastic about remaining part of this vibrant network moving forward.”

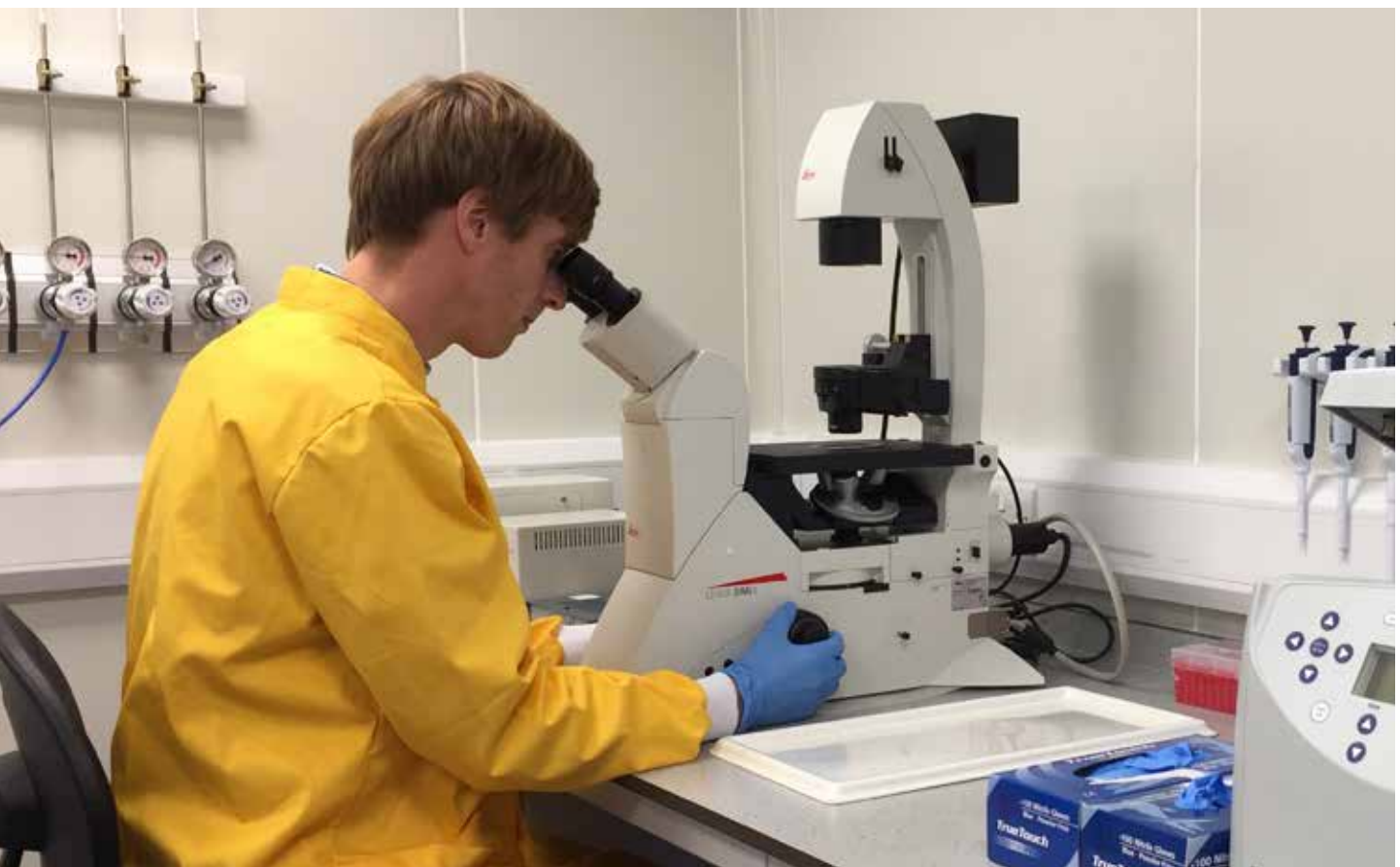
Benchmark Holdings
www.benchmarkplc.com



INNOVATION

Scotland has a long history of innovation, particularly in the biotechnology sector, from fermentation technologies used to produce whisky to the development of novel therapeutics. Our industry and universities have world class research expertise in chemistry, biology and engineering, which form the bedrock of biotechnology. If research converts money into knowledge, business innovation capitalises on that knowledge and converts it back into money, returning on the initial investment many times over. The Scottish Government's goal to fully develop a Circular Economy aligns perfectly with the development of the bioeconomy to ensure maximum value is extracted from precious bioresources using innovative technologies.

