Anaerobic Digestion

A Market Profile. March 2013

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OVERVIEW

As a niche but thriving industry this report highlights the potential of Anaerobic Digestion (AD) to deliver new green jobs and renewable energy. The study provides a snapshot of the health and prospects for this growing sector highlighting its scale, economic significance, key drivers and trends. Using available intelligence it also assesses the current and future composition of the workforce. Data is presented about the sector's size, demography and geography as well as its occupational structure, skills and qualifications. Given that it is quite a new sector (at least outside the water industry), much of the intelligence is fairly recent, the technology still undergoing refinements and the learning and skills infrastructure still quite embryonic, having to react quickly to the relatively fast pace of change.

INTRODUCTION AND POLICY BACKGROUND

Though well documented elsewhere, this study briefly describes the AD process, its main feedstocks and the variables affecting the AD viability. This includes the availability of feedstocks and their yield. Their waste status, that is how they are classified, determines how a particular facility is regulated and controlled. This is important given the resultant implications for recruitment as well as the appropriate training and skills of operators. Operators and those involved in AD need to have the right skills to operate a particular plant safely and efficiently (see later).

The UK has a binding target under the European Commission's Renewable Energy Directive to source 15% of its overall energy from renewable sources by 2020. This is a key driver for AD and there are others including the EU Directive to divert bio-degradable waste from landfill, the landfill tax escalator, and the use of Renewables Obligation Certificates (ROCs). In a commitment to increase energy from waste the government has produced (and is reviewing) an AD Strategy and Action Plan (July 2011, Defra/DECC). In the wake of the Action Plan there are a series of activities and working groups to help remove some of the barriers to growth currently faced by the industry and to promote the benefits of AD to the UK. Many of these are being led by the Anaerobic Digestion & Biogas Association (ADBA) in association with a range of interested companies and organisations involved in the sector and its supply chain.

AD PLANT DEVELOPMENT IN THE UK

Analysis in chapter two of the report filters the current 105 UK AD plants into three categories now used in the official Biogas Map: agricultural (41 plants in March 2013), community (46) and industrial (18). They cover on-farm, multiple food waste and by-products from the food and drink sector respectively. Case studies from across the

UK are presented throughout the report giving examples of each category of facility describing their development and operation. Most plants generate Combined Heat and Power (CHP) and there is small (3) but growing number of Biomethane to Grid (BtG) systems (the barriers to implementation here are briefly touched on in chapter three of the report). This study excludes water industry AD plants, which have been used in the UK for over 100 years to treat sewage sludge. Water UK claim there are 146 of these facilities giving a total of 251 AD plants.

Approximately 30% of AD plants cost under £2m, 33% between £2m and £4m and 37% are over £5m. With an average build cost of £6.2m the total capital investment in the sector could be as high as £0.65 billion (excluding water industry plants). Just over two thirds of plants (67%, 66 plants) have come on stream since 2010, an average of about 20 plants a year. There is no reason to believe that the scale of change will slow with 123 additional sites having received planning permission nationally[1] including 38 farms. The location and capacity of different plant types is also presented in chapter two.

BENEFITS, BARRIERS AND DRIVERS

AD benefits many different organisations, businesses and individuals (see chapter three). Farmers and entrepreneurs have looked to AD to diversify and bring in a predictable income stream and energy source reducing their use of fossil fuel and mineral fertilisers. The food and drink sector has embraced the technology to process its by-products in an environmentally acceptable way avoiding landfill fees. Local communities can benefit from sustainable local heat and power as well as direct and indirect employment opportunities. For local and national government AD can make a valuable contribution to various policies and legislative targets. There are substantial waste, environmental and renewable energy benefits such as the constant source of energy that can be supplied. The sector also creates economic opportunities within the AD supply chain (see chapter three).

AD is not without its barriers and challenges these include a lack of confidence in the stability of financial incentives, an inability to secure funding, the high costs and stringent regulatory requirements to connect to national grids. There is much commentary on the absence of a mature market for digestate, and the need for new collection infrastructure, greater segregated waste collection and uses for biomethane. There is unanimity within the sector that the AD industry requires action on a number of fronts from finance to regulation and waste policy to ensure its potential growth trajectory is not inhibited. Chapter three highlights how some

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[1] Anaerobic Digestion Strategy and Action Plan Annual Report on Progress 2011/12, DEFRA, July 2012

leading EU countries have successfully, and sometimes aggressively, pursued a suite of policy measures often backed by statute to promote AD development.

There are three substantive drivers for the sector including policy and legislation, technology development and research and development. Despite the barriers to the sector commentators tend to be quite optimistic about its prospects.

THE CURRENT AND FUTURE WORKFORCE

The sector is worth some £320m, employing around 2,650 (some 210 direct and 2440 indirect) employees across the supply chain in at least 140 firms (see chapter four). There are four principle AD employment sectors including feedstock supply, plant design and development, plant commissioning and construction and plant operation. AD provides a variety of employment opportunities from manual work collecting waste to highly specialized engineering. The main manufacturing roles are in engineering, assembly and biochemistry/biology (expertise in the latter is important to understand and manage the safety risks). Using NNFCC (high scenario) projections the estimated number of UK direct jobs alone could be as many as 2,458 by 2020 with over half of these in operation and maintenance – a twelve fold increase on the current position.

CURRENT SKILLS AND TRAINING

The skills required for AD are very diverse ranging from general awareness to health and safety and detailed process and operations. They cover technical competencies as well as knowledge of plant and equipment, environmental monitoring and gas management – and they are skills which need updating periodically as the sector develops and legislation changes.

Chapter five provides an overview of some of the key skills required to support a growing AD industry. It is possible to identify four levels of training (1) general information and AD focused awareness (level one) (2) AD competency and health and safety (level two) (3) operator competency (level three) and (4) AD education and R&D (level four). These do not relate to qualification levels but are simply used as a way a categorising provision. A review of each is provided in the report. As you move from level one through to level three training availability becomes less, the cost becomes greater and, as a result, uptake becomes lower (especially for agricultural representatives). At the moment level four is still very much in development.

There is a lot of training activity in levels one and two, trying to fill knowledge gaps and covering a diverse range of subjects from introducing people to AD, AD efficiency, health and safety, specific aspects of AD operation, legislative compliance and registration schemes, courses and generic training.

In terms of level three progress has been made in developing a skills matrix by the Chartered Institution of Waste Management (CIWM) in identifying AD training needs and the recently developed National Occupational Standards (NOS) by EU Skills which highlight the standards of performance individuals must achieve to carry out functions in the workplace. This paves the way for an apprenticeship framework to support the anticipated growth of the sector outlined earlier. There are currently four AD operator qualifications in the CIWM/WAMITAB[2] Operator Competence Scheme hierarchy table for technical competence.

TOMORROW'S WORKFORCE

As many as approximately 2,250 new AD jobs could be created by 2020 generating demand for science and engineering related occupations, construction, planning and design, process operation and auxiliary occupations. Farm, community and industrial plants are all forecast to increase with community and industrial facilities generating the largest volumes of employment demand. To some degree new opportunities will replace or displace traditional technologies. The pace of change will reflect a range of factors and the way the sector develops will influence the levels of demand for particular occupations (see chapter six).

Many of the technicians that work for AD consultants which support the sector need to be multi-skilled; operating computerised AD control systems / logic flows and diagnostics. Advanced programmers are required to design and install equipment and technicians need to be able to interrogate the systems to undertake maintenance and system improvements. Technicians need to fix and make enhancements – managing, maintaining and operating equipment. Process engineers are required to take responsibility for the development and documentation of processes and process automation within AD facilities.

Training should strike a balance between meeting training criteria (confined space training for instance) and its application in context so it resonates with the trainee. There is not much understanding of the future scale of demand for AD training by occupation and, to inform future provision, this is suggested as an area for further research.

The new generation of AD plants and supporting firms will be faced with the challenge of attracting the right calibre of individual with the appropriate mix of skills, knowledge and experience. This presents a very real challenge for AD. There will be a need for more bespoke educational provision to supplement the extensive on-the-job training that is prevalent within the sector. Customer service skills will be required in the future so AD personal are able to combine new technology with excellent customer service – by phone, in person or on-line.

AD is a highly regulated and skilled industry with increasingly sophisticated skills requirements and further work is needed to understand the precise scale and type of

[2] The Waste Management Industry Training and Advisory Board.

provision required in the next two-five years. The conclusions within the report make recommendations around further research, future provision, operator competency and entry to the sector and awareness. The industry really needs to take action to stimulate awareness of AD and training provision to encourage uptake. This will require government support and funding building on its experience gained to date through the permitting requirements.

CHAPTER ONE: INTRODUCTION

INTRODUCTION, STUDY BACKGROUND AND METHODOLOGY

The Anaerobic Digestion (AD) sector is a niche but thriving industry. It is predicted to continue to grow in the UK in the coming years, delivering new green jobs and renewable energy. This study provides a snapshot of the health and prospects for this growing sector. It is supported by Cogent via an investment from the UK Commission for Employment and Skills (UKCES) under the Employer Investment Fund Round 2 (EIF2). The report will supplement other AD related activities currently being undertaken through the sector skills council.

Cogent is the expert skills body for science-based industries with a particular interest in the skills and employment dimension of process industries. It is an employer-led organization and works with industry to research and forecast skills needs and develop fit-for-purpose standards, qualifications and skills solutions. Cogent's role is to develop and deliver activities identifying and addressing skills and training gaps.

The study has two components. First it provides a definition of AD highlighting its scale, economic significance and key drivers and trends. Second it distills the current and future make-up of the workforce summarising its size, demography and geography as well as its occupational structure and key skills and qualifications.

The research for the study involved a desk review to define the sector highlighting its economic contribution as well as key influences and trends in AD technology and waste management. The report briefly describes the different kinds of AD plants and technologies and products (these aspects are well covered in the literature) as well as the sector's capacity and potential.

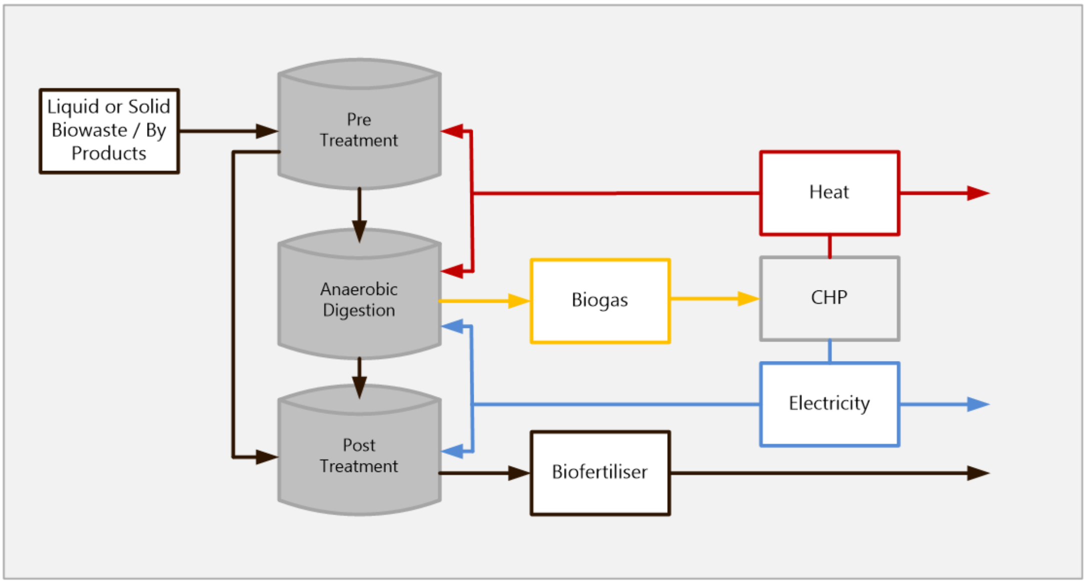
Using available data (which is limited on the skills side) the study distils the current and future make-up of the workforce summarising its size, demography and geography as well as its occupational structure and key skills and qualifications. The study was informed by a small number of face to face and telephone discussions and five case studies. These are listed in Annex One. The case studies – which appear throughout the study - are used to illustrate different kinds AD plant, key skills and any notable implementation or operational issues. The aim of the report, which is part of a series of four studies, is to provide a distillation of current labour market intelligence already available.

POLICY BACKGROUND

The UK needs to make a significant investment in waste infrastructure to deal with the declining landfill capacity. It has a binding target under the European Commission's Renewable Energy Directive to source 15% of its overall energy from renewable sources by 2020. This is a key driver for AD and there are others including the EU Directive to divert bio-degradable waste from landfill, the landfill tax escalator, and the use of Renewables Obligation Certificates (ROCs). Following the Government's Review of Waste Policy[3] it aims to move towards a zero waste economy and published an Anaerobic Digestion Strategy and Action Plan in July 2011 (Defra/DECC). It highlights the cost and benefits of AD to developers and local authorities, the value of digestates, and talks about developing skills and training for AD operators highlighting 'best practice' projects delivering community benefits. Defra has established a steering group to monitor and co-ordinate progress under the Action Plan to ensure the actions remain relevant to the challenges the AD sector faces. There are also a number of working groups taking forward activities from the Action Plan, a list of many of these appears on the Anaerobic Digestion & Biogas Association (ADBA[4]) website[5].

ANAEROBIC DIGESTION: DEFINITION, THE PROCESS

Figure 1: Typical AD Plant Process



Source: Anaerobic Digestion Strategy and Action Plan: Defra, DECC, June 2011

The Renewable Energy Association (REA) note that the UK produces over 100 million tonnes of food waste and animal slurry a year with food waste and livestock production accounting for some 3% of UK greenhouse gas (CHG) emissions[6]. The AD process is able to capture the biogas potential of organic wastes through its bacterial

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[3] http://www.defra.gov.uk/environment/waste/review/

[4] ADBA was established in 2009 as a not-for-profit organisation representing businesses in the AD sector, to help remove the barriers to growth currently faced by the industry and to promote the benefits of AD to the UK.

[5] http://www.adbiogas.co.uk/members-area/working-groups

[6] Renewable Energy: Made in Britain, REA, 2012, p32.

fermentation thus reducing methane emissions. The AD Action Plan describes it as a "natural process in which micro organisms break down organic matter, in the absence of oxygen, into biogas (a mixture of carbon dioxide (CO2) and methane) and digestate (a nitrogen-rich fertiliser)"[7]. The previous figure illustrates a typical AD process which treats by products/biowaste (inputs) producing biogas/fertilizer (outputs) for heat, electricity and fuel purposes (see next section). Biogas contains a mixture of 60% methane, 40% carbon dioxide and traces of other 'contaminant' gases. It can be used in engines for Combined Heat and Power (CHP), burned to produce heat, or can be cleaned and used in the same way as natural gas or as a vehicle fuel.

