Circular Biogas-Based Economy in a Rural Agricultural Setting

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Farming in Northern Ireland

• Agriculture dominates the land area in Northern Ireland with almost 60% covered by grassland employ over 47,700 people employed (9.9% of the overall workforce).
• It represents about £354 million of gross value added (GVA), 4.2% of the overall value of the NI economy.
• There are 2,694 dairy farms in Northern Ireland, 11% of all farm types, with over 317,000 dairy cows.
• Milk and milk products have a turnover of £974 million.
• The main milk products in Northern Ireland are cheese and powdered milk.
GHG Emissions in Northern Ireland

- Northern Ireland accounts for 4% of total UK greenhouse gas (GHG) emissions and 8.1% of total UK methane emissions.
- Two closely linked sectors, agriculture and transport, are the largest contributors of GHG, accounting for 28% and 21% respectively (2014).
- The Renewable Energy Directive requires that all EU member states fulfil at least 20% of their energy needs with renewables by 2020, with at least 10% of transport fuels coming from renewable sources i.e. biomethane.
- Biogas could be key to meeting this target – electricity generation and vehicle fuel.
Aim and Objectives

The aim of this study is to investigate the application of a circular economy in a rural agricultural setting.

Objectives

- Determine the electrical and fuel energy requirements of the average sized dairy farm in Northern Ireland for milk production.
- Determine the electrical energy requirements of a typical milk processing plant.
- Determine the diesel fuel energy required for the collection and transport of milk by a local haulage firm.
- Determine the biomethane and electricity production potential of an typical AD plant, and show how this plant can fulfil the renewable energy needs of the agricultural community.
- Show how the average farm in Northern Ireland can, in turn, fuel the AD plant.
Anaerobic Digestion

- AD is a growing industry in Northern Ireland.
- 500,000 tons of food waste generated annually in NI: enough biomethane to displace 10% of diesel.
- Typical feedstocks: pig and cattle, slurry, poultry litter, energy crops and food waste.

<table>
<thead>
<tr>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD Plants (operating/planned)</td>
<td>42/86</td>
</tr>
<tr>
<td>Total installed capacity</td>
<td>23.99</td>
</tr>
<tr>
<td>Feedstock demand</td>
<td>479,950</td>
</tr>
<tr>
<td>Biogas production capacity</td>
<td>31.74</td>
</tr>
<tr>
<td>Potential biogas capacity</td>
<td>133 – 585</td>
</tr>
<tr>
<td>Potential electric capacity</td>
<td>458 - 2020</td>
</tr>
<tr>
<td>Potential heat energy capacity</td>
<td>655 - 2885</td>
</tr>
</tbody>
</table>
40 AD Projects in NI
£100m investment
At least £50m spent locally
£10m/yr of feedstock
£5m/yr in operational services
80 to 100 jobs created
### AgriAD / Bridge Energy AD Plant

<table>
<thead>
<tr>
<th>Project SPV</th>
<th>Bridge Energy Ltd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Type</td>
<td>500kW on-farm AD</td>
</tr>
<tr>
<td>Primary Energy</td>
<td>Electrical generation</td>
</tr>
<tr>
<td>Promoter</td>
<td>agriAD Power Ltd</td>
</tr>
<tr>
<td>Location</td>
<td>Banbridge, Co. Down, Northern Ireland</td>
</tr>
<tr>
<td>Feedstock</td>
<td>Grass silage, slurry, poultry litter</td>
</tr>
<tr>
<td>Technology</td>
<td>Williams Industrial Services</td>
</tr>
<tr>
<td>Investment</td>
<td>£3.5m</td>
</tr>
<tr>
<td>Lead Funder</td>
<td>UK Green Investment Bank</td>
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<tr>
<td>Project Status</td>
<td>Operational in commissioning phase.</td>
</tr>
<tr>
<td>Phase 2</td>
<td>Biogas upgrading to RNG; 2,000,000m³</td>
</tr>
</tbody>
</table>
Biomethane for Transport

- Biomethane offers a lower carbon footprint if sustainably derived from organic materials.
- Biomethane from animal slurry offers 84% GHG savings compared to diesel.
- Biomethane from grass silage offers 75% GHG savings.
- 1 hectare of grassland can produce 2400m³ of biomethane: equivalent to 4,500L of diesel.
- 80% diesel displacement would require 8.75% total grassland in Northern Ireland.
- In order to make natural gas transport fuels feasible in Northern Ireland, biomethane infrastructure is required.

