
Green Investment Bank

Introduction

The Green Investment Bank (GIB) was established by the Government to “accelerate investment in the green economy”. Waste, including recycling and energy from waste, is one of GIB’s priority areas for investment.

Anaerobic Digestion (AD) is at the core of the Government’s waste policies. In 2011 DEFRA and DECC jointly issued an “Anaerobic Digestion Strategy and Action Plan”ⁱ; which set out the opportunity for the AD sector (including sewage treatment) and indicated that AD could deliver between 3 and 5 TWh of electricity by 2020. Consistent with these policies, renewable energy produced by AD facilities is entitled to support under the Renewable Obligation Scheme, Feed in Tariff (FiT) and the Renewable Heat Incentive (RHI).

The sector is developing rapidly. In March 2013, it was reportedⁱⁱ that the AD industry in the UK had 106 anaerobic digestion plants operating outside the regulated water industry, with a reported processing capacity of up to 5.1 million tonnes of food and farm waste every year. A further dozen plants were reported to be under construction.

The AD industry has however expressed concerns to GIB that securing funding, and in particular senior debt finance, is one of the key constraints to the on-going development of the sector. Yet, from discussions with prospective debt investors, the general view is that the UK AD industry is relatively immature and consequently has a risk profile better suited to equity rather than debt investment.

Rationale for Market Report

In order to better understand the sector, GIB has commissioned research from SLR Consulting which, alongside GIB’s in-house analysis, assesses the development of the AD market and the operational performance of UK facilities. It is hoped that sharing the findings of this research, on an on-going basis, will help to improve industry and investor understanding of the sector. Better understanding of the necessary factors required for project success should enable the investment community to allocate capital appropriately to AD projects, and successful projects should in turn increase investor confidence in, and capital commitments, to the sector.