The main sources of feedstocks for AD are food and drink waste, sewage sludge, animal slurries and solid manures and the raw material used largely determines the amount of methane produced (see next table). The resultant by-product produced by the AD process is referred to as 'digestate', an inert and sterile wet product containing valuable plant nutrients and organic humus. It can be separated into 'liquor' and fibre for application to land or as secondary processing renewable solid or liquid fertiliser or soil conditioner. AD has been widely applied in the UK for the treatment of sewage sludge for over a century but its use for treating other waste or with crops feedstocks is a relatively new phenomenon here.

Table 1: Feedstocks: Availability, Methane Yield and Waste Status

Feedstock	Methane yield (m3/wet t)	Max UK availability (wet weight, million tonnes)	Waste Status
Food & Drink Waste	30 - 145	8.3 Mt from homes. Approx 3.6-5.8 Mt from commerce.	Waste
Sewage Sludge	9-16	24-34 Mt. 71% recycled in 2010.	Waste, exempt from Environmental Permitting Regulations
Animal Slurry & Manure	12 – 238	Approx. 76 Mt.	Waste if used in AD. Digestate is not a waste[8].
Crop Feedstocks	50 – 220	10–29 Mt could be grown for all energy uses by 2020.	Not waste.

Source: Anaerobic Digestion, Houses of Parliament, Parliamentary Office of Science and Technology, Number 387 September 2011

[7] Anaerobic Digestion Strategy and Action Plan: A commitment to increasing energy from waste through Anaerobic Digestion, DEFRA, DECC, June 2011, p5

[8] The regulations can be complex – its classed as waste if it is transferred between sites or digested at a different site to where its generated; but non-waste if it's used on same site as its generated. It is also eligible for an Environmental Permit exemption when it is digested on the site it's generated on.

The economic viability of an AD plant is very dependent on the type and quantity of feedstock and the utilisation of the by-products, biogas, bio-fertiliser and, to a lesser extent, heat. The process of AD requires careful management to exploit its potential and there are several design options operating at different temperature levels, moisture contents and tank layouts with either continuous or batch systems and single, double or multiple digesters[9]. These all have different cost implications, design requirements, and returns on investment.

REGULATION AND LEGISLATION

The waste status identified earlier is important as different environmental regulations apply to the supply and treatment of each material. Whilst not the main focus of this study, as chapter five notes, regulation and legislation have important implications for recruitment, training and skills. Operators/those involved in AD need to have the right skills to operate a particular plant (on licensed sites demonstrating company-wide and/or individual operator competence).

The digestion of wastes requires a permit from the Environment Agency (EA). End of Waste (EoW) criteria also need to be met by AD wastes to ensure they, their biogas and the resultant digestate does not harm human health or the environment. Once satisfied the material is no longer classed as a waste it can be used without a permit. Existing EoW criteria for digestate (the quality protocol for anaerobic digestate) require that the feedstock must be source-segregated, recycled to the land and meet an approved specification (PAS110). There are also particular regulations (Animal By-product Regulations (ABPR)) to control the use of materials of animal origin not intended for human consumption. Food waste (and imported manure) must be batch pasteurised at 70°C for an hour to reduce the content of possible disease-causing microorganisms.

There is work on-going on regulation as part of the AD action plan and consultees for this study stressed the importance of proportionate risk-based regulation that supports the development of the AD sector.

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[9] See "A Detailed Economic Assessment of Anaerobic Digestion Technology and its Suitability to UK Farming and Waste Systems, 2nd Edition, the Andersons Centre, DECC, 2010"

REPORT STRUCTURE

The report is structured as follows:

- Chapter 2 outlines AD plant development in the UK including the number and cost of facilities and their location and capacity.
- Chapter 3 examines the benefits, barriers and drivers.
- Chapter 4 profiles the current and future workforce.
- Chapter 5 looks at skills demand and supply.
- Chapter 6 assesses the workforce of tomorrow.
- Chapter 7 makes a series of concluding observations.

CHAPTER TWO: AD PLANT DEVELOPMENT IN THE UK

The UK has witnessed a significant growth in AD plants in the last few years for all types of plant. Levels of investment and capacity have increased noticeably recently. This chapter charts the changing shape and makeup of the sector.

CURRENT FACILITIES

The official Biogas plant map on the official AD information portal[10] shows operational AD plants in the UK (excluding those in the water industry). Plants are filtered using the following categories:

- **Agricultural:** an anaerobic digester exclusively using slurries, manures, crops or crop residues (maize or grass for instance) produced on-farm.
- **Community:** an anaerobic digester predominantly using food waste, collected from multiple sources including food waste from commercial and industrial sources and/or municipal source segregated waste. Case study one (Deerdykes Recycling Centre) at the end of this chapter provides a good example of a community facility.
- **Industrial:** an anaerobic digester used to treat on-site waste, such as brewery effluent or food processing residues from the food and drink sector.

Each of these categories can be further filtered according to the end-use of the biogas:

- **Heat and/or Power (CHP):** an anaerobic digester generating biogas which is burned on-site to generate heat, power or both (by far the most common facility).
- **Biomethane to Grid (BtG):** an anaerobic digester generating and upgrading biogas, to derive biomethane for injection into the national gas grid (a less common practice to date, see below).

Looking at the spread of plants, community and agricultural facilities account for 81% of all (non-water industry) facilities (95 plants). The following chart shows that of the current 105 AD plants in the UK there are only three (3%) Biomethane to Grid plants. According to ADBA there are a number of challenges in connecting to the grid including the high cost, ensuring the quality and compatibility of biomethane gas and the ability of a low pressure network to accommodate injections of biomethane. There is work on-going to look at this issue through for instance ADBA's biomethane to grid working group.

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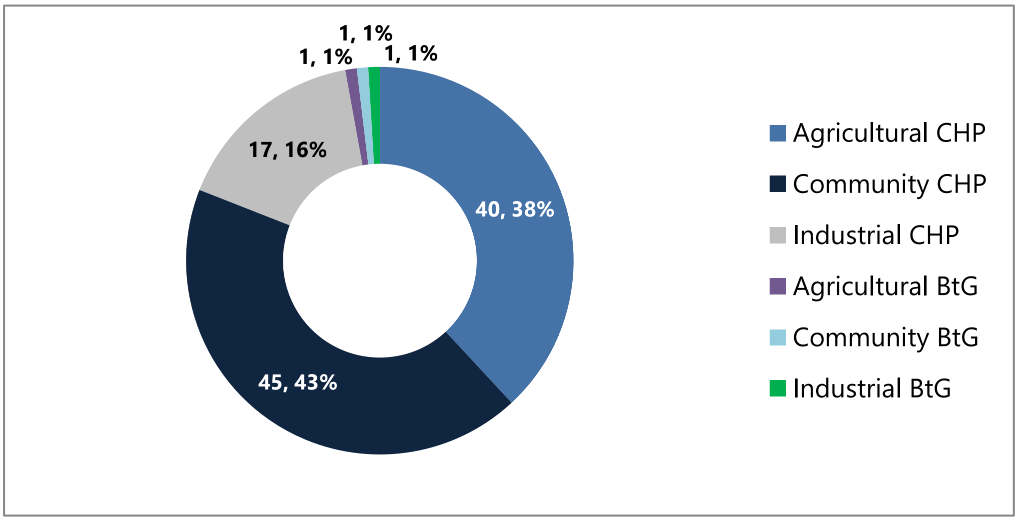
[10] Which is operated by the National Non Food Crops Centre (NNFCC) and funded by Defra. See www.biogas-info.co.uk

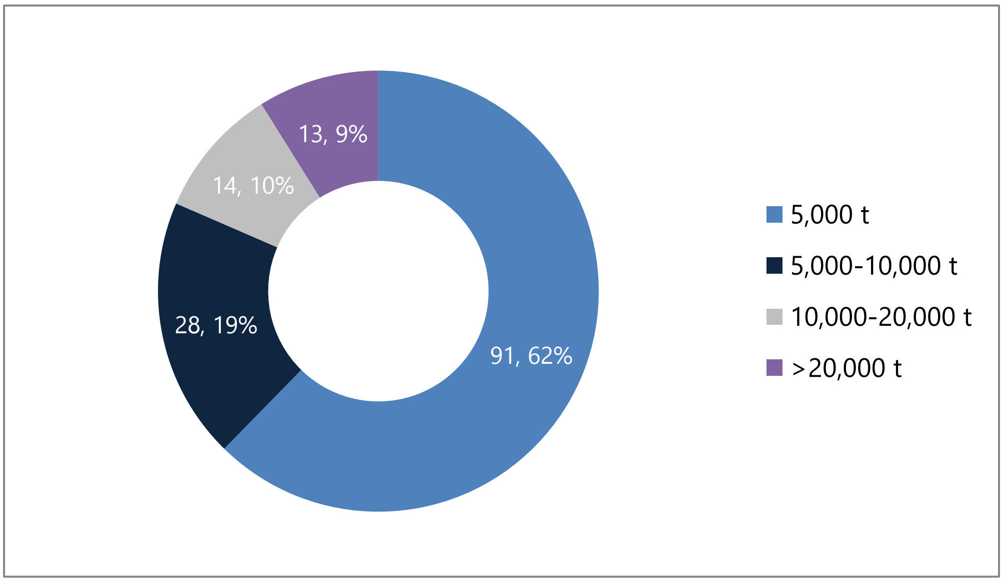
Figure 2: AD Plants by Type



Source: Using data from the Official Biogas Portal (March 2013)

The previous chart excludes water industry plants - Water UK claim there are 146 of these giving a total of 251 AD plants in the UK. The following figure shows the number and capacity of UK water industry AD plants though this is not the primary focus of this report. AD technologies have been used in the UK for over 100 years to treat sewage sludge. It shows that whilst 19% (27 plants) process more than 20,000 dry tonnes per year and the majority (62%, 91 plants) process under 5000 tonnes. Three companies have almost half the UK plants (Severn Trent Water, United Utilities Water and Yorkshire Water Services).

Figure 3: Water Industry AD Plants: Number and Capacity (Dry Tonnes per year)



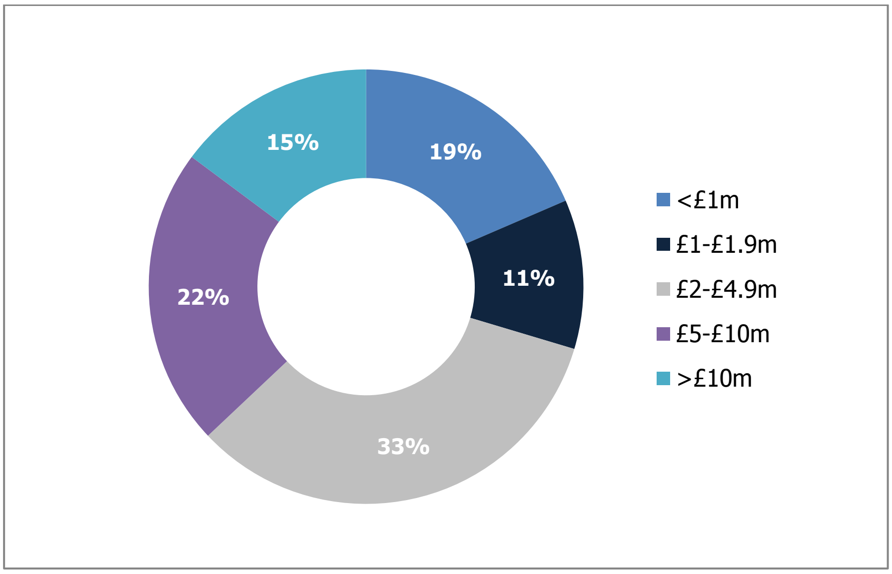
Source: Using data from the Official Biogas Portal (March 2013)

THE COST AND PACE OF DEVELOPMENT

Cost intelligence is available on a quarter of all plants on the AD portal. The data shows that 30% of plants cost under £2m, 33% between £2m and £4m and 37% are over £5m. The larger facilities tend to include community waste transfer stations/facilities and larger food and drink producers such as distilleries. With a couple of exceptions new agricultural AD facilities tend to cost under £5m and there is trend here towards lower value facilities.

With an average build cost of £6.2m the total capital investment in the sector could be as high as £0.65 billion (this excludes water industry plants that are likely to exceed this amount given the number and capacity of these facilities). Much of the investment in AD plants has occurred in since 2010. The relatively high cost of plants can act as a deterrent. Some developers and practitioners are responding to this by developing more cost effective options from smaller more efficient facilities to retrofitting existing facilities (see case study three for an example of smaller scale plants). Again finance is a key work stream within the AD Action Plan and there are a number of schemes designed to stimulate AD investment[11].

Figure 4: The Cost of AD Plants



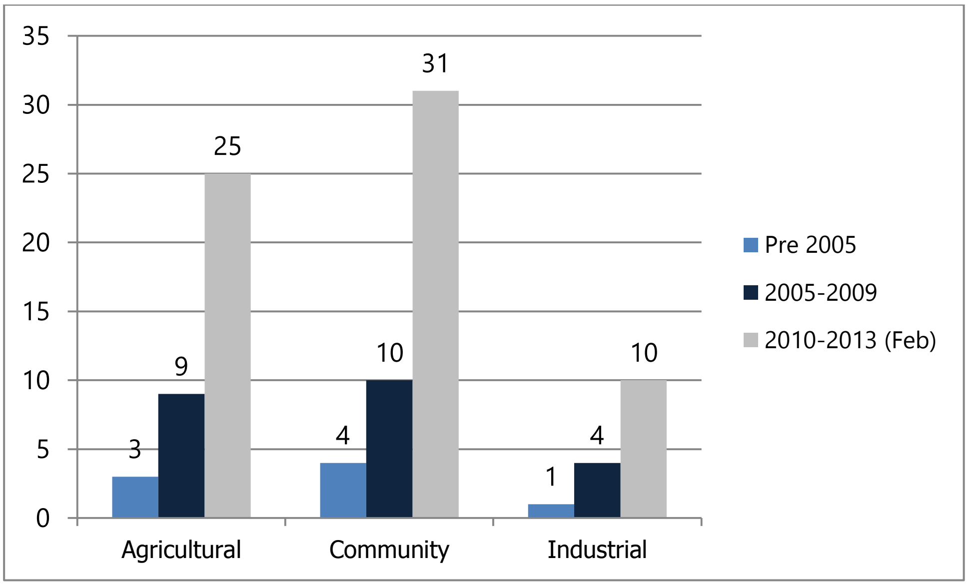
Source: Using data from the Official Biogas Portal (March 2013)

The following chart traces the very rapid development of non-water AD plants (the age of plants is recorded for most facilities). Just over two thirds of plants (67%, 66 plants) have come on stream since 2010 – an average of about 20 plants a year.

