SOLIDSENSE

Cambridge Eco Ltd

enscape ENVIRONMENTAL & DEVELOPMENT SERVICES

ZERO WASTE SCOTLAND

Scottish anaerobic digestion and biogas sector survey 2017

Prepared by: Brian Menzies, Mary Dimambro, Thomas Aspray

Date: 29th March 2019

ZERO WASTE SCOTLAND

European Union gov.scot

EUROPE & SCOTLAND
European Regional Development Fund
Investing in a Smart, Sustainable and Inclusive Future

Executive Summary

This report describes the results of the survey of the Scottish biogas and anaerobic digestion industry, for the year 2017. All four key sectors have been comprehensively surveyed: (i) farm; (ii) merchant; (iii) industrial; and (iv) waste water treatment. A total of 35 sites completed surveys (70% of the total operating in 2017), with estimates made to account for those not participating (14).

The Anaerobic Digesion (AD) & Biogas sector in Scotland is estimated in 2017 to have processed a total of 9.3 million tonnes of varying feedstocks, with the table below summarising the position on a sector basis.

Category of Facility	Biogas Output, m^3			Tonnage Throughput		
	2017	2014	2013	2017	2014	2013
Farm	63,079,213	No data	No data	458,032	157,000	132,000
Merchant	51,101,413	8,500,000	No data	338,783		
Industrial	84,571,404	No data	No data	7,885,225	No data	No data
Waste water	18,381,414	No data	No data	631,078	No data	No data
TOTAL	**217,133,444**	**-**	**-**	**9,313,118**	**-**	**-**

Overall the AD sector in 2017 generated 217 million m^3 of biogas, with significant growth in the industrial and farming sectors, which generated by far the largest volume of biogas, at 84 and 63 million m^3 respectively – cumulatively, 68% of the total. These sectors have seen significant developments in terms of gas to grid projects, with 41% of total biogas generated estimated as having been used for this purpose. The survey took place in late 2018 and early 2019, along with a parallel survey of the composting sector, the results of which can be read along with this report. A key output from the composting survey is that food waste accounted for 34,300 tonnes of composting feedstocks in 2017, broadly comparable to the total for 2014 (32,000). With an estimate from the 2017 AD survey of 141,651 tonnes of food waste being processed at AD facilities this gives an overall total of 175,951 tonnes, compared with an overall total of 141,028 tonnes (composting and AD) processed in 2014. This tonnage refers to food waste from households and commercial sources (processors, hospitality and catering sectors).

In terms of potential there are some uncertainties in the period ahead, with the Feed-in Tariff system closing in 2019 which removes subsidies for electricity generated from facilities with an installed capacity of 5MW or less. The current Renewable Heat Incentive (RHI) system will also come to an end in 2021, with little certainty of what will happen after this.

However, there is clearly scope for significant developments in the Scottish AD sector, with feedback from various stakeholders identifying where these could be. There is no data to suggest that the significant growth in the farming sector could not be continued, if the financial incentives continue to be attractive. Feedback from stakeholders engaged in the project also pointed to other important areas with the potential for significant development in the future:

- The industrial sector is considered to be an area with significant room for growth, with many thousands of tonnes of potential feedstock currently being discharged to sea and/or land.
- There is real potential in terms of on-site AD at the smaller, more remote distilleries, dairy food processors, brewers etc. The energy value of food residues is not recognised by food companies and greater effort is needed to highlight what can be done with the opportunity.
- Municipal waste collections, including households, where participations levels can be significantly improved. It is estimated, for example, that around 29% of residual, household black bag waste consists of food waste and that in 2017 over one million tonnes of household waste was landfilled. This situation, along with the forthcoming landfill ban of organic waste streams (2021) indicates that there is real potential in terms of recovering significant tonnages of food waste for anaeorobic digestion (and/or composting).
- Stakeholders identified the importance of increasing the amount of awareness-raising work, to improve participation levels and reduce contamination such as food packaging.

Glossary of terms

Anaerobic Digestion (AD)	Process of controlled decomposition of biodegradable materials under managed conditions where free oxygen is absent, at temperatures suitable for naturally occurring mesophilic or thermophilic bacteria that convert the inputs to biogas and whole digestate.
Animal By-Products Regulations (ABPR)	The Animal By-Products Regulations (EC) 2009 (142/2011) indicate clearly what may or may not be done with any part of an animal or product of animal original not intended for human consumption. This is transposed into Scottish law through The Animal By-products (Enforcement) (Scotland) Regulations 2013. This controls the collection, transport, storage, handling, processing and use or disposal of animal by-products in Scotland, including catering wastes. Similar legislation applies in England and Wales.
Crop residue	Crop residues are defined as 'production residues' produced as an integral part of the commercial production of agricultural crops; these may include 1) Damaged or misshapen fruit or vegetableswhich are unsuitable for sale as food for consumption or 2) Trimmings and other plant parts which are not the intended end product, such as straw, leaves or tops. These may be sourced from the field or from a packing unit.
Digestate	Digestate is the residue resulting from the anaerobic digestion of biodegradable materials. See also Fibre digestate, Liquor digestate and Whole digestate.
Farm-fed AD Facility	Site which is both located on a farm and processes only material generated on-farm (such as energy crops, crop residues and livestock slurries).
Fibre digestate	This is the solid fibrous fraction of the whole digestate that has been separated from the liquor fraction. Fibre digestate is a source of organic matter and nutrients.
Industrial AD Facility	A site which processes its own by-products, typically on a large scale, such as food and drink manufacturers.
Liquor digestate	This is the liquid fraction of the whole digestate that has been separated from the solid fibre fraction. Liquor digestate is a source of nutrients.
Manure	Organic material that is used to fertilize land, usually consisting of the faeces and urine of domestic livestock, with or without accompanying litter e.g. straw.
Merchant AD Facility	Site which accepts waste from off-site, on a commercial basis (i.e. for a gate fee). Could be a farm based enterprise.
Operating capacity	The capacity of material that the site can handle. This is commonly lower than the permitted capacity of the site.
Organic waste	Waste of animal or plant origin which, for recovery purposes, can be decomposed by micro-organisms, other larger soil-borne organisms or enzymes.
PAS 110	Publicly Available Specification 110, which is the British Standards Institution's specification for anaerobic digestion systems that accept source-segregated biowastes. It specifies: • Controls on input materials and the management system for the process of anaerobic digestion and associated technologies. • Minimum quality of whole digestate, separated fibre and separated liquor. • Information that is required to be supplied to the digestate recipient.
Permitted capacity	The capacity of material that the site has been permitted to treat. This figure can be higher than the actual amount of material treated by a site and represents the maximum amount that the site can treat per annum.
Permitted/exempt waste operation	A permitted waste operation is one which is subject to the granting of a Pollution Prevention Control permit. This is a permit is granted by the regulator allowing the operation of a regulated facility subject to certain conditions. Some activities are exempt from permitting or waste management licencing provided they meet certain conditions. Further information is available on the SEPA website: www.sepa.org.uk.

Purpose grown crops	Energy crops grown specifically for AD, such as grass, wholecrop cereals, maize and energy beet (not classed as a waste).
Slurry	Slurry is defined in the Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) (Scotland) Regulations 2003 as a mixture consisting wholly of or containing excreta, bedding, feed residues, rainwater and washings from a building or yard used by livestock, dungsteads or middens, high level slatted buildings and weeping wall structures, or any combination of these, provided such excreta is present. The PEPFAA code states that drainage from parlour standings and the parlour pit must be collected and contained and that this may be included in the slurry system.
Source-segregated feedstock	Feedstock kept separate from other waste types so as to reduce contamination and facilitate treatment. It is referred to as 'separate collection' in the Waste Framework Directive (2008/98/EC).
Whole digestate	Digestate before separation into liquor and fibre fractions. See also Digestate, Fibre digestate and Liquor digestate.

Acronyms

ADBA	Anaerobic Digestion and Bioresources Association.
AfOR	Association for Organics Recycling (now merged with REA – see ORG, below).
FTE	Full time equivalent.
NNFCC	The National Non-Food Crops Centre, www.nnfcc.co.uk.
ORG	The Organics Recycling Group. A section within the REA which represents the membership of the former AfOR.
REA	Renewable Energy Association.
SEPA	Scottish Environment Protection Agency.
WRAP	Waste and Resources Action Programme

Front cover photo courtesy of Future Biogas Ltd.

Contents

List of tables

List of figures

1 Introduction

Surveys of the anaerobic digestion (AD) and biogas sector in Scotland were last carried out on behalf of Zero Waste Scotland and the Scottish Government for the years 2014[1] and 2013[2]. Prior to this, surveys of the Scottish sector were part of UK-wide projects, the most recent carried out by the Waste and Resources Action Programme (WRAP) in 2012[3] and the Association for Organics Recycling in 2010[4].

The purpose of this report is to present updated information for the Scottish anaerobic digestion and biogas sector covering the period January-December 2017 and, where applicable, make comparisons with previous survey data. The AD facilities targetted are those anaerobically digesting organic materials and generating biogas and value from these e.g. through grid gas injection, heating and/or electricity production.

This survey aimed to estimate the volume of biogas produced from the Scottish AD & Biogas sector as well as the amount of organic feedstocks, by-products and waste treated as well as the type and variation of processing infrastructure.

Zero Waste Scotland supports this survey with the data widely used by private and public sector bodies to better understand the development of the sector and inform decision making and policy intervention. The results also help Zero Waste Scotland inform its own work and assess the extent to which it is meeting its objectives.

2 Methodology

Surveys were carried out with organisations in the latter part of 2018 and early 2019, and the questions used are provided in Appendix A. The data presented in this report is based mainly on responses from organisations that participated in the survey. For those not participating, alternative data was secured and estimates made, informed from a range of online sources. The details behind the methodology are provided in Appendix B, with this section providing a brief overview of the approach.

As with previous surveys, grossing was required for individual sites not participating in the survey or not responding to specific questions. The foundation of the approach used here was to determine either the feedstock tonnage, the installed CHP capacity or biogas throughput for the relative feedstock , using a range of different sources. Once specific input criteria and data were obtained, other values (e.g. biogas output, electricity generation etc) were estimated.

Other results, in terms of sector/business concerns and opportunities were based on information from participating sites only.

A number of changes have been made to the survey, in comparison with previous years, as summarised below:

- The survey questions were reformatted to focus on current, key areas of interest.
- In the 2014 survey, no farm-based data was reported. In the period since then there has been significant growth in this part of the AD market which is covered in depth in this report.
- This report also provides detailed results for the industrial AD and waste water treatment AD sectors. The latter has not been covered in previous surveys, and the industrial sector only touched on.

[1] https://www.zerowastescotland.org.uk/sites/default/files/2014%20organic%20survey%20Final%20%2801-07-2016%29.pdf
[2] http://www.organics-recycling.org.uk/uploads/article2928/Scottish%20ASORI%20Report%2020140924.pdf
[3] http://www.wrap.org.uk/sites/files/wrap/ASORI%202012.pdf
[4] http://www.organics-recycling.org.uk/uploads/article2439/ASORI%20Final%20Report%202010.pdf

- The results shown in this survey are based on the development of full datasets to represent all sites that are anaerobically digesting organic feedstocks in Scotland, generating biogas for use in CHP engines, injection into the gas grid, vehicle fuel or heat production.
- This report includes *'have your say" questions* which focus on potential sector issues of physical contaminants, offsite odour, and more generally on threats and opportunities.

The results are presented, quantitatively and qualitatively, in a number of different sections covering:

- Combined data for all sectors
- The merchant AD sector, taking mainly waste streams and by-products.
- Farm-based AD, processing mainly slurries/manure and crops and/or crop residues.
- Industrial facilities processing their own by-products.
- Waste water treatment – treating indigenous (sewage – waste water) plus miscellaneous, imported feedstocks.

3 Results and interpretation

3.1 Combined AD Infrastructure (Merchant, Farm, Industrial and Waste Water Treatment)

3.1.1 Number of sites contacted and engaged by sector

The number of sites identified to be operating target AD facilities (see *Introduction*) and contacted, for each of the sectors in 2017, is shown in the table below. The numer of sites contacted in 2017 is the same as the number of operational sites during that year, with a participation level of 70% achieved.

Table 1. Scottish AD sector and survey participation in 2017 compared to previous years

Sectors	2017		2014[5]		2013[6]	
	Operating & Contacted	Engaged	Contacted	Engaged	Contacted	Engaged
Farm	27	20	2	1	2	1
Merchant	9	8	8	8	5	5
Industrial	7	3	6	3	4	2
Waste water treatment	6	4	0	0	0	0
TOTAL	**49**	**35**	**16**	**12**	**11**	**8**

3.1.2 Site licensing status

The following table describes whether sites were operated on the basis of waste management licensing (WML), pollution prevention control (PPC) permits, waste exemptions, or without any such regulatory

[5] Zero Waste Scotland, Scottish survey, 2014
[6] Zero Waste Scotland, Scottish survey, 2013

control (not waste) – assumptions have been made for those sites that did not participate based on knowledge and understanding of how these operate (e.g. one merchant site did not participate, but is known to operate against a PPC permit. No farm sites are known to be processing waste streams, nor are any industrial sites).

This level of data is not available for AD sites in the 2014 and 2013 surveys so cannot be shown here for comparison.

Table 2. Scottish AD sector in 2017 – licensing status

Category of Facility	Licensing Status				
	WML	WME	PPC	None	ABP
Farm	0	7	0	20	0
Merchant	1	1	7	0	6
Industrial	0	0	7	0	0
Waste water	6	0	0	0	0
TOTAL	**7**	**8**	**14**	**20**	**6**

3.1.3 Sector employment

The full time equivalent (FTE) employment associated with the AD and biogas sector as a whole is summarised in the following table.