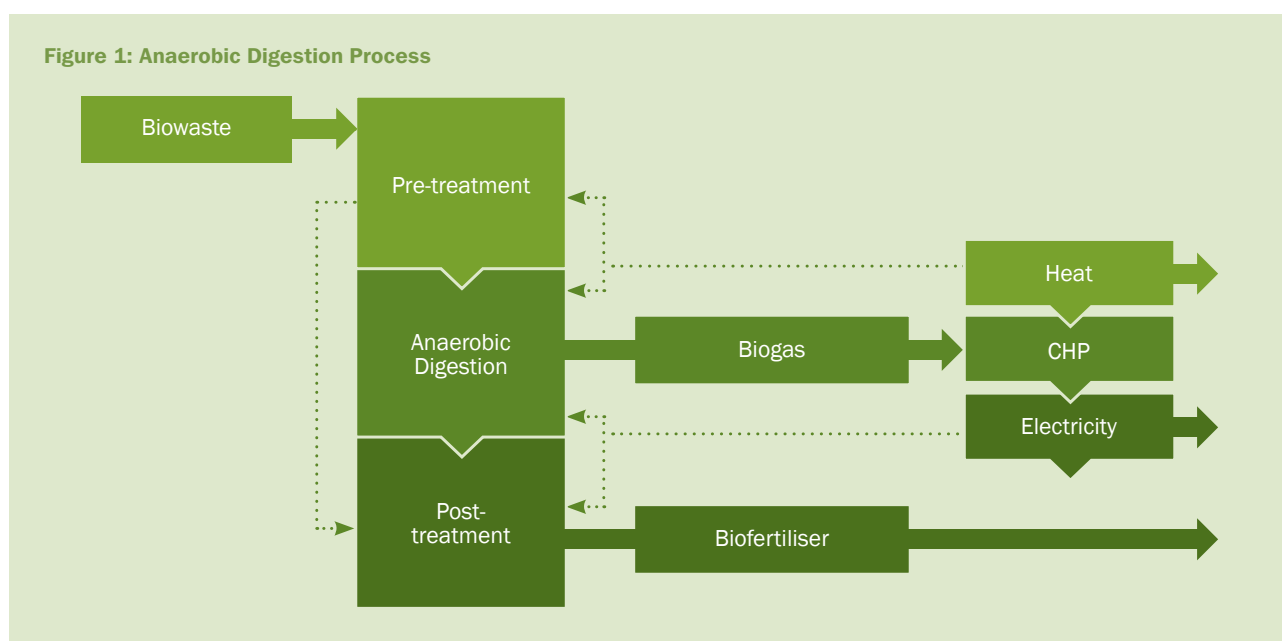
Key Findings

- **Growing opportunity:** There has been significant recent growth in the AD sector with 106MWe of capacity installed or in construction by FY2012, versus 45MWe in FY2010. An additional 148MWe of specific capacity has been identified as available to be developed which would require capital investment of circa £650 million;
- **Fragmented and immature market:** AD sector is highly fragmented and immature – with the top 5 operators accounting for less than 28% of the market with the majority of facilities in the UK having been in operation for less than 3 years;
- **Wide ranging industry load factors:** There is a marked divergence in operational performance between different facilities much of which is attributed to feedstock. Operational performance for agricultural facilities in 2012 was 69%; 67% for source segregated food and 19% for residual waste;
- **Critical Factors to Project Success:** a) Feedstock selectivity; b) Deep understanding of, and access to local markets for Digestate; c) Dedicated operating personnel; d) Active process management

Understanding Anaerobic Digestion (AD)

AD is not a new technology, and has been widely applied in the UK for the treatment of sewage sludge for over 100 years. However, only recently has it been used in the UK for treating other waste and purpose-grown crops, in order to generate renewable energy and divert waste from landfill.

AD is a natural process in which micro-organisms break down organic matter or biowaste (such as food waste, slurry, crop residues, etc.), in the absence of oxygen, into biogas (a mixture of carbon dioxide (CO₂) and methane) and digestate/biofertiliserⁱⁱⁱ. AD is used for industrial or domestic purposes to manage waste and/or to release energy. The biogas can be used in a number of ways: directly in engines for Combined Heat and Power (CHP); burned to produce heat; or can be cleaned to become bio-methane and used in the same way as natural gas or as a vehicle fuel. The digestate/biofertiliser, which is made from the left over indigestible material and dead micro-organisms, contains valuable plant nutrients like nitrogen and potassium, and can be used as a renewable fertiliser or soil conditioner^{iv}.



Source: DEFRA and DECC

The Development of AD in the UK

The focus of GIB's commissioned research has been upon three broad feedstock categories:

- **Agricultural** - farm wastes, as well as purpose grown energy crops;
- **Source segregated food** - controlled wastes produced by households, commerce and industry;
- **Residual waste** - waste which is left after recycling, composting etc. AD is utilised as part of a mechanical biological treatment process in order to treat residual waste.

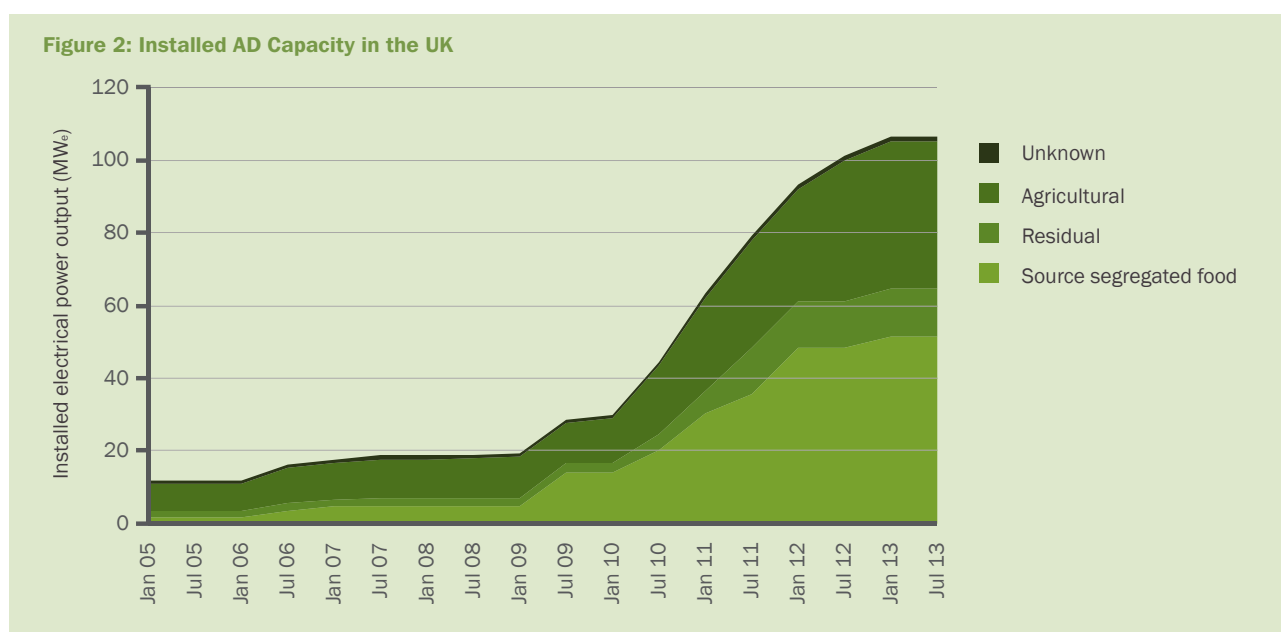
Dedicated facilities in the mature waste water/sewage treatment sector, operated as part of the regulated waste water industry, have been excluded from the research.