[11] For instance the £10m Anaerobic Digestion Loan Fund was launched in July 2011. Funded by Defra and administered by WRAP it aims to support the development of 300,000 tonnes of new capacity to deal with food waste through AD.

There is no reason to believe that scale of change will alter drastically in the next few years with 123 additional sites having received planning permission nationally[12] including 38 farms.

Figure 5: The Age of AD Plants



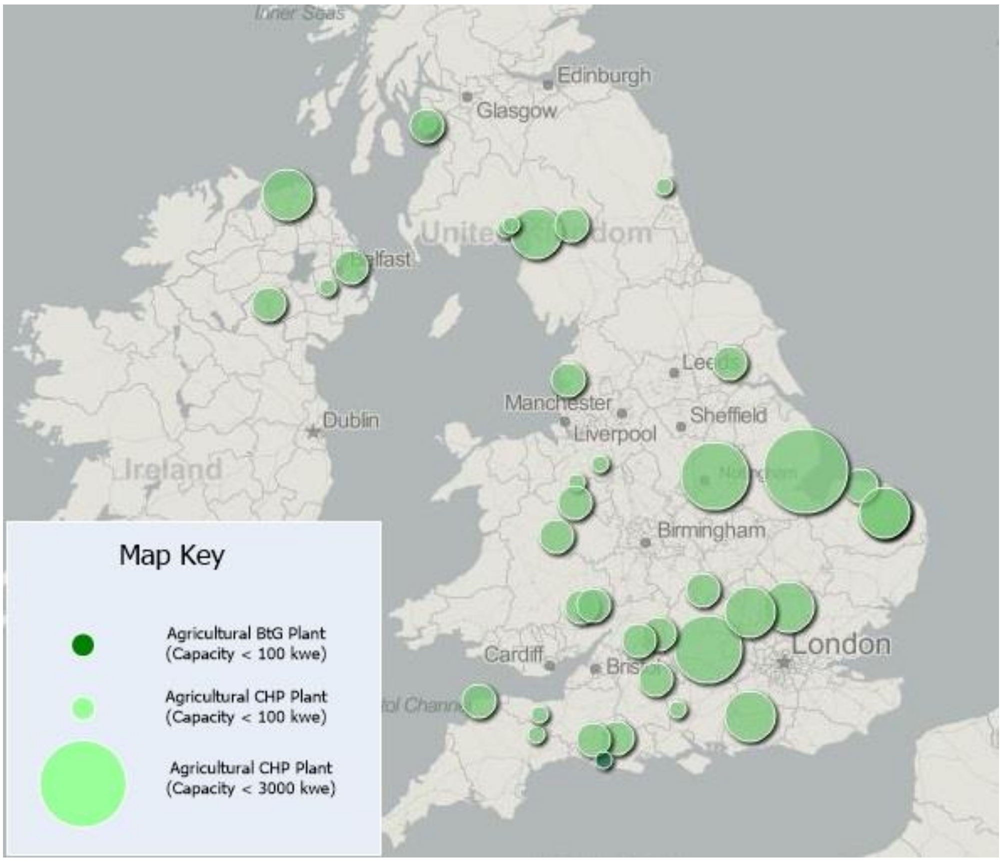
Source: Using data from the Official Biogas Portal (March 2013)

[12] Anaerobic Digestion Strategy and Action Plan Annual Report on Progress 2011/12, DEFRA, July 2012

GEOGRAPHY AND CAPACITY

Annex Three plots each of the UK's known AD plants. The following three maps illustrate plants by type against categories outlined earlier and show their capacity (where known). Map 1 shows that, not surprisingly, agricultural plants tend to be located in the more fertile agricultural rural areas with extensive arable and livestock production – including the rural south west and western border counties, the east, Cumbria, South Scotland and rural Northern Ireland.

Map 1: Agricultural Plants by Capacity

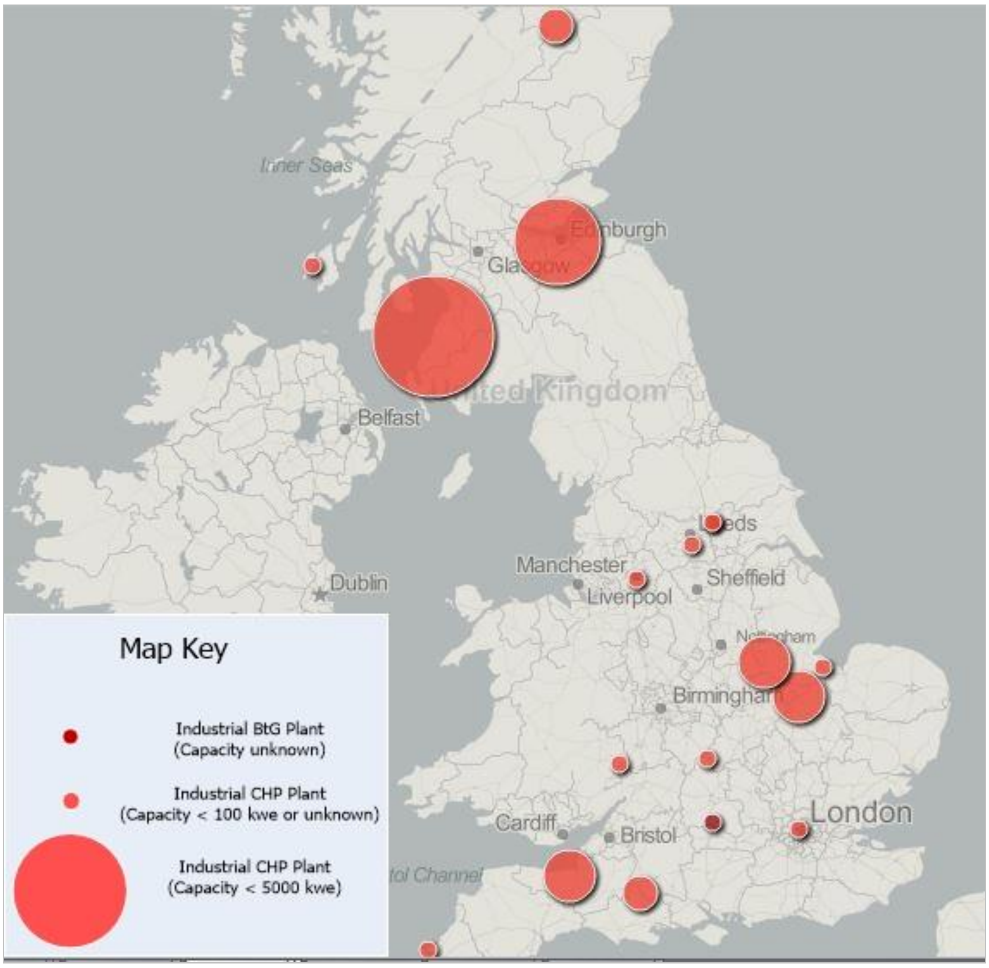


Source: Cogent Analysis using data from the Official Biogas Portal (March 2013)

Industrial plants (Map 2) tend to be located within food and drink manufacturing operations in both urban and rural areas (examples include Scottish Distilleries). There is less known about the capacity of plants in this sector[13], those unknown are simply marked with a smaller location point.

[13] This is because this sector tends to be more interested in waste treatment than energy output, so typically quote capacity in m3 throughput, rather than MWe.

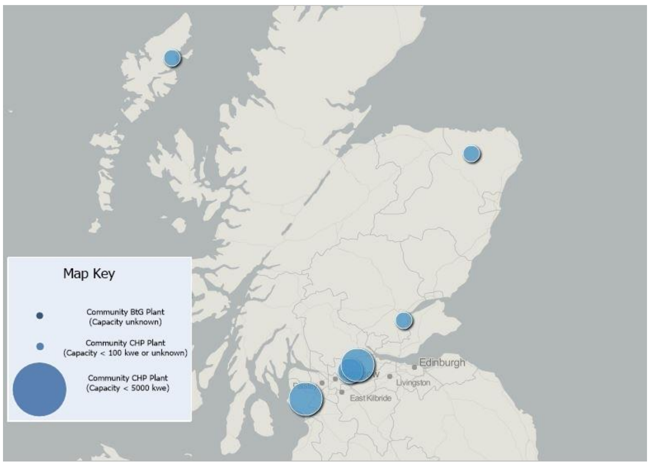
Map2: Industrial AD Plants Location and Capacity (where known)



Source: Cogent Analysis using data from the Official Biogas Portal (March 2013)

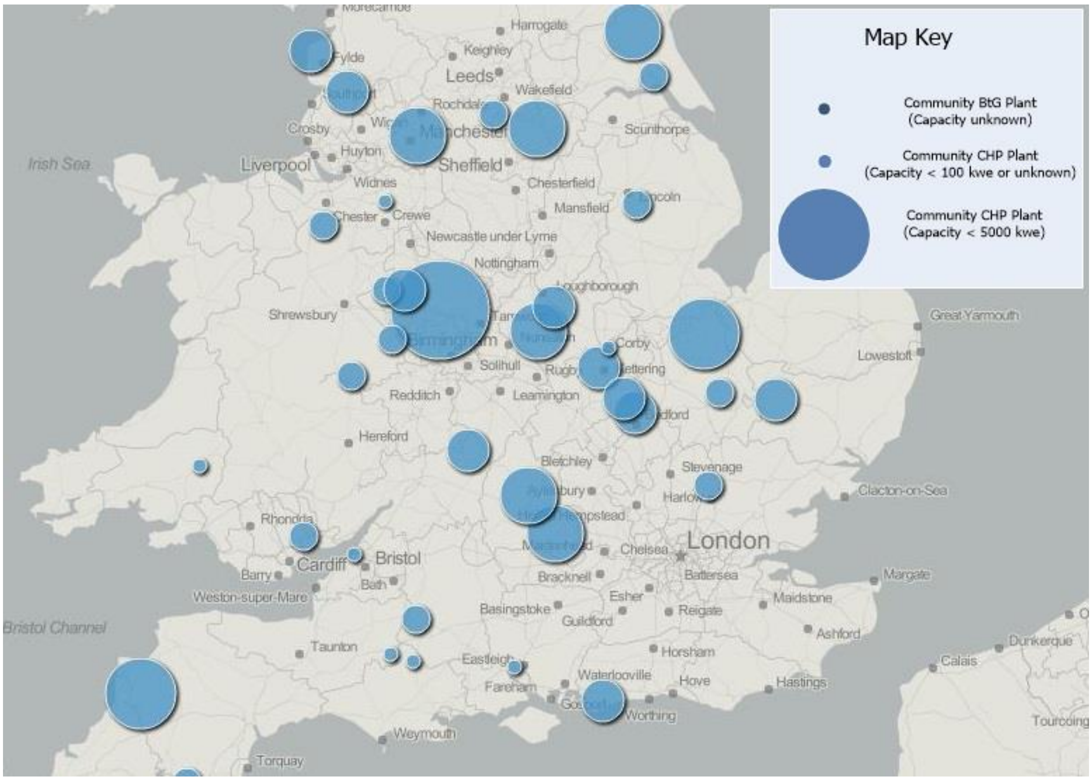
Community plants are often located on the periphery of, or in close proximity to, larger urban centres – some are located on the motorway network away from densely populated areas but with good communications ensuring ease access to feedstocks.

Map 3a: Community Plants



Source: Cogent Analysis using data from the Official Biogas Portal (March 2013)

Map 3b: Community Plants



Source: Cogent Analysis using data from the Official Biogas Portal (March 2013)

CASE STUDY ONE: DEERDYKES RECYCLING FACILITY (SCOTTISH WATER)

The Anaerobic Digestion facility at Deerdykes Recycling Centre in Cumbernauld (see photo) was developed in 2010 at a cost of £7.5 million including funding of £1.7 million from the WRAP Organics Programme. The first facility of its kind built in Scotland it takes some 30,000 tonnes of waste feedstock per annum. It is fed by segregated kerbside and commercial food waste, liquid slurries, fish waste, and category three animal by-products.

The company has contracts with several nearby local authorities. The plant's CHP generates 1 MWe of output which is fed into the grid. The key challenges for developing a facility of this scale include securing appropriate planning permission, permits and finance. The technology selection and procurement takes some time as does the sourcing of raw material feedstock and developing an appropriate energy strategy. Markets for products are also required – it produces power, heat, whole digestate, digestate cake and liquor and feedstock contaminants.

As well as an experienced plant manager a team of nine is employed to run the facility including one administration post, four operational personnel, two technical personnel, and two senior mechanical and engineering staff. All employees are local and finding personnel with electrical, operations and maintenance experience has not been problematic, many of whom have come from the food processing sector. The plant is located on the M80 motorway in Scotland's central belt (with a population of 1.2m) and the construction phase took 12 months.

Operational staff are trained on the job to deal with the day to day running of the plant through Scottish Water's internal training programme. This is supplemented with AD operational competence training from the Waste Management Industry Training and Advisory Board (WAMITAB). Four employees are currently undertaking this training ensuring they have sufficient knowledge of the operational and legislative requirements (BSI PAS 100, and ABPR for instance). Marketing and sales support is provided centrally. A considerable number of indirect local jobs are supported in the haulage supply chain.

Managing a variable waste stream with different densities requires considerable operator skill to ensure the most efficient mix. This is a key skills' requirement for the plant that is not easy to find and comes with experience. Another challenge is maintaining the resilience of the plant. Scottish Water have had to make some on-going adaptations and enhancements to the plant which can be costly. The plant was constructed by Henry Boot Scotland and Nottinghamshire based Monsal. The digester tank was supplied and erected by UK-based Kirk Environmental with pumps sourced from Germany (Vogelsang). Cat Finning has a power generation contract at the site. The company is looking to export some of its excess heat locally and invest in plastic recycling facilities (for the food packaging) to make the plant more efficient. The economic viability of plant is sensitive to prevailing haulage rates and gate fees. The key challenge for the future is securing an optimum gas yield. The plant offers a stable energy source, provides valuable local employment and is making an important contribution to Scotland's zero waste ambitions.

CHAPTER THREE: BENEFITS, BARRIERS AND DRIVERS

The benefits of AD are well documented but it is not without its barriers and challenges. This chapter summarises some of the key advantages and drawbacks and sets AD within a wider global context. It concludes with a resume of drivers influencing the development of the sector and future trends.

BENEFITS AND ADVANTAGES

"Locally, a digester reduces odour, improves fertilizer's value, biologically stabilizes organic wastes, reduces pathogens and provides methane gas that can then be utilized for various energy purposes. Globally, the use of digesters reduces methane emissions (a greenhouse gas), and decreases our dependency on fossil fuels".[14]

It is possible to look at the **benefits** of AD from different perspectives. From the point of view of **farmers and entrepreneurs** AD can improve business viability and stability by generating new revenue streams and giving a calculable source of income from generating a power supply not dependent on the weather or subject to price fluctuations. The predictability offered by the technology was what attracted Melrose farm to AD (see case study two at the end of this section). The AD process tends to retain all the nutrients of the feedstock enabling a farm to plan its nutrient management and reduce its use of fossil fuel and mineral fertilisers decreasing its overall input costs.

