The Biorefinery Roadmap for Scotland

Chemical Sciences SCOTLAND

FOREWORD

In Scotland we have vibrant chemical sciences, life sciences, engineering and oil and gas sectors with many industrial biotechnology users and strong industrial and academic linkages. Biorefining and the production of high value bio-based chemicals have an important role to play in driving Scotland's low-carbon agenda and contributing to the country's emerging bioeconomy.

The National Plan for Industrial Biotechnology aims to increase the turnover related to industrial biotechnology from £189m in 2012 to £900m by 2025 and biorefineries have the potential to make a substantial contribution to this goal. An early success in the implementation of the National Plan for Industrial Biotechnology is the Industrial Biotechnology Innovation Centre (IBioIC), launched in 2014. It is already making excellent progress in building on Scotland's strengths in R&D, innovation and academic excellence to create a competitive and sustainable manufacturing base.

Scotland already has a great deal of biorefining expertise including research into brewing and fermentation, the future potential for marine biomass and excellence in synthetic biology and molecular and micro-biology. The next step is to develop cost-effective technologies for biotransformations and to convert sustainable feedstocks into high value chemicals, biofuels and other renewable products for a range of industries. In addition biorefining could offer significant economic benefits for the forestry, timber and agricultural industries in Scotland as well as across the supply chain.

The Biorefinery Roadmap for Scotland is an industry-led document that outlines the actions required and some of the support needed to deliver many of these opportunities in order to position Scotland as a country seeking to encourage sustainable manufacturing in the global marketplace. I would urge businesses in the relevant industries to give serious consideration to biorefining in order to benefit from this fast-growing, innovative and burgeoning sector.

Fergus Ewing MSP
Minister for Business,
Energy and Tourism

January 2015

INTRODUCTION

Climate change and global warming, as well as the uncertainty over the size and viability of fossil fuels as a resource, provide a global imperative to develop technologies and infrastructures for biorefineries which can play an important part in moving towards a low carbon bio-based economy. Biorefining offers Scottish companies the opportunity to build on existing expertise in order to improve the competitiveness and sustainability of industries.

Biorefining includes the integrated production of materials, chemicals, fuels and energy from biomass, and may include the application of bioprocesses for the conversion of these feedstocks into useful products or the use of innovative biotransformations of more traditional feedstocks. The concept is similar to that of a petroleum refinery which produces multiple fuels and products from crude oil or natural gas.

Europe is currently lagging behind in the area of biorefining because of fragmented R&D activities and the low levels of state-funding and resources needed to create large demonstration facilities.

In Scotland the establishment of a viable biorefinery sector has the potential to deliver numerous benefits. These include the development of innovative products with reduced environmental impacts, the expansion of Scottish expertise in relevant disciplines and the creation of new jobs in the bioeconomy. Additionally this sector could attract long-term investment, facilitate knowledge transfer and develop integrated supply chains.

Many early biorefineries have focused on biofuels due to subsidies and incentives. Scotland aims to develop biorefineries for the production of higher value chemicals not requiring subsidies and hence having a robust and sustainable economic basis.

Biorefinery development globally is at an early stage with opportunities determined by a combination of specific location, technology push and occasionally demand-side interest. While the focus in Scotland needs to be on understanding product value propositions and the development of integrated supply chains, the latter need not be restricted by geographical boundaries. Alongside encouraging indigenous companies to expand, it is likely to be both advantageous and necessary for them to build partnerships with technology companies and supply chain partners outside Scotland.

In this respect, the success of biorefineries in Scotland will rely on processes that use feedstocks that do not compete with food and feed supply chains or the development of innovative biocatalyst technologies. The assessment of feedstock potential identifies three possible renewable feedstocks: the co-products and residues of the timber value chain, household, commercial and industrial waste and macroalgae. Although there are competing uses for some of these feedstocks - for instance anaerobic digestors and compost - these are not mutually exclusive. The aim is to ensure that the maximum value can be extracted from each feedstock, with the co-products of higher-value product manufacture being utilised to produce lower value products including heat, energy or fuel.

OPPORTUNITIES

As part of the assessment and appraisal of the biorefining opportunities available, a number of priority areas have been identified including feedstock opportunities, technology platforms and products.

Feedstock opportunities

As the economics of platform chemicals are highly dependent on material costs, it is essential to gain a greater understanding of their availability in terms of their location, volume and specification, ie. composition.

