Scotland’s National Plan for Industrial Biotechnology to 2025
Contents

- Introduction to IB and Bio-refining
- Progress of National Plan for IB
- Growth Opportunities
- IBioIC
- Resource Mapping Project
- Conclusions
National Plan for Industrial Biotechnology

“Our mission is to grow industrial biotechnology related turnover in Scotland to £900m by 2025”
National Plan Progress

- **£900 million sector by 2025**
  2015 target of £200m was exceeded

- **Industrial engagement**
  50 IB companies identified +14%

- **Network of Innovation Centres**
  IBiolC
  Synthetic Biology task group

- **Bio-refineries**
  Roadmap published
  Proposition document in planning

- **Skills**
  CSS Skills Development plan
  Specific IB courses available at HND, MSc and PhD level

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Graph showing:
- **Gap**
- **Where we currently are**
IB in Scotland
2014 - £230million

Technology providing companies make up the remaining 3%
IB in Scotland
2025 - £900 million

Feedstocks
- Grown Crops
- Marine
- Renewable Electricity

Waste/ Co-products
- Agriculture incl. forestry
- Industrial incl. distilleries & gases
- Municipal

Processes
- Extraction
  - Technology: Ligno-cellulose Enzymes
- Pyrolysis
- Fermentation
  - Technology: Syn Bio Bio-process Eng Enzymes
- Chemical
  - Anaerobic digestion

Sector
- Fuel/Electricity
  - £0.5/kg
  - Products: Biodiesel Electricity Ethanol Biogas
  - 17%
- Food/Feed
  - £0.3 - £10,000/kg
  - Products: Animal feed Fish feed Human Protein Fermentable sugar Vanillin
  - 4%
- Commodity Chemicals
  - £1 - £5/kg
  - Products: N-Butanol Propanone Ethanol Monomers (acrylates etc) Others
  - 4%
- Speciality Chemicals
  - £2.5 - 1000/kg
  - Products: Omega 3 oils Hyaluronic Acid Alginites Nanocellulose Additives Lignin derivatives
  - 24%
- Pharma & Clinical
  - £20/kg
  - Products: Opiates Clavulanic acid Amoxycillin Polysaccharides Phycocyanines Others
  - 39%
Technology
Grow Aggressively

Opportunities

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>TRL</th>
<th>Years to market</th>
<th>Opportunity Size (£M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syn Bio through strong academic capabilities and company growth</td>
<td>3-8</td>
<td>0-3</td>
<td>20-50</td>
</tr>
<tr>
<td>Biotechnology in Oil and Gas</td>
<td>1-3</td>
<td>7-10</td>
<td>50-100</td>
</tr>
<tr>
<td>Bio-process engineering and new processing technologies</td>
<td>3-7</td>
<td>3-10</td>
<td>20-50</td>
</tr>
<tr>
<td>Diagnostics, analytical and consumable supply and services</td>
<td>3-9</td>
<td>0-5</td>
<td>20-50</td>
</tr>
<tr>
<td>Biotechnology and renewable energy (bio-batteries)</td>
<td>1-6</td>
<td>5-10</td>
<td>20-50</td>
</tr>
</tbody>
</table>

Characteristics and Key Strengths

- High value, low capital
- Many niche opportunities
- Geographically neutral & easy to acquire
- Strengths in academia, oil and gas, renewable energy, some unique process technologies
- Relatively fast to market

Development Support Required

- More of project support through academia
- Closer integration with Oil & Gas the Technical Centre
- Identifying and supporting potential spin-outs
- Synthetic biology centre(s) of excellence
- Attracting inward investment through skills availability
- Develop plan for bio-battery opportunities

£ Millions

2014 | 2020 | 2025
--- | --- | ---
0.0 | 20.0 | 120.0
20.0 | 40.0 | 80.0
60.0 | 100.0 | 120.0

Strains | Process Eng. | Equipment | Clinical
Pharmaceutical/Clinical
Grow Aggressively

Characteristics and Key Strengths
- High value; huge headroom for growth
- High value; huge headroom for growth
- Many niche applications
- Small volume, high quality (GMP) manufacture
- Strengths in mammalian syn bio, academia, Algae, GSK.

