Material change for a better environment

Environment Agency

Waste Protocols Project

Anaerobic Digestate

Partial Financial Impact Assessment of the introduction of a Quality Protocol for the production and use of anaerobic digestate

Contents

1.0 The market for anaerobic digestate

This is a partial impact assessment that focuses on the financial costs and benefits of the Quality Protocol to those involved in the supply of anaerobic digestate. It excludes social and environmental impacts with the exception of carbon dioxide emissions. Furthermore, the analysis focuses only on the financial costs and benefits to the waste producers, processors and users. Impact to those involved in the supply of virgin or other secondary materials are not included.

1.1 Feedstocks for anaerobic digestion and their arisings

1 Anaerobic digestion (AD) is an effective means of treating organic wastes from households and municipal authorities, organic solid wastes from industry and agricultural residues/wastes. It also increases the positive options to use these materials to produce a feedstock for renewable energy generation [31]; the biogas produced during anaerobic digestion can be used as a fuel source for heating and/or electricity production.

2 The end products of anaerobic digestion are biogas, liquors and solid organic materials. The digestate liquor is a nitrogen-rich fertiliser. The solid organic material can either be used without further pre-treatment as a soil improver or further processed to yield a compost, which could be used in a growing media for use in horticulture and landscape activities. Within this report, the terms 'digestate', 'fibre', 'digestate compost' and 'liquor' will be used for the unseparated residue, untreated separated solid material, composted separated solid material and the separated liquid fraction respectively.

3 In the UK, farm-scale AD plants typically digest the agricultural slurries from the farm for use as a soil conditioner on its land. Centralised anaerobic digestion (CAD) plants digest different mixtures of animal slurries and industrial organic waste (e.g. from milk processing).

4 Sources [7, 22] suggest there are currently 23 commercial-scale AD plants in the UK. Of these 23, only three are centralised plants. Of these three plants, only one is attempting to recycle household wastes; the other two are recycling agricultural (animal slurries) and industrial (food processing) wastes. The other plants are farm-scale plants recycling their own agricultural residues/wastes and using the digestate for their own end uses. A small number may be selling the digestate as a soil conditioner [40]. Other (older) estimates suggest that there are 15–20 farm-scale units operating at a small-scale generating heat only [30].

5 The average digestate production from manures is one tonne of digestate per tonne of feedstock, though this varies with the dry weight percentage [40]. Municipal and industrial wastes tend to generate less digestate due to the lower moisture content of the waste and greater loss through biogas production. Food waste digestion from municipal collections gives a digestate product of 83 per cent together with 17 per cent biogas [20]. Average biogas production is 140 m^3/tonne of municipal organic household waste; agricultural residues/waste generate much less at an average of 15 m^3/tonne [31, 46]. Anaerobic digestion in the UK generates 277,000 tonnes/year of digestate; (this includes 50,000 tonnes/year from municipal kitchen/food waste) [25]; the proportion from agricultural and commercial/industrial (C&I) sources is uncertain [11].

Agricultural residues and wastes

6 A study for the Department for Environment, Food and Rural Affairs (Defra) in 2005 stated that 88 million tonnes of manure are produced each year in the UK, of which just under one third is in liquid slurry form and just over two-thirds is solid farmyard manure or poultry litter [30].

7 Manures likely to be treated are from pigs and cattle rather than from chicken or sheep; where alternative disposal options exist for treatment, collection would be difficult. However, data from a more recent ADAS study for Defra [1] allows the projected arisings shown in Table 1 to be estimated.

Table 1: Estimated manure arisings and nitrogen content					
	2004	2010	2015	2020	2025
Manure arising all livestock (kt)	90,700	86,552	84,835	83,293	81,567
Manure arising cattle and pigs (kt)	83,700	79,467	77,763	76,208	74,410
Average nitrogen – all livestock	1.20%	1.18%	1.19%	1.20%	1.21%
Average nitrogen – cattle and pigs	0.92%	0.91%	0.92%	0.93%	0.93%

8 These manures will not all be collected separately for processing and composting will be the main alternative option to AD. There is also competition in terms of the various systems and combustion of crop residues and food processing wastes as biofuels. The vast majority of manures and crop residues will be landspread on the holding where they are generated and remain outside the waste system.

9 Current disposal of agricultural waste, residues and slurries is primarily by application as untreated manure to land either on the farmer's holding or nearby. This land spreading is regulated in parts of the UK under the EU Nitrates Directive and Nitrate Vulnerable Zones (NVZs) Regulations; manure is not regulated as a waste, although application may be limited by site-specific factors. Once digested, the digestate is classified as waste; this may be a disincentive to further expansion of manure processing.

10 Some expansion of AD has been prompted by eutrophication of surface waters. One example is the seven plants operated by Greenfinch Ltd in south-west Scotland, which were supported by the Scottish Government to help alleviate nutrient run-off problems in the area. Although this may be replicated elsewhere, we are not aware of any schemes currently in preparation. However, Technical Advisory Group (TAG) members suggest that the expansion of AD as a result of environmental and energy pressures is accelerating.

Sewage sludge

11 Sewage sludge was not considered in this study because, while sludge is digested in many sewage treatment works (STW), the sludge will not be covered by the Quality Protocol and thus uptake of digestion of sewage sludge will be unaffected by its introduction. Approximately 1.8 million tonnes of dry solids are treated in the UK each year and approximately half is digested in 150 STW [6]. The landspreading of sewage sludge is governed by The Domestic Sludge (Use in Agriculture) Regulations (1989, SI 1263).

Municipal wastes

12 Of the 12.5 million tonnes/year of municipal solid waste (MSW) identified as organic (Table 2), only 50,000 tonnes/year are digested [25].

Table 2: UK organic waste arisings by sector (million tonnes/year) [12]				
Type of waste	Commercial	Industrial	Municipal	Total
Kitchen/food	3.5	2.2	6.1	**11.8**
Garden/plant	3.2	1.0	6.4	**10.6**
Other organic	0.5	2.1	0	**2.6**
Total	**7.2**	**5.3**	**12.5**	

13 A survey by The Composting Association [41] indicated that, of the 2.67 million tonnes of municipal and similar waste treated in 2004/05, only 5,000 tonnes were digested (the number of AD plants has increased since then). Of this 2.67 million tonnes, 2.18 million tonnes were from households and a further 430,000 tonnes of commercial wastes were composted or digested (Table 3).