Table 3. Number of FTE employees in 2017 compared to survey data for 2013 and 2014

Sectors	2017	2014	2013
Farm	43	64.5	70
Merchant	94		
Industrial	16	No data	No data
Waste water	71	No data	No data
TOTAL	**224**	-	-

A significantly higher number of employees in the merchant sector was identified for 2017 than in previous surveys. With farm sites also adding significantly to the AD picture, and including industrial and waste water treatment sites, the level of employment in the sector is shown to be 209 FTEs in 2017.

3.1.4 Feedstock throughput

The following table summarises the throughputs for each of the AD sectors, with a comparison where possible with survey results from 2014 and 2013.

Table 4. All feedstocks - tonnage throughput

Category of Facility	Tonnage Throughput		
	2017	2014	2013
Farm	458,032	157,000	132,000
Merchant	338,783		
Industrial	7,885,225	No data	No data
Waste water	631,078	No data	No data
TOTAL	**9,313,118**	**-**	**-**

Incorporated within the throughput data of Table 4 is food waste, processed through the merchant AD facilities only. A summary of the tonnages is provided below, in Table 5.

Table 5. Food waste feedstock – total tonnage throughput

Category of Facility	Tonnage Throughput		
	2017	2014	2013
Farm	0	-	-
Merchant*	141,651	107,574	128,789
Industrial	0	-	-
Waste water	0	-	-
TOTAL	**141,651**	**107,574**	**128,789**

*The estimate is based on a calculation of food waste being 10% (Zero Waste Scotland information through consultation with AD operators) of mixed food and garden waste collections (6% of the 2017 total) across the three years shown.

It should be noted that the food waste total for 2017 ***excludes*** distillery/brewing waste such as pot ale, draff and malt pellets - 58,992 tonnes of such by-products were processed through merchant facilities in 2017. The food waste tonnage for 2017 should also be considered in terms of the quantity processed through composting facilities – a total of 34,300 tonnes in 2017 (compared to 32,000 tonnes in 2014).

A breakdown of the type of feedstocks making up the food waste total is described later in this report, in Table 12.

3.1.5 Sector capacities

Table 6 below shows actual throughput versus technical (design) and permitted capacities of AD sites. This information is shown for 2017 only (not available for 2014 and 2013).

Table 6. Site throughput verus technical and permitted capacity

Parameters	2017, tonnages per annum				
	Farm	Merchant	Industrial	WWT	TOTAL
Permitted capacity	N/A	372,000	7,885,225	631,078	9,346,335
Actual throughput capacity	458,032	338,783	7,885,225	631,078	9,313,118
Technical capacity	524,216	411,500	8,067,725	1,038,715	10,042,156
Available capacity	66,184	72,717	182,500	407,637	729,038

a) Waste water treatment capacity is based on imported waste only, rather than indigenous throughputs – the permitted capacity has been shown to equal "actual" for ease of calculation.

b) Technical capacity stated for the farm-based sector should be read with caution – the numbers quoted are illustrative/indicative.

3.1.6 Outputs

It is estimated that 217 million m^3 of biogas was produced from the four sectors surveyed (Table 7). It has not been possible to make a comparison with 2014 and 2013 because there are no comparable datasets for these years.

Table 7. 2017 Scottish AD biogas production

Sectors	Biogas Output, m^3		
	2017	2014	2013
Farm	63,079,213	No data	No data
Merchant	51,101,413	8,500,000	No data
Industrial	84,571,404	No data	No data
Waste water	18,381,414	No data	No data
TOTAL	**217,133,444**	**-**	**-**

The following, Table 8, shows that there was an estimated 245 MWh of electricity produced across all four AD sectors in 2017. The comparison with previous years is based on limited datasets for these.

Table 8. Scottish AD sector in 2017 – electricity generation

Category of Facility	Electricity Output, MWh		
	2017	2014	2013
Farm	89,332	No data	No data
Merchant	79,063	21,000[1]	41,000[2]
Industrial	51,204	No data	No data
Waste water	25,921	No data	No data
TOTAL	**245,520**	**-**	**-**

1. 2014 survey, 21,000 MWh based on data from 7 merchant sites

2. 2013 survey, 41,000 MWh based on data from 4 merchant sites

An estimate of heat generated and used is provided in the following Table 9. Subsequent sector specific sections of this report describe the amount of heat generated, both used and wasted (i.e. heat lost/vented to atmosphere).

Table 9. Scottish AD sector in 2017 – heat generated and used*

Category of Facility	Heat Output, Used, MWh		
	2017	2014	2013
Farm	102,182	No data	No data
Merchant	27,976	No data	No data
Industrial	97,043	No data	No data
Waste water	52,179	No data	No data
TOTAL	**279,380**	**-**	**-**

*This table does not show the heat wasted from each sector – this is detailed later in the report

Table 10 below provides an estimate for the digestate produced. It should be noted that with the industrial sector providing the lowest level of engagement, the estimates provided in terms of digestate should be treated with caution (estimates associated with other outputs, e.g. biogas volume, are based on more robust data sources, as explained in Appendix B).

Table 10. Scottish AD sector in 2017 – digestate produced[1]

Category of Facility	Digestate Output, Tonnes		
	2017	2014	2013
Farm	417,935	200,000[2]	104,000[2]
Merchant	250,676		
Industrial	7,490,964[3]		
Waste water	599,524		
TOTAL	**8,759,099**		

1. Data on separated fractions is provided later in the report.

2. 2014 and 2013 data based on tonnages from 9 sites.

3. This includes significant quantities of digestate from liquid feedstocks, subsequently disposed of to sewer, river/sea outfalls.

3.2 Feedstocks by Sector Split

3.2.1 Farm-based AD

3.2.1.1 Feedstock types and tonnage

The tonnage and split of feedstocks for the farming sector is shown in Table 11, with 70% of the tonnage shown is derived from survey responses, and 30% from estimates based on online data publically available.

AD sites in this sector now treat, as an overall total, the largest tonnage of feedstocks, the vast majority of which (approximately 94%) comes from farm operations, through crops grown as feedstock and slurries/manure from a range of livestock including cattle and poultry.

Table 11. Scottish farm AD sector in 2017 – feedstock split

Feedstock Categories	2017	
	Tonnes	%
Crops from own farm or 3rd parties	298,972	65%
Crop residues / off-cuts / outgrades	7,237	2%
Manure/slurry from own farm or 3rd parties	129,100	28%
Glycerol	0	0%
Fats, Oils, Grease	0	0%
Commercial solid food waste	0	0%
Household solid food waste	0	0%
Mixed commercial and household food waste	0	0%

Mixed green/garden and food waste	0	0%
Green/garden waste (gardens, parks)	0	0%
Solid industrial organic residues	0	0%
Liquid industrial organic residues	22,723	5%
Total	**458,032**	**100%**

3.2.1.2 Food waste % and estimated tonnage

No food waste was accepted at any of the farm-based AD sites.

3.2.2 Merchant AD

3.2.2.1 Feedstock types and tonnage

The categories of feedstock used in the survey are summarised below, with 65% of the tonnage shown being derived from survey responses, the remaining 35% derived from online data and associated estimates.

Table 12. Scottish merchant AD sector in 2017 – feedstock split

Feedstock Categories[1]	2017	
	Tonnes	%
Crops from own farm or 3rd parties	5,486	1.6%
Crop residues / off-cuts / outgrades	0	0.0%
Manure/slurry from own farm or 3rd parties	22,323	6.6%
Glycerol	1,443	0.4%
Fats, Oils, Grease	2,927	0.9%
Commercial solid food waste	66,886	19.7%
Household solid food waste	41,319	12.2%
Mixed commercial and household food waste	4,468	1.3%
Mixed green/garden and food waste	35,547	10.5%
Green/garden waste (gardens, parks)	4,270	1.3%
Solid industrial organic residues	77,387	22.8%
Liquid industrial organic residues	76,727	22.6%
Total	**338,783**	**100.0%**

It should be noted that the Table 12 waste feedstocks above come under the European Waste Catalogue (EWC) codes:

- 20 01 08 – biodegradable kitchen & canteen waste
- 02 XX XX – wastes from food preparation and processing (animal origin, fruit, vegetables, dairy products, baking etc)

The following pareto chart of the feedstocks indicates that more than 80% of the input is provided by five types of feedstock: (i) solid industrial organic residues, (ii) liquid industrial organic residues and (iii) commercial solid food waste, (iv) household solid food waste, and (v) mixed green/garden & food waste.

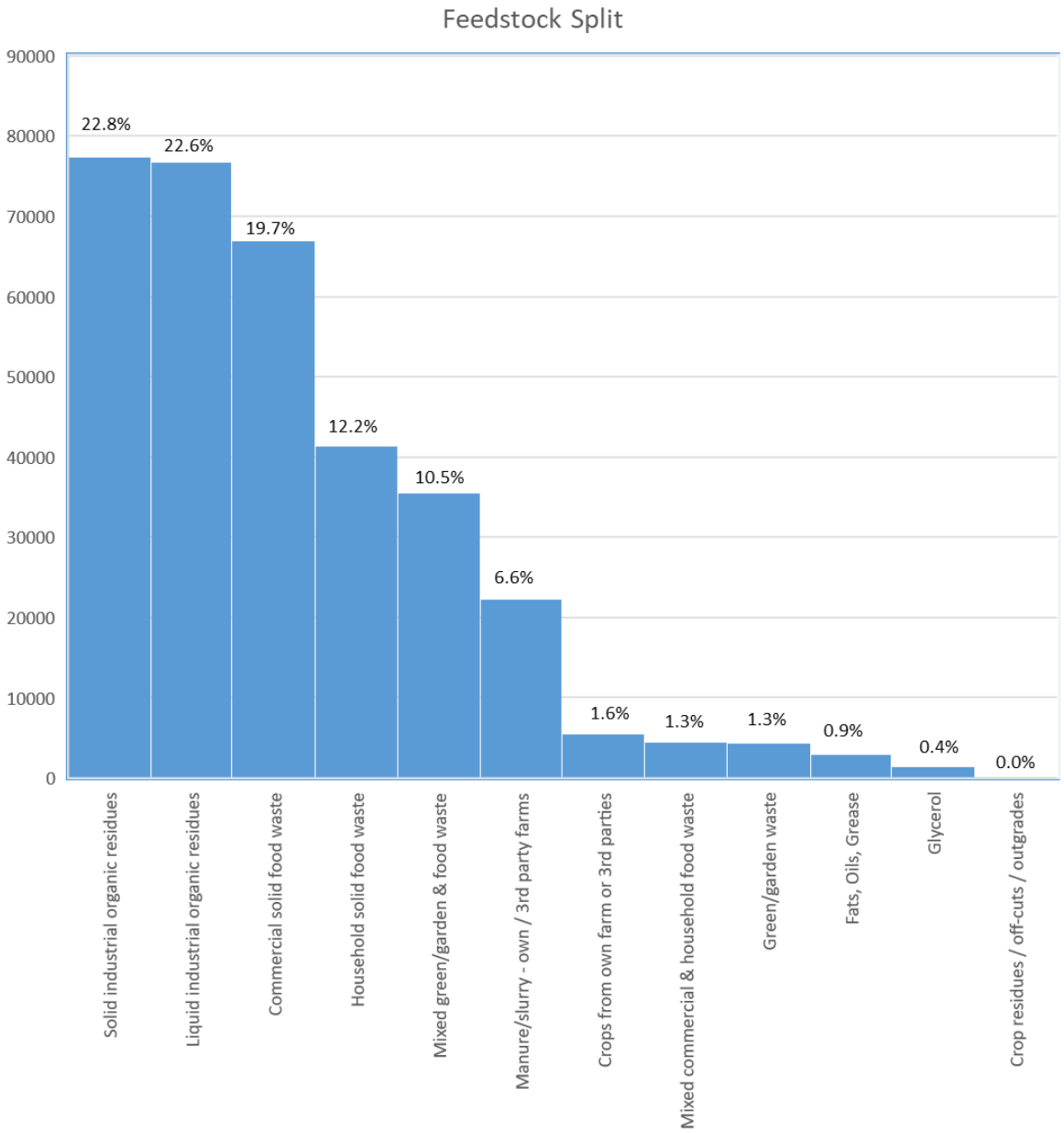

Figure 1. Pareto chart of merchant AD feedstock types

The following figure groups a number of the feedstocks into categories to allow for comparison with the type of inputs being managed in 2017 to those in 2014 and 2013.