The greatest opportunity for biorefining feedstocks, based on volume, is the bio-fraction of household, commercial and industrial waste. On the supply side, Scotland may offer a number of small, location-specific opportunities. Existing waste management companies are well-placed to exploit these resources as part of large-scale biorefineries with added-value applications.

Timber value chain co-products and residues also represent a significant resource. At the moment there are a number of forestry co-products not harvested, such as tree stumps, brash and thinnings, which could be used as biorefinery feedstocks if they can be extracted cost-effectively. This would also create another income stream for the forestry sector. At the moment Europe, and Norway in particular, leads the development of biorefineries based on forest products and Scotland is well-placed to import technology platforms or technology know-how via collaborative partnerships.

Although there is some uncertainty around the total volumes of macroalgae that might be available and how they might be sustainably harvested, this abundant natural resource could provide the country with a niche opportunity in the medium to long-term. Due to the length of Scotland's coastline and area of its continental shelf, the country boasts a large suitable habitat for macroalgae. There needs to be further assessment of production costs and the market price that would have to be realised to stimulate the supply chain.

Further, and more detailed, analysis of all three potential feedstocks is required to assess their local availability and the specific price hurdles in relation to collection costs, local infrastructure and competing uses that need to be overcome in order to secure appropriate supply contracts.

Technology platforms

Scotland's main areas of academic and industrial strengths include industrial biotechnology, chemical synthesis and material science, production and utilisation of micro and macroalgae, and pyrolysis. At the moment there are a limited number of technologies relating to biorefineries that have been demonstrated at commercially relevant scales. In order to create a viable biorefining sector it is essential that technological developments are supported through the pilot and demonstration stages. This is a critical phase in achieving commercial success therefore it is imperative that companies have access to adequate test, demonstration and scale-up facilities.

Products

The bio-based chemicals attracting the greatest interest globally at present are the high volume commodity chemicals such as ethanol and n-butanol which relate to the production of biofuels. This is because value can be added in the downstream conversion of these high volume chemical building blocks using existing technology and infrastructure. New chemical intermediates and materials can be used to develop new products with additional functionality like polylactic acid and succinic acid. Scotland currently produces primarily bio-based products in the higher value speciality chemicals markets, for example, healthcare and personal care applications.

Therefore, in Scotland, there needs to be a focus on products that are price competitive both with fossil-based products and bio-based production elsewhere in the world, or speciality chemicals and materials with additional functionality. It is also important to have a comprehensive understanding of product value propositions and the development of integrated supply chains.

THE ROADMAP

The Biorefinery Roadmap for Scotland will be delivered through four key themes over the next ten years: Innovate in Scotland, Engage Industry, Foster Research & Innovation and Stimulate Market Demand. The actions delivered within these themes will support the development of a biorefining sector in Scotland which builds on the academic and research skills in the country and utilises the feedstocks largely produced within Scotland.

Innovate in Scotland – To develop the unique resources and capabilities in Scotland to create compelling cases for biorefineries.