The recent growth of the AD sector (see Figure 2), as measured by the "nameplate" installed generation capacity, has been significant, with 106MW_e of capacity identified by SLR Consulting's research as currently operational or

under construction. SLR Consulting’s research has identified a further 148MW_e of capacity either with planning consent or for which planning has been applied based on known facilities, although naturally not all of these planned facilities will be built. The rate of additional growth in the sector will be driven by a number of factors, including the availability of finance and feedstock.

By way of illustration, if it is assumed that this identified pipeline were to be built out, using DECC assumptions^v of a median cost of £4.4 million per 1MW of installed capacity (consistent with GIB’s own project specific information), circa £650 million of additional investment would be required.

The AD sector is also currently highly fragmented. GIB analysis indicates that the top 5 players account for c.28% of the total installed capacity. This compares to approximately 75%^{vi} in the UK Municipal Solid Waste Incineration sector and 71%^{vii} in the UK offshore wind sector. In addition, according to SLR Consulting’s analysis, no one developer/operator accounts for more than 8% of the total installed capacity in the AD sector.



Source: SLR Consulting

Figure 2 also serves to highlight the immaturity of the UK market; with the majority of facilities in the UK having been in operation for less than 3 years. GIB also note that according to Ofgem data, there are a total of 84 facilities^{viii} (excluding sewage industry) currently accredited under ROCs, FITs and RHI and claiming benefits.

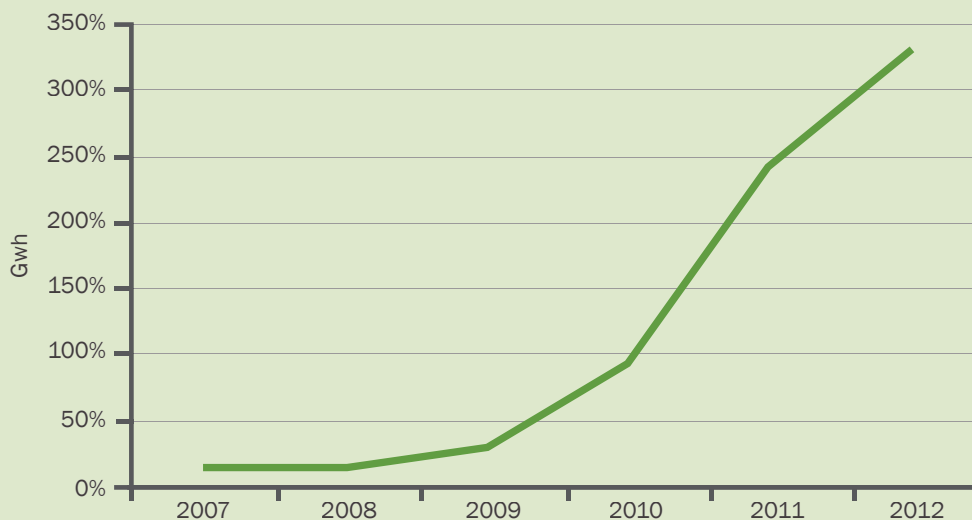
Figure 3: Accredited AD Capacity in the UK

Accredited Facilities	
ROCs	33 ^x
FITs	49 ^x
RHI	2
Total	84

Source: Ofgem

There has been a steady increase in the renewable power exported from AD corresponding to this increase in installed AD capacity. Preliminary data for 2012 in Figure 4^{xi} shows total power generation from AD (excluding sewage sludge digestion) had increased by 38% to 330 GWh in 2012, from 239 GWh in 2011. It is worth noting that this is circa 10% of the potential identified in the government's "Anaerobic Digestion Strategy and Action Plan".