Table 3: Composting Association survey data, 2004/05 [41]

	Estimate total collected (tonnes)	Category percentage	Total percentage
Municipal household			
Garden waste from civic amenity/ bring sites	1,127,000	51.8%	42.2%
Garden waste from kerbside collection	779,000	35.8%	29.2%
Garden and kitchen waste from kerbside collection	128,000	5.9%	4.8%
Kitchen waste only from kerbs	3,000	0.1%	0.1%
Green waste from schools, higher education institutions (HEI) and colleges	6,000	0.3%	0.2%
Other municipal household waste	135,000	6.2%	5.0%
Total	**2,178,000**	**100.0%**	**81.5%**
Municipal non-household			
Council park and gardens waste	51,000	81.1%	1.9%
Council – collected food processing by-products	<100	0.0%	0.0%
Council – collected food waste from shops/catering outlets	<100	0.0%	0.0%
Other municipal non-household waste	12,000	18.9%	0.4%
Total	**63,000**	**100.0%**	**2.4%**
Non-municipal waste (commercial)			
Landscape/ grounds maintenance	135,000	31.3%	5.0%
Forestry/ timber/ bark/ by-products	57,000	13.3%	2.2%
Food processing by-products	93,000	21.6%	3.5%
Food wastes from shops/ catering outlets	2,000	0.4%	0.1%
Paper and cardboard	2,000	0.4%	0.1%
Sewage sludge	7,000	1.7%	0.3%
Paper sludge	1,000	0.3%	0.1%
Manures/ straw	3,000	0.6%	0.1%
Other	131,000	30.4%	4.9%
Total	**431,000**	**100.0%**	**16.1%**
Total composted	**2,672,000**	**–**	**100.0%**

Industrial and commercial wastes

14 Organic industrial waste includes a wide range of materials from C&I operations. Organic solid wastes from industry are increasingly regulated and treatment of these wastes by AD allows additional value to be gained through providing products and reducing the cost of disposal [27].

15 Potential feedstocks for AD from commercial waste sources include catering waste from hotels and restaurants. The high moisture content of these wastes causes problems for incineration, but makes them suitable for AD [33]. Other sources include solid residues such as vegetable packing, abattoir waste and oilseed wastes. Other industries have lower overall quantities of suitable feedstocks, but there are opportunities for residues from, for example, the pharmaceutical, paper and rubber industries [48].

1.2 Existing markets for anaerobic digestate

16 Whole digestate could be aerobically stabilised, and sold or given away as a compost alternative. It could also be used as an input to the composting process to produce nutrient-rich compost.

17 Digestate derived from primarily wet agricultural wastes is currently marketed to agriculture and the horticulture sector as three different products:
- Whole – as a soil conditioner adding nutrients and bulk to soils (typically on soils planted for arable crops and not in horticultural applications);
- Fibre – as a soil conditioner adding bulk and improving water drainage of soils;
- Liquor – as a fertiliser adding and increasing nitrogen uptake (typically used on grassland and for topdressing arable crops).

18 Possible markets for the solid products can be divided into different sectors:
- horticulture – amateur and professional (amateur sector is likely to only use solid and composted digestate);
- landscaping;
- forestry;
- land reclamation;
- agriculture.

Agriculture

19 The potential size of the UK agricultural market for organic waste-derived products is difficult to determine partly due to the variation in farming practices across the country [47]. Digestate reduces the potential for soil erosion and improves productivity by:
- increasing the soil organic matter and soil fertility;
- supplying additional nutrients.

20 Agriculture represents up to 97 per cent of the potential market for waste-derived digestates and composts, but has one of the lowest values. In 1996 it was estimated that waste-derived composts sold into agriculture as a soil improver could probably command a price in the range of £0 to £10/tonne (£0–13/tonne, 2007 prices) delivered and spread at that time. A supplier of digested fibre in the earlier 1990s[1] could command up to £20/tonne (£26/tonne, 2007 prices). Given the cost of transport and spreading, this would indicate that the value applied to the material itself was close to zero.

1 Information provided by TAG member regarding Heritage composts.

21 One estimate of the current price of digestate (whole, fibre or liquor) is £5 per tonne (including transport). This is paid to a farmer to accept the digestate from CAD plants [40], although other evidence (TAG comments) suggests the value is zero or slightly positive, i.e. plants do not pay farmers for accepting digestate. This is a key parameter as the industry is keen to maintain the 'product' rather than 'waste' status. It shows that the value of the digestate/compost has fallen as supply has increased and the market has declined due to lower allowable nitrogen application rates.

22 The biogas and heat produced by AD results in a net gain of electricity and heat over the energy requirements of the process. The profits generated from the sale of the excess electricity and heat are reported to be greater than the £5/tonne paid to local farmers to dispose of the digestate [40].

Horticulture and landscaping

23 Peat has dominated the market for soil improvers and growing media in the UK for a number of decades. The use of alternatives to peat including waste-derived composts, spent mushroom compost, bark, coir, etc. has increased in recent years.

24 The accurate determination of market size is difficult [47]. In the mid-1990s, the potential market in professional horticultural and landscaping for composts and digestates derived from municipal waste was limited to a part of the 3–4 million m^3 per year market occupied by peat, bark and other materials.

25 The use of digestates to improve soils is one of the more encouraging areas of market potential. Large amounts of organic matter are required to establish landscaped areas, for major roadway construction, for topsoil replacement and for golf course construction. There is currently comparatively little activity of this type in the UK.

Land reclamation

26 Many types of industrial land require soil improvement as part of the reclamation process including:

- opencast mines or mine spoil heaps;
- land contaminated during use for chemical manufacture and other industrial processes.

27 The degree to which the reclamation is performed depends on the proposed end use. If the land is to be returned to agriculture, then a high quality soil is required. If lower quality grass is adequate, then lower quality reclamation will suffice. The requirement to reclaim to a high standard will normally require organic matter to be added [47].

28 The application rates for waste-derived composts in land reclamation vary considerably; application rates on a one-off basis of 500–1,000 tonnes/ha have been reported [24]. This rate of usage is not suitable for all sites due to nutrient limits, but it provides a useful guideline for the maximum application rate for composts. Application rates using digestates might need to be reduced due to their higher nitrogen levels, with corresponding reductions in organic matter loading.

29 The value of this type of product is difficult to gauge. In 1996, competing products were typically sold for less than £5/tonne delivered. But for the lowest quality uses, prices may be zero – especially for reclamation of mine spoil, landfill restoration, etc.[47].

Forestry

30 The potential value of various organic amendments to the soil is well known to those managing forest nurseries [32]. The suitability of a forest site for the application of an organic waste will depend on the capacity of the crop to use the nutrients it contains without detrimental effects – on or off-site.