Key Development Support
- Taskforce to spot and develop opportunities
- Clinical/user ‘pull’ rather than technical ‘push’
- Linkage to relevant ICs (SMS-IC; Censis; DHI)
- Linkage to red IB sector. MedTech, esp. those needing IB
- Specialist skills provision
- Inward investment strategy/support facilities

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<tbody>
<tr>
<td>Production of novel therapeutics using SynBio</td>
<td>2-3</td>
<td>5-7</td>
<td>20-50</td>
</tr>
<tr>
<td>Specialised enzymes or whole cell coupled enzyme systems or novel products, including post-transitional modifications</td>
<td>2-3</td>
<td>3-4</td>
<td>20-50</td>
</tr>
<tr>
<td>Capatilise on Mammalian SynBio, Regenerative Medicine, Stratified Medicine Centres</td>
<td>1-3</td>
<td>5-10</td>
<td>50-100</td>
</tr>
<tr>
<td>Gene Therapy tools</td>
<td>2-3</td>
<td>3-5</td>
<td>20-50</td>
</tr>
<tr>
<td>Novel biotherapeutics based on microbiome</td>
<td>2-3</td>
<td>3-5</td>
<td>5-20</td>
</tr>
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Speciality Chemicals
Grow Aggressively

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<tr>
<td>Aginates</td>
<td>5-8</td>
<td>3-5</td>
<td>50-100</td>
</tr>
<tr>
<td>Lignin derived chemicals</td>
<td>2-4</td>
<td>7-10</td>
<td>50-100</td>
</tr>
<tr>
<td>Nanocelluloses</td>
<td>5-8</td>
<td>3-5</td>
<td>20-50</td>
</tr>
<tr>
<td>Enzymes</td>
<td>3-8</td>
<td>3-5</td>
<td>20-50</td>
</tr>
<tr>
<td>Micro Algae - for fine chemicals</td>
<td>1-8</td>
<td>10-15</td>
<td>50-100</td>
</tr>
<tr>
<td>Niche feedstocks</td>
<td>2-5</td>
<td>5-7</td>
<td>20-50</td>
</tr>
<tr>
<td>Chitosan and derivatives</td>
<td>3-5</td>
<td>5-10</td>
<td>20-50</td>
</tr>
</tbody>
</table>

Characteristics and Key Strengths
- Medium volume & medium/high value
- Cost and skills dependent
- Many niche opportunities
- Strengths in niche feedstocks, existing chemical sector and assets.

Key Development Support
- Medium volume & medium/high value
- Cost and skills dependent
- Many niche opportunities
- Strengths in niche feedstocks, existing chemical sector and assets.
Commodity Chemicals
Grow selectively

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</thead>
<tbody>
<tr>
<td>Waste to chemicals</td>
<td>1-5</td>
<td>5-7</td>
<td>20-50</td>
</tr>
<tr>
<td>Carbon Capture and Utilisation (10 tonnes pa)</td>
<td>2-3</td>
<td>5-7</td>
<td>20-50</td>
</tr>
<tr>
<td>Biosynthesis Gas as a feedstock</td>
<td>3-7</td>
<td>3-4</td>
<td>5-20</td>
</tr>
<tr>
<td>Conversion of low cost 2G sugar</td>
<td>2-3</td>
<td>5-7</td>
<td>5-20</td>
</tr>
</tbody>
</table>

Characteristics and Key Strengths
- High volume/low value chemicals
- Cost base hugely important
- Feedstock price is critical
- Requires low cost assets/economies of scale
- Strengths in CO2 availability, hydrogen from renewable electricity and manufacturing sites,

Key Development Support
- Investigate opportunities for inward investment
- Collate and publicise available feedstocks
- Demonstration scale facility through Celtic Renewables
- Collaboration with Scottish Hydrogen & Fuel Cell Association; Offshore Renewables Catapult; Vanguard Initiative and other EU consortia
Food/Feed
Grow selectively

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<tbody>
<tr>
<td>Source of fermentable sugars</td>
<td>5-8</td>
<td>3-5</td>
<td>50-100</td>
</tr>
<tr>
<td>Micro Algae - for fine chemicals and fuel</td>
<td>1-3</td>
<td>10-15</td>
<td>50-100</td>
</tr>
<tr>
<td>Spent grains from brewing and distilling (as a feedstock/fuel)</td>
<td>6-8</td>
<td>3-5</td>
<td>5-20</td>
</tr>
<tr>
<td>Food waste : root veg, domestic, commercial - as a feedstock</td>
<td>5-8</td>
<td>3-5</td>
<td>20-50</td>
</tr>
<tr>
<td>Macro Algae - for food &amp; extractives</td>
<td>2-8</td>
<td>7-10</td>
<td>20-50</td>
</tr>
<tr>
<td>Fish waste (as a feedstock)</td>
<td>6-8</td>
<td>3-5</td>
<td>5-20</td>
</tr>
<tr>
<td>Insect protein from waste</td>
<td>1-3</td>
<td>7-10</td>
<td>5-20</td>
</tr>
</tbody>
</table>