For the **food and drink processing industry** AD offers an environmentally acceptable by-product disposal option avoiding increasing landfill fees. This sector seems to be embracing the technology in recent years. **Local communities** can benefit from sustainable local heat and power supply from AD as well as direct and indirect employment opportunities. It is claimed that it is more environmentally beneficial to treat food waste by AD than via centralised composting or incineration[15]. For **local and national government** AD can make a valuable contribution to various policies and legislative targets including the EU Renewable Energy Directive and it offers greater energy security.

There are **waste, environmental and renewable energy benefits** too. AD offers **waste management** advantages reducing volumes of, and charges for, co-products going to landfill and greenhouse gas emissions, as well as providing a nutrient rich organic fertiliser. AD reduces the costs of sending residual materials off site for

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[14] AD 101 An introduction to Anaerobic Digestion Overview & Analysis, 2011, 2nd edition Prepared for: Info.octaform.com/ad

[15] Managing Biowastes from Households in the UK, Eunomia, 2010.

aerobic treatment. In terms of the **environment,** AD stabilises organic wastes and prevents unwanted pollution, avoids uncontrolled methane emissions, significantly reduces foul odours and eliminates pathogenic organics and weed seeds.

AD provides a valuable **renewable energy source.** Biogas can be used in a conventional boiler, as the fuel for a combined heat & power (CHP) unit or can be cleaned of impurities to use as a vehicle fuel or injected to gas grid. AD therefore reduces energy costs, as purchased fossil fuels (i.e. electricity, fuel oils and natural gas) are replaced by renewable energy (biogas) generated on site. Biogas generation is not dependent on climatic factors, offering a reliable energy source that can be stored and converted to energy at any time.

Of course there are **economic benefits** too as the AD supply chain becomes more mature and technologies continue to develop to maximize biogas production. These benefits are discussed further in chapter four.

The Defra AD Strategy and Action plan (p6) notes that AD has a number of **advantages** over other renewable energy technologies including the provision of a constant source of energy. Unlike wind and tidal renewable energy and it can be stored in the grid (in the form of gas). Methane is one of the few renewable fuels suitable for Heavy Goods Vehicles (HGVs) and has the potential to reduce reliance on imported gas.

Defra also notes that "*the construction of AD facilities can be comparatively swift, and compared to some other waste management technologies can be relatively inexpensive*". The technology also offers the flexibility to design plants to meet local feedstock or output requirements providing low carbon fertilisers for agriculture. Farmers perceive the reduction in GHG emissions and the provision of secure inputs as particularly attractive.

AD offers a series of attractive benefits to a broad range of potential users and can demonstrate strong environmental and waste management advantages as well as economic opportunities.

CASE STUDY TWO: MELROSE FARM - BIOGAS ANAEROBIC DIGESTION PLANT

Melrose Farm - a 600 acre family farm in Yorkshire - opened a 500kW biogas AD in September 2012. It took nine months to build at a cost of over a million pounds. EnviTec Biogas was commissioned to develop the plant. They were chosen for their experience in the sector (with over 500 hundred employees they are listed on the Frankfurt Stock Exchange).

The plant (see picture) is fed with a mix of slurry from its pigs' business and maize. Two factors motivated the farm to invest in AD: (1) a constant supply of slurry from its pig business, at any one time the farm has 5-6000 pigs (2) the high energy costs incurred by its sister company Northern Crop Driers which manufacturers dried grass horse feeds (http://www.northerncropdriers.co.uk/).

The AD process has helped simplify slurry storage at Melrose with the resultant digestate reducing fertiliser costs. The slurry is processed and cleaned before it ever needs to be stored in lagoons, reducing odour, resulting in a better quality final product with more readily-available nutrients for uptake by the crops. Melrose has a separator on site with the liquid being used to fertilise the crops and solids being exported.

One of the Directors at Melrose, commented "*we're looking at payback on the investment within five years. Drying grass to produce feed for horses is pretty energy-intensive, so we'll be using some of the electricity for that, while some of it will go to the grid. The Feed in Tariffs will help with revenues, and because they're set for the long term it helps with business planning*". Pork prices have always fluctuated so the AD plant builds in an element of predictability to the business.

In terms of operation and maintenance the farm has integrated new AD roles into the current staffing compliment (six employees mange the crops business and two manage the pigs). It has been a steep learning curve involving lots of background research. The farm team were keen to run the facility themselves sorting out any technical issues as they arose, learning by doing and ensuring the facility is operating as efficiently as possible. The site is run under the Waste Management Industry Training and Advisory Board (WAMITAB) Operator Competence, Waste & Resource Management scheme and training was provided for staff on site.

In the future the farm is looking to sell some of the heat and electricity provided by the (AD) plant to power a new horticultural glasshouse facility. In terms of challenges to date the feed-in-tariff paperwork was quite time consuming, it took some time to research the AD requirements and importing technology from Europe required the farm to employ a consultant to ensure it was fully compliant in terms of UK legislation and regulation. Overall however the director felt that the hard work has been worthwhile to future proof the business, bring in a new income stream and eliminate the high costs of energy (amounting to many tens of thousands of pounds).

BARRIERS AND SOLUTIONS

A number of barriers and challenges have inhibited the growth of AD[16]. As one consultee mentioned as the sector has developed quite organically there is a high degree of innovation. "*There are many systems out there and lots of advice on offer….it might be helpful if there was more standardization*". Whilst there is a growing desire to provide UK sourced AD expertise and infrastructure many of the plants developed to date have relied on imported technology. Whilst some operators have benefited from international state of the art equipment this trend has brought some challenges and difficulties in translating technologies to UK context. With as many as four or five countries supplying one plant, repair and maintenance can be a costly and time consuming business.

There is also a lack of confidence cited in the stability of financial incentives such as Feed in Tariffs, and a shortage of long term contracts for feedstock as a result of a deficiency of segregated waste. An inability to secure funding was mentioned by several respondents and the water industry[17] claims there is a need to build investor confidence to promote the development of further AD capacity.

The 'Hit the Gas' (2012) report also notes the high costs and stringent regulatory requirements which must be met in order to connect to national grids. It notes the absence of a mature market for digestate too (this is echoed by the water industry that is calling for safe and secure markets for digestate). It claims "*amendments to the gas regulations*" are required and "*more education about the benefits of digestate amongst farm end users and major supermarket buyers is also needed*". The Defra AD Action Plan update recognises that a lack of markets for digestate could significantly constrain the future development of the AD sector.

Some commentators[18] feel the roll-out of new collection infrastructure needs to increase significantly and collection and treatment systems should be developed in tandem with new AD infrastructure. Hit the Gas suggests that the government should commit more funds to support AD development, phase out organic waste to landfill by 2020, push source segregated collection of Municipal Solid Waste (MSW) and Commercial and Industrial (C&I) Waste and encourage biomethane injection to the grid and its use to fuel Heavy Goods Vehicles. Water UK notes that achieving the uptake of biomethane from AD as a transport fuel will be difficult unless it can

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[16] See Hit the Gas: how to get the anaerobic digestion sector moving, Thomas Brooks and Quentin Maxwell-Jackson, CentreForum for ADBA, 2012

[17] Developing an Anaerobic Digestion (AD) Framework: Defra Consultation Water UK response, December 2010, Water UK

[18] Managing Biowastes from Households in the UK, Eunomia, 2010

achieve 'end of waste' status. To summarise there is general consensus that the AD sector requires action on a number of fronts from finance to regulation and waste policy to ensure its potential growth trajectory is not inhibited.

THE GLOBAL PICTURE

The Royal Agricultural Society[19] notes that the adoption of AD is more widespread in Europe. In Denmark farm co-operative AD plants produce electricity and district heating for local villages. The Society claims that the proliferation of AD in Germany and Austria has been stimulated by favourable government-led market developments and renewable energy policies. In Germany, a global leader in AD, these include reduced energy tax and incentives for gas driven vehicles. Germany had about 7500 plants in 2012 (which is predicted to rise to 7900 or so in 2013) mainly producing electricity. These include several thousand on-farm digesters treating mixtures of manure, energy crops and restaurant waste, with the biogas used to produce electricity[20].

Sweden has 173 plants chiefly supplying heat and transport fuel and in Finland the government have introduced tax exemptions for gas vehicles[21]. Sweden has investment grants for the marketing of new technologies and new solutions for biogas and a very active HE sector researching biogas[22].

In Denmark[23] a task force for biogas was established for the period 2012-2015, to evaluate and support new biogas projects. It has set targets (for instance 50% of the manure must be supplied to biogas plants by 2020), and promoted the integration of biogas into the energy system through technical and organizational support as well as supporting analysis of market opportunities/opportunities to promote biogas investment.

Biogas is an integral part of Danish Energy Policy and the government offers a number of support measures including new subsidies for the use of biogas for process purposes in companies and for transport and an increase in start-up grants from 20 to 30% from 2012. In a similar vein, AD projects in Switzerland can get financial support. The Swiss government's 2050 energy programme is abandoning

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[19] A Review of Anaerobic Digestion Plants on UK Farms: A Review of Anaerobic Digestion Plants on UK Farms - Barriers, Benefits and Case Studies, A Bywater for The Royal Agricultural Society, March 2011

[20] IEA Bioenergy Task 37, April 2011, Country Reports (Germany)

[21] IEA Bioenergy Task 37, April 2011, Country Reports (Finland)

[22] IEA Bioenergy Task 37, April 2011, Country Reports (Sweden)

[23] IEA Bioenergy Task 37, April 2011, Country Reports (Denmark)

nuclear energy production, pushing energy efficiency and renewable energies and the development of the energy grid and energy research. It would appear that leading EU countries have successfully, and sometimes aggressively, pursued a suite of policy measures often backed by statute to promote AD development.

DRIVERS AND FUTURE TRENDS

There are several key drivers behind the development of AD in the UK. These include energy and environmental **policy and legislation** comprising both incentives and obligations[24]. Escalating energy costs and pressure on disposal fees combined with its revenue generation potential is encouraging people to consider AD. A feature of the sector is **technology development**. New technologies include those in component and system design such as plant monitoring and optimization systems. Other innovations include retrofit systems on slurry storage, more efficient digestors[25], new uses for gas (vehicles[26] or heating), and prefabricated so called "turnkey" solutions. The development of new systems and prototypes is likely to continue. For instance micro systems are being developed to fit on the back of a house and many suppliers are developing equipment that is aimed at small scale AD installations (see case study three at the end of this chapter).

Research and development is an integral part of the development of AD and has tended to focus on enhancing the efficiency of the AD process. Trials across the UK include: finding alternative markets for digestate including landscaping, horticulture and regeneration[27]; analysing biofertiliser properties, nutrient level and biogas treatment; and biological assessments of feedstock or feedstock mixtures. Several companies are looking at different types of waste, how they interact with one another, how they behave in the AD process and their potential biogas yield. As understanding improves AD plants will adapt to meet emerging and future needs.

The National Farmers Union (NFU) would like to see 1000 on-farm digesters by 2020. The AD Strategy and Action Plan (p19) claims the forecast capacity potential for AD deployment for electricity could reach between 3–5 TWh by 2020. Modelling undertaken by Eunomia claims food waste 'availability' in GB could be as high as 8

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[24] Such as Feed-in Tariffs (FiTs), Renewables Obligation Certificates (ROCs), the Renewable Heat Incentive (RHI)), the Landfill Tax, the Climate Change Levy, the Renewable Transport Fuel Obligation (RTFO) and the Nitrates Directive.

[25] The digester can be wet or dry, mesophilic or thermophilic, and single or multistage.

[26] In March 2012, the Department for Transport launched a competition for demonstration funding for low carbon trucks and their supporting infrastructure.

[27] Trials include testing the viability of using digestate in sports turf and turf production, energy crop establishment and soil improvement and manufacture.

million tonnes per annum (tpa). With existing treatment capacity of some 1.5 million tpa, the current national capacity gap for treatment of food waste in Great Britain is in the order 6.5 million tpa. "*This tonnage represents a major opportunity for project developers and investors if it can be captured*[28]". Looking at future predictions for the sector therefore commentators tend to be quite optimistic about the prospects for AD.

[28] Managing Biowastes from Households in the UK, Eunomia, 2010

CASE STUDY THREE: SMALL SCALE ON-SITE AD PRODUCING RENEWABLE ENERGY FROM LIQUID RESIDUES

British AD technology provider Clearfleau (www.clearfleau.com) designs and builds AD plants for the treatment of on-site effluent and generation of renewable energy. The company has built three on-site AD plants in the UK, on a dairy, distillery and food processing site, each with a power output below 500kWh. This is produced by feeding the biogas to a combined heat and power (CHP) engine and the renewable energy generated is used on the processing site. The company has run trials on a range of feedstocks and is building at least three more plants in 2013. It is also developing a smaller modular unit, based on its mobile trials unit, for installation on confined sites for businesses with more modest effluent flows.

These innovative on-site AD plants will treat effluent and co-products from dairy processing, food manufacturing, drinks, bio-fuels and other industry sectors (most unwanted food and drink processing residues can be treated with AD). The on-site AD plants are tailored to the available feedstocks and will reduce treatment and disposal costs, as well as benefiting from the renewable energy Feed in Tariff and savings on purchase of fossil fuel derived energy.

Smaller scale AD plants that can be installed at the location where bio-waste is generated (on farms and in smaller rural communities as well as industrial sites) and can offer a viable alternative to the larger scale "merchant" AD plants. For these larger plants, which handle municipal waste that is being diverted from landfill, feedstocks are transported by road to the centralised digester site. Although, there are concerns about these centralised plants, including their environmental impact and disposal of large volumes of digestate (post-digestion liquor), there are opportunities for a range of technologies and plant sizes.

Whilst smaller scale AD plants may not generate large volumes of energy they also provide other benefits such as cutting greenhouse gas emissions and more efficient handling of production residues, farm manures and food waste. Also, in addition to up to 500 kWh of electrical power, industrial sites can make use of surplus heat from the CHP engine, with the power and heat output contributing to the site's energy demand. BV Dairy in Dorset has reduced energy (power purchase) costs by 22% and also reduced their CO_2 emissions.

The most recent Clearfleau commissioned plant is a bio-energy plant installed at Diageo's Dailuaine Distillery in Speyside (see picture). Here the AD stage is followed by an aerobic treatment process allowing watercourse discharge of final water output. This plant treats dark grain pressings and other co-products from the distillery, supplemented by feedstock from other local distilleries, resulting in more efficient co-products handling and a major contribution to site energy needs.

