Anaerobic Digestion in the UK - an overview

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What is Anaerobic Digestion?

A microbial process which breaks down organic matter into simpler chemical components in the absence of oxygen, resulting in the production of biogas (60% CH\textsubscript{4}, 40% CO\textsubscript{2}) together with liquid and solid digestate.
Figure 1. Primary energy production of biogas in the EU, 2006: ktoe

Source: EurObserver
## Global AD Capacity

<table>
<thead>
<tr>
<th>Country</th>
<th>AD plants</th>
<th>Installed Capacity</th>
<th>Average Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>3700</td>
<td>550</td>
<td>0.15</td>
</tr>
<tr>
<td>Austria</td>
<td>309</td>
<td>69</td>
<td>0.22</td>
</tr>
<tr>
<td>UK</td>
<td>16</td>
<td>7.3</td>
<td>0.44</td>
</tr>
<tr>
<td>Ireland</td>
<td>5</td>
<td>0.2</td>
<td>0.04</td>
</tr>
<tr>
<td>Italy</td>
<td>80</td>
<td>62</td>
<td>0.78</td>
</tr>
<tr>
<td>China</td>
<td>&gt;15 M</td>
<td>??</td>
<td>Very small</td>
</tr>
</tbody>
</table>

Source: DEFRA UK Biomass Strategy 2007
A simple AD system used in China and India
Use of biogas in Germany: development 1992 – 2010

- Number of plants
  - Development from 1992 until 2010
- Installed electrical capacity (MW)
  - Development from 1999 until 2010
  - * No statistics available for the period prior to introduction of the EEG (1992 to 1998)
German Renewable Energy Law: Fixed prices for biogas electricity

<table>
<thead>
<tr>
<th>Avg. system power (kW)</th>
<th>Guaranteed fixed price (cents / kWh electricity)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basic price i.e., using manure and crops</td>
</tr>
<tr>
<td>0 - 150</td>
<td>11.5</td>
</tr>
<tr>
<td>150 - 500</td>
<td>9.9</td>
</tr>
<tr>
<td>500 - 5000</td>
<td>8.9</td>
</tr>
<tr>
<td>&gt; 5000</td>
<td>8.4</td>
</tr>
</tbody>
</table>
Map of UK AD Plants operating January 2011

Source: http://www.biogas-info.co.uk/index.php/ad-map
AD Plants registered for ROC’s at the end of Dec 2009.

<table>
<thead>
<tr>
<th>Generator Name</th>
<th>Type</th>
<th>Capacity kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedfordia ~ Twinwoods Bedfordshire</td>
<td>Farm</td>
<td>786</td>
</tr>
<tr>
<td>Mauri Products Hull</td>
<td>Non-Farm</td>
<td>850</td>
</tr>
<tr>
<td>BioGasK Turiff Aberdeen</td>
<td>Farm</td>
<td>340</td>
</tr>
<tr>
<td>Creed Park Lewis</td>
<td>Non Farm</td>
<td>237</td>
</tr>
<tr>
<td>Holsworthy Biogas</td>
<td>CAD</td>
<td>2,696</td>
</tr>
<tr>
<td>South Shropshire Biowaste</td>
<td>Non Farm</td>
<td>200</td>
</tr>
<tr>
<td>Wanlip AD plant Leicester</td>
<td>Non Farm</td>
<td>1,434</td>
</tr>
<tr>
<td>Smerrill Generating Station Cirencester</td>
<td>DairyFarm</td>
<td>300</td>
</tr>
<tr>
<td>Lowbrook Dorset</td>
<td>Farm</td>
<td>365</td>
</tr>
<tr>
<td>Mellington Cow Power Montgomery Wales</td>
<td>Farm</td>
<td>100</td>
</tr>
</tbody>
</table>

Total 7,308

Source - Andersons 2010
Scale of operation

Small domestic food waste – CCN operation
Single farm facility e.g. Cockle Park Farm (75 kWe), Kemble Farms (300kWe)

Co-operative of farms within close geographical proximity

CAD – Centralised AD Facility e.g. Holsworthy plant in Devon (25 farms within an 8km radius, 2.6MWe)

Large waste facilities e.g. Water companies, MSW
Kemble Farms Cirencester

700 cow dairy unit 17,000-20,000 t/p/a of slurry
50-60 hectares of maize ~2,000 t/p/a
1.2 t of glycerol per day 450 t/p/a

300kW CHP unit

Total Project Costs £1.2 M including two new silage clamps
£70,000 for Grid Connection

Expected payback 5-6 years
GWE Biogas Driffield

• 2 x 1MW Jenbacher engines
• Two stage process
• 50,000 tonnes of food waste per annum both liquid and solid
• Funding from the Environmental Transformation Fund – innovative technology both front and back end
• Approximate cost of £10 Million
The European Agricultural Fund for Rural Development: Europe investing in rural areas.

