CDT Conference
Low Grade Biomass: Challenges and Opportunities

Grass to Gas: Roadside Verge Biomass
CDT Mini-Project

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Outline

- Background
- Biomethane potential (BMP)
- Ensiling
- Harvesting Costs
- Business Model
- Confirming a Market
- Wider Use of Verge Grass
- Conclusions
Biomass Feedstocks from Public Spaces

Credit: Lincolnshire Wildlife Trust

Credit: Leeds1

Credit: Flickr

Credit: 4-designer

Credit: Lincolnshire Wildlife Trust
Biomass Feedstocks from Public Spaces

Potential benefits of collecting grass

• Generation of renewable energy from anaerobic digestion.
• Potential source of income for local authorities?
• Mitigation of methane (powerful greenhouse gas) emissions from decomposing grass clippings.
• Improved biodiversity of plants and animals (including pollinators).
Case Study: Lincolnshire County Council

- LCC already cuts their verges but leaves the grass in situ to decompose
- Could LCC reduce road maintenance costs by selling verge grass?
- Pilot harvest was carried out and data used to model potential costs
- Grass samples collected from various sites across Lincolnshire

Does the verge grass produce competitive levels of biomethane?
Theoretical Biomethane Potential (BMPth)
Experimental BMP (BMPex) Conditions Based Upon Scrivelsby Farm

- Low temperature thermal hydrolysis
- 51°C for 24 hours
- 53°C for a further 24 hours
- Laboratory-scale digestion
- Feedstock and inoculum concentrations of 10g VS/L (1:1 VS ratio)
- 45°C
- 15 days
Experimental BMP (BMPex) Raw Grass

- **BMPex:**
  - S2/H1.1 = 222 ml CH$_4$/g VS
  - Maize = 202 ml CH$_4$/g VS

- **Biodegradability:**
  - S2/H1.1 = 45%
  - Maize = 43%

Addition of verge grass into Scrivelsby Farm AD Plant produced so much biogas it set off the safety flare!
• Currently harvesting of roadside grass occurs in summer

• **Ensiling** could be used as a method to preserve the grass for year-round supply

• Ensiling has been used for years in agriculture to preserve forage for winter animal feed

Credit: Latia Resource Center
Ensiling

• Could the ensiling process alter the biomethane potential?

• Increase in readily available fermentation products
Ensiling can accumulate fermentation products increasing levels of lactic acid

Presence of fermentation products may lead to increased rate of biomethane generation

Preparation of ensiled grass for analysis is challenging to prevent volatile losses

Future work: derive the BMPex of ensiled Lincolnshire roadside grass.
Can verge grass be used in practice?

To be a viable feedstock verge grass must

• Be free of contaminants: heavy metals/potentially toxic elements and PAH (polycyclic aromatic hydrocarbons). These can inhibit digestion and contaminate digestate. This was investigated by Luke and Nando who found contamination levels to be acceptable.
• Produce adequate levels of biomethane.
• Be available in adequate amounts.
• Be economic to process.
• Have AD plants in place able and willing to process it.
Case Study: Lincolnshire County Council

University of Leeds research

Lincolnshire already has **28 Anaerobic digestion plants** which could use grass as a feedstock.

Mapping exercise identified that there are **6,900 km** of rural roads within 15km of one of these AD plants, and grass available for each AD plant was calculated.

Potentially **50,000 tonnes** of grass per annum from the verges within 15km of an AD plant.
Supply and Demand

Map of 28 AD plants in Lincolnshire
10km harvesting areas shown
15km harvesting areas would cover most of the county
Good spread of existing plants means that transport distances are short.
Grass is a bulky, low energy density feedstock, but there are no cultivation costs.

Harvesting and transport costs are vital in determining feasibility and were calculated by modelling:
- Cutting and travelling distances and times,
- Speed and fuel consumption figures from the LCC pilot machinery,
- Grass yield,
- Assumptions of plant hire costs and staff costs,
- Different widths of cut (or swath),
- Different sizes of harvest areas around a central processing plant.
Harvesting Costs

Cost of harvesting verge grass per tonne using single vehicle

Cost of harvesting £/tonne

Radius of Harvest area km

- swath 1.1m
- swath 2m
- swath 3m
Harvesting Costs

Cost of harvesting verge grass per tonne using single vehicle

Radius providing 25% capacity for Scrivelsby (500 kW)

Radius providing 25% capacity for a 1200 kW plant

Cost of harvesting £/tonne

Radius of Harvest area km

- swath 1.1m
- swath 2m
- swath 3m
Power Generation from AD

Anaerobic Digestion of Verge Grass to Generate Power

- Grass harvested and delivered for AD
- Animal manures
- Energy crops
- Digestate used as fertiliser for crops

Hydrolysis tank → Main AD tank

Heat and power used in AD

Biogas: methane and CO₂

Gas upgrading and compression

- Heat for local buildings or processes
- Power for local use or export to grid
- Gas to network
- Gas for transport use

Gas to network

Heat for local buildings or processes
Business Model

Potential Income from digesting grass
• Electricity can be sold or used on site.
• Heat can be used locally to generate income or save on heating bills.
• If heat and power are used by the generator then significant savings can be made on power bills.
• Feed in tariff (FIT) earned on all power generated.
• Renewable Heat Incentive payable on acceptable uses of heat (RHI).