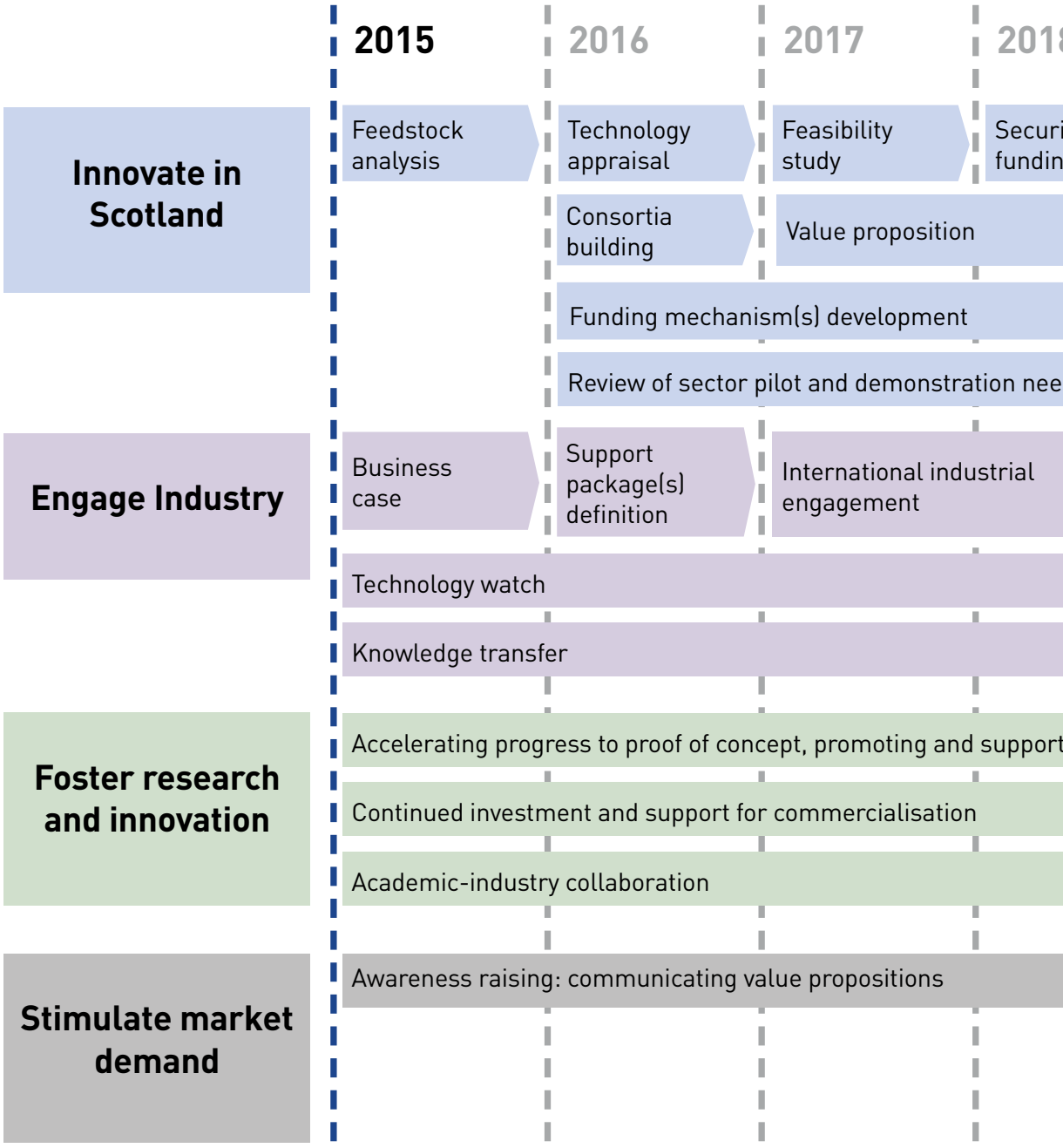
Innovation is vital to ensure the progress of Scottish-based technology from pilot scale validation of a concept to demonstration stage. Further analysis will seek to identify and promote the interaction and involvement of companies along the biorefining supply chain. Previously unexpected synergies and partnerships are envisaged. This engagement involves consortia building which could involve waste management companies, forest managers, technology partners, engineering providers and end-users depending on the nature of a particular project.

Funding is critical, whatever the stage in a project's development, and there are already some funding mechanisms in place. These include the IBioIC Exemplar Programme as well as support for R&D such as SMART: SCOTLAND, Innovate UK and Europe's Horizon 2020 programme and Bio-Based Industries Consortium. Currently available funding will be assessed and alternative mechanisms for funding capital spend on infrastructure and capacity building will be considered. The roles of the Scottish Investment Bank and Green Investment Bank will also be explored.

Innovative ways will be sought to identify markets for such products, thus framing the value proposition of a new product that can be further developed and refined as it progresses through proof of concept to demonstration. Not only will a robust biorefining sector boost Scottish-based manufacturing capacity but the export of intellectual property associated with the processes developed here also has potential.

