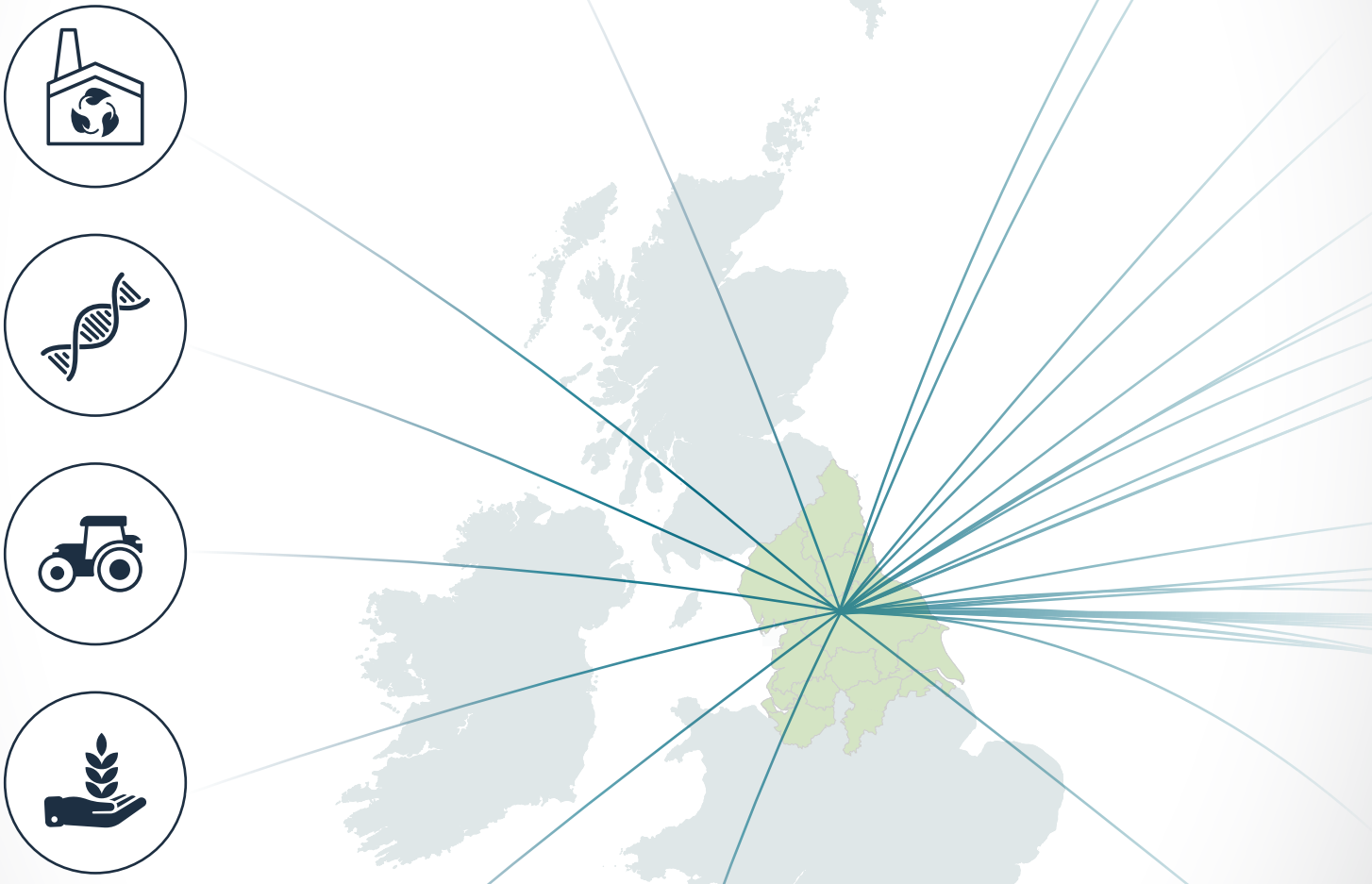
Appendices

August 2017

THE BIOECONOMY IN THE NORTH OF ENGLAND



A Science and Innovation Audit Report sponsored by the Department for Business, Energy & Industrial Strategy

Appendix A: Consortium membership

Durham University
University of Hull
Lancaster University
University of Leeds
University of Liverpool
University of Manchester
Newcastle University
University of Sheffield
Sheffield Hallam University
University of York
Biorenewables Development Centre (BDC)
Crop Health and Protection (CHAP)
Centre for Innovation Excellence in Livestock (CIEL)
Centre for Process Innovation (CPI)
Fera Science Ltd
Stockbridge Technology Centre
Science City York
Biovale
AB Connect
Brocklesby Ltd
Croda
Drax Power Ltd
Precision Decisions
Quorn Foods
RAFT Solutions Ltd
Unilever
Wheatsheaf
Ben Pearcy
National Non Food Crop Centre
Greater Manchester LEP
Humber LEP
Leeds City Region LEP
North East LEP
Sheffield City Region LEP
Tees Valley Unlimited LEP
York and North Yorkshire and East Riding LEP
Cogent Skills
Askham Bryan College
Bishop Burton College
Reaseheath College
CATCH

Appendix B: Higher education institutions in the North of England

1 Durham University
2 Edge Hill University
3 Lancaster University
4 Leeds Beckett University
5 Leeds College of Art
6 Leeds Trinity University
7 Liverpool Hope University
8 Liverpool Institute of the Performing Arts
9 Liverpool John Moores University
10 Liverpool School of Tropical Medicine
11 Manchester Metropolitan University
12 Newcastle University
13 Northumbria University Newcastle
14 Royal Northern College of Music
15 Sheffield Hallam University
16 Teesside University
17 The Open University
18 University of Bolton
19 University of Bradford
20 University of Central Lancashire
21 University of Chester
22 University of Cumbria
23 University of Huddersfield
24 University of Hull
25 University of Leeds
26 University of Liverpool
27 University of Manchester
28 University of Salford
29 University of Sheffield
30 University of Sunderland
31 University of York
32 York St John University

Appendix C: SIC Code definition of the bioeconomy

Sort Order	Main Industry	Main Activity	Sub Activity	SIC2007 Code
1	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Cereals, leguminous crops, oilseeds	0111
2	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Rice	0112
3	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Vegetables, melons, roots, tubers	0113
4	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Sugar cane	0114
5	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Tobacco	0115
6	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Fibre crops	0116
7	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Other non-perennial crops	0119
8	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Grapes	0121
9	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Tropical and subtropical fruits	0122
10	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Citrus fruits	0123
11	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Pome fruits and stone fruits	0124
12	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Other tree, bush fruits, nuts	0125
13	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Oleaginous fruits	0126
14	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Beverage	0127
15	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Spices, drug, pharmaceutical	0128
16	Agriculture, Forestry, Fishing, Veterinary	Growing crops	Other perennial	0129
17	Agriculture, Forestry, Fishing, Veterinary	Crop, plant support activities	Crop production support activities	0161
18	Agriculture, Forestry, Fishing, Veterinary	Crop, plant support activities	Post-harvest crop activities	0163
19	Agriculture, Forestry, Fishing, Veterinary	Crop, plant support activities	Seed propagation for propagation	0164

20	Agriculture, Forestry, Fishing, Veterinary	Crop, plant support activities	Plant propagation	0130
21	Agriculture, Forestry, Fishing, Veterinary	Animal production, hunting	Raising of dairy cattle	0141
22	Agriculture, Forestry, Fishing, Veterinary	Animal production, hunting	Raising of other cattle, buffaloes	0142
23	Agriculture, Forestry, Fishing, Veterinary	Animal production, hunting	Raising of horses, equines	0143
24	Agriculture, Forestry, Fishing, Veterinary	Animal production, hunting	Raising of camels, camelids	0144
25	Agriculture, Forestry, Fishing, Veterinary	Animal production, hunting	Raising of sheep, goats	0145
26	Agriculture, Forestry, Fishing, Veterinary	Animal production, hunting	Raising of swine, pigs	0146
27	Agriculture, Forestry, Fishing, Veterinary	Animal production, hunting	Raising of poultry	0147
28	Agriculture, Forestry, Fishing, Veterinary	Animal production, hunting	Raising of other animals	0149
29	Agriculture, Forestry, Fishing, Veterinary	Animal production, hunting	Mixed farming	0150
30	Agriculture, Forestry, Fishing, Veterinary	Animal production, hunting	Animal production support activities	0162
31	Agriculture, Forestry, Fishing, Veterinary	Animal production, hunting	Hunting, trapping, related activities	0170
32	Agriculture, Forestry, Fishing, Veterinary	Forestry and logging	Silviculture, other forestry activities	0210
33	Agriculture, Forestry, Fishing, Veterinary	Forestry and logging	Logging	0220
34	Agriculture, Forestry, Fishing, Veterinary	Forestry and logging	Gathering wild growing non-wood	0230
35	Agriculture, Forestry, Fishing, Veterinary	Forestry and logging	Support services to forestry	0240
36	Agriculture, Forestry, Fishing, Veterinary	Fishing and aquaculture	Marine fishing	0311
37	Agriculture, Forestry, Fishing, Veterinary	Fishing and aquaculture	Freshwater fishing	0312
38	Agriculture, Forestry, Fishing, Veterinary	Fishing and aquaculture	Marine aquaculture	0321
39	Agriculture, Forestry, Fishing, Veterinary	Fishing and aquaculture	Freshwater aquaculture	0322
40	Agriculture, Forestry, Fishing, Veterinary	Veterinary activities	Veterinary activities	7500

57	Manufacture food, drink, tobacco	Food products - meat, fish	Meat processing, preserving	1011
58	Manufacture food, drink, tobacco	Food products - meat, fish	Poultry meat processing, preserving	1012
59	Manufacture food, drink, tobacco	Food products - meat, fish	Meat, poultry meat production	1013
60	Manufacture food, drink, tobacco	Food products - meat, fish	Fish processing, preserving	1020
61	Manufacture food, drink, tobacco	Food products - fruit, vegetables	Potato processing, preserving	1031
62	Manufacture food, drink, tobacco	Food products - fruit, vegetables	Fruit, vegetable juice	1032
63	Manufacture food, drink, tobacco	Food products - fruit, vegetables	Other fruit, vegetable	1039
64	Manufacture food, drink, tobacco	Food products - other	Oil, fat manufacture	1041
65	Manufacture food, drink, tobacco	Food products - other	Margarine, edible fats	1042
66	Manufacture food, drink, tobacco	Food products - other	Dairies, cheese making	1051
67	Manufacture food, drink, tobacco	Food products - other	Ice cream	1052
68	Manufacture food, drink, tobacco	Food products - other	Grain mill products	1061
69	Manufacture food, drink, tobacco	Food products - other	Starches and starch products	1062
70	Manufacture food, drink, tobacco	Food products - other	Bread; pastry goods, cakes	1071
71	Manufacture food, drink, tobacco	Food products - other	Rusks, biscuits; preserved pastry	1072
72	Manufacture food, drink, tobacco	Food products - other	Pasta, other farinaceous	1073
73	Manufacture food, drink, tobacco	Food products - other	Sugar	1081
74	Manufacture food, drink, tobacco	Food products - other	Cocoa, choc, sugar confectionery	1082
75	Manufacture food, drink, tobacco	Food products - other	Tea, coffee processing	1083
76	Manufacture food, drink, tobacco	Food products - other	Condiments and seasonings	1084
77	Manufacture food, drink, tobacco	Food products - other	Prepared meals and dishes	1085

78	Manufacture food, drink, tobacco	Food products - other	Homogenised/dietetic food	1086
79	Manufacture food, drink, tobacco	Food products - other	Other food products nec	1089
80	Manufacture food, drink, tobacco	Food products - other	Prepared farm animals feeds	1091
81	Manufacture food, drink, tobacco	Food products - other	Prepared pet foods	1092
82	Manufacture food, drink, tobacco	Beverages	Spirits distilling, rectifying etc	1101
83	Manufacture food, drink, tobacco	Beverages	Wine from grape	1102
84	Manufacture food, drink, tobacco	Beverages	Cider, other fruit wines	1103
85	Manufacture food, drink, tobacco	Beverages	Other non-distilled fermented	1104
86	Manufacture food, drink, tobacco	Beverages	Beer	1105
87	Manufacture food, drink, tobacco	Beverages	Malt	1106
88	Manufacture food, drink, tobacco	Beverages	Soft drinks; waters	1107
89	Manufacture food, drink, tobacco	Tobacco	Tobacco products	1200
90	Manufacture textiles, leather	Textiles	Textile fibres preparation, spinning	1310
91	Manufacture textiles, leather	Textiles	Weaving of textiles	1320
92	Manufacture textiles, leather	Textiles	Finishing of textiles	1330
93	Manufacture textiles, leather	Textiles	Knitted and crocheted fabrics	1391
94	Manufacture textiles, leather	Textiles	Made-up textile exc apparel	1392
95	Manufacture textiles, leather	Textiles	Carpets and rugs	1393
96	Manufacture textiles, leather	Textiles	Cordage, rope, twine, netting	1394
97	Manufacture textiles, leather	Textiles	Non-wovens exc. apparel	1395
98	Manufacture textiles, leather	Textiles	Other technical, industrial textiles	1396

99	Manufacture textiles, leather	Textiles	Other textiles nec	1399
113	Manufacture coke, petroleum, chemicals, pharmaceuticals	Coke, refined petroleum	Refined petroleum products	1920
114	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Industrial gases	2011
115	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Dyes and pigments	2012
116	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Other inorganic basic chemicals	2013
117	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Other organic basic chemicals	2014
118	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Fertilisers and nitrogen compounds	2015
119	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Plastics in primary forms	2016
120	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Synthetic rubber in primary forms	2017
121	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Pesticides, other agrochemical	2020
122	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Paints, varnishes, printing ink etc	2030
123	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Explosives	2051
124	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Glues	2052
125	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Essential oils	2053
126	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Other chemical products	2059
127	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Man-made fibres	2060
128	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Soap and detergents, cleaning	2041
129	Manufacture coke, petroleum, chemicals, pharmaceuticals	Chemicals, chemical products	Perfumes, toilet preparations	2042
196	All other Manufacturing	Wood,cork, straw,plaiting materials	Sawmilling, planing of wood	1610
197	All other Manufacturing	Wood,cork, straw,plaiting materials	Products of these materials	1620
198	All other Manufacturing	Wood,cork, straw,plaiting materials	Veneer sheets, wood-based panels	1621

199	All other Manufacturing	Wood,cork, straw,plaiting materials	Assembled parquet floors	1622
200	All other Manufacturing	Wood,cork, straw,plaiting materials	Other builders carpentry, joinery	1623
201	All other Manufacturing	Wood,cork, straw,plaiting materials	Wooden containers	1624
202	All other Manufacturing	Wood,cork, straw,plaiting materials	Other products	1629
203	All other Manufacturing	Paper and paper products	Pulp	1711
204	All other Manufacturing	Paper and paper products	Paper, paperboard	1712
205	All other Manufacturing	Paper and paper products	Corrugated paper, containers	1721
206	All other Manufacturing	Paper and paper products	Household, sanitary, toilet goods	1722
207	All other Manufacturing	Paper and paper products	Paper stationery	1723
208	All other Manufacturing	Paper and paper products	Wallpaper	1724
209	All other Manufacturing	Paper and paper products	Other	1729
216	All other Manufacturing	Rubber and plastic products	Rubber tyres, tubes, retreading	2211
217	All other Manufacturing	Rubber and plastic products	Other rubber	2219
218	All other Manufacturing	Rubber and plastic products	Plastic plates, sheets, tubes etc	2221
219	All other Manufacturing	Rubber and plastic products	Plastic packing goods	2222
220	All other Manufacturing	Rubber and plastic products	Builders' ware of plastic	2223
221	All other Manufacturing	Rubber and plastic products	Other plastic	2229
296	Utilities, sewerage, waste and recycling	Electricity, gas, steam, air con	Electricity production	3511
304	Utilities, sewerage, waste and recycling	Water and sewerage	Water collection, treatment, supply	3600
305	Utilities, sewerage, waste and recycling	Water and sewerage	Sewerage	3700
306	Utilities, sewerage, waste and recycling	Waste	Non-hazardous waste collection	3811

307	Utilities, sewerage, waste and recycling	Waste	Hazardous waste collection	3812
308	Utilities, sewerage, waste and recycling	Waste	Non-hazardous treatment, disposal	3821
309	Utilities, sewerage, waste and recycling	Waste	Hazardous treatment, disposal	3822
506	Business services	Scientific research, development	Biotechnology	7211
507	Business services	Scientific research, development	Other natural sciences, engineering	7219

Appendix D: Research centres supporting the bioeconomy across the North of England

University / Host	Topic Area	Institute / Centre
Durham University	Bio	Biosciences Newcastle-Liverpool-Durham BBSRC Doctoral Training Partnership
Durham University	Energy	EPSRC-funded Multidisciplinary Centre for Doctoral Training in Energy
Durham University	Bio	Biophysical Sciences Institute
Durham University	Energy	Durham Energy Institute
Durham University	Data	Institute of Advanced Research Computing
Durham University	Agri	Crop Improvement Technology, Centre for
Durham University	Bio	Durham Centre for Bio and Materials
Lancaster University	Agri	Soils Training and Research Studentships (STARS)
Lancaster University	Food	BBSRC Doctoral Training Partnership in Food Security
Lancaster University	Bio/sustainability	Centre for Global Eco-Innovation
Lancaster University	Business Sustainability	Pentland Centre for Sustainability in Business
Lancaster University	Chemicals	Collaborative Technology Access Programme (cTAP) Facility for business
Lancaster University	Energy	Energy Lancaster
Lancaster University	Data	Data Science Institute
Lancaster University	Materials	Materials Science Institute
Leeds Beckett University	Sustainability	Leeds Sustainability Institute
Liverpool John Moores University	Data	Data Science Research Institute
Liverpool John Moores University	Eng	General Engineering Research Institute (GERI)
Liverpool John Moores University	Sustainability	Built Environment and Sustainable Technologies Research Institute
Manchester Metropolitan University	Sustainability	Environmental Science Research Centre
Manchester Metropolitan University	Bio & Energy	Engineering and Materials Research Centre
Manchester Metropolitan University	Data	Informatics Research Centre
Newcastle University	Agri -Food	Institute for Agri-Food Research and Innovation
Newcastle University	Sustainability	Institute for Sustainability
Newcastle University	Agri-Food	Centre for Rural Economy
Newcastle University	Bio	Centre for Synthetic Biology and the Bioeconomy
Newcastle University	Bio	Sir Joseph Swan Centre for Energy Research
Newcastle University	Bio	nanoLAB
Northumbria University Newcastle	Data	Computer Science and Informatics
Northumbria University Newcastle	Bio	Bioeconomy
Northumbria University Newcastle	Eng	Future Engineering
Northumbria University Newcastle	Enterprise/Commercial	GETM3 Global Entrepreneurial Talent Management 3

Sheffield Hallam University	Bio	(BMRC) Biomolecular Sciences Research Centre
Sheffield Hallam University	Materials	(MERI) Materials and Engineering Research Institute
Sheffield Hallam University	Food	National Centre of Excellence for Food Engineering
Sheffield Hallam University	Robotics	Centre for Automation and Robotics Research
Teesside University	Data	Digital Futures Institute
Teesside University	Tech	Technology Futures Institute
University of Bolton	Energy	Institute for Renewable Energy and Environmental Technologies
University of Bolton	Materials	Institute for Materials Research and Innovation IMRI
University of Bradford	Data	Applied Computing Research Unit
University of Bradford	Chemicals	Chemical and Process Engineering
University of Bradford	Engineering	Advanced Engineering Systems Optimisation
University of Bradford	Sustainability	Bradford Centre for Sustainable Environments
University of Central Lancashire	Bio	Centre for Materials Science (CMS)
University of Central Lancashire	Data	Advanced Digital Manufacturing Technology Research Centre (ADMT)
University of Central Lancashire	Bio	Institute of Nanotechnology and Bioengineering
University of Central Lancashire	Biophysics	Physics and Mathematics
University of Chester	Food	Environmental Quality and Food Safety Research Unit
University of Chester	Energy	Thornton Science Park
University of Chester	Food	(NoWFood) North West Food Research Development Centre
University of Leeds	Energy	UK Energy Research Centre
University of Leeds	Energy	Centre for Industrial Energy, Materials and Products
University of Leeds	Bioenergy	EPSRC Centre for Doctoral Training in Bioenergy
University of Leeds	Bio	Astbury Centre for Structural Molecular Biology
University of Leeds	Agri	Centre for Plant Sciences
University of Leeds	Energy	Centre for Integrated Energy Research
University of Leeds	Process	Institute of Process Research & Development (iPRD)
University of Leeds	Energy	Energy Leeds
University of Leeds	Sustainability	water@leeds
University of Leeds	Energy	Petroleum Leeds
University of Liverpool	Bio	Microbiorefinery (MBR)
University of Liverpool	Materials	Materials Innovation Factory (MIF)
University of Liverpool	Materials	Centre for Materials Discovery (CMD)
University of Liverpool	Bio	MIF OMICs facility
University of Liverpool	Bio	GeneMill Synthetic Biology Services
University of Liverpool	Bio	Energy and Catalysis Research Group
University of Liverpool	Bio	Stephenson Institute for Renewable Energy

University of Liverpool	Bio	Institute of Integrative Biology (IIB)
University of Liverpool	Agri	Tesco Dairy Centre of Excellence
University of Manchester	Bio	SuperGen Bioenergy Hub
University of Manchester	Data	Data Science Institute (part of Manchester Informatics)
University of Manchester	Bio	Manchester Energy
University of Manchester	Data	Manchester Informatics
University of Manchester	Bio	Manchester Institute of Biotechnology
University of Manchester	Food / Sustainability	Sustainable Consumption Institute
University of Manchester	Bio	COEBio3
University of Salford	Energy House	Sustainable Chemical Processes, Centre in
University of Salford	Food	Autonomous Systems and Advanced Robotics Research Centre
University of Salford	Data	Informatics Research Centre
University of Sheffield	Bio	Advanced Biomanufacturing Centre (ABC)
University of Sheffield	Agri	P3 Centre
University of Sheffield	Bio	CBMNet
University of Sheffield	Sustainability, Food, Energy	Grantham Centre for Sustainable Futures
University of Sheffield	Bio	Algal Biotechnology Sheffield Network
University of Sheffield	Food	SheFF - The Sheffield Sustainable Food Futures
University of Sheffield	Bio	Energy2050
University of Sheffield	Water	Sheffield Water Centre
University of Sheffield	Bio	SCARAB - Sheffield Centre for Antimicrobial Resistance And Biofilms
University of Sheffield	Bio	Sheffield RNAi Screening Facility
University of Sheffield	Bio	SInFoNiA
University of York	Bio	Biorenewables Development Centre
University of York	Sustainability	York Environmental Sustainability Institute
University of York	Agri-Food	N8 Agri Food Programme
University of York	Bio	Biological Physical Sciences Institute (BPSI)
University of York	Agri	Centre for Novel Agricultural Products (CNAP)
University of York		Centre of Excellence in Mass Spectrometry
University of York	Chemicals	Green Chemistry Centre of Excellence (GCCE)
University of York	Bio	Science and Technology Studies Unit (SATSU)
University of York	Data	Centre for Complex Systems Analysis
University of York	Bio	York Structural Biology Laboratory
University of York	Robotics	York Robotics Laboratory

Business Input to North of England Bioeconomy SIA

Business case studies and perspectives

June 2017

SQW

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Approved by:	Richard Hindle Director	Date:	21 June 2017

Overview

1. Introduction

Purpose and content

This Annex provides a set of business-based perspectives which inform and elaborate the Science and Innovation Audit for Bioeconomy in the North of England. It draws on 23 interviews, undertaken in April and May 2017, in person and by telephone, with senior business leaders and managers of relevant organisations in the North. These are presented in the form of individual case studies, together with a brief overview summarising key points.

The interviewees were drawn from a list prepared by the University of York, with other names and contacts added by the University's SIA collaborators. The intention was to reflect the breadth of the Bioeconomy, as defined for the SIA; most are businesses directly engaged in the specified activities; a few other operations are included which contribute to the wider assets and infrastructure. Businesses of very different scale and maturity were interviewed.

The case studies and perspectives provide specific information on the drivers for individual businesses, why they were established, how they operate, and the collaborations and business relationships which have supported their development to date; also, their views on future potential, the opportunities and barriers which are most relevant to their own growth, and actions that might be taken to encourage the growth of the wider Bioeconomy.

The findings in this Overview provide summary informed reflections: given the small number of firms involved, their selection based on known contacts, and the 'willingness to be involved' criterion, these findings cannot be considered as a rounded representation of bioeconomy activity, and are not scaleable. But they do provide detailed information from a range of types of business across the Bioeconomy in the North: the key characteristics of these businesses – their main activity, scale and regional location – are summarised below.

The analysis of key findings which follows this introductory section, is set out under four headings:

- Key business drivers (section 2)
- Regional competitive advantages (section 3)
- Business-science base interactions (section 4)
- Opportunities and challenges (section 5)

Analysis of businesses, by size, sector/activity/maturity and location

The 23 interviews span the four themes of the Northern Bioeconomy: i) feedstocks products derived from biomass or waste; ii) bio-transformative activities; iii) bio-based upstream activities; iv) bio-based downstream activities.

The firms fall into three main groups: i) six firms were at ***pilot and/or early/small stage production and process development***; ii) eight were engaged in ***large-scale production, on their own behalf, or as contract research and development organisations (CRDOs)***; iii) seven were mainly engaged in ***intermediate activities, spanning specialist technical and business services, and investment***. Two industry representative/membership organisations were also interviewed.

Table 1, below, shows key characteristics (activity, scale and location) of the 23 organisations interviewed. Two others are also included in the table: i) Arcinova, a business which is directly owned by the specialist investment vehicle, Shott Trinova, and which was discussed in the course of the interview; ii) Biovale, a York-based initiative with a marketing and development remit to promote the bioeconomy, and which has close links and is co-located with the Biorenewables Development Centre (BDC).

Most of those interviewed were located in Yorkshire, the Humber and the North East. Within that geography, the different types and scales of activity were well-distributed, as shown in the table.

Table 1: Businesses interviewed, characterised by main activity, scale and location[1]

	Feedstocks	Bio-trans-formative	Bio-based upstream	Bio-based downstream	All
Pilot/ early development/ small scale/ niche	• Nova Pangaea (NE) • Amur (Y) • Plaxica (NE)	• Viderabio (NE) • Green Biologics (X) • Wilson Bio-chemical			
Large-scale	• Brocklesby (Y) • CRODA (H) • Geenergy (NE) • Vivergo (H)	• FUJIFILM (NE) • Unilever (NW) • (Arcinova-NE)	• DRAX (Y) • Thomas Swan (NE)		
Intermediate – research support and technical/ financial services		• BDC (Y) • Shott Trinova (NE)	• Wheat-sheaf (NW) • Narec Distribut-ed Energy (NE)	• Precision Decisions (Y) • RAFT (Y)	• FERA (Y)
Representative/ member organisations		• (BioVale-Y)	• HCF Catch (H)		• BBIA (X)

Source: SQW

2. Key business drivers

The key drivers for the businesses reflect their activity and maturity, and therefore vary significantly between firms. In this section, we have tried to bring out some broad themes.

Business leadership and innovation sourced internally

All those interviewed have some internal development expertise, in some cases substantial: three main drivers of innovation can be distinguished:

- Businesses developing a specific new technology, including university spinouts, and typically aiming at a quite radical product. In some cases they are receiving assistance from customers/suppliers based in the North
- Businesses where corporate expertise, and new investment, is being applied to an existing plant, which operated in the same broad sector
- Individual entrepreneurs, bringing a substantial track record of technical and business knowledge and in-depth experience of industrial biotechnology processing.

Innovation through collaboration, networking and shared capacity

- Incremental advances are in many cases made through a combination of internal development and assistance from universities and others. Again, customers/ suppliers may be involved.
- A structured approach to source technology globally through associations with other companies, universities and research institutes. CRODA, Unilever and Drax are examples from those interviewed.

[1] Abbreviations are: H- Humber; NE– North East; NW- North West; Y- Yorkshire; X- Elsewhere.

Markets (regional/national/global)

All businesses are, or expect to, sell outside the North, although in some cases the business model is driven by access to markets, as well as the availability of local inputs. Nevertheless, most are, or will be, exporting: in some cases on a small scale, but some businesses in the sample were already selling internationally (exceptionally, over 80% of the product).

For those with global markets, the key driver is sustainability in the supply chain through renewable inputs and energy efficiency. These are also important in the UK market but the increasing costs of waste products as an input is also driving a search for greater production efficiency.

Technologies

Technology drivers vary substantially, across the disparate activities which make up the bioeconomy: several interviewees are seeking to achieve higher value outputs from recycling waste, although the methods for achieving this also differ between sectors.

Regulation

Regulation is an important driver especially in relation to the proportion of bio-fuels contained in diesel/petrol. Higher standards are required in the UK to stimulate investment.

There is a possibility that REACH[2] regulations could be abandoned with the UK's exist from the EU. One interviewee believed it would be a mistake to sacrifice longer-term opportunties for short-term profits.

3. Regional competitive advantages

The North was widely thought to possess significant competitive advantages. This was true for long-established businesses located there for historical reasons as well as inward movers. These advantages result from a number of factors.

Science base and research

Many businesses identified research capabilities as a major strength of the North. Specific references were made to:

- At the University of York; the National Non-Food Crops Centre, and others involved in Green Chemistry, bio catalysts and bio transformations
- Applied surfactants, advanced materials at Liverpool
- Huddersfield for its industrial relevance
- Durham for chemistry and some specialist applications such as MRI
- Newcastle for agricultural related research
- Manchester for a wide range of bio-related research and engineering.

The universities are considered to possess complementary research strengths which, in combination, gives the North world-class capabilities.

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[2] ***REACH*** is the European Union regulation regime, concerning the Registration, Evaluation, Authorisation & restriction of Chemicals (from 2008).

Research capabilities are not restricted to the universities and the following were also important to some of those interviewed.

- ***Fera*** (earlier the Food and Environment Research Agency) at Sand Hutton near York, with its emphasis on translational research and other activities to support technological development.
- ***CPI*** (Centre for Process Industries) which is a key intermediary for industrial biology and life sciences working from its main facility at Wilton, and ***the National Formulation Centre*** at Sedgfield, specialising in product development and applications, and ***the National Biologics Centre*** at Darlington, which supports the UK biopharmaceutical industry through collaborative working on process innovation and the development and adoption of new manufacturing and analytical technologies.
- The Biorenewables Development Centre (***BDC***) at York which focuses on ways of converting plants, microbes and waste into profitable bio-renewable products.
- Major businesses in the area which have substantial internal capabilities and have engaged with other companies in their supply chains. Our sample was too small to draw conclusions about business linkages in the Region, but Unilever and CRODA have both adopted open innovation strategies and are working with some Regional businesses as well as the universities (and of course organisations outside the Region and the UK).

Agricultural base

Many of those interviewed, from a diverse range of sectors, cited the importance of their local and regional agricultural sectors. The sector as a whole is diverse, with a wide range of crops (especially in Yorkshire) and animals. This leads to a number of locational advantages:

- Availability of crops as feedstocks
- Agricultural waste for feedstock purposes, and also a Regional demand to treat and add value to agricultural waste
- Opportunities to develop and test new technologies for agriculture.

Existing businesses

In addition to the agricultural sector the North possesses important concentrations of food processors, businesses engaged in recycling, e.g. wastes into fuels, and those producing higher value chemicals from waste or renewable inputs. While, as noted above, we were unable to map linkages between these businesses, there were mentions of:

- Supply chain relationships, sometimes involving knowledge exchange
- Access to feedstocks from food processing waste
- Collaboration on R&D.

In addition, interviewees from the North West and the North East pointed to the strong, separate, pharmaceutical sectors in these regions: this long experience of industrial biotechnology is a real asset in that the technologies can be transferred to other sectors. So far, this potential has not been exploited on a significant scale, although it seems likely that other sectors may recruit from pharma, and the large Contract Research and Development Organisations (CRDOs) in the North East provide significant sources of expertise and capacity.

Other interviewees noted that the history of process industries in the NE meant that (non-bio) skills which it required were readily available.

Transport

Road communications, especially the A1M and M62 were noted as excellent by several businesses. This is an important consideration given the high transport costs associated with biomass and waste inputs. The geographies for business interaction varied, as might be expected, by location and type of activity: agri-based businesses in Yorkshire & Humber tended also to look across the Pennines; for some North East operations, north-south links, including those to southern Scotland, dominated.

Knowledge transfer intermediaries

FERA drew attention to a new joint Institute with Newcastle University formed in October 2015 (Institute of Agri-Food Research and Innovation) with work being undertaken both in Newcastle and York. The Institute specialises in translational research to enable the excellent fundamental research and understanding generated at Newcastle to be translated into new science services and products. There are five Jointly appointed research posts between Fera and Newcastle University plus a growing cohort of joint PhD students, currently nine in number and expected to grow to 15. To date, the Joint Institute has involved collaborations between over 50 staff from both Fera and the University.