The Speyside plant is reducing the chemical oxygen demand (COD) in the feedstock by over 95%, and producing biogas that is fed to a 500kW CHP engine on the nearby distillery site which is supplying heat and power to the distillation process. Also at one of the UK's main confectionery production sites at Fawdon in Newcastle, Nestlé have installed a Cleafleau on-site AD system that will convert liquid and solid confectionary by-products into energy. It is part of plans to make the whole site a blueprint for sustainability, while realising the energy potential of the by-products, reducing sewage discharge and cutting energy use by around 15%. This plant is being commissioned in April 2013 and will be fully operational in July.

Clearfleau's AD plants can process both lower and higher strength liquid residues. Bio-degradable solids are retained in the digester for up to 50 days, to optimise biogas output but the liquid fraction is retained for less than six days, reducing the size (footprint) and cost of the digester, as well as operating costs. Unlike some other liquid digestion processes, the AD technology is able to treat feedstocks that contain fats or suspended solids. At BV Dairy in Dorset bio-degradable fats and sugars are converted into biogas.

Build times vary between five and ten months (depending on the complexity of the design) and the containerisation of equipment facilitates off site manufacture and can reduce the duration of the plant build. Apart from requiring a compact, robust plant that is easy to operate and maintain, clients in the food and drink sector require payback times of less than five years (with stronger feedstocks this can be as little as two years in some instances). In addition, Clearfleau will provide process guarantees and can reduce operator risks through deployment of a mobile on-site trials unit that has been used on a number of sites in the past 3 years. The unit shown in the image below is a valuable technology development tool.

Now, based on this unit, the company is developing a pioneering Small Anaerobic Treatment Plant (SATP) that can be installed on sites with lower flows, such as speciality cheese makers or micro-breweries. Like the larger on-site plants, the SATP unit offers efficient digestion and effective COD load reduction alongside with ease of installation and proven operation on a range of food production residues. With support from WRAP, the first small scale unit should be installed on a site by the end of 2013.

In response to growing demand, the company has expanded in the last two years from four to 18 staff, recruiting engineers typically from waste water industry. New recruits are trained in-house as it is not always easy to find engineers who are familiar with AD design and operation. With a number of UK projects in the pipeline, Clearfleau are developing their operations and maintenance capability and looking at some export markets. The company will be recruiting more people in the next 12 months and, as the AD industry as a whole expands, there will be more job opportunities in design, construction and operation of AD plants.

CHAPTER FOUR: THE CURENT AND FUTURE WORKFORCE

This chapter looks at the size and employment and occupational distribution within the AD sector. Standard Industrial Classifications are too blunt an instrument to define AD as many of the companies involved are classified as environmental consultants, agricultural businesses, haulage or feedstock companies or engineering or process industries. National data also does not adequately capture the wide range of skills within the sector. So much of the intelligence that exists on the sector (and used in this chapter) is generated through surveys and membership data.

SIZE AND DEMOGRAPHY

Renewable Energy: Made in Britain (REA, 2012) presents some useful facts on the AD Sector (see Table). It is worth some £320m, employing around 2,650 (some 210 direct and 2,440 indirect) employees across the supply chain.

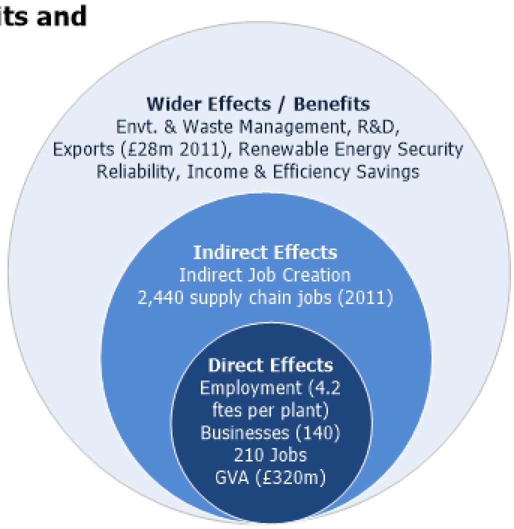
Table 2: AD Key Facts (2010/2011)

Key facts 2010/11	AD Sector
Current employment across the supply chain	2,650
Number of UK companies in supply chain	140
Current sector turnover	£320m
Global market value	£8.8bn
UK export market	£28m

Source: Renewable Energy: Made in Britain (REA, 2012)

The following figure summarises the AD Value chain. It includes modest and growing direct and indirect effects and substantial wider benefits ranging from exports to energy security, environmental gains and income and efficiency savings.

Figure 5 AD Value Chain: Key Benefits and Effects



Source: Kada Research using REA and NNFCC data.

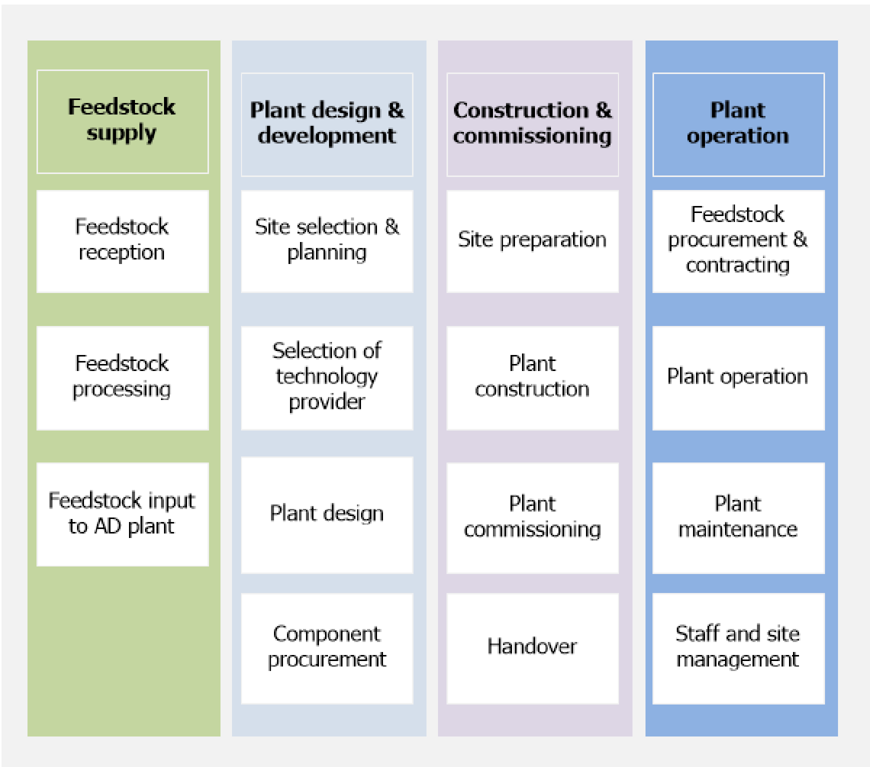
EMPLOYMENT DISTRIBUTION

Bio economy consultants NNFCC provide a useful breakdown of employment in the AD sector. A niche sub-sector has developed around plant design and development, representing typically around 5% of all occupations. There are also companies providing plant preparation, construction, and commissioning services, these account for typically less than a third of all AD posts created. Plants also require on-going periodic servicing and maintenance and a number of companies offer such services.

Of course once a plant is handed over it offers a number of permanent or contract job opportunities whilst in operation. Typically over half the total employment posts are in plant operation. The size of the feedstock supply chain varies by plant depending on the feedstock type, volume and source. On a farm much of the process is mechanised as there tends to be a consistent feedstock supply whereas a large community facility is likely to have a much larger number of suppliers.

The operation of the plant requires as little as a few hours a day or much as a full team of engineers and maintenance staff depending the plant's capacity/type, with an average of 4.2 fte per plant. Plants require feedstock procurement and sourcing staff time as well as plant management and administration. Again the number of posts will vary depending on the type of plant. Some posts are full time, others are part time and they include temporary, contract or permanent positions.

Figure 6: AD Employment Sectors



Source: UK jobs in the bioenergy sectors by 2020, NNFCC, April 2012

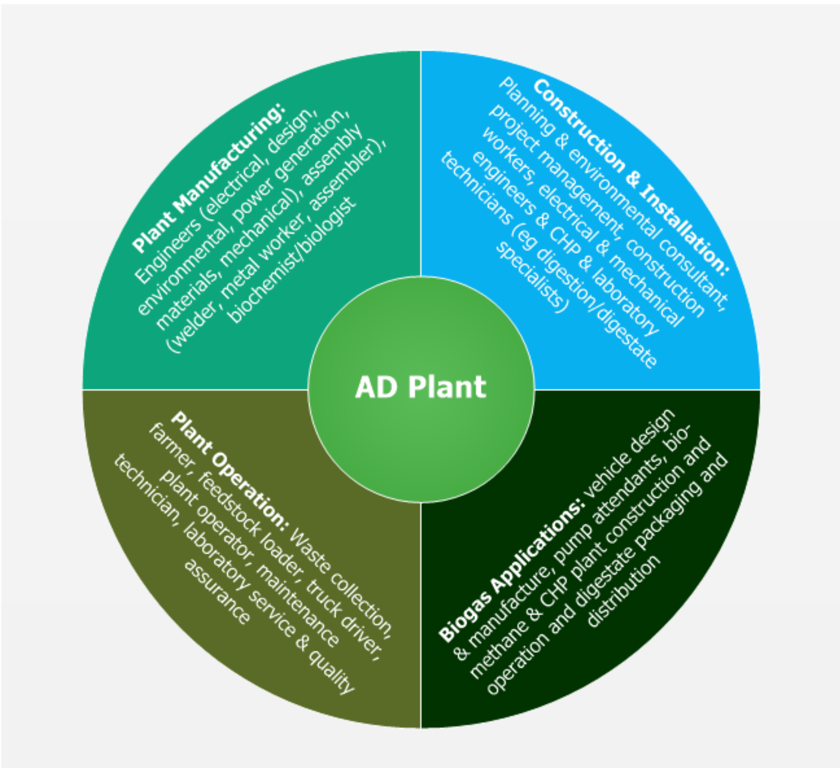
OCCUPATIONAL DISTRIBUTION

"AD provides a very broad range of employment opportunities, from manual work collecting waste to highly specialized engineering in its many applications…"[29]

Looking at the distribution of employment across the supply chain there are four principle occupation types. The figure shows that the main manufacturing roles are in engineering, assembly and biochemistry/biology. Manufacturing and engineering capabilities are required for fabrication and assembly, the supply of key plant components and maintenance services for the AD industry.

The construction and installation occupations mirror the primary stages of AD plant development from planning to assembly and process engineering. The workforce required to run a plant comprises operation and maintenance occupations as well as some technician posts. Biogas applications require power generation construction and operation occupations as well as digestate distribution. Indirectly other posts are created in vehicle design and at fuelling stations for instance.

Figure 7: AD Occupations



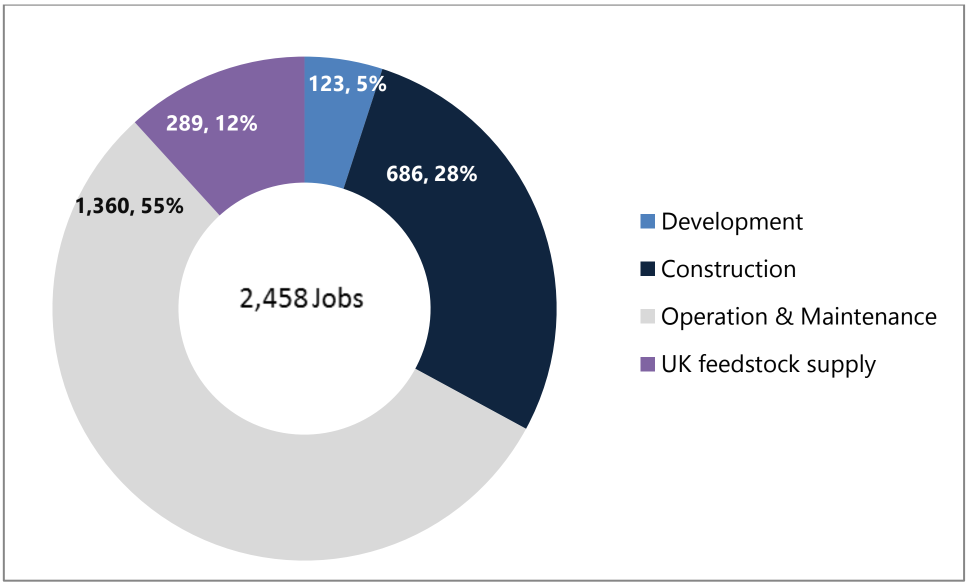
Source: Using Intelligence from Renewable Energy: Made in Britain (REA, 2012)

[29] Renewable Energy: Made in Britain (REA, 2012).

PROJECTED JOBS

Using NNFCC (high scenario) projections the estimated number of UK jobs could be as many as 2,458 by 2020 with over half of these in operation and maintenance.

Chart 6: Estimated UK jobs in Anaerobic Digestion by 2020 (High Scenario)



Source: Chart using data from UK jobs in the bioenergy sectors by 2020, NNFCC, April 2012

Case study four at the end of this chapter illustrates one agricultural company's growth aspirations. The following chapter looks at skills' demand and supply.

CASE STUDY FOUR: FARMGEN

Farmgen is a leading independent UK company specialising in developing, managing and operating AD plants. Established in 2009, the company has assembled a consortium of expert UK-based firms to deliver its first tranche of AD plants. It comprises technology business Monsal and engineering specialist Agrilek from Barrow-in-Furness which bring expertise in grid connections. The directors bought a large share in AD tank manufacturing company Kirk Environmental ensuring much of the plant assembly can take place in house.

Farmgen is guaranteeing farms and sites that move into AD generation a fixed 10-year income stream with an agreed level of crop production and land rental over that period. As well as this guarantee the company provides a management service running the plant and making available low cost heat for buildings or the AD process.

Farmgen employees six fte staff and there are currently five people running two digesters at Dryholme and Carr Farm including an environmental manager and an operations director. The power generators are monitored remotely via operations and maintenance contracts. The high level of training undertaken by operators is perceived to have improved farm safety and improved the skills base of farm labourers. There were wider employment benefits realised during the initial six-month construction stage and afterwards. A one MW plant can create two full time posts and safeguard other agriculture-related jobs on the farm.

At Carr Farm, in Warton, near Preston, Farmgen built and operate an 800 kWe AD plant. It opened in November 2010. They provided the finance and managed the whole process, from planning and gaining the necessary consents to hooking up to the National Grid. The plant is fed by 16,000 tonnes (per annum) of maize and other farm crops

A £4 million AD plant at Dryholme Farm, near Silloth in Cumbria started supplying electricity to the national grid in November 2011. Farmgen received a £350,000 grant from Nuclear Management Partners to help connect the energy plant to the national grid. The 1.2 MW facility is fed by energy crops (maize) and slurry with inputs of some 32,000 tonnes per annum (25,000 tonnes of energy crops, 7,000 tonnes of slurry).