Biffa Food waste AD plant at Cannock

- 6MW facility
- 120,000 tonnes of commercial and industrial food waste per annum (from Sainsburys, Bakkavor etc)
- Cost £24 M
Substrates for Anaerobic Digestion

- Cattle and pig (manure and slurry)
- Poultry manure
- Silage effluent
- Industrial waste – from: food, brewing and soft drinks, distillery, pulp and paper, chemical industries etc.
- Sewage sludge – provides sanitisation and reduces odour
- Organic fraction of MSW
- Energy crops

Ideal C:N 13:1 to 28:1
### Biogas production from different substrates

<table>
<thead>
<tr>
<th>Substrate</th>
<th>DM%</th>
<th>Biogas yield M³/t substrate</th>
<th>CH₄ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy cow slurry</td>
<td>8</td>
<td>20</td>
<td>55</td>
</tr>
<tr>
<td>Fattening cattle slurry</td>
<td>10</td>
<td>34</td>
<td>55</td>
</tr>
<tr>
<td>Pig slurry</td>
<td>5</td>
<td>18</td>
<td>60</td>
</tr>
<tr>
<td>Chicken manure</td>
<td>25</td>
<td>93</td>
<td>65</td>
</tr>
<tr>
<td>Vegetable residues</td>
<td>6</td>
<td>35</td>
<td>56</td>
</tr>
<tr>
<td>Rapeseed meal</td>
<td>91</td>
<td>612</td>
<td>63</td>
</tr>
<tr>
<td>Whole crop silage</td>
<td>40</td>
<td>195</td>
<td>53</td>
</tr>
<tr>
<td>Grass silage</td>
<td>35</td>
<td>183</td>
<td>54</td>
</tr>
<tr>
<td>Maize</td>
<td>27</td>
<td>200</td>
<td>54</td>
</tr>
</tbody>
</table>

*Source: Kottner et al 2004*
The European Agricultural Fund for Rural Development: Europe investing in rural areas.

Biogas yield and methane content of various substrates
Capital Costs

Every AD plant is different in terms of technology, inputs, outputs, location etc such that accurate costs can only be obtained from a system supplier. Component costs:

• Civil Engineering works

• System components and installation

• CHP system

• Grid connection

Range from £2,500 to 7,000 per kW with maintenance costs at 1-2% of capital costs (Redman 2010)
Financial support for AD in the UK

ROC’s introduced in 2002, banded in 2008 so that AD currently receives 2 ROC’s i.e. ~£90 MWhₑ

Feed In Tariffs – introduced in April 2010 for <5MWₑ

<250kW - 14p kWhₑ

250-500kW – 13p kWhₑ

500kW - 9p kWhₑ

Based on generation not export

Export bonus of 3pp kWhₑ
2011 Renewable Heat Incentive

<200\text{kW}_{th} \quad 6.5 \text{ p kWh}_{th} \text{ lifetime of 20 years}
The 200\text{kW}_{th} \text{ capacity equates to about } 160\text{kW}_e

Of the 200\text{kW}_{th} \text{ you deduct up to 20\% for heating the digester so net thermal output is } \sim 160\text{kW}_{th}

Need to be careful with Grant Funding (e.g. RDPE) for ROC’s, FIT and RHI as in some cases classed as double counting i.e. State Aid
Income/Returns

• Production and use of electricity on site

• Export of electricity to the National Grid

• Production and use of heat on site

• Biomethane injection into the National Gas Grid – depends on RHI and only economic for large scale systems e.g. 500m³ per hour

• Digestate – use on site or sale
Further information

Further information on feedstocks and costs and can be obtained from the AD Portal operated by the NNFCC - www.biogas-info.co.uk.
This includes the biogas calculator model.
The European Agricultural Fund for Rural Development: Europe investing in rural areas.