Figure 4: AD Power Generation in the UK



Source: DUKES

Operational Performance of AD

Gross power generation is of itself not a particularly meaningful basis for considering operational performance of the sector.

The selected operational performance metric is "average load factor", calculated by comparing reported power production eligible for support against reported installed capacity.

It is recognised that average load factor is but one of a series of potential measurements of operational performance – and subject to the accuracy of the information provided, level of parasitic loads etc. – but it is a convenient method by which the relative performance of facilities can be measured and/or aggregated. Of particular significance is the absolute level of operational performance and its variability over time.

Low absolute operational performance will most likely arise through one or a combination of the following reasons:

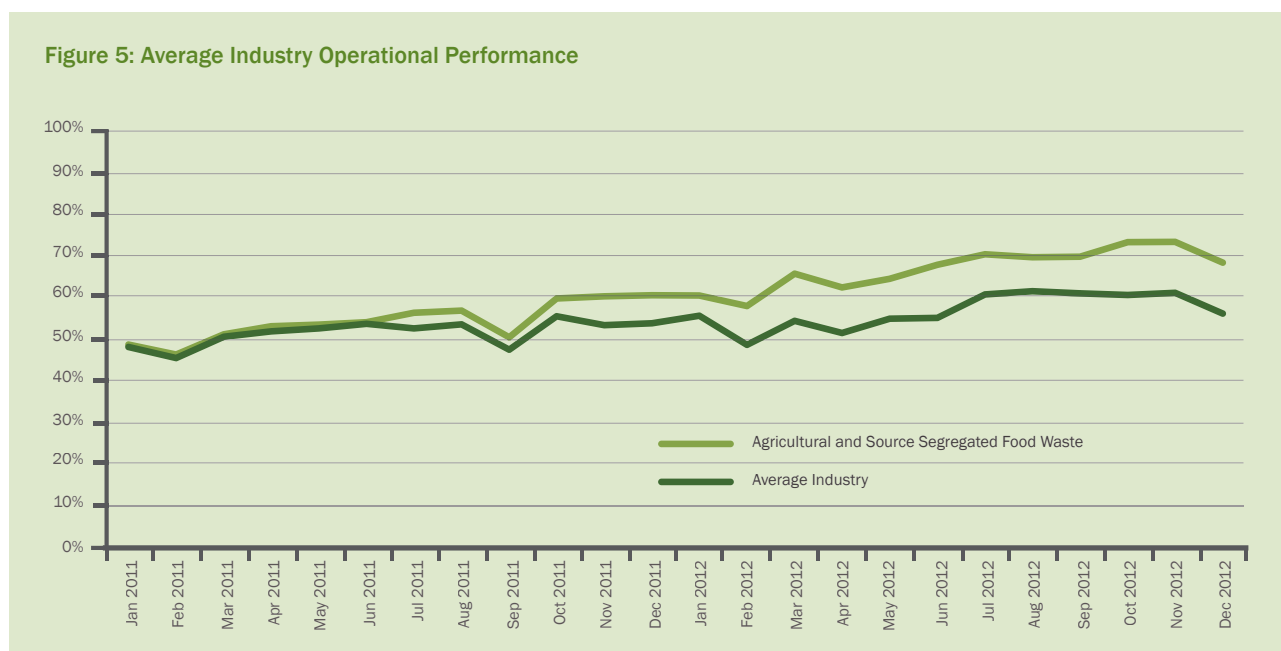
- Insufficient feedstock for the design capacity and/or lower biogas yields than projected;
- Operational/technical issues restricting the ability to process feedstock and/or the biogas yields from the facility and/or power production from the gas engines;
- An excess in the reported/installed capacity when compared with the overall facility design capacity – where developers may apply a natural 'optimism bias'.

Whilst GIB is aware of a limited number of specific examples where installed capacity was known to be greater than initially required, the principal underlying cause of a low operational performance is most likely to arise from feedstock and/or operational/technical reasons. This is due to the lack of a large, centralised and commoditised food or crop waste feedstock market, and a limited supply of highly trained and experienced AD operators.

For investors, it is important to note that whilst operational performance is generally a key metric, other factors, including gate fee and the revenues/costs associated with digestate, may influence overall financial performance. It should also be noted that a very limited number of AD facilities operate on the basis of 'peak loading' output – i.e. where load factor is not a key performance indicator, rather it is one of revenue per kWh exported.