Like the NFU Farmgen's experts believe the UK's farming sector could sustain up to 1,000 AD plants using marginal land to diversify into 'energy farming'. These plants would produce organic silage and help to protect and sustain existing land used for food production. AD plants provide jobs, bring inward investment into the rural economy and support the need for renewable energy sources. The process uses locally produced crops and crop residues.

The technology in terms of appearance and operation is among the most 'farm friendly' available and not very visually intrusive. The bio-product of the plant digestate, has far less odour than other slurries and also contains less pathogens, is returned to the surrounding land as fertiliser to support the growth of the following year's crops. This reduces the need for carbon-intensive industrial fertilisers, a major source of greenhouse gas emissions. Livestock farmers faced with investment challenges under the Nitrates Vulnerable Zones legislation can benefit from an AD plant boosting storage capacity and improving incomes from renewable energy sales.

Farmgen has an ambitious expansion programme with ten projects in the pipeline with funding in place. A current challenge is the large amount of rainfall raising water tables and affecting crop yields and prices on their 2000 acres. That said tens of thousands of pounds annually are being saved on farm fertiliser.

CHAPTER FIVE: CURRENT SKILLS AND TRAINING

It is important the AD industry has the relevant skills and trained staff required as the sector continues to expand. Defra notes this "*will help provide confidence to investors that the industry has the right level of operator competence, for example to ensure high levels of health and safety, or meet the necessary requirements for environmental permitting*"[30].

This chapter provides an overview of some of the key skills required to support a growing AD industry and a brief resume of what training is available at different levels.

AN OVERVIEW OF AD SKILLS' REQUIREMENTS

The skills required for AD are very diverse ranging from general awareness to health and safety and detailed process and operations. They cover technical competencies as well as knowledge of plant and equipment, environmental monitoring and gas management. Disciplines such as bio chemistry are included as well as specialist AD knowledge including digestate management, PAS 110 /ADQP, AD permitting and duty of care obligations. AD plants also require staff with management, negotiation and communication skills and those who understand the economics of plant operation. Regulatory and technical changes within the sector require ongoing training and updates on new developments.

Progress has been made in developing a skills' matrix by the Chartered Institution of Wastes Management (CIWM) in identifying AD training needs. It sets out the variety of competencies required for a wide range of AD stakeholders[31] and will incorporate health and safety training matrix developed by ADBA. ADBA's AD health and safety focused competency skills matrix offers a general guide to the level of understanding and knowledge required for AD. It identifies AD specific and generic skills also those relevant to other industries. It indicates the level of awareness (from no awareness to detailed awareness) required for different individuals (designer, constructor, manager etc). Generally supervisors, operative and maintenance teams need detailed operational awareness and designers, commissioners and managers require in depth design and management awareness.

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30 Anaerobic Digestion Strategy and Action Plan: A commitment to increasing energy from waste through Anaerobic Digestion, DEFRA, DECC, June 2011

31 Procurement, sales, regulators, council members, planners, WDA / WCA, operators (operative & management levels), gas utilization, digestate users, consultants, retail, waste producers, environmental monitoring, the public, design & build & equipment manufacturing.

It is possible to think about training for AD on four levels (and these in no way reflect qualification levels but are used simply as a way of categorising provision):

a) **Level One General Information and AD Focused Awareness:** including conferences, exhibitions, and learning about renewable energy or AD, typically pitched at people starting out and wanting to confirm whether AD is right for them. This level also includes AD focussed conferences and workshops to raise developer awareness. Once someone has committed to being involved in AD in one way or another, this provides them with enough knowledge to continue their journey.
b) **Level Two AD Competency training**: this level covers those who are actively involved in AD, they need to better understand the technology, process, benefits and issues. This varies hugely by sub sector.
c) **Level Three Operator Competency:** looks at the training offered and competencies' required to actually operate a plant.
d) **Level Four AD Education and R&D**: comprising higher and further education (and even schools) and applied and academic research. It includes people wanting to learn about AD as well as academic and commercial organisations researching the technology.

The following sections provide a resume of each.

LEVEL ONE: GENERAL INFORMATION AND AD AWARENESS

There are a number of courses aimed at **introducing people to AD technology.** Typically these offer a mix of informal training and often involve a study tour of a facility and are aimed at helping users understand the issues involved. The Renewable Energy Association runs a biogas training programme. This £60,000 EU funded programme runs to May 2014. 'Advanced Biogas Learning in Europe' (ABLE) will fund trips to Germany for 30 UK professionals and young graduates, enabling them to learn from leading practitioners in all areas of AD technology. The project is principally aimed at young people looking to develop a 'hands on' career in the green economy. At any one time there are a number of **more generic AD training courses** examples include WRAP's business strategy in a volatile market course. There are also annual conferences and low carbon technology exhibitions etc.

LEVEL TWO: AD COMPETENCY TRAINING

In addition to general information there are a number of courses on AD. These tend to be listed on the REA and ADBA websites (see http://www.adbiogas.co.uk/events/). A brief resume of some of these follows.

There are training courses on **specific aspects of AD operation.** WRAP for example is offering a course on how to market, distribute and utilise anaerobic digestate in agriculture. Other courses include training on the feed-in-tariff, on-farm energy or odours.

There are courses aimed at improving **AD efficiency**. In response to a desire from the sector to optimise the efficiency of the AD process to enhance productivity the UK's National Skills Academy for Process Industries launched a one-day training module aimed at the country's growing AD industry (see box). In a similar vein WRAP is offering a one day training course 'improving operations at AD facilities' to help AD operators optimise their process, tackle process problems and manage stable, efficient AD facilities.

Increasing Methane Yields: One Day AD Course National Skills Academy for Process Industries

This course was developed in conjunction with bioeconomy consultants, NNFCC, and is the first in a series being planned by the Academy to up-skill workers in the technical and safety aspects of the AD process. It is aimed at operating staff employed on farm and commercial AD sites and focuses on providing underpinning scientific knowledge appropriate for technicians operating the units. It offers a chemical understanding of how an AD process works, for example the importance of variables such as pH and acidity. This will improve the knowledge of the technicians enabling them to interpret trends better and make informed decisions about how the plant is operated. It will increase the yield of methane, creating greater economic benefit and increasing plant profitability. To date the response has been good from all areas of the sector and all levels. The course covers feedstock procurement and preparation, the AD process and AD outputs (Biogas and Digestate).

Operators need to understand the procedures they are required to follow **to comply with the appropriate legislation/licensing requirements** and deal with any risk and health and safety issues. Training in this area includes overall plant safety (functional safety management) and working with dangerous or regulated substances (see box). Courses such as the PAS course for beginners or courses on health, safety and environmental management are available to meet this need. For instance the Association for Organics Recycling has run a course focused on HACCP (Hazard analysis and critical control points), helping them design and implement a HACCP plan in line with PAS 110 requirements. This will enable the production of digestate products that are safe and fit for purpose and trainees completing obtain a Foundation Certificate in HACCP – a Level 2 qualification issued by the Royal Society for Public Health (RSPH). AD is not immune from 'incidents and accidents' and safety training is often carried out as part of the commissioning process and linked to the operator competencies required to secure an Environmental Permit. The growth of the AD sector is likely to result in an increasing demand for process safety leadership as operators will be keen to demonstrate and ensure they have taken appropriate protection measures.

Protecting AD Employees, Communities and Industries through Skills and Training

In the wake of major accidents around the globe, and building on the recommendations of the Process Safety Leadership Group, in 2010 the National Skills Academy for Process Industries and Cogent SSC announced the formation of a Process Safety Management Project Board with senior industry and union representatives, the HSE, and industry bodies, to tackle the issue of quality assuring Process Safety training. This Project Board is leading the establishment of the industry training and standards that will underpin the Process Safety Management skills, knowledge and competence in the UK Process Industries. The Academy is building a network of quality assured Academy Accredited training providers specialising in Process Safety to ensure it can offer employers a choice of endorsed courses and approved trainers that fully meet the standards that have been set by industry and its representatives.

There are also a number of more **formal schemes** including the Green Gas and Biofertiliser Certification Schemes. The Biofertiliser Certification Scheme provides assurance to consumers, farmers, food producers and retailers that biofertiliser is safe and of good quality meeting the appropriate PAS110 & ADQP or ASRS specifications. Similarly the Green Gas Certification Scheme (GGCS) tracks biomethane, or 'green gas' through the supply chain to provide certainty for those that buy it.

LEVEL THREE: OPERATOR COMPETENCY

One of the recommendations in the AD Action Plan was to develop 'National Occupational Standards to cover the AD process in more detail'. These highlight the standards of performance individuals must achieve to carry out functions in the workplace, together with specifications of the underpinning knowledge and understanding required. EU Skills led this process[32]. They found that most of the standards for AD were already in existence. One new standard was developed from an existing Lantra standard – EUSAD01 – the standard to maintain site biosecurity and personal hygiene on AD plants.

A total of 22 standards were identified and agreed as being relevant and a proposed qualification structure was identified and consulted on with employers (see table). EU Skills note that these will now be taken forward with awarding organisations who wish to develop and offer the qualification with their support. Information on operator competence requirements is also published on the AD Portal[33].

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[32] See report into development of National Occupational Standards for Operators working in Anaerobic Digestion Plants, EU Skills 2013

[33] http://www.biogas-info.co.uk/index.php/regulations-qa#opcomp

Whilst consulting with employers on the standards applicable to operators working in AD plants a number of units were also identified that could be developed in the future for supervisors working in the industry. Now that the NOS are in place it will be possible to develop an apprenticeship framework providing further vocational opportunities for the sector (once generic personal and functional skills have been integrated).

Table 3: National Occupational Standards for AD Operators

Mandatory Units (8 from 8)	Optional Units 4 units from the following 16
Monitor and maintain health and safety in the workplace during recycling activities	Control vehicle movements on site of recycling activity
Maintain sustainable development and environmental good practice during recycling activities	Control the reception of recyclables and other materials
Develop and maintain personal performance on recycling activities	Sort and prepare recyclables and other materials
Establish and maintain effective working relationships during recycling activities	Mechanically handle recyclables and other materials
Process received waste	Manual handling and lifting of loads
Maintain the security of facilities and equipment used for recycling activities	Control the handover of recyclables and other materials
Maintain biosecurity and personal hygiene on anaerobic digestion plants	Working in low risk confined spaces
Emergency procedure in processing industries operations	Carry out routine checks on plant and equipment used in recycling activities
	Prepare plant and equipment for processing recyclables and other materials
	Operate and shut down plant used for processing recyclables and other materials
	Operate programmable processes
	Adjust process equipment to meet operating requirements
	Maintain the quality of treatment process
	Exchange responsibility for control of waste processing operations
	Receive, store and handle processing chemicals, reagents and other consumables
	Promote recycling service

Source: EU Skills

The case studies were asked to provide some observations around the skills required for operators, they stressed the importance of:

- Controlling vehicle movements on site especially for larger plants with a large number of HGV deliveries (including those that have a large number of visitors).
- Process operation skills and the ability to adjust process equipment to improve plant efficiency and maintain the quality of the treatment processes.
- The effective processing of waste to ensure there are no avoidable blockages due to foreign bodies resulting in costly 'downtime'.
- Applying any skills developed to the plant in question and tailoring training to particular circumstances.

Prior to April 2010 AD was exempt from Environment Agency permitting. This is no longer the case and in applying for an environmental permit for AD, operators need to understand the permit requirements. These include the operation of relevant equipment, legal and policy requirements and the minimization of environmental and human health risks. In order to show this, operators must demonstrate their technical competence.

Of course this generates an immediate demand for training and a Technical Operator Competence Scheme has been jointly developed by CIWM and WAMITAB against which individuals are able to demonstrate personal competence within the prescribed framework. It reflects the fact that different types of waste facilities present different levels of risk to the environment. AD is classed as medium risk in terms of the categorisation of permitted facilities[34].

There are currently four AD operator qualifications listed in the CIWM/WAMITAB Operator Competence Scheme hierarchy table for technical competence (see table).

Table 4: WAMITAB AD Registrations

Certificate Title	No. of Registrations
Anaerobic Digestion facility including use of the resultant biogas	24
On Farm Anaerobic Digestion facilities including the use of the resultant biogas	16
Storage of digestate from Anaerobic Digestion plants	1
WAMITAB Level 4 Diploma in Waste Management Operations : Managing Biological Treatment - Non Hazardous Waste Anaerobic Digestion	3

Source: WMITAB, March 2013

The table shows that to date there have been 44 AD registrations. WMITAB lists 20 centres offering these qualifications across the UK so it would appear there is adequate provision given the levels of throughput.

Some AD operators will undertake training related to Thermal Treatment / Biogas Engines which is related in terms of treating gasses produced either from sewage treatment plants or landfill sites producing gas. It is also possible to undertake commercial international biogas operators' courses too (though clearly knowledge of UK legislation is essential).

To ensure that all technically competent persons maintain their knowledge and skills operators are required to demonstrate *continuing* competence. Up to February 2013 25 people had completed an AD related continuing competency test. There will be others who update their competency quite legitimately through alternative routes for

[34] For further information go to www.wamitab.org.uk and see 'Competence' and 'Risk Tiers' - the Risk Tier Table provides further information

instance waste treatment qualifications (both hazardous and non-hazardous waste) cover a range of activities including AD[35].

LEVEL FOUR: AD EDUCATION AND R&D

This report has not reviewed AD education provision extensively. That said, specialist teaching and research is available at the University of Southampton which has a Bio-Energy Research Group and the University of Glamorgan which houses the Wales Centre of Excellence for AD based in the Sustainable Environment Research Centre (SERC). AD is often taught as a component of renewable energy. There are also a number of demonstration projects including one at Reaseheath College who are undertaking trials with the use of digestate in horticulture.

ASSESSEMENT

In short there is a lot of activity trying to fill knowledge gaps rather than advanced AD skills and training is widely available where licencing is generating a demand. Operators and those involved in AD require a coherent and clear training offer that offers them the appropriate skills at the right moment in their development. There are host of other people in the AD supply chain from equipment and service suppliers to regulators and waste producers who need to understand key elements of AD.

As you move from level one (general awareness) through to level three (operator competence) the training availability becomes less, the cost becomes greater and as a result uptake becomes lower (especially for agricultural representatives). At the moment level four (education) is still very much in development. The following section looks what future skills and training may be required for the sector.

[35] This includes Level 3 Award in Waste and Resource Management: Biological Processing involving taught units and a project (see www.wamitab.org.uk).

CHAPTER SIX: TOMORROW'S WORKFORCE

As many as approximately 2,250 new AD jobs could be created by 2020 generating demand for new personnel in science or engineering related occupations, construction, planning and design, process operation and auxiliary occupations. As the number of plants grows, the requirement for AD design and maintenance engineers will increase. On one farm visited a sister agricultural engineering business was an integral part of AD plant's success (see case study five at the end of this chapter).