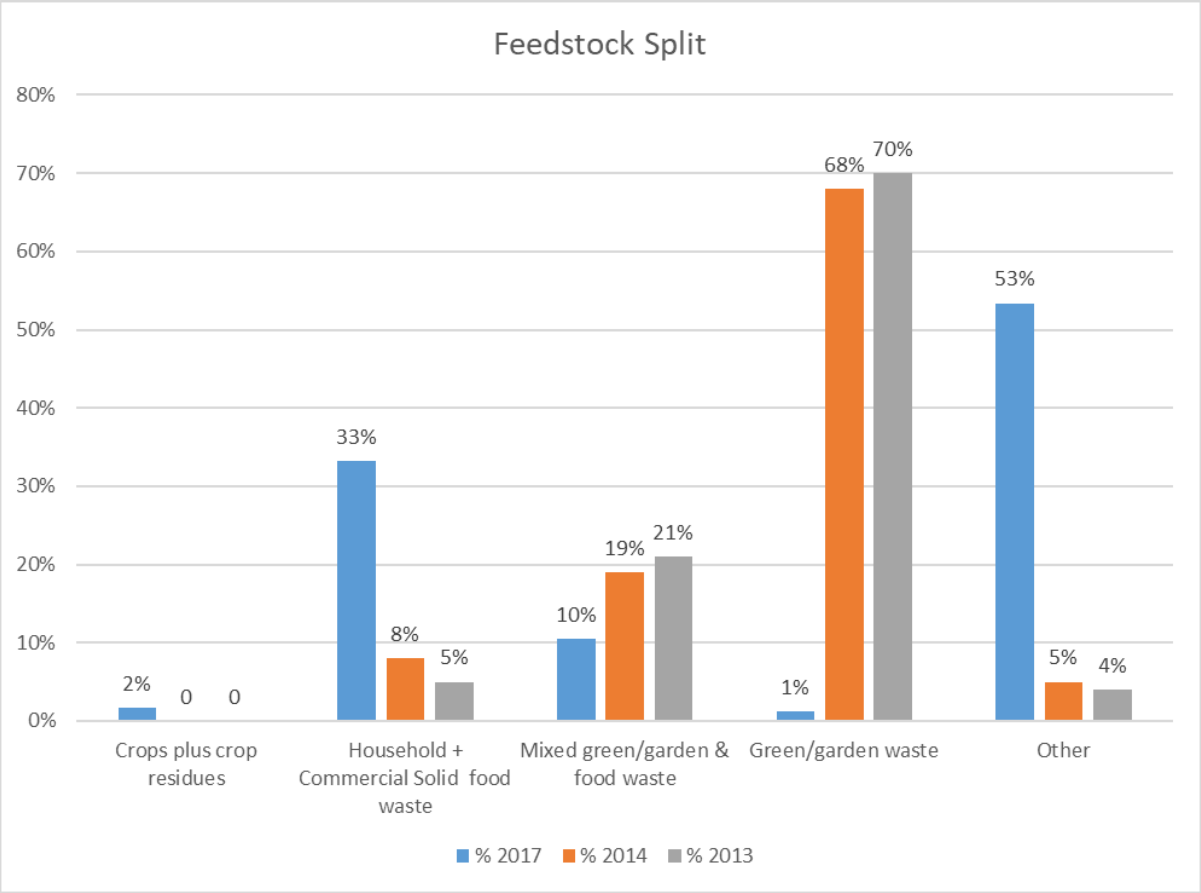

Figure 2. Chart comparing feedstocks for merchant AD sites in 2017, 2014 and 2013.

3.2.2.2 Food waste % and estimated tonnage

The following Table 13 provides a detailed split of the categories of food waste used to give a total of 137,474 tonnes processed in 2017. It should be noted that the only food waste processed (identified in the survey) is that which is managed through the ***merchant*** AD sites. A comparison with previous years is given after this table, since the categories provided in previous years were different.

Table 13. Detailed food waste AD feedstock split

Food waste category	2017	
	Tonnes	%
Glycerol	722	1%
Fats, Oils, Grease	1,464	1%
Commercial solid food waste (hotels, restaurants, retailers etc)	66,886	47%
Household solid food waste e.g. from LAs or their contractors	41,319	29%
Mixed commercial and household food waste	4,468	3%
Mixed green/garden and food waste (food element only)	3,555	3%

Food processing - solid	6,482	5%
Food processing - liquid	16,756	12%
Total	**141,652**	**100%**

The 2017 data above can be compared with 2014 and 2013 data, with grossed up values for the latter used for comparison purposes (the categories shown are those used in the previous surveys) - as summarised in Table 14 below.

Table 14. Detailed food waste AD feedstock splits for 2014 and 2013

Type	Food Waste Split, Tonnes	
	2014	2013
Solid food	97,689	84,432
Liquid food	6,978	44,000
Mixed food & garden	2,907	357
TOTAL	**107,574**	**128,789**

3.2.3 *Industrial*

3.2.3.1 Feedstock types and tonnage

The following Table 15 provides a split of the estimated feedstocks for the industrial sector with 37% of the total feedstock being derived from survey data (3 sites). The remaining 63% of feedstock (for 4 sites) was derived from online sources and assumptions. There is no data from the 2014 and 2013 surveys which can be used for comparison purposes.

Table 15. Feedstock splits for industrial AD facilities

Feedstock Categories	2017	
	Tonnes	%
Distillation by-products	7,182,498	91.1%
Fermentation by-products	20,000	0.3%
Diluted distillation by-products	687,727	8.7%
Total	**7,885,225**	**100.0%**

3.2.3.2 Food waste % and estimated tonnage

No food waste collected.

3.2.4 Waste water treatment

3.2.4.1 Feedstock types and tonnage

The waste water AD treatment sector processes a combination of "indigenous" feedstocks (e.g. sewage) and miscellaneous imported feedstocks. The throughput shown for this sector in 2017 in Table 16 is based on data from all of the pertinent sites.

Table 16. Feedstock splits for waste water treatment AD facilities

Feedstock Category	2017	
	Tonnes	%
Imported plus indigenous	631,078	100%

3.2.4.2 Food waste % and estimated tonnage

No food waste was identified as being collected or processed in waste water treatment AD facilities.

3.3 Process Overview

3.3.1 Types of AD systems used

The following Table 17 summarises the types of AD systems being used by companies/farms considered as part of this 2017 review, for all sectors.

Table 17. Overview of AD system types operating in 2017

Descriptions	No. of sites	% of sites
Number of stages		
One stage	25	50.9%
Two-stage	24	49.1%
Flow type		
Continuous	44	90.7%
Batch	5	9.3%
Moisture		
Wet	47	95.4%
Dry	2	4.6%
Temperature		
Mesophilic	43	87.2%
Thermophilic	6	12.8%

The majority of the 2-stage systems were in the farming sector - 19 of the 27 sites (71%).

3.3.2 Pasteurisation status

Under the ABPR, an EU pasteurisation approach is compulsory for all systems accepting low-risk ABP for digestion. However, European regulation allows Member States to adopt alternative standard approaches for systems that are only accepting catering waste.

Table 18 provides a summary of the extent to which pasteurisation is employed at AD facilities in Scotland, in 2017, with descriptions of the methods used.

Table 18. Overview of the extent of pasteurisation in AD facilities

Type	No. of sites	Pasteurising	% Pasteurising
Farm	27	8	22%
Merchant	9	8	89%
Industrial	7	0	0%
WWT	6	3	50%
Total	**49**	**19**	**38%**

Table 19. Summary of the pasteurisation methods employed

Type	No. of sites	Pasteurising
70 Celsius for 1 hour	15	79%
60 Celsius for 48 hours	0	0%
Other*	4*	21%
Total	**19**	**100%**

*Includes processes such as thermal hydrolysis at 6 Bar pressure (140^{o}C) for 30 minutes and 57^{o}Celsius for 5 hours.

The following pie charts provide an overview of where in the process (i.e. before or after digestion) pasteurisation is employed at the merchant and farm-based AD facilities.

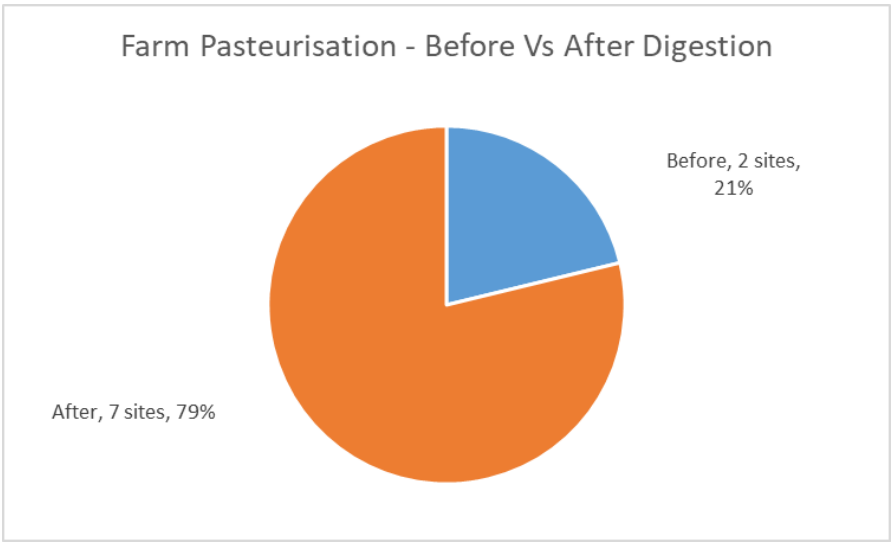

Figure 3. Chart showing where pasteurisation is employed in the AD process at farms

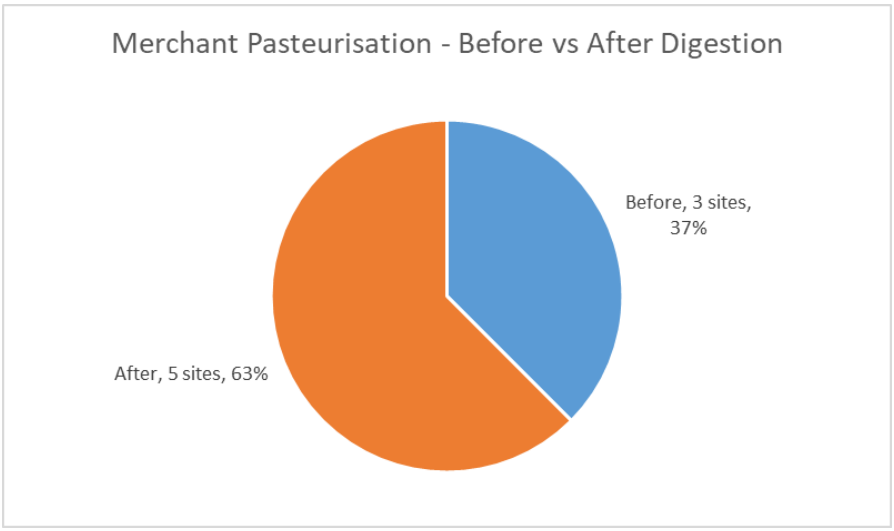

Figure 4. Chart showing where pasteurisation is employed in the AD process at merchant sites

At all of the waste water treatment sites pasteurisation is employed before the digestion process. There is no pasteurisation taking place at the industrial sites.

3.3.3 Contamination

3.3.3.1 The scale/extent of contamination

Figure 5. Chart showing responses to concerns about feedstock contamination for all AD sites below summarises the feedback from all of the sites in terms of how contamination of feedstocks, i.e. non target material such as packaging, was ranked as an issue.

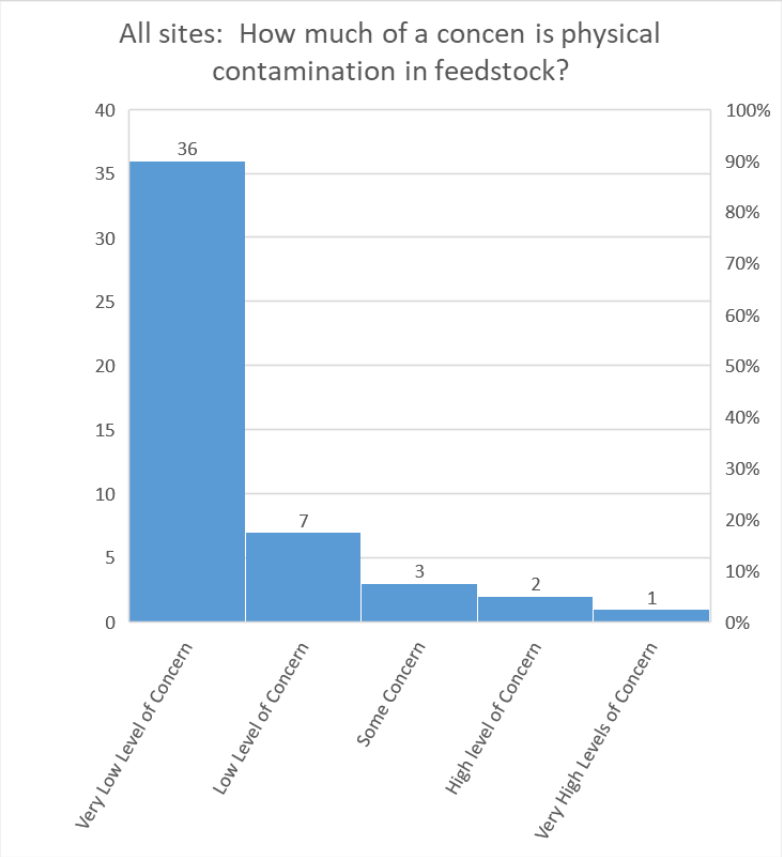

Figure 5. Chart showing responses to concerns about feedstock contamination for all AD sites

From the answers received, 74% (36 sites) gave contamination the lowest possible category in terms of concern i.e. “very low level of concern”.

One farm commented that contamination was a “high level of concern”, with this related to stones in the feedstock, which meant that the stone trap had to be cleaned out regularly. No other farms, industrial or waste water treatment AD sites gave more than the lowest ranking (“very low level of concern”) to contamination.

The merchant sector was the only one therefore where feedstock contamination was identified as causing some concerns. A summary of this is shown in Figure 6. Chart showing merchant site responses to concerns about feedstock contamination.