THE ROADMAP

Roadmap for the development of a



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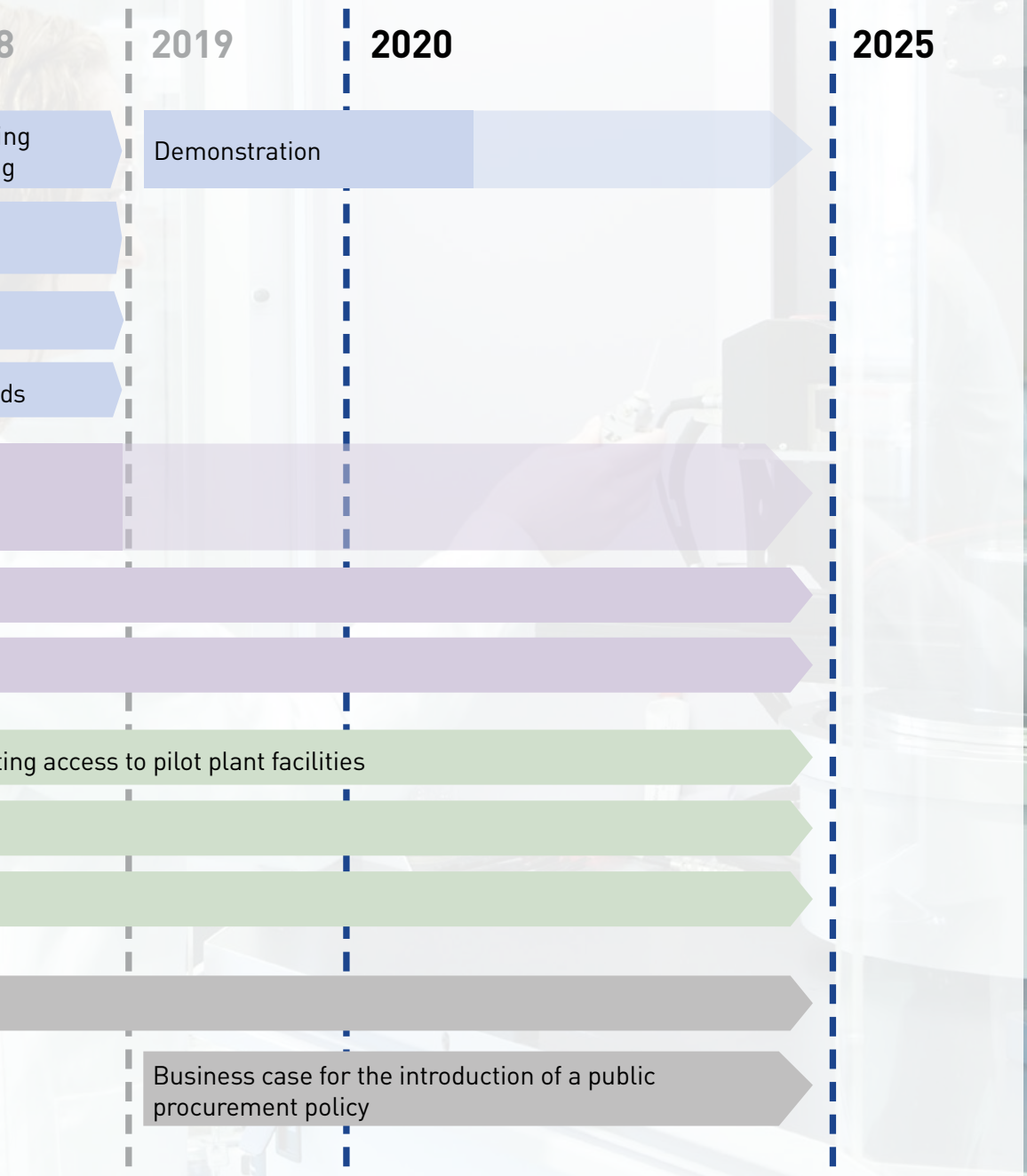
Proposed timings are indicative only, recognising delivery is unlikely to be sequential, rather overlapping/in parallel, allowing for later proposed activities to happen sooner.

biorefining sector in Scotland



nes indicate delivery will be dependent upon specific project requirements

KEY ACTIONS:

2015

- Feedstock analysis into wood (led by Forestry and Timber Technology Industry Leadership Group), wastes and co-products (led by Zero Waste Scotland) and Macroalgae (led by Seaweed Industry Association/Scottish Association for Marine Science)
- Develop a value proposition for biorefining in Scotland based on the Biorefinery Roadmap, led by Scottish Enterprise, Highlands and Islands Enterprise and Scottish Development International

2016

- Technology appraisal including mapping of Synthetic Biology, Biotransformations and integrated Bio-processing to be led by IBioIC
- Consortia building through multinational linkages and collaborations around wood, wastes/ co-products and macroalgae to drive innovation and commercial delivery with Scottish Enterprise, Scottish Development International and Highlands and Islands Enterprise leading
- Development of funding mechanisms through Research Councils, Innovate UK, Horizon 2020 and others, led by Scottish Enterprise
- Review of demand and availability of pilot and demonstrations facilities in Scotland led by IBioIC

2017

- Conduct feasibility studies in the three main feedstock areas based on technology appraisals to build a compelling case for biorefinery construction in Scotland, led by Scottish Enterprise/ Highlands and Islands Enterprise

BEYOND 2017

- IBioIC to lead on biorefining demonstration and securing funding for biorefinery construction in Scotland

NB Proposed timings below are indicative only, recognising delivery is unlikely to be sequential, rather overlapping/in parallel, allowing for later proposed activities to happen sooner.