Detailed site by site data is currently only available in the public domain through the ROC Register for facilities earning ROCs, whilst for facilities under FITs and RHI, only limited aggregated data is available. Extending the publicly available data relating to FITs/RHI accredited facilities would be of help to investors by providing the opportunity for greater industry operational benchmarking, and increasing transparency in the sector.

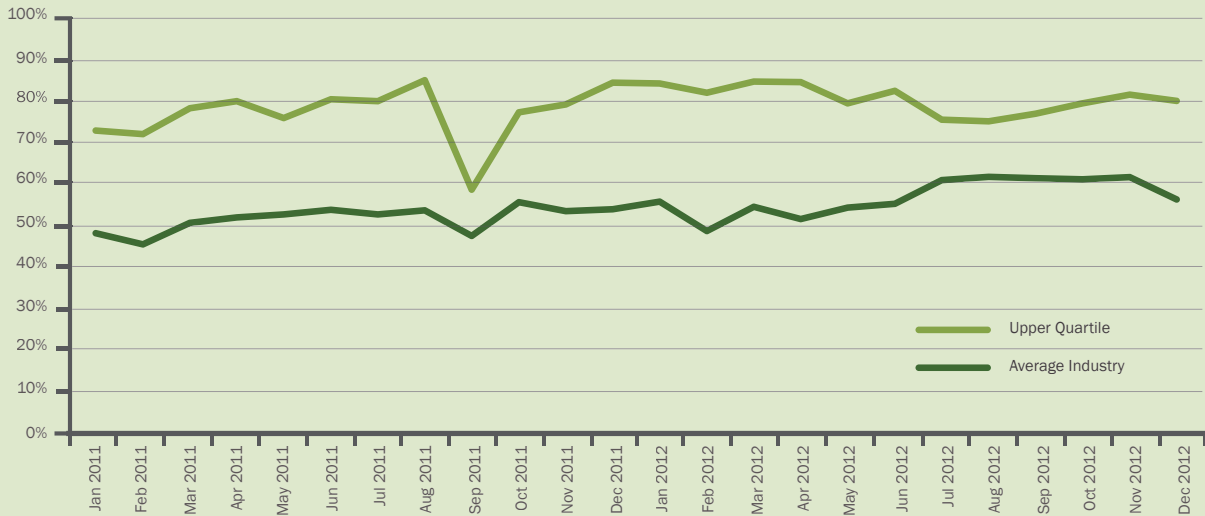
Across those facilities for which ROC data is available, the operational performance in 2012, measured by average load factor, was 57%. Encouragingly, this represented an uplift of 6% from the previous year's performance of 51% - suggesting a steady improvement across the sector. If we exclude the residual facilities from average industry load factors, the improvement in load factor from 2011 to 2012 is even more pronounced rising from 54% in 2011 to 67% in 2012, as shown in Figure 5.



Source: ROC Register

The fragmented nature of the AD market means that there is a wide range in operational performance. The 2012 average load factor of 80% for the identified facilities in the Upper Quartile is 23% higher than the industry average (Figure 6).

Figure 6: Average vs Upper Quartile Industry Operational Performance

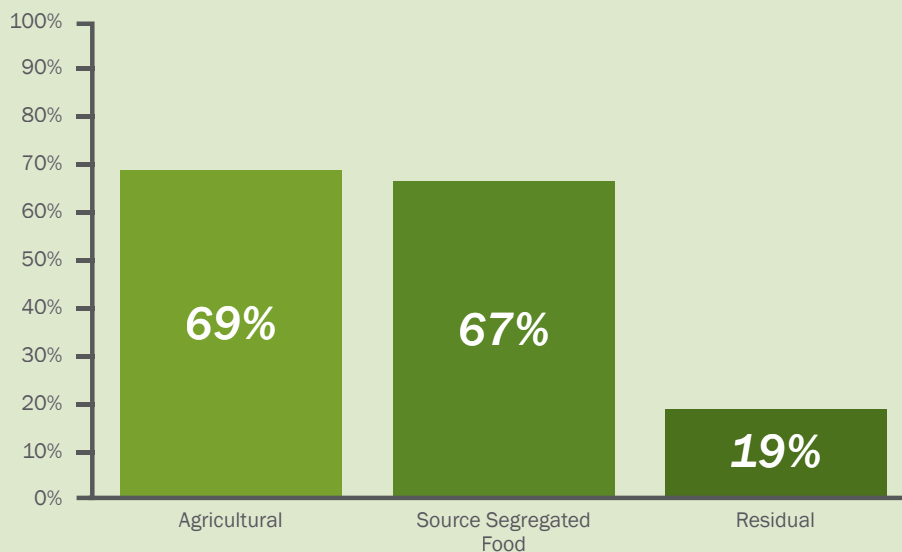


Source: ROC Register

These operational performance figures are, on the face of it, disappointingly low, given that investors typically assume load factors of 80% – 90%, and a shortfall in load factor will have a material impact on the overall financial performance of a facility.