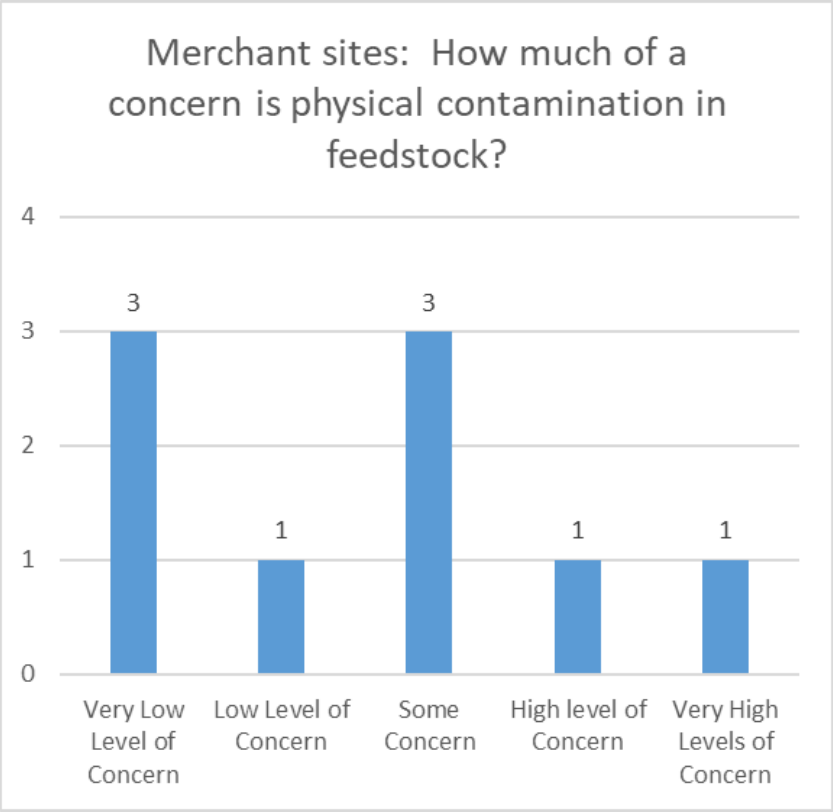

Figure 6. Chart showing merchant site responses to concerns about feedstock contamination

Of the merchant sites, 4 of 9 commented that the contamination created issues. The remaining sites commented that managing contamination was part of their operational activities – that it was "normal".

In terms of the scale of contamination at merchant sites:

- 4 respondents indicated that contamination was less than 1% of the feedstock
- 1 that it was between 1 and 5%
- 1 stated it was between 6 and 10%; and
- 2 that it was over 10%

3.3.3.2 Managing contamination

One farm uses hand-picking to manage its contamination issues. The only other processes and techniques used are those associated with merchant sites, nearly all of which are pre-digestion (one site has screening in place post digestion). A summary of the pre-digestion processes in place is provided in the following figure.

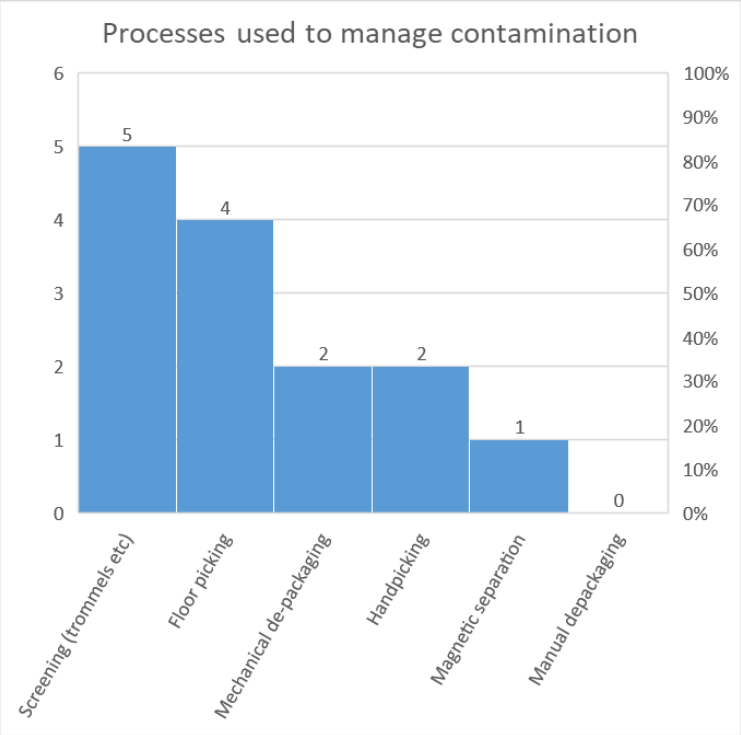

Figure 7. Chart showing processes for managing contamination at merchant sites (pre-digestion)

3.3.4 Odour

Of the sites, 84% (39) indicated that odour is a very low level of concern, or low level of concern. The full response for all of the sites is shown in the following Figure 8. Chart showing all site responses to concerns about offsite odour.

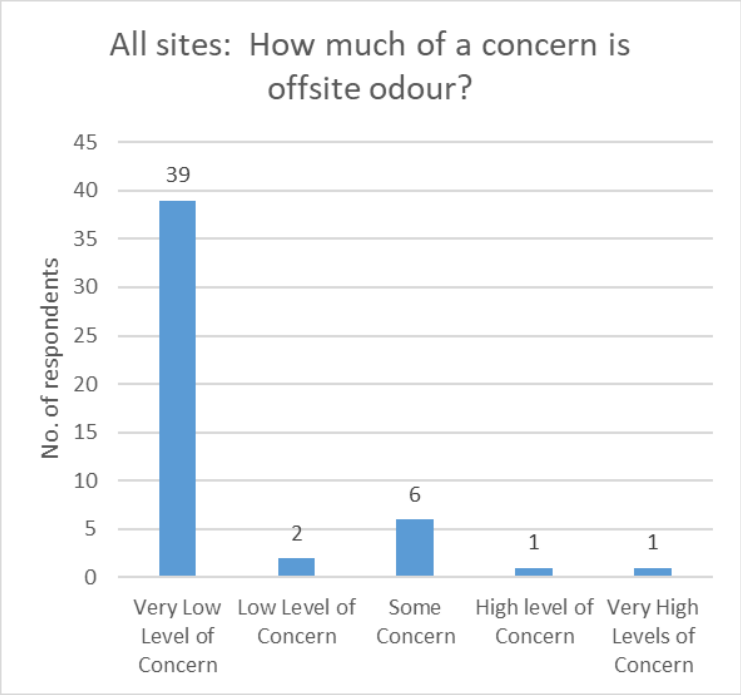

Figure 8. Chart showing all site responses to concerns about offsite odour

In terms of those sites ranked “Some Concern” or more serious, the issues were associated with the merchant and waste water treatment facilities:

- Merchant facilities: 2 sites had comments, one with “some concern” about fish waste (maintaining a watching brief). Another site had a “high level of concern” in general, without specific details mentioned.
- Waste water treatment: Concerns raised around three of the sites.

3.4 Outputs (Split by Sector)

3.4.1 Farm

3.4.1.1 Gas Generation and use

The following table summarises how the biogas produced from farm-based AD facilities has subsequently been used in 2017. A further breakdown of the uses or wastage, associated with biogas fed into the CHP unit is provided in later figures.

Table 20. Summary of the biogas volume generated by farm-based AD facilities and its use

Applications of biogas generated	2017	
	m^3	%
Total biogas generated	**63,079,213**	**100%**
Combined heat & power (CHP)	42,280,316	67.0%
Boiler heating only (not through CHP)	44,678	0.1%
Gas injection	20,615,959	32.7%
Gas flare	138,260	0.2%

A significant development of the last few years has been the growth of the biomethane for injection to the gas grid, with 32.7% of the biogas produced being used in this way for farm-based facilities. These farms tend to have larger AD plants than those not injecting gas to the grid, with higher percentages of crops being grown for this purpose. These crops also have higher yields of gas than obtained from slurries and manures, which are more commonly digested at the smaller sites.

Of the gas utilised via a CHP engine, Figure 9 below indicates that lower levels of biogas are lost through waste heat, compared to the other sectors. This is associated with applications for waste heat being found on the farm-based facilities. The 25% shown as being lost as waste heat in CHP engines translates to 17% of the overall gas yield.

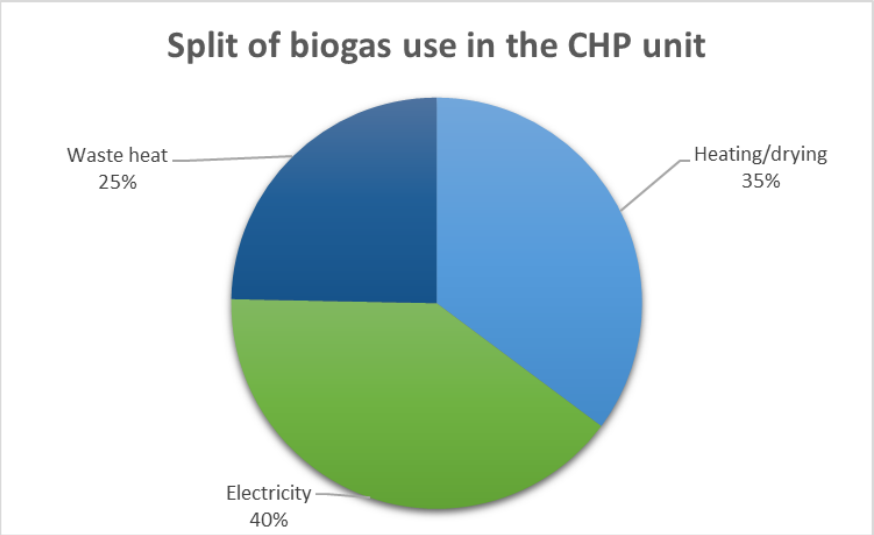

Figure 9. Chart showing how gas to the CHP is consumed within the farming sector.

3.4.1.2 Electricity Generation and use at farm AD sites

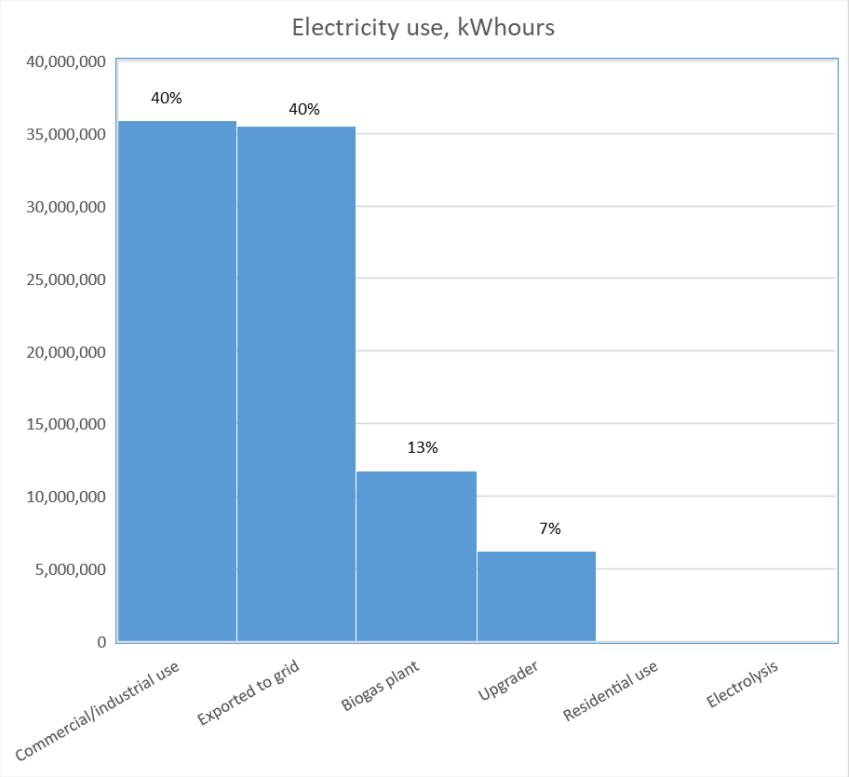

Figure 10. Chart showing electricity use at farm AD sites

3.4.1.3 Heat Generation and use – on farm AD sites

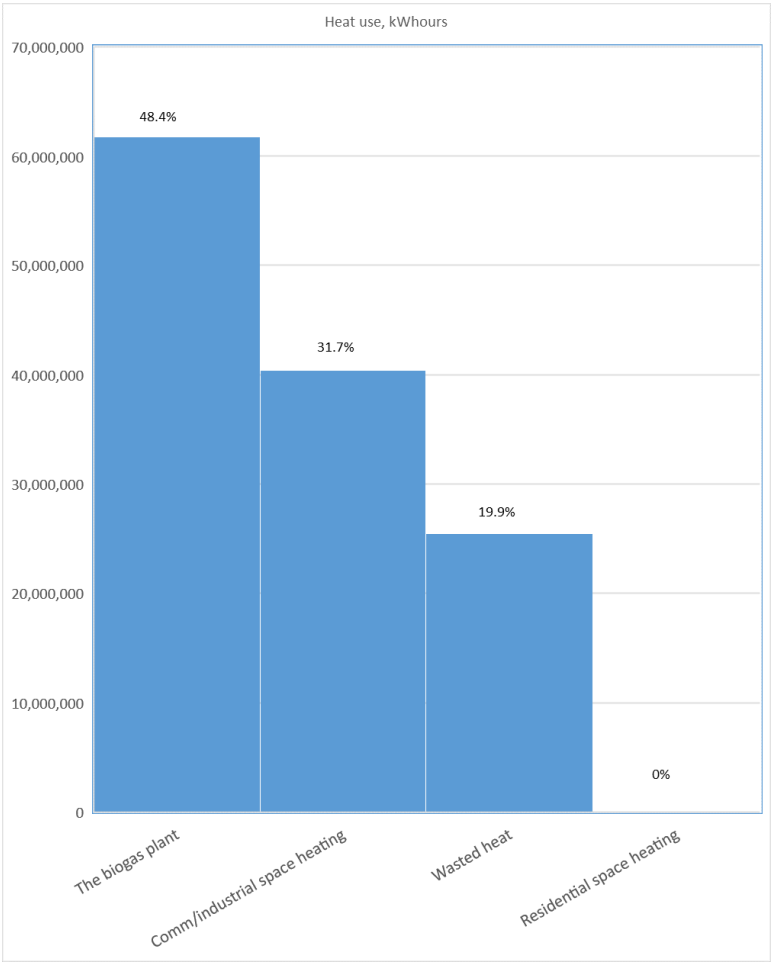

Figure 11. Chart showing heat use on farm AD sites

3.4.1.4 Digestate generation and use – on farm sites

The farming sector (27 sites) is estimated to have produced 417,935 tonnes of digestate during 2017. Key points in terms of the processing of digestate:

- No farm-based AD facilities (out of 27) were producing whole or separated PAS110 certified digestates.
- 20 of the farm-based facilties were separating the digestate into fibre and liquor fractions, while 7 produced only whole digestate.
- The most common means used of processing digestate (17 out of 20 responses) to produce fibre and liquor was by means of a screw press.