The Joint Institute's main focus is on agricultural diagnostics, crop protection and production and food safety & nutrition. This utilises some of the specialist facilities available at Newcastle including Cockle Park Farm as a research and demonstration centre for specialist diagnostic and sensing, imaging including satellite and UAV imaging, animal welfare and field based sensing equipment. The research includes specialised work on pesticide resistance e.g. of herbicides and using research on the fundamental mechanisms of resistance (Newcastle) and developing novel diagnostics from this (Fera).

Skills

The availability of key skills for the bioeconomy was also cited by many interviewees. Critically, this included process engineers and managers with experience of large-scale production to extremely rigorous quality standards, as well as graduates and post-graduates with high levels of technical knowledge.

The areas where it is more difficult to recruit and retain include biochemists and analysts with industrial experience: the North is not unique in this, and the quality of life and 'returnees' can be significant attractors. But more may need to be done to demonstrate that critical mass is being built in key locations and across the North. It was also suggested that, to maintain the company and skills base and build the next generation of bioeconomy businesses, more entrepreneurial attitudes need to be built into local cultures.

4. Business-science base interactions

Regional/national/global

Most of those interviewed had some contact with science-base institutions: the links identified included with:

- the National Non-Food Crops Centre NNFCC) at the University of York for advice and support to both waste and agriculture-based AD Operators
- Biorenewables Development Centre (BDC), which is also part of the University of York, for lab scale development and testing, providing proof of concept services and advice on presenting the business case
- Fera's key business area is agri-food, covering both pre- and post- farm gate, and impact of agri-food on the environment. It has collaborations with a range of companies in Yorkshire including Croda (multi-national specialist Chemicals Company based at Goole) and a wide range of food businesses including

retailers (eg ASDA in Leeds) and manufacturers (eg *Nestlé* in York). Pharmaceuticals and human healthcare is not a core market for Fera, although research is undertaken on the fate of veterinary medicines in the food supply chain e.g. antibiotics and other pharmaceuticals after they are released into the environment. Agri-chemical and vet drug firms need data on the fate and toxicology of new chemicals before they can be licensed. And all chemicals have to be tested for their environmental impacts under the REACH regulations

- CPI – as noted under research capabilities, the Centre operates several facilities, providing access to specific assistance for different types of industrial biotech businesses, and including support for innovation, product development and testing as well as collaboration around process issues
- the Supergen Bioenergy Hub (which is managed through the Tyndall Centre for Climate Change at the University of Manchester)
- University of York (Chemical engineering department) into methods for the removal of sulphur.

The extent and natures of links, of course, varies considerably according to size, sector and the companies' stage of development. Of those interviewed, Unilever has the most substantial collaborations including a major new (£50m) facility has recently been completed at the University of Liverpool campus which provides facilities for collaborative research between the company and the University and which includes the previous initiatives named Centre for Material Discovery (CMD) and a Micro–Bio Refinery (MBR). This provides facilities for collaborative research and development between Unilever and the University of Liverpool. The facility includes a 'research hotel' where external companies and technology suppliers can be brought in to work collaboratively in an open innovation environment. This facility has been in development for some 2-3 years and is now becoming fully operational.

In most cases the links are concerned with applied research or, in a few cases, use of specialist equipment/pilot facilities. As discussed further below, the interviewees cited little activity around direct commercialisation of universities' research. Many, including some small firms, have close links with universities in the North, and some value research networks, in particular the N8 Group of research-intensive universities, but they also cite good links with universities elsewhere in the UK. In some cases these are based on past contacts, but they are seeking the most relevant expertise.

The large firms in the sample have global markets, and sometimes operations abroad, and source technology globally. Some smaller firms also have international links although they tend to reflect specialist requirements and individual linkages, and of course, operate on a much smaller scale.

Role of intermediaries

The nature, scale and function of intermediaries varies considerably. In applying its expertise to offer industry-relevant services, the Biorenewables Development Centre (BDC), a not-for-profit company owned by the University of York, works directly with businesses, for the most part SMEs, to bring forward, test and operationalise ways of converting plants, microbes and waste into profitable bio-renewable products. The company was set up as part of the University's mission to make R&D relevant to the local and wider economies. BDC has worked with approximately 300 businesses: most of them SMEs, assisted with the help of European funding; 20-30 large projects with medium-sized and larger firms have also been undertaken over BDC's six years' operation.

Gaps in provision

Across the North as a whole, there do not appear to be any gaps so far as disciplines are concerned and most of those we interviewed considered this a major strength. There were also some positive comments concerning the various translational centres which have been established. However, comments were also made that the

universities were unwilling to become involved in the commercialisation of their knowledge, were out of touch with business requirements, unwilling to take risks and unrealistic as to their value of their inputs. This was generally attributed to lack of incentives and grant funding.

This is far from an unusual or novel business response to university capabilities and we expect the universities' response would be that it is not their role to act as a commercial technology organisation. Indeed, one interviewee who identified this as a problem stated that universities should not reduce traditional academic research, but that additional funding was required for directly commercial activities.

5. Opportunities & Challenges

Opportunities

The main opportunities cited were with regard to:

- The potential to move to higher value products from waste feedstocks, and to utilise more effectively the North's distinctive combination of resources and assets – including agricultural production, food companies and infrastructure. Intellectual knowledge, industrial process expertise, and existing and potential supply links within a fast-developing set of activities are all highly relevant
- The long and substantial industrial biotechnology expertise in the NW and NE pharmaceutical sectors: this knowledge, and capability, could be transferred to other sectors promoting the output of high-value products from sustainable inputs, and the transfer of technologies from established industrial biotechnology in the pharmaceutical sector to other sectors
- The scope to shift to higher value and sustainable products, which would require knowledge sharing across as well as within sectors, enhanced levels of co-operation between universities, and an increased willingness to undertake applied research for commercial organisations
- Demonstrable and transparent sustainability in the supply chain
- Universities and research institutes across the North working more actively to exploit their capabilities, which are recognised as outstanding, with the explicit aim of developing industrial biotechnologies for a diverse range of sectors. This would also involve greater collaboration between universities to exploit their world-class capabilities.
- Building further on the industry-based networks and personal links between key actors across the North, drawing also on the international profile of Fera (eg in accrediting laboratories world-wide) and other assets such as high level computing capacity at Sci-Tech Daresbury, with the aim of developing wider awareness of the North's bioeconomy offer.

Challenges

Key challenges relate to the potential for intelligent design and operation of the UK regulatory regime post Brexit, as well as to the focus on priorities, and marshalling the required resources, for responses at the level of the North of England.

- The biomass industry suffers from conflicting messages in relation to issues such as carbon pricing, future biomass subsidies and investment in technology such as carbon capture and storage. Some of this is a product of the recent machinery of Government changes, but DRAX noted that constant policy change has led to a brake on investor confidence and makes it difficult to plan beyond the next five years. Government interventions in Germany and Italy provide major drivers for new markets – for example, mandatory food recycling and favouring of bio-products in public procurement processes has propelled growth and innovation. The UK isn't short of mature investors, but the lack of a clear domestic market has been a brake on investment in plants.

- The taxation of methane is a constraint on its production from green processes as the tax authorities assume that methane will be used for burning rather than as a feedstock. More methane might be produced as a feedstock if this tax burden were eliminated.

- UK Regulations on bio content for fuel are relatively undemanding. Although many governments have moved, or are committed to moving, to 'E10', ie towards adopting a directive that 10% of transport fuel is sourced from renewables, different levels have been proposed, or are being enacted, for different users. Taken overall, it was pointed out that the process of adopting higher standards has stalled since 2012, and the resulting commercial uncertainty has been exacerbated by the falls in oil prices. E10 nevertheless provides a generally recognised 'standard': most modern cars can use this fuel mix, and there is no need for new infrastructure, as is required for wholly electric vehicles. In the North of England, there are issues related to the business case as well as the environmental case for utilising bio – techniques to convert feedstocks into more valuable or interesting products. Scale and supply of available feedstock is one of these. The legislative positions may make certain opportunities possible if the UK were to look at the possible changes in regulations, standards etc. that would make certain processes more viable. The production and use of new ingredient by biotechnology processes requires a great deal of work to overcome regulatory and safety hurdles.

- Ideally, central Government would make food waste collections and 'bio procurement' mandatory, and offer stronger incentives for biofuels and anaerobic respiration – this would drive both investment and innovation. Local interventions (e.g. on waste collection) could be helpful but economies of scale are important – changes of policy at city region level or higher would provide a solid and investable market. Issue here may be vested interests – many local authorities have long term waste management contracts and would be unwilling to break these and/or incur higher council tax rates to drive a bio-economy related policy.

- An opportunity is being pursued in collaboration with the Chemical Cluster in Teesside (NEPIC) and the 'Chemistry Growth Partnership' to reduce barriers to the greater use of green energy on the demand side. In particular, this collaboration is seeking to change the regulations around the supply of clean energy in a closed local area. At present, if a company has an electricity producing plant on its site, it can utilise the electricity produced on site utilising the various incentives available. However, once the electricity is sent outside the boundaries of that particular plant, other local potential users of the electricity must pay national rates. The collaboration is seeking a change in the regulations to allow closed networks of local electricity suppliers and users to be formed to allow electricity from green energy sources to be supplied within its boundaries (increasing the potential market for green electricity). NEPIC is leading on this proposal

- The industrial biotechnology expertise within the pharmaceutical sector remains, for the most part, within that sector rather than being diffused between sectors. The KTNs have been successful in their aims but these are sector-based rather than seeking to transfer knowledge between sectors. BioVale is a step in the right direction, but it is under-funded and the activities need to be undertaken on a Regional basis drawing on the combined expertise of the universities. IBioIC in Scotland is an excellent model for

what the Region should be seeking to achieve. FUJIFILM Diosynth and Acrinova (owned by Shott Trinova) are CDMOs - contract development manufacturing organisation. The key expertise is in the manufacturing processes which underpin industrial biotechnology:

- FUJIFILM operates internationally on a substantial scale and is managed from Teesside. It works closely with drug development and marketing multinationals, and also with the smaller specialists in the pharmaceutical industry – in some cases, virtual companies with an embryonic drug, and financial backing, but no facilities of their own. While it represents a substantial asset for the Northern bio sector, its customers are US-based firms in the biopharmaceutical sector: they buy the capacity and skills to turn their own IP, through several stages of development, into working commercial production.

- The research capabilities of the northern Universities are considered to be excellent, there are two few incentives for academic to undertake applied research to meet commercial requirements. The UK needs a re-balancing of its portfolio of research activities with a greater emphasis on translation of knowledge into commercially viable products or services. This should not be achieved by removing funding from excellent basic research but by providing new funding and other support to drive translation science and applied innovation. The Catapult Centres, for example, have been valuable, but there is a need for a range of other mechanisms. Could, for example, the German Fraunhofer model – which was used in developing UK Catapult Centres – be applied to enable existing entities to step up their activities, avoiding the need to set up further new catapult centre.

- Key barriers to innovation lie in the 'valley of death' where new knowledge developed in universities faces a range of barriers – funding, connectivity, capacity – is failing to be translated into new commercially viable products and services. This is particularly the case in biotechnology, where concept development, testing and scaling-up, and building market awareness and take-up for radically different products can take a decade. Translational science organisations like Fera have a critical role in trying to overcome obstacles and de-risk the process as far as possible, but appropriate support is required across the entire innovation landscape.

- The growth of recycling of waste materials by municipal authorities is reducing the amount of material available for waste burning plants and other bio-related streams.

- In the longer term, the possibility of manufacturing / processing in the North is constrained by the costs of relevant feedstocks in the UK with much more competitive sources available in other countries e.g. Asia, South America etc.

Potential policy/programme responses

Three main policy areas are suggested for further consideration.

First, there is a strong desire on the part of businesses for universities to become more involved in commercialisation and to combine the expertise across the region. As mentioned above this may be difficult for universities given their other responsibilities, and funding sources. Possible responses could be to:

- Establish applied research institutes along the lines of FhG. These would need to be involved in close to market activities and would certainly need to draw on the existing expertise within the HEIs and other technology organisations. More generally, the aim should be to build on the existing translational centres, strengthening where appropriate and developing closer collaboration between them where necessary

- Encourage a bid(s) to the Connecting Capability Fund (CCF). The Higher Education Funding Council for England (HEFCE) funds CCF, which will make £85m available for activities between 2018 and 2021. It will be funded through competitive bidding for university collaborative projects which:

    - *Delivers pooling of Knowledge Exchange (KE) expertise and capabilities so that businesses and other users can access a range of KE offers or critical mass of knowledge.*

    - *Builds capacity to provide cross-university responses to technological, industrial sectoral or inter-disciplinary challenges, or to regional alignments and challenges.*

    - *Incentivises sharing of expertise in KE and commercialisation and dissemination of good practice across the HE sector*

Second, there are major concerns amongst some companies that regulations are inhibiting market development. There may be a role for lobbying in relation to these regulations, including post-BREXIT outcomes.

Third, some major companies (Drax, CRODA, Unilever) are keen on open innovation strategies and there may be a role to publicise these opportunities and assist businesses across the North to enter such relationships.

Business case studies and perspectives

A: Amur

Christine Parry, Technical Development Manager

Telephone interview

Key messages

- Amur is a new venture based in North Yorkshire, developing and testing new technologies for handling waste at plant level in ways which generate value.
- As part of AB Agri (owned by ABF) it draws on specialist expertise developed over the long term, and a substantial UK and international market presence.
- The company operates its own Anaerobic Digestion (AD) plant, which provides a practical experience of issues arising with material handling, production processes and markets.
- The new company's key links outside AB Agri are with the National Non-Food Crops Centre, and others involved in Green Chemistry at the University of York; also with the BioVale cluster network based in the area.

The business operation

Amur is part of AB Agri, a division of ABF (Associated British Foods). AB Agri was established in 1984, to handle and find profitable opportunities for the waste pulp generated by British Sugar's beet handling operations.

Amur is a specialist handler of food and green waste, creating quality feedstock for anaerobic digestion (AD operations). The company was established to follow through on a new business opportunity ('concrete cow') identified by AB Agri. Amur has been operating for less than a year: the company was launched in July 2016 at the UK AD & Biogas Show.

Amur works on a co-producer basis, with and alongside, plants handling crop/agricultural and other waste. Its technical expertise is in the blending process through which feedstock of consistent high quality is produced from variable inputs. AB Agri invested £4m in Amur's own AD plant at South Milford near Selby, a 3MW gas-to-grid plant which has an annual waste handling capacity of 60,000 tonnes.

Another site, also in Yorkshire, was also considered, but this is seen as definitely the right location. The road access (A1M, M62) is excellent for access to the feedmills across Yorkshire and beyond, and in particular for the major, ABF-owned, Vivergo (wheat-based ethanol and animal feed) plant in Hull; this central location makes for a sustainable operation, given that transport costs are a very significant item. It is also advantageous to be close to large areas of agricultural land for spreading the digestate (as natural fertiliser).

The new AD plant has a direct gas pipe link to AB Agri's ABN plant, which produces pig and poultry feed at Sherburn-in-Elmet, one mile away: co-location was not an option for biosecurity reasons.

Amur's management team consists of a General Manager, responsible to AB Agri for its commercial operation, a Technical Development Manager, a Sakes Manager and an Operations/ Category Manager, who is responsible for the five plant operatives.

Collaborations and business relationships (including supply chain)

Amur was set up by AB Agri and this is the key business relationship. But those involved were already aware of the Green Chemistry expertise (biorenewables, biochemicals) at the University of York, and had some links with key people. Local collaborations have already developed and proved useful: these relationships are expected to deepen.

- Amur's close working relationship with the National Non-Food Crops Centre NNFCC) at the University of York is highlighted on the company website. The linkage with this advisor on bio-economy policies, markets and technologies is to offer advice and support to both waste and agriculture-based AD Operators, across the UK.
- There is also a good working link to the Biorenewables Development Centre (BDC), which is also part of the University of York, and specialises in lab scale development and testing, providing proof of concept services and advice on presenting the business case
- Amur has, and expects to build further on, a close working relationship with the wider BioVale Cluster around York; this provides the small management team with the networking informal connections and events through which they can increase the growing sector's awareness of their expertise and offer - in particular through the AD special interest group; also with intelligence on new developments in the area and possible market opportunities.
    - Amur faced an early issue when seeking planning permission for the AD facility. BioVale and the York and North Yorkshire LEP were able to provide a planner who acted as intermediary.
- There is also a research-based relationship with Fera, based on the expertise there in animal feed, and specifically on the role of larvae in blood.
- Amur is aware of CPI, and will look to maintain the existing, low-level, business relationship, engaging and deepening this link when process expertise is needed.

Growth opportunities and barriers

The company is in its first stage of operation, and the immediate business focus is on the north of England (and national) market. There are already local opportunities being put in place, for example at BTS, which operates 3 UK plants including close by at Garforth, Yorkshire.

- The AD plant is important as it gives Amur direct experience of the practical issues that can be faced – for example a recent issue when a spell of mild weather meant that the gas produced could not go into the grid.

AB Agri has a very substantial international presence, and the Amur facility is seen as a flagship for the AD industry, identifying opportunities and solving problems at plant level through its offer of specialist expertise and experience of in-house testing and work with other experts. Given the range of activities and wider profile of the parent company, there are aspirations, but nothing more as yet, to take the business, or the business model, international.

Local expertise and networks are seen as 'fantastic', but AD technology, and in particular economic applications on a 'real world' scale, is still being developed: Amur expects to play an important part in this, working with others. The AD facility was deliberately oversized, to give potential for further growth and development.

Beyond this, Amur's Technical Director is already looking for new products and processes, with better use of feedstocks to add value to 'next generation' plants, eg prior treatment enabling chemicals to be extracted from the digester without the use of intermediaries.

- Carbon capture is coming back as an issue that needs to be addressed: while the CO^2 produced from the digester can be 'cleaned' this may not be an economic solution.

B: Biorenewables Development Centre (BDC)

Dr Joe Ross, Director

Telephone interview

Key messages

- BDC is a not-for-profit company that works directly with businesses, in particular SMEs, to bring forward, test and operationalise ways of converting plants, microbes and waste into profitable bio-renewable products.
- The company was set up by the University of York as part of its mission to make R&D relevant to the local and wider economies. Owned and directed by the University, BDC is based outside the campus, in an industrial park which offers scope for further expansion and joint working. It provides a bridge to the University's knowledge which starts from business need, rather than being research-led.
- BDC has collaborated successfully, and built a track record with, other intermediary organisations and service providers in the bioeconomy, both public-funded and commercial. Productive long-term relationships have been developed with larger corporates as well as with SMEs.
- The position and profile built by BDC over the last 6 years has led to its active involvement in scoping technologies and market testing for several major new investment propositions in the North of England: these are, in turn, likely to provide a stream of new opportunities for the future.

The business operation

The Biorenewables Development Centre (BDC) is a York-based not-for-profit company that provides technical services to help businesses develop ways of converting plants, microbes and biowastes into profitable bio-renewable products. BDC's sole guarantor is the University of York.

> *"The BDC bridges the gap between the world-class science base at the University of York and the needs of industry to develop and scale-up new greener processes and products."*

BDC was established in 2011; it resulted from collaboration between two specialist units in the University, the Green Chemistry Centre of Excellence and the Centre for Novel Agricultural Products (CNAP). At that time it was described as a 'semi-scale' (10-100 kg/litres) research and testing facility. BDC's services now span pre-processing, process development, genetic analysis, plant science and micro-biology. Open access laboratory space and testing facilities, in which businesses can explore and develop their ideas, are a key part of the offer.

The five-person BDC Board includes senior University of York academics with in-depth knowledge in relevant fields, and networks spanning business as well as research; also the University's Finance Director and the BDC executive Director. Approximately 25 people are now employed at BDC (full-time and part-time), with teams focusing on feedstock development, process development and business development.

The BDC offer spans a wide range of technical development issues, and access to scientific knowledge and experience in specialist applications across chemistry and biology is a critical part of the offer. As BDC grew, more space was needed and the office, laboratories and workshops were moved from the University Science Park to Chessingham Park, Dunnington. This is outside the York ring road, but only 5km from the University.

As BDC has grown over the last six years, the space and value offered by its current premises has enabled an efficient offer of tailored services to industry; a detailed understanding has been gained of the priorities and criteria of potential funders, including those relating to match funding and state aid. On-going relationships have been built with many business partners, large corporates as well as SMEs; more recently, some larger projects have been undertaken over longer timespans. BDC's reputation and reach has also become increasingly national and international, with a wide range of collaborations and partnerships further afield.

Two examples illustrating the range of BDC's activities, from the hundreds of projects undertaken, are:

- Work with a successful Ripon-based artisan bakery, *nibnibs.* undertaken on an incremental basis to improve production processes in existing and new lines
- On-going engagement with Wilson Biochemical, which is now based at Dunnington, alongside BDC. Wilson Biochemical has a track record in developing waste handling systems, and taking innovative approaches through to commercial operation. The company has developed a **Micro Autoclave Fibre Production Plant for turning municipal solid waste (MSW) into biomass fibre that can then be used for a range of useful products. This new technology should divert substantial amounts of mixed waste from landfill, producing chemicals and fuels which can replace the use of fossil-resource-based products. BDC's assistance included advice on public R&D funding as well as technical support: BDC assistance is acknowledged on Wilson Biochemical's website. Significant further investment is now likely, and BDC anticipates involvement in the next stage development.**

Collaborations and business relationships (including BioVale)

The focus is on a sustainable business model: key relationships for BDC are therefore with those who value its services, including client businesses paying direct, and funders enabling market development and early-stage support. Funding through ERDF has been important in enabling services to be marketed that are attractive to SMEs (2 days' free initial consulting support and small grants), and in-house experience and expertise to be developed through this offer. Horizon 2020 has also been important for project funding, where BDC has been a partner, notably in the field of waste valorisation.

BDC has close operational linkswith **BioVale**, an initiative with a marketing and development remit to promote Yorkshire and the Humber as a thriving centre of successful innovation for the bioeconomy; Biovale is also active in catalysing business-university interactions. The BDC Director, Joe Ross, is a member of the BioVale Steering Group, which is chaired by Professor Debbie Smith, Pro-Vice-Chancellor for Research at the University of York, and includes senior managers from the biotech industry and from the Local Enterprise Partnership and City of York Council, as well as academics. BioVale has a small (four person) executive, and operates from the same offices as BDC, at Dunnington. Biovale has set up a special interest group on anaerobic digestion and food waste, which has attracted strong interest and engagement from industry.

There is also a strong relationship with the **N8 Group** of research-based universities across the North of England: awareness of research, and the potential applications of industrial biotechnology into other sectors, sub-sectors and processes, are important to BDC's positioning.

Across a wider geography, an important recent BDC collaboration is **BioPilotsUK,** which involves five R&D centres working in biorefining technology development and bio-based product manufacture across the UK, and was launched in October 2016, The other founding Centres were BEACON (Wales), the Centre for Process Innovation (CPI – Redcar), IBioIC (Scotland) and The Biorefinery Centre (Norwich). The aim is to collaborate,

exchange expertise and cross-refer where appropriate, and to avoid duplication. BDC has a good, long-standing. relationship with CPI on Teesside; the latter's engineering facilities and in-depth knowledge of production processes complement BDC's expertise in bioscience and biotechnology.

In looking for new commercial opportunities, BDC has a bilateral agreement with **Aqua Enviro**, to pursue joint tendering opportunities, and look for active cross-referrals, Aqua Enviro, also based in Yorkshire, is a leading environmental consultancy, conference and training provider working in the water, wastewater, bio-resources and organic waste sectors.

Growth opportunities and barriers

BDC has worked with approximately 300 businesses: most of them SMEs, assisted with the help of European funding; 20-30 large projects with medium-sized and larger firms have also been undertaken over BDC's six years' operation. BDC has active relationships with some of the largest firms engaged in the bioeconomy across the north of England, including Croda, Drax and Unilever.

Looking forward, BDC will continue to work through what is styled the **'B2B Pipeline'**: most BDC projects are still expected to be relatively small projects with SMEs, using small-scale equipment and facilities. This is where businesses face a challenge in terms of specific knowledge and expertise, and where the available resources of people and money can be used most effectively. In current market and technological conditions, there is no shortage of potential projects, and there is scope to utilise currently underused land and buildings close to the BDC at Dunnington: **'the BDC Biotechnology Enterprise Park'.**

EU funding was important in building BDC, and Brexit will inevitably cause changes. But as current funding is still on-going, it is not an immediate problem: nor is it seen as an issue that seriously threatens BDC's existence in the longer-term. The Director notes that there is time to adjust – Horizon funding will not cease until 2023: other potential funding streams have opened up at national level – for example, Local Growth Funds, and the UK Industrial Strategy Challenge Fund which offers the scope to plan for customised partnership collaboration to meet specific opportunities. There are also bilateral international opportunities: a current example is the on-going discussion with a potential German collaborator.

There are also important opportunities outside Europe, which BDC hopes to access through collaborations under the £1.5bn Global Challenges Research Fund (GCRF), which involves the Research Councils and national academies. Another potentially important resource is the Newton Fund, launched in 2014 with a focus on science and innovation partnership working, and involving Innovate UK. This has £735m allocated from UK Government to 2021. Both GCRF and the Newton Fund are part of the UK's overseas development programme.

The areas of anaerobic digestion and micro-biological analysis have become increasingly important recently. More widely, the varied nature of raw materials and feedstocks in the bioeconomy means there is single approach to biorefining: technologies must be trialled and combined. The BioPilotsUK alliance is potentially important, in that it can enable the right teams to be assembled across a wide range of bio-based projects, drawing on expertise and facilities from all five Centres.

Other opportunities are arising, and are expected to arise in future, from changes in the regulatory frameworks across the bioeconomy and related areas, driven by the imperatives of climate change and sustainable food production. BDC is currently involved in several active collaborations, including the following.

- Discussions on the scope for a 'world-scale' new sugar refinery: interest from a major international investor has been prompted by the end of the EU sugar beet regime in September 2017: the scope, planning conditions and logistics and market requirements for a competitive new plant in the York area are now being tested in detail.

- Work with a major pharmaceutical company looking for a new more sustainable source of glucose for an important drug product, and a specialist waste-handling firm with an interest in replacing a wheat-derived feedstock with cellulose, or low-value by-products or waste sourced material. Lab-scale and pilot-scale trials and a techno-economic assessment are currently underway. If successful, the ambition would be to undertake further testing and then feasibility studies for a plant in the UK that would supply a range of industrial biotechnology users with a renewable and UK-sourced feedstock for food and non-food production.
- Collaboration with a material science company based in Scotland which is at the forefront of development and commercialisation of 'nano-cellulose' products based on sustainable resources (root vegetables rather than cellulose) for which there are potential applications in a large range of industries including paints and coatings, consumer care and food.

C: Bio-based and Biodegradable Industry Association (BBIA)

David Newman, Chief Executive

Telephone interview

Key messages

- Northern Bioeconomy is relatively small, and is a 'colony market' for rUK, large European players (notably Italy and Germany). Despite this, some firms stand out – notably Fuchs, Innovia and CPI.
- UK's strength (and by extension the North) is in academic research. No incentive to move beyond grants towards commercialisation or collaboration.
- Under investment is a national policy problem. UK Government needs to step in to provide markets for bio-products, this will stimulate innovation and commercialisation. Under-investment not an issue, but lack of investable opportunities is.

The Bioeconomy Offer in the North

DN gave a broad overview of the strengths of the North's bioeconomy. He noted that **CPI**, through their anaerobic digestion sites at Newcastle, Darlington and Middlesbrough were a key commercial player. CPI were an outlier in terms of scale but other firms, including **Fuchs** (bio-lubricants) in Lancashire and **Innovia** (bio-films) in Cumbria were doing interesting work and attracting investment.

Academic research was the core of the North's strengths, with **University of York** cited. DN shared frustration that the UK was behind markets in mainland Europe and the USA in terms of commercialising research IP.

Some of this is down to broader UK business customs, but DN cited Government interventions in Germany and Italy as major driver of new markets. In both these countries mandatory food recycling and favouring of bio-products in public procurement processes has propelled growth and innovation. The UK isn't short of mature investors in the field (DN noted some UK VCs are investing in European companies) but the lack of a clear domestic market was a brake on investment in local firms.

Collaborations, business relationships and international engagement (including supply chain)

DN was unable to offer full detail on specifics, especially with regard to monetary values but estimated the value of the North of England's entire bioeconomy in the **'low tens of millions'**. The UK is a net importer of bio-goods, and the North is even a colony market for the rest of the UK.

He did note a few significant instances of collaborations across industries and borders. Notably:

- **Fuchs** were working closely with Jaguar Land Rover to allow all of their lubricants to be used in JLR's vehicles;

- **Crowder** and **Azko Nobel** – major players in the international market were now using some suppliers and basing small facilities in the North (no details given when pressed);
- **Innovia** in North Cumbria have the contract to supply the UK's new generation currency and were recently bought by a Japanese parent company who have undertaken a 'hands off' approach;
- **CPI's** North East base is doing good quality process research but this is still some way behind the cluster in Rhine-Essen.

Growth opportunities and barriers

DN took the view that the UK bio-economy was being constrained at the national level through a **lack of willingness to open up markets.** Ideally central Government would make food waste collections and 'bio procurement' mandatory, and offer stronger incentives for biofuels and anaerobic respiration – this would drive both investment and innovation.

Local interventions (e.g. on waste collection) could be helpful but economies of scale are important – **changes of policy at City Region level** or higher would provide a solid and investable market. Issue here may be vested interests – many Local Authorities have long term waste management contracts and would be unwilling to break these and/or incur higher council tax rates to drive a bio-economy related policy.

The sector is pushing for a **National Centre for Research in Anaerobic Digestion** which includes the Universities of Leeds and Manchester as part of a **Sector Deal** under the Industrial Strategy. Such an intervention would go a long way to helping to commercialise R&D in this sub-sector.

D: Brocklesby

Robert Brocklesby

Telephone interview

Established in 1987, Brocklesby is a leading food waste recycling company committed to collection and conversion services. Brocklesby's expertise lies in recycling edible oils and food fats for a diverse range of end user industry sectors including biofuels and energy generation.

- The Brocklesby site has the following facilities:
- Purpose built site complete with 1000m2 bulk storage facility
- Modern used cooking oil recycling plant
- Food recycling and anaerobic digestion plant

Brocklesby work closely with major UK retailers and food manufacturers throughout the UK and Ireland, to provide a bespoke waste management and recycling service.

T/o ~£50m and 70 employees. Soon to increase to 100.

Works with York (Green Chemistry Centre of Excellence – KTPs. Highly rated and believed to understand commercial needs which many universities do not) and Sheffield (logistics institute) Universities. Small pieces of work which they cannot do in-house:

- BDC also useful
- Historical reasons for location but M62 corridor has transport advantages
- Primary competitors are UK based

Trends:

- Green resource management becoming more important and more mainstream
- Technology is changing rapidly and becoming more efficient
- Accessing raw materials is main problem.

E: CRODA

Will Cannon, Project Development Director

Telephone interview

Key messages

- The scientific and agricultural base in the North of England makes it an excellent location for some bioeconomy businesses
- CRODA's markets are global and it requires global access to technologies
- There is scope to shift to higher value and sustainable products, but this requires knowledge sharing between sector, cooperation between universities and an increased willingness to undertake applied research for commercial organisations

The business operation

The business

CRODA manufactures speciality chemicals for use in a diverse range of products. The business is split into three core market sectors:

- Personal Care
- Life Sciences (Crop Care and Health Care)
- Performance Technologies (Coatings and Polymers, Geo Technologies, Home Care, Lubricants and Polymer Additives).

The company also manufactures industrial chemicals.

Global sales in 2016 were £1.2bn and employment around 4,200 (of which 2,200 are based in Western Europe) CRODA exports around 80% of its output. It is a global business with manufacturing plants in North and South America, Continental Europe and Asia as well as the UK. The UK manufacturing plants are located at Hull, Goole, Widnes and Leek (Staffs).

The key driver for CRODA is sustainability in its manufacturing operations. Customers, and the final consumers of their products, are demanding sustainable products and information on production methods and the supply chain is easily available to them. This has two broad implications for CRODA – it needs to become more energy efficient and to utilise sustainable feedstocks from agriculture and recycled waste products. The technology strategy is **global** and has three main strands:

- Internal R&D
- An open innovation strategy – in 2016 CRODA had 250 partnerships with SME, HEIs and research institutes in the UK and abroad

- Acquisition and licensing through the Technology Investment Group (TIG). TIG's remit is to acquire disruptive technologies which can address identified gaps in the company's portfolio.

Company history and reason for location in the North of England

The business was established in 1925 to refine wool grease into lanolin. There are, therefore, important historical reasons for its current UK locations, but also a number of major advantages to continuing in the region. These include:

- Excellent research and technology capabilities provided by the universities and research institutes, but also other business sectors
- Crop production, especially High Erucic Rapeseed varieties but looking to the future sugar beet, may become an important feedstock
- "World's best woody biomass transport infrastructure" based on the Drax development
- Food wastes from food processing; another potential feedstock.

Collaborations and business relationships (including supply chain)

CRODA has close contacts with many of the Region's universities/research institutes and the following were identified as high quality:

- At York; its green chemistry department along with CNAPs world leading research on enzymatic biomass hydrolysis, Material innovation factory (MIF) at Liverpool
- Huddersfield for its industrial relevance in Metrology
- CPI and the BDC for the demonstration capabilities

CRODA also works closely with Unilever, one of its customers, and the two firms have collaborated on an Innovate UK project together with other partners. Indeed, it was working with Unilever, which has long had an open innovation strategy, which led CRODA to develop its own strategy in this area.