The incentives earned depend on the commissioning date of the AD plant and its output e.g.
   500 kW plant commissioned in June 2014 gets FIT of 12.14p/kWh and RHI of 6.21p/kWh
   500 kW Plant commissioned in June 2017 gets FIT of 5.90p/kWh and RHI of 2.51p/kWh.

Each plant has its own running and feedstock costs.
We modelled the income for a selection of farms and found it profitable.

Simple check
What is case study farm paying for grass to digest? **£14 per tonne in 2016**

Compared with calculated verge grass harvesting costs of **£5 to £10 per tonne** for this farm.
**Business Model Summary**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of rural roads in Lincolnshire within £15km of an AD plant</td>
<td>6900 km</td>
</tr>
<tr>
<td>Mass of grass available from these roads</td>
<td>50,000 tonnes</td>
</tr>
<tr>
<td>Grass could power</td>
<td>900 Homes (3,000MWh)</td>
</tr>
<tr>
<td>Grass could heat equivalent of</td>
<td>350 Homes (3,900MWh)</td>
</tr>
<tr>
<td>Cost of harvesting from an area of radius 15km</td>
<td>£6 to £11 per tonne</td>
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<tr>
<td>Cost of harvesting from an area of radius 10km</td>
<td>£5 to £10 per tonne</td>
</tr>
<tr>
<td>Price paid by plants for similar grass</td>
<td>£14 per tonne</td>
</tr>
<tr>
<td>Potential income per tonne</td>
<td>£15 2014 plant   £10.00 2017 plant</td>
</tr>
<tr>
<td>Potential income per tonne – electricity and RHI 2017 plant</td>
<td>£22 2014 plant   £12.82 2017 plant</td>
</tr>
<tr>
<td>Energy Return on Energy Invested (EROI) for grass</td>
<td>4.2 – 7.2</td>
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Is There A Market For Verge-Grass?

Interviews were held with 6 AD operators from a number of UK counties to understand their attitudes to grass:

All the operators interviewed would use verge-grass. All thought that grass could make up a maximum of 25% of their feedstock. None of them wanted to commit vehicles or staff to harvesting grass, all would want it to be delivered. Most operators were willing to pay between £10-£20 per tonne (more than the harvesting costs calculated). One thought that they should receive a gate fee. All operators were attracted by the prospect of generating more digestate.
But there were concerns:

Visible refuse e.g. cans or plastic bags in the grass would impact on the quality of the digestate, and make it unacceptable to other farmers.

Volume of feedstock available – concern that for large plants adequate volumes could not be met.

Size of grass cuttings - may need to be cut very finely.

Delivery methods: some wanted it bailed, some loose, some in boxes, some bagged.

Concluded that there does seem to be a market for verge grass.
**Wider Use Of Verge Grass**

Is grass verge harvesting suitable for other areas of UK?

Lincolnshire has a lot of rural roads with wide verges and a good distribution of farm AD plants and fertile land.

Other areas of UK may not be as suitable because of fewer roads or narrower roads and verges.

Each area will need to calculate the area of grass available from their own road networks, assess potential local grass yield (depends on local soils and rainfall) and assess demand for grass from local AD plants.

May be suitable for agencies such as Highways England, Network Rail.

Could be used for Lincolnshire drains, public parks, gardens and sports fields if AD plants are nearby.
Project Conclusion

- Grass is a suitable feedstock for AD processing with acceptable levels of contamination and similar methane production levels to maize.
- AD operators may be willing to use verge and could pay £10-20/tonne.
- Harvesting grass and transporting to central AD plant costs £6 to £11 for a £15km radius area.
- Harvesting and selling verge grass could provide local authorities with income and even make a profit.
- Viable model requires councils to organise harvesting and delivery.
- Most profitable if older AD plants are used which receive higher incentives and may be willing to pay higher price.
- Potential to roll out to other parts of UK.

- Further research needed on grass yield, impact of harvesting on future grass yields and harvesting machinery available.
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- Andrew Price-Allison
- The AD plant owners interviewed
Thanks for Listening