The AD process requires underpinning skills in science and engineering as well as knowledge of the regulatory requirements. Typically this will manifest itself in demand from employers for managerial, professional, technical and associated professional and process operator occupations. Skills Oracle data (Cogent 2012) identifies that Health, Safety and Environment training was the most frequent type of training undertaken for the process industries sector. This is mirrored in the AD sector where, as mentioned earlier, regulation drives much of the training provision.

Whilst one might expect more remote AD plants to find it a challenge to recruit experienced operatives we have not found that to be the case – often farms for instance are drawing on existing staff or experts willing to travel. In the farming sector there is a requirement for health and safety awareness and as mentioned there are a number of courses around process safety leadership. This is particularly pertinent following the Buncefield oil depot disaster were it was revealed that there were a high number of sub-contractors each with a different level of understanding of process safety. The levels of competence are now more clearly defined to ensure that these risks and hazards can be sensibly managed. AD operators and companies need to ensure there are adequate risk management systems and audit procedures in place and demand for training in this area is likely to grow given the anticipated rate of AD development outlined earlier.

TRANSFERABLE SKILLS

It is possible to say with some certainty that there will be expanding demand and some replacement demand across all parts of the AD sector, leading to a positive overall requirement for labour. Farm, community and industrial plants are all forecast to increase with agricultural and industrial facilities generating the largest volumes of employment demand with possibly the greatest demand for skills in Community AD. Industrial and agricultural operations will be simplified to meet specific needs, and therefore should be able to make better use of existing skills, for instance their knowledge of nutrition. There are likely to be new entrants to the AD market too. Supermarkets for instance are looking at AD waste food facilities, to sign up with companies that carry out AD on their behalf or promote it within their supply chain.

To some degree new opportunities will replace or displace traditional technologies and there is likely to be some movement from other sectors arising from food and drink restructuring, agricultural diversification and the shift towards renewable energy. Given that there are lots of transferable skills from other sectors such as oil, gas and chemical industries, one consultee was surprised that there was not much on transferable skills or the adaptation of skills or training materials from other sectors. This is one area were further research would be helpful and this will become more relevant as the technology develops. The pace of change overall will reflect a range of factors including the state of the economy and availability of finance, the increased affordability and efficiency of technologies and legislative change.

NEW AD SERVICES AND PLANT TYPES

Companies are looking to export, form collaborations with each other and offer customers more diverse and sophisticated services and customised concepts. Customer service skills will increasingly be required ensuring AD personnel are able to combine new technology with excellent customer service – by phone, in person or on-line. Other services likely to increase include parts-supply, biological services and product servicing and consultancy on improving production.

One company consulted was looking at a ‘hub and spoke’ model for farm waste collection and processing. Work for Defra in 2007 claimed that centralised AD plants, based at or close to industrial dairy sites have the potential to be economically viable with payback periods as low as three years[36]. The study suggested facilities could be designed to co-treat organic wastes from industrial dairy sites along with animal wastes from nearby livestock farms and other food manufacturing wastes. Centralised plants can be enormous and highly efficient, creating large amounts of biogas but raise transport costs, require good cooperation. Furthermore issues like planning consent and managing supply chain logistics become more demanding[37].

Alongside the possible growth in centralised plants the micro sector is likely to expand as people look for affordable AD solutions. These trends will influence the levels of demand for particular occupations. In centralised plants for example logistics and feedstock staffing levels are higher than on more self-contained operations.

FUTURE SKILLS REQUIREMENTS

Although AD is perceived as a simple technology, the process and operation is in fact quite complex and in order to run an efficient plant the process must be well understood. Many new operators assume it’s simple and plants are almost able to

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[36] Feasibility of Centralised Anaerobic Digestion Plants linked to Dairy Supply Chain, AEA Technology for DEFRA, 2007.

[37] A Detailed Economic Assessment of Anaerobic Digestion Technology and its Suitability to UK Farming and Waste Systems, 2nd Edition, the Andersons Centre, DECC, 2010

run themselves, but then wonder why they're not getting the outputs that the technology providers or the literature has suggested. Many plants experience technical problems with equipment, with for instance, IT or pump failures. AD technology brings with it therefore a requirement for employees with the appropriate skills. This, in turn, will stimulate the requirement for new standards of education and training aimed at workforce development and new recruits. Some of the provision is in its infancy in this sector as it has grown so quickly relatively recently.

Many of the technicians that work for the new generation of AD consultants which support the sector need to be multi-skilled; operating computerised AD control systems/logic flows and diagnostics. Advanced programmers are required to design and install equipment. Technicians need to an ability to interrogate the systems for maintenance and system improvement purposes. Process engineers are required to take responsibility for the development and documentation of processes and process automation within AD facilities. Typically new posts require a process or chemical engineering degree (1st or 2nd Class Honours) and an understanding of the design and implementation of automated plant control systems.

The level of knowledge and skills required for AD plants is quite specific. Technicians need to fix and make enhancements – managing, maintaining and operating equipment. The AD technician role is likely to grow in number and complexity as the sector develops.

AD will require some standards and qualifications focused on science-using occupations and addressing any skills gaps in the areas of technical and regulatory compliance. Some of the training currently available needs to cover these requirements and be flexible enough to be tailored to each type of AD plant – as demand grows this is especially pertinent. The AD supply chain requires assurance that its skills standards are sufficiently rigorous to cover the necessary safety and regulatory requirements. AD operators will want to ensure there are sufficient initiatives and interventions to up-skill technicians, process operatives and skilled trade occupations. There is not much understanding of the future scale of demand for AD training by occupation and this is another area for further research.

Technical competence needs updating regularly too and operators benefit from a wider understanding of the sector so that they are able to maximise a plants' efficiency and effectiveness. For example in terms of feedstock production, logistics and preparation on a farm you need to know what makes a good feedstock, how store to it and preserve the gas content and the best way to transport it through pumps or manual handling. Identifying and sourcing good feedstock mix to the plant requires a deeper understanding of the processes at work. Whilst the information may be available the interpretation of that knowledge isn't as well established or readily accessible.

AD plants and support firms in coming years will be faced with the challenge of attracting the right calibre of individual with the appropriate mix of skills, knowledge and experience which presents a very real challenge for AD. Whilst skills provision may be available, bespoke educational provision is more limited meaning new recruits to the industry do not often possess the required skill set or experience. AD companies consulted were providing on-the-job training sharing knowledge and experience from experienced employees (see case studies one and three). Some operators in small facilities especially on farms received varying degrees of training from digester suppliers.

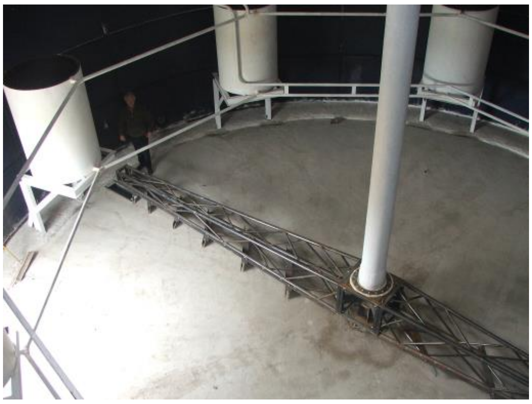
On-site training giving trainees hands experience of plant equipment and feedstocks/outputs is a common feature of AD. The focus here is typically 'how to operate' a plant at the handover stage, so in effect making sure the operator understands the user guide and can undertake straightforward diagnostics and troubleshooting. A more fundamental, often ignored requirement is the 'why' element, for instance if the pH levels drops and the operator is told to increase throughput by two. Operators need to understand why is this, why has pH dropped and what they need to do to increase throughout to address the issue. This way, next time it happens the operator may recognise it before it becomes an issue, or can vary the feed accordingly to avoid a reoccurrence. (This operational requirement provided the rationale for the course on Increasing Methane Yields with National Skills Academy).

In the context of a changing sector consultees suggested that raising awareness of AD was important amongst young people, planners, regulators, financiers and further and higher education to promote the benefits of the sector. ADBA are continuing to develop the key elements of a toolkit that can be used by all those with a role in planning, procuring, delivering and operating AD. It was suggested that existing training needs to be promoted more widely too.

To summarise whilst the volume of jobs may be modest in the AD sector it is growing rapidly and is a highly regulated and skilled industry with increasingly sophisticated skills requirements as the sector continues to expand. However there is further work needed to understand the scale and type of provision required in the next two-five years.

CASE STUDY FIVE: FRE-ENERGY LODGE FARM

Fre-energy, a farm-based company from Wrexham, has won an ADBA award for the implementation of its AD technology within farming. Located at Lodge Farm, near Holt, where the AD processes wastes from the organic dairy unit at 460 acre Lower Park Farm, they collected the award in 2012 for 'Best Integration of AD into a Farming Business'. The main objective for the development of the plant was to efficiently manage on-farm wastes to complement the core business of organic milk production.



The farm owner, along with his brother and a colleague, formed Fre-energy Ltd to build, operate and sell the unique AD auto de-gritting technology they have designed and developed. The innovative de-gritting process (see picture) allows the processing of organic wastes containing grit, silt, sand, stones, glass and metal, as are invariably found in farm slurry, root crops, high grit manures (chicken litter) and food waste. Ash or sand used for cow bedding would silt up a conventional digester; however, the technology designed by Fre-energy routinely manages feedstocks that contain these contaminants as standard.

For a digester to be able to process variable wastes it must be able to manage grit and foam. These two critical elements, along with other key features identified as lacking in conventional digesters, have been engineered into the Fre-energy AD technology making it the first digester in the world to be able to manage different types of wastes in addition to crops. It is the combination of these innovative features that make this AD design different from others on the market, Fre-energy perceive themselves as leaders in the field of using AD for the efficient management of organic waste. The patented auto de-gritting technology combines a non-mechanical gas agitation system. This technology has enabled the Lodge Farm AD to run constantly for three years. Reduced mixing allows material in the tank to stratify, so it is possible to be more selective when extracting the digested material, encourages bacterial growth, and results in improved digestion.

The foam alleviation system, incorporated within the thermally insulated fibreglass roof, enables the processing of high strength feedstocks and allows bacteria to recover quickly to optimum gas production. Feedstocks containing fats and sugars are prone to cause foaming or acid indigestion. Foam is extremely corrosive and if it enters the gas off-take pipe, can irreversibly damage the engine. The rigid roof structure provides stability in extreme weather conditions and also incorporates a partial desulphurisation scrubbing system. In many cases, on-farm AD plants are a one-man operation, so health and safety was also high on the agenda for the Fre-energy design team. As biogas contains H_2S (hydrogen sulphide), which is highly toxic, the digester is designed such that all serviceable parts are external to the tank – once the tank is sealed at point of construction, there is no need for the seal to be broken. The AD system is very low maintenance, requiring about one hour a day for loading the feedstock into the digester and routine maintenance. The AD management control system allows remote monitoring of the AD plants' status; settings, log and diagnostics. This helps to ensure the AD system achieves optimum performance, and alerts the client or the team of any potential problems. The on-site operational AD pilot plant has been further developed in a range of sizes to meet the needs of the client (broadly the size of farm). The biogas engines, pumps, pipework and management control system are fitted within a container unit, making it easy to transport and install. Designed as a plug and play system, the Fre-energy AD has a small footprint with low parasitic load, making it an attractive option for farmers to invest in. An 80kW Fre-energy AD plant costs £650,000 to build, with an anticipated five year payback and a return on investment of 15%-20%.

The AD plant at Lodge farm consistently demonstrates high quality outputs; the biogas is low in H_2S, and the digestate is sufficient to support the fertiliser requirement of the farm. The AD is fed 30 tonnes farm slurry per day, plus six tonnes of chicken litter from a local broiler unit, and has planning permission to import 2000 tonnes of food waste annually. At the front end of the process, Fre-energy has also developed an automated feedstock mixing pit and loading system, and at the back end, a high output separator to separate the digestate into the liquid and solid fractions. The liquid digestate is a highly nutritious bio fertiliser which is injected into the land. Recycling nutrients through AD is the ideal closed loop system and supports sustainable primary food production. The solid digestate, which contains a higher proportion of the phosphate and potash, is a valuable soil conditioner and is used for growing winter crops to feed the dairy herd. Several Universities are conducting trials on the Fre-energy system as the process has identified unique beneficial characteristics. A PhD student studying the environmental and economic effects of the Fre-energy AD process has identified the digestate has significant pollution abatement properties, including up to 95% reduction in nitrate run-off, as well as supporting improved harvest yields. In addition to enhanced slurry utilisation, the AD process kills pathogens (TB, *E.coli*, *Salmonella,* F&M) and most weed seeds; hence there is less reliance on herbicides. Along with the reduction of odour by some 80%, compared to undigested slurry, the social benefits of AD is realising it as the increasingly favoured option in rural communities.

The pilot plant at Lodge Farm was self-funded, with the help of a £45,000 Smart Innovation Grant from the Welsh Assembly. Having built an additional two commercial plants with the fourth in construction, and many more in the pipeline, Fre-energy have found securing capital investment has not been easy even though the government financial incentives (FIT's LEC's &

RHI) make it very lucrative (and that's without taking the free electricity, heat and fertiliser uplift into account). The engineering business located at Lodge Farm, owned by one of the co-founders of Fre-energy, has played an integral role in the development of the patented AD technology, and it is worth noting the engineering business now operates from 100% renewable energy.

The plant produces 160kW of electricity and 200kW of heat. Some 30kW electricity is used on site to power the engineering business, the Fre-energy office, and a large seven bedroom farmhouse. 60kW of heat is used to heat the cow slurry and chicken litter in the digester up to 40°C and the rest is used to heat the house and office. The surplus electricity is exported to the National Grid. Lodge Farm does not import any chemical fertiliser to grow grass or crops; it is completely served from the AD outputs which contain not only NPK but also micro-nutrients. Equally important, the AD business is providing an additional income stream which is non-food based and outside of the control of supermarkets, making AD a sustainable option for the future of farming and the agricultural industry.

CHAPTER SEVEN: CONCLUDING OBSERVATIONS

As a niche but thriving industry, AD has the potential to deliver new green jobs and renewable energy. Much AD intelligence is fairly recent, the technology still undergoing refinements and the learning and skills infrastructure still quite embryonic, having to react quickly to the relatively fast pace of change. In the wake of Defra's Action Plan the activities and working groups are playing a valuable role in helping to remove some of the barriers to growth currently faced by the industry and promote the benefits of AD to the UK.

There is no reason to believe that the recent scale of change will slow with 123 additional sites having received planning permission nationally[38] including 38 farms. It is abundantly clear the sector offers a very diverse and potent range of benefits on a number of fronts. Despite some of the barriers to the sector commentators tend to be quite optimistic about its prospects.