The NW's strength in pharmaceuticals, and particularly industrial biotechnology, was also identified although, as is discussed further below, this potential is felt to be under-exploited.

Growth opportunities and barriers

For CRODA, and also other businesses in the Region, the key opportunity is to develop more sustainable manufacturing processes and supply chains. In addition to greater reliance on renewable feedstocks and recycling waste, this also requires extracting higher value products from these feedstocks. Burning, or producing fuels from bio materials in other ways, is not considered to be a long-term solution. Mr Cannon believes that the North is well placed to exploit this opportunity. In particular:

- The NW pharmaceutical sector has long and substantial industrial biotechnology expertise and this knowledge, and capability, could be transferred to other sectors promoting the output of high-value products from sustainable inputs
- Universities and research institutes in the Region have, in combination, outstanding capabilities and this could be exploited to develop industrial biotechnologies for a diverse range of sectors.

The challenge is capitalising on this potential and there are two main issues. First, the industrial biotechnology expertise within the pharmaceutical sector remains within that sector rather than being diffused between sectors. The KTNs have been successful in their aims but these are sector-based rather than seeking to transfer knowledge between sectors. BioVale is a step in the right direction, but it is under-funded and the activities need to be undertaken on a Regional basis drawing on the combined expertise of the universities. IBioIC in Scotland is an excellent model for what the Region should be seeking to achieve. All the major Scottish universities are members. It has five themes at present (feedstocks, enzymes and biocatalysts, cell factory construction, downstream processing and integrated bioprocessing) and its core industrial members, which includes CRODA, come from a diverse range of sectors.

Second, while the research capabilities of the Northern Universities are considered to be excellent, there are too few incentives for academics to undertake applied research to meet commercial requirements. The Region needs a service akin to that provided by the Fraunhofer institutes in Germany.

The interview also touched on the potential impacts of leaving the EU. The direct market impacts are not considered to be significant but it is essential that:

- REACH regulations are maintained
- Participation in pan-European research programmes continues to be possible.

F: Drax

Darren Walker, Laura Craggs and Graham Backhouse

Telephone interview

Key messages

- Drax is a key player in the Northern bioeconomy, and in the international biomass economy.
- Its drive to upgrade facilities has led to significant investment, knowledge spillovers and innovation throughout the local and national supply chain. Much of this has crystallised locally;
- There is a disconnect in the North between large and small businesses, and between business and academia – Drax has an open door (and often is the one engaging first) but feels that it hasn't regularly been approached with ideas and collaboration projects by potential partners;
- Sustainability of growth is contingent on policy stability and the skills pipeline – both look problematic in this moment.

The business operation

Drax plc is a major electricity generation and retail energy supplier based in Selby, North Yorkshire. It employs 2300 staff and supports over 14,000 jobs across its UK supply chain. Drax contributed £1.2bn to UK GDP in 2015, of which £277m was generated in Yorkshire and Humberside where 932 staff are employed.

Drax produced 16% of the UK's renewable electricity in 2016 having upgraded half of the power station to use sustainable biomass from coal. The compressed wood pellets Drax uses are manufactured using residues from commercial forestry operations and wood processing facilities. The conversion of the three generating units to biomass itself generated £430m for the UK economy and 7,000 job days of which over half were in the North.

Drax has strong international links. Its biomass supply business is headquartered in Atlanta, Georgia in the USA with pellet production facilities in Louisiana and Mississippi as well as a port facility in Baton Rouge, Louisiana. Additionally the UK business imports biomass from other sources including Canada, the Baltic and Mediterranean regions.

It is a key partner in the Sustainable Biomass Program, which brings together companies from the UK, the Netherlands, Belgium, France and Denmark (including Dong, Vattenfall and RWE) to provide industry standardisation of sustainability requirements for woody biomass. The SBP certification facilitates and promotes the trade of legal and sustainable woody biomass across international markets, and enables the calculation of the full energy and carbon footprint of biomass from its origin to its end use.

Collaborations and business relationships (including supply chain)

Drax has strong relationships with the broader business and academic communities across the North of England bioeconomy.

It works with the Supergen Bioenergy Hub (which is managed through the Tyndall Centre for Climate Change at the University of Manchester), offering opportunities for researchers to engage with Drax, such as through panel events on the future of energy and sustainability. Alongside this Drax sponsors a PhD student in Forest Carbon at the University of Leeds.

Drax is also engaged with the University of York's Biovale programme, which seeks to connect businesses in the bioeconomy to cultivate links and supply chain opportunities. The company is keen to engage further; is often seen as a 'big player', but has an open door and a policy of engagement, especially on sustainability issues.

On the supply chain side, Drax has undertaken large scale innovation to support the conversion to biomass which has led to significant economic spillovers and collaboration. The firm remodelled its entire global supply chain to source sustainable wood fibre from areas with strong forest industries and therefore abundant availability of low grade wood fibre, and then reverse engineered this through its logistics chain. This included:

- Purchase of an inland port in Baton Rouge, LA to ensure the lowest carbon journey for compressed wood pellets being transported from North America;
- Unlocking £250m of investment across four UK ports (£20m of investment at the Port of Tyne, £100m at the Port of Liverpool and £130m at Humber Ports at Hull and Immingham) to convert the facilities so they could provide the 25,000 tonnes of biomass used at Drax daily;
- Worked to use local suppliers in the delivery of these conversions, including Spencers of Hull and Shepherds of York;
- Supported creation of 120 new jobs at rail freight carriers DB Cargo and GB Railfreight;
- Supported UK engineering/manufacturing by ordering the build of its bespoke biomass rail wagons at WH Davis waggon builders of Mansfield; and
- Internal innovation using 'off-the-shelf' contract capture and execution, rail tracking and logistics optimisation software which drives sustainability, just-in-time modelling and in future will support the tracking of greenhouse gas emissions.

Growth opportunities and barriers

Drax foresees two real 'crunch' areas which affect future success and growth.

The first of these is a skills shortage. Drax is often faced with graduate applicants with little understanding of large scale supply chains, the biomass industry, or forest sustainability. It believes that many UK courses in Renewable Energy are too squarely focussed on wind and solar power. It is keen to engage with secondary and tertiary educational providers to help fill in these gaps.

The second issue is a lack of policy certainty at national level. The biomass industry suffers from conflicting messages in relation to issues such as carbon pricing, future biomass subsidies and investment in technology such as carbon capture and storage. Some of this is a product of the recent machinery of Government changes, but Drax feels that constant policy change has led to a brake on investor confidence and makes it difficult to plan beyond the next five years.

Less fundamental, but still problematic are the lack of incentives for academia to properly engage with businesses to drive innovation and commercialisation and productisation of new processes and ideas. There is a still a 'grants culture' when it comes to collaboration, rather than a commercial one.

Logistics investment is also an issue – both from an economic and environmental point of view, idling trains are bad for business, and are regularly second priority behind passenger train movements.

Drax is happy to play a role in delivering change in all of these areas – both in terms of knowledge and expertise, and as a large business practicing what it preaches. It also actively engages with Government, and academia, to help improve understanding of problems and concerns but needs definitive statements and funding streams in order to fully unblock problems.

G: Green Biologics

Dr Tim Davies, Chief Technical Officer

Telephone interview

Key messages

- Green Biologics is a specialist biotechnology company, formed in 2003, with 40 staff in the UK where its R&D and senior management functions are based and 60 staff at two main sites in the US.
- The company specialises in advanced fermentation for both C3 and C4 products to produce higher value chemicals such as butanol and acetone using clostridium microbes for novel synthesis processes.
- The company has major strategic investors and partners which are providing support while the Company's developments are coming to commercial realisation.
- There are numerous collaborations and interactions with Universities in the North including York, Newcastle, Manchester and Nottingham.
- Long term collaborations with the University of Manchester on the potential for graphene meshes in separation technologies are also important.
- There are other relationships in the North e.g. with major companies but these are mainly at the investigation discussion stage.
- Opportunities for further collaboration in projects, studentships, advisory boards would be welcome but these are dependent on their being a suitable source of funding.
- The Company has developed interesting consumer related products such as bio-synthesised barbecue lighter fuel with significant consumer advantages as well as environmental benefits which has recently been launched in the US.
- In the longer term, the possibility of manufacturing / processing in the North is constrained by the costs of relevant feedstocks in the UK with much more competitive sources available in other countries e.g. Asia, South America etc.
- In the longer term, there are likely to be significant opportunities for the Company's expertise in the conversion of feedstocks into bio-fuels to be important for major industries such as synthetic kerosene for aeroplane fuel.

The business operation

Green Biologics was founded in Oxford in 2003 and specialises in the development of industrial biotechnology and is a leading supplier of advanced fermentation techniques for the conversion of biomass to renewable fuels and chemicals. The primary activity is to provide process technology for the production of butanol, a high value chemical which also holds great promise as an advanced biofuel.

The company is based at Milton Park in Abingdon in Oxfordshire where there are some 40 staff, the majority of these are scientists mainly in the fields of biochemistry, formulations, analytical chemistry and chemical engineering, but also senior management and finance staff. The Abingdon facility includes laboratories as well as a library of clostridium microbes which provide the basis for the fermentation technologies as well as a range of novel synthetic biological tools. The Company synthesises renewable chemicals (acetone and butanol) using these clostridium microbes through fermentation of plant derived sugars

It has two US sites employing some 60 staff which are mainly concerned with production operations involving pilot and full scale plants for the production of acetone and butanol which are utilised in a variety of further chemicals such as solvents, paints, coatings, plastics, foods, home care and consumer products. In the US, the Company has a production plant and associated pilot facilities at Little Falls Minnesota and laboratories at Ashland Virginia. It also has a few staff in China, India and Brazil

The company has recently started the manufacture and sale of its first consumer product a biologically produced charcoal barbeque lighting fluid 'Greenflame' which has significant advantages over the traditional lighter products made from kerosene which burn with an oily smell and can impart this to the food being cooked. The 'Greenflame' product does not have these disadvantages and is also derived from natural / renewable products and, therefore produces fewer GHGs. The product has recently gone on sale through major supermarket chains in the US including the Kroger and Safeway chains of supermarkets.

Green Biologics is revenue generating, but is also supported by a number of major investors for its longer term development. These include Swire Pacific which is a strategic investor in the company and also a major owner of other companies in the Airline business (Cathay Pacific), ground services, airports, shipping, coca cola bottling in Asia and shopping centres and some chemical companies in Asia. Swire Pacific has interests in renewable fuels, particularly in relation to the possibilities for renewables for its airline businesses and also, possibly its shipping businesses.

The Company has a number of other strategic partners including:

- Jungbunzlauer in relation to bio-based plasticisers
- HOC industries of Wichita in relation to high quality /value consumer products
- Caldic – an EU distribution partner for Green Biologics' renewable chemicals
- Acme Hardesty for bio-based personal care products distributing caster oils, palm derivatives, preservatives and surfactants
- Nexeo Solutions who are distributors of renewable n- butanol and acetone in the USA for coatings, adhesives, sealants , elastomers, personal care and energy chemicals. Nexeo has worldwide operations in the distribution of these products to a wide range of industries including chemicals, automotive, healthcare etc.

Collaborations and business relationships (including supply chain)

The Company has no direct investments or operations in the North of England, but has had a series of collaborations, contracts and other linkages with organisations in the North. These include:

- academic collaborations through PhD studentships supported by the Company at the University of Newcastle as well as some other collaborations related to EU funded project
- PhD studentships supported by the company in engineering and at University of York in Molecular Biology
- A new PhD studentship which is about to start at Sheffield University in synthetic biology
- At Nottingham University there is collaboration through an EU funded ERA net projects and two projects funded by Innovate UK and BBSRC
- There is also one project which was funded through the White Rose partnership which is based at the University of York

The Company is also involved in a number of projects through membership of its Advisory Boards and the provision of support in kind and staff time. The following projects are currently active:

- Detox involving University of York, University of Nottingham and CPI
- Conbiochem involving University of Nottingham and CPI
- Max –Bio Project involving U of Dundee , University of York and CPI
- A project concerned with the use of graphene membranes at the U of Manchester for the use of graphene in separation of chemical products – this however has a long perspective of 5-15 years.

In each of these projects, the Company's contribution may include staff time, the provision of data and or materials, use of the Company's laboratory etc. and the guidance and focus on exploitation possibilities / perspectives.

The Company has also had a commercial contract with CPI in which CPI provided specialist distillation processes to enable the Company to progress its fermentation activities at scale. This involved Green Biologics sending one of its staff to CPI to play an active role in the process

In addition, the Company has had a number of discussions with major companies in the North.

The role of funding in facilitating these collaborations in the North is important and the Company would consider involvement in projects in the North which were relevant to its developing interests.

Growth opportunities and barriers

In addition to the involvement in research and development activities discussed above, Green Biologics could have an interest in the longer term if there were advantages in being close to sources of relevant feedstocks. However, feedstocks in the UK are not particularly competitive with the US, Asia and South America providing much greater competitiveness because of the abundance of forest and sugar cane related feedstocks.

The North could possibly provide a source of lignocellulosic sugars and agricultural waste.

There are opportunities for greater involvement in the Northern science base if relevant projects and funding sources became available

There may also be opportunities for greater collaboration with other companies in the North including opportunities for more 'open innovation' projects

Constraints

- Costs of UK produced feedstocks
- Availability of funding for projects involving relevant collaboration with Northern University departments.

H: Greenergy

Frank Mowatt, Chemical Engineer

Telephone interview

Key messages

- Major bio-fuel market and capabilities= Greenergy is a major supplier
- Two bio fuel plants in the North of England, Immingham can take used oils with high Free Fatty Acid content (FFA). Seal Sands was acquired from Harvest Energy in 2015 to provide more biofuel capacity – but typically takes used cooking oil with low FFA
- Some commissioned research with University of York on issues related to sulphur removal
- Collaboration with px group (Stockton on Tees)to enable Immingham plant to produce bio diesel from high FFA used oil and tallow feedstock
- Further collaboration with px group to find new ways to create sustainable products from the Immingham plant's waste stream
- Market development highly dependent on regulations, taxation, economic regime surrounding bio-fuels
- Also some collaboration with Bocklesby at North Cave near Brough on reduction of FFAs

The business operation

The business operation

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The Company has a number of other strategic partners including:

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Collaborations and business relationships (including supply chain)

The Company has no direct investments or operations in the North of England, but has had a series of collaborations, contracts and other linkages with organisations in the North. These include:

- academic collaborations through PhD studentships supported by the Company at the University of Newcastle as well as some other collaborations related to EU funded project
- PhD studentships supported by the company in engineering and at University of York in Molecular Biology
- A new PhD studentship which is about to start at Sheffield University in synthetic biology
- At Nottingham University there is collaboration through an EU funded ERA net projects and two projects funded by Innovate UK and BBSRC
- There is also one project which was funded through the White Rose partnership which is based at the University of York

The Company is also involved in a number of projects through membership of its Advisory Boards and the provision of support in kind and staff time. The following projects are currently active:

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In addition, the Company has had a number of discussions with major companies in the North.

The role of funding in facilitating these collaborations in the North is important and the Company would consider involvement in projects in the North which were relevant to its developing interests.

Growth opportunities and barriers

In addition to the involvement in research and development activities discussed above, Green Biologics could have an interest in the longer term if there were advantages in being close to sources of relevant feedstocks. However, feedstocks in the UK are not particularly competitive with the US, Asia and South America providing much greater competitiveness because of the abundance of forest and sugar cane related feedstocks.

The North could possibly provide a source of lignocellulosic sugars and agricultural waste.

There are opportunities for greater involvement in the Northern science base if relevant projects and funding sources became available

There may also be opportunities for greater collaboration with other companies in the North including opportunities for more 'open innovation' projects

Constraints

- Costs of UK produced feedstocks
- Availability of funding for projects involving relevant collaboration with Northern University departments.

I: FERA Science Ltd

Prof. Rick Mumford, Director of Science

Telephone interview

Key messages

- Fera Science Ltd is a major research and testing organisation focussed on the farming, food and environmental sectors with strong linkages to University research in the North of England, as well as to the agriculture industry and major food manufacturing companies in the North of England
- Fera has recently become part of a JV involving Capita plc and DEFRA providing the organisation with new opportunities as part of a major UK plc.
- Fera is a major resource in terms of agriculture, food and environmental testing in the North of England and UK more widely with major investments in laboratory equipment and over 350 specialist scientific staff.

Fera has important opportunities flowing from:

- Its specialist knowledge and major scientific resources of laboratories, people, equipment and specialist facilities e.g. quarantine glasshouses, CAT3 microbiology
- Strong existing contracts with government departments e.g. DEFRA and other agencies such as the HSE's Chemicals Regulation Division (also based in Yorkshire)
- Its collaboration with the major universities in the North – e.g. N8 - particularly in translational research and development.
- The main collaborations with U of Newcastle, U of Manchester and the White Rose universities of Yorkshire and opportunities for translational research. This includes a joint institute with Newcastle University – the Institute of Agri-Food Research and Innovation (IAFRI)
- It works for a wide range of major food processing companies and agricultural businesses in the North of England
- Opportunities in the food packaging field e.g. smart packaging
- Its strength in winning a large share of relevant funding under European programmes under Framework 7 and Horizon 2020
- Its status as a recognised National Reference Laboratory, as well as managing the FAPAS proficiency testing scheme, provides Fera with contacts all over the World, which gives the organisation a major marketing entrée into world markets as a credible partner/ supplier of research services

- The changed status of Fera from government agency to majority private sector ownership provides both opportunities from being part of a major plc, but also some constraints related to the conditions for public funding of research contractors.

The business operation

Fera has some 400 staff and an annual revenue of £40m.

Up until April 2015, Fera was an Executive Agency of Government (Food and Environment Research Agency ;(Fera) and part of DEFRA.

In 2015, Fera Science Ltd was formed as a Joint Venture between Capita and DEFRA (75% Capita, 25% DEFRA). The Fera facilities in Cambridge and Stafford remained with DEFRA and the main Fera Science facilities in the North, near to York, became part of the new JV. As a consequence, all Fera Science facilities are now all in the North of England with the main laboratories about 5 miles east of York.

The change of ownership has had a number of significant consequences:

- Fera Science has the backing of a major publicly quoted company giving access to commercial capital that was not there previously (Fera is the only major science-based investment made by Capita)
- The change of ownership status has also had some implications for Fera's status in relation to applications for grants (see later).

The key activity is scientific research and development in the fields of agriculture, food, and environment with an annual turnover of some £40m. This is a mixture of:

- Long term supply agreements (LTSA) contracts with DEFRA
- Open competition for research programmes funded by the UK Government, the EU etc.
- Commercial research contracts including food testing, chemical safety and diagnostics services
- Commercial services for other government departments
- Overseas reference laboratory activities

Fera Science also has considerable other international activity

Collaborations and business relationships

There are strong scientific relationships with Universities in the North, particularly the N8 group of Northern Universities. These include:

Newcastle University

A new joint Institute with Newcastle University formed in October 2015 (Institute of Agri-Food Research and Innovation) with work being undertaken both in Newcastle and York. The Institute makes joint appointments and specialises in translational research to enable the excellent fundamental research and understanding generated at Newcastle to be translated into new science services and products. There are five Jointly appointed research posts between Fera and Newcastle University plus a growing cohort of joint PhD students, currently 9 in number and due to grow to 15. To date, the Joint Institute has involved collaborations between over 50 staff from both Fera and the University

The Joint Institute's main focus is on agricultural diagnostics, crop protection and production and food safety & nutrition. This utilises some of the specialist facilities available at Newcastle including Cockle Park Farm as a research and demonstration centre for specialist diagnostic and sensing, imaging including satellite and UAV imaging, animal welfare and field based sensing equipment. The research includes specialised work on pesticide resistance e.g. of herbicides and using research on the fundamental mechanisms of resistance (Newcastle) and developing novel diagnostics from this (Fera).

University of York

Other long standing expertise at Fera includes research on the 'fate of chemicals' in the environment, developing an understanding of scientific problems such as what happens to chemicals that are sprayed onto the soil and how much remains in the soil, how much in plants, animals etc. and how do chemicals break down. Some of this work in this area is done for Government including the Chemicals Regulation Division (CRD) which is part of HSE and based in York. A large portion of this work is also undertaken for multinational companies and consultancy businesses (including many based in North Yorkshire). The University of York has been a long-standing partner in this area with collaborations stretching back over 20 years. This collaboration has included a large number of joint research projects and PhD students.

Leeds University

There is considerable collaboration with Leeds University as well as other members of the White Rose partnership of Yorkshire based universities including studentships and internships with funding from BBSRC and others.

Manchester University

Collaboration with Manchester is primarily focussed on food safety with the development of new methodologies for testing, analytical chemistry, in particular focused on allergens. The core skills brought by Fera are related to providing a mechanism for delivering testing services e.g. using the organisation's suite of 50-60 mass spectrometers

Other collaborations

Fera has also developed collaborations in the North through Biovale which provides a bio-economy network based from York with a secretariat organising events involving industry, academics and research labs such as Fera

Company collaborations

Fera has collaborations with a range of companies in Yorkshire including Croda (multi-national specialist Chemicals Company based at Goole) and a wide range of food businesses including retailers (e.g. ASDA based in Leeds) and manufacturers (e.g. nestle based in York). Pharmaceuticals and human healthcare is not a core market for Fera. Its key business area is agri-food, covering both pre- and post- farm gate, and impact of agri-food on the environment. For example, research undertaken on the fate of veterinary medicines in the food supply chain e.g. antibiotics and other pharmaceuticals after they are released into the environment. Agri-chemical and vet drug firms need data on the fate and toxicology of new chemicals before they can be licenced. In addition, all chemicals have to be tested for their environmental impacts under the REACH regulations.

International markets / collaborations

Fera has operated as a government research organisation for over 100 years and has a strong background in the impacts of regulations in areas including:

- Plant health and crop protection
- Food safety and authenticity
- Chemical safety

Regulations and studies in these areas will continue to be of importance in not only the UK, but also many overseas markets including Europe and beyond. Fera has always had a large number of its staff involved in international panels involved with food safety etc. including EFSA, the European Food Safety Agency and EPPO (the European Plant Protection Organisation).

Fera also has had a strong involvement in EU research projects under Framework 7 and more recently in Framework 8 (Horizon 2020). For example, under FP7 KBBE (Food, Agriculture and Biotechnology), Fera was ranked number 1 in the UK in terms of project co-ordination.

More widely, Fera is involved in collaborations all over the world e.g. in East Africa on plant health in Kenya.

Proficiency Testing

An important aspect of the international market is 'proficiency testing' where accredited laboratories are required to participate in formal PT schemes to ensure that their results conform to accredited standards. Fera runs the FAPAS scheme for proficiency testing, which operates in over 100 countries in the world. This is an excellent mechanism for promoting the Fera brand and ensuring that Fera is known and respected world –wide. This creates new opportunities for Fera in export markets

Being part of Capita also creates opportunities in the UK and in export markets through the contacts and reach of investment by a major UK plc.

Agri – Tech centres

In 2013, the UK launched its Agri-tech strategy, which included a £160 m investment in agri-tech research and the development of four new Agri – Tech centres, including two centres in livestock and crop health, co-located with Fera at the National Agri-food Innovation Campus (NAFIC) at Sand Hutton. For the crop health centre ('Centre for Applied Crop Science'), Fera led the bid consortium and some of the major facilities of the centre will be based on site at Sand Hutton. In particular, a major investment is being made in an aquatic mesocosm facility, which allows for the field-scale evaluation of chemical environmental impacts under conditions that closely resemble real world ones. This is a £4m investment which will allow British and International companies to more rapidly test and develop new crop protection products. The Agri-Tech Centre facilities will be manned by Fera staff but are owned by the Centre.

Growth Opportunities

Opportunities

Fera is well situated within the UK in an area where there is a large concentration of food and agriculture related businesses. In particular, along the M62 corridor from Liverpool to Hull, the food industry is well established with a strong export businesses. Examples of key regional food businesses include Nestle, Young's, Findus, Cranswick Foods, Warburton, Coca Cola, R&R near Richmond (ice cream), Asda, Morrison's. In terms of

agriculture, Yorkshire is the third largest cereal growing region in the UK. Fera has contracts for testing and other activities with many of the major businesses based in the region.

Working across the agri-food supply chain, Fera has opportunities through two routes:

- Inputs – into agriculture e.g. disease-free seeds
- Outputs including both products and waste where there are opportunities for testing food and also for research and development to turn waste products into useful products such as high value protein for animal feed, where Fera is developing new approaches for turning waste into protein using insects. This has grown out of a major European research programme.

Food packaging is another growth opportunity with packaging accounting for some 2% of GDP and Fera has an opportunity to develop a new centre of excellence in this field related to food packaging. Fera is already a National Reference Laboratory for testing the migration of chemicals out of packaging into food, but there are opportunities for further developments in food packaging research and innovation.

Fera has also collaborated with the Centre for Process Innovation on Teesside specialising in bio-technology and fermentation.

Skills: Fera is also involved in a range of programmes linked to developing regional skills, including CASE PhD awards with local universities, the development of new higher level apprenticeships with York College and providing internships for both under- and post-graduate students.

Barriers

Key barriers to innovation lie in the 'valley of death' where new knowledge developed in universities faces a range of barriers – funding, connectivity, capacity – is failing to be translated into new commercially viable products and services . Translational science organisations like Fera have a critical role in trying to reverse this situation but can only do so if the entire innovation landscape is properly supported.

The UK needs a re-balancing of its portfolio of research activities with a greater emphasis on translation of knowledge into commercially viable products or services. This should not be achieved by removing funding from our excellent basic research but by providing new funding and other support to drive translation science and applied innovation. The development of Catapult centres, for example, has been valuable, but there is a need for a range of other mechanisms. So for example could they extend the German Fraunhofer model – currently used within UK Catapult centres – to other entities or organisations; who are providing that role but without the need to set up further new catapult centre.

The government also needs to develop schemes that consider applicants for funding schemes not in relation to their ownership (e.g. private sector or public sector) but in relation to the function they are performing in the project. Ultimately the eligibility for funding should be based upon the role an organisation plays and not its legal status. This has proved to be a problem for Fera following its change in status from a government Agency under DEFRA to part of a privately owned company (Capita). So, for example, in the past Fera had been successful in obtaining funding from Innovate UK, but when their ownership status changed, Fera was deemed no longer eligible to act as a research partner in innovation projects.

J: FUJIFILM Diosynth Biotechnologies

Steve Bagshaw, Chief Executive Officer

Face-to-face meeting

Key messages

- FUJIFILM Diosynth is a CDMO - contract development manufacturing organisation. The key expertise is in the manufacturing processes which underpin industrial biotechnology: the firm operates internationally on a substantial scale and is managed from Teesside.
- FUJIFILM's customers are mainly US-based firms in the biopharmaceutical sector: they buy the capacity and skills to turn their own IP, through several stages of development, into working commercial production.
- The inherent risks relate to the lengthy timescale, regulatory requirements and the complexity of the processes and handling involved; FUJIFILM's offer is based on customised toolkits, which aim to reduce this last risk as far as possible.
- The business is profitable, and a substantial new investment to expand its facilities has been approved, and is expected shortly to start on site.
- The management is well-networked with industry organisations and researchers, nationally, across the North of England and locally. 'The story of industrial biotechnology' needs to be made more evident to policy-makers and the public, in order to raise profile, and attract the skills required to realise its potential: the SIA for the Bioeconomy in the North has a potential role in this.

The business operation

Fujifilm Diosynth Biotechnologies (FUJIFILM) is a contract development manufacturing organisation (CDMO) working with partners in the biopharmaceutical sector. Although the pharmaceutical and health industries are excluded from the definition of 'Bioeconomy' adopted for this SIA, this operation represents a significant industrial biology asset for the North of England, and is included here as a bio-transformational activity utilising high-level process expertise.

History

The FUJIFILM facility on a 15 acre site at Billingham, Teesside dates back to the break-up of ICI in the early 1990s, when ICI's biopharmaceuticals operations became the core of the demerged Zeneca, later AstraZeneca. The CDMO on Teesside was not included when AstraZeneca was formed in 1999, but was sold

to Avecia, the UK based speciality chemicals company. In 2010, it became part of the global pharmaceutical/ healthcare company Merck (MSD), which had earlier merged with Schering-Plough, owners of Diosynth. The operation was restructured by management, then sold to the Japanese Fujifilm (Fuji) in 2011.

The heritage of the Teesside plant, and experience in working with mammalian cells (in particular, the Apollo CHO cell line) as well as handling bacteria (including yeast and e-coli), have been important enablers of this growth. R&D at ICI, and its immediate successors, included several products which were only realised much later in commercial form, including Pruteen, initially developed for animal feed, later in the form of the meat-substitute Quorn; also, Biopol, a biodegradable plastic which latterly has been used in medicine.

In addition to the Teesside facility, FUJIFILM Diosynth has two CDMO plants in the USA, at Research Triangle Park, North Carolina, and College Station, Texas, which work to the same business model (modified only by a US Government requirement to switch to vaccine production at short notice in the event of a 'flu pandemic).

The company is now owned 80% by Fujifilm, 20% Mitsubishi.

The business offer and operation

FUJIFILM works closely with drug development and marketing multinationals, and also with the smaller specialists in the pharmaceutical industry – in some cases, virtual companies with an embryonic drug, and financial backing, but no facilities of their own. FUJIFILM prefers to operate through long-term partnerships rather than single contract deals, enabling the business to be involved (and obtain return) at all stages, from early development through to the much small number of market successes.

The offer is

> *"highly flexible clinical and commercial cGMP facilities for the production, by microbial fermentation and cell culture, of biologics including gene therapy and vaccine products"*[3]

Over 300 projects have been undertaken at Teesside; across the company as a whole, only five projects have resulted to date in a commercially approved product taken to market, the first in 2009; two of these five were developed at Teesside. Individual production runs are very costly, £750k is typical, and the commercial pressure and internal controls designed to reduce risk and failure are, as would be expected, very strong. Turnover is currently £50-60m pa, with £10m profit.

People

The firm grew from 25 people when it separated from ICI to approximately 100 in 2005; there has been substantial growth over the last decade, to the 550 employees (including non-permanent staff) on Teesside today, and a further 600 employed at the two US plants.

The CEO, who joined in 2004, with substantial experience in fine chemicals and intermediate pharmaceuticals, is based at Teesside. In 2014, he became responsible for all three plants, reporting to FUJIFILM Japan.

The keys to its survival through successive rounds of corporate ownership change have been continuity of skills, embedded in key members of the team, which 'got biotechnology'

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[3] FUJIFILM Diosynth website: cGMP refers to the US FDA seal of approval for good manufacturing process, for food and drug products

The workforce at Teesside is highly qualified: about 80% of the workforce is qualified to first degree level or above. Of the 550 employed, approximately:

- 175 are qualified in biology or related fields
- 50 are engineers – chemical, mechanical or electrical
- 50 analysts, also with science qualifications
- 200 technicians, including 100 working on manufacturing process, 100 on activities including quality and design
- 75 in sales, marketing and administration.

Technicians, graduate level employees and non-technical staff are recruited from the local area, approximately 25 will be needed this year. Skilled and experienced industrial biologists are scarce in the market, and difficult to attract to Teesside. Those looking to return to their native area are targets, some have moved around the North, for example from Covance in Liverpool, and for some the opportunity for work for a period in the States is important.

With a global brand name and a substantial local operation, retention of key staff has not to date been a major issue.

Collaborations and business relationships (including supply chain)

Key collaborations are with customers and also with specialists who work with FUJIFILM to develop the process products which form a key part of the company's offer.

Buyers of CDMO services bring their own intellectual property, which they need to be turned into 'what works'. Most are American companies, many based in California. The inherent (and substantial) risk involved is reduced through the application of biology-based processes, in the form of toolkits – an example is FUJIFILM's **pAVEway™**, marketed as an innovative and proven technology for the efficient microbial expression of proteins.

In-house development work focuses on approaches to deliver product effectively and safely, rather than research. This for example includes purification through chromatography, and for the recycling of expensive resins.

Strong relationships are maintained with key specialists with knowledge in relevant areas: the company has a long-term relationship with UCL and in the region with Durham and Newcastle Universities; also with York and Leeds on aspects of industrial biotechnology, with the University of Nottingham, and locally with Teesside, particularly for people. KTNs are important, and there is also a direct link with BBSRC.

FUJIFILM sees the importance of positioning itself as a key element in the wider industrial biotechnology community, and has invested senior time and effort in this, at national level as well as in its immediate area.

- The CEO chairs the Industrial Biotechnology Leadership Forum, a specialist interest group facilitated by InnovateUK; he is also involved in other national initiatives, notably the Chemicals Growth Partnership and the Medicines Manufacturing Industry Partnership.
- Regular exchange takes place with CPI (Centre for Process Innovation) – in particular, the National Biologics Manufacturing Centre at Darlington, which was established in 2015, and offers advanced

facilities for upstream and downstream processing, high throughput process development, comprehensive analytical characterisation and capabilities for formulation, fill and finish.

