Non-Food Opportunities Underpinning Development of an Irish Bio Based Economy

Biofuels, Bio Chemicals, Bio Materials and Bio Energy

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Biomass Growth Potential

Large Agri Food Industry

Efficient Waste Systems

Efficient Distribution Systems

Forum for Industrial/Academic Collaboration to Develop the Bio Economy

Bridge gaps to develop economically viable routes to produce and market bio-products and bio-energy
1. EU Policy Overview
2. Supply Chain Dynamics
3. Irish Market Opportunities
4. Factors Impacting Market Dynamics
   a. Market Availability
   b. Supply Chain Issues
   c. Policy & Regulatory Matters
   d. Funding
“Sustainability” is a cross-cutting theme across EU policies.

**Economic Sustainability** - investment, employment, tax base, balance of trade

- **Resource Efficiency** - reduce demand on finite supplies of raw materials:
  - Security of supply (energy, industrial & agricultural raw materials)
  - Price Stability
- **Maintain & Promote Indigenous Production:**
  - Improve industrial competitiveness, revenue diversification & profitability
  - Displace imports & promote new markets for indigenous industry
  - Recover indigenous manufacturing base

**Import Displacement Offers a Large Indigenous Market Opportunity**

- Energy - Fossil Fuel imports € 6,500 M
- Organic Chemical Imports € 3,500 M
- Paper Imports € 375 M
- Bulk Plastic Imports € 200 M
- Fertiliser Imports € 150 M

Export Opportunities Arise in Parallel
Environmental Sustainability – maintain the planet for future generations

- Mitigate Drivers of Climate Change
- Improve Human/Animal Health and Wellbeing – address air/water/soil quality
- Habitat maintenance to maintain biodiversity
- Compliance with Binding Obligations
  - Renewable energy obligations increasing to c. 27% by 2030
  - GHG emissions reduction obligations increasing to 40% over baseline by 2030
  - ETS obligations becoming onerous for qualifying Agri-food companies
  - Water Quality
  - Waste Management
  - avoiding Non Compliance Penalties

Geo-Social Sustainability - market mechanisms replace taxation re wealth redistribution

- Urban/Rural Divide – wealth creation supports maintenance of rural middle class/social infrastructure
EU is investing €€ Billions in Transition –

- **BIC Consortium Programme** –
  - Demonstration scale Bio-economy Projects - €3.7 Bn

- **Horizon 2020**
  - 35% of Societal Challenges & Industrial Leadership Programmes directed at Sustainable development €28 Bn

- **ERDF** – 25% of Regional Funds Directed Toward Sustainable Development
  - *InterReg initiatives*
  - *LIFE Environmental Programme*
  - *Financing initiatives such as JESSICA Programmes*

Ireland Can Leverage EU Resources to Expedite Efficient Transition
Tangible Examples - Bio Economic Development in EU

- German AD Industry - 6,000 digesters over 10-12 yr period
- Pomacle Bazancourt Biorefinery – Reims, FR
- Futero Bioplastics – Galactic (BE) & Total (FR)
- Chemrec BioDME Demo Plant - SWE
- Novozymes Plant - DEN
- Abengoa - ESP

- Research Institutes / Programmes
  - Fraunhoffer - DE
  - VTT - FIN
  - VITO - BE
  - State of the Art Pilot Plants
    - DSM – Delft (NED)
    - BBE (BE)
    - CPI Centres (UK)

Ireland Can Leverage EU Experience to Expedite Efficient Transition
Biorefining - Processing compositionally complex biomass into a variety of products improves economic viability

• Biomass is chemically complex (high oxygen) requiring fractionation & technical process development

• Economics optimised by co-extracting multiple products via staged processing of different fractions

Think in terms of Processing “Systems”
Cascade Concept
Optimise Value by Extracting Highest Value Components First
Match Feedstock Cost to Product Value
Ireland’s Bio Based Economy

Market Dynamics

1. EU Policy Overview
2. Supply Chain Dynamics
   a. Wastes & Residues
   b. Primary Agricultural / Forestry / Marine Outputs
3. Irish Market Opportunities
4. Factors Impacting Market Dynamics
## Under Utilised Organic Wastes
### Market Opportunity