31 In the 1990s, application rates up to 448 tonnes/ha (200 tonnes/acre) of composted MSW and sewage sludge were demonstrated to be effective in forestry applications. Under current guidelines, however, such rates may well exceed recommended nitrogen application rates with composts.

32 Given an area of 22,000 ha of forest planting per year with application rates up to 400 tones/ha, the total potential market would be 8.8 million tonnes/year. However, much of the land used in forestry is remote from centres of population and transport costs would be prohibitive. The probable market is therefore likely to be 20–25 per cent of total potential market, i.e. approximately 2 million tonnes/year. The value of the material is likely to be no more than the cost of fertilisers that are displaced [47].

1.3 Substitute materials

33 Digestate has two primary substitute products – soil conditioners (compost and mulches) and inorganic manufactured petroleum-based liquid fertiliser. Table 4 shows the current market values of these possible substitutes.

Table 4: Digestate substitutes and their associated market values [16, 26, 40]

Substitute	Example	Cost (£/ tonne)*	Cost (£/tonne) of active element (N, P K)
Fertiliser	Ammonium nitrate (NH_4NO_3)	133-199	378-568
	Phosphate (P_2O_5)	595–615	1,363–1,409
	Potash (K_2O)	235–245	283–295
	Sulphur	65–95	65–95
Agricultural and horticultural soil improver	PAS 100 compost	5–10	

*** Given the diversity and volatility of the fertiliser market the range in these values is used later in the sensitivity analysis.**

Inorganic manufactured fertilisers

34 The price of inorganic manufactured fertilisers varies according to oil and gas prices because production is highly energy dependant.

35 The nutrient content of digestates of all types depends primarily on the feedstock, as the nutrients are largely retained either in the solid or liquid phase. Where composted digestate is produced, nitrogen is lost to atmosphere in the composting process. To a lesser extent, nitrogen is lost during the storage and spreading of whole digestate or separated liquor; Table 5 gives examples of nutrient levels in products. The loss of nitrogen is also observed in untreated manures during storage and spreading; this has been estimated as 38.4 per cent of nitrogen in the UK [28].

Table 5: Example nutrient contents of selected digestate products [42, 49]

Parameter	Digested dairy slurry liquor (g/m^3)	Digested broiler litter liquor (g/m^3)	MSW digestate (% DM)	Broiler litter compost (% DM)
Nitrogen (N)	2,500	5,544	0.84	0.295
Phosphorus (P) (as P_2O_5)	2,800	1,980	0.3	1.02
Potassium (as K_2O)	5,300	1,980	1.3	2.1
Sulphur (S)	80	-	0.2	0.46
Estimated value (total N,P,K,S)	£3.91	£3.76	£8.25	£12.69
Accounting for availability	£3.26	£2.80	£1.71	£3.28

DM = dry matter

Table 6: Example nutrient contents of further selected digestate products [8, 4, 21]

Parameter	Digested cow slurry			Digested pig slurry			Mixed digester output (30% cow, 50% pig 20% C&I)		
	Whole	SL	SF	Whole	SL	SF	Whole	SL	SF
Dry matter (DM) (%)	7	3.1	23	5	1.5	30	4	1	30
Total N (kg/tonne)	5.47	4.6	9	5.05	4.36	9.56	5.15	4.49	12.5
Available N (kg/tonne)	3.29	3.3	3.3	3.78	3.79	3.72	4.12	4.13	4
Organic N left (kg/tonne)	2.18	1.3	5.7	1.27	0.57	5.84	1.03	0.36	8.5
Phosphate (kg/tonne)	1.02	0.2	4.2	1.21	0.56	5.49	1.16	0.37	10
Estimated value (total N,P)	£3.73	£2.22	£9.65	£3.82	£2.62	£11.69	£3.79	£2.41	£19.22
Accounting for availability	£1.74	£1.46	£2.86	£2.01	£1.79	£3.48	£2.14	£1.87	£5.17

SL = separated liquor
SF = separated fibre

36 The replacement value of the inorganic manufactured fertiliser is not 100 per cent as the availability of the nutrients is low in the first year of application for fibre and compost fractions; liquor has equivalent availability to inorganic manufactured fertilisers (though some TAG comments suggest it may be higher). Solid residues are very slow release, while digestate composts and fibre have year one availabilities[2] of 5–10 per cent for nitrogen and 25 per cent for P and K [29]. Liquor fractions hold the fertiliser in more available forms than solid parts of the digestate and are likely to be closer to 50–70 per cent (compared to an inorganic manufactured fertiliser efficiency of approximately 60 per cent.

37 These values and availabilities give the value of the products shown in Table 5 and Table 6. These values compare well with the value calculated for green waste compost in 1996 of £2/tonne (£2.64/tonne, 2007 prices) [45]. These estimates are comparable; although they are performed on slightly different bases and the range of nutrients considered varies, they do illustrate a value range that can be ascribed to these materials.

2 Nutrient availability is a measure of the total nutrient content becoming available to plants as soluble chemical species that plants can use.

38 Although this value is not realised by the AD plant operator in sales value, it is a benefit gained by the land user if the digestate supplements materials applied to land rather than simply processing materials that would be otherwise applied to land. The benefits of AD in nutrient management are substantial in that nutrients can be applied more reliably and precisely to crops. However, it is difficult to ascribe a value to this management benefit.

Soil conditioners

39 Graded, clean and contaminant-free compost/mulch sells for £5–10/m^3 (2007 prices) and has done so for the last 10 years. In 2004/05, 2.76 million tonnes of compost were generated; this was 2.6 times the amount generated in 2000/01 of 1.03 million tonnes [36, 41].

40 The quantity of organic waste derived from household waste recycling centres increased by 5 per cent from 1.07 million tonnes in 2003/04 to 1.13 million tonnes in 2004/05, and accounted for 42 per cent of all organic waste collected for composting. The amount of commercial organic waste (comparable to CAD plants) composted has remained virtually the same at 0.43 million tonnes (0.44 million tonnes in 2003/04) but its share of the total has fallen from 23 per cent of the overall organic waste collected in 2003/04 to 16 per cent in 2004/05. Table 7 shows the quantities and percentages of compost sold in the UK for 2001/02 to 2004/05 [41].