- The company has good links with other organisations which aim to build understanding and profile for and around the biotech industries, notably NEPIC (North East Process Industries Cluster), Bionow, which has widened its membership and activities beyond its North West roots, and BioVale focused on Yorkshire and Humber, and the York & N Yorkshire Bioeconomy Task Group

Growth opportunities and barriers

The major investment in plant and laboratories under FUJIFILM (£50m to date) is to continue. Plans have been approved in outline for a major (£50m) development on a 10 acre site immediately opposite the existing plant, across Belasis Avenue: this will be styled 'BioPark' and will give more capacity, in the form of both new laboratory facilities and plant.

A key factor determining market direction and pace is public policy; for obvious reasons, this is a highly regulated industry, with long-term horizons, and with high levels of risk, which are determined by politics and changes in policy in key countries as well as commercial imperatives.

This condition is accepted as inherent in the industry, but a key area where public policy could help this business, and others in related fields, to operate more effectively is in 'telling the story' of biotechnology, why it is important across the economy both now and in the future, and the range of highly skilled employment opportunities it offers.

Skills at all levels are critical, and the planned expansion at FUJIFILM will need to attract and retain the right people. There are real capabilities in the North, including strong teaching and research universities. But more capacity is needed to realise the potential, and this will involve joined-up action to change attitudes and culture. Effective and suitably resourced intermediary organisations are needed – comparison was drawn with IBioIC, the Scottish Industrial Biotechnology Innovation Centre, set up in 2014.

The SIA should have an important part to play in facilitating the actions needed: this will happen through telling the story and raising the profile and attractiveness of the industry; this will generate a culture change towards entrepreneurial behaviour, and help FUJIFILM and others generate and sustain incomes and prosperity.

K: HCF Catch

Katie Hedges, Membership Services Manager

Telephone interview

Key messages

- HCF Catch is primarily a membership organisation networking activities in the energy, chemicals and renewables sectors
- Humberside has major renewables facilities including wind, biofuels and electricity generation from bio mass including Vivergo making bio-fuels from wheat, Greenergy making biofuel, Drax producing electricity from wood pellets and BNNL producing electricity from straw
- Many of the smaller bio-related plants are limited is relation to having sufficient space, or with restricted supplies of materials including waste
- There are significant problems in converting wood and straw into electrical power mainly related to the combustibility of the associated dust
- Collaboration with universities is more likely to be associated with major activities such as wind power than with smaller scale activities such as anaerobic digestion
- There are issues related to the supply of electricity from renewable sources outside the particular plant in which it is produced and opportunities to increase the supply of green electricity if electricity could be supplied to close neighbouring companies within a 'closed network' at negotiated prices rather than at national rates. This might increase the supply of electricity produced from green sources
- The taxation of methane is a constraint on its production from green processes as the tax authorities assume that methane will be used for burning rather than as a feedstock. More methane might be produced as a feedstock if this tax burden were eliminated

The business operation

HCF Catch is a membership organisation and employs some 20 people with 40 members in the process industries, energy, chemicals and renewables sector and some 250 companies in the supply chain. HCF Catch is based in Stallingborough near the Humber.

The company organises networking activities in the Humber region including networks of Environmental Managers and others in member organisations, local authorities, Environment Agency and others.

In addition, HCF Catch operates training facilities and two supply chain qualification schemes, ConCom and Prequal for qualification of contractors (ConCom) and for prequalification of contractors (Prequal).

In addition, the organisations runs capital and business support programmes, network groups, skills programmes, conferences, events and publications aimed at encouraging best practice, knowledge exchange and business excellence.

The HCF Catch operation is focussed on the £6bn Humber chemical and chemistry using sectors including companies, the four main local authorities, regional and national government agencies.

Collaborations and business relationships (including supply chains)

In the main, the focus in the Humberside area is on large facilities with renewable programmes being dominated by the wind energy programmes in the area which involve supply and maintenance of wind energy platforms in the North Sea.

A major focus is also on large bio-fuels plants including:

- Vivergo which has a massive plant in the area making bio-fuels from wheat. The Vivergo plant utilises wheat produced in the East of England that is low grade and which used to be shipped to Spain to produce bio-diesel as well as a protein by- product which is used as feed.
- Greenergy (already interviewed by SQW)
- BNNL based at Briggs which is a very large straw fired power station
- Drax which is a major power station utilising imported wood pellets to produce green energy

There are also a variety of smaller plants in the area undertaking anaerobic digestion of waste materials, burning straw and lower grade wood for power etc. and burning municipal and other waste.

A large part of this activity is utilising currently available technologies and is often dependent on public support e.g. through ROCS.

There is quite a large amount of smaller facilities for bio related activity in the area that operates at a relatively small scale e.g. anaerobic digestion of waste materials, burning of straw, wood etc.

The supply of materials such as wheat, straw and municipal and other waste in the East and North of England is a major factor

The Drax power station relies to a large extent on imported wood pellets brought by sea to Immingham and transported to Drax at Selby by rail for co-firing with coal. There are several large case studies of this operation.

A key issue with the supply of wood (and other materials such as straw) is the prevalence of dust which can create explosive or flammable atmospheres with a corresponding high risk. As a consequence, many wood burning operations are either small or utilise pelleted materials with a considerable water content. The transportation of wood, straw and similar materials also involves a very high risk due to the combustibility of the associated dust.

As a consequence, of the need for these materials to have a high moisture content and the processing of the materials requires large storage areas where they can be dried before burning

One of the larger anaerobic digestion plants has been built by Singleton Birch which operates a lime quarry as its main business. This uses waste materials such as carrots in the anaerobic digester to produce green energy for heating to make lime.

Linkages and collaborations with Universities including the University of Hull are not specifically related to the bio-economy with more significant collaboration on some of the other important sectors in the area such as wind power.

Whilst there are interesting projects being undertaken in universities such as the production or algae to be used in anaerobic digestion e.g. Durham University, many of the university projects are not particularly commercially relevant to firms in the area because the research has been relatively far from market and insufficiently relevant to local firms.

Growth opportunities and barriers

A number of issues and opportunities are relevant to the bio-related sector in the Humberside area. These include:

- The growth of recycling of waste materials by municipal authorities has the effect of reducing the amount of material available for waste burning plants and other bio-related streams. This has been particularly significant in Scandinavia and is an issue of growing importance in the Humberside area where it is having an increasing impact due to the increase in recycling activity.
- There is an opportunity which is being pursued in collaboration with the Chemical Cluster in Teesside (NEPIC) and the 'Chemistry Growth Partnership' to reduce barriers to the greater use of green energy on the demand side. In particular, this collaboration is seeking to change the regulations around the supply of clean energy in a closed local area. At present, if a company has an electricity producing plant on its site, it can utilise the electricity produced on site utilising the various incentives available. However, once the electricity is sent outside the boundaries of that particular plant, other local potential users of the electricity must pay national rates. The collaboration is seeking a change in the regulations to allow closed networks of local electricity suppliers and users to be formed to allow electricity from green energy sources to be supplied within its boundaries (increasing the potential market for green electricity). NEPIC is leading on this proposal
- The price of methane is determined, in part, by taxation which assumes that the gas is to be used for burning, making its cost to a potential user higher. However, methane from bio- related sources could usefully be used as a feedstock for manufacture of other materials. Companies with plants in the Humber area including BP, Ineos and Vivergo may have a perspective on these issues.

L: Narec Distributed Energy

Tom Bradley, Senior Project Engineer and Director

Telephone interview

Key messages

- NAREC is an SME spin-out from the National Renewable Energy Centre and Offshore Catapult offering energy consultancy services, with a particular focus on Lifecycle Assessments for Bioproducts.
- Despite being a Catapult spin-out they are not collaborating within the North-East or North of England Bioeconomy. They are aware of potential opportunities, but do not feel that there is the right climate to foster these.
- Brexit is a major concern. NAREC collaborates with strategic Southern European partners on H2020 and FP7 projects and often needs to hire from mainland Europe to meet skills needs.

The business operation

NAREC is an SME spin-out from the National Renewable Energy Centre and Offshore Catapult. The business offers consultancy services which help customers reduce carbon, alleviate fuel poverty, improve energy security, stimulate economic growth and educate energy users. Their services include offering strategy advice and support to businesses, training for energy users and workers within the supply chain (for example gas engineers fitting wood pellet boilers) and offering engineering services which help clients choose the correct energy solutions.

Their major focus in the bioeconomy is through provision of Lifecycle Assessments for Biofuels – these reports look at the environmental, social and climate impacts of bio-fuel products and are helping push forward understanding of these impacts on the global stage.

Collaborations and business relationships (including supply chain)

Despite being a spin-out of the National Renewable Energy Centre, NAREC does not have a broad range of local or national collaborators. It has worked with the Universities of Newcastle, York and Durham on algae testing and is aware of the positive work undertaken by the Manchester Bioenergy Hub in terms of both research and outreach. They are also aware of the positive work undertaken in the testing of biofuels at Newcastle University but have yet to find a means to collaborate. They have a positive relationship with CPI who have helped them engage with funding opportunities and projects under H2020 and FP7.

NAREC's chief collaborator in the biofuels space is with a company based in Olahõ in Portugal, a project in which they are providing a Lifecycle Assessment for a project funded under FP7. The project is based around pilot facilities for the cultivation, harvest and usage of algae as a feedstock; the Lifecycle Assessments are intended to show how/whether this feedstock impacts environment and climate in comparison to traditional methods of production for biofuels and chemical and biological inputs to products such as cosmetics. The facility is the biggest in the world and will help move towards commercialisation of algae products as both a biofuel and for

other end-uses – the real innovation is through scale, which makes NAREC's outputs stronger and the 'science' behind the test bed more robust. The feedstock is weather dependant – this isn't a stock which could be cultivated in the UK

Growth opportunities and barriers

The biggest barrier for NAREC is likely to be leaving Europe. The majority of their innovative work is currently back by H2020 and FP7 funding. They are increasingly finding it difficult to secure roles within consortia due to the European Commission's line on the applications including UK based partners. This is frustrating in both directions as NAREC's work is world-leading in its field; partners want to use them but recognise this jeopardises their chances of being funded.

Uncertainty over immigration is a concern in relation to hiring. NAREC requires very highly skilled staff with very specific skillsets and tends to hire these from the EU mainland due to a complete lack of suitable UK based candidates. This could threaten their growth in both the short and long term as potential hires are less keen on a move to the UK.

Nevertheless, NAREC expects to continue to win Lifecycle Assessments work, especially in the field of algae research, due to the growing nature of this industry and a swift drive towards commercialisation.

NAREC would welcome more formal means to share their ideas and research with potential collaborators – this can even become siloed within universities. Local conferences and collaboration sessions would be welcome.

M: NovaPangaea Technologies

John Nicholas, Founder and Commercial Director

Face-to-face interview

Key messages

- NovaPangaea Technologies (NPT) is developing the commercially efficient conversion of wood-based biomass, replacing oil and gas-based products in liquid fuels (ethanol) and a range of other useful chemicals.
- Following the successful operation of a small pilot plant, a medium-scale demonstration plant is now under construction at Wilton, Teesside: this location offers suitable workspace and expertise in process engineering.
- NPT's business is built on specialist knowledge and networks: in particular, a long-term partnership with the Latvian State Institute of Wood Chemistry has been key to developing, testing and applying the technology.
- Other important links are with CPI at Wilton, with UK universities (Bath and York) and with a Baltic R&D company (VTT Finland) specialising in green chemistry and new products from wood.
- A series of agreements are already in place with global chemical companies and other industry majors. Their realisation will depend on next stage funding being put in place, through or alongside licensing agreements and joint ventures/special delivery vehicles. Possible downstream applications are now being actively explored: some are expected to be realised, in the UK and internationally, in the next 2-3 years.

The business operation

The business

NovaPangaea Technologies (NPT) is working to achieve the effective, efficient and profitable conversion of non-food biomass into liquid fuels and a range of useful chemicals. Its Refnova™ technology is a process for physical and thermochemical fractionation of lignocellulosic materials into their constituent parts. Birchwood chips are the feedstock for an internally catalysed thermochemical hydrolysis and steam thermolysis process. This process does not use bioactives such as enzymes or bacteria, it has already proved to be efficient and quick at small volumes, and it now has the potential to be scaled up to large volume production.

A one tonne (dryweight input)/hour demonstration plant is being constructed at Wilton, Teesside: this will be operational by the end of 2017. A 20kg/hour pilot plant is already being working successfully.

A wide range of products can be produced at different stages of the process: for example levulinic acid, an important chemical intermediate to renewable polymers, and renewable ethylene from green ethanol.

NPT's core business is the process for conversion, not the generation of new products: patent protection has been granted in key countries in Europe, Asia, Africa and South America.

The three-person management team consists of

- a chief executive/project director who earlier led and realised major chemical engineering development and scale-up projects
- a finance director bringing experience in industrial and commercial contracts and risk management
- John Nicholas, an experienced biofuels promoter, who successfully conceived, funded and commissioned the world's largest biodiesel plant on Teesside.

There are also three non-executive board members, bringing expertise in business strategy (Chair), business finance, and process engineering.

Company history and reason for location in the North of England

NovaPangaea Technologies was founded in Ireland in 2008. The business relocated to England, as the key first stage angel funders came from here, and the Wilton International site at Tees Valley offered a large facility with an overhead crane.

The development, testing and application of the underpinning technology – and in particular techniques for product recovery and heat recovery – has been realised through a long-term partnership with the Latvian State Institute of Wood Chemistry.

Investment and spend in developing the company to date totals c.£7m. A Department for Transport grant (c.£1.5-2m) focusing on the conversion of sugars to fuel ethanol, was important in the development and demonstration phase, alongside other grants totalling £3m and directors and angel investment of c.£2m. Ethanol could be produced as early as 2018.

Collaborations and business relationships (including supply chain)

The key collaborator, bringing the knowledge of wood-based science and technology which underpins the business model, is the Latvian State Institute of Wood Chemistry. The Institute had developed expertise in this technology prior to 2007, utilising the ready availability of birch in that region, but did not have the resources or market knowledge to apply this into industrial-scale production. The relationship is on a commercial basis, with testing and other development work undertaken under a monthly retainer fee.

People with the technical skills required to develop the business have been found and brought in, as and when needed.

- A collaboration agreement is in place with CPI around one potentially interesting technological application (yeast substitute)
- NPT presented at the 2nd LBNet conference, held in Cheshire in April 2017. Several leads were identified with possible collaboration partners, and these discussions have already begun. (LBNet is the Lignocellulosic Biorefinery Network, a BBSRC Network in Industrial Biotechnology and Bioenergy, which is coordinated by CNAP, the University of York's Centre for Novel Agricultural Products, in the Department of Biology.)
- There has been other extensive collaboration with other experts in renewable energy engineering and applications, based at Wilton and across the North East; some of NPT's contacts with industry have been facilitated by NEPIC (North East England Process Industry Cluster).

- NPT also has important on-going links with the University of Bath, and with VTT Finland, a major technical research company, with a strong focus on the bioeconomy, and the replacement of fossil fuels with renewables.

- NPT has several non-disclosure agreements in place with chemical and pharmaceutical companies, to share the development risk with those down the value chain: testing the use of specific lignocellulosic sugars as intermediates, and developing commercial price models.

Growth opportunities and barriers

The technology provides for the effective exploitation of a natural product based value chain. It is in line with political and industrial aspirations for a greener, more sustainable, economy, with greenhouse gas production minimised.

NPT is confident that there will be no price premium on these products over their equivalents generated in the oil and gas industry that different routes to market are possible and that in some respects the wood-based products will perform better. An example is the industry move to replace PET drinks containers: 'Green PET' can be produced through a renewable process but PEF – polyethylene furanoate – can also provide a renewable drinks bottle and this has superior properties.

NPT's business model envisages both licensing and the formation of joint ventures and special delivery vehicles. Further funding of c£10m is now required, and actively being sought, to realise the full potential of the demonstration plant ie to develop and test the process at a larger scale, with next-stage engineering design work. Other grant applications are also expected to be made to support the development of related processes, still at an early stage.

The next few weeks will be important, as building a commercial business will require NPT to show how the technical and commercial risks involved in this new process will be minimised: there is a high level of awareness across process industries of the potential for disasters and unforeseen delays in implementing new technological applications.

Time is needed to do this effectively and well: NPT estimates that with this new funding, they will be 2-3 years away from full commercial operation. The relationship with the key personnel in Latvia will, if and when necessary, be continued on a consultancy basis.

The downstream market opportunities now being actively pursued include work to develop and realise projects with:

- Scottish Forestry, where NPT is exploring the potential use of local woods, notably spruce, in a flagship biorefinery

- A Brazilian chemical company

- Other possible partners in Canada and Europe.

In summary, Teesside has proved a good base, both for finding collaborators and partners in specific aspects of the business, and for developing wider networks. In addition to offering access to equipment, skills and networking, the port facility can handle timber imports: this might prove to be an important part of a commercial business model.

N: Precision Decisions

Clive Backer, Chief Executive

Face-to-face meeting

Key messages

- Precision Decisions provides technical equipment and data-based services which enable arable farmers to operate more efficiently, particularly in understanding soil and growing characteristics in small areas, and delivering precise measures of nutrient inputs.
- The firm has grown over the last decade from a farm-based operation north of York, gaining customers across the UK and with some international clients.
- Its business is based on a series of key commercial relationships with farm equipment suppliers and data-handling specialists
- Growth has been facilitated by the expertise and knowledge available in universities; also, by the market awareness and promotional activities facilitated locally in York and North Yorkshire, and by national Government.
- These relationships and networks are expected to deepen in the future, as Precision Decisions' service offer is augmented to utilise fast-changing technological possibilities, and new market opportunities are identified.

The business operation

Precision Decisions provides technical equipment and data-based services to primary agricultural producers; the business aim is to add value by enabling farmers to operate more efficiently. The firm was established in 2004, and operates from its own premises at Shipton by Beningbrough, close to York. Its website summarises the scope of the operation as follows.

> *"Precision Decisions grew out of our family farming business, and continues to offer comprehensive precision farming services based on sound agronomic and practical experience. Our expanding team now has specialities across agronomy, engineering, software and customer service, working from our new premises with dedicated workshops and development facilities."*[4]

[4] http://www.precisiondecisions.co.uk/

Precision Decisions' offer is based on being an early adaptor and user of technology. As the firm has grown, the emphasis has shifted from the supply of equipment and hardware, to software development and data-based analysis. In the early years, the development and adaptation which underpinned this was undertaken internally, but more recently it has involved a more networked approach, linking with individuals and institutions which can offer relevant research and expertise.

The firm's main offer is a web-based product combining satellite GPS mapping with soil sampling and analysis, in order to give arable farmers detailed advice on nutrient inputs. The solutions are tailored to take into account physical variations between small areas within fields. The soil/ground sampling is non-invasive, undertaken through electromagnetic induction (EM) mounted on autonomously controlled vehicles. The results are provided to clients in the form of large-scale, colour-coded maps, showing key characteristics and variations, and the recommended nutrient applications. Reassessment will normally take place at four-yearly intervals.

Precision Decisions has built a customer base across the UK and Ireland: there are also customers further afield, notably in Africa.

The firm now has 18 staff, including six soil scientists, five software engineers, three sales people, three other engineers, and management.

Collaborations and business relationships (including supply chain)

The services provided today have been developed through a series of collaborations with commercial partners: these include:

- multi-nationals such as Massey Ferguson (farm vehicles), and smaller specialists such as Agrovista and Peacock & Binnington
- Yara (originating in mineral fertilisers, more recently specialising in applications technology) - a long-standing collaborator on the N-Sensor variable rate technology
- state-of-the-art IT equipment and systems providers, including Avanti, and Satel and agricultural IT specialists such as Next Instruments pty.

As the firm's area of expertise became more widely recognised across the agricultural supply sector, larger businesses began to approach them, to collaborate in developing services customised for their next generation products. Precision Decisions draws on these relationships for technical and market knowledge, while looking to maintain its positioning as an independent adviser, which is important to its offer.

Alongside these business relationships, Precision Decisions recognises the value of collaboration with key interlocutors in government, wider research communities and other organisations. Participation in a UK government-organised mission to Africa led to new thinking on how the firm might identify and realise new opportunities. This wider awareness of networking to understand farmers' needs and what others are doing, has led to new directions for the business being explored and followed-up.

These other important relationships include:

- An on-going working relationship with the Biorenewables Development Centre (BDC) at the University of York; also with BioVale, respected for its efforts, and where Clive Backer is a member of the Leadership Council (and indirectly with York & North Yorkshire LEP; earlier, with Science City York)
- On-going links with the Department for International Trade

- Networking with the wider infrastructure in the North – notably Fera, Stockbridge Technical Centre and the N8 Research Partnership , Knowledge Transfer Partnership and Knowledge Transfer Network
- An active link with a specialist at Edge Hill University (Ormskirk), focusing on high resolution satellite data on weather, and its interpretation
- A valued relationship with Harper Adams University (Shropshire) – an agricultural university with a specific competence in the applications of robotics in that sector.

The firm is also building internal knowledge and expertise for the future through:

- A Knowledge Transfer Partnership with Newcastle University; this is now 2 years into a three year project focused on data management; analysing data series over time, and learning from this
- An internee from University of York was recently agreed, who will work with Precision Decisions on a micro-biological bacterial study.

Growth opportunities and barriers

Precision Decisions is a specialist technology-based developer and supplier of agricultural services. Precision Decisions recognises that its business activities fall within what is now widely referred to as the 'bioeconomy', but notes that this label is not necessarily understood by the wider agricultural community. The business is based on scientific research, its selling point is the technical know-how to deliver and continuously update its offer, to a customer base, which it understands well: the firm was born from a North Yorkshire farm business.

Looking forward, the business operates in an area which will continue to change rapidly, as technologies, and market awareness and take-up, both advance. Ideas which are now at an early stage of application, notably around 'the internet of things' will become widely disseminated in the form of new products and services. This will have direct implications for their business.

The key challenge facing this relatively small specialist business is therefore to drive existing services to the next level, through making the right choices at the right time.

Some indication of the range and potential for scaling of the offer is provided below.

- An early priority for gaining more knowledge and understanding is robotics. Precision Decisions is aware of the expertise at the University of Sheffield and the Advanced Manufacturing Research Centre, and expects to make an early connection there.
- There are potentially major implications from applying wireless technology to farm vehicles: until now, most rural areas have had low broadband service provision, but wireless technology is now changing this without the need for major investment in infrastructure.
- The delivery of high capacity wireless bandwidth to rural areas could also open up big opportunities with regard to animal tagging and monitoring of behaviour, taking Precision Decisions into non-arable agricultural management.

The firm's relationships and networks are valued, and these will be developed further to provide a strong basis for future anticipated growth.

With regard to possible actions that might be taken to facilitate Precision Decisions' operations and enhance its prospects:

- Support for intermediaries is important, and should be maintained/taken further
- Public funding for wifi rollout and applications development in rural areas is important.

O: Plaxica

Dr Ed Marshall, Chief Technical Officer and Co-founder

Telephone interview

Key messages

- Plaxica, a NE-based technology licensing company, has filed worldwide patents for processes which take low value waste, from the pulp and paper industries, and convert this feedstock to fermentable mixed sugars.
- A spin-out from Imperial College, the company was set up in 2009 and has operated from the Wilton Centre, Tees Valley, since 2010.
- Key partnerships and collaborators exist with the engineering and process industry expertise, both locally and more widely across the North of England: there are also valued relationships with universities in the area.
- The Wilton location has been the right choice for the company, the specialist skills, facilities and networks available locally have facilitated its development.

The business operation

The business

Plaxica is a technology licensing company developing innovative green chemistry. Its processes, for which patents are in place in its key markets including Asia, N & S America, take low value waste, in particular from the pulp and paper industries, and convert this feedstock mixed sugars.

Plaxica's market pitch is to offer licensees within the pulping sector the opportunity to convert a sizeable waste stream (which is currently incinerated) into a variety of medium to high value products, by chemical and / or fermentation processes. Plaxica also helps broker the link to partner companies with sugar upgrade technologies.The company has looked to global markets, outside the UK and Europe, largely from its outset, as potential licensees with the lowest operating costs are found elsewhere in the world.

Company history and reason for location in the North of England

Plaxica was founded in 2009, by two academics from Imperial College. They moved out of the University to ensure that the Company owned all intellectual property outright.

The first location was an innovation centre in South Kensington, and a London office was retained until two years ago. At an early stage, Plaxica's founders brought in strong expertise in process engineering and

commercial contracting, at board and management level, which has complemented their own scientific and technical skills.

The company's development and testing operation was established at the Wilton Centre, Tees Valley in 2010. The founding partners had links to the North East, and were aware of Wilton's history (ICI) and the availability of scale up chemistry and process engineering skills in the area. Other possibilities were considered, but this was the preferred location: process engineers were recruited at an early stage, and links were established with CPI (Centre for Process Innovation), also at Wilton.

Approximately £20m funding has been raised through several rounds, including £5m in 2011. The key investors, from the outset and now, are Touchstone Innovation (Imperial Innovation) and Invesco Perpetual, with smaller investments from NESTA and The Carbon Trust. The company has also been assisted by several grants, from the Technology Strategy Board/ Innovate UK.

Plaxica occupies office, laboratory and piloting space within the Wilton site allowing the Company to scale up its technologies from small laboratory scale to feedstock volumes of several tens of litres per day. The company now employs 15 people.

Collaborations and business relationships

The key partner expertise required is process engineering skills. AMEC Foster Wheeler, at Darlington is the most important partner; there is also an on-going relationship with CPI, including the National Industrial Biotechnology Facilities (NIBF) at Wilton.

There are active relationships, covered by non-disclosure agreements, with a number of local companies in the area. Local toll converters (process contractors) have helped to scale up operations, and new links are expected to arise in the future. Plaxica has worked successfully with two North East universities, through ad hoc contracts:

- Durham University on NMR (Nuclear Magnetic Resonance spectroscopy)
- Newcastle University, on a continuous flow chemistry project.

Links with NEPIC (North East Industry Process Industries Cluster) are occasional only, but the effectiveness of the industry body's lobbying role at Westminster is acknowledged.

Growth opportunities and barriers

The Wilton location has been the right choice for the company, offering the combination of skills, facilities and networks which have facilitated its development. Wilton, and North East England more generally, continues to be recognised internationally for its expertise in process industries.

In broad global terms, biocatalyst/ biomass technologies are moving from prototype to large-scale production and increased visibility in the market.

Plaxica will look to grow new streams of business and alternative products – the company recognises the need to adapt to changing geo-political conditions.

The UK is unlikely to provide partners for large-scale applications of Plaxica's technologies; as appropriate waste feedstocks are unavailable on a sufficiently large scale.

P: RAFT Solutions Ltd

Sophie Throup, Managing Director

Telephone interview

RAFT Solutions Ltd was established in 2010 to look for innovative research, advanced breeding and training solutions to food sustainability questions. It was established by a vet practice to provide an additional income stream. There are 5 staff but it draws on the 48 vets in the original practice.

Main income comes from advising farmers on animal fertility and sustainable food production. It also provides training to farmers in various areas.

To support this work RAFT undertakes research and clinical trials drawing on the vet practice. It has been involved in 6 Innovate UK projects and also received a grant from the LEP.

It has worked with University of Glasgow, the University of Nottingham, University of Newcastle, Fera Science Ltd and Cranfield University and Bristol vet school. Of these, Nottingham is by far the most important.

Q: Thomas Swan & Co Ltd

Harry Swan, Manging Director

Telephone interview

Thomas Swan has three divisions:

- **Performance Chemicals** provides a broad range of additives, resins and active pharmaceutical ingredients
- **Custom Manufacture** works in close collaboration with a wide range of customers to manufacture their products on a contract or toll basis
- **Advanced Materials** is on the cutting-edge of material science, developing niche, high value materials for emerging technologies in the composites, energy and water sectors.

The company is one year into a 5 year strategy to increase sustainability of its operations: it is now looking at each product in turn to identify what can be done

Thomas Swan is currently working with Durham University (Chemistry) and has worked with York in the past. Outside the North of England, it has worked with Cambridge, Oxford, Nottingham. UCL and Imperial. Access to skilled people is the key motivation; the company has undertaken KTPs. Universities don't understand how to collaborate with business and are "too greedy" not recognising risk they are taking. Durham is seen as an exception.

At present all manufacturing is at Consett, for historical reasons. Thomas Swan is now considering an additional manufacturing base, in the USA.

R: Unilever *(Port Sunlight)*

Neil Parry, Programme Director for Biotechnology and Bio-Sciences

Face-to-face interview

Key message

- Unilever's Port Sunlight facility is a major centre of **science** translation in the North of England employing @750 scientists including biologists, physical chemists and chemical engineers, psychologists, etc.
- The company also works with science and research colleagues in Unilever sites across the World including Europe, America and Asia.
- The company has developed an 'Open innovation' approach which encourages collaboration to the mutual benefit of the company and external science and technology suppliers. The Open Innovation platform is fully described on the Company's web-site.
- Major collaborations in the North include strategic collaborations with three local strategic partners – The University of Liverpool, Manchester University and Daresbury Laboratory,
- A major new (£50m) facility has recently been completed at the University of Liverpool campus which provides facilities for collaborative research between the company and the University and which includes the Centre for Material Discovery (CMD) and a Micro – Bio Refinery (MBR). This provides facilities for collaborative research and development between Unilever and the University of Liverpool; the University has three floors and Unilever one floor. The facility includes a 'research hotel' where external companies and technology suppliers can be brought in to work collaboratively in an open innovation environment. This has been in development for some 2-3 years, and is now becoming fully operational.
- Important collaborations with companies are confidential but Unilever have quoted Novozymes (EU) and Terravia (US) in their Biotechnology position paper.
- The company also collaborates with academic researchers to utilise major facilities such as the Super- Computing facilities at Daresbury, the Diamond Synchrotron for x ray crystallography, and the ISIS spallation neutron source to support its science base.

The Business Operation

Port Sunlight on the Wirral is a Unilever centre for Home Care and Personal Care R&D with major programmes for hair, laundry, deodorants and household care being run from the site. Unilever products such as Dove,

Sunsilk, Rexona, Axe, Domestos, TREsemme, Comfort, Dirt is good, Surf and Signal all benefit from technologies developed at Port Sunlight

Unilever's biotechnology activities were clearly visible in the early 1990s at the Colworth Research Centre in Bedfordshire with the development of anti-body technologies used in the 'Clear Blue' pregnancy testing kits (subsequently sold to Inverness Diagnostics).

Biotechnology has subsequently been directed from Port Sunlight to determine the potential of biotechnology derived ingredients in the USLP and in doing so accessing external skills in protein engineering, gene cloning and molecular biology. The Port Sunlight facility has a large microbiology facility. The Company has an internal team at Port Sunlight that is mainly concerned with technology translation of biotechnology, material development and optimising and **applying** biotechnology developments. Unilever's Biotechnology activities are international, with activities in Europe, the Americas and Asia with biotechnology partners reflecting Unilever's interests in these areas.

There are four main industrial areas where biotechnology has important applications which include:

- Health care (medical)
- Crop production and agriculture
- Non-food (industrial) uses e.g. biodegradable plastics, vegetable oils , biofuels
- Environmental uses

Unilever's biotechnology interests are primarily in the use of biotechnology to enhance industrial uses and to use the technologies to enhance material performance and / or to minimise environmental impacts. Examples include the use of algal oils in personal care products such as soap to replace palm oil. Biotechnology is used to create materials and products such as skin cleansers and enzymes. The use of these biotechnology derived ingredients and processing can improve cleaning performance across different water qualities and temperatures , deliver better hygiene and provide improved health and nutrition benefits.

Unilever's international biotechnology research and development is managed from Port Sunlight. The internal team is mainly concerned with optimising and reiterating the bio technologies developed through the collaborative R&D programmes organised by the Company. Research and Development into areas such as protein engineering, gene cloning and molecular biology tends to be undertaken outside the Company with the Company's 'Open Innovation' approach leading to a 'collective eco-system' of virtual teams which involve about 50% company researchers and 50% external researchers from universities, major companies, SMEs, research institutes etc.

The company works with a wide range of science and technology suppliers / collaborators including companies, university researchers, research organisations etc. **All these relationships are bound by their terms of engagement** and remain confidential.

There are some 750 professional R&D staff at Port Sunlight covering a wide range of science and technology specialisms including chemistry, physics, biology, formulations etc.

The Port Sunlight biotechnology activities are primarily carried out though an 'Open innovation' approach. This involves a collective eco-system of enablers working through an 'open innovation' approach involving external researchers in companies, SMEs, universities and research centres. About 50% of this collective eco- system is composed of Unilever staff.

The Company has recently launched a 'Position paper' on biotechnology which is available on the web describing the Company's approach to the use of biotechnology. The paper also describes two examples of industrial collaboration with companies:

- Novozymes - which is based in Copenhagen and is a world leading company in the manufacture of enzymes
- Solazyme – Now called Terravia, which is a US company collaborating with Unilever to utilise re-engineered algae to produce palm oil using waste materials from sugar production. This collaboration began some 10 years ago and was driven by the demand and responsible sourcing of palm oil which is used in a wide range of Unilever's products

Collaborations and business relationships (including supply chains)

Unilever has a wide range of collaborations and relationships in the North of England, the UK and internationally. Some of the most relevant are described below. The company has an 'Open innovation' philosophy which is described on its web-site and which list specific scientific / technological and problem areas where the company would like to work in a collaborative mode with technology facilitators including companies, university researchers, research laboratories etc.