The type of digestate produced and the processing methods used, is described in the following charts.

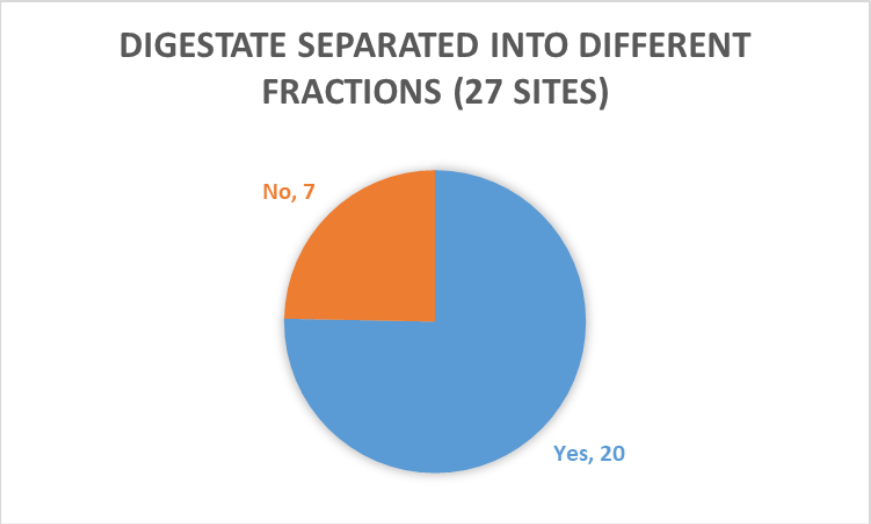

Figure 12. Status regarding the separation of digestate into fibre and liquor

Farmers not separating the digestate applied the whole digestate on their own farm, often using an umbilical system for application. Application of separated liquor and fibre was mostly on own or neighbouring land, often land where the AD crops were produced.

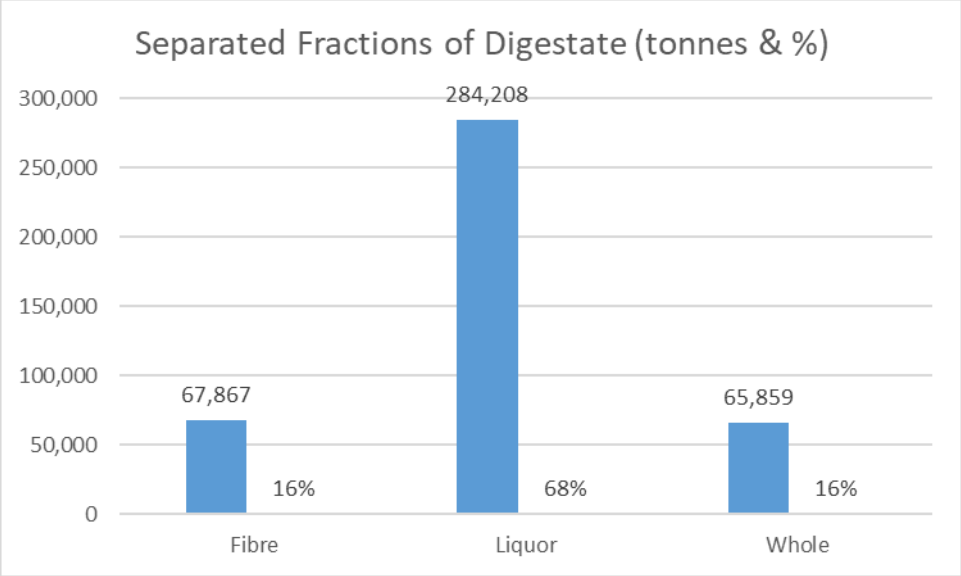

Figure 13. Tonnages and percentages of digestate types produced

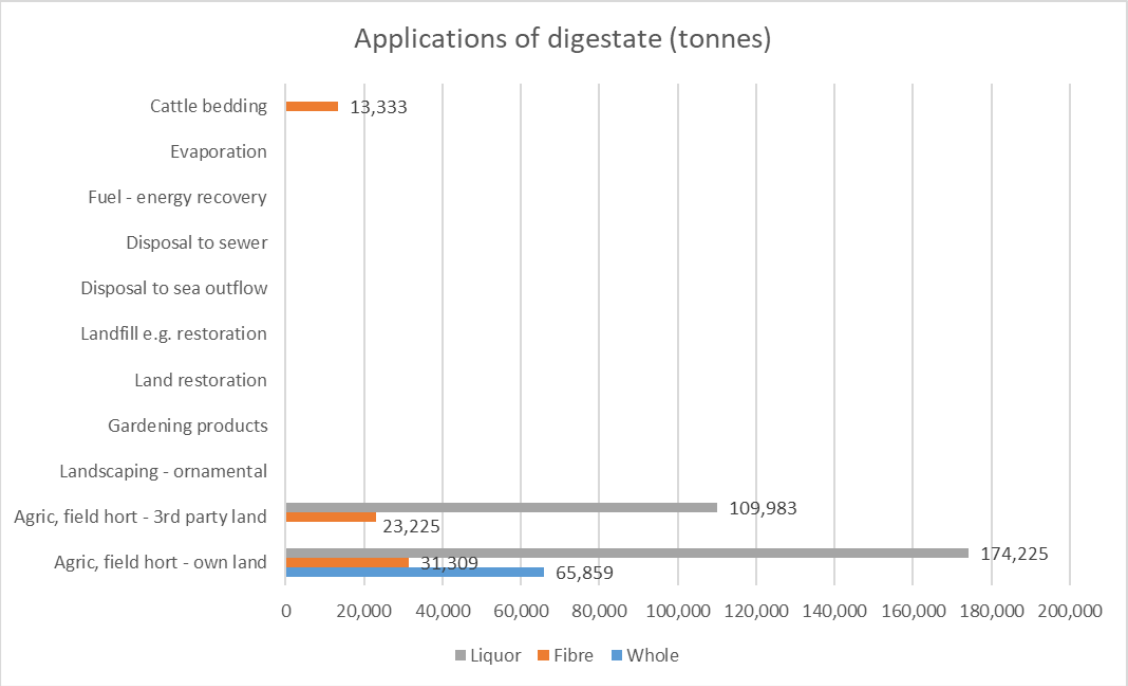

Figure 14. Summary of application options and those used for digestates

3.4.1.5 Digestate markets

The following two tables summarise the value generated by the use of digestate on both farmers' own and 3rd party land/locations.

This data is based on small samples, with a number of other farms indicating that they either did not know if using digestate was providing financial benefit,or they felt that it had done, but they were unable to quantify this. The values shown below are, in the case of applications to land, based on the farmers' own estimated cost savings for the use of digestate, this substituting for the purchase of inorganic fertilisers.

It should be noted that for two farms there was no distinction made between the value of applying separated liquor and fibre, just an overall cost saving – the column headed "Fibre + Liquor" is a reflection of this.

Table 21. Value secured for using digestates on own farms

Description	£/Tonne				
	Fibre	Liquor	Whole	Animal bedding	Fibre + Liquor
Own farm use	0.00	3.81	1.79	4.07	6.23
Range of prices	0	2.67 - 4.94	1.23 - 2.35	4.07	4.22 - 9.18
No. of farms data is based on	2	4	2	1	2

Table 22. Value secured for using digestates on 3rd party farms

Description	£/Tonne				
	Fibre	Liquor	Whole	Animal bedding	Fibre + Liquor
3rd party farm use	2.50	2.50	?	?	?
Range of prices	0 - 7.00	0 - 7.00			
No. of farms data is based on	4	4			

3.4.2 Merchant

3.4.2.1 Gas Generation and use

The following table provides an estimate of how biogas produced from merchant AD facilities has been used in 2017. A further breakdown of the uses or wastage, associated with gas burned by the CHP unit is provided in later figures.

Table 23. Summary of the biogas volume generated by merchant AD facilities and its use

Feedstock Categories	2017	
	m^3	%
Total biogas generated	**51,101,413**	**100%**
Combined heat & power (CHP)	43,508,900	85%
Gas injection	7,592,513	15%

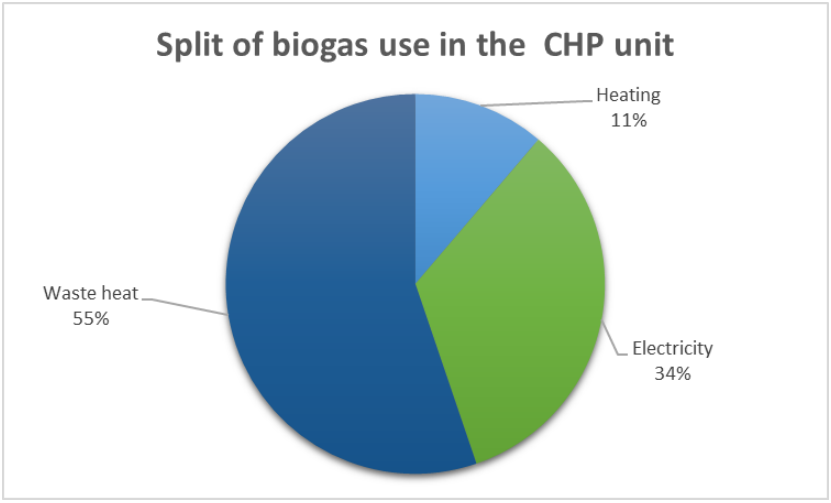

Figure 15. Chart showing how gas in CHP units is used by merchant AD facilities

The 55% shown as being lost as waste heat in the CHP engines translates to 47% of the overall gas yield (compared to 25% and 17% for farm-based systems).

3.4.2.2 Electricity Generation and use in merchant AD facilities

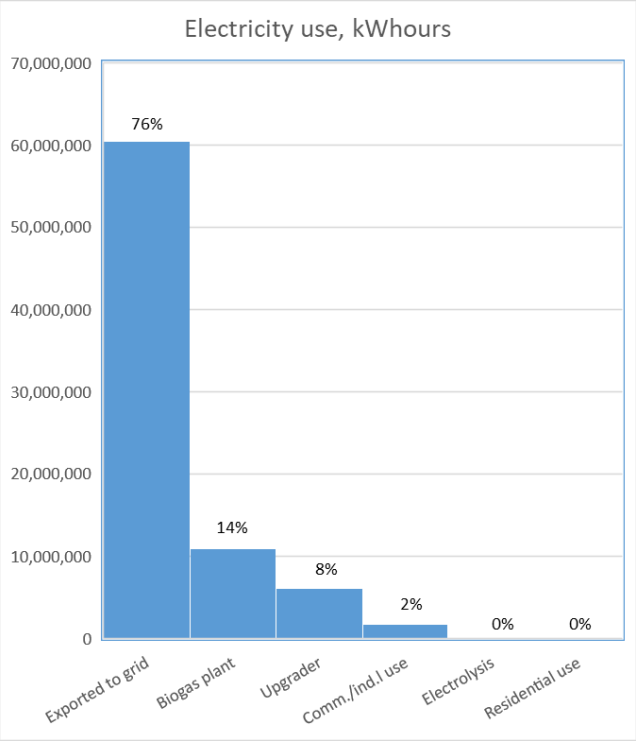

Figure 16. Chart showing how electricity generated is used

3.4.2.3 Heat Generation and use in merchant AD facilities

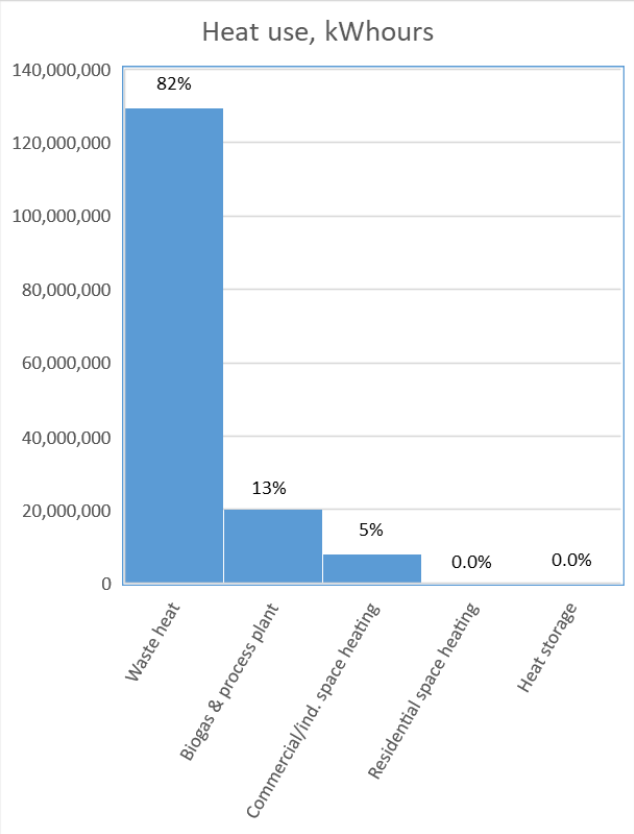

Figure 17. Chart showing how electricity generated is used in merchant AD facilities

3.4.2.4 Digestate generation and use by merchant AD facilitis

250,676 tonnes of whole digestate was estimated to have been produced from the merchant sector (9 sites). The type of digestate produced and the processing methods used, is described in the following charts.