Table 7: Quantities and percentages of compost sold in the UK [41]

	2001/02		2003/04		2004/05	
	Quantity ('000 tonnes)	Percentage of product (%)	Quantity ('000 tonnes)	Percentage of product (%)	Quantity ('000 tonnes)	Percentage of product (%)
Sold	445	47	476	40	784	49
Use on sites	369	39	594	50	496	31
Distributed without charges	132	14	119	10	320	20
Total	**946**	**100**	**1,189**	**100**	**1,600**	**100**

41 Other materials used as soil improvers such as spent mushroom compost, sewage sludge and wood wastes are competitors to AD residues and composts. Some of these materials are classified as waste and are regulated but, overall, the use of these materials is unlikely to be affected by a Quality Protocol for digestate as transport costs mean they can only find local markets.

42 The agricultural market is far larger than all the other market sectors put together. Significant penetration of the agricultural market will be essential for the recycling of digestate to develop to its full potential [47].

43 The introduction of AD materials will influence the market through the forces of supply and demand. Price elasticity is known to be high for soil improver type of product. The low value with which digestates are perceived in the agricultural market is partly due to a lack of appreciation of the contribution that these materials can make to soil structure, plant nutrition and plant health, and partly the associated 'waste' connotations. As the value of these materials becomes better quantified and better understood, these perceived values may rise. But as detailed in Section 2, this study assumes that as a baseline the value of digestates in an agricultural context remains constant.

1.4 Barriers and opportunities for growth in end markets

Opportunities

44 Companies face increases in energy costs for both heat and electricity, and pressures to reduce the carbon footprint of their products. However, instruments such as the Renewable Obligation Certificates[3] (ROCs) provide financial incentives to produce electricity from renewable energy sources. The Government is using PFIs (private finance initiatives) and, where appropriate, Enhanced Capital Allowances (ECAs) and/or ROCs to encourage a variety of energy recovery technologies (including anaerobic digestion) so that unavoidable residual waste is treated in this way and provides the greatest benefits to energy policy. The proposal to double the ROCs allocation has further improved the economics of AD.

45 Increasing the AD capacity in the UK would help to achieve the renewable energy targets set by the EU and reduce greenhouse gas emissions from both offset energy and fertiliser production. This expansion of AD plant capacity will increase the supply of digestate.

46 Higher national recycling and recovery targets are set in *Waste Strategy for England 2007* [11] for the recycling of household waste (40 per cent by 2010, 45 per cent by 2014, and 50 per cent by 2020) and the recovery of municipal waste (53 per cent by 2010, 67 per cent by 2015, and 75 per cent by 2020).

47 Overall AD compares well with its competitors as it provides recycling of organic matter and nutrients, as well as generating renewable energy with a minimum of emissions [27].

48 The introduction of the landfill tax improved the economics for AD plants [30]. As the cost of landfilling will continue to rise due to the landfill tax escalator, producers of organic wastes will increasingly need outlets such as AD plants and the manufacture of digestate, as it can be sold instead of landfilled. According to the *Waste Strategy for England 2007*, the standard rate of tax will increase by £8 per year from 2008 until at least 2010/11 (from £24/tonne in 2007/08 to £48/tonne in 2010/11) to give greater financial incentives to businesses to reduce, reuse and recycle waste. This supports the availability of inputs to AD digestion which, in turn, would support any increased demand in the digestate market.

49 The upfront investment costs of advanced in-vessel composting systems are lower to those for anaerobic digestion [27]. However the operational costs for advanced in-vessel composting systems are higher. Therefore the costs balance out and the overall costs for advanced in-vessel composting systems and anaerobic digestion are comparable.

50 One advantage of AD is that it has the potential to capture larger amounts of available nitrogen that farmers can use as nitrogen fertilisers replacements in the growing crops. They can be used in NVZ's where faster uptake is beneficial and therefore liquids are preferred over solid fertilisers.

3 Renewable Obligation Certificates (ROCs) are digital certificates providing a premium on top of the price paid for the unit of electricity.

Barriers

51 The availability of outlets may be an issue. In practice, not all agricultural land will be suitable for spreading digestate because of NVZ controls and site-specific circumstances (slope, watercourses, etc.) may limit the use of digestate.

52 Of the available land bank, cropping cycles will reduce the potential for applying solid materials to times when the soil is not occupied; although compost and digestates can be stored, nutrient status is lost through ammonia release and nitrate leaching. Manure-based digestates have a much lower solid content and are much easier to apply all year round but, if inappropriately applied, the greater nutrient availability increases opportunities for leaching at certain times of the year.

53 Anaerobic digestion will have to compete with existing well-established materials and other composted organic wastes. The degree of substitution into existing markets will depend on performance and competition for land bank from other organic wastes and non-municipal waste based materials.

54 Public and commercial acceptance is another important issue; there is a deep-seated distrust of waste-derived products with scepticism about safety and quality. This is particularly relevant to large retailers and the public who may reject foodstuffs grown with waste-based products as happened with sewage sludge. Demonstrable standards through the introduction of the Quality Protocol may help overcome this barrier.

55 Operators face technical and mechanical problems through lack of operational knowledge and poor availability of technical assistance [30]. With appropriate investment in training these could be minimised. There are also significant capital and operational costs associated with anaerobic digestion and storage.

56 Products derived from anaerobic digestion can only be sold if offered at prices competitive with existing products and with similar performance characteristics. Customer's requirements will also vary; if the requirement is for organic matter, then the comparison with composts is appropriate while, if the demand is for nutrients, then fertiliser cost is the primary comparator.

57 No matter what environmental benefits are offered or technical specifications claimed, digestate will not be bought if the customer can buy an equivalent, existing product at the same or lower price [47].

58 It is therefore essential that the production and sale of digestates is based on realistic estimates of the price that can be commanded in the market. As noted above, the price of bulk composts has remained in the range from -£5/tonne to £10/tonne even though the first year nutrient value alone may be £2/tonne plus the benefits of organic matter to water retention, soil structure and soil fertility. Data for the price of digestates price are currently unavailable.

2.0 Methodology and options

59 The options to be assessed within the financial impact assessment are:
- Business As Usual (BAU);
- Introduce a Quality Protocol.

60 Under the Quality Protocol adopted scenario, it is assumed that all AD operators in England adopt the protocol apart from farmers operating AD for their own residues and wastes and applying them to their own fields. This is unlikely; depending on take-up, the likely result will be proportionately between the two scenarios.

61 This analysis is intended to apply to England but, by necessity, much of the data is derived from UK data. While the precise details of regulations and controls vary slightly in the devolved administrations, the overall conclusions of this study are expected to also be valid for these other areas.