There is a range of existing collaborations with companies on specific issues which are not in the public domain, but examples of Unilever's collaboration with university research include:

- **Industrial Biotechnology** BBSRC strategy board on which Unilever is represented by Neil Parry and where the company is involved in a variety of **initiatives**
- Liverpool University where there is a strong partnership with Unilever through the '**Centre for Materials Discovery (CMD**) which has been in operation for some 10 years…
- …and also more recently in **the Micro Bio Refinery (MBR).** These involve joint people from Unilever and from the University working together in an open access laboratory facility
- Liverpool University is also the location for a new 'Materials Innovation Factory' which has been under development / construction for the past 2-3 years and is currently going live. The MIF is a new building with four floors, three of which are utilised by the University and the fourth is an open access research floor where Unilever research staff can work collaboratively with others from the university and elsewhere including a 'Research hotel'. Unilever has space for some 50+ researchers to work on its floor of the building. This enables Unilever to work with University researchers and also to foster relations with other companies where collaborative projects can be developed. For example, any **new material or ingredient** project can utilise the new facility to understand the chemistry, functionality, benefits and business opportunities
- The MIF is also a new mechanism for Unilever to be able to support programmes and grants from **government / EU** for collaborative projects. The facility **further** enables the company to engage in constructive practical collaboration with other companies or researchers
- Unilever also links through the Catapult centres **where possible**
- Industrial Biotechnology Leadership Forum (IBLF) meets about 3 time per annum and is setting a biotechnology strategy for the UK – Neil Parry represents Unilever on the IBLF and Steve Bagshaw is Chair
- University of Manchester have a dedicated biotechnology team
- Nottingham University are also building their biotechnology capability
- University of York where there is a Biobased Centre and a Green Chemistry Centre

- In Scotland, the company is linked with the International Biotechnology Innovation Centre (IBIOC)which is based at Glasgow
- Daresbury where collaboration is mainly related to the use of the high performance computing systems
- Diamond Synchrotron where there is a variety of collaborations with university researchers mainly in X Ray crystallography
- ISIS spallation neutron source where there is on – going research into materials
- There are also a wide variety of collaborations outside the UK mainly with chemical companies
- Industrial Biotechnology Leadership Forum is seeking to develop the strategy for biotechnology in the UK. Many big companies are members and about 50% are from the North including Unilever. Yvonne Armitage is Secretary and Mr Bagshaw is Chair
- Biovale – based at York and Green Chemistry Centre at York are collaborators with Unilever
- Public Private Partnerships programme (PPP). This is a European initiative funded by the EU for bio – based industry including companies, research etc. It has 2.7bn Euros of funding over 10 years. So far, it has developed a research agenda and funded a number of flagship projects. The EU provides 50% of the project funding. Unilever is part of the PPP

Growth opportunities and barriers

Drivers/ opportunities

In the past, the main driver for biotechnology was its use to develop specialty materials, high price, small volume applications. There is now a new emphasis on the role of biotechnology to solve key sustainability challenges facing the environment and human use of resources. An example of this is the use of biotech at Solazyme where waste products in the manufacture of cane sugar are being used to make palm oil and reduce the environmental impacts of palm oil production.

A key factor in the development of biotechnology is the understanding of the full life cycle of the manufacture, use and disposal of the product. **The key is to understand the costs across the supply chain of biotechnology enabled partners and where it would make sense to operate with a lower footprint. This is a responsible sourcing journey and opportunity.**

Barriers/ opportunities

In the North of England, there are issues related to the business case as well as the environmental case for utilising bio – techniques to convert feedstocks into more valuable or interesting products. Scale and supply of available feedstock is one of these. The legislative positions may make certain opportunities possible if the UK were to look at the possible changes in regulations, standards etc. that would make certain processes more viable. The production and use of new ingredient by biotechnology processes requires a great deal of work to overcome regulatory and safety hurdles.

Actions that might be taken

There is a need for full awareness of who is doing what and where in the field of biotechology in the North, and to develop a strategy to enhance collaboration and success.

There is a specific need to encourage biotechnology related material developments to overcome the 'valley of death' e.g. from laboratory through pilot plant through to commercial development.

So far, the significant efforts going into biotechnology have been mainly focused on energy rather than the development of materials with particular functionalities. There are major opportunities to utilise biotechnology methods to reduce environmental impacts through the replacement of materials with more effective bio based alternatives. Materials with superior/ differentiated performance are the drivers for this.

There is a need to consider the whole life cycle cost of products/ materials e.g. cost of production, cost in use, cost of disposal so that new products using biotechnologies can be developed which can replace products with major life cycle costs including harmful environmental impacts/costs.

Also, **UK regulations post Brexit will need to be formulated and understood,** in order to facilitate the development of biotechnology industry – this is needed to clarify and enable the roles and opportunities for biotechnology enabled companies, SMEs and academics

Companies, academic researchers, research organisations should be encouraged to participate in Unilever's Open Innovation approach, in particular, to encourage them to examine the open innovation website, where there is a list of problems where Unilever is seeking to work with others in a collaborative approach to solve technology/knowledge issues

The company is keen to encourage companies/technology suppliers in the North to collaborate with Unilever at its 'Research Hotel' at the University of Liverpool.

S: Shott Trinova LLP

Ian Shott, Managing Partner

Telephone interview

Key messages

- Shott Trinova provides advice and investment to help realise the potential of 'new paradigm' pharma businesses. The opportunities stem from the different parameters now governing the global life sciences business: the strengths of pharmaceutical manufacturing in the North East mean this is an important area of focus.
- Shott Trinova is utilising in-depth knowledge of the chemical and pharma industries and industrial biotechnology, entrepreneurial and business acumen, and strong personal reputations and networking, to reshape SMEs with high growth potential, and transform their business performance.
- Its key asset is Arcinova at Alnwick, a Contract Research and Development Organisation (CRDO) occupying the former Covance site. This is a significant industrial biotechnology asset for the North East and beyond.
- The strengths of the North East in pharma, life sciences and industrial biology are underpinned by the technical expertise and specialist services available in intermediaries, particularly CPI; also, the research base and trained people in the region's universities and beyond.
- Realising the potential economic contribution from these industries will require business and policy-makers to collaborate over the medium-long term, working to change internal cultures and external perceptions, and build their position and profile across the North of England, the UK and internationally.

The business operation

Shott Trinova describes itself as

> *" A specialist investment and advisory firm, focused on established small-and-medium-size enterprises with high growth potential in chemicals, materials, industrial biotech, pharma and medical technology sectors"*[5]

Ian Shott founded Shott Trinova in 2012, in partnership with Paul Ryan, a chartered accountant with experience in the food, pharma and service industries. Ian's key skills are as an entrepreneur and engineer. He held senior executive positions in several multinational chemical and life science companies over 30 years, including

[5] http://www.shotttrinova.com/

management roles in France and Switzerland as well as the UK, and involving extended periods in the USA and Australia.

In 2004, Ian Shott founded Excelsyn, which he then built into a successful drug substance development and commercialisation company, out of a failing facility in North Wales, sold to him by the Great Lakes Chemical Corporation. Excelsyn received other investment from two north of England-based venture capital funds, before being sold to Albany Molecular Research Inc (AMRI) in 2010.

Ian Shott has also been actively involved in a wide range of professional and industry organisations, frequently in a leadership role, involving business representation and strategic advice to Government. His perspectives are drawn from an inside view of global developments, and of the implications of these, particularly regarding the changing opportunities for the life sciences and related industries in the North East. Some of his key roles are listed below, under 'Collaboration and business partnerships'.

The rationale for Shott Trinova, and the basis for the strategic advice offered to companies and policy-makers, is as follows.

- The blockbuster model for drugs development worked through high value, (typically 35x earnings) multi-national companies operating with a very high cost base. When, exceptionally, these companies produced a market-making drug on a global scale, extremely high profits resulted which could be sustained over decades. However, the technological and market conditions which enabled this no longer apply, and the business model is now defunct.

- The 'new paradigm' model for the pharma business encompasses a wide range of smaller, lower value, lower cost, and more nimble operations, with strong specialisms, local control and supply chains, clear financial accountability and effective external business relationships and networks with other specialists. These specialists facilitate the new model, providing effective support in developing, testing and bringing new products to market more quickly: these products will have limited lifespans, and will be replaced in turn by others.

- While this shift threatened, and has led to the closure of some, UK-based operations in the sector, a lower cost base, with strong process capabilities, skills and management, and supported by effective business networks and intermediaries, also provides major new opportunities.

- These opportunities are underpinned by global trends under which competitor countries, in particular India, have lost some of their earlier advantage based on cost; they are now looking for new platforms in the West which can 'legitimise' and provide market position to enable their own development as worldwide players.

- In recent years, the major pharma plants in the North East, which in most cases have operated there for 40-50 years or more, have transformed, or been transformed, to operate under this new industry paradigm. The key enabler has been high quality management, combining technical expertise with global business understanding, and supported in some cases by VC funding. Examples include:

    - GSK, now expanding tablet manufacturing at Barnard Castle for the first time in decades

    - QuantuMDx, specialising in diagnostic technologies

    - MSD (Merck & Co) Cramlington, which has received substantial reinvestment in recent years: this plant is regarded as an exemplar for continuous production, and used as a benchmark for worldwide performance

    - Sterling Pharma Solutions at Cramlington, formed through an MBO in 2016 to build on a history of manufacturing using small molecules and fine chemicals from Sterling Drug in the late 1960s

through Chirex, Rhodia and Shasun, with various owners over time including Sanofi and Eastman Kodak

- Sanofi, which closed its Newcastle (Fawdon) site, but backed a proposal for a science & technology park which was expected to have found demand for space from small life sciences businesses. Accord Healthcare, a UK pharmaceutical company with an extensive international network will now take all 400,000 sq ft of laboratories and offices.

Shott Trinova has made several investments in businesses it advises, in most cases as a minority shareholder.[6] Its key investment to date, and the only one which is wholly-owned, is **Arcinova**, a Contract Research and Development Organisation (CRDO), a substantial and significant North of England industrial biology asset.

Arcinova's offer to the pharmaceutical industry is process research, drug development, scale-up and small scale manufacturing, including bioanalysis, and regulatory and consulting services leading through to market. Shott Trinova acquired the ex-Covance site at Alnwick in February 2016, and provides the MD/Chair of Arcinova, and the Finance Director. As a CRDO, its operations involve bio-transformational activity based on high-level process expertise: it was established with no debt, additional venture finance backing has already been attracted, and 20 graduates were recruited in the first year of operation.

Collaborations and business relationships (including supply chain)

Ian Shott's business career and connections have resulted in exceptionally strong personal networks, national and international, which he has used to inform and help articulate life sciences' business in the North East. His involvements include:

- Governing Board member of Innovate UK
- Lead for Accelerated Innovation in the Chemistry Growth Partnership
- Chair of IBIOIC, the Scottish Industrial Biotechnology Innovation Centre
- Fellow of the Royal Academy of Engineering
- A founder, with others, of CPI (Centre for Process Industries) at Wilton
- Involvement in the North East Manufacturing Cluster network, 'First for Pharma' (see below).

CPI's expertise in process makes it the key intermediary for industrial biology and life sciences in the North East. In addition to its main facility at Wilton, CPI owns and operates two other nodes, ***the National Formulation Centre*** at NETPark, Sedgfield, specialising in product development and applications, and ***the National Biologics Centre*** at Darlington, which supports the UK biopharmaceutical industry through collaborative working on process innovation and the development and adoption of new manufacturing and analytical technologies.

North East life science and bioeconomy businesses can also draw on facilities, expertise and services from a wider area, including the Biorenewables Development Centre at York. The in-depth strength of research and higher education in relevant subjects across the universities of the North East – Durham, Newcastle, Northumbria, Sunderland and Teesside is augmented by the nearby Universities to the north (in particular Edinburgh) and south (York and Leeds); potential across the North is represented by the N8 partnership of research intensive universities.

[6] These include BPE Design and Support (design and modelling in chemical/biochemical engineering) and Kiln Flame Systems (combustion technology)

Shott Trinova and Arcinova will look to build bilateral business collaborations as well as supply relationships: these might, for example, involve complementarities around shared space, and exploring opportunities with other CRDOs such as FUJIFILM Diosynth on Teesside.

Growth opportunities and barriers

Ian Shott noted that the life sciences sector between the Tees and the Tweed is a microcosm of the global pharmaceutical industry: businesses have adapted to radical changes in the global environment, and the sector is well-positioned to be an economic driver in the future, The range of facilities and operations in the North East of England includes:

- Production based on small chemically manufactured molecules, which provide the basis for 90% of the drugs on the market today, and also large molecules (biologics/biopharmaceuticals), which as therapeutic proteins are becoming increasingly common
- Both continuous and batch production
- Large well-established players, which have adjusted to a changed business environment, and small start-ups operating as producers, developers and service providers in specialist life sciences/industrial biology niches.

This strength is not always appreciated within the region, and certainly not widely understood outside. ***'First for Pharma'*** was launched in January 2017 to give more profile to the North East as a Pharmaceutical Manufacturing Cluster network. The founding members of this specialist business community operate 13 large pharmaceutical manufacturing sites directly employing 2,600, exporting 95% of its £2bn+ production, and with a supply chain turnover estimated at £0.5bn.

A wide range of specialist skills, including chemical engineering, process manufacturing, chemists and biologists, are required to enable this cluster to function. Arcinova's recent experience in recruiting graduates shows that new people can be attracted – some of these came from the south of England and continental Europe, citing quality of life as a factor. But inevitably, some skills, notably biochemists, experienced analysts and quality assessors, are in scarce supply, particularly at present when most firms are expanding, changing their operations and looking for new people.

Against this backdrop, the role of Government is important, in working with business to ensure favourable economic conditions and in establishing clear direction and priorities for economic development and improving productivity in its Industrial Strategy: also, in facilitating the supply of high level skills through working with the educational and training sector.

'First for Pharma' shows that the industry recognises its own responsibility, to build awareness among people looking to develop their careers in the North East, as well as promoting the profile more widely, and encouraging business collaboration, effective intermediaries and new investment. The initiative reflects the view that, in this industry, there is a distinctive cluster based in the North East, with close working relationships with businesses and organisations in other parts of the North of England, particularly Yorkshire & Humber, and also reaching into Scotland.

The aim is to establish a clear identity, and to show that this is a place where these type of businesses flourish. As with knowledge-based industries in Cambridge, and the 'Golden Triangle' where London and Oxford represent the other nodes, this is less about boundaries than creating momentum around a positive image based on a distinctive competitive position.

T: Viderabio

Adriana Botes, Director

Face-to-face interview

Key messages

- Viderabio is a start-up seeking to use innovative processes in bio-informatics and synthetic biology to turn waste and by-products from industrial processes into high value compounds;
- UK currently underpowered in this sector, but North East has perfect combination of readiness of technical skills, facilities and the feedstocks around which to build a supply chain (mostly from oil refineries);
- Viderabio is well networked, tech is being proven quickly and drawing interest from commercial partners;
- UK business culture is a barrier to growth and understanding – commercial research is under-funded and the market either moves too slowly or is driven by the wrong incentives (often Government brokered) to high-throughput, low-yield products and services

The business operation

Viderabio is a Redcar based start-up focussed on the use of bio-informatics, biological systems and synthetic biology to construct high-value products. By using knowledge of these processes they hope to be able to take platform molecules which are waste and by-products to create organic compounds for the flavours and fragrances industry, natural steroid products, insect repellents and new materials.

The UK has no current strengths in synthetic biology, especially given the size of investment in the industry. This is due to a focus on a small number of high-volume, low-output processes and hosts (notably e.coli) – most of this activity is driven by large companies who have little bandwidth to innovate but want to feel like they are adapting to new opportunities and challenges.

Viderabio's work to date has focussed on three processes; in the first two instances they have applied for funding from Innovate UK (they were successful in regard to the first project), and the third application is in the pipeline. All three projects will be completed even without Innovate UK support.

These projects are focussed on the use of oxygenated sesquiterpenes and fatty aldehides. The former have potential to drive innovations in well-being (anti-cancer treatments) as well as materials and fragrances, the latter are slightly less 'high end' but have a higher production volume and could still produce medium value compounds.

Collaborations and business relationships (including supply chain)

Viderabio works with partners across the North.

Their key academic partners are currently Durham University, who host their existing lab space. As activity intensifies, they expect to work closely with the Gene Mill at the University of the Liverpool and Manchester Institute of Biotechnology at the University of Manchester. The company has strong links with both institutes and are actively discussing the commercial application of their research, and how they can work in mutually beneficial relationships.

The company is closely engaged with CPI, drawing on their networks and providing consultancy support to make their institutional approach more commercially focussed and to provide insights and consultancy to their supported businesses.

They have emerging relationships in the North East supply chain, including with both Crowder and Unilever who could be end-users of their products and may provide commercial support for ongoing research. The North East was chosen specifically due to the availability of waste and by-products from nearby palm and rapeseed oil refineries; contact with these partners is relatively early stage already ongoing. Part of the issue is communication is too 'high level' given the technical expertise required to understand the processes and potential of the products they are selling.

Growth opportunities and barriers

Viderabio feel the entire niche in which they are working has huge growth opportunities. They are taking existing waste and by-products and seeking processes and means to convert them to materials and compounds with high market demand – the trend for organically sourced products is enormous and the yield is potentially huge (in the realm of €1500-€4000 per unit).

Viderabio is hoping to have proof of concept for their three host molecules within 3 months, after which they hope to secure fuller industry investment. Their intention is to use facilities in the North East – the Innovation Centre at Wilton Centre and BVC in York, to further incubate and test the outputs.

Their intention is to retain the IP and work with local collaborators to build out the capability and delivery chain. Licensing the processes and compounds is an opportunity they will consider but they would prefer that the high-end value divests in the UK (particularly in the North East) – the supply chain and skills are here, but this isn't always backed by funding and entrepreneurial nous.

In Viderabio's opinion the biggest barrier is culture – UK academia is too focussed on early stage research and the market in organic and waste products is currently focussed on high throughput, 'big capital' programmes, many of which offer large amounts of Government subsidy based on poor understanding of potential and yield. The vast majority of research funding available is just that – it doesn't require demonstration of any practical, social or economic output.

The Catapult should be the bridge and help drive this culture change but are too weighted in the opposite direction, facilitating understanding in big corporates rather than acting as a facilitator between capabilities at facilities such as BVC, MIB and Gene Mill and the problems of the commercial sector. Companies such as Viderabio may act to fill the void and show concept proofed case studies, but may need a critical mass to move the market or draw attention of HM Government.

U: Vivergo Fuels

Mark Chesworth, Managing Director

Face-to-face interview

Key messages

- Vivergo Fuels utilises feed-grade wheat drawn primarily from Yorkshire and Lincolnshire in a process which operates 24/7 to produce bioethanol (which is blended into petrol) and protein-rich animal feed,
- The company, owned by ABF and based near Hull, is the largest UK supplier into both these markets.
- Vivergo has active research links with NNFCC at York, and with Bangor and Hull Universities; also close links with other parts of ABF and industry bodies
- Its future depends on government policy: the move to increase the bio-based renewable proportion of transport fuels has been slower than expected, given the increasing significance of transport in carbon, and national and international commitments to ameliorating climate change.

The business operation

Vivergo's large plant at Saltend Chemical Park near Hull, takes feed-grade wheat, through a process involving milling, brewing/ fermentation and distilling into bioethanol and protein-rich animal feed. Virtually no waste is produced from this process.

Vivergo was formed in 2007 as a joint venture between AB Sugar, BP and Du Pont, with the aim of building a biofuels business for the future. The environmental agenda is the core driver for the business, and for its people.

- The plant capacity for bioethanol production is 420m litres each year: this is blended into petrol at the pump, the ratio is currently 5% (see below).
- 450,000 tonnes of high protein animal feed are produced each year: initially seen as the second product, this can meet the feed requirement of c.20% of the UK dairy herd. For the most part, this directly substitutes for protein feed which would otherwise be imported. The feed is sold primarily across northern England and southern Scotland, with smaller amounts going further afield to Wales and the South West: relatively small amounts are exported.

The 1.1m tonnes feed-grade wheat used annually by Vivergo is not suitable for bread and high quality food products: if the plant did not exist, the wheat would mainly be exported to mainland Europe at relatively low prices, and used for animal feed.

On commissioning in 2008, the £350m Vivergo plant, which makes an estimated £600m annual contribution to UK GDP, was the largest of its type in Europe. Production started in 2012, and the plant has operated to capacity from 2014. It is now the second-largest in Europe, the largest is in Rotterdam. Its most direct UK competitor is Ensus on Teesside, with 400m litres capacity, which began operations in 2010 and is now owned by a German company, CropEnergies. The only other UK plant is the British Sugar 70m litre capacity operation in Norfolk, a sister company of Vivergo Fuels.

The wheat supplied to Vivergo is contracted entirely through Frontier, a crop production and grain marketing company owned jointly by AB Agri and Cargill: almost all is sourced from Yorkshire and Lincolnshire. The 120 HGV movements in and out of the plant each day represent one of the largest supply flows in the UK.

Commercial results at Vivergo and Ensus have been seriously affected by falling oil prices after the recession: the original investment in Vivergo has been written off, but the plant has continued to operate24/7, while Ensus has been mothballed for substantial periods.

The structure of the company has changed over the last ten years. Du Pont's main interest was in biobutanol, which depends on the same feedstock as bioethanol and was originally expected also to be a main product. Once it became apparent that the process for commercial scale biobutanol production was not yet technically achievable, Du Pont's interest was diluted by the other partners as further investment was required. In 2015, as BP moved back to its core businesses, ABF acquired its share, and now owns 94% of Vivergo Fuels Limited, with 6% still held by Du Pont.

Vivergo directly employs c.150 people, with between 2,000 and 3,000 jobs estimated to depend on the operation, mainly at the wheat-growing farms and in logistics. Of its own employees, between one-third and a half are STEM; the company offers both internships and apprenticeships. Process engineers are available locally, as are graduates (although there is also a good link with Nottingham University). Key management and technical positions can be more difficult to fill, as highly qualified experienced people are sometimes reluctant to move.

Collaborations and business relationships (including supply chain)

The Vivergo plant is a large-scale operation which has reached and sustained full production over several years. Its management looks to improve processes and forward planning through engagement with i) the wider R&D community ii) those involved in process technology as operators and practitioners iii) public policymakers and influencers. These links include research projects focusing on different aspects of 'second generation bioethanol', but are also valued as a way of keeping abreast of technology developments more widely. There is:

- A strong relationship with NNFCC, a commercial consultancy based at York Science Park which specialises in strategy for the bioenergy and biofuels markets and the growing biobased products sector: NNFCC was established by Government as the National Non Food Crops Centre in 2003
- Active links with university researchers at Bangor
- A link locally with Hull University, which has a pilot-scale bioethanol plant, focusing on chemical engineering.

Vivergo also has active links with other ABF divisions, notably:

- AB Sugar

- AB Agri (owner of Amur, based in Yorkshire, which is developing a process for producing quality feedstock for anaerobic digestion from sugar beet waste)
- AB Mauri, which operates globally as a specialist supplier of bakery and yeast products.
- Vivergo also has strong relationships with Humber LEP and industry groups across the Humber Estuary, including the industry organisation, HCF Catch.
- The company is a member of the European Ethanol Association (see below, regarding the importance of industry policy and lobbying).

Growth opportunities and barriers

The prime factor in choosing to locate on Humberside was the local availability of feed-grade wheat, on the scale required for commercial operation. The production of crop-based ethanol on this scale was expected from the outset to require patient capital, despite the evident commitments of the UK and other Governments, and international organisations, to a low carbon future.

However, the key feature of Vivergo's business is that it is policy-dependent: this is both a major opportunity and the biggest barrier. While governments around the world have recognised the need to increase the utilisation of bio-based renewable fuels to meet national and international obligations on climate change, they have done so at different rates and over different timescales.

Although many governments have moved, or are committed to moving, to 'E10', ie towards adopting a directive that 10% of transport fuel is sourced from renewables, different levels have been proposed, or are being enacted, for different users. Taken overall, the process of adopting higher standards has stalled since 2012, and the resulting commercial uncertainty has been exacerbated by the falls in oil prices. E10 nevertheless provides a generally recognised 'standard': most modern cars can use this fuel mix, and there is no need for new infrastructure, as is required for wholly electric vehicles.

Against this backdrop, the UK Renewable Transport Fuels Obligation is currently set at 4.75%: it has not proved possible for industry to obtain a commercial, or near-commercial, return on investment at that level. The Government held a public consultation on this issue between November 2016 and January 2017. This included the proposition to:

"Raise the RTFO in equal steps to 9.75% (by volume) in 2020 to achieve 5-6% renewable energy in transport, supporting the achievement of UK Carbon Budgets and the transport sub-target in the RED, and maintain at least that level of obligation to 2030."

For Vivergo, the adoption of E10 is more important than the implications of Brexit, but the results of the consultation will not now be available until after the May 2017 election, which inevitably means further delay and uncertainty on the future viability of the business.

Second generation ethanol, perhaps drawing also on other materials such as straw cellulose, is seen as a potential next step for the future of the plant, pending a viable market in the near term. The way forward in this and other areas may be a focus of smaller scale investments and the production of lower volumes of more specialist products in the future.

V: Wheatsheaf Group

Tim Shaw, Head of Research

Telephone interview

Wheatsheaf is part of Grosvenor Estate. It was established in 2012 and incorporated 2 Grosvenor Estate businesses: Grosvenor Farms and Cogent Breeding. It is an investment company active in:

- Breeding in plants & animals
- Efficient production of protein
- Improving nutrient cycles
- Value for natural capital
- Energy efficiency.

The Group has no investments in the Region. It does not work with universities anywhere in the world, as the research is too early stage. This might, however, change in the future.

TS felt that was a real opportunity for the N bio economy to process waste from the food processing industry in the NW. Mid West USA was leading at present and had benefitted from risk capital climate in USA

W: Wilson Bio-chemical

Peter Metcalfe, R&D Director and Sheila Hughes, Sales and Marketing

Telephone interview

Key messages

- Small company of 5 people based in York with unique technologies for converting municipal waste into fuels, energy and feedstocks primarily based on bio-chemical engineering
- Operates from the Biorenewables Development Centre (BDC) at York
- Relationships with a range of University research departments including York, Nottingham and Leeds
- Need to demonstrate its next commercial plant which is about to be located in Chesterfield to prove the effectiveness of this technology in converting municipal waste into fibrous fuel which can be mixed with coal as a fuel or used as a feedstocks to make higher value products such as acetone, butanol and hydrogen
- Have obtained significant development funding from a range of sources including Innovate UK, the EU and Bio-Energy Securing the Future (BESTF)
- Need to demonstrate the effectiveness of the technology both in terms of delivering outputs from a range of feedstocks including municipal waste streams and also in terms of elimination of smells from storage and processing of waste and to demonstrate this capability to the Environment Agency
- Need to gain commercial contracts for the delivery of systems, but major customer sectors are very risk averse and effective demonstration is essential
- The technology which is already proven could eventually make a major contribution to reduction of landfill, reduction of methane from landfill, and turning waste into valuable fuels and feedstocks
- Opportunities for using agricultural waste as a feedstock will provide an a further stage of development which will be relevant both to agricultural waste in the North of England and in other countries where there are significant waste streams e.g. from wine and beer production.

The business operation

Wilson Biochemical has five staff, four of whom are based at York and one in Belfast. The Company is primarily a technology provider in the field of autoclave systems 'Wilson System®' for converting waste products into useful

feedstocks and diverting waste from landfill. Its specialist expertise lies in the development of steam autoclave systems for converting waste products including municipal waste into useful feedstocks and energy.

The company is currently at the stage of developing pilot and demonstration waste-t-chemicals systems to demonstrate to and enable major potential users to see the special technologies demonstrated at semi-industrial scale.

Wilson Bio-chemical is seeking to demonstrate at scale the capabilities of its technologies to turn municipal waste destined for land-fill into high value chemicals and fuel. Its technologies can be used for a variety of purposes:

- Wilson Systems® to turn municipal and other waste that would otherwise go to landfill into a fibrous material that can be used for a variety of other purposes
- Utilising this fibrous material in a torrefaction process to create a coal – like substance that can be used with coal in power plants or non-WID approved combustion systems
- Further processes that can create acetones, ethanol, butanol and hydrogen through hydrolysis and fermentation

Currently, the company is installing its next commercial system that can process 150,000 tons per annum (20 tones/hour) which is planned to be commissioned later in the year in Chesterfield.

Wilson Bio-chemical is funded by private investors, its staff and has enjoyed several project grants from Innovate UK and European funding through BESTF2.

At present, the company is awaiting the building of the next commercial autoclave system in Chesterfield and seeking to develop relationships with major customer sectors such as municipal waste organisations, private landfill owners, project developers and renewable heat and transport fuel interests.

The company is also starting to carry out experimental tests using agricultural wastes such as wine waste and beer waste in order to develop that area of the potential market.

Collaborations and business relationships (including supply chain)

Currently, the company's main base is at York in the Biorenewables Development Centre. It has important research interests which are being followed through with the Universities of York, Nottingham and Leeds. Substantial R&D work is undertaken through BDC and Biovale.

Growth opportunities and barriers

Opportunities

The supply chain for feedstocks could be an important market area for the company with the large urban conurbations in the North including, West Riding, Lancashire, Merseyside, Newcastle and South Yorkshire with the attendant municipal waste streams.

Major markets could also include power generators such as Drax where the output from the company's autoclaves could be mixed with coal for power production. Other markets could be developed among waste disposal companies such as Veolia, Viridor, Biffa etc.

Some smaller waste disposal companies are very interested and when the next commercial plant is up and running in Chesterfield, the intention is to demonstrate the plant capabilities Process guarantees underwritten by Lloyds of London are available to potential clients to protect their capital up to a value of £30 million.

In addition to the Biorenewables Development Centre activities, the company has received specific grants, as below:

- A £5m grant from Bio-energy Securing the Future for a bio refinery at York (BESTF) funded by the EU
- Funding for an integrated demonstrator to make butanol and hydrogen, with the butanol being mixed with petrol to increase the renewable content and the hydrogen becoming part of the hydrogen power of the future e.g. in fuel cells for electric vehicles etc.
- A grant from Innovate UK to produce pelletized torrefied fuel from waste to be used in power stations and the domestic market. This fuel carries an "End of Waste" certification.

Opportunities for using agricultural waste streams are also being considered and this is particularly relevant to the BESTF funding from the EU where there is an important role for utilisation of agricultural waste from products such as grapes and wine

Barriers

Most municipal waste disposal is tied up in long term contracts of up to 25 years and when these contracts are due for renewal, the relevant agencies are very risk averse leading to low take up of possible new solutions such as those of Wilson Biochemical. These bodies prefer to give contracts for recycling, incineration and land-fill.

Gaps / constraints

An important gap is that investors always want to see a plant working before they will invest and customer sectors are often risk averse

Some of the company's earlier competitors had run into problems with the treatment of municipal waste due to local communities complaining about smells coming from the process. These smells emanated from two main sources:

- The storage of municipal waste materials before conversion
- Smells emanating from the conversion process itself

Wilson Bio- Chemicals has developed different, proven, solutions to overcome these issues.

Appendix F: Identifying and measuring companies in the bioeconomy of the North: Methodology

Purpose

The aim of this element of the SIA study was to identify all of the companies in the SIA footprint that are relevant to the Bioeconomy. Once identified, the companies were to be measured in terms of number of active trading locations within the SIA footprint, the number of employees working for companies in the sector, and the financial turnover of the companies applicable to the SIA footprint.

The primary data source for the company information was the FAME database of companies that are registered at Companies House.

Selection and Segmentation

A definition of the sector was made using the Standard Industry Code classification scheme (SIC2007), by selecting which company activities, as described by their Primary SIC Code, were considered to be within the scope of the Bioeconomy. Due consideration was given to the classification schemes used by previous studies in this sector, and an approach was selected which gave the most reliable comparison to relevant previous works.

Once a definition of scope was finalised, the activities of companies were then segmented by Primary SIC code (SIC2007) using a three level scheme:-

- Main Industry
- Main Activity
- Sub Activity

Upon completion of the segmentation scheme, an extract was made from the FAME database of companies to select those companies that fell within the sector definition that had at least one active trading address within the SIA footprint.

Data Cleansing and Normalisation

Having established the initial extract of company data, a period of data cleansing followed, where company information was analysed. Duplicate and misleading information was removed or adjusted eg holding companies, consolidated accounts etc. to leave a dataset that could be further analysed.

Where companies had multiple active trading locations, some of which were outside the SIA footprint, adjustments were made to ensure only the economic activity within the SIA footprint was considered.

Where companies reported their accounting information under exemption schemes, significantly less information was directly available for analysis. To overcome this, industry norm values for the relevant SIC code were used. The source for these norms was the “Office for National Statistics Business Population Estimate for UK and Regions 2016 by SIC code”.

Analysis and Reporting

Upon completion of the data preparation, the characteristics of the business population and economic activity of the Bioeconomy of the North was analysed by the SIA team using the Tableau business intelligence tool.