<table>
<thead>
<tr>
<th>Agri-Food / MSW Residuals</th>
<th>DMT (M$^3$)</th>
<th>Under-utilised Agri-Food / MSW Residues</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Livestock / Dairy/Poultry</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Manures/Litters</td>
<td>2,000 k</td>
<td>Manures/Litters land spread - underutilised</td>
</tr>
<tr>
<td>• Meat &amp; Bonemeal</td>
<td>100 k</td>
<td>MBM exported</td>
</tr>
<tr>
<td>• Paunch Contents</td>
<td>20 k</td>
<td>Paunch contents unutilised</td>
</tr>
<tr>
<td>• Dairy Whey &amp; WWT Fats</td>
<td></td>
<td>Delactosed whey supplied as low value animal feed – milk production to increase on lifting of quota</td>
</tr>
<tr>
<td><strong>Tillage Chain</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Straws/Stovers/Husks</td>
<td>1,000 k</td>
<td>Straw/stover used as compost &amp; animal bedding – RES applications starting to come to market. Spent grains supplied as animal feed – reasonable alternative value</td>
</tr>
<tr>
<td>• Spent Grains</td>
<td>150 k</td>
<td></td>
</tr>
<tr>
<td><strong>Forestry Pulp &amp; Paper</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Recovered paper</td>
<td>500 k</td>
<td>Mixed paper exported at low value</td>
</tr>
<tr>
<td>• Forestry product residues</td>
<td>1,000 k</td>
<td>Pulpwood/sawdust/chippings used in renewable energy. bark used in landscaping, branches unharvested</td>
</tr>
<tr>
<td><strong>Horticultural</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Spent Mushr’m Compost</td>
<td>300 k</td>
<td>Landspread or disposal</td>
</tr>
<tr>
<td>• Apple Pomace</td>
<td>5 k</td>
<td>Low value animal feed</td>
</tr>
</tbody>
</table>
## Underutilised MSW Feedstocks
### Market Opportunity

<table>
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<tr>
<th>Agri-Food / MSW Residuals</th>
<th>DMT (M³)</th>
<th>Under-utilised Agri-Food /MSW Residues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landfill Gas – Bio methane</td>
<td>80 M M³</td>
<td>Landfill gas – flared if not recovered for CHP</td>
</tr>
<tr>
<td>Source separated food waste</td>
<td>40 k</td>
<td>AD or Composted – collection can increase</td>
</tr>
<tr>
<td>Organic MSW - RDF</td>
<td>430 k</td>
<td>OFMSW to be separated/stabilised before landfill, RDF exported</td>
</tr>
<tr>
<td>Aerobic WWT COD</td>
<td>75 k</td>
<td>Production to increase by 25% - milk quota removal - WWT constraint due to EPA discharge limits</td>
</tr>
<tr>
<td>Aerobic WWT Sludges</td>
<td>100 k</td>
<td>ABP requires heat treatment prior to land spread</td>
</tr>
</tbody>
</table>

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Organic Wastes = Market Opportunity
### Agri/Forest/Marine Feedstocks