62 The assumptions made in order to carry out the assessment are detailed in Annex A.

2.1 Option A – 'Business As Usual (BAU)'.

63 This is the baseline scenario. Under this option, no Quality Protocol would be introduced and the current situation as regards regulatory control of management of anaerobic digestate would remain.

64 There would continue to be uncertainty among some purchasers over the point at which anaerobic digestate ceases to be waste. Anaerobic digestate supplied from all recyclers would still be classified as waste. Buyers would be required to comply with waste regulations.

Assumptions used in the baseline

65 Landfill costs are assumed to be an average gate fee of £30/tonne[4] with the landfill tax increasing to £48/tonne by 2010/11.

66 Net benefit is determined as the difference in cost based on an AD plant gate fee for catering wastes of approximately £47/tonne[5] and the cost of landfilling. The landfill tax is deflated as the cost base of the analysis is 2007 prices and tax values are not subject to inflation.

Municipal waste arisings

67 The arisings of source-separated feedstocks are based on the following assumptions:
- The arisings of municipal kerbside biowaste in England are based on predictions for biowaste processing using Defra's LAWRRD (Local Authority Waste Recycling, Recovery and Disposal) model.
- The proportion of this biowaste sent for AD as opposed to composting assumes compost has a Quality Protocol and that AD receives increases in ROCs in line with the current proposals out for consultation. The future increase will be a balance of the two technologies.
- Given the technical benefit for food waste to AD and garden waste to composting (of which there are approximately equal quantities, see Table 2), there will be a 50:50 split between the two technologies reflecting a simple competitive position.[6]

Commercial and industrial arisings

68 Industrial and commercial operations will come under increasing pressure to find treatment options for their wastes as the landfill tax increases and environmental pressures from customers encourage carbon issues to be considered. The increase in treatment of the arisings will therefore rise, but will be limited by the competition with landfill prices, which will respond to keep market share.

4 Based on page 34 of the Partial Regulatory Impact Assessment of the Review of England's Waste Strategy (http://www.defra.gov.uk/environment/waste/strategy/review/index.htm).
5 Derived from typical values on www.letsrecycle.com, which quotes the market values for September 2007 as £42–52/tonne.
6 TAG confirmed this assumption as reasonable, but indicated that further comment in the consultation would be welcome.

69 It is assumed that C&I waste will increase in line with the prediction in the *Waste Strategy for England 2007* of overall C&I waste from 57.9 million tonnes in 2002/03 to 70.5 million tonnes in 2019/20 (a rate of 1.16 per cent growth per year). It is also assumed that this growth will be entirely in the commercial sector, with industrial waste remaining constant.

70 The proportion of the waste arising as organic waste is also assumed to be constant. The proportion of the organic fractions that are treated will increase due to the pressures on costs from waste disposal. The targets in *Waste Strategy for England 2007* suggest a reduction in landfilling of C&I waste of 15–20 per cent by 2010 and it is assumed that the organic fraction will contribute to this reduction. Therefore, overall it is assumed that there will be a reduction of 15 per cent in landfilled C&I waste by 2010 and 20 per cent by 2020.

71 There is no indication of the amount of C&I waste entering AD. The total of 277,000 tonnes/year of digestate generated in the UK [25] is known to include 50,000 tonnes/year of digestate from municipal kitchen/food waste, but also includes both agricultural and C&I waste. In the absence of other data, it is assumed that C&I waste accounts for 25,000 tonnes/year (one tonne of digestate gives one tonne of feedstock).

72 These factors lead to an increase in the recycled/recovered fraction of C&I waste of 43 per cent by 2020. Given the organic fraction is a currently untapped resource, the increase in this sector will be greater than the baseline and it is assumed that the growth in organic waste treatment will be double that of the general increase in recycling/recovery. The proportion that is treated by AD will increase due to the carbon issue linked to corporate social responsibility (CSR) reporting and ROCs benefits, such that 50 per cent of the new treatment tonnage will be AD based.[7]

Agricultural residues and waste

73 The arisings of agricultural residues and waste is assumed to be in line with the values in Table 1. The amount of waste treated through AD is unlikely to increase dramatically as the option of directly applying manures to land is a competitive one and this will be the primary route. Only where environmental pressures such as control of excess nutrient make alternatives mandatory will AD be adopted – possibly in conjunction with other commercial wastes to provide financial support. It is estimated that the current 202,000 tonnes/year (derived from references 7 and 22) processed through AD will increase at 10 per cent per year.[8] The input of agricultural residues and wastes to composting operations is assumed to remain insignificant.

74 The costs of the regulatory burden on AD operators will be related to the application for exemptions under Paragraph 7 of Schedule 3 of the Waste Management Licensing Regulations 1994[9] (as amended) for the sites where digestate will be applied. Regulatory controls on the operation of the AD facility will be applicable to all options. The assumptions surrounding the cost for application of exemptions are given in table A1 in the appendix and relate to administrative costs, testing and Environment Agency costs. The cost of compliance with a Quality Protocol is assumed to be £1.67/tonne of digestate in line with the compost QP Financial Impact Assessment (FIA). This was also confirmed following consultation with the Association for Organics Recycling (formerly the Composting Association) as reasonable when compared to the more recent experience of Compliance Costs for PAS 100.

7 The assumption of a doubling of the rate of increase in commercial waste organic waste treatment and the 50% split to AD was discussed and agreed with the TAG. Further data from the consultation would be welcome.

8 Comments from some TAG members suggested that new agricultural AD plant capacity could be as 1.6 million tonnes/year. However, this view was not provided more generally and we are currently unaware of the 4–8 facilities that would need to be at the planning stage to meet this aspiration; 10% is assumed in that is provided approximately 400,000 tonnes/year of new agricultural AD capacity.

9 In 2008 Environmental Permitting Regulations were introduced to combine PPC and Waste Management Licensing (WML) regulations into a single regulatory framework.

75 Landspreading costs for manure or digestate are considered to be equivalent and are thus ignored.

76 Nitrogen loss through direct manure application is assumed to be 38.4 per cent [28] and first year availability is assumed to be 30 per cent[10] [37, 40], with an average manure nitrogen content of 0.92 per cent (Table 1) and inorganic manufactured nitrogen cost of £473/tonne N.

77 However, there are variations in the estimates of nitrogen availability of manures and digestate manure. Therefore a sensitivity analysis was run with the nitrogen content at 0.45 per cent, 0.92 per cent (central estimate) and 1.5 per cent, and availability of the digestate N at 50 per cent, 60 per cent and 70 per cent.

78 In addition, the price of inorganic manufactured fertilisers is volatile as it is linked to oil prices. Thus the range of prices from £378/tonne N to £568/tonne N was examined.