Appendix G: University translational facilities and institutes in the North of England

University of Chester The Thornton Science Park is a major research and innovation hub, and **NoWFOOD** is a centre of excellence for food science and technology for food and drink companies across the region providing technical support, test kitchens, incubation space for start-ups, sensory testing units, and business advice.
Durham University The **Centre for Crop Improvement Technology** integrates research in plant-genetics, cell biology and biochemistry with expertise in chemistry, physics, mathematics and engineering to develop technologies for crop improvement and protection. **Bio-X** multidisciplinary research supporting the bio-economy including Bioactive Chemistry
University of Hull The University of Hull provides state of the art next generation sequencing in the **Evolutionary and Environmental Genomics Group**, adopting environmental DNA (eDNA) approaches for biomonitoring and early detection of invasive species in aquatic systems to improve fisheries management. The **Hull Logistics Institute** is a world-class centre of excellence in global logistics and supply chain management.
Lancaster University Lancaster University supports the **Lancaster Environment Centre**, one of the largest centres in Europe to conduct interdisciplinary research across agri-food that combines natural, social and management science. The **Pentland Centre for Sustainability in Business** explores environmental sustainability, ethical trade, human rights, and how business can be a force for positive global change The **Centre for Global Eco-innovation (CGE)** is a growing alliance of HEIs and business working across the boundaries of commercial sectors and academic disciplines to focus on six shared global environmental challenges including food, water, energy, natural capital, waste and resource efficiency.
University of Leeds The University of Leeds hosts a **Centre for Doctoral Training on Bioenergy** and the **Institute of Process Research and Development** works closely with the chemicals industry. The **Sustainability Research Institute** combines natural and social sciences, while **water@leeds** is one of the largest interdisciplinary centres for water research in the world. The **Leeds University farm** is part of the Centre for Innovation and Excellence in Livestock (CIEL) and its **Field Research Unit** includes laboratories, glasshouses, animal accommodation and commercially-farmed fields.
University of Liverpool The University of Liverpool is a global knowledge leader in advanced materials, with the Chemistry Department ranked 2nd in the UK (REF2014) and biotechnology outputs generating important impacts in society and industry. This is best exemplified by the £68 million investment in the **Materials Innovation Factory** as part of a strategic partnership with Unilever. The University of Liverpool activities strongly support the development of the emerging bioeconomy, in particular demonstrating a cohesive approach to agri-tech research through the **Centre of Excellence for Sustainable Food Systems**. This covers all aspects of the industry from sustainable production, resilient supply and value chains to positive health outcomes for people, animals and the environment. Also, the **MicroBioRefinery** facility is dedicated to the valorisation of biomass towards the production of chemicals, fuels and materials.

University of Manchester
Manchester has industrial biotechnology projects worth over £100 million with leading companies including GlaxoSmithKline, Shell, Unilever and Pfizer to drive the creation of new bio-based chemicals and materials. The **Manchester Institute of Biotechnology (MIB)** focuses on the green manufacture of industrial chemicals, first, second-generation and third generation biofuels, while **SYNBIOCHEM** deploys synthetic biology to optimise fine and speciality chemicals production. Manchester is also home of the **Manchester Biomanufacturing Centre**, the **Centre of Excellence in Biocatalysis, Biotransformations and Biocatalytic Manufacture (CoEBio3)** and the **Supergen Bioenergy Hub**. Working with Syngenta, among others, **e-Agri** designs smart integrated "e"-devices for modern agronomy and food science to reduce waste, increase yields and improve nutrition.

Newcastle University
The **Centre for Synthetic Biology and the Bioeconomy** targets the commercial exploitation of synthetic biology, while the **Institute for Agri-Food Research and Innovation** is a joint venture between Newcastle University and Fera Science Ltd that delivers innovation in research across the Agri-Food supply chain. The university has two research farms: **Cockle Park Farm** focused on livestock production, **Nafferton Farm** on dairy, beef production, arable crops and small scale vegetable production. Research programmes investigate organic production, food, nutrition and health covering primary production and produce quality, consumer social research and policy, and dietary intervention and clinical studies.

Northumbria University
The bioeconomy is one of the university's eight research themes, with a focus on replacing toxic methods of chemical production with 'green chemistry', capturing carbon within bioeconomic systems and improving food quality through biorefineries. Particular emphasis is placed on technological applications of high throughput genomics, metabolomics and proteomics techniques.

University of Sheffield
The University of Sheffield **Sustainable Food Futures (SheFF**) is an interdisciplinary research cluster focused on delivering resilient sustainable agri-food systems from production through to consumption and human health impacts. SheFF includes international strengths in consumer practice and human health and the social and environmental impact of changing consumption and diet. **Plant Production and Protection** is a translational biology centre drawing on twenty-seven world-class research groups working across fundamental plant and soil biology. The **Advanced Biomanufacturing Centre** is a translational knowledge-hub for biomanufacturing.

Sheffield Hallam University
Sheffield Hallam University is home to the **National Centre of Excellence for Food Engineering**, with extensive support from food and drink manufacturers including UK and international OEMs such as Premier Foods, William Jackson Food Co., Nestlé and Mondelez to tackle issues of productivity, energy efficiency, process capability and skills.

The University of York
The University of York hosts two internationally leading bioeconomy-related research groups, the **Centre for Novel Agricultural Products** and the **Green Chemistry Centre of Excellence**, with a combined research project portfolio of £40 million. York leads the HEFCE-funded £16 million **N8 AgriFood Resilience Programme** and four of the thirteen BBSRC Networks in Industrial Biotechnology and Bioenergy (NIBBs). The University of York has also secured £2.4 million in HEFCE support and £1.79 million in ESIF funding for the **BioVale** Innovation Cluster. The **Biorenewables Development Centre** is a wholly-owned not for profit subsidiary of the University of York.

Appendix H: Key innovation providers in the North of England

Biorenewables Development Centre (BDC) The Biorenewables Development Centre (BDC) at York connects the region's world-class scientific research with innovative businesses. It has equipment for scaling up from the laboratory to kilogrammes of biorenewable materials, with an experienced team of applied researchers and experienced business development professionals. The BDC has delivered over 200 innovation projects with regional SMEs and in doing so has created approximately £13 million of GVA to date.
Centre for Applied Crop Science (CACS) CACS is an international centre for innovation in crop protection, uniting industry, agriculture and academia to revolutionise the way global farming deals with crop threats. Launched in April 2016 with over £21 million funding as part of the UK government's Agri-Tech strategy, CACS is headquartered at the National Agri-Food Innovation Campus near York.
Centre for Innovation Excellence in Livestock (CIEL) CIEL has received £27 million state funding to revolutionise the UK's capacity for livestock research, development and innovation. CIEL provides access to twelve world-class research institutes and commercially-managed trial farms for 'real world' testing. Like CACS, CIEL is also located at Sand Hutton near York.
HCF CATCH HCF CATCH Ltd is an industry led partnership supporting the process, energy, engineering and renewable industries in the Humber region. HCF CATCH operates the world renowned CATCH training facility in North East Lincolnshire that has a three storey liquid circuit process plant developed to support training for the process, energy, engineering and renewable sectors.
The Centre for Process Innovation (CPI) CPI is a major UK based technology innovation centre and the process industries division of the High Value Manufacturing (HVM) Catapult. CPI collaborates with universities, SME[1]s and large companies to help overcome innovation barriers and develop next generation bioproducts and bioprocesses. CPI has dedicated national innovation centres supporting industrial biotechnology and biorefining, such as the National Industrial Biotechnology Facility, and developed and manages the National Biologics Manufacturing Centre in Darlington. HVM Catapult investment in CPI means that Tees Valley ranks second out of all UK regions for Innovate UK funding in Biosciences in the period 2010-2015.
The Materials Innovation Factory (MIF) The Unilever - University of Liverpool MIF is a unique £68 million open-access facility based around 'high throughput' automated robotic methodologies that will accelerate the research process by factor of up to 200, greatly reducing new product discovery times for numerous companies and driving economic growth and international competitiveness. It will support a community of up to 300 industry and academic researchers to deliver innovative products in globally competitive markets using efficient, sustainable and cost-effective processes and drive forward research innovations in academic and industrial fields challenged by complexity. The MIF draws together world-leading research and technologies, and the seamless integration of computational and experimental models.
MicroBioRefinery (MBR) The £2.83 million open access MicroBioRefinery research facility was established with Unilever and AB Sugar and funded by BIS. The MBR provides access to state-of-the-art high-throughput synthesis, biomass characterisation and testing facilities under high temperatures and pressure of reactive gases, as well as the expertise required to develop novel routes and functional materials from biomass and bio-derived feedstocks. This includes the identification and design of the next generation of sustainable chemicals derived from agricultural, forestry and food residues and waste. The facility provides access to equipment for the study of bio- and chemo-catalytic routes, alongside unique new technologies available for biomass pre-treatment and chemical valorisation, such as pressurised microwave reactors, sonication and photocatalysis for biomass reforming.

Fera Science Ltd Fera Science Ltd supplies scientific solutions, evidence and advice across the agri-food supply chain, and is the UK's premier laboratory providing food and environment services to Government. Employing over 350 scientists, it serves over 7,500 clients and collaborates with more than 1,000 partners. Fera is the preferred supplier for both CACS and CIEL. Fera is based at the National Agri-Food Innovation Campus (NAFIC) near York, which has global relationships with a number of similar agri-food science parks in Europe & Australasia.
Food Innovation Network The Food Innovation Network (FIN) will also be coordinated from NAFIC. FIN is a UK-wide body linking existing food support activities to help business innovate. It signposts information and access to funding, research, expertise and tools to help develop new business ideas as well as connecting businesses to world leading science and research to create and optimise new market opportunities.
Stockbridge Technology Centre Stockbridge Technology Centre is a grower-led, independent contract research company and research farm undertaking applied research and development across a range of disciplines on horticultural and arable crops.

Appendix I: Local Enterprise Partnerships, the Importance of the bioeconomy, and key bioeconomy assets within the North of England

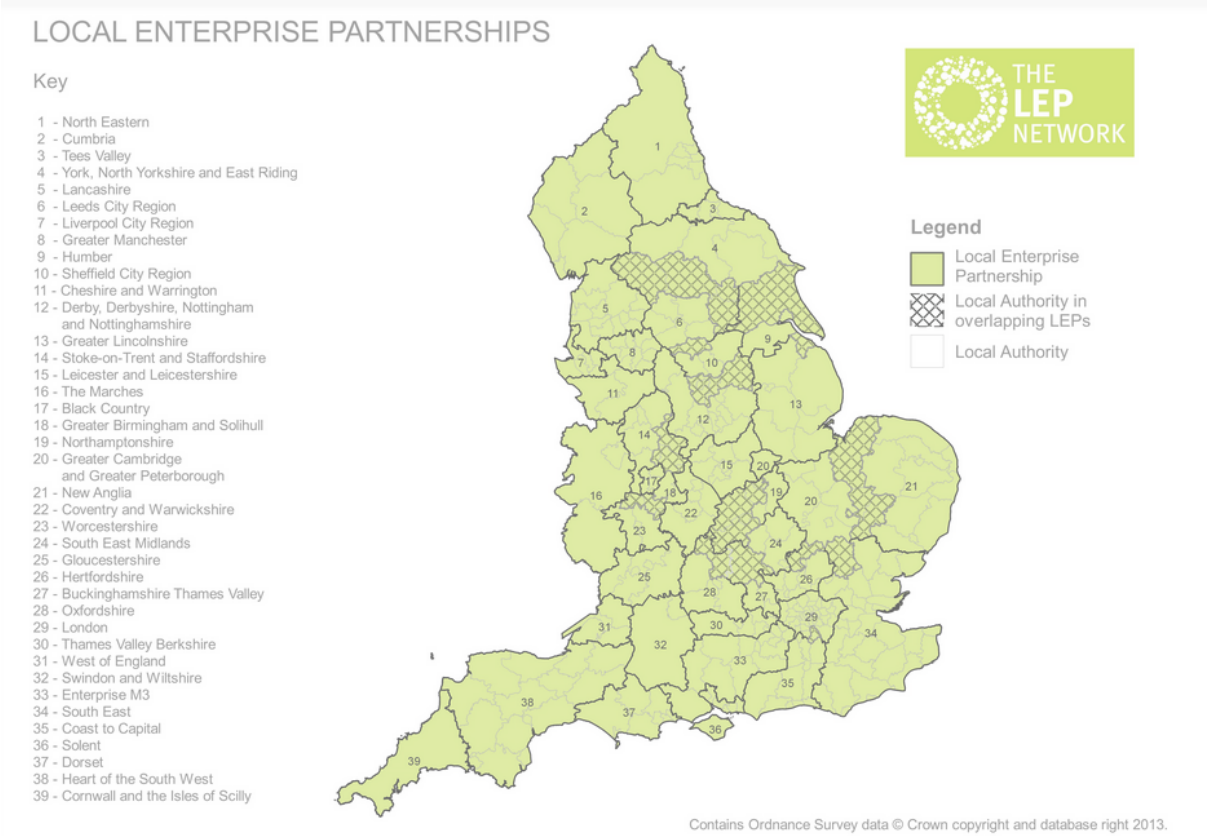
Introduction

The Strategic Economic Plans published by the 11 Local Enterprise Partnerships (LEPs) in the North of England along with documents relating to their future economic development strategies were reviewed for the purpose of identifying the importance of the bio-economy. What follows summarises these findings and identifies some key bio-economy assets within these LEP areas.

Although medical biotechnology is not within the scope of the SIA report, it is noted throughout this LEP review as it represents a sector of the bio-economy which shares similar expertise and scientific resources and is considered an important sector within the LEP strategic development plans.

The Local Enterprise Partnerships covering the North of England are shown on the map below initially published by the LEP Network, They include:

1. North East
2. Cumbria
3. Tees Valley
4. York, North Yorkshire and East Riding
5. Lancashire
6. Leeds City Region
7. Liverpool City Region
8. Greater Manchester
9. Humber
10. Sheffield City Region
11. Cheshire and Warrington



http://www.lepnetwork.org.uk/leps/

The bio-economy was found to feature prominently in the strategic economic plans of all but one LEP (Cumbria), with strengths in pharmaceuticals or health commonly cited as opportunities to build upon. In part this was driven by the NHS being a significant employer and through links with universities who are

a noteworthy creator of innovation opportunities, particularly those based around city regions. Several LEPs also demonstrate strengths in pharmaceutical development, or manufacture including (Cheshire, Manchester, Liverpool, North East and Tees Valley). As expected, LEP's with large rural areas were stronger in farming and forestry, but food production and processing from primary farm products appears to be a strength shared by all LEPs to varying degrees. Production of biodiesel and bioethanol for petrol was mainly concentrated in the Tees Valley, Humber, Liverpool and Cheshire LEP areas, while biomass to energy facilities are strongest in the North East, Tees Valley and Humber LEP areas with a significant facility also situated in Cumbria.

Cumbria is the only LEP area which does not specifically identify the bio-economy as key to its future economic development. The importance of the bio-economy to the area, however, was evidenced by the importance placed on farming, forestry, papermaking and its biomass to energy facility in Workington along with its involvement in pharmaceutical production.

Identified LEP Strengths within the Bio-Economy

Ten of 11 LEPs identified key areas of the bio-economy in their strategic economic plans or related documents. As previously mentioned, Cumbria was the only LEP who did not mention the bio-economy relative to future development plans however, it is clear that Cumbria LEP is developing strengths in this sector.

- The North East LEP has significant strengths in pharmaceuticals (8 large businesses identified), health, farming, food production and a growing strength in biomass to energy as approved and proposed facilities come on-line
- Cumbria LEP has significant strengths in farming, food, forestry, paper manufacture and because of its landscape has an important visitor economy. Additionally, pharmaceuticals manufacture takes place in Ulverston, and a large biomass to energy plant is operating in Workington.
- Tees Valley LEP has significant strengths in bio-refining; biofuels; pharmaceuticals & industrial biotechnology, including producing energy from biomass; and the manufacture of ammonium nitrate fertilizers.
- York, North Yorkshire and East Riding LEP is strong in several business sectors including food and drink, agriculture, agri-technology, and biorenewables.
- Lancashire LEP has significant strengths in farming and food production as well as in forestry
- Leeds City Region LEP has the largest professional services sector in the UK outside of London. Leeds University is home to the EPSRC Centre for Doctoral Training in Bioenergy, which is recognised for its world class contributions to the development of low carbon energies and is a strong link between the public and private sectors.
- Liverpool City Region LEP has particular strength in pharmaceuticals and the biomedical sectors and along with food processing and biofuel production and also operates a biomass to energy plant in the region.
- Greater Manchester LEP has many small and medium sized pharmaceutical and biomedical companies and has identified strengths in pharmaceutical manufacturing with facilities at Alderley Park, Macclesfield and nearby in the Liverpool City Region and Cheshire and Warrington LEP areas. This LEP area is also strong in food processing.
- Sheffield City Region LEP is home to The University of Sheffield who are a member of the research intensive Russel Group of Universities and Sheffield Hallam University, both of which have strong research outputs and expertise in the Bioeconomy.
-
- Humber LEP highlights its ports as an important asset along with strengths in manufacturing, chemicals/petrochemicals, healthcare, food and drink, agriculture, logistics, electronics, and renewable energy.
- Cheshire and Warrington LEP has strengths in pharmaceuticals, biologics & biomedicine; food production food processing with some biofuels, fertilizer and agrochemicals production

Alignment of the Bio-economy with the Needs of the Northern Powerhouse

Several LEPs demonstrated alignment between the key sectors being focused on in their Strategic Economic Plans and the needs of the Northern Powerhouse. In particular health innovation and pharmaceuticals production were commonly highlighted.

LEP Summaries

North East LEP

Area covered

The North East LEP encompasses County Durham, Gateshead, Newcastle, North Tyneside, Northumberland, South Tyneside, and Sunderland. This is an area of 3,195 square miles with a population of 1.93 million (2011), 51, 000 businesses (2016), 888,000 jobs (2016) and a **GVA of £35.4 billion (2014)**. Important sectors related to GVA contributions include: public services, education & health; wholesale, retail & transport; manufacturing; real estate; professional & businesses services; and construction. In comparison agriculture, forestry & fishing contributed less than 1% of the areas GVA.

Overall objectives

The North East LEP has identified both a need to address its performance gap in relation to other parts of the UK to become less reliant on public service jobs and, to grow the size and productivity of its business base. The LEP aims to create a further 100,000 jobs by 2024 to address unemployment and has identified wholesale, retail & transport, manufacturing and real estate as the fastest growing parts of the area's economy. In its 2013 Strategic Economic Plan, four smart specialisation areas were identified as opportunities for providing long-term competitive advantage passenger vehicle manufacture, subsea & offshore technology, life sciences & health, and creative & digital. An independent economic review also proposed manufacturing, energy, health innovation and digital as key northern specialisation areas likely to be a focus for the Northern Powerhouse. Health related and alternative bio-economy opportunities were identified.

Pharmaceuticals and Biomedical

Within health and life sciences the LEP has identified a cluster of 144 companies with a turnover of £683 million (95% from exports) employing 5,644 people and further people within their supply chain. However, it is likely some of these businesses may fall in the neighbouring LEP area of Tees Valley which also has significant pharmaceutical and biomedical assets. A recent report commissioned on behalf of the LEP recommended the North East should focus on two priority areas to drive forward its life science smart specialisation: ageing innovation (with the proportion of people over 65 expected to rise rapidly in the area), and supporting effective translation of medicines and applications into the NHS. The report also recommended taking advantage of the National Bio-Pharmaceuticals Centre being developed in Darlington and other regional assets. Significant LEP assets include:

- GSK in Barnard Castle employing over 1000 people producing: sterile products for injection, nasal sprays, dermatological creams & ointments, and cephalosporin antibiotics. The facility supplies up to 1500 different packaged drug products to 140 countries. Recently production of Stiefel's dermatology products was also transferred to the plant following a 2009 takeover and a further £90 million investment.

- MSD (Merck, Sharpe & Dohme) pharmaceutical manufacturing and stability testing facility in Cramlington, Northumberland, which employs approximately 400 people.

- Aesica a global leader in the manufacture of generic: non-steroidal anti-inflammatory, antidepressant and anaesthetic products (Consort Medial Group) has two manufacturing plants and an active pharmaceutical ingredient pilot plant at Cramlington in Northumberland employing 210 people. The site also has development facilities for lab and pilot scale production of drugs.

- Piramal Pharma has a large development and commercial manufacturing facility in Morpeth for the production of generic hormonal products, press coated tablets and blister / bottle packaging. This employs 150 people and in 2013 had an $11 million investment tripling production capacity.

- The Specials Laboratory operates 3 GMP manufacturing plants employing 125 people in Prudhoe Northumberland, producing a large range of medicinal products including antibiotics.

- Sterling Pharma Solutions (previously Strides Shasun Pharma) in Dudley, undertakes contract development and manufacture of active pharmaceutical ingredients and employs approximately 50 people.

- Shield Therapeutics based in Gateshead is a small pharmaceutical company focused on developing late stage hospital pharmaceuticals meeting previously unaddressed conditions such as iron deficiency anaemia and hyperphospateemia. The company recently raised £32 million through an Alternative Investment Market (AIM) listing on the London Stock exchange.

- Shire Pharmaceuticals employs 80 people in Prudhoe and Newburn, Northumberland following its takeover of the former SCM Pharma drug production sites there.

The area is also home to a number of smaller companies including: e-Therapeutics (Newcastle), which uses specialist software to identify drug candidates, for licensing; High Force Research (Bowburn Co Durham) employs 20 people and provides services for producing and scaling up new molecules for the pharmaceutical and other industries; Onyx Scientific (Ipca Laboratories) in Sunderland employs 40 people and provides similar services to High Force; Ithaka Life Sciences (in Sedgefield), is a specialist consultancy advising businesses and universities regarding the commercialisation of life science technologies.

400,000 sq feet of pharmaceutical laboratory, manufacturing and office space has been transformed into a science park and Biopharmaceutical Bioprocessing Technology Centre at Newcastle University. This will support businesses with designing and engineering bioprocesses, scaling up production and will also work closely with the Centre for Process Innovation in Redcar and the National Industrial Biotechnology Facility in Darlington.

Food and Drink

The GVA for the North East LEP is £35.4 billion. Despite large amounts of farmland in Northumbria and Country Durham, agriculture, forestry and fishing were identified by the LEP as contributing less than 1% to the area's GVA. In terms of the total value at market prices the most important products were: beef, wheat, lamb, and barley. The area also has a strong food processing industry. The most significant assets include:

- Nestle with a large sweet factory in Newcastle which employs over 400 people and produces 40,000 tonnes of chocolate products per annum.

- Walkers Snacks Distribution in Peterlee employs 380 people and produces Wotsits, Smiths Fries, Smith Moments and Walkers Sensations among other products.

- 2 Sisters Food Group operate a factory in Sunderland where 40,000 chicken fillets per week are prepared for the sandwich and pizza market.

- KP Snacks (intersnack Group) employs at least 50 people in Stanley.

- From a large factory in Peterlee, Kookaburra Ltd supply cooked poultry products to the food industry for use in salads, sandwiches, and ready meals.

- Warburton's operate a large bakery in Newcastle.

- Grainco based in South Shields is the largest grain trading and marketing business in the North of England and Scotland with sales of £183 million. The company provides seed and fertilizers to famers as well as grain drying, and storage. Grainco also markets grain in the UK and for export markets

Biofuels

Dalkias-Veolia have a 17.5 MW CHP biomass to energy plant at Bishop Auckland (Chilton Biomass Energy Centre) employing 20 staff to operate a local district heating system which uses 120,000 tonnes of wood waste each year. Two further such plants have also been approved:

- Energetický a průmyslový holding's (EPH's) 420 MW Lynemouth Power Station, is due to be converted to biomass by the middle of 2017, it will create 130 jobs and is expected to use 3.3 million tonnes of biomass a year including 800,000 tonnes of imported wood pellets.

- Estover's £138 million 27.7 MW biomass CHP plant in Cramlington Northumberland will supply electricity and heat to Aesica Pharmaceuticals and MSD and will use 270,000 tonnes of waste wood as well as new wood from local growers, creating 25 more jobs.

These plants are likely to be supported with wood from two large forests: Kielder in Northumberland and Hamsterley in County Durham.

Other Assets

- North East Technology Park (NETPark) near Sedgefield is home to 35 high-tech related business, 8 of which are pharma or biomedical. The National Printable Electronics Centre and National Formulation Centre are also housed here; supporting the design of formulated products ranging from pharmaceuticals to detergents, and will accommodate the £18 million National Centre for Healthcare Photonics, due to open in 2018. The latter centre will provide facilities enabling businesses to develop light-based medical imaging solutions and treatments for medical conditions such as eye disease. NETPark also provides incubation services to its resident companies.

- Newcastle Science Central is a science park covering 24 acres in a redeveloped area of Newcastle City Centre. This is the largest development of its kind in the UK and has enterprise zone status. The Science Park houses the National Centres for Ageing, (a Newcastle University and the NHS collaboration) Energy Systems Integration, and the National Innovation Centre for Data. It provides 2700 m^2 of office space with a further 20,000 m^2 currently being constructed. The Newcastle Laboratory will also provide 7100 m^2 of commercial lab space.

- Campus North Incubator in Newcastle

- The universities of Newcastle, Durham, Northumbria and Sunderland are also important assets: these specifically include the Bioactive Chemistry and Synthesis Group and the Biophysical Sciences Institute at Durham and at Newcastle; the Biopharmaceutical Processing Technology Centre, numerous biomedical research centres (covering areas including: mitochondrial, stem cell, muscular dystrophy, cardiovascular and oncology research) and also the Centre for the Rural Economy.

- 13 Enterprise zones

- East Durham College delivers agricultural courses.

- The area is also served by Newcastle International Airport, the ports of the South Shields and Sunderland as well as significant ports just out of LEP area at Teesport and Berwick-upon-Tweed, as well as the East Coast main rail line.

References

https://en.wikipedia.org/wiki/North_East_England
http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/rel/mro/news-release/census-result-shows-increase-in-population-of-the-north-east/censusnortheastnr0712.html
http://www.nelep.co.uk/wp-content/uploads/2016/05/NELEP-Economic-Analysis.pdf
https://www.gov.uk/government/statistics/agriculture-in-the-english-regions
https://www.firstforpharma.co.uk/sector-companies/

Cumbria LEP

Area covered

The Cumbria LEP includes the whole of Cumbria, the second largest county and one of the most sparsely populated in England with 500,000 people spread over 2,613 square miles. Cumbria has a workforce of 236,000 employed in 21,375 VAT registered businesses and in 2015 had a GVA of 11.2 billion. The economy is characterised by a strong tourist sector, world class engineering, manufacturing and energy companies alongside smaller companies offering high quality food and drink with local provenance.

Overall objectives

Cumbria needs to increase GVA per job, address pockets of unemployment, build on its business strengths, exploit opportunities in low carbon and renewables and develop higher value agricultural products.

The LEP's vision for Cumbria is to maintain one of the fastest growing economies in the UK and to become a high-value, low-carbon economy by focusing future investment on four priority areas identified as being key drivers of local economic growth:

- Advanced manufacturing
- Nuclear and energy excellence
- A vibrant rural and visitor economy
- Strategic connectivity of the M6 corridor

Additional investments in business support, skills development, infrastructure improvements and environmental sustainability will support this work. By 2024 the LEP aims to create 15,000 additional full-time jobs and boost the economy by £600 million.

Important business sectors and importance of the bio-economy within these

The Cumbrian economy is characterised by world class engineering, manufacturing and energy companies concentrated in the west of the county, along with high quality food and drink with local provenance, farming, forestry and a strong tourist sector.

The challenge within the farming sector (sheep and dairy), is to increase profitability and enable investment in essential business infrastructure. A recent venture supporting this sector is a dairy processing facility (880,000 $m^{3)}$ which will significantly reduce the quantity of the area's milk processed outside Cumbria.

The county has several large food producers, including:

- Nestle
- Calder foods
- First Milk's Creamery which is provisioned by 250 local suppliers and employs 95 people.
- Kendal Nutricare which is Britain's only manufacturer of infant formula milk.
- The Pladis biscuit factory which produces many of the UK's best known biscuits.

Many smaller companies produce products such as beer, meat, game, dairy, and fruit preserves.

Cumbria has a woodland area of 58,500 ha or 9% [(1)] of the county and has some of the largest areas of forestry in the UK with good access to the road and rail network [(2)]. Cumbria's woodlands are also of significant importance to the county's visitor economy. Across the county timber processing and manufacturing employ 6,100, forestry related tourism 1700, forestry services 500 and support activities 300 [(2)]. BSW operate a large timber mill just north of Carlisle, producing up to 185,000 m^3 of sawn timber products a year [(3)] and Jenkinson Forest Products near Penrith, is a large provider of wood chip for power generation; bark for gardens and wood flake and saw dust based animal bedding [(4)]. Cumbria Woodlands' Sawmill directory, list a further 38 sawmills and providers of forestry products within Cumbria [(5)], and this is by no means an exhaustive list. Additionally the county is home to several large paper

mills provisioned by locally grown timber, these include Inggesund in Workington, James Cropper in Kendal, Kimberly Clark in Barrow, BillerrudKorsnas at Beetham. Inggesund has also developed a paperboard mill and is operating a £108 million 150 MW biomass CHP plant using 500,000 tonnes of wood per year.
GlaxoSmithKline produces antibiotics at Cumbria's single large pharmaceutical manufacturer, located at Ulverston, and is currently being expanded through a further £350 million investment. This is expected to increase the number of permanent jobs at the site to 500 and allow biologic products to also be produced.

1 http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0010/346366/6b-Annex-1-Draft-Cumbria-and-the-Lake-District-Trees,-Woodlands-and-Forestry-Strategy.pdf
2 http://northwestforestry.org.uk/documents/Greenleaf_Cumbria.pdf
3 http://www.bsw.co.uk/locations/carlisle
4 http://www.awjenkinson.co.uk/about/fp/penrith.php
5 https://www.google.co.uk/?gfe_rd=cr&ei=QIahWO_jOM7W8gfZhLroAw&gws_rd=ssl#q=cumbria+woodlands+sawmill+directory

Tees Valley Unlimited LEP

Area covered

The LEP comprises the local authority areas of: Darlington, Hartlepool, Middlesbrough, Redcar & Cleveland and Stockton-On-Tees covering an area of 304 square miles. It is home to 16,500 businesses, a population of 662,800 (2011) and 303,500 jobs, collectively generating a gross GVA of over £12.3 billon per annum.

Overall objectives

Similarly to other LEPs, Tees Valley aims to create new high value jobs to offset the decline of traditional industries and reduce the costs of public services resulting from under or unemployment. The LEP's vision is to become a high-value, low-carbon economy by focusing future investment on:

- Business Growth
- Research, Development, Innovation & Energy
- Education, Employment & Skills
- Place
- Culture
- Transport & Infrastructure

The LEP aims to create 25,000 additional jobs boosting the economy of the area by £2.8 billion by 2026 and to contribute 10% of the total GVA of the Northern Powerhouse by 2040 using 4 just percent of its population.

Important business sectors and importance of the bio-economy within these

The LEP has identified it has internationally competitive sectors in: chemicals, energy, health innovation, and advanced manufacturing (including biologics), with the second largest integrated chemicals complex in Western Europe and chemicals manufacturing being spread across the 3 main sites of Wilton International, Billingham and Seal Sands. Together these sites run for approximately 12 miles east to west along both sides of the river Tees. Additionally, aerospace, automotive, creative and digital industries and logistics make major contributions to the local economy.

Moving forward, the LEP intends to boost foreign direct investment and encourage growth into the most promising business sectors. These include the internationally competitive sectors of: chemicals, energy, health innovation and advanced manufacturing, together with further diversification into: logistics, digital and creative and industries, culture & leisure, and business & professional services. The bio-economy is integrated within the first four of these sectors.

Chemicals and energy are particularly significant within the bio-economy. In the Tees Valley Unlimited LEP there is a cluster of biofuel plants which evolved out of oil refining and creating energy from waste plants. The LEP also has plans to develop Europe's first industrial carbon capture and storage equipped

industrial zone. Crop Energies (Ensus) operate one of Europe's largest biofuel plants producing 400,000 m^3/year of bioethanol for petrol from wheat. The plant also captures carbon dioxide for use in the food and drinks industry and produces animal feed from waste yeast. Greenergy have the capacity to produce up to 250,000 tonnes/year of biodiesel at its Seal Sands facility. Other notable assets include Sembcorp's 35MW and 44MWbiomass to energy plants. Additionally 2 further 50MW (Gaia Power) and 40MW (Glenmount Partners) biomass to energy plants have been approved with a further plant proposed by MGT Power. Producing the necessary crops for these sites is also underpinned by CF Fertilizers' ammonium nitrogen fertilizer plant in Billingham.

The chemicals industry has also spawned complementary investments in the manufacture of speciality chemicals, pharmaceutical intermediates, pharmaceuticals and biologics. The area is home to world leading biologics manufacturers and sub-clusters of companies in biological reagents, assistive technology and health informatics and pharmaceuticals. Key assets in this area which help bring industry, university research and NHS facilities together to support innovation include:

- The Centre for Process Innovation which helps clients develop, prove, prototype and scale-up products and processes and also includes the £38 million National Biologics Manufacturing Centre which opened in 2015.

- Durham University and their Centre for Integrated Health Care Research which provides a leading academic interface for health care professionals.

- South Tees Institute of Learning, Research and Innovation based at the James Cook University Hospital in Middlesbrough.

- Wilton Centre provides office, laboratory and pilot plant accommodation for 60 businesses including multi-nationals and has over 90 labs covering 7,400 square meters for businesses to use.