Since the launch of the National Plan in 2013, IBiolC have created a large and diverse network of companies and researchers to build collaborative partnerships for development of IB-based technologies, processes and products and co-funding research and development projects through innovation journeys while developing a skills programme to ensure the growth of the bioeconomy is supported by access to talented people with the correct expertise. Two open access equipment centres have been built: RapidBio (for upstream bioprocess development) and FlexBio (for downstream bioprocessing). The role of the IBiolC moving forward aligns with the mission set out in the Innovation theme.



Mission

- To provide strategic leadership
- To accelerate commercialisation
- To develop new value chains
- To invest in value chains using biotechnology
- To skill the necessary workforce



Lucite International Ltd. are a leading methacrylate manufacturer supplying approximately one third of the global market demand. Through its collaborative relationship with Ingenza Ltd., the partners are pursuing the development of a more sustainable biobased methacrylate manufacturing process which can utilise renewable feedstock options whilst also being commercially competitive with existing petrochemical feedstock routes. Ingenza Ltd. is leading this bioprocess development programme utilising its cutting-edge synthetic biology capabilities and implementing its biology, chemistry and fermentation scientific disciplines to realise this objective.”

Ingenza Ltd.
www.ingenza.com

Next Steps

The next steps to achieving the mission are as follows:

- To develop funding support for the bioeconomy and build a network of private investors to drive continued development of new biotechnology projects through their commercialisation journey
- To continue building value chains from neighbouring technologies and supply chains
- To encourage the utilisation and development of Scotland’s strong synthetic biology background by supporting the creation of an Engineering Biology Centre for technical development and incubation of new companies with financial, technical and mentoring support
- To incentivise the construction of demonstration scale facilities in Scotland to accelerate biotechnology commercialisation, particularly to support the development of the six key feedstocks highlighted above



3FBIO spun out of the University of Strathclyde in 2016 and benefitted from support from IBioIC and Scottish Enterprise for the development of a green manufacturing process for ABUNDA[®] Mycoprotein from sustainable resources. The company successfully raised £400k in 2017 and a further £6M in 2018 to scale up and commercialise their process. Compared to traditional beef farming, 3FBIO will produce protein with a 97% reduction in CO₂, 93% reduction in water use and 97% reduction in feedstock consumption”

3FBIO
www.3fbio.com



SKILLS

Developing a skilled workforce for the bioeconomy is essential to meet the demands of IB, which is a disruptive technology. IBioIC has provided critical leadership and resources through its skills and training programmes, from upskilling the existing workforce to educating a new generation at PhD, MSc and HND levels.

The newly developed Skills Investment Plan for Scotland's Life and Chemical Sciences (launched May 2018) indicates there is an imbalance in volume of graduates versus the supply of technicians: there are sufficient graduates with appropriate degrees, but they lack basic work skills, practical lab experience and the ability to problem solve; skills and training delivery are mainly limited to the central belt of Scotland. The top skills shortages identified by industry are the following:

- Technicians and (bio)engineers
- Data, software and informatics skills
- Multi disciplinary skills
- Regulatory, compliance and quality assurance
- Quality control expertise
- Business, commercial and leadership skills



Mission

- To increase the workforce to 2,500 by 2025
- To address skills shortages identified
- To Improve student access to industrial work experience
- To encourage the next generation of entrepreneurs
- To develop the importance of in-work learning and development



Ingenza, a world leader in the application of IB and Synthetic Biology have invested in skills through the Modern apprenticeship pathway. This has been exemplified by Jack Kay, who joined Ingenza in 2012 as a Life Science apprentice direct for school. Since then, combining Work Based Learning with academic study Jack has achieved a degree in Chemistry with Industrial Experience and been promoted to the role of Scientist in Molecular Biology and recently recognised as the industry's **Rising Star** (www.lifesciencesscotland.com). **His career path highlights there are many ways young professionals can work their way into the sector."**