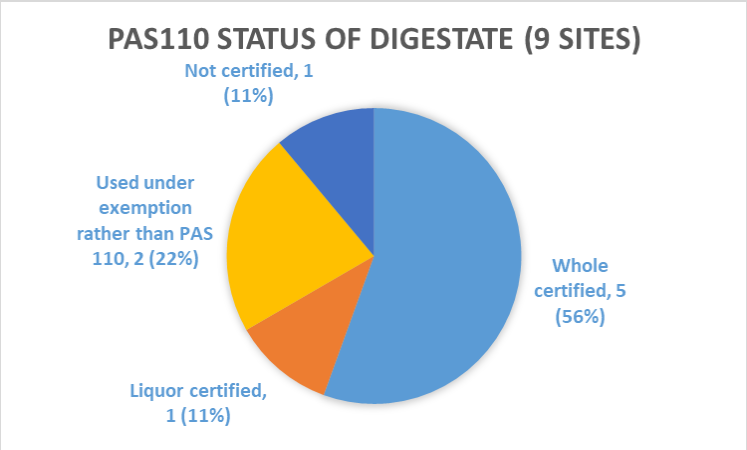

Figure 18. PAS 110 Certification

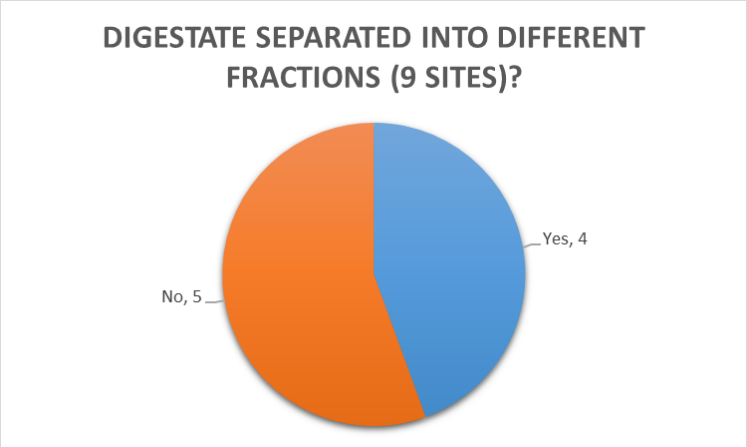

Figure 19. Status regarding the separation of digestate at merchant sites.

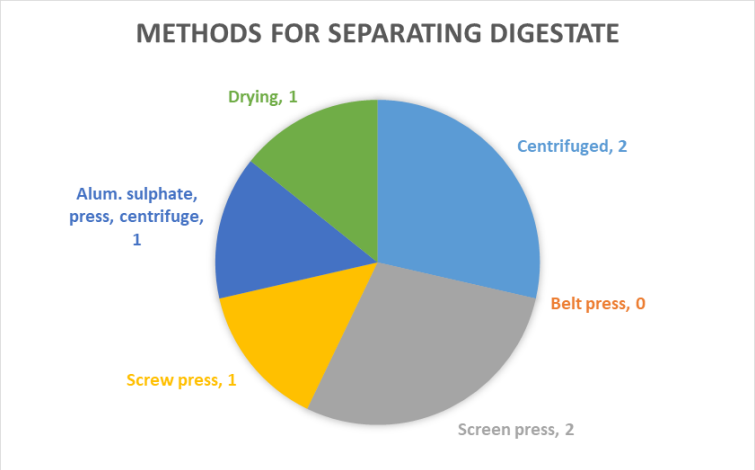

Figure 20. Methods used for separating digestate

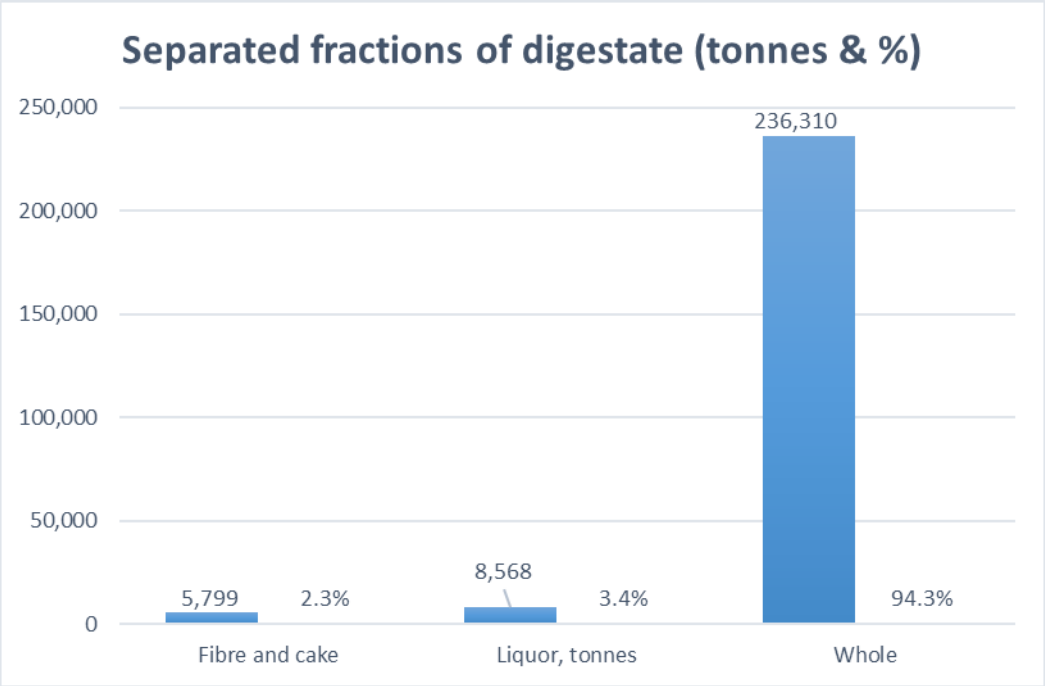

Figure 21. Tonnages and percentages of digestate types produced by merchant AD facilities

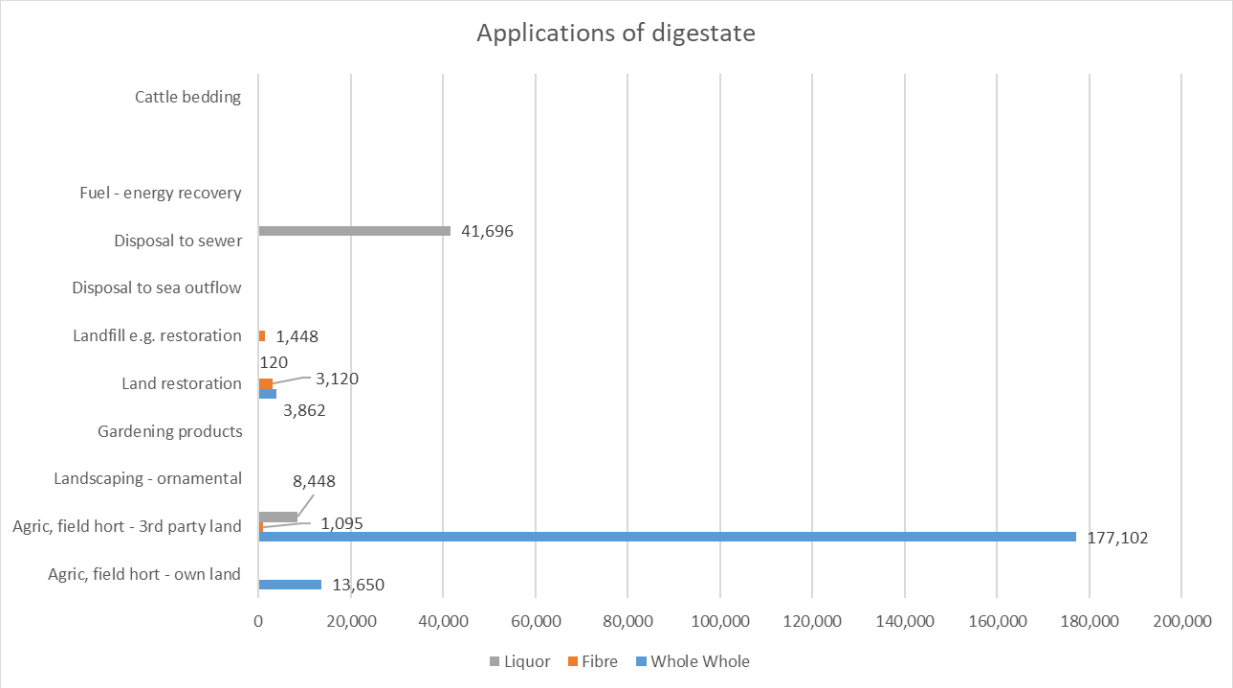

Figure 22. Applications of digestate types from merchant AD facilities

3.4.2.5 Digestate markets

The following two tables summarise the value generated by the use of digestate from merchant facilities at 3rd party sites. The first table provides a split in terms of sales value, with haulage/applications costs also shown to give a net price/cost.

The second table provides aggregated costs and also an avoided cost associated with using digestate.

Table 24. Prices and costs (-ve numbers), broken down, associated with digestate going to agricultural land for merchant AD facilities

Description	£/Tonne		
	Fibre	Liquor	Whole
Gate Price	10.00	1.00	3.00 to 10.00
Haulage and spreading cost	-8.75	-7.00	-8.75
Net Price	1.75	-6	-5.75 to 1.25
No. of AD sites data is based on	1	1	3

Table 25. Prices and costs (-ve numbers), aggregated, associated with digestate going to agricultural land or for landfill resoration for merchant AD facilities

Description	£/Tonne		
	Fibre	Liquor	Whole
Agriculture - delivered			-4.50 to -5.00
Land restoration - delivered			-10
Landfill restoration delivered (avoided cost)	26		
No. of AD sites data is based on	1		3

3.4.3 Industrial

3.4.3.1 Gas Generation and use

The following table provides an estimate of how biogas produced from industrial AD facilities has been used in 2017. A further breakdown of the uses or wastage, associated with gas burned by the CHP unit is provided in later figures. This split is particularly vulnerable, in terms of accuracy, because survey data coming from only 3 of the 7 sites that overall estimates are provided for.

Table 26. Summary of the biogas volume generated by industrial facilities and its use

Feedstock Categories	2017	
	m3	%
Total biogas generated	**84,571,404**	**100%**
Combined heat & power (CHP)	21,876,031	26%
Gas injection	61,695,373	73%
Boiler heating only (not through CHP)	1,000,000	1%