Major players in the health area include: Fujifilm Diosynth a world leading contract manufacturer of microbial based biologics and mammalian cell-culture biopharmaceuticals and Hart Biologicals who produce reagents for monitoring blood clotting in patients taking blood thinning medications. The health and biologics sector provides over 5000 jobs in the LEP area.

In summary, the expertise and facilities the Tees Valley Unlimited LEP possesses in chemical and bio-processing, provide strong support to the biofuels, pharmaceuticals and energy from waste clusters and also has huge potential to support the development of chemical feedstock production from agricultural biomass. The nearby Tees port and Tees valley airport also provide the facilities required for both provisioning supplies and exporting the finished products related to these industries.

York, North Yorkshire and East Riding LEP

Area covered

The LEP area is one of the largest in England covering an area of 10,700 sq. km. and with a population of approx. 1.14 million people. Its southern districts include Harrogate, Selby, Craven, and the City of York. Areas to the north include the North Yorkshire districts of Ryedale, Hambleton, Richmondshire and Scarborough. The East Riding extends from north of the Humber estuary to Bridlington. It is home to 177,930 businesses and provides 483,000 jobs.

Within the area of this LEP the bioeconomy sector already generates £8.7 billion GVA and employs 105,000 people.

Overall objectives

The LEP has identified priority objectives and developed a pathway for achieving these with a particular focus on ensuring that skill development keeps pace with business demand and that expertise is shared across sectors so as to continue building on existing globally recognised successes in innovation. Foremost, the vision of the LEP is to make York, North Yorkshire and the East Riding the place to grow small businesses. Achieving this goal will require:

- The development of entrepreneurs

- Building on the region's international reputation in agri-tech, food manufacturing and biorenewables
- The ongoing development of a skilled workforce
- Continued development and promotion of the Humber corridor as a global gateway to the UK
- Increased productivity
- Improved competitiveness
- Enhancement to the transportation and communication infrastructure.

Important business sectors and importance of the bio-economy within these
This LEP region has strength in several business sectors including food and drink, agriculture, agri-tech, and biorenewables.

Locally there are four times more agriculture and food businesses than the English average, along with a significant number of global food brands such as Nestle, Heineken and McCain and far more sector specialist scientists than average.

The bioeconomy is a growing, innovative industry undergoing many exciting technological advances. The LEP recognises that propel ling this industry forward will require a skilled workforce who are up-to-date with the latest research, processes and techniques.
Local Enterprise Partnership (LEP) Chairman Barry Dodd CBE said:

"It makes sense to focus our efforts in the bio-economy. We have had some major wins recently in terms of agriculture and food, such as a £50m Government investment in two Centres of Excellence at Sand Hutton. The University of York is leading a large agri-food project for the N8 consortium of northern universities, and Yorkshire's first Food Enterprise Zone is getting underway in Malton."
Commitment to developing the bioeconomy across the region of the York, North Yorkshire and East Riding LEP is reflected in the launch of a £10m Bioeconomy Growth Fund. At the launch of this fund Chairman Barry Dodd, CBE, commented:

"*The bioeconomy affects everybody but not everyone realises it. This is about looking to the future and creating a long term solution to our global food and energy problems using renewable resources. Our area has the foundations to lead the world in this sector, and we are looking forward to receiving some exciting and highly commercial proposals for this fund.*" The deadline for full applications was February 20th, 2017.

The National Agri-Food Innovation Campus (NAFIC) Sand Hutton is a life sciences campus and home to a lively mix of private and public sector science-based organisations. It is a leading centre for Agri-Food research and is also home to the government's Animal/Plant Health Agency (APHA) as well as FERA Science Ltd. who are leaders in the global challenge of food security and supply chain integrity https://nafic.co.uk/

National Food Innovation Network (FIN) tackles issues which are currently impeding innovation, productivity and growth in UK Agri-Food & Drink businesses http://foodinnovationnetwork.co.uk/

CRODA is a British specialty chemical company that creates high performance ingredients and technologies. http://www.croda.com/en-gb

Yorkshire's first Food Enterprise Zone, Malton: Food Enterprise Zones http://www.hwrcc.org.uk/downloads/fez-press-release-27-march-final.pdf are designed to support existing local businesses as they expand and to encouraging new businesses to start up in the area. For Malton, this means a new agri-food park will be created which will employ over 500 people. The plans also include the relocation of Malton's livestock market to a purpose-built facility.

Innovative Agri Centre is an agricultural and engineering hub at York's Askham Bryan College This £2.4m facility provides a valuable training resource and link with industry. The Centres for Agricultural Innovation are a new collaborative model between the agri-tech sector and government. The centres will help the UK to turn agricultural innovation into commercial opportunities for UK businesses; encourage inward investment and improve farming practice http://www.askham-bryan.ac.uk/news/innovative-agri-

tech-hub-opens

Agrifood Yorkshire - brings together (via an online platform), a number of business networks from the AgriFood sector. It is a secure communication forum providing news and information about events and is a place to express opinions and to network with associates in the AgriFood industry.

The Innovative Farmers Network-is a structure which supports innovation amongst farmers, providing research support and funding on their own terms. The network is part of the Duchy Future Farming Programme, funded by the Prince of Wales's Charitable Foundation. The Soil Association, Organic Research Centre and Waitrose have been partners in the programme and are now joined by LEAF (Linking Environment and Farming) and Innovation in Agriculture, ensuring that the new network represents farmers and growers across the industry https://innovativefarmers.org/

University of York-leading edge science, innovation and knowledge based capabilities including the Green Chemistry Centre of Excellence https://www.york.ac.uk/chemistry/research/green/ Biorenewables Development Centre http://www.biorenewables.org/ Novel Agricultural products https://www.york.ac.uk/biology/centrefornovelagriculturalproducts/ and York Environmental Sustainability Institute https://www.york.ac.uk/yesi/.

Drax biomass carbon capture and storage is Britain's largest generator of renewable energy, supplying 20% of the country's clean power http://www.drax.com

Nestlé http://www.nestle.co.uk/aboutus is a subsidiary of Nestlé SA, a world leading nutrition, health, and wellness company which employs 8,000 people across 20 sites in the UK and Ireland. Nestlé's confectionery headquarters are located in York with another facility located in Northallerton. They are a major exporter of almost £350m worth of products every year to over 70 countries around the world.

McCain Foods Limited https://www.mccain.co.uk/is one of the world's largest manufacturers of frozen French fries and potato specialities. The company arrived in Britain over 45 years ago, building a manufacturing site in Scarborough, where the UK Head Office still remains. In recent years McCain Foods have appointed Soltens to remove and recycle by-products from their production facility in Scarborough

Soltens http://www.soltens.eu/ is Europe's largest procurement company of co-products released in the production and processing of food products. Soltens adds value to liquid, solid and dry streams and was appointed to remove and recycle by-products from McCain's production centre at Scarborough.

Ripon Select Foods Ltd. are food ingredient manufacturers http://www.riponselectfoods.co.uk/ located on an 8 acre site at Ripon situated on the western edge of the Vale of York, encompassing a Flour Mill, Rusk, Breadcrumb, Dry Mixing and Batter Factories as well as an Administrative Block, Laboratories & Warehousing. It has a pilot plant equipped with a Stein MB3 Mini-Batter and Breading Line, an FA3 continuous Fryer and a blast freezer and chillier. This small-scale setup permits very rapid changeovers between different products and allows for recipe modifications to be made on the spot.

Breckenholme Trading Company-cold press oilseed rape for the food industry. https://btcyorkshire.com/ Pride themselves in producing high quality extra virgin rapeseed oil from seed grown within Yorkshire BTC's. They champion low food miles, local produce and chemical free production.

Firmenich creates fragrances and flavours for the world's most desirable brands. The company's scientists design new and safe ingredients using their knowledge of biological processes, coupled with a selection of new leading technologies in biochemistry, receptor and cellular biology, microbiology, plant and animal biology, human physiology and cognitive neuroscience. http://www.firmenich.com/en_INT/company.html

Pro-Pak Foods based in Malton, North Yorkshire http://www.pro-pakfoods.co.uk/ serves the whole of the UK and have among their customers a number of Britain's most demanding retailers and brands. Their range of foods include: chilled and ambient ready meals; British, Chinese, Indian, Italian and Vegetarian cuisines, gluten and dairy free products, vegetable accompaniments, sauces and toddler food. They are

accredited by the Coeliac Association on their 'Kirsty's' range, by the Soil Association and Organic Farmers & Growers on their toddler ambient ready meals as well as with the Red Tractor for (beef products only) as wellas Halal approved foods.

Sarnia Food and Drink Manufacturing: http://www.sarniafoods.co.uk/ is situated in Leeming Bar in North Yorkshire just off the A1, with easy access to major motorways and fast rail links both North and South from Northallerton station. Sarnia offers assistance with product development, technical compliance, production management, and logistics and supply chain services, allowing clients to focus on selling and marketing their food and drink brand.

References

https://www.nomisweb.co.uk/reports/lmp/lep/1925185568/report.aspx#tabidbr
https://www.nomisweb.co.uk/reports/lmp/lep/1925185568/report.aspx#tabjobs
http://www.businessinspiredgrowth.com/news/call-proposals-10m-bioeconomy-growth-fund/
https://www.businessinspiredgrowth.com/wp-content/uploads/2015/06/EUSIF-Strategic-Economic-Plan.pdf
https://nafic.co.uk/
http://foodinnovationnetwork.co.uk/
http://www.croda.com/en-gb
http://www.hwrcc.org.uk/downloads/fez-press-release-27-march-final.pdf
http://www.askham-bryan.ac.uk/news/innovative-agri-tech-hub-opens
https://innovativefarmers.org/
https://www.york.ac.uk/chemistry/research/green/
http://www.biorenewables.org/
https://www.york.ac.uk/biology/centrefornovelagriculturalproducts/
https://www.york.ac.uk/yesi/.
http://www.drax.com
http://www.nestle.co.uk/aboutus
https://www.mccain.co.uk/
http://www.soltens.eu/
http://www.riponselectfoods.co.uk/
https://btcyorkshire.com/
http://www.firmenich.com/en_INT/company.html
http://www.pro-pakfoods.co.uk/
http://www.sarniafoods.co.uk/

Lancashire LEP

Area covered

The LEP covers the whole of the modern boundaries of Lancashire with over 1.46 million people in an area of 1,189 square miles. Lancashire has a workforce of 685,000, over 40,000 businesses and a GVA of £29 billion in 2015.

The key business sectors are Aerospace, Digital and Creative, Advanced Manufacturing (Aerospace and Automotive), Professional and Business Services, Energy and Environment (nuclear, off shore wind & gas, Tourism and Food and Drink.

Overall objectives

The LEP is focusing on job creation (particularly for high value jobs) and economic growth, having identified the county's economy is growing around hotspots such as Preston and Lancaster, but still lags behind the UK average and neighbouring city regions. For instance GVA per resident is below the national average by over 20 percent. The LEP's focus therefore, is on strategic interventions to address this gap through priority projects. These include:

- The Lancashire Enterprise Zone – (one of only 24 nationally) based around the BAE Systems sites at Samlesbury and Warton, which will form a centre of excellence for high technology manufacturing.
- Blackpool Airport Enterprise Zone - target sectors include: energy, advanced manufacturing & engineering, food & drink manufacture & digital/ creative.

- Hillhouse International Enterprise Zone, which is a former ICI chemical production facility at Thornton-Cleveleys. Target sectors include: chemicals, polymer manufacture, energy generation & management, advanced manufacturing & engineering, and low carbon.
- City deal –addressing improved infrastructure in the south Preston area, to support the areas' economic growth.
- Growth deal – Largely infrastructure investments and town centre improvements, but also including a phased investment in a health innovation campus at Lancaster University
- Transport and connectivity - improvements to congestion points which are limiting business growth in several areas.
- General business support.
- Skills development focusing on: advanced manufacturing, energy & environmental technologies, creative & digital, health & social care, finance & professional services and the visitor economy.

Overall the LEP is targeting the creation of 50,000 new jobs and £3 billion of GVA by 2023.

Important business sectors and importance of the bio-economy within these

From the above information it is apparent that the Lancashire LEP does see the bio-economy as important, but the focus is on food and drink as well as a future health innovation campus at Lancaster University. Health and social care was also mentioned in relation to skills development, but the jobs identified in this sector relate mainly to hospitals, public services, care homes and medical practices etc, rather than business providing products to this sector.

Food and drink manufacturing has a workforce of over 13,000 in Lancashire including global brands such as Dr Oetker fozen foods in Leyland and Pepsico in Skelmersdale. Other producers include: A host of breweries the largest of which are Thwaites in Blackburn and Lancaster Brewery; Farmhouse Biscuits in Nelson, Walkers Snack Foods, Skelmersdale; Fiddler's Lancashire Crisps in Ormskirk, Nutrition Group in Blackpool producing dietary supplements, European Freeze Dry in Preston, AM Seafoods and Neve in Fleetwood, and cheese from Delay, Kirkham's, JJ Sandam or Greenfields between Lancaster and Preston.

The farming industry in Lancashire is mostly livestock and dairy farming with 83.8% of the agricultural area being grassland or rough grazing in 2013. However, west Lancashire is a significant producer of field vegetables and protected crops (under glass or plastic) with 94% of its farmland allocated to fruit and vegetable production. Producers include Dawndew Salad Ltd in Poluton-le-Fylde, FlavourFresh Solfresh Group a salad producer in Banks West Lancashire, Len Wright Salads and Byrans Salads and Huntapac one of the largest root vegetable producers in the UK are at Tarleton and also Lovania Nurseries Ltd. In 2013 Lancashire was estimated to have approximately 10,000 people employed in farming. The combined income from farming, forestry and fishing in Lancashire in 2014, was £221 million.

Forestry in Lancashire encompasses over 5200 hectares of managed woodlands with the 1,245 hectares at Gisburn Forest being the largest in Lancashire. There is a large and well-established sawmill business in Carnforth (P Irving & Sons) and Logs Direct based in Lancaster is a large local provider of fuel logs. Black Pearl Capital Partners (BPCP) have also proposed a biomass to energy plant on the former Sappi Paper Mill site in Blackburn.

References

http://www.lancashirelep.co.uk/about-us.aspx
http://www.lancashirelep.co.uk/media/8856/LEP-strategic-economic-plan.pdf
http://www.sqw.co.uk/files/5414/6723/8824/16987_-_TfN_-_NPH_IER_-_Executive_Summary_-_Final_24_June_2016.pdf
http://www.lancashire.gov.uk/media/896995/sector-a-agriculture-forestry-and-fishing.pdf

Leeds City Region LEP

Area covered

The LEP covers the local authority areas of Barnsley, Bradford, Calderdale, Carven, Harrogate, Kirklees, Leeds, Selby, Wakefield and York. This is an area of 2,200 square miles making the LEP the UK's largest city region with a population of 2.95 million (2012), 119,000 businesses (2016) and a GVA of 64.6 billion (2015). Current major employment sectors include: financial & professional services,

manufacturing, tourism, healthcare & life sciences, tourism, food and drink and digital technologies. In common with many other LEPs the area has a combined local authority (West Yorkshire Combined Authority) and will have a mayor from May 2017.

Overall objectives

The vision of the Leeds City LEP is "to be a globally recognised economy where growth delivers high levels of prosperity, jobs and quality of life for everyone'' It aims to create 3,200 new jobs and increase GVA by £1.4 billion by 2020, with the overall goal of extending beyond baseline growth and generating an additional 35,000 jobs and 3.7 billion of GVA by 2036.

In order to achieve these objectives a need for further skills development relating to the delivery of new infrastructure; digital engineering; and manufacturing was recognised and four priority areas were identified.

- The development of a resource smart city
- The delivery of major infrastructure schemes
- The support of growing businesses
- The development of a skilled and flexible workforce

Initiatives within these priority areas include: the development of the city as a global digital centre with specialisms in data storage, analytics, digital health and technology; increased investment and innovation with the goal of making the city a leading centre for low carbon energy; and the encouragement of investment, productivity and business growth.

With low carbon energy at the centre of the future plans of the Leeds City LEP coupled with their alignment with the needs of the northern powerhouse and with high levels of employment in healthcare, life sciences, and food and drink, the importance of the bio-economy is clearly underlined.

Important business sectors and the importance of the bio-economy within these

Leeds City Region has the largest professional services sector in the UK outside London, which is by far Leeds and the LEPs biggest economic sector and includes Head Offices of Banks (Lloyds Bank, Yorkshire, and Skipton Building Society) and legal firms. Also, the City Region is home to 9% of the UK's electricity generating capacity, including Drax power station – England's largest power station fuelled by mixed coal and biomass units and a major potential site for Bioeconomy development. The Drax power station provides the City Region with the opportunity to become one of the foremost UK centres for low carbon energy generation. (Drax has some geographical overlap with the Humber LEP and both York, North Yorkshire and East Riding LEP and Leeds City LEP list Drax as an asset).

Bioeconomy Assets

- The Universities of Leeds and York (The University of York is included in the LEP reports of Leeds City and also the York, North Yorkshire and East Riding LEP) Both universities are members of the Russel Group of Universities, and the N8 University partnership. Leeds University is home to the EPSRC Centre for Doctoral Training in Bioenergy, which is recognised for its world class contributions to the development of low carbon energies and is a strong link between the public and private sectors. The University of York is a major Bioeconomy Research and Innovation Centre, and is home to the Bio renewables Development Centre.

- Drax Power Station – Drax, is the UK's largest power station, responsible for generating 7% of the UK's electricity and an employer of 2300 people. Drax is now a predominantly biomass-fuelled generator with 70% of the electricity produced using compressed wood pellets rather than coal. Drax's innovation and development has been supported by the All Party Parliamentary Group and the Renewable Energy Association. In 2015, Drax contributed more than £1 billion to the UK's GDP and supported some 14,000 jobs across the country as a whole.

- Biovale is a network for the promotion of the Bioeconomy and Development throughout Yorkshire and the Humber, making it a key asset to Leeds City LEP and York, North Yorkshire and East Riding LEP.

'BioVale is an innovation cluster that will broker the development and promotion of Yorkshire and the Humber (Y&H) as an international hub for the emerging, knowledge-based bioeconomy'.

- Bio renewable Development Centre, York is based within the University of York, 'helping businesses to develop ways to convert plants, microbes and bio wastes into profitable bio renewable products. Using cutting-edge science and technology, to bridge the gap between academia and industry and assist companies both in the development and scale up of new greener processes and products'. This network is key to the development of the Bioeconomy throughout the LEP, not only by knowledge sharing, but also by the opportunities of bioeconomic development offered to small and medium sized businesses.

- Brocklesby Ltd – is one of the largest producers of recycled Biofuel feedstock in the UK, with strong partnerships between major industry partners across different sectors throughout the UK and Ireland. 'Brocklesby's expertise lies in recycling edible oils and food fats for a diverse range of end user industry sectors including biofuels', and a service which collects used fats and oils and converts them to Biodiesel, or other usable products.

References

https://www.the-lep.com/LEP/media/New/SEP%20documents/SEP-2016-2036-FINAL.pdf
http://www.the-lep.com/LEP/media/New/SEP%20documents/Economic-Assessment-2016.pdf

Liverpool City Region LEP

Area covered

The LEP covers the whole of the county of Merseyside (boroughs of Knowsley, St Helens, Sefton, Wiral and Halton and Liverpool) In total this is an area of 280 square miles with a population of 1.507 million (2011), 43,500 businesses and a GVA of £29.5 billion (2015), which provides 649,700 jobs. The LEP sees existing strengths, competitive advantage and future potential for growth through smart specialisation in: Advanced Manufacturing, Digital & Creative, Financial & Professional Services, Health & Life Sciences, Low Carbon Energy, Maritime & Logistics, and the Visitor Economy. The area will also receive devolved powers from central government forming a single combined local authority and mayor's office across the same area as the LEP from May 2017.

Overall objectives

The LEP has identified the need to address: the GVA per person being 75% of the UK average; low rates of business density; business creation and business survival; insufficient skilled workers; an over dependence on public sector jobs and the lowest employment rate of the 63 largest cities in the UK. To do this the LEP wishes to build on its core strengths and capacity for innovation to create a globally competitive city region by:

- Developing and attracting more businesses.
- Growing its talent base.
- Enhancing and protecting the distinctive culture of the city region.
- Creating more sustainable employment and higher value jobs.

Overall the LEP aims to create an additional 100,000 jobs, 20,000 businesses and £20 billion of GVA by 2040 and substantially increase the number of exporting businesses and commercialisation of the area's research and development. Innovation based on strong scientific and knowledge assets such as The National Oceanography Centre, Liverpool School of Tropical Medicine, Sci-Tech Daresbury, The Hartree Super Computing Centre, two enterprise zones and Burbo Bank offshore wind farm is seen as being key to enabling future economic growth. For instance the Liverpool city region (LCR) has been identified as being part of the UK's second largest manufacturing region and having one of Europe's largest health and life science clusters. The latter accounts for 20% of the LCR's workforce, £4.1 billion of its GVA and involves 150 companies providing 6-10,000 jobs.

Important business sectors and importance of the bio-economy

The LEP's identification of: Advanced Manufacturing, Digital & Creative, Financial & Professional Services, Health & Life Sciences, Low Carbon Energy, Maritime & Logistics, and the Visitor Economy as

its key sectors for the future places the bio-economy at the centre of its future economic development plans as does the LEP's desire to increase its economic productivity by starting and growing more businesses by promoting innovation and entrepreneurial activity. Health and life sciences is critically important for the Liverpool City Region with over £1 billion of recent investments by the NHS, universities and businesses, along with the neighbouring LEP areas of Cheshire and Greater Manchester the area forms one of three main life science clusters in the UK.

Pharmaceuticals and Biomedical

The LCR has a nationally significant pharmaceuticals manufacturing and health research cluster with vaccine production in particular being seen as an expertise that could be built on to make the LCR a recognised centre of excellence for this. The LEP's strategic vision in this area is "to be home to world leading centre of excellence for precision medicine, infectious disease, children's health and independent living and ehealth, attracting research funding, talent, investment and business to commercialise this excellence" and this builds on increasing global demand for healthcare products. Assets include:

- Sequiris' vaccine plant in Speak which employs 600 people and is the world's second largest flu vaccine producer.

- Astra Zeneca's biologics site in Speake which manufactures a nasal spray flu vaccine and employs 360 people.

- Actavis Biologic's global centre for developing and manufacturing all of Teva Pharmaceuticals (its parent company's) protein based anti-inflammatory drugs.

- Eli Lilly's fermentation and biotechnology production site in Speake which produces animal health products for its Elanco division and employs 600 people.

- Bristol-Myers Squibb's research centre at Moreton, Wirral employing 100 people understanding how medicinal compounds can be turned into medicines capable of commercial manufacture and distribution.

- Evgen Pharma an SME on Liverpool Science Park developing treatments for breast cancer, prostate cancer and stroke which are currently in clinical trials.

- Bell's Healthcare in Southport who produce over the counter generic medicines including: pain killers, cough medicines, antiseptic creams and stomach relief products.

- Baxter Healthcare who manufacture hospital drips and renal and cancer therapies at one of their three UK production sites in Wavertree.

- Biofortuna at Bromborough, Wirral who develop and produce freeze dried molecular diagnostic products for applications such as blood grouping.

- Mast Group in Bootle who manufacture microbiological culture media and antibiotic susceptibility testing kits.

This cluster is also supported by significant NHS and university fundamental and clinical research facilities which provide an excellent source of potential new products for the above companies or new start-up businesses to engage with. These include:

- Alder Hey Hospital which is the national headquarters for clinical research by National Institute for Health Research into conditions affecting children. The hospital undertakes research in to better medicines, paediatric oncology, infection and inflammatory disease and is also home to an innovation hub.

- Liverpool Pancreas Biomedical Research Unit (Royal Liverpool University Hospital) is the only UK NIHR funded specialist unit researching pancreatitis and pancreatic cancer and one of Europe's top three centres for this. The units research focuses on: drug discovery, application of new diagnostic imaging techniques, validation of new biomarkers and clinical trials and it works closely with commercial partners.

- The Clatterbridge Cancer Centre employs 1000 staff and is one of the UK's largest cancer centres, the only provider of proton therapy, pioneering chemotherapy and radiotherapy treatments and medical imaging techniques.

- The Walton Centre in Liverpool is the only specialist hospital trust in the UK providing comprehensive neurology, neurosurgery, spinal and pain management services and employs 1300 staff.

- The Royal Liverpool University Hospital's Clinical Research Unit is the first NHS facility in England to be granted MHRA standard and Phase I Accreditation for early clinical trials.

- The Wolfson Centre (Liverpool University) has the only NHS funded professor of pharmacogenetics, an area that seeks to understand how genetic differences cause individuals to respond differently to drugs, as regards how much of a drug is required and its effectiveness on target cells.

- Liverpool School of Tropical Medicine is a leading international teaching hospital and undertakes research into: neglected tropical diseases, malaria and other vector borne diseases, lung health, TB and understanding the development of drug resistant infections.

- Liverpool Health Partners, North West Coast Genomic Medicine Centre which will sequence 100,000 human genomes to help understand the genetic causes of diseases including cancer and also rare diseases.

- The National Medical Research Council Centre for Drug Safety Science within Liverpool University. This seeks to understand the causes of adverse drug reactions and how they can be prevented.

- Liverpool Institute of Veterinary Science a leading UK centre for teaching which also has a wide range of research in both fundamental and clinical veterinary research.

- Liverpool Bio-Innovation Hub, a new 4100m^2 incubator including office and lab space operated by Liverpool University. This is situated next to the Royal Hospital and supports SMEs working in personalised medicine. The facility also houses the Liverpool Bio-Bank, which collects tissue and blood samples from patient surgical or biopsy procedures as a resource for research groups investigating the molecular mechanisms of a range of diseases and is one of the oldest tissue banks in the UK.

Food and Drink

Given the developed nature of the Liverpool City Region farmland will only be a small proportion of its total area. Therefore farming is not expected to make a significant contribution to the area's GVA, while the contribution from forestry will be even smaller. However, the LCR does possess a strong food processing industry, making use of agricultural products imported through the port of Liverpool or produced in neighbouring LEP areas. Significant assets include:

- Nestle's three production sites for: well- known breakfast cereals (Cheerios, Shreddies, & Shredded Wheat etc) in Bromborough; Vitaflo specialist nutrition products for people with metabolic disorders, or kidney disease in Liverpool; and Purina Petcare producing dog and cat food under the Bakers, Winalot, Felix and GoCat brands in Aintree.

- Cargill's four production sites employ 200 people, these include: a soybean crusher and refinery in Seaforth; a rapeseed crusher and refinery in Bootle; a 650,000 tonne capacity feed ingredient import terminal in Seaforth; and a chocolate and compound production facility. Meal from the two crushing

plants is used in catering, biodiesel and animal feed production, while the crude soya and rapeseed oil is used in food processing.

- Nutricia in Wavertree (owned by Danone) employ 270 people, who develop and manufacture foods for special medical uses such as early life nutrition, or people with specialised metabolic disorders.

- United Biscuits operate the Jacob's bakery in Aintree, employing 800 people and producing over 55,000 tonnes of products including crackers and club biscuits annually.

- Trigon snacks in Aintree employ 110 people and produce Big D and Planters nut and other snacks.

- Allied bakeries have a manufacturing, warehousing and distribution centre in Liverpool, while Antoni's Bakery also in Liverpool employ 40 people and supply 350 shops with bread across the North West, producing products under the KingsMill, SunBlest and Roberts brands.

- The Billington Group consists of a family of food related businesses, with those based in the LCR supplying frozen fruit and vegetables (Billington Food Ingredients), an animal feed (Carrs Billington).

- ADM a global agricultural product processor operate a flour mill in Bootle.

- There are also many other food businesses in the LCR https://www.yell.com/s/food+manufacturers-liverpool.html. However some more obvious names only appear to have head office functions based in the area (John West & Princes Food and Drinks Group) or produce non-food related items in the area (Unilever).

Biofuels

- Olleco operates a plant in Liverpool with the capacity to produce 16,000 m^3 of biodiesel annually from used cooking oil. The company also operate an anaerobic digester using food waste to supply its biodiesel plant with heat and power and are a large national provider and collector of cooking oil for the catering trade and food processors. It is the used cooking oil that is converted to biodiesel, while food waste that is also collected drives their anaerobic digester. Possibly also supporting this business is KTC Edible Oils in Liverpool who are a large producer of cooking oils and Eccelso also in Liverpool producing vegetable suet for the food processing industry using imported palm oil.

- Widnes waste wood biomass plant has a 147,000 tonne per annum and 20.2 MW capacity and is due to commence operation in April 2017. The plant will be run by BWSC with heat from this CHP plant being used in a nearby wood drying facility able to produce 140,000 tonnes of wood chip and wood pellets for biomass boilers per year. A further plant has been proposed by RES and Peel Ports using 1.5 million tonnes of wood per annum in the port of Liverpool, which would presumably benefit from new £100 million biomass terminal that is being built there to supply the biomass facility at Drax in South Yorkshire.

- Fuller Fuel Widnes can produce up to 30 m^3 of biodiesel per day.

- Argent Energy commissioned a 75,000 tonne per annum biodiesel facility at Stanlow 2016 and operates a fuel storage, blending and distribution facility in Ellesmere Port. The latter facility may include the former Ennover facility at Bromborough which is able to produce 57,000 m^3 of biodiesel from waste oils.

Other Assets

- Science and Technology Facilities Council (STFC) Sci-Tech Daresbury with 1200 people on site including 500 scientists is home to a new £5m rapid prototyping facility for use by manufacturing

companies. The site is part of an enterprise zone and has several bio-medically based SMEs as well as office space and laboratories for rent.

- Liverpool Science Park with 120,000 square feet of office accommodation and commercial laboratory space. The latest addition opened in 2014 and provides eleven fully fitted containment level two biology and chemistry laboratories. The Science Park is home to approximately 50 businesses including several biomedical businesses.

- The Heath Business and Technology Park in Runcorn provides office and laboratory space and is home to approximately 170 businesses with several falling into the biomedical, life science and environmental sectors appropriate to the bio-economy

- Liverpool Bio-Innovation Hub as described above.

- The 4100 m^2 National Bio-manufacturing Facility in Speke with 3 GMP suites and category 2 containment able to manufacture biopharmaceutical products from mammalian, microbial and viral sources.

- National Oceanography Centre and its ability to bring together marine scientists, social scientists &economists to meet the challenges of a changing ocean &coastal populations.

- The Universities of Liverpool, Liverpool John Moores and Edge Hill.

- Businesses in the area are also served by the Port of Liverpool and Liverpool Airport.

References

https://www.liverpoollep.org/economic-strategy/intelligence-evidence/
https://www.liverpoollep.org/wp-content/uploads/2016/06/SGS-Final-main-lowres.compressed.pdf
https://www.liverpoollep.org/wp-content/uploads/2015/06/GVA-Briefing-December-2016.pdf
https://www.liverpoollep.org/wp-content/uploads/2015/06/wpid-liverpool-city-region-evidence-report-09-2013.pdf
http://webarchive.nationalarchives.gov.uk/20160105160709/http:/www.ons.gov.uk/ons/rel/mro/news-release/census-result-shows-increase-in-population-of-the-north-west/censusnorthwestnr0712.html

Greater Manchester LEP

Area covered

The LEP covers the whole of Greater Manchester (the local authority areas of Bolton, Bury, Manchester, Oldham, Rochdale, Salford, Stockport, Tameside, Trafford and Wigan). This is an area of 493 square miles with a population of 2.76 million (2015), 91,500 business (Sept 2016), 1.27 million jobs (sept 2016) and a GVA approaching £60 billion (2015). Current major employment sectors include: financial & professional services, manufacturing & engineering, health, retail, education, creative& digital and food & drink. The LEP has also identified that it has competitive advantage capable of exploitation in: financial & professional services, advanced manufacturing (including low carbon technologies), health & life sciences, education, creative & digital, education, sport and culture & heritage. The area has a combined local authority and will receive further devolved powers with the creation of a major's office from May 2017. Greater Manchester (GM) has also been identified as the city region (excluding London) most likely to increase its long-term growth rate.

Overall objectives

Within its Strategic Economic Plan, the GM LEP has identified it needs to address a severe recession since 2008, which has significantly affected its ability to drive economic growth, causing unemployment to increase to approximately 260,000 and the loss of over 1000 businesses. Simultaneously, cuts to government spending and increased demand for welfare and other public services (despite attempts to control spending) have resulted in a £5 billion gap between public spending and local tax local receipts.

The LEP is further challenged by GM's productivity lagging other areas of the UK, due to high unemployment and low skills in several areas and increased levels of ill health in its workforce. To address these issues, the LEP has identified four priorities:

- Creating the conditions for growth – for businesses, this means reshaping the economy to meet new global demands through targeted investment, improved business support including around exporting and provision of enabling infrastructure.

- Public sector reform- to improve efficiency, effectiveness and reduce demand for areas such as welfare, with the aim of GM's tax receipts exceeding public spending costs.

- Reform of worklessness and skills – to tackle social issues leading to: people leaving education with lower skills levels than employers need and unemployment.

- Supporting businesses to improve their competitiveness and exploit the growth potential of low carbon and resource efficiency opportunities.