Credit: GAS NETWORKS IRELAND
Circular Economy

- Digestate used as fertiliser
- Biomethane for rural public transport
- Biogas for on farm heat
- Milk
- Biomethane for transport of milk
- AD Plant
- Biogas
- Energy Crops
- Biomethane for farm vehicles
- Electricity for milk processing and packaging
- Food processing waste
- Electricity
- Milk
- Biomethane for transport of dairy products
Typical Dairy Farm and AD

**Average Dairy farm statistics:**

<table>
<thead>
<tr>
<th>Dairy Farm Average</th>
<th>All Farm Averages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Dairy Farms</td>
<td>Average Grass Silage Feedstock (t/farm/year)</td>
</tr>
<tr>
<td>Cows in Milk per farm</td>
<td>34.6</td>
</tr>
<tr>
<td>Milk Yield (litres/farm/day)</td>
<td>1482</td>
</tr>
<tr>
<td>Cattle Slurry Feedstock (t/farm/year)</td>
<td></td>
</tr>
<tr>
<td>2694</td>
<td>108.9</td>
</tr>
<tr>
<td>2363</td>
<td>950</td>
</tr>
</tbody>
</table>

**AgriAD AD Plant characteristics:**

- The AgriAD plant requires 7,500 tons of grass silage feedstock per year, which could be supplied by 5 average sized dairy farms in Northern Ireland.
- Wasted whey used as an AD feedstock is calculated to have potential to produce 1,220 MJ/farm/day.
A Dual-Fuel Road Trial in Northern Ireland

**Section 1**
- Increasing payload (empty to maximum GVW)
  - B & C roads.

**Section 2**
- Maximum payload
  - A roads

**Section 3**
- Empty (no payload)
  - A roads

**Milk Tanker with a Dual-Fuel Tractor unit**
- Volvo, Euro V DF truck
- ~37.8 tonnes of milk transported (16 dairy farms)
- ~365 km per route

**Results**
- Saving up to £40 per day per truck (27% savings)
- Fuel Energy Required – 182.8 MJ/farm/day
Energy requirements

- From dual-fuel vehicle trial:
  - Milk tanker fuel requirement = 182.8 MJ/farm/day
- Dairy farm electricity: 0.3 MJ/kg milk produced
  - Dairy farm electricity requirement = 708.8 MJ/farm/day
- Dairy farm transport fuel: 0.1223 MJ/kg milk produced
  - Dairy farm electricity requirement = 288.9 MJ/farm/day
  - Dairy processing electricity requirement = 680.4 MJ/farm/day
- Total electricity requirement = 1389.2 MJ/farm/day = 3626 MJ/farm/day of biogas
- Total transport fuel = 471.7 MJ/farm/day = 530 MJ/farm/day of biomethane

- One AD plant has the potential to fuel 22 average sized dairy farms per day in Northern Ireland, providing electricity and replacing diesel fuel, for production of 51,986 litres milk per day.
Dairy Farming & Milk Processing

AD plant
- Biogas produced 102,429 MJ/day
- Parasitic demand 10% = 10,243 MJ/day
- Chicken litter 8.5 t/day
- Cattle slurry 13.7 t/day
- Grass silage 20.5 t/day

Biogas available 92,186 MJ/day

Poultry farm
- Poultry
- Chicken litter

Whey
- Powdered milk + cheese

Milk processing facility
- Milk 2363 l/farm/day
- Milk tanker 182.8 MJ/farm/day
- Electricity requirements 708.8 MJ/farm/day
- Diesel for on-farm transport 288.9 MJ/farm/day

Dairy farm

Transport fuel
- 530.0 MJ/farm/day
- 89% conversion efficiency

Energy
- 3626.1 MJ/farm/day
- 42.1% electrical efficiency, 91% CHP availability

Heat
Conclusions

- Anaerobic digestion has the potential to reduce Northern Ireland’s dependence on imported fuels, as well as to help fulfill the requirements of providing increased energy needs through renewables.
- This paper shows how an actual AD plant can fuel the electricity and diesel fuel energy needs for an average sized dairy farm in Northern Ireland, and associated milk processing facilities.
- The average dairy farm in Northern Ireland produces around 2,363 litres of milk per day, requiring a total of 1860.9 MJ/farm/day in electricity and transport fuel energy.
- The total biogas required to fulfil the fuel and electricity needs is 4,156.1 MJ/farm/day.
- The AgriAD plant analysed in this study has the potential to fuel 22 average sized dairy farms in Northern Ireland, equating to the production, transport and processing of 51,986 litres of milk per day.
- In order to fulfil the feedstock requirements of the AgriAD plant, it was calculated that five dairy farms per year could provide the grass silage, and five dairy farms per year could provide the cattle slurry.
- Waste whey from milk processing could provide 1,220 MJ/farm/day in energy if used as an AD feedstock.
Thanks for your attention