Engage Industry – to identify and work with the companies that will deliver the biorefineries in Scotland.

As well as encouraging local companies to embrace the benefits of biorefining, there is also the potential to attract international project or technology developers to Scotland by providing a supportive and competitive environment for R&D, manufacturing and investment.

Developing pathways for knowledge transfer locally and internationally will be necessary to build collaborative relationships, showcase Scottish expertise and accelerate progress in biorefining processes. Because there is a limited number of biorefining technologies that have been demonstrated at commercially relevant scales at the moment, it is essential that businesses are supported at all stages in order to achieve commercial success. Building a viable biorefining sector requires support through the pilot and demonstration stages including access to adequate test, demonstration and scale-up facilities.

KEY ACTIONS:

2015 – 2017

- Build a business case for biorefining in Scotland, based on the Biorefinery Roadmap, led by Scottish Enterprise, Highlands and Islands Enterprise and Scottish Development International

2016

- Provide appropriate support packages for the development of biorefineries in Scotland, Scottish Enterprise to lead

2017

- Build partnerships to support knowledge transfer and collaboration for the development of biorefineries in Scotland, led by the Knowledge Transfer Network
- Develop a project pipeline for international industrial engagement through Scottish Development International, GlobalScots and others, led by Scottish Development International
- Monitor international technology developments, particularly projects that support the delivery of the National Plan, led by IBioIC with support from the Industrial Biotechnology Development Group

Foster research and innovation – To strengthen research and innovation in biorefining technologies and markets

Continued support for research and innovation in biorefining is essential to ensure Scotland is an attractive location for biorefining activities and is able to realise the value from the export of technology and services this generates. IBioIC is well-placed to identify existing academic and industry capabilities and collaborations in key technology areas and build on existing strengths to successfully accelerate Proof of Concept and to promote access to pilot plant facilities and commercialisation.

KEY ACTIONS:

2017

- Identify and potentially jointly-fund innovation projects around lignin with IBioIC and the Forestry Futures Programme
- Support industry's commercial ambitions by identifying required resources
- Deliver a series of industrially-led development projects that support the National Plan for Industrial Biotechnology, led by IBioIC

Stimulate market demand – to create the market environment for investment

Raising awareness of the opportunities for commercially viable biorefineries will help attract investment and open up new markets for industrial biotechnology companies. As the demand for bio-based products continues to grow, so will the production capacity. Improved awareness and engagement across industry of the value propositions for bio-based products may also increase market demand from industrial users and Chemical Sciences Scotland is well-placed to lead these activities.

KEY ACTIONS:

2015 – 2017

- Raise awareness of value propositions by maximising the publications and communication opportunities for biorefining in Scotland to stimulate market awareness, led by Chemical Sciences Scotland

Beyond 2017

- Make the business case for the introduction of a public procurement policy, led by Chemical Sciences Scotland
- Maximise publication and communication opportunities for biorefining in Scotland to stimulate market awareness, led by Chemical Sciences Scotland

CONCLUSION

Biorefining is a relatively nascent industry, but given Scotland's strong chemical sciences, life sciences and engineering base, and a strategic drive to deliver commercial and economic benefit through the National Plan for Industrial Biotechnology, the country has the opportunity to be at the forefront of sector developments in Europe.

This Biorefinery Roadmap for Scotland, detailing a strategy for developing a robust and vibrant sector is just the beginning of the journey. Over the next 10 years there is scope to harness Scotland's natural resources, innovation and technological expertise, skills base and supply chain networks to boost the bioeconomy and drive the country's low carbon agenda. A versatile and robust biorefining sector will give a much-needed fillip to Scotland's manufacturing industry and act as a beacon to companies in the rest of Europe looking to collaborate or relocate.

Windows of opportunity can be short, therefore it is vital that all sectors with a potential interest in biorefining - from agriculture, life sciences and chemical sciences to forestry, oil and gas and food and drink - join forces to realise a biorefining future for Scotland.

All stakeholders across private, public and academic sectors will continue to work in partnership to align their investments and activities towards delivering the Biorefinery Roadmap for Scotland. Only by joining forces will we grow a sustainable and vibrant biorefinery industry for the future benefit of society and the economy.

Alan Wolstenholme
Chair, Scottish IB Development Group

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