The LEP's 2020 vision is to "have pioneered a new model for sustainable economic growth based around a more connected, talented and greener city region where all residents are able to contribute to and benefit from sustained prosperity and enjoy a good quality of life".

In achieving the above vision, investment priorities in areas such as: skills levels, infrastructure and housing have been identified. However, the priority most directly affecting business investment is the LEP's wish to exploit and commercialise GM's academic research and development strengths to provide the foundations for long-term economic growth. This will be achieved by building on GM's strengths and potential in: health & life sciences, financial & professional services, creative & digital, education, sport, culture & heritage and advanced manufacturing (including low carbon technologies). GM's Combined Authority Growth and Reform Plan also identifies, "securing GMs and the North West's place as a major centre for life sciences" as one of its 5 priorities, placing the bio-economy at the heart of both organisations future growth plans. Indeed, the LEP has identified health and life science assets support 163,000 jobs and a GVA of £4.7 billion within GM, while the GM Combined Authority has identified that GM and Cheshire account for 23% of the UK's life science employment, which nationally involves4500 companies with a £50 billion turnover. Co-operation with the Cheshire LEP and Cheshire East local authority to further develop a life science cluster at Alderley Park is seen as being key, and the GM Combined Authority has recently allocated £10 million of funding to support this development, which will be matched by the Cheshire and Warrington LEP.

<u>Pharmaceuticals and Biomedical</u>

Despite the GM LEP and Combined Authority describing a large health and life science sector within GM, the reality is that large scale pharmaceutical manufacturing is mostly based nearby, but outside of GM, either at Alderly Park and in Macclesfield (Cheshire and Warrington LEP area), or in the Liverpool City Region. However, GM does possess several smaller pharmaceutical businesses that are still developing their products and have potential to be large employers of the future, provide supporting services to the pharmaceutical sector, or are biomedical instrument and device providers. In a number of cases these are businesses that have spun out of, or have close links to Manchester University and Manchester's hospitals and which with the right support have significant potential to generate many more such businesses. Current businesses include:

- Cellular Therapeutics - an SME based in Manchester University, developing tumour infiltrating white blood cells for cancer treatment.

- C4X Discovery an SME based in central Manchester using computer analysis to determine the 3-dimensional shape of and to appropriately design potential drug to combat: addiction, diabetes, inflammation and cancer. The company work with clients including international pharmaceutical companies such as: Astra Zenaca, Takeda and Evotec.

- Evotec a global drug discovery alliance and development partnership working in neuroscience, diabetes, pain, inflammation, cancer and infectious diseases, which has partnerships with several leading pharmaceuticals companies and took over Euprotec Ltd in 2014. Euprotec were a contract research organisation working in anti-infectives and antimicrobial drug discovery with office and laboratory space in Manchester Science Park, which Evotec still occupy. The company also own Cyprotex, which is based at Alderley Park.

- Carbogen Amcis is an organic chemistry service provider for the pharmaceutical industry. The company's site in east Manchester near Clayton Vale, specialises in process research and custom synthesis of pharmaceutical intermediates in quantities up to 4500 litres and probably employs around 50 people.

- Epistem which provides a DNA analysis device to identify tuberculosis, or antibiotic resistant infections, undertake analysis for disease-associated DNA or RNA biomarkers for the pharmaceutical industry (Pharmacogenomics) and undertake biomedical contract research supporting the pharmaceutical industry from a base in Manchester University.

- F2G based in Eccles which recently raised £60 million and develop anti-fungal drugs for immune-compromised patients following cancer treatment, or organ transplants.

- Oxyrane based in central Manchester is developing enzyme replacement therapies to treat lysosomal storage diseases, but only appears to have its head office in GM.

- Opticin Therapeutics based in Manchester University, develop protein based drugs targeting underserved eye diseases with few or no current treatments.

- PharmaKure an SME based in Manchester Science Park is developing new drug treatments for Alzheimer's disease the first of which it is now starting to commercialise via licensing.

- MicroBiosensor based in the Manchester Incubator is developing a platform technology for improved and continuous infection diagnosis in areas including wound care, kidney dialysis and urinary catheters.

This cluster is also supported by significant NHS fundamental and clinical research facilities within the GM area. For example Central Manchester University Hospitals focus on 6 areas of clinical research in which they are internationally recognised: cardiovascular disease, eye disease, genomic medicine, hearing & deafness, musculoskeletal medicine, and women's & children's health. The hospitals involved include: Trafford Hospitals, Manchester Royal Eye Hospital, Royal Manchester Children's Hospital, Saint Marys Hospital, University Dental Hospital of Manchester and Manchester Royal Infirmary.

Food and Drink

Given the developed nature of the Greater Manchester farmland land will only be a small proportion of its total area and is not expected to make a significant contribution to the area's GVA. The area surrounding the major conurbations within GM is also clearly not forested frequently being open farm or moorland and therefore any contribution for forestry will be much smaller again. However, GM does possess a significant food processing industry making use of agricultural products produced in surrounding LEP areas and elsewhere. Significant assets include:

- Kellogg's which has is European headquarters and the largest cereal factory in Europe in Trafford, employing over 1000 people and producing up to 34,000 tonnes of cornflakes annually.

- Kraft Heinz have their UK and Ireland main manufacturing facility at Kitt Green near Wigan, which is the largest food processing factory in Europe and employs 1200 people.

- Warburton's with their head office, a large bakery, distribution centre and plans to develop a research and development bakery in Bolton, employ several hundred people.

- The Authentic Food Company in Wythenshaw employs 240 people producing frozen ready meals and snacks based on recipes from around the world.

- Duerr's in Wythenshawe produce Jams, marmalades, peanut butter and preserves from a large factory in Wythenshawe employing over 200 people and achieving annual sales of £65 million.

- Creamline Dairies has a large dairy and distribution centre in Trafford Park and additional sites in Red Bank (Central Manchester) and Stockport which use milk from farms across a 30 radius. In addition to supplying dairy products, the business also supplies fruit, vegetables, bread, biscuits, chutneys and pet food, with non-dairy products being bought in from other local companies. The company probably employ several hundred people across the above sites.

- McVitie's Biscuits (Pladis) in Heaton Chapel/ Stockport employs 630.

- Patak's (Associated British Foods) employs 50 in Leigh.

- Firstplay Dietary Foods supply a range of low protein foods across a wide range of foods for people with phenylketonuria from a 5000 sq feet site in Stockport.

- Other food producers include: Hargreaves Quality Foods in Worsley producing cooked meat based pizza toppings for the fast food and wholesale sectors, Willam Jackson Food Group producing prepared salads and salad vegetables in Wigan and the Bury Black Pudding Company, but there many more

https://www.yell.com/ucs/UcsSearchAction.do?keywords=food+manufacturers&location=greater+manchester&find=Y&pageNum=1

Biofuels

Currently there appear to be no biofuel production facilities or biomass power stations in Greater Manchester, with biofuel production being restricted to the Liverpool City Region LEP area along the banks of the Mersey. However Peel Energy plan a 20MW combined heat and power plant at Davyhulme on the outskirts of Manchester, which will use 200,000 tonnes of recycled and virgin wood per annum and is due to be commissioned in mid-2019. Additionally, Manchester University co-ordinates the Supergen Bioenergy Hub, which brings together academic researchers and businesses from across the UK through events and collaborative R&D projects to focus on the key challenges in developing sustainable bioenergy. The university also has over 60 researchers and additional support staff involved in bioenergy and biofuel research.

Other Assets

- Manchester Science Park has 4 main areas:
    - Citylabs 1.0 is a biomedical centre of excellence located on the Central Manchester University Hospitals campus that brings together NHS and academic researchers and provides businesses with access to specialist NHS clinical resources and expertise. The facility includes high specification laboratory, office space and meeting space.

    - Central Campus provides work space for health, life science and digital companies, has enterprise zone status and has approximately 120 resident companies. The facility is close to Manchester University, Central Manchester University Hospitals and Manchester

Metropolitan University and provides laboratory, office and meeting space. A new building (No1 MSP Central) providing dedicated networking and relaxation space is also about to open. The area also houses MedTech, a specialist incubator for digital and health businesses.

- Salford Innovation Park provides office and meeting and networking, but not laboratory space.

- Alderley Park which is in the Cheshire and Warrington LEP area and described there.

- The 9320 m^2 University of Manchester Innovation Centre is a specialist biotechnology R&D centre providing sixteen 93m^2 laboratory suites with containment facilities, as well as office space. The Innovation Centre has 3 sites comprising the Manchester Incubator Building, Core Technology Facility and North Campus Incubator which together have 18 resident businesses.

- The UK Biobank based at Manchester University is a major international health resource aimed at improving the prevention and diagnosis of serious illnesses including cancer, heart disease, stroke, diabetes, arthritis, osteoporosis, eye disorders, depression and dementia. The biobank holds personal data from 500,000 people aged 40-69 and samples of blood, urine and saliva for future analysis as the volunteers health is monitored. The Biobank was established by multiple UK research funders and is open to bona fide researchers across the world.

- The universities of Manchester, Manchester Metropolitan, Salford and Bolton, including the University of Manchester's: Faculty of Biology, Medicine & Health; Manchester Institute of Biotechnology's 47 research groups; the Tyndall Centre and its work on bioenergy and biomass crops; the Manchester Bio-Manufacturing Centre for biocompatible medical products and devices; and Manchester Metropolitan's School of Health Science.

- The Christie Hospital which is the largest single site cancer centre in Europe and serves people across Greater Manchester and Cheshire and together with Manchester University forms part of the Manchester Cancer Research Centre.

- The area is also served by Manchester Airport and 19 NHS trusts.

- The proposed new MediPark Business Centre, will be the largest health life science, pharmaceutical and healthcare R&D centre in Europe, with enterprise zone status and will be part of the £800M Airport City development adjacent to Manchester Airport

References
https://www.nomisweb.co.uk/reports/lmp/lep/1925185547/report.aspx#tabempunemp
http://www.investinmanchester.com/why-manchester/economic-overview/
https://www.liverpoollep.org/wp-content/uploads/2015/06/GVA-Briefing-December-2016.pdf
https://www.greatermanchester-ca.gov.uk/info/20074/growth_and_reform_plan
https://www.greatermanchester-ca.gov.uk/info/20067/greater_manchester_strategy

Humber LEP

Area covered

The LEP area is 90% rural and is home to over 11,000 agriculture, forestry and fishery enterprises. Kingston upon Hull is the only city within the LEP with a population of 300,000 people and a travel-to-work population of 450,000 people. Kingston upon Hull was named UK City of Culture 2017 and this has served to highlight the economic, social, cultural and infrastructural renaissance Hull is experiencing, which is at the forefront of driving growth and prosperity of the region. The Humber LEP has a total population of 918,000 across the East Riding and North and North East Lincolnshire. Other significant

communities within the LEP include Grimsby (A key national site of food production) Scunthorpe, Cleethorpes and Bridlington as well as the market towns of Beverley, Driffield, Brigg, Epworth and Barton.

The Humber LEP has 32,500 businesses, 365,000 jobs a GVA of £17.8 billion and produces 12% of all British exports. The region has over 14,000 businesses working in the bioeconomy. More than 450 chemical companies are based here, accounting for 10% of the UK's chemistry-related activity.

The LEP's Strategic Economic Plan highlights strengths in: manufacturing, chemicals/ petrochemicals, healthcare, food & drink, agriculture (cereals and livestock), logistics, ports, electronics, renewable energy, tourism, digital & creative and work undertaken by the University of Hull for the LEP in 2013 identified: retail, health, education, logistics, and administrative support as the area's major employers.
The Humber is the largest trading Estuary in the UK (by tonnage) and the fourth largest in northern Europe, handling almost 80m tonnes of cargo in 2011 and experiencing strong year-on-year growth. As the UK's most northerly ports complex able to offer overnight services of less than 12 hours to and from continental Europe (Rotterdam), the location of the Humber ports is nationally strategic with regards to exports. The Humber Estuary supports a Petro Chemicals industry worth £6bn annually.

Overall Objectives
The ambition is to maximise the potential offered by the Humber Estuary, and facilitate the Humber's position as a renowned national and international centre for renewable energy.

Important business sectors and importance of the bio-economy
12,500 people are employed within the Food and Drink industry across the LEP region with a GVA of £738 million
Grimsby is recognised worldwide as 'Europe's Food Town' due to the presence of over 500 food related companies in the area, with continually increasing numbers. The seafood industry in North Lincolnshire is of international significance, with a value of £1.8 billion.
Key employers in the food processing sector include AAK UK, Aunt Bessie's, Coldwater, Country Style, Cranswick PLC, Findus, Golden Wonder, Greencore, Lincoln & York Ltd., Pipers Crisps, TSC Foods, Saxon Quality Food Scunthorpe,[7] William Jackson Food Group, Young's Seafood, Morrison's, Hains Daniels Group (Covent Garden Soup Co) and Icelandic Seachill.[8]

North East Lincolnshire Council was successful in securing part of an ongoing funding bid of £3.3m for a proposed Food Manufacturing Cluster programme. The funds will be used to deliver private sector food projects; the latest will see some £26m of private sector leverage and creation of 389 new jobs.
Agri-food companies have had some recent export successes and the British Agri-Food Consortium is based in Hull.[9]

Engineering / Manufacturing
Advanced engineering alone employs 25,000 people in the Humber area, ports and logistics (intrinsically linked to the Estuary), chemicals (the Humber has the second largest chemicals sector in the UK and £3bn of planned investment on the South Humber Gateway alone), and agribusiness/food, which represents excellent opportunities for joint working with our overlapping LEPs to the north and south.
The Humber Estuary secured in March 2014 a £310 million transformational investment in renewables at Green Port Hull and Paull in the East Riding and offers the potential for further transformational investments in renewables, e.g. via the Able Marine Energy Park and Port of Grimsby, which would

[7] https://youngsseafood.co.uk/our-story/

[8] https://www.morrisons-corporate.com/media-centre/corporate-news/morrisons-expands-site-in-grimsby/

[9] https://www.greaterlincolnshirelep.co.uk/assets/documents/Agri-food_sector_plan_final.pdf

provide huge injections into the local economy and transform the Humber's manufacturing and engineering sectors.
Due to a concentration of carbon intensive industries in chemicals and steel in particular, the Humber is currently a significant source of carbon emissions. Continuing to support the sustainable diversification of these two bedrock industries is a key priority for local partners. This will mean supporting the development of new products in chemicals such as bio-ethanol and exploiting huge opportunities in green energy. Rising fuel bills and tough new European rules on emissions (these are also propelling the development of offshore renewables) mean the local steel industry will need to take measures to reduce emissions too (desulphurisation infrastructure, for instance). Promoting resource efficiency is critical to improving the productivity of businesses across the LEP area.

Chemicals:
The Humber petrochemicals/chemicals sector is of European scale and the second largest in the UK, supported by the Humber Ports.
The Humber is now home to one of the UK's four main petrochemical clusters. Two oil refineries, Phillips66 and Total Lindsey, provide 27% of the UK's refinery capacity.

The chemical and health care sectors are very important with BP, Smith & Nephew, Seven Seas, and Reckitt Benckiser all based in Hull.

Companies active locally, include Croda, Air Products, BP Chemicals, Nippon Gohsei, BOC (LINDE), BASF, Phillips66, Cristal, Kemira, Knauf, Novartis, Syngenta, Total and Yule Catto.

University of Hull
The region benefits from strong university support with award-winning Centres of Industrial Collaboration allowing the industry to access university expertise in key areas of technology. Examples include Particles CIC, Institute of Pharmaceutical Innovation, Polymer CIC and Environmental Technologies CIC.
Local private sector led support organisations also work together to encourage growth and increase the competitiveness of the region's chemicals sector.
One emerging area, is bio-derived chemicals. The Humber is highlighted as being well-placed to become the UK's bio-fuel/bio-mass capital (UKTI, 2009). There are relatively few companies in the UK that currently produce biomass-based chemicals, but there are a number that make use of such chemicals in their products, such as Croda, headquartered in the Humber. (Supporting further innovative activity (private sector – university partnerships) to strengthen existing niches and develop new ones)

Vivergo's £350m plant near Hull, is one of Europe's largest bioethanol producers and the UK's largest single source supplier of animal feed employing over 200 people [10]

References
http://www.humberlep.org/wp-content/uploads/2014/11/StrategicEconomicPlan.pdf
_http://www.humberlep.org/wp-content/uploads/2014/11/Capability-of-the-Humber-region-excluding-

Appendices-November-2013-for-web.pdf

http://www.r-e-a.net/pdf/member/13_Biomass_Power_Group_Flyer_November_2016.pdf

https://www.morrisons-corporate.com/media-centre/corporate-news/morrisons-expands-site-in-grimsby/
https://youngsseafood.co.uk/our-story/
https://www.greaterlincolnshirelep.co.uk/assets/documents/Agri-food_sector_plan_final.pdf

Sheffield City Region LEP
Area Covered
Sheffield City Region includes the eight local authority areas of Barnsley, Bassetlaw, Bolsover, Chesterfield, Doncaster, North East Derbyshire, Rotherham and Sheffield. The region is geographically, economically and commercially diverse with a total population of 1.8 million, 700,000 jobs and an

[10] https://vivergofuels.com/about/

economic output of £33.1 billion per annum. Sheffield itself has two Universities, The University of Sheffield, a member of the research intensive Russel Group Universities and Sheffield Hallam University. (Both have strong research outputs/expertise in the Bioeconomy)
The traditional Sheffield/South Yorkshire industries of manufacturing and steel have declined over recent decades. The end of their dominance over the region's economy has facilitated developments in advanced manufacturing, healthcare technologies, low carbon technologies and the creative arts.

Overall Objectives of the LEP's SEP

- Create an additional 70,000 jobs
- Increase GVA by 10% (or £3bn) and create 6,000 additional businesses in 10 years.
- Support growth in Key sectors such as digital technologies, engineering, manufacturing and low carbon.
- Continue to create hundreds of new apprentices and trained staff for the Small and Medium Enterprises (SMEs)
- A single investment fund focused on growth and jobs to prioritise the LEP resources on economically critical projects; and a £280m first phase of investments that could add £5.3bn to the SCR's economic contribution to UKPLC.

Principles for growth:
1. Lead on issues of Sheffield City Region significance;
2. Have a true partnership between the public and private sectors;
3. Adopt a collaborative approach between sectors;

Assets in Sheffield City Region: (Bioeconomy)

The University of Sheffield is a member of the Russel Group Universities, and is in the top 10 per cent of all UK universities, according to the results of the 2014 Research Excellence Framework (REF). The University of Sheffield's quality, breadth and volume of research activity is further demonstrated by the fact that 99% of research at Sheffield was assessed as internationally recognised or better, with 33% recognised as 'World-Leading' and 52% as 'Internationally Excellent.'[11] The University of Sheffield also had the UK's largest Engineering Department and 89% of its research outputs were deemed 'World-Leading' or 'Internationally Excellent' in the 2014 REF[12]. Further, CBMNet, one of thirteen unique collaborative Networks in Industrial Biotechnology and Bioenergy (BBSRC NIBB) designed to boost interaction between the academic research base and industry, promoting the translation of research into benefits for the UK is managed by Academic staff at the University of Sheffield, and funded by The Biotechnology and Biological Sciences Research Council (BBSRC). In 2015, CBMNet had approximately 930 members; 75% Academic and 25% industry, predominantly from the UK but also from across the EU.[13] The University of Sheffield's Advanced Manufacturing Research Centre (see below) is a key point of collaboration between the private and public sectors and has attracted many world-leading manufacturing and engineering companies and enabled the city region to secure major investment in world leading research and development facilities. The Advanced Manufacturing Research and Training Centre (AMRC-TC) situated next to the Advanced Manufacturing Park, opened in 2013, and provides practical and academic skills that manufacturing companies require to compete globally. The (AMRC-TC) provides full progression engineering training. Linked with Sheffield universities, doctorate and MBA specialty programs, apprenticeships and continuing professional development training is provided.

Sheffield Hallam University's research programme was ranked in the top five of all UK modern universities which submitted more than one research area, in the national Research Excellence Framework (REF) 2014. Overall, 65% of the research was deemed world-leading and internationally

[11] http://www.sheffield.ac.uk/about/assessment

[12] http://www.sheffield.ac.uk/research/ref2014

[13] http://cbmnetnibb.group.shef.ac.uk/wp-content/uploads/2016/12/Introductory-presentation-Social-and-Political-Aspects-of-the-Bioeconomy.pdf

excellent, moving the University up 25 places in the national research league tables. Sheffield Hallam University is also home to the Materials and Engineering Research Institute (MERI).

Don Valley Power Project

The National Grid is working with 2Co to develop the Don Valley Power Project. This project seeks to develop Carbon Capture and Storage (CCS) on a new power station at Stainforth near Doncaster, West Yorkshire. This represents one of the most advanced full chain carbon capture and storage projects in Europe and represents up to £5 billion of capital investment into UK infrastructure.

2Co is responsible for the design and construction of the power station and carbon capture facilities. National Grid will be responsible for the design, construction and operation of the transportation and storage assets. National Grid's assets will become the common infrastructure used to support a cluster of CCS plants where emissions from a string of power stations and industrial sites around the Humber estuary could be piped to the offshore storage site.

The Don Valley Power Project was awarded a €180m European Energy Programme for Recovery (EEPR) grant which contributes towards the feasibility and design phase of the development. National Grid is a co-beneficiary of the EEPR grant.[14]

The Advanced Manufacturing Park

The AMP has some of the world's leading materials and manufacturing technologies organisations: the University of Sheffield Advanced Manufacturing Research Centre with Boeing (AMRC), Rolls-Royce, Castings Technology International (CTi), TWI Technology Centre (Yorkshire) and the Nuclear AMRC.[15] The mutual and over-arching aim of all the diverse range of enterprises in the park is to strengthen the region's capability to be competitive. A full list of companies at the AMP can be found here: https://www.attheamp.com/clients

The Advanced Manufacturing Research Centre

The advanced Manufacturing Research Centre is led in partnership between the University of Sheffield and Boeing. The Centre is based in the Advanced Manufacturing Park in Catcliffe, South Yorkshire (within the Sheffield City Region LEP). In a purpose built site. THE AMRC employs a diverse staff 500 people including leading research staff and engineers. The AMRC conducts practical and industry led research in collaboration with its 90-plus partners. These range from long term projects with multi-nationals like Boeing, Rolls-Royce, BAE Systems and Airbus, to more local and small scale projects. The most relevant areas of the AMRC expertise for the Bioeconomy are Healthcare, Energy and Food & Drink.

Dearne Valley:

The Dearne Valley Eco-Vision will be a place where everything is eco and transformation will touch every aspect of life in the area in a dynamic, low carbon and innovative way. The Enterprise Zone sites in the western area of the Dearne (see section 6.3.1), provide incentives to businesses to locate here.

The Dearne Valley Eco-Vision is a joint Barnsley, Rotherham and Doncaster local authority project that is designed to transform the Dearne Valley into one of lowest carbon communities in the UK and across Europe within twenty years. Established in 2008, the Eco Vision is supported by local, regional and national partners including Job Centre Plus, Dearne Valley College, Groundwork Dearne Valley, the Homes and Communities Agency, Natural England and the RSPB.

Number 1 Enterprise Zone

Sheffield City Region is rated the number 1 Enterprise Zone for Modern Manufacturing and Technology in the UK by the Financial Times fDi magazine. It's strength lies in advanced manufacturing and materials, feeding into global markets.

- Modern Manufacturing
- Creative and Digital Industries
- Healthcare Technologies

[14] http://www2.nationalgrid.com/About-us/European-business-development/carbon-capture-and-storage/don-valley/

[15] https://www.attheamp.com/

- Low Carbon and Environmental Goods and Services

Since the launch of our Enterprise Zone, 18 new companies have located on the Enterprise Zone with 480 jobs already created on site and around 400 set to be created in the coming months. The Zone is also home to over 160 students at the University of Sheffield's AMRC Training Centre −providing the skills that manufacturing companies need to compete globally.
Sheffield City Region is home to world-leading manufacturing and engineering companies, including Boeing, Rolls-Royce, Tata Steel, Siemens VAI, Koyo Bearings, Bridon International, Pegler Group and Outokumpu and is also home to the strategic operations of major organisations such as HSBC, B Braun, Aviva, DLA, Polestar, Sandvik, IKEA, Amazon and ASOS.

References
https://sheffieldcityregion.org.uk/about/overview/
http://sheffieldcityregion.org.uk/wp-content/uploads/2013/12/SCR-Growth-Plan-191213.pdf
http://sheffieldcityregion.org.uk/wp-content/uploads/2013/08/Economic-Overview-web-version.pdf
http://www.welcometosheffield.co.uk/content/images/fromassets/100_2002_280313101103.pdf
http://www2.nationalgrid.com/About-us/European-business-development/carbon-capture-and-storage/don-valley/
http://www.sheffield.ac.uk/about/assessment
http://www.sheffield.ac.uk/research/ref2014
http://cbmnetnibb.group.shef.ac.uk/wp-content/uploads/2016/12/Introductory-presentation-Social-and-Political-Aspects-of-the-Bioeconomy.pdf

Cheshire and Warrington LEP
Area Covered
The LEP covers the local authority areas of West Cheshire, East Cheshire and Warrington, but excludes Halton. In total this is an area of 871 square miles, with a population of 902,000 (2011), a GVA of over £27.6 billion which provides 430,000 jobs. Existing strengths are in: Engineering, Energy, Chemicals, Life Sciences & Pharmaceuticals, and Financial & Professional Services. Growth potential in food, agri-tech and biological engineering has also been identified.

Overall LEP Objectives
The LEP has identified Cheshire as having the strongest economy in the North of England, with a strong enterprise culture, a highly skilled workforce and a fifth of the jobs being export orientated (the third highest on any LEP area in England). The economy is seen as preforming well against national benchmarks. This is a success on which the LEP wishes to build significantly, by creating an additional 75,000 jobs and £15 billion of GVA by 2030 and 127,000 jobs and £30 billion of GVA by 2040. Three major projects have been prioritised:

- Atlantic Gateway in Cheshire – a trade, business and innovation corridor stretching from Deeside and Merseyside through the northern Cheshire and Warrington to Manchester.

- Cheshire Science Corridor – a string of interconnected scientific centre of excellence with potential to contribute significantly to national science innovation, which has recently been awarded Enterprise Zone status.

- Crewe High Growth City, placing the city at the heart of HS2

Underpinning these projects are 6 enabling programmes grouped into 2 themes:

- Creating the Conditions for Sustainable Growth - through transport, housing and infrastructure improvements.

- Accelerating Smart Growth - by supporting business growth, innovation and skills development for employment.

Important business sectors and importance of the bio-economy

The LEP has identified strengths in high vale engineering, energy, chemicals, life sciences & pharmaceuticals, and financial & professional services, with growth potential in food, agri-tech and biological engineering, which places the bio-economy at the centre of its future economic development plans. The LEP is also working with the Greater Manchester and Liverpool City Region LEPs to look at practical steps to increase commercialisation and the economic contribution of its science and innovation assets.

Significant assets in the Cheshire science corridor include: Capenhurst Technology Park, Thornton Science Park as a centre for advanced energy systems, Birchwood's nuclear and forensics clusters, and Alderlery Park's specialist life science laboratories within what was Astra Zeneca's 3000 employee, 300,000 sqm^2 R&D facility. Alderley Park is now being developed as a specialist 86,000 sq ft life innovation hub, additionally incorporating Astra Zeneca's reduced (700 employee) presence. The first 20 million of a £40 million Growth Deal funding for life sciences has also been made available to local businesses and to support the future development of Alderley Park, in partnership with the Greater Manchester LEP.

Pharmaceuticals and Biomedical

Current Alderley Park residents include: Astra Zeneca's lead discovery centre for oncology and early pharmaceutical development (700 people), Redx Pharma (formed in 2010), but growing rapidly, the lab chemical and equipment providers: Fisher Scientific and Sigma Aldrich and 147 small businesses mostly operating in pharmaceutical development, supporting this or offering biomedical services.

Astra Zeneca also employ a further 1800 people in Macclesfield at their second largest pharmaceutical manufacturing and packing site. This produces over different 50 medicines for worldwide distribution. In recent years around £120 million has been invested in a new advanced manufacturing facility and a further £60 million to improve packing and warehousing.

Sanofi a French multinational pharmaceuticals company produces inhalation and nasal spray products in Homes Chapel at a site employing 320 people which the company is seeking to expand significantly.

Cyprotex (taken over by Evotec AG in late 2016), undertake contract research for 1500 international customers in the pharmaceuticals, cosmetics, personal care, chemical and agrochemical markets from two sites in Macclesfield and Alderley Park. The work is about understanding how specific chemicals will behave in the human body, but using vitro or in silico methods.

Advanced Medical Solutions produce wound-care products and have their head office and R&D function at Winsford.

Claris Lifesciences produce sterile injectable in the anaesthesia, blood products and anti-infective markets in Crewe.

Other notable companies although small, include: Medtrade producing wound-care products in Crewe, Peckforton Pharmaceuticals (now part of Abbey Pharma) in Crewe, Sinclair Pharma supplying dermatology products from Chester and Lupin Pharmaceuticals who resell pharmaceutical products from Knutsford.

The most notable businesses at Capenhurst and Thornton Science Park respectively, that impact the bio-economy are: C-Tech Innovation a process and engineering consultancy business that have supported some clients to develop food processing technologies and Byotrol who develop and supply antimicrobial surface cleaners. Some other large pharmaceuticals businesses within the science corridor and identified by the LEP actually fall within the neighbouring Liverpool City Region and Greater Manchester LEP areas. Overall the LEP identified the Life Science and pharmaceuticals sector employs 6,500 people across it area.

Agriculture Food and Drink

Cheshire is well known for dairy farming, initially for cheese then milk. However, the amount of agricultural land had declined to163,000 hectars by 2007 with approximately 716 dairy farms many of which were struggling with declining incomes. In 2006 dairy and beef cattle accounted for 23% of the North West heard. In East Cheshire alone the food and drink sector employees 6,500 staff with a GVA of 128 million.

Within Cheshire the agricultural sector is also supported by the presence of two large chemical companies:

- CF Fertilizers at Ince, who operate 3 nitric acid plants and an ammonia plant with a staff of 400 to produce 1 million tonnes of ammonium nitrate and NPKS fertilizers annually.

- UPL Europe production facility near Sandbatch, part of United Phosphorus a leading global producer of crop protection products including fumigants, insecticides and herbicides.

- A notable newcomer is Redag Crop protection based in Alderley Park, with a novel screening system for new agrochemicals

There are also many food processing businesses in Cheshire, larger ones and certainly not an exhaustive list include:

- Morning Foods in Crewe, who produce £135 million of milled oat products for direct consumption, use in cakes and cosmetics annually, which are exported to over 60 countries.

- Meadow Foods in Chester where their head office and a large dairy are located. The dairy produces butter, butter oil and milk concentrates on an 11 acre site with a staff of 30.

- New Prime Bake (Bakkavor Group) in Nantwich emploing 340 people producing chilled bread products, filled baguettes and craft breads.

- Joseph Heler Cheese in Nantwich produce cheese under four brands using milk from their own and up to 100 local farms.

- Wrights Pies in Crewe, operate a £20 million bakery and a chain of shops with 450 staff producing up to 5 million pies, pasties and related products per week.

Other assets include:

- Reaseheath College in Nantwich, which recently completed a £7.3 million investment in a food processing facility, comprising a small commercial dairy and butchery for trial work.

- The North West Food Research and Development Centre at the University of Chester, comprising development kitchens, a sensory analysis unit, labs and incubator space to support product development and testing by food producers.

<u>Biofuels</u>

Argent Energy owned by John Swire & Sons is one of the UK's foremost suppliers of biodiesel mainly for fleet operators across the UK. They produce up to 75,000 tonnes annually (planned to rise to 150,000 tonnes) from waste fats and oils at £75 million facility at Stanlow employing 60 people. They also have a fuel storage, blending and distribution facility at Ellesmere Port within the Liverpool LEP area.

Olleco now operate the former Convert2Green biodiesel production facility at Middlewich. This uses waste cooking oil to produce up to 20,000 m^3 per annum and employs 60 people.

Peel Energy are building a £100 million 21.5MW biomass to energy plant at Ince. The plant will use a 170,000 tonnes of waste and virgin wood per annum and employ 27 people.

The Delamere (972 hectares), Macclesfield Forests (400 hectare) are the largest wooded area within the LEPs boundaries.

References
http://www.871candwep.co.uk/strategic-priorities/science-corridor/
http://www.bionow.co.uk/abouttheregion/nwbiomedicine/pharmaceuticals.aspx
The Northern Powerhouse Independent Economic Review. Workstream 2: City Region & Local Area Profiles – Final Report May 2016
http://www.biofuelwatch.org.uk/uk-campaign/companies/
http://www.871candwep.co.uk/content/uploads/2015/05/Strategic-and-Economic-Plan-and-Growth-Plan-for-Cheshire-and-Warrington.pdf
http://www.letsrecycle.com/news/latest-news/work-begins-on-100m-cheshire-waste-wood-biomass-project/
https://en.wikipedia.org/wiki/List_of_forests_in_the_United_Kingdom

The Strategic Economic Plans of the 11 Local Enterprise Partnerships represented in the 'Bioeconomy in the North of England SIA' were reviewed, the importance of the Bio-economy was summarised, and key bio-economy assets were identified.

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