However, when facilities are analysed by known feedstock, there is a marked divergence in operational performance as shown in Figure 7. In 2012 those facilities classed as agricultural had an operational performance of 69%; for source segregated food the figure was 67% and for residual waste the operational performance was just 19%^{xii}. There appear to be a number of specific, structural reasons for the low operational performance for residual waste including for example a tendency for an excess of installed capacity.

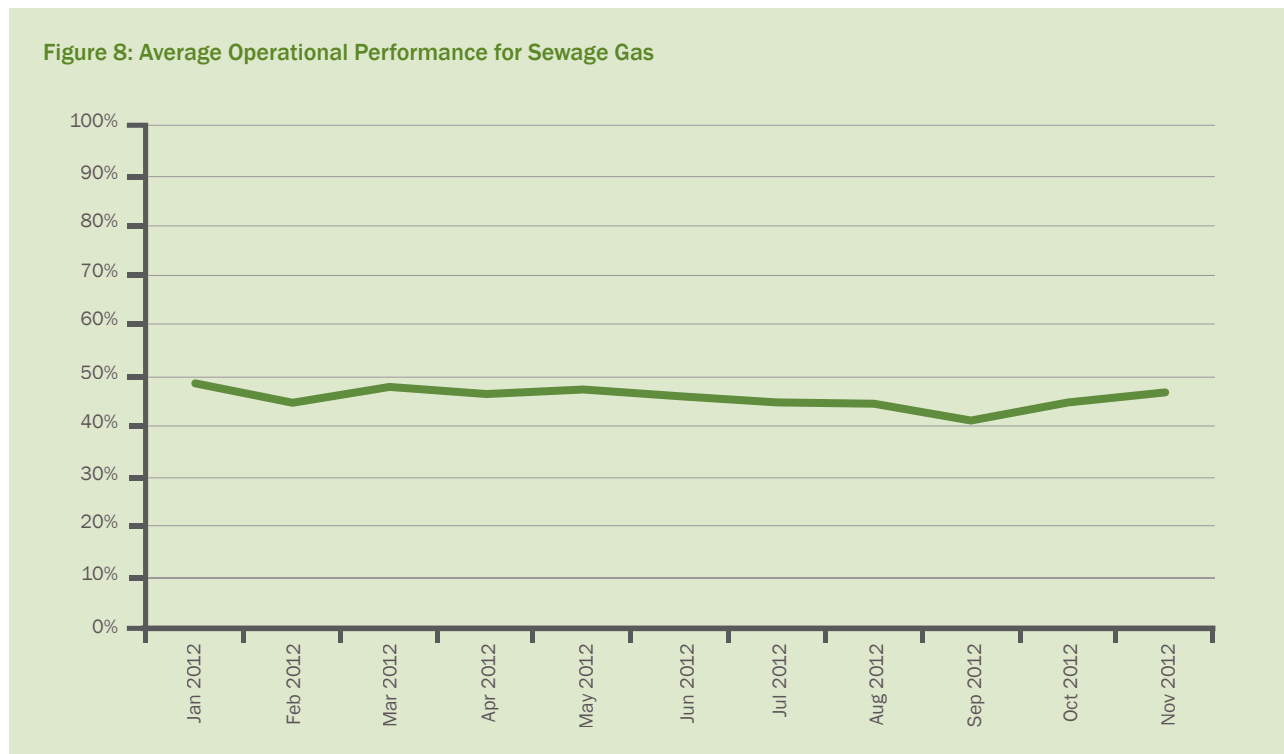
Figure 7: Average Operational Performance by Feedstock



Source ROC Register

Sector Maturity

Figure 5 demonstrates that the AD sector in the UK continues to mature with a steady improvement in average operational performance across the sector. There is a point however at which the sector will reach maturity; at this point, evidence from other sectors would suggest that average operational performance from month to month across a number of facilities will level off. Indeed this is demonstrated in Figure 8 by the mature UK sewage gas sector.



