

## Performance of an on-farm anaerobic digester using dairy cow slurry as the sole feedstock

J P Frost, S R Gilkinson

Agri-Food and Biosciences Institute, Hillsborough, Northern Ireland, United Kingdom

Email: [peter.frost@afbini.gov.uk](mailto:peter.frost@afbini.gov.uk)

**Introduction** Anaerobic digestion (AD) is employed widely across the world to produce a source of renewable energy as biogas (mainly methane). However, there has been only limited uptake of AD in the UK, particularly at farm level. The aim of this study was to assess the performance of on-farm AD, using fresh dairy cow slurry as the sole feedstock.

**Materials and methods** An anaerobic digester at AFBI-Hillsborough was used to study the performance of AD using farm based organic materials as feedstock. The digester was a 660m<sup>3</sup> insulated above ground tank, maintained at an average of 39°C (s.d. 2.2), discharged and fed hourly and mixed *via* biogas recirculation. Slurry from dairy cows at AFBI was the sole feed at approximately 20 t d<sup>-1</sup>. Process data were automatically recorded every 30 seconds throughout the 20 week recording period (12 December 2008 to 1 May 2009). Biogas composition was recorded once daily with a hand held gas meter (Gas Data GFM400, UK). Feedstock and digestate were sampled daily, bulked weekly and analysed for DM, ash, N, NH<sub>3</sub>-N, P and K. Volatile solids (VS) contents were calculated as the difference between DM and ash contents. Hydraulic retention time was a nominal 27 days (s.d. 1.0).

**Results** The mean biogas composition during the recording period was 0.57 methane (s.d. 0.028), 0.37 carbon dioxide (s.d. 0.025) and 0.002 hydrogen sulphide (s.d. 0.0004). The average weekly feedstock temperature was 7.7°C (range 4.6–11.4°C). The proportion of gross biogas energy required to maintain digester temperature was 0.39 (range 0.30–0.51). Table 1 summarises digester performance.

**Table 1** Summary of daily digester performance using dairy cow slurry as feedstock over a 20 week period

Parameter	Unit	Value	Standard deviation
Slurry loading rate	t d <sup>-1</sup>	19.8	0.86
VS loading rate	kg VS m <sup>-3</sup> d <sup>-1</sup>	2.36	0.146
Biogas produced	Nm <sup>3</sup> d <sup>-1</sup>	310	31.4
Biogas productivity	Nm <sup>3</sup> m <sup>-3</sup> of digester d <sup>-1</sup>	0.58	0.055
Biogas yield	Nm <sup>3</sup> kg <sup>-1</sup> VS	0.25	0.022
Methane yield	Nm <sup>3</sup> kg <sup>-1</sup> VS	0.14	0.013
Gross energy in biogas	kWh d <sup>-1</sup>	1758	201
Energy to maintain AD temperature	kWh d <sup>-1</sup>	689	129

The digester produced 0.14 Nm<sup>3</sup> methane kg<sup>-1</sup> VS in feedstock (Table 1) equivalent to 89 kWh t<sup>-1</sup> of feedstock. This is an extremely useful source of renewable energy. This overall performance was very similar to that predicted by Frost *et al.* (2006), though was less than predictions of some AD suppliers e.g. approximately 0.16 less methane per unit of VS in the feedstock. Furthermore, the AFBI AD produced 0.61 less methane per unit of VS than the average of 41 Austrian digesters reported by Braun *et al.* (2009). The majority of these Austrian digesters used energy crops as the major component of their feedstock and had hydraulic retention times that were on average about five times longer than in the AFBI AD. Both of these factors would account for the higher degradation of VS in Austria (0.83) than at AFBI (0.24). In the AFBI digester approximately 0.20 of the DM and 0.24 of the VS were degraded (Table 2). The total N, P and K concentrations of the digestate were not significantly (P>0.05) affected by digestion (Table 2). However, the crop available nitrogen (NH<sub>3</sub>-N) concentration of the digestate was significantly (P<0.001) increased by 0.16 relative to the feedstock.

**Table 2** Summary of nutrient concentrations in dairy cow slurry feedstock and digestate over a 20 week period

g kg <sup>-1</sup> fresh	Feedstock	Digestate	s.e.d.	P
DM	81.1	64.9	0.86	<0.001
pH	7.66	8.05	0.059	<0.001
Total N	4.12	4.10	0.062	0.682
NH <sub>3</sub> -N	2.26	2.63	0.055	<0.001
Total P	0.59	0.61	0.124	0.102
Total K	4.52	4.52	0.134	0.992
VS	63.5	48.2	0.77	<0.001

**Conclusions** Dairy cow slurry is a useful source of renewable energy. The crop available nitrogen in the digestate, compared to the feedstock, was enhanced.

### References

Frost P, Gilkinson S and Buick J. 2006. [www.actionrenewables.org](http://www.actionrenewables.org), accessed 13 October 2009.

Braun R, Weiland P and Wellinger A. 2009. Biogas from Energy Crop Digestion. [www.iea-biogas.net](http://www.iea-biogas.net), accessed 11 January 2010.