Characteristics and Key Strengths
- Low – high value for small volume extractives
- Emerging technologies for waste to feed
- Strengths in feedstocks (fish waste, spent grains, food waste) and demand for animal and fish feeds

Key Development Support
- Wood based demonstration bio-refinery
- Marine bioprocessing centre
- Support for companies beyond academia
- Investigate opportunity for insect protein as a feed

![Graph showing estimated opportunity size from 2014 to 2025](image-url)
## Fuels/Electricity

### Maintain

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>TRL</th>
<th>Years to market</th>
<th>Opportunity Size (£M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth in existing technologies</td>
<td>9</td>
<td>0-5</td>
<td>20-50</td>
</tr>
<tr>
<td>Bio-ethanol from 2G fermentable sugars</td>
<td>5-9</td>
<td>5-7</td>
<td>20-50</td>
</tr>
<tr>
<td>Bio-jets fuels</td>
<td>3-5</td>
<td>5-7</td>
<td>20-50</td>
</tr>
<tr>
<td>Co-products conversion where no higher value can be found</td>
<td>3-7</td>
<td>3-4</td>
<td>5-20</td>
</tr>
</tbody>
</table>

### Characteristics and Key Strengths
- Low value product
- Largely established technologies
- Easy way to valorise waste streams

### Key Development Support
- Investigate opportunities for bio-jet fuels
- Open access and demonstration facilities for key feedstocks e.g. algae and wood
In summary

- IB is high growth, high potential sector in Scotland
- The IB National Plan is making excellent progress but still has much to achieve
- Due to feedstock constraints growth must concentrate on higher value opportunities
- A much more integrated and collaborative innovation landscape is required to deliver this plan
- Key focus areas will include: inward investment, support for scale-up, specific opportunities to investigate in CO$_2$ utilization, oil & gas, enzymes and bio-batteries.
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Growth of a new industry

Deliver industry-led Collaborative Innovation in IB

- Support and enable businesses to increase competitiveness
- Create economic impact through increased revenues and jobs
- Focus on transformational innovation opportunities
- Develop into open organisations that seek new industry partners
Key Activities

**Industry Engagement**
- Industry Membership
- Community building
- Global IB Community Engagement

**Projects**
- Collaborative Funding Calls
- Industry Challenges
- Open Access Equipment Centres
- Technical Network

**Skills**
- Collaborative PhDs
- MSc Industrial Biotechnology
- HND Industrial Biotechnology
Key Activities

**Industry Engagement**
- Industry Membership – 97
- Community building – 12 events/year, social media, website
- Global IB Community Engagement – 30+ conferences/year

**Projects**
- Collaborative Funding Calls – 3/year, 33 industrially led projects funded, >£10m invested
- Industry Challenges – 6 further projects funded
- Open Access Equipment Centres – 2 Centres + Biopilots UK
- Technical Network – 20+ experts recruited

**Skills**
- Collaborative PhDs – 44 awarded across 4 cohorts
- MSc Industrial Biotechnology – 66 students graduated
  Industrial Biotechnology - HND in 3 FE colleges
IBioIC Vision

IBioIC will accelerate and de-risk the development of IB in Scotland to create £900m in industry by 2025

Creating the environment

Developing opportunities:
• Identifying Scotland’s unique and globally competitive resources and supporting their commercial exploitation.
• Horizon scanning for new opportunities and emerging technologies that meet Scotland’s company and academic strengths
• Bringing industry, policy makers and academia together to create a uniquely supportive environment

Training a skilled workforce:
• Delivering formal opportunities and bespoke training and education to employees and potential employees driven by industrial need.