79 Release of methane from digestates stored in the open is assumed to be similar to those from similarly stored manures. Unused biogas is flared, and the energy production values take account of this by assuming 80 per cent utilisation. Energy and carbon assumptions are given in Table 9.

Table 8: Energy and carbon assumptions

Parameter	Value
Calorific value (CV) of methane	39.75 MJ/m^3
Efficiency of electrical conversion	32%
Energy used in composting	75 kWh/tonne
Equivalent CO_2 per kWh electricity generated	0.00049 tonnes
Equivalent CO_2 impact of avoided landfill from avoided landfill of C&I waste (avoided fugitive methane emission)	0.0974843 tonnes
Equivalent CO_2 impact of natural gas used for ammonia production per tonne N	1.08 tonnes CO_2
Shadow Price of Carbon per tonne of CO_2, inflated at 2 per cent per year in line with Government guidelines*	£25.50/tonne CO_2

*** See http://www.defra.gov.uk/Environment/climatechange/research/carboncost/index.htm**

2.2 Option B – Introduce the Quality Protocol

80 It is assumed that the Quality Protocol (QP) will operate along similar lines to the compost Quality Protocol and that similar costs will apply.

81 The Quality Protocol does not cover digestate from the treatment of sewage sludge.

82 It is assumed that, where operators supply digestates to external customers, they will work towards achieving the Quality Protocol, whereas farmers that apply the digestate to their own land will not formally comply with the Quality Protocol.

83 The Quality Protocol will be voluntary. If recyclers do not comply, then their anaerobic digestate will still be waste and their buyers will need to comply with waste regulations.

10 TAG recommend 30% quoting Bulletin 209 and higher pig proportions, although literature (Oternblad) suggests 25%

Assumptions used in option B

84 The use of a Quality Protocol is unlikely to alter the amount of municipal waste diverted to organic waste treatment as the main driver is Landfill Allowances and recycling targets. However, the Quality Protocol will influence the proportion of treatment that follows an anaerobic rather than an aerobic route. In this option, it is assumed that the distribution will be two-thirds to AD and one-third to composting rather than the 50:50 split assumed in the baseline.

85 The Quality Protocol will improve the economics of AD plant operation through the reduced need for regulation and reduced marketing costs. Assumed marketing costs of £50,000 for a 30,000 tonnes/year facility give a compliance cost of £1.67/tonne. The confidence generated by the Quality Protocol is assumed to halve this cost. A sensitivity analysis was carried out on the marketing costs looking at marketing costs 25 per cent either side of these values.

86 It was impossible to ascribe an improved value to the digestate due to the current marketing difficulties, with other compost-like materials available for land application essentially pinning the value. Hence the value of the digestate is assumed not to alter with the introduction of a Quality Protocol.

87 The supply of C&I waste to AD processes is likely to be influenced by the Quality Protocol, but there is no information on the extent. There will be pressures to increase the use of AD arising from the improved confidence in the route in order to comply with targets set by environmental management systems as well as the economic benefit in the gate fee from the reduced costs compared with landfill. To reflect this change in the pressures on industry, the quantity of C&I waste digested is assumed to increase by 5 per cent per year. This tonnage will be additional waste diverted from landfill.

88 Introduction of the Quality Protocol will result in an increase in the use of agricultural waste and residues in AD as the disincentive of waste designation will be removed from the resultant digestate. The benefits from the use of digestate will come from improved nutrient management and increased utility of nitrogen from wastes. It is assumed that the Quality Protocol will increase manure digestion linearly from the current 0.23 per cent for agricultural residues/waste to 1 per cent by 2020.

89 The loss of nitrogen from the digestate prior to field application will increase to 18 per cent[11] with a nitrogen efficiency of 50–70 per cent[12] [37, 40], which is the range studied in the sensitivity assessment.

2.3 Methodology

90 The method for assessing the financial impact of the Quality Protocol for anaerobic digestate involves comparing Option A (baseline) with Option B.

91 The quantifiable benefits and costs of the Quality Protocol are calculated for each year over a 10-year period. They are then discounted at 3.5 per cent (following HM Treasury Green Book guidance[13]) and summed to provide the total net present value (NPV) benefit or cost. Average values are simply the mean, undiscounted value of the 10 year period. Landfill tax costs as a set price are deflated at Treasury projections of inflation. Costs for climate change benefits are based on the Shadow Price of Carbon (SPC) as set out in Defra guidance at £25.50 and inflated at 2 per cent per year.

11 The data suggest 10–18 per cent loss during storage, but a pessimistic assumption has been made given the various stages in the process where loss can occur (storage, spreading. etc.)
12 TAG comments suggest an average of 50 per cent given the higher utilisation in spring of c.70% but lower at other times of the year. Ortenblad [37] suggest 60 per cent.
13 http://www.hm-treasury.gov.uk./media/3/F/green_book_260907.pdf

92 For example, the annual additional total market value attributable to the Quality Protocol is calculated by subtracting the annual total market value[14] for Option A from the annual market value for Option B. This is repeated for each year over the 10-year assessment period. These additional market values are then discounted (using 3.5 per cent) and summed to provide the increase in market value as a result of the Quality Protocol. This produces an overestimate of the benefits. The true benefits are the increase in profits, but it was not possible to estimate this for reasons of confidentiality.

93 The reduction in waste regulation compliance costs as a consequence of the introduction of the Quality Protocol is calculated by taking the annual total waste regulation compliance cost in Option A and subtracting the annual waste regulation compliance costs in Option B. The annual net waste regulation compliance costs are then discounted and summed to provide the total benefit of the Quality Protocol.

94 As the benefits could continue beyond the 10-year assessment period, the estimates are an underestimate.

2.4 Consultation

95 Members of the TAG and representatives of wider industry were contacted as appropriate to gain a better understanding of the impacts of the introduction of the Quality Protocol. Section 3 highlights the key benefits and costs of the Quality Protocol identified by consultees.

14 To calculate market value, the costs associated with processing by anaerobic digestion are multiplied by the quantity processed. This is repeated for each sector and the products summed. A lower cost operations or increases in market share would increase these values.

3.0 Costs and benefits to industry of introducing the Quality Protocol

96 This section sets out the costs and benefits to industry of introducing the Quality Protocol, including the sectors and groups affected.

3.1 Benefits of the Quality Protocol and groups affected

97 Introducing the Quality Protocol for digestates to standardise and increase their quality will stimulate the development of the anaerobic digestion option and the available markets for the products. This would provide more certainty in the market place; though it is unlikely to increase the value of the digestates, it will reduce costs and improve the public acceptance of the products. The Quality Protocol may also reduce the costs of marketing by providing users with information/knowledge about the product and thereby engender confidence.

