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Report on the potential of Parsonage farm to produce biogas

Introduction

The task was to provide an assessment of onsite feedstock production, seasonal variation and calorific value relating to the biogas volume that can be produced at Parsonage farm and is as follows;

1. 85 dairy jersey cattle are housed for 180 days and produce slurry
2. 163 followers (partly housed through the year and a goat herd of 200 housed all year that produce farm yard manure.
3. Food waste can also be sourced from the estate and averages about 300kg/day.
4. An additional whey source can provide 1.4 tons/day.
5. Grass silage 2.6 tons/day and garden waste 500kg/day

Feedstock Seasonality

The dairy cattle are housed for 6 months in the winter period. Only slurry is collected in the summer when they are milked.
The dairy followers on are housed for ½ the year and goats are housed all year round and provide a constant feedstock supply of FYM (straw and manure) that can be stored. The grass silage is stored once harvested and the garden waste mostly composed of grass and clippings is collected from May until late October.
Whey should be permanently available, and a supply contract should be sought. The food waste is collected from the student halls and canteens, again this would have terms time imposed on the supply. Seasonally food has higher fat content in the winter.

Feedstock types and daily mass requirement

Below is a table with inputs and the predicted range of biogas outputs for each of the feedstock types. Please note the biogas output closely relates to the dry matter content and the dry matter content are the averages from official sources (e.g. DEFRA RB209 document).
A range of biogas outputs has been presented as this reflects the variability due to feedstock quality, digester design and operator efficiency. Within the calculations of the biogas output known values and data are used from DEFRA databases. These are there are 85 milking Jersey cows in sheds 180 days/year on straw bedding. Jersey cows produce 40 litres of manure/day and need one third in slurry weight of straw bedding to be clean and comfortable. A third of the weight of manure produced is added as straw for other the followers and the goat herd.
Followers of about 163 cattle are in half the year on straw. Jersey cow young cattle / followers produce an average of 10 litres of manure/day. The 200 goats each of which produces 5 litres of manure/day. The whey should have a biogas yield of about 50 m3/ton depending on the method of separation, if the process occurs by membrane technology the is less energy ca. 10 to 20 m3 biogas/ton.

Table 1 Biogas output from feedstock types at Parsonage farm

Feed stock Type	Vol per day (tonne)	Dry Matter DM %	Biogas Output minimum (m3/t)	Biogas Output optimum (m3/t)	Biogas output minimum per day (m3/t)	Biogas output optimum day (m3/t)
FYM goat and dairy cattle	4.5	25%	80	96	360	432
Slurry dairy cattle	3.0	8%	25	30	74	89
Crops						
Grass silage	2.6	24%	180	216	475	570
garden waste	0.5	35%	200	240	100	120
Food waste						
Sharpham & Parsonage Whey	1.4	5%	100	110	139	153
Food Wastes	0.29	13%	150	180	43	51
Total	**12**				**1190**	**1420**

The use of biogas is assumed to be with a CHP system(heat could be provided as an alternative). This would be a 120kW CHP system. The feedstock produces between 100 and 130 kW of electricity and about 130 to 145 kW of heat at the same time. At the lower rate the electrical output would be between 90 and 110 kW. Most CHP systems can operate in a modulated mode and run over a range between 50% and 110 % electrical output. Conversely the feedstock loading can be adjusted, especially with the conserved grass silage.

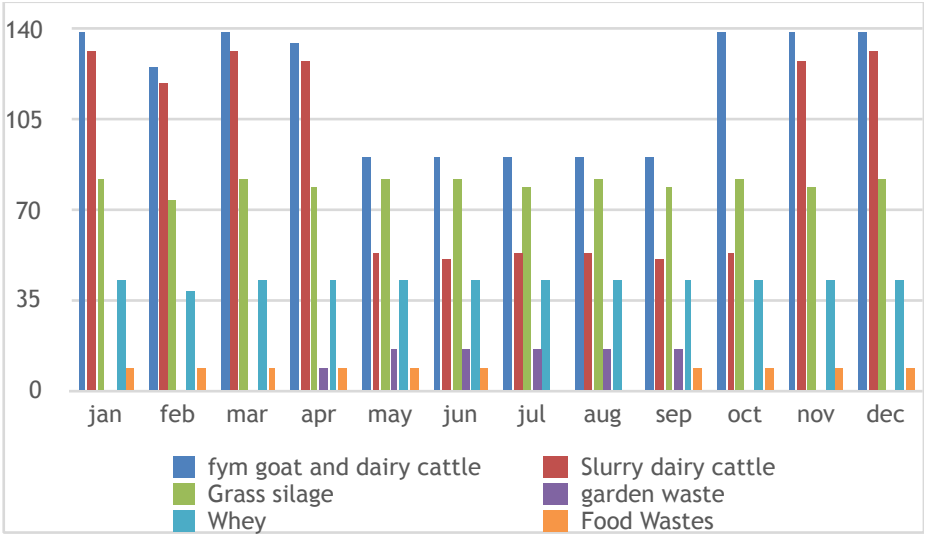

Figure 1Monthly feedstock supply providing between 110 and 130 kW of electrical output

Energy output for each of the feedstock types is given as a range in table 2. From our conversations with the Farmer at Parsonage farm there is more than a 1/3 straw added to the manure. As straw produces about 300m3/ton of biogas then there would be a higher daily rate biogas production.

Table 2 Showing the energy output from each of the feedstock types

Feed stock Type	kWh lower output	kWh higher output
FYM- goat and dairy cattle	2158	2590
Slurry -dairy cattle	446	536
Crops		
Grass silage	2565	3078
garden waste	540	648
Food waste		
Sharpham & Parsonage Whey	708	779
Food Wastes	236	283
Total	**6653**	**7913**

Plant size and daily biogas production

The CHP operates at about 37% efficiency, so this gives a CHP power output of 110 and 130 kW respectively. The corresponding heat output would be from 130 to 150 kW. However, a larger engine can give more power output on request. Second most biogas plants wished they had options to produce more energy.

Influences on power output

There are several influences that can affect power output.
First during operation there can be about a 20 to 40% variation of biogas output per ton. The biogas produced is influenced by the hydrolysis rate and the biochemistry of the methane producing stage. At higher temperatures the conversion of organic material to products that can be converted to methane is high by about 30% for energy crops.
Second the quality of the feedstock should be high. A drop of silage quality can cause a 20 to 30% reduction in biogas output.
Third breakdowns or maintenance schedules contribute to about 10 to 20% drop in time the plant operates. The output has been calculated including a 10 to 15% drop in output.

Viability of the biogas plant

Generally, biogas plant systems of about 100 to 120 kW CHP size are considered as viable with extenuating circumstances that include the following ;

1) Effectively reducing the Dartington college food waste disposal fee to zero. However, the food waste only contributes 4% of the biogas output! (The food waste sterilizer costs about 56k).
2) Supplying 110 to 130kW of electricity to the Dartington estate grid 24/7.
3) Providing additional nutrients to Parsonage farm to reduce fertilizer bills and enhance crop micronutrient supply to provide a better growth environment for crops.
4) Rationalise waste from the farm to a collection point for better landspreading.
5) Significantly reduced pathogen and weed seed content of the digestate spread on land compared to the current manure, especially for a higher temperature digester.
6) Enhance the farm income.

7) Provide an improved energy infrastructure for the farm.
8) Extra heat to provide a drying business.
9) Provide green heat source for the colleges.

These options will be further explored in the final collated report.