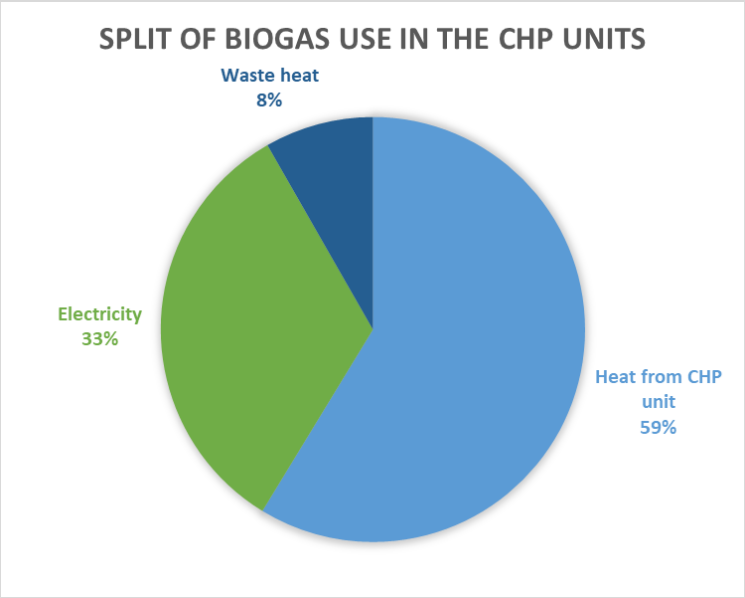

Figure 23. Chart showin the split in terms of biogas used in the CHP Units

3.4.3.2 Electricity Generation and use in industrial AD facilities

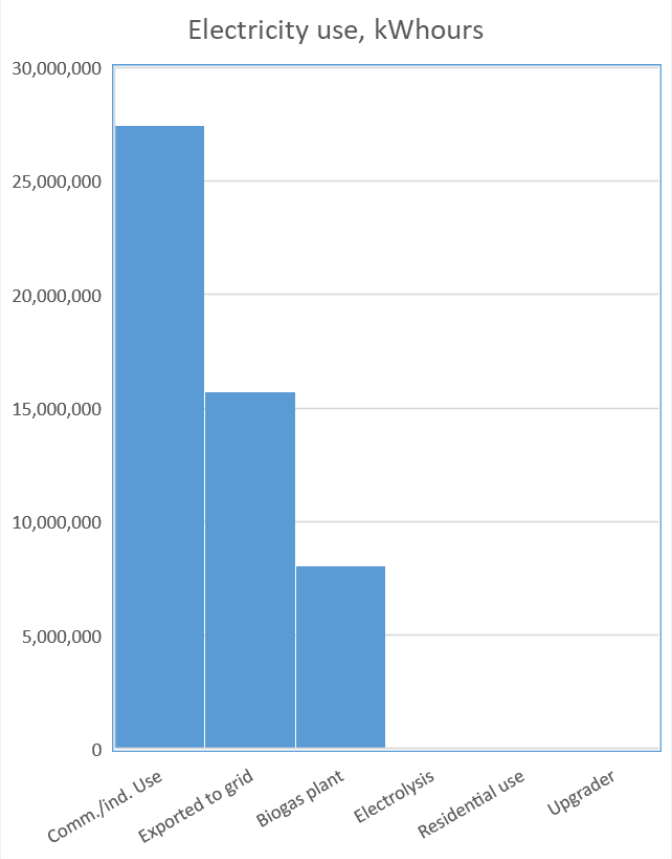

Figure 24. Chart showing how electricity generated is used

3.4.3.3 Heat Generation and use in industrial AD facilities

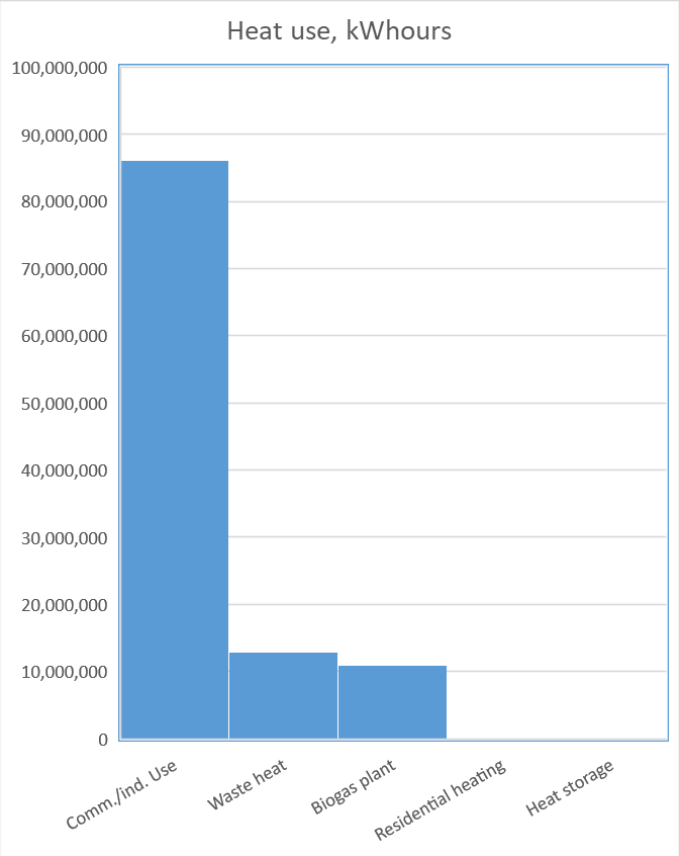

Figure 25. Chart showing how heat generated is used in industrial AD facilities

3.4.3.4 Digestate Generation and use for industrial AD facilities

With the industrial sector providing the lowest level of engagement in the survey, the estimates provided in terms of digestate application are extrapolated from the 3 sites that responded and applied to all 7 identified to be operating in 2017. As such the data in this section, should in particular, be treated with caution. Estimates associated with other outputs (e.g. biogas volume, described previously) are based on more robust data sources, as explained in Appendix B.

There is no PAS110 certified digestate and limited processing and separation identified – an estimated 125,067 tonnes (1.7% of total) is produced as a dewatered output, with 165 tonnes produced as a biosolid fraction for a non-agricultural market.

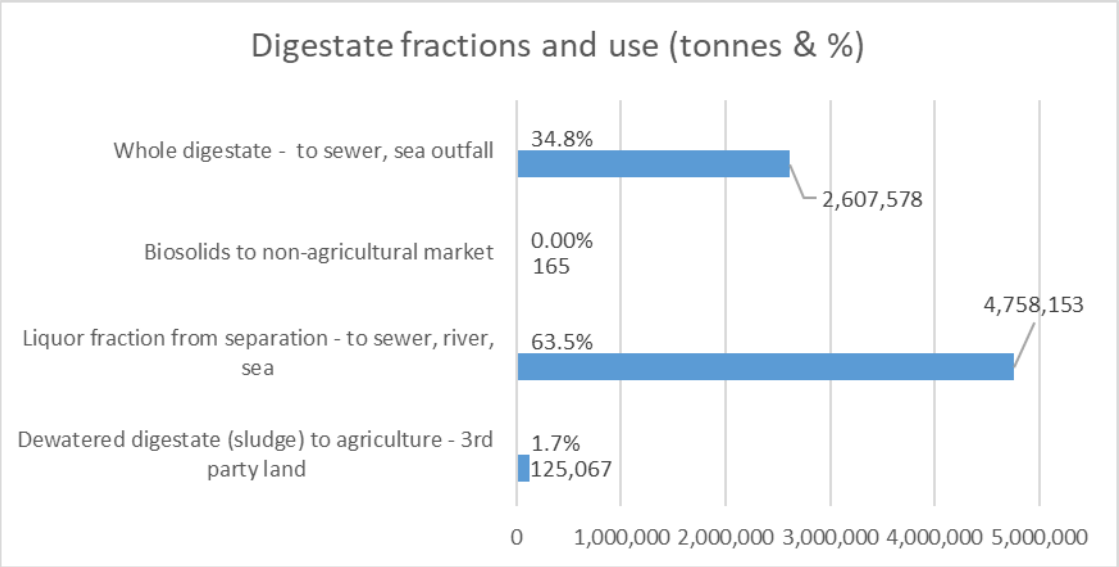

Figure 26. Chart showing the management of digestate fractions in industrial AD facilities

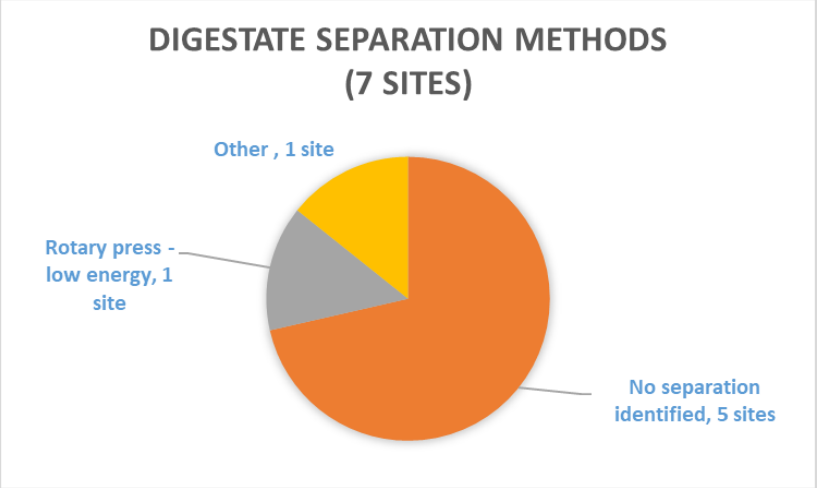

Figure 27. Chart showing digestation separation methods, where identified

3.4.3.5 Digestate markets

Agricultural use of separated solids was identified, given free of charge to local farmers. An alternative, commercial transaction, was also identified outwith agriculture (details not known).

3.4.4 Waste Water Treatment

3.4.4.1 Gas Generation and use

The following table provides an estimate of how biogas produced from waste water treatment AD facilities has been used in 2017. A further breakdown of the uses associated with gas burned by the CHP unit is provided in later figures.

Table 27. Summary of the biogas volume generated by waste water treatment facilities and its use

Feedstock Categories	2017	
	m3	%
Total biogas generated	**18,381,414**	**100%**
Combined heat & power (CHP)	16,007,146	87%
Boiler heating only (not through CHP)	103,450	1%
Gas flaring	2,270,817	12%

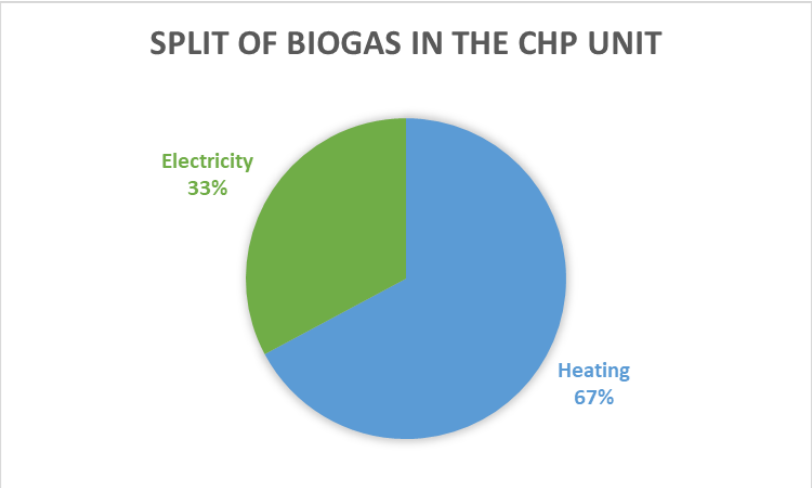

Figure 28. Estimated split of biogas use in the CHP units (no data available in terms of waste heat – assumed to all be used for processes)

3.4.4.2 Electricity Generation by waste water treatment AD facilities and use

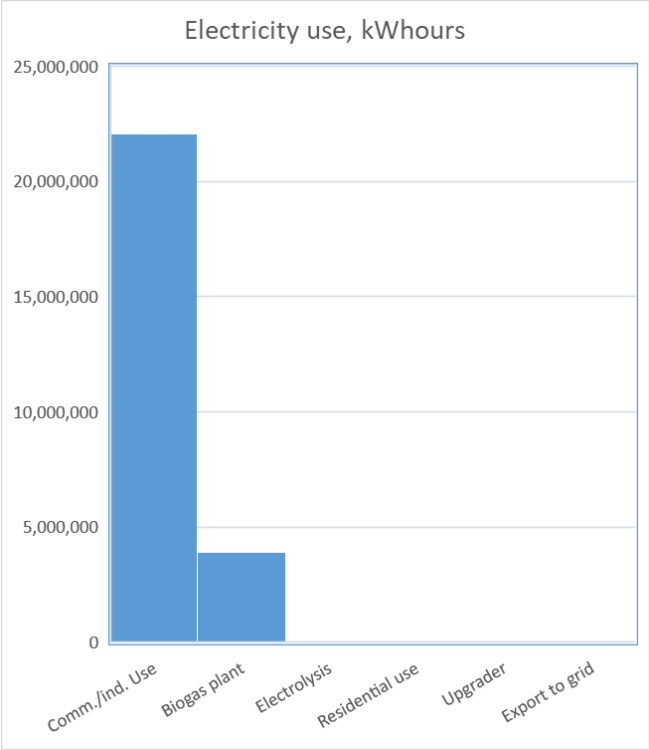

Figure 29. Chart showing how electricity generated by waste water treatment AD facilities is used

3.4.4.3 Heat Generation by waste water treatment AD facilities and use

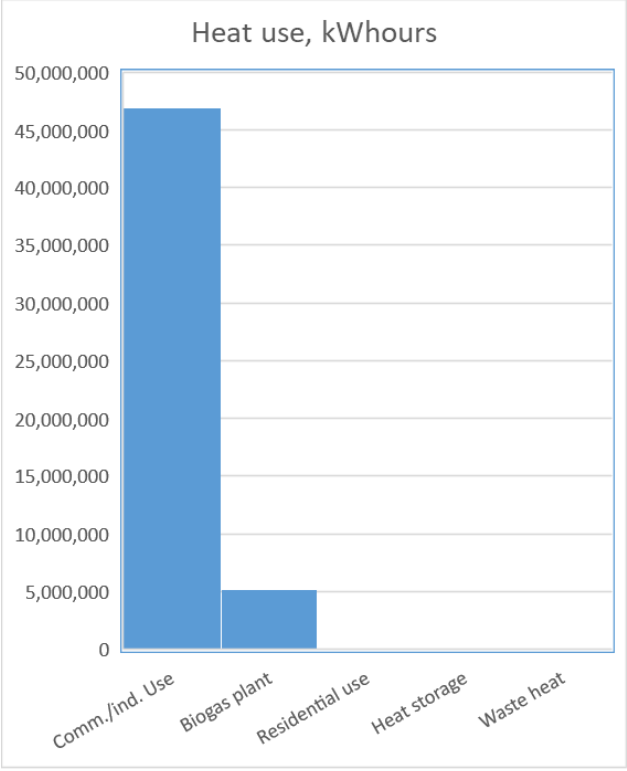

Figure 30. Chart showing how heat generated by waste water treatment AD facilities is used

3.4.4.4 Digestate Generation and use

An estimated total of 599,524 tonnes of whole digestate is produced, none of which is PAS110 certified (processes using sewage sludge as an input is not allowed to be PAS certified). An estimated 62,548 tonnes (9% of total) is produced as a dewatered and/or dried output.