98 Overall, the increase in the amount of waste diverted from landfill due to the introduction of the Quality Protocol will be small as the main drivers already provide the incentive to increase uptake in organic waste treatment. However, it is likely to improve the proportion of this organic waste treated by AD. However, the increase was modelled primarily as commercial and industrial wastes.

99 Methane is a potent greenhouse gas. Anaerobic digestion with energy recovery offers an effective means of trapping this gas and converting it to less harmful carbon dioxide while producing a renewable source of energy.

100 Obtaining heat from a renewable source such as combined heat and power (CHP) scheme based on biogas is a valuable means of reducing the carbon footprint of industrial processes. This is of particular value if the site is impacted by the EU Emissions Trading Scheme (EU ETS). Introduction of a Quality Protocol for digestate could increase the provision of AD plant capacity in the UK, which would help to achieve the renewable energy targets set by the EU and reduce UK greenhouse gas emissions.

101 Current producers of AD who have to apply for Environmental Permits, etc. would avoid some of the costs of compliance with waste regulation. The plant would still require an Environmental Permit but exemption costs would be avoided if it is applied to land. This would include the cost of consultancy fees, and some element of training and registration for Waste Management Industry Training and Advisory Board (WAMITAB) purposes, etc. However, this benefit will be offset by the cost of complying with the Quality Protocol.

102 Income from gate fees for receiving and processing organic waste is especially relevant to CAD plants. This gate fee would have to be set at a level competitive with local landfill charges in order to attract the waste. The local authority, or other organisation, supplying the waste would obtain a benefit from paying lower charges.

103 There will also be cost savings through reduced use of inorganic manufactured fertilisers. This benefit is mainly relevant to farm land application as, in other applications (landscaping, horticulture, etc.), the use of inorganic manufactured fertilisers is generally less and compensation for digestate nutrients is likely to be site specific.

104 The use of AD systems will lead to the sale of renewable electricity and associated ROCs, which will contribute to the overall renewable supply for the UK.

105 The impacts of the carbon balance of using AD will come from:

- avoided landfill of waste;
- reduced energy consumption of AD compared with composting;
- renewable energy production;
- reduced mineral fertiliser production;
- fugitive methane and N_2O emissions from stored and spread digestates and residues.

106 Annex A details that the Carbon benefits are derived from electricity production only; heat uses are ignored. Emissions from fugitive methane and aerobic degradation as well as nitrous oxide (N_2O) emissions are considered to be similar for wastes and residues applied to land. The average carbon benefit for MSW is 0.35 t CO_2/t digestate, for agricultural wastes it is 2.87 t CO_2/t digestate, and for C&I wastes it is an overall loss of 0.63 t CO_2/t digestate,

3.2 Costs of the Quality Protocol and groups affected

107 If buyers in the market respond readily to the voluntary Quality Protocol such that it becomes a normal requirement, other operators will be forced to invest to upgrade their operations.

108 Additional costs for the digestate producer would be incurred for processing and compliance. These are estimated at £1.67/tonne, although the increased marketability of the product would reduce costs by an estimated £0.835/tonne.

109 Soil improvers and growing media based on municipal waste are unlikely to command high prices in the short term. Even if their performance equals traditional products, the benefits of their use will have to be demonstrated to the end user. It is probable that waste-based products will be used for cheaper general growing applications.

110 The model results are summarised in Table 9.

Table 9: Model results (basis 2007, period of costs 10 years, discount rate 3.5 per cent)*

Factor	NPV cost over 10 years (£ million or kt)			
	Baseline	Quality Protocol introduced	Difference	
			NPV	Average
Costs of exemption charges	£3.68	£0.00	-£3.68	-£0.46m
Costs of admin burdens	£2.55	£0.00	-£2.55	-£0.32m
Costs of marketing	£13.24	£9.53	-£3.71	-£0.45m
Compliance costs of Quality Protocol	£0.00	£13.47	£13.47	-£1.70m
Savings to industry on landfilling	£0.00	-£1.64	-£1.64	-£0.21m
Value of displaced fertiliser	-£522.61	-£526.36	-£3.75	-£0.49m
Total direct	**-£503.13**	**-£505.00**	**-£1.86**	**-£0.43m**
Carbon balance				
Energy used in composting (kt CO_2)	344	303	-41.05	-
Energy produced from AD (kt CO_2)	-526.48	-668.85	-142.37	-
Carbon avoid from fertiliser offset (kt CO_2)	-1,189.74	-1,198.29	-8.54	-
Carbon saved by avoided landfill (kt CO_2)	0.00	-5.51	-5.51	-
Total carbon saved (kt CO_2)	**-1,371.10**	**-1,569.62**	**-198.52**	**-**
Value of carbon	-£39.29	-£45.08	-£5.79	-

*** Rounding errors may occur.**

111 However there are substantial uncertainties in the value of fertilisers and the quantity and availability of the nutrients supplied in comparison with inorganic manufactured fertilisers. A sensitivity analysis was therefore performed with a set of low and high assumptions as set out in Table 10.

Table 10: Input assumptions for sensitivity assessment

Scenario	Low	Baseline	High
Manure N availability	20%	25%	30%
Digestate N availability	50%	60%	70%
Manure N content	0.45%	0.92%	1.50%
Digestate N content	0.45%	0.92%	1.50%
Value of nitrogen	£378/tonne N	£473/tonne N	£568/tonne N
Average size of exemption site (ha)	30	40	50
Compliance Costs (£)	£1.57	£1.67	£1.77
Average marketing costs per site (£)	£37,500	£50,000	£625,000
Size of average site	22,500	30,000	37,500

Table 11: Sensitivity assessment: result of 'low' nutrient sensitivity

Factor	NPV cost over 10 years (£ million or kt)		
	Baseline	Quality Protocol introduced	Difference
Costs of exemption charges	£2.40	£0.00	-£2.40
Costs of admin burdens	£1.67	£0.00	-£1.67
Costs of marketing	£13.24	£9.53	-£3.71
Compliance costs of Quality Protocol	£0.00	£12.72	£12.72
Savings to industry on landfilling	£0.00	-£1.64	-£1.64
Value of displaced fertiliser	-£163.97	-£165.38	-£1.41
Total	**-£146.66**	**-£144.76**	**£1.90**
Carbon balance			
Energy used in composting (kt CO_2)	344.08	303.03	-41.05
Energy produced from AD (kt CO_2)	-526.48	-668.85	-142.37
Carbon avoid from fertiliser offset (kt CO_2)	-466.60	-470.61	-4.01
Carbon saved by avoided landfill (kt CO_2)	0.00	-5.51	-5.51
Total carbon saved (kt CO_2)	-647.96	-841.95	-193.98
Value of carbon	**-£18.64**	**-£24.30**	**-£5.65**