AD provides a variety of employment opportunities from manual work collecting waste to highly specialized engineering. The skills required for AD range from general awareness to health and safety, biology and detailed process and operations. They cover technical competencies as well as knowledge of plant and equipment, environmental monitoring and gas management. Progress has been made in identifying AD skills and the NOS paves the way for an apprenticeship framework. The availability of operator qualifications is quite widespread and uptake has been steady and reflecting the relatively small size of the sector. There is a lot of training activity trying to fill knowledge gaps covering a diverse range of subjects – understanding the science behind the process is an important part this.

As many as approximately 2,250 new AD jobs could be created by 2020 generating demand for science or engineering related occupations, construction, planning and design, process operation and auxiliary positions. To some degree new opportunities will replace or displace traditional technologies. The pace of change will reflect a range of factors and the way the sector develops will influence the levels of demand for particular occupations. The benefits to the UK economy of the drive to greater energy sustainability and carbon reduction will be even greater if the technologies deployed can be designed and sourced in the UK.

Although AD is perceived as a simple technology the process and operation is in fact quite complex and in order to run an efficient plant the process must be well understood. Many of the technicians that work for AD consultants which support the sector need to be multi-skilled. The new generation of AD plants and supporting

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[38] Anaerobic Digestion Strategy and Action Plan Annual Report on Progress 2011/12, DEFRA, July 2012

firms will be faced with the challenge of attracting the right calibre of candidates which presents a very real challenge for AD.

The industry really needs to take action to stimulate awareness of training provision and encourage uptake. This will require government support and funding building on its experience gained through the permitting requirements. In light of the above there are some key skills and learning areas that need addressing in the coming years. They are as follows:

Further Research

I. Further research to inform provision identifying:
   a. the precise scale and type of training required by employers in the next two-five years
   b. the future scale of demand for AD training by occupation
   c. future employer recruitment demand and the calibre (skills, knowledge and experience) of individuals required.

Future Provision

II. The availability of training needs improving. Whilst the provision is largely available there needs to be more incentives (other than the permitting requirement which is quite new) for operators to attend. Public sector support and a specific minimum skills requirement for all plants would significantly enhance AD productivity and skills levels especially if cheap short courses were available (and flexible enough for farmers to attend for instance).

III. In light of the above new AD skills provision should be considered to fill any gaps identified/demanded using existing or adapted material. An example is the customer service skills that are required to maintain plants remotely. Dealing with sophisticated customer requirements is a feature of this industry.

IV. The continued development of more bespoke educational provision to supplement the extensive on-the-job training currently prevalent within the sector. Conversely some trainees might welcome some ‘knowledge’ prior to undertaking formal assessments/qualifications.

V. The continued refinement of education and training aimed at workforce development and new recruits in the AD sector to ensure it matches technology change and the increasingly multi-skilled nature of the job.

VI. There is a need to develop the quality and availability of trainers providing formal and informal training to meet the growing needs of the sector – teaching skills in particular are required.

VII. The growth of the AD sector is likely to result in an increasing demand for process safety leadership as operators will be keen to demonstrate and ensure they have taken appropriate protection measures.

Operator Competencies

VIII. Continuing to build operator competencies on both permitted and not permitted sites. Training should strike a balance between meeting training criteria (confined space training for instance) and their application in context so it resonates with the trainee, is relevant and has some future currency.

IX. Ensuring operator competencies are appropriately updated to match technological and legislative change.

X. Operators need support, CPD and suitable training to understand the AD process better. This should transcend plant operation giving operators an insight into why things change and why certain changes can have a serious impact on gas yield, quality, or safety.

Entry to the Sector and Awareness

XI. AD should continue to be pushed as a viable option for young people and an apprenticeship framework should be supported to match the anticipated growth of the sector.

XII. The development of a clear pathway for employees who wish to transfer into the AD sector from similar industries should be considered (engineers from other sectors may require an understanding of AD legal requirements and feedstock knowledge for example).

XIII. There is a need to continue to the raise awareness of AD which is currently quite low, and signpost and promote existing training including National Skills Academy for Process Industries' increasing methane course and training offered via WRAP, ADBA, the REA and others.

ANNEX ONE: CONSULTEES AND CASE STUDIES

Name	Title	Organisation
Dr Jenny Clucas	Strategy Director Chemicals & Petrochemicals	Cogent SSC
Claire Pool	Education and Training Manager	CIWM
David Collins	Head of UK Biogas Group	REA
Denise McGlynn	Client Manager – Waste and Recycling	EU Skills
Dr Stephen Rosevear	Research & Policy Director	Cogent SSC
Jonathan Scurlock	Chief Adviser, Renewable Energy & Climate Change	NFU
Kevin Thrower	Biotechnology Skills Manager	National Skills Academy Process Industries
Lisa M. Charles	SME Engagement Manager	Cogent SSC
Lucy Hopwood	Head of Biomass & Biogas	NNFCC
Maggie Newton	Programme Area Manager - Market Development (Organics & EfW)	WRAP
Ray Burberry	Qualifications Manager	WAMITAB
Richard Gueterbock	Director	Clearfleau
Sam Grundy	Farm Demonstrator and Coordinator	Reaseheath College
Sarah Ford	Research Manager	EU Skills
Tina Benfield	Senior Technical Officer	CIWM

Name	Case study
Pamela Dear	Melrose Farm
Graham Martin	Deerdykes Recycling Centre
Richard Gueterbock	Clearfleau
Denise Nicholls	Fre-energy Ltd, Lodge Farm
Gary Bonnette	Farmgen Limited

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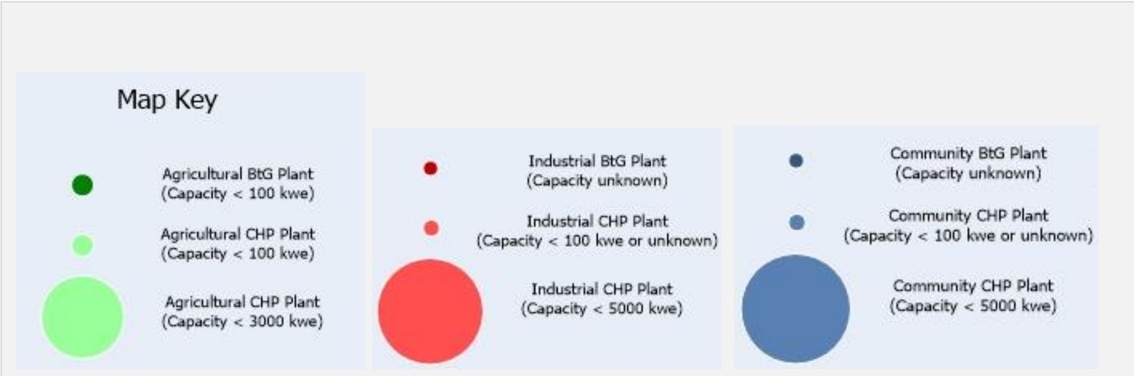
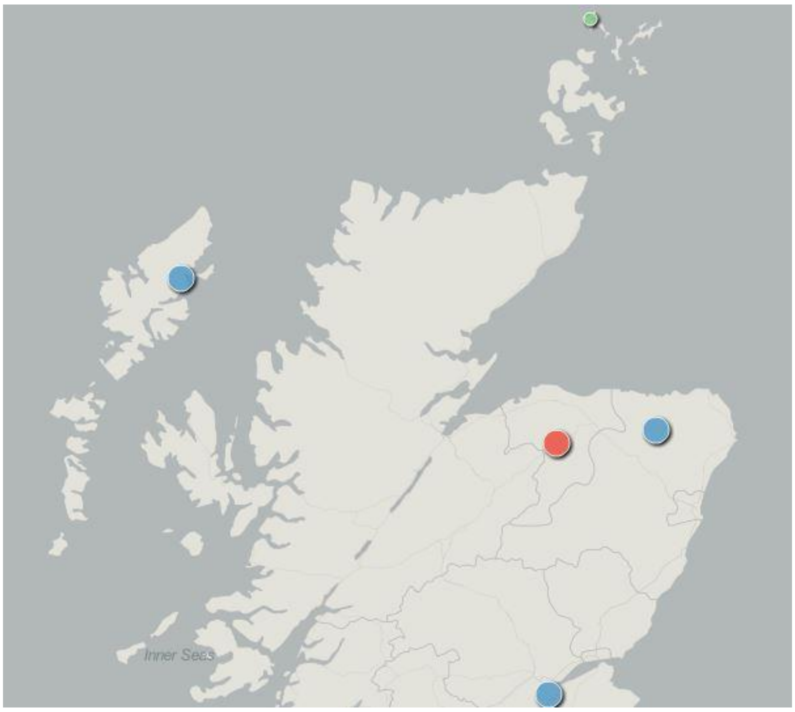
UK jobs in the bioenergy sectors by 2020, A report for DECC by NNFCC, April 2012

ANNEX THREE: AD MAPS

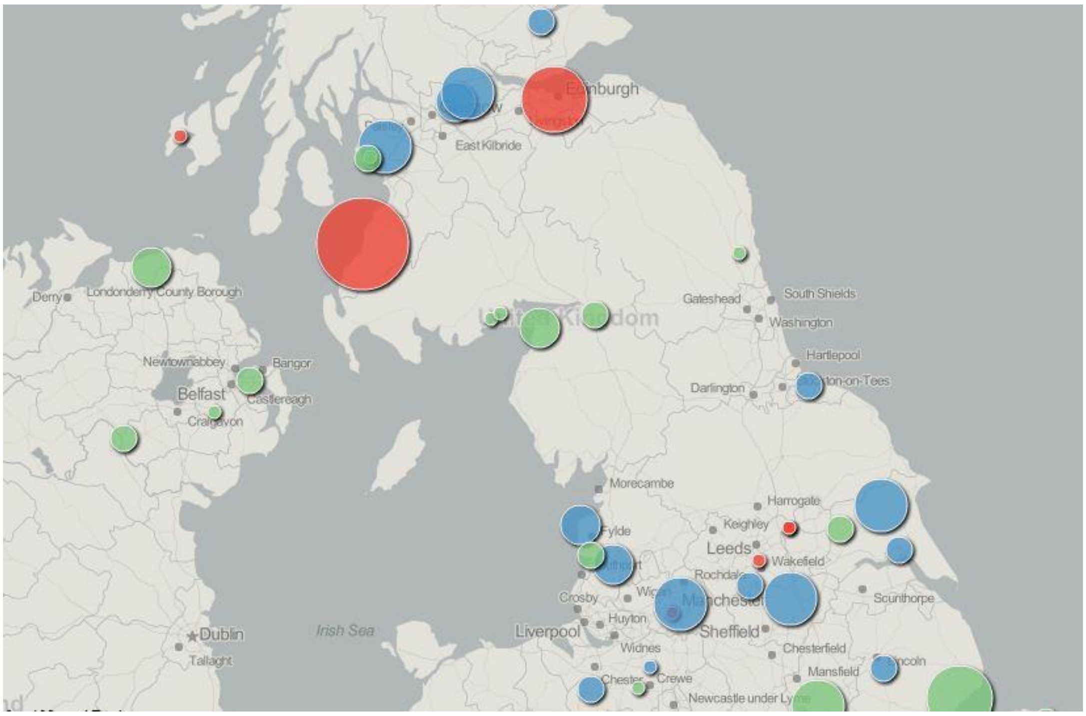


Map 1: The Highlands and Islands



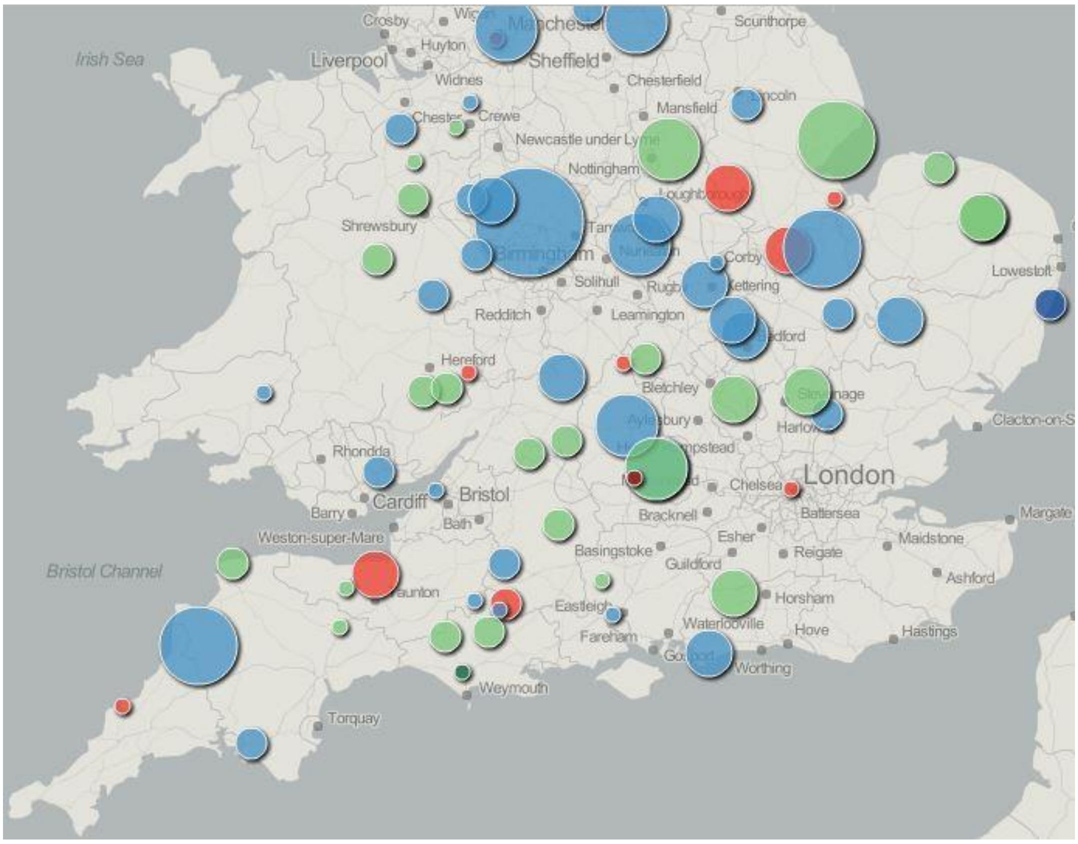
Source: Cogent Analysis using data from the Official Biogas Portal (March 2013)

Map2: Southern Scotland, Northern Ireland and Northern England



Source: Cogent Analysis using data from the Official Biogas Portal (March 2013)

Map 3: Southern England, the Midlands and Wales



Source: Cogent Analysis using data from the Official Biogas Portal (March 2013)

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