Source: ROC Register

Whilst operational performance in the sector should continue to improve in the near term, the average performance of AD facilities in the UK would appear to be significantly below that achieved in the more mature, northern Europe markets. For example, one of the largest, agricultural AD operators in Germany is understood to have achieved an average load factor of >90% in 2011-12.

Project Maturity

The AD sector is characterised by a slow and steady commissioning phase, with low initial load factors, reflecting both the need to build up biological activity levels and also the challenges associated with accessing feedstock. Securing feedstock is particularly an issue for source segregated food facilities, where the development by third parties of separate collection infrastructure will generally await the development of a local AD facility. As a result, GIB analysis suggests that AD facilities generally only achieve 'steady' operational performance following circa 12 months of operation.

Critical Success Factors

From analysis of the data and discussions with industry, GIB has identified the following macro factors consistent with the delivery of an upper quartile operational performance.

Assuming that the specified AD technology is 'fit for purpose', the factors are predominantly market/operational rather than technology driven:

- a** Feedstock selectivity; including the ability to ensure both a continuous supply of suitable feedstock throughout the year and to ensure optimal biology at all times;
- b** Deep understanding of, and access to, local markets for digestate;
- c** Operational personnel who are able to dedicate sufficient time to the operation of the facility;
- d** A culture of seeking to make a series of small changes to actively improve operational performance.

It is encouraging for investors to note that, particularly given the current fragmented nature of the industry, the various trade associations are working hard to share understanding and disseminate information on best practice across the industry. This includes, for example, potential due diligence requirements which can be found on the ADBA website (www.adbiogas.co.uk) and further information on the REA biogas website (www.biogas.co.uk)

Funding the AD Sector

A relatively high construction risk profile is typical in the waste industry, and as a result this risk is often mitigated through use of turnkey Engineer, Procure and Construct (EPC) contracts. However, GIB discussions with the AD industry suggests that a number of operators question the value of a full EPC contract, particularly where such a wrap can add 10-30% onto the overall capex – which has the potential to impact on the long term competitiveness of a facility.

Furthermore, as the analysis above suggests, in general terms and irrespective of project specifics, during the commissioning/early operational period an AD project also has a relatively high risk profile relating to power generation.

On balance, GIB analysis suggests that the typical risk profile of an AD facility is such that the initial project funding, unless backed by robust alternative (i.e. not just project security) or delivered by an experienced UK operator with a track record of delivery, is likely to be better suited to equity rather than debt investment. In the longer term, as the data above suggests, it is anticipated that the characteristics of the better performing AD facilities may be such that they are suited to refinancing with some debt finance. However, this is likely to be dependent on a facility achieving project specific metrics which could include requirements relating to:

- Robust feedstock contracting arrangement - particularly in the absence of a local authority 'anchor' contract;
- Sustainable arrangements for the processing and use of digestate;
- PPA or other appropriate offtake agreement in place;
- Steady operational performance - with a project specific metric of a quarterly backward looking average load factor achieved for a continuous specified period of months.

GIB Activity

GIB intends to update this AD Market report on a regular basis and share its findings with industry and potential investors. The findings of this report will be used to inform GIB's strategy with respect to the potential for debt investment in the AD sector.

For debt investment in the sector, GIB is actively investigating the opportunity to directly participate in up to £50mn of financing for AD projects which achieve the specific metrics identified above.

For equity investment in new AD facilities, GIB will continue to make any investments through its nominated waste fund managers, Foresight and Greensphere, both of whom have already made investments in the AD sector.