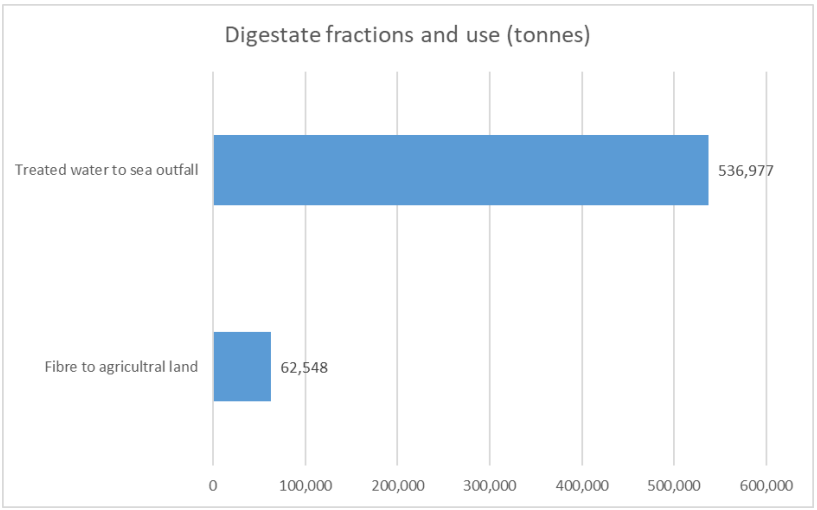

Figure 31. Chart showing digestate generation and use from waste water treatment AD facilities

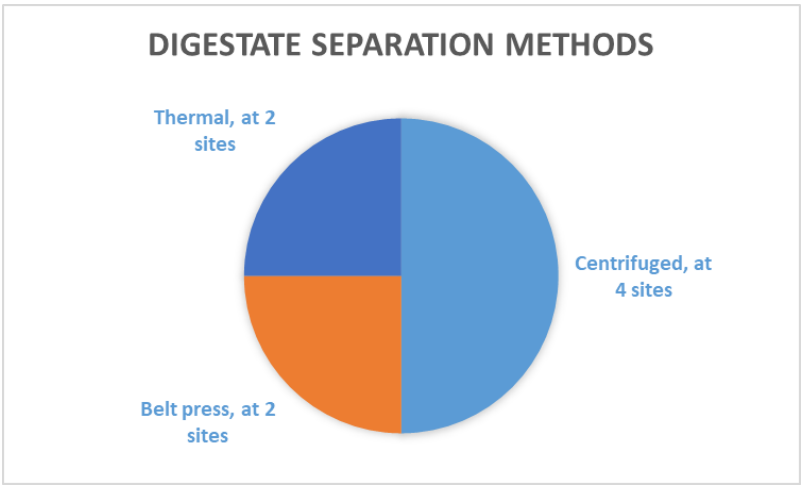

Figure 32. Chart showing digestate separation methods by waste water treatment AD facilities

3.4.4.5 Digestate markets

All separated fibres were applied to third party agricultural land, with no commercial data provided, in terms of costs.

4 Have Your Say

4.1 Overview

The survey of the AD sector for 2017 included questions on the following:

- How much of a concern is physical contamination in the feedstocks?

- How much of a concern is offsite odours?
- Are there any other threats you see in your business/the sector?
- What are the key opportunities in terms of support that your business or the sector would benefit from?

The responses to each of the above questions are summarised in the following sections, for (i) the farm-based sector, (ii) the merchant sector and (iii) industrial/waste water treatment sector (together).

Feedback from the merchant, industrial and waste water treatment sites was more varied in nature than the views expressed by the farm-based AD operators. As such, the feedback from the former is shown under the two headings, "Threats" and "Opportunities", with the wording only changed to maintain anonymity.

4.2 Farm-based AD operator feedback

The 19 site operators who provided general feedback were predominantly positive in outlook for their sites, and keen to discuss aspects of the Scottish on-farm AD sector.

Regulatory issues: Ten site operators (53%) highlighted red tape (including APHA, QMS, SQC and SEPA rules and regulations) as a major issue. This includes rules being too restrictive, strict, costly or unclear. For example regulations regarding specific feedstock types and categories, with several farms aware of brewery or other residues, food and abattoir wastes which they could in theory take, but were unclear of the regulations. At least 3 farmers (16%) processing only crops and / or manures were confused as to whether PAS110 is needed. One site had issues with the electricity network and getting what it felt was a suitable grid connection. They commented that, in the end they had to secure two separate grid connections with significantly higher costs than had been planned.

Connection issues: Electrical grid connection was highlighted as an issue for 8 (42%) farms, predominantly paperwork regarding connection and restrictions with permitted input load. Gas grid connection was highlighted as an issue for 16% of farmers.

Finance issues: Feed-in tariff value for new entrants to the Scottish AD industry was deemed an issue by 7 (37%) of respondents, with lack of available finance also being a consideration by 2 farmers (11%). An unclear distinction between business rates and agricultural rates was highlighted by 3 (16%) of the farmers. More support for on-farm dairy and beef sites where AD is not yet installed, or no longer operational, to manage slurry and manures was also recommended.

AD equipment: Farmers were generally satisfied with their AD systems, with 3 farmers specifically stating they were happy and the same number (16%) having some issues with their technology provider, with only one AD system not working well at all. However, 2 farmers felt the AD market was dominated by systems designed for crops less suited for the Scottish climate such as maize, and hence some issues were encountered when feeding with grass silage and other crops. The AD maintenance and general running costs were higher than anticipated for 3 of respondents. Several sites commented that several of the on-farm staff need to clearly understand the AD process and that this makes minor adjustments to the equipment easier, cheaper and quicker to do in-house.

Agronomic benefits: The farmers generally felt the digestate had some agronomic benefits, with 5 (26%) highlighting fertiliser cost savings and 16% soil improvements (organic matter, soil health). Moreover, 4 (21%) noted an improvement in spreading consistency and a reduction in odour as compared to the application of raw slurry or manure, and hence a cessation in complaints from the general public. One farmer suggested that future surveys include a question on application technique. The provision of a simple calculation for avoided cost / spreading / fertiliser value of digestates was suggested. Potential alternative uses for the digestate was discussed by 2 (11%) of farmers, with clear guidance regarding what is currently permitted /feasible was proposed.

Support for the on-farm AD sector: 21% of farmers (4 farmers) felt that capital grants for supporting infrastructure would be beneficial, including digestate storage (container/lagoon) and store covers to reduce ammonia emissions, gas upgrading and compression equipment for smaller on-farm AD systems

to enable biogas use in farm vehicles, and electric charging points for on-farm electric vehicles. Farmer-focussed AD groups were highlighted by 3 farmers as an ideal means for peer support to discuss issues and compare tips.

4.3 Merchant AD operator feedback

Waste stream issues: The availability of food waste from both business and households was discussed, including how to improve participation and put-out rates. More communication and support for raising awareness was recommended.

Feedstock competition: Competition over feedstock both within Scotland and also from English AD sites as far away as London were highlighted as being an issue by several operators, for example from larger sites that can get higher revenue streams from biomethane production, or English sites where there is a view that these are already set up to process feedstocks such as fish waste. One operator commented that increasing co-mingled collections (garden + food) from LAs is removing food waste from AD feedstocks, whilst another highlighted that the demand for animal feed means that pot ale is being sent south of the border.

Feedstock opportunities: The potential for managing and keeping feedstocks processed locally was commented by two operators. Three site operators commented on the potential for digesting fish waste, distillery residues, glycerol or molasses as an additional feedstock, although current challenges described include fish waste blood content, storage and transport, with sites needing a guaranteed feedstock in order to make the relevant changes to the AD process (potential capital expenditure) and additional paperwork (including Ofgem) to accommodate this new feedstock, or even obtaining a waste management licence. One operator recommended regional depots for ensiled fish, which would assist in making this a more viable feedstock for Scottish AD facilities in in the future.

One operator highlighted that the impending 'no organics to landfill' regulation should result in more organic waste feedstock being available for AD, but felt that enforcement would be needed to make this happen.

Comments regarding opportunities around education of the public to reduce contamination and to increase capture rates, was discussed by one operator, suggesting that if the public were informed what happened to their waste this would help.

Digestates: Feedstock contamination and hence potential for digestate to be contaminated is an issue, and so more education was commented on as being key to reducing this. Hence, people need to know where their food waste is going. One operator commented that if they were to lose their exemption for landfill restoration and PAS 110 certification, for example as a result of contamination, this would be an issue. Another operator was concerned that there was a lack of destinations for the digestate.

Two site operators commented that encouraging the use of digestates on agricultural land, such as facilitating interaction between site operators and farmers to discuss the benefits and fertiliser value of digestates would be beneficial. One site operator commented that solutions for the plastic waste (contamination) should be developed.

Capital support: One operator made comments relating to capital support which they believe is needed to upscale their AD capacity, in particular to invest in equipment which allows the energy produced to be used for higher income generating purposes.

Staff: One operator commented on challenges recruiting for the facility, including a lack of skilled engineers in the local area. They queried whether the Scottish government could encourage more people into engineering through college and university.

Regulations: There has been a missed oppportunity with the Waste (Scotland) 2012 Regulations, when businesses were required to make food waste available for collection, and the threshold reduced from 50 to 5kg for commercial food waste collections. There has been no enforcement of this and the company has seen no change in behaviour.

Financials: One site mentioned that pricing made business more difficult. It was also mentioned that government intervention to remove the Levy Exemption Certificates (LECs) was a major hit to their income stream. In addition, the government removed the 100% rebate for non-domestic business rates – this was a major hit.

4.4 Industrial and waste water treatment AD operator feedback

Small-scale AD: Several industrial sites felt there was real potential for small-scale (e.g family-run processing sites, remote distilleries, dairy food processors, brewers, small factory sites and remote rural communities) AD sites to process residues produced onsite and locally, with the right support, in the form of funding and advice. One site operator commented that advice to small companies could also include highlighting the potential energy within the food waste/residues and the opportunities that AD can offer as a waste management solution.

A site operator commented that SME local AD sites are a big opportunity for low carbon and the circular economy. Development of the AD technology for processing specific feedstocks and small scale was highlighted by one operator as being beneficial, with demonstration sites, case study and other relevant information well communicated to potential site operators.

Feedstock opportunities: One operator commented that pot ale and spent lees which are currently being discharged to sea, plus other residues from the dairy and other industries could be processed via AD.

Beneficial heat use: Two sites commented that guidance on how to maximise heat usage, with both general and site-specific guidance on the RHI (including what is allowed and how to apply) and potential opportunities for using waste heat would be beneficial. The potential for ZWS or other organisations to assist in heat recovery advice was commented by several sites.

5 Conclusions

This 2017 survey has shown a number of major changes in the Scottish AD sector since 2014, with the key conclusions summarised below.

Feedstocks

There has been a significant increase in the digestion of manures, slurries, crop residues and purpose grown crops at farm-based AD sites across the country.

In terms of growth in the sector, the 2014 and 2013 surveys identified 157,000 and 132,000 tonnes of feedstock being processed, combined, through farm and merchant AD facilities (no tonnage identified for industrial and waste water treatment sites). In 2017 the farm-based AD sector alone processed three times this combined feedstock, predominanty from crops, crop residues and manures.

The only food waste identified from the survey as being processed in Scotland was through merchant AD facilities, with 141,651 tonnes supplied as feedstock in 2017. This compares to 109,028 and 128,969 tonnes processed in 2014 and 2013 respectively. However, for a more complete picture of how much food waste is being generated and processed, it is important to also note that in 2017 34,300 tonnes of food waste was processed in composting facilities, which compares to 32,000 tonnes in 2014. The combined total of food waste processed through AD and composting facilties in 2017 was therefore 175,951tonnes, compared to 141,028 tonnes for 2014.

Industrial facilities have the largest throughput (almost 8 million tonnes estimated), with large volumes of liquid feedstocks (mostly pot ale) being processed. For facilities where solid organic waste is a key feedstock, farm-based AD facilities processed 458,032 tonnes in 2017, with merchant facilities doing 338,783 tonnes. Waste water treatment AD facilities processed 631,078 tonnes.

Heat and Power

Electricity generation in 2017 was estimated to be 245,519MWh, with the largest generator being the farming sector (89,332 MWh, 36% of the total).

Heat generated and used, across all sectors in 2017, was estimated to be 279,381MWh, with the farming and industrial sectors accounting for 37% (102,182) and 35% (97,043 MWh) of this respectively.

Farm-based AD facilities are generating significantly lower levels of waste heat from CHP units, a result of both gas grid injection and on-site applications for the heat that is generated from CHP units – an estimate of 25% of biogas lost through these units as waste heat compared to 55% for the merchant facilities modelled.

Biogas

It is estimated that 217 million m^3 of biogas was generated by Scottish AD facilities in 2017. Injection to the gas grid network is now a significant feature of the Scottish AD sector, mostly from industrial and farm-based facilities, these representing 39% and 29% respectively of biogas produced and being processed for this purpose.

The industrial AD sector is now estimated to be the largest in the country in terms of biogas production, with 84.6 million m^3 produced in 2017. This is followed by farm-based AD, which is estimated to produce 63 million m^3, and then the merchant and waste water treatment sectors, producing circa 51 million and 18 million m^3 respectively.

Significant volumes of by-products and food waste are still being lost, discharged to sea or in landfill respectively, representing a loss of a substantial volume of biogas potential as well as an economic loss of resources.

Digestates

Digestate produced by merchant and farm AD systems is mostly used on agricultural land, and in the case of the latter is often used on the farm's own land, where it is recognised as a valuable biofertiliser, replacing inorganic fertilisers.

6 Acknowledgements

The authors thank all AD site staff who dedicated time to discussing their sites for this project. The authors also acknowledge stakeholder organisations and individuals for promoting the project and providing comments on previous surveys to support the design of this 2017 survey. The authors acknowledge Joachim Steiner (Cambridge Eco Ltd) and Donna Wood (Enscape Consulting Ltd) for input to the project and reviewing this report.

01786 433930 zerowastescotland.org.uk @ZeroWasteScot