Providing the tools

De-risking scale up
• Accessing suitable facilities for process development
• Supporting the construction of bespoke demonstration plants to accelerate commercialization
• Developing new facilities that support Scotland’s unique capabilities and resources

Innovating from invention
• Creating opportunities for innovative solutions to develop
• Providing technical solutions using Scottish academic resources, expertise and facilities
• Signposting and facilitating to available support

Current Activities

Extended mission
Organisational model

Activities

Glasgow

Core Activities:
• Core team
• Membership
• Events/networks
• Skills funding
• Project funding

Oban

Marine Biotech Centre
• Harvesting
• Farming
• Storage
• Extracting
• Processing
• Business incubation

Grangemouth

Demonstration Centre
• Logistical support
• Modelling
• Finance support
• Business incubation
• CO₂/renewable power development centre

MMIC/IBioIC Centre
• Strain development
• Process Development
• Scale up
• Small scale production
• Formulation
• Business incubation

TBA

MMIC operational by 2019
IBioIC Centre operational by 2020

Glasgow

Existing

New

Demo Centre operational by 2018, development Centre operational by 2020

Operational by 2019

Operational by 2019

Operational by 2019
### Organisational model

#### Costs & Funding

<table>
<thead>
<tr>
<th>Activity</th>
<th>Cost</th>
<th>Funder</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Core team</strong></td>
<td>1.7/yr</td>
<td>SFC 80% Ind 20%</td>
</tr>
<tr>
<td><strong>Networking</strong></td>
<td>0.5/yr</td>
<td>SE/HIE 40% Ind 60%</td>
</tr>
<tr>
<td><strong>Skills</strong></td>
<td>1.5/yr</td>
<td>SFC 60% BBSRC 40%</td>
</tr>
<tr>
<td><strong>Projects</strong></td>
<td>6.6/yr</td>
<td>SFC 30% SE 10% Ind 60%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity</th>
<th>Cost</th>
<th>Funder</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-dev</strong></td>
<td>0.3</td>
<td>HIE 100%</td>
</tr>
<tr>
<td><strong>Capital</strong></td>
<td>5.0</td>
<td>HIE/BEIS 80% Ind 20%</td>
</tr>
<tr>
<td><strong>Yr 1-3 Ops</strong></td>
<td>1.5/yr</td>
<td>HIE/BEIS 40% Ind 60%</td>
</tr>
<tr>
<td><strong>Yr 4+ Ops</strong></td>
<td>2.0+/yr</td>
<td>Ind 100%</td>
</tr>
</tbody>
</table>

**Glasgow**

**MMIC/IBioIC Centre**

**Oban**

**Marine Biotech Centre**

Operational by 2019

**Grangemouth**

**Demonstration Centre**

MMIC operational by 2019

IBioIC Centre operational by 2020

**TBA**

**Demo Centre**

Operational by 2018, development Centre operational by 2020
Fit to current UK policy

Pillars of UK Industrial Strategy

- Investing in science, research and innovation
- Developing Skills
- Upgrading infrastructure.
- Supporting businesses to start and grow
- Improving procurement
- Encouraging trade and inward investment
- Delivering affordable energy and clean growth
- Cultivating world-leading sectors
- Driving growth across the whole country
- Creating the right institutions to bring together sectors and places

Industrial Strategy Challenge Fund

Specific challenges

- Bioscience and biotechnology;
- Leading edge healthcare and medicine;
- Manufacturing processes and materials of the future;
- New energy technologies including battery storage and grid technologies;
- Robotics and artificial intelligence (including driverless cars and drones);
- Satellites and space technologies; and
- Transformative digital technologies including supercomputing, advanced modelling, and 5G.
- Quantum technologies;

Additional themes

- Integrated and Sustainable Cities
- Technologies for the Creative Industries
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Resource Mapping model project aims

- Identify key data sources on the arisings of materials streams valuable to the biorefining industry;
- assess the quality of these data sources and critically review them;
- map the material arisings that can be quantified regionally across Scotland; and
- using the known fate of these arisings, to estimate the quantity of available arisings for industry; and
- generate indicative figures of available bioresource arisings regionally across Scotland

- Resources by volume, composition, location and value
Model Approach

Materials Arising × Bioresource Content = Bio-resource Arising

Model Outputs

By-products by source and LA area

Protein Heat Map
Next Steps

• Fully assess all the information available in the current model and act on recommendations
• Agree model hosting and enquiry management
• Further model development:
  • Collation and addition of further waste/byproduct data sets
  • Addition of further bioresource types
  • Development of a more user friendly tool
  • Development of forecasting capabilities
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Conclusions

Developing an emerging sector requires:

• An agreed and ambitious vision and strategy
  • Owned by the industry and facilitated & funded through a specialised team

• A connected community composed of
  • Companies – big and small
  • Academics – focussed on translation/innovation
  • Effective multi-agency government supporters
  • Willing investors

• Brutal and continuous analysis of strengths and weaknesses

• Support throughout the innovation journey

• Tolerance of failure – fail early

• Confidence and perseverance
Conclusions

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