Ingenza Ltd.
www.ingenza.com

Next Steps

The next steps to achieving the mission are as follows:

- To review and develop new qualifications suitable for industry to ensure their skills needs are met
- To engage industry support to inform training, with industry offering placement opportunities to ensure participants are work ready across all levels
- To build a skills system that can react to the rapid change with this technology. Upskilling the existing workforce to ensure technical, collaborative, communication and interdisciplinary capability are combined with commercial and entrepreneurial acumen required for business



uFraction8 took two students from the Industrial Biotechnology MSc programme to develop a new project of digestate separation. This resulted in the decision to proceed into the biomanufacturing market exploiting other market possibilities.

Ten-week projects are great opportunity to engage with upcoming biotechnology stars and to give them a shot at real life industrial biotechnology labs, which definitely helps in their future career"

uFraction8
ufraction8.com



BIOREFINING

The themes of the National Plan are all intrinsically linked, the biorefining theme is critical to deliver the majority of the £900m turnover target by 2025 through combining the outcomes of the other key themes to drive forward the adoption of novel technologies and processes utilising bio-based resources to manufacture innovative and higher value products.

Our location and geography give us the potential to generate competitively priced, green, renewable energy to power these biotechnology processes while further reducing its carbon footprint. Innovation in manufacturing and production coupled to innovation in green energy will be advantageous to ensure that Scotland develops its bioeconomy and drives income from exporting technologies worldwide. Developing this symbiotic relationship between our natural resources and innovation in biotechnology are key to our competitive advantage in a global economy.

A phase 2 – 'Building a Sustainable Future', of the Biorefinery Roadmap for Scotland strategy and associated milestones will follow on from the publication of this document. The focus of this will be the evolution of the roadmap and the emphasis for the next phase of activity.



Mission

Outlined within the next phase of 'The Biorefinery Roadmap for Scotland – Building a Sustainable Future', 6 main resource streams will be investigated further, having been identified as holding the greatest potential to further develop Scotland's bio-based economy. These are:

- Whisky co-products
- Municipal solid wastes and food processing by-products
- Agricultural biomass
- Forestry biomass
- Marine biomass
- Carbon dioxide

Next Steps

An analysis of biorefining clusters was undertaken which benchmarked Scotland against other International regions. From this analysis, the following next steps have been identified:

- To develop a dedicated resource to lead of biorefining cluster activities in Scotland
- To expand existing equipment centres to support biorefining of the identified key feedstocks
- To develop infrastructure to help support the commercialisation of biorefining activities in Scotland
- To investigate new value chains and the development of sustainable supply chains for key feedstocks, including the further development of the bioresource mapping tool
- To actively address recent policy challenges concerning aspects of seaweed harvesting



Maximising value from Scottish resources is at the heart of the whisky industry. Partnering on projects with the industrial biotechnology community has the potential to bring new innovative high value products from whisky co-products and thereby sustainably grow the Scottish Whisky Industry.”

Scotch Whisky Research Institute
www.swri.co.uk



Engaging with the Industrial Biotechnology support network in Scotland is key for us to find the right partnerships and collaboration in the forestry biorefinery supply chain to demonstrate and commercialise our technology.”

Nova Pangaea Technologies
www.novapangaea.com

CONCLUDING REMARKS



I am delighted with the progress made in the National Plan to date as outlined in this update most importantly demonstrated by the sharp growth in the industry turnover in just a few years. It proves that Scotland is a great place to develop biotechnology. The bioeconomy is good for the environment because it is sustainable and clean. However, it is also disruptive: it requires transformative manufacturing processes and new supply chains to ensure successful delivery. Hence, there is still much to be done to anchor this important technology in Scotland. This updated plan outlines the key steps that are required to deliver the £900 million turnover targeted for 2025. It will require resource, willingness and coordination to make this happen and when it does, it will be a great exemplar of industry, government and academia working together to deliver this highly ambitious plan.

Roger Kilburn
Chair, Scottish Industrial Biotechnology
Development Group.



This document has been prepared by Scottish Enterprise on behalf of the Scottish Industrial Biotechnology Development Group and Chemical Sciences Scotland.

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