**Excellent Biomass Potential**

<table>
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<tr>
<th>Biocrop</th>
<th>Estimated DMT /M³</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass/Silage</td>
<td>20,000 k</td>
<td>10 mo growing season &amp; rainfall generates highest biomass growth rates (plant matter per hectare) of any country in Europe. -4.4m Hctrs of avail land, very high biomass growth but variable in character, good alternative value in grass based livestock system</td>
</tr>
<tr>
<td>Tillage - Cereals</td>
<td>2,000 k</td>
<td>-378K Hct in tillage – costly to produce, homogenous character facilitates easier processing, value as drinks/food ingredient is high. Movement to resurrect sugar beet production</td>
</tr>
<tr>
<td>Oilseed Sugar Beet</td>
<td>-0-</td>
<td></td>
</tr>
<tr>
<td>Forestry Harvest</td>
<td>3,700 k</td>
<td>Set to grow to c. 7,000K over next 10-12 years on back of private forest growth. Primary roundwood use is construction materials. Near term demand may exceed supply - peat co-firing/ RES obligation</td>
</tr>
<tr>
<td>Energy Crops</td>
<td>40 k</td>
<td>Strong SRC energy crop potential – Market Economics favour grassland as feed, Establishment grants available but need market outlet</td>
</tr>
<tr>
<td>Macro Algae</td>
<td>40 k</td>
<td>Long shoreline offers aquaculture opportunity - Cottage industry, manual harvesting &amp; environmental issues drive cost concerns</td>
</tr>
<tr>
<td>Micro Algae</td>
<td>-0-</td>
<td>Potential for indigenous production but subject to capital investment and availability of external heat – cost considerations</td>
</tr>
</tbody>
</table>

**Grass/Tillage/ Afforestation /Energy Crops offer Routes to Diversify Agricultural Revenues – Target High Value Outputs**
Irish Supply Chain is Substantial but Fragmented

- Large number of small feedstock supplies
- Variable Character
- Difficult to transport

Challenge - Develop systems that do not require extraordinary scale to extract optimal value
Ireland’s Bio Based Economy Market Dynamics

1. EU Policy Overview

2. Supply Chain Dynamics

3. Irish Market Opportunities
   a. Bio Refining – Sugar Beet
   b. Bio Refining – Dairy Residues
   c. Bio Refining – Lignocellullosic Paper and Pulp
   d. Bio Refining – Mixed Organic Residues
   e. Bio Energy Market Opportunities

4. Factors Impacting Market Dynamics
Ireland’s Bio Based Economy

Market Opportunities

US Dept of Energy Developed Report to Prioritise Top Value Added Chemicals

• Platform chemicals with prospects to develop range of end products
• Lactic acid, succinic acid, levullinic acid......
Sugar Beet Offers Substantial Exploitable Supply Chain

- Sugar Beet industry may revive after lifting of sugar quota
- Sucrose content of beet is readily fermentable to range of bio chemicals
  - 1 MT Beet = c 150 kg table sugar @ €450/MT = € 67.50
  - 1 MT Beet = c 110 kg lactic acid derivatives @ €1,200/MT = € 132.00
  - R&D required to optimise added value from pulp ........ c. 20% of dry matter
  - Foliage refining comprises 15% of dry matter - offers large feedstock supply
Existing Exploitable Supply Chain

- Dairy Residues will Increase Pursuant to Elimination of Dairy Quota
  - De-lactosed whey residues offer useful source of glucose/galactose sugars
  - R&D to Optimise Fermentation of Acidic Whey to Lactic or Succinic Acid
  - 25% lactose content = 180kg lactic acid/ DMT = €200/DMT
  - Additional value from bioactive extracts – requires R&D
Wood/Straw/Energy Crops Lignocellulosic Plant Structure Comprised Of

- **Cellulose Fibrils**
  - *Primarily Strings of C₆ Sugars*
- **Hemi Cellulose & Pectins**
  - *Polysaccharide C₅ & C₆ sugars*
- **Lignin**
  - *Complex Polymer Providing Rigidity & Protection*

Complex Structure Must be Broken Down Allowing Access to Useful Fractions
Lignocellulosic Biorefining Systems

Substantial Exploitable Supply Chain
- 500k MT Paper Waste – Currently exported @ < €100/MT – already pulped, needs de inking
- Exported @ €55-75 / MT, 35% mass conversion to levullinic acid @ > €1,000/MT = €350/MT
- Process optimisation needs R&D – not high risk R&D
- Post market development can add processing of straw/energy crops/forestry residues – requires complex pre treatments
Organic Waste Biorefining Systems

Municipal/Industrial Wastewaters

Low Temp Hi Rate Anaerobic Digester

Pre-treatment Degradation

Enzyme Technologies Expedite Hydrolysis

Recalcitrant Structures

Adapted Microbiology

Uses adapted AD to convert heterogeneous feedstocks to homogenous energy carrier - designed for a fragmented supply chain