www.foresightgroup.eu

www.greenspherecapital.com

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Glossary of Terms

Defined Term	Meaning
AD	Anaerobic digestion
ADBA	Anaerobic Digestion & Biogas Association
Biogas	Mixture of gases produces by anaerobic digestion
CHP	Combined heat and power
DECC	Department of Energy and Climate Change
DEFRA	Department of Environment, Food and Rural affairs
Digestate	Nutrient-rich material left following anaerobic digestion
Feedstock	Any renewable material that can be used directly as a fuel, or converted into another form of fuel or energy ^{xiii}
FiT	Feed in Tariff – UK Government incentive scheme introduced in 2010 to support production of energy by small scale renewable projects (by small businesses and households)
Gate fee	Charge levied upon a given quantity of waste received at a Waste processing facility
GIB	Green Investment Bank
kWh	Measure to describe how much energy is generated, sold or consumed KiloWatt hour (1kWh = 1,000Wh)
MW	Megawatt 1MW = 1000kW
MWe	Megawatt electrical
Ofgem	Office and Gas and Electricity markets
PPA	A Power Purchase Agreement is a legal contract between an electricity generator (provider and a power purchaser). The PPA defines all of the commercial terms for the sale of electricity between the two parties (e.g. start date, tenor, payment terms...)
Residual Waste	Waste which is left after recycling, composting, etc.
RHI	Renewable heat incentive - UK Government incentive scheme designed to increase the uptake of renewable heat technologies by providing incentive payments to eligible generators of renewable heat and producers of bio-methane (including anaerobic digestors)
RO	Renewable Obligation scheme is a requirement on energy suppliers to source a proportion of the electricity they provide from renewable sources, including AD. Renewable obligation certificates (ROCs) are issued proportionally to the level of power produced from renewable sources. Where suppliers do not generate enough renewable electricity they can buy ROCs from other companies or individuals that have generated renewable electricity. If they fail to buy sufficient ROCs they have to pay a penalty known as the buyout price
ROC	Renewable obligation certificate – please see definition above
Turnkey EPC contract	A contract comprising Engineering, Procurement, Construction and commissioning under which a contractor will carry out the detailed engineering design of the project, procure all the equipment and materials necessary, and then construct to deliver a functioning plant to their clients. A turnkey EPC contract typically places the risk for schedule and budget on the EPC Contractor
TWh	Measure to describe how much energy is generated, sold or consumed TeraWatt hour (1TWh = 1,000GWh)
Waste Water	Term that encompasses domestic waste water from kitchens, bathrooms and toilets, waste water from industries discharging to sewers and rainwater run-off from roads and other impermeable surfaces such as roofs, pavements and roads draining to sewers

Data Source

Sector	https://www.biogas-info.co.uk
Sector	https://www.gov.uk/government/publications/anaerobic-digestion-strategy-and-action-plan
ROC	https://www.renewablesandchp.ofgem.gov.uk/Public/ReportManager.aspx?ReportVisibility=1&ReportCategory=0
FITs	https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/feed-in-tariff-statistics
RHI	https://rhi.ofgem.gov.uk/Public/ExternalReportDetail.aspx?RP=RHIPublicReport
DUKES	https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/renewables-statistics

References

- i <https://www.gov.uk/government/publications/anaerobic-digestion-strategy-and-action-plan>
- ii <http://www.biogas-info.co.uk/>
- iii Anaerobic Digestion Strategy and Action Plan
- iv <http://www.biogas-info.co.uk/>
- v DECC - Review of the generation costs and deployment potential of renewable electricity technologies in the UK Study Report, October 2011
- vi 75% represents top 5 operators in England & Wales in terms of Municipal Solid Waste Incineration facility capacity (ktpa). Based on GIB analysis and [http://www.environment-agency.gov.uk/research/library data/142773.aspx](http://www.environment-agency.gov.uk/research/library/data/142773.aspx)
- vii 71% represents top 5 operators in UK OSW market in terms of MW capacity. Based on GIB analysis and www.renewableuk.com
- viii The 76 accredited facilities have a reported installed capacity of 216MW, but this capacity total includes three ROC accredited facilities for which the reported installed capacity is misleading and, thus, excluded from further analysis. The facilities are two sugar production facilities and a paper mill and account for 129MW of the installed capacity. It is also noted that there is a divergence between data sources with respect to the number of operational facilities in the UK
- ix Data refers to the number of AD facilities that claimed ROCs in December 2012. It does not include accredited facilities that were not recorded in the Ofgem dataset in December 2012. In total, 41 AD facilities have claimed ROCs since it was introduced
- x Data refers to the number of accredited facilities as of April 2013 on the Central Feed-In-Tariff Register (<https://www.gov.uk/government/statistical-data-sets/monthly-central-feed-in-tariff-register-statistics>)
- xi DUKES Provisional Renewable Energy Report 2012
- xii Some caution is required with this data given the relatively small sample size which would be much improved by the inclusion of facility-level FiT data
- xiii http://www1.eere.energy.gov/biomass/biomass_feedstocks.html

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