- Process design to fit in decentralised locations – platform chemicals
- Short chain VFA are suitable fermentation media or working on methods to readily elongate & saturate molecules as basis for biofuel
- Requires ongoing R&D

Organic Fertilisers

Amines

Range of Bio Fuels or Plastics

Solid Organic Wastes

Straw/Stover

Greenwaste

Farmyard Manures

Source Separated Food Waste

Biogas

Separation & Recovery Technologies
Proven Technologies De-risks Deployment in Ireland

Variety of Proven Anaerobic Digestion Technologies

- Farm Digester
- High rate WWT
- Landfill Gas
- MSW Dry Digester

Biogas Upgrade Units

Transport via Gas Grid Injection

Dispensing via High-Speed Commercial Units

CNG can fuel both short haul and long haul trips

Variety of technologies are proven & commercially available

Natural Gas Production

Or Compressed Gas Cylinders

Or Low Speed Residential Units

Wide Range Of NGV’s
GREEENGAS Micro Grids in Localised Off Grid Markets

• Allows producer to deliver energy supply to point of demand – overcomes “High Efficiency” constraint
• Competes with higher priced imported oil
• Averages demand over a number of users
• Allows producer to sell at “retail” – less subvention
• Development of distribution network can be modular
• Network rollout can be EU supported
• Gaseous energy is useful in a range of applications
• GREEENGAS is storable & despatchable
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   a. Market Availability
   b. Policy & Regulatory Matters
   c. R&D Programmes / Facilities
   d. Access to Funding / Finance
Development of the Bio Economy
Role of the State

Successful Domestic Deployment Requires Holistic Approach - Integration of Variety of Factors

- Routes to Market
- Supply Chain & Feedstocks
- Technology Development
- EU Framework
- National & Local Gov’t Regulation
- Access to Capital

Role of the State is to Assist with Development of Viable Supportive Commercial Frameworks
**Bio Economy**

**Market Development**

Assistance with Development of Viable Long Term Market Outlets Needs to be Integrated with Development of the Supply Chain for Bio Chemicals & Materials

- Specification Standardisation
- Sustainability Criteria Developed for Chemicals / Materials
- Biochemical or Biomaterial Utilisation Obligations
- Public procurement criteria
- Promotional taxation structures

Integration of Supportive Regulatory Policies & Frameworks –

- Supportive Bio Energy Policy
  - Continuation of Supportive REFIT tariffs for high efficiency CHP
  - Extend adapted Renewable Heat Incentive for ETS sector
  - Continuing aforestation policy & energy crop grant schemes

- Upcoming grid access framework for biogas injection
  - low cost injection & distribution for bio energy technologies

- Attractive Excise Tax Rate Enshrined for Use of Gaseous Fuels

- Climate Action & Low Carbon Development Bill
  - Preparation of a Low Carbon National Mitigation Plan
  - Expert Advisory Council on Climate Change
• Adaptation of R&D Programmes to De Risk Technology Deployment & Improve Access to EU Programmes
  - Ireland boasts excellent R&D skills, laboratory facilities and access programmes –
  - Gap in existing R&D programmes -
    - Oriented toward bench scale R&D, or
    - Commercialisation programmes are linear – need to develop “systems”
  - State will benefit from facility offering scale up, process engineering, systems integration & output validation supporting commercialisation – see exhibits

• Access to Risk Capital –
  - Programmes offering promotional financing for early deployment of sustainable technologies will overcome market deficits
    - BIC & H2020 Programmes for Demonstration of New Technologies
    - LIFE Programme & Transport Efficient Europe Programme
    - ERDF Programmes for Low Carbon Applications

Combination of Supportive Policies, Skilled R&D, Technology Development & De-Risking together with Access to Risk Financing is Very Powerful
1. Exploiting large non-food opportunity will contribute to sustainable economic development

2. Ask Foresight Working Group to incorporate development of the non-food opportunity in the plan

3. Requirements include not only technology development, but holistic programme for market development
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