Table 12: Sensitivity assessment: result of 'high' nutrient sensitivity			
Factor	**NPV cost over 10 years (£m or kt)**		
	Baseline	**Quality Protocol introduced**	**Difference**
Costs of exemption charges	£4.80	£0.00	-£4.80
Costs of admin burdens	£3.33	£0.00	-£3.33
Costs of marketing	£13.24	£9.53	-£3.71
Compliance costs of Quality Protocol	£0.00	£14.22	£14.22
Savings to industry on landfilling	£0.00	-£1.64	-£1.64
Value of displaced fertiliser	-£1,225.90	-£1,233.99	-£8.09
Total	**-£1,204.53**	**-£1,211.88**	**-£7.35**
Carbon balance			
Energy used in composting (kt CO_2)	344.08	303.03	-41.05
Energy produced from AD (kt CO_2)	-526.48	-668.85	-142.37
Carbon avoid from fertiliser offset (kt CO_2)	-2,325.69	-2,341.04	-15.35
Carbon saved by avoided landfill (kt CO_2)	0.00	-5.51	-5.51
Total carbon saved (kt CO_2)	-2,507.05	-2,712.37	-205.32
Value of carbon	**-£71.73**	**-£77.72**	**-£5.99**

Table 13: Summary results of sensitivity assessment		
Scenario	**Overall cost (£ million)**	**Value of carbon (£ million)**
High	-7.35	-5.99
Baseline	-1.86	-5.79
Low	1.90	-5.65

112

113 The results from the extremes in the nutrient inputs are shown in Tables 12 to 14. These show that the range of the results is about £11 million, which is in the order of some of the other estimated costs.

4.0 Small firms impact test

114 The small firms impact test was carried out according to BERR's *Small firms guidance – guidance for policy makers*.[15]

115 The impact of the Quality Protocol will largely be on small and medium enterprises (SMEs) as the operators of the waste treatment facilities are generally independent companies either working on a single project or a small group of facilities.

116 In the municipal sector, waste treatment operations are increasingly being conducted by large waste management companies and, where these operations are not sub-contracted, the effects of the Quality Protocol are likely to be spread across these wider operations.

117 The larger waste management companies are likely to be in the vanguard of implementers of the Quality Protocol for digestate – as demonstrated by the composting compliance with PAS 100 and the APEX marketing brand, which has lead the development of higher standards for compost.

118 The customers (for waste supply) for these municipal contracts and the suppliers of industrial waste are also more likely to be larger organisations. They will benefit only by the stabilising of waste management charges, rather than seeing their inflation through landfill tax increases.

119 The users of the digestate will be principally farmers and will be largely small businesses. However, there will be some organisations that have more intensive produce supply operations and which require substantial staffing for picking and packaging the fruit and vegetables. The impacts on farming-based users of the digestate are not expected to be materially affected by the company size.

120 As costs are determined to be proportional to waste processed, they are therefore not disproportionate to small companies. For the purposes of determining cost per organisation, the capacities shown in Table 15 are assumed to relate to business size definitions.

Table 15: Definition of business size

Description of size	Capacity (tonnes/year)
Micro	5,000
Small	20,000
Medium	50,000
Large	100,000

121 The average saving from the Quality protocol is £0.10 /t direct (£0.21/ t cost to £0.41/t saving) and when carbon benefits are accounted for the savings are on average £0.43/t (£0.21/t to £0.75/t). The cost assumed are the net costs of the Quality Protocol and the savings to the digestion plant operators which is on average £0.23/t, total values are given in Table 16.

15 'http://www.berr.gov.uk/bbf/enterprise-smes/regulation-and-tax/info-officials/Small%20Firms%20Impact%20Assessment/page38021.html

Table 16: Cost impacts by company size

Size	Waste handled (tonnes/year)	Annual cost of implementation
Micro	5,000	-£1,162
Small	20,000	-£4,646
Medium	50,000	-£11,616
Large	100,000	-£23,231

122 The Quality Protocol is voluntary. Companies can avoid the costs avoided by choosing not to comply.

5.0 Competition assessment

123 The impact on competition is limited by the voluntary nature of the Quality Protocol. The current market can be classed as difficult and sales to users of digestate are governed by long-term relationships and strong marketing skills.

124 The introduction of the Quality Protocol will provide an option to secure markets and open new markets. However, it is unlikely to influence the overall competitive market as all producers will be able to work to the Quality Protocol if it becomes a market requirement to sell digestate.

125 The main driver on the development of AD will be regulatory. Thus the Quality Protocol is likely to influence only the gate fees to waste suppliers.

126 One area which may be interesting will be the manner in which the C&I sector uses the environmental benefits within their corporate social reporting. Enhanced waste treatment will provide environmental benefits that can be reported. It will also provide some carbon trading benefits to those companies in the carbon trading scheme and 'green' image benefits that can be used in marketing.

5.1 Required tests

Will the introduction directly or indirectly limit the number or range of suppliers?

127 There is no evidence to suggest that the number of suppliers of AD equipment or the number of AD plant operators is likely to decrease due to the introduction of the Quality Protocol. The current market is likely to increase, with or without the Quality Protocol, and the expansion will be generated by organic growth as well as new entrants.

128 Obviously those players that choose not to comply with the Quality Protocol may face greater competition from those that do, but the voluntary nature of the protocol means that commercial pressures, of which competitors' actions will be one factor, will govern the choice.

129 The increase in digestion of agricultural residues is likely to increase the number of specialist suppliers, as manure injection is often (but not always) performed by the farmers themselves. Digestion is more likely to be a service provided by a third party and hence competition for providing this service to the farmers would increase.

130 The biggest competition disadvantage would come from the application of a Quality Protocol to composting and not to anaerobic digestion; or the reverse, where the technology without the access to a Quality Protocol would suffer because the perceived 'waste' label would deter users. This would reduce the choices for organic waste treatment and reduce the number of players.

Will the introduction limit the ability to compete?

131 The voluntary nature will allow all players to comply with the Quality Protocol. The details of the system are not finalised, but the controls required are unlikely to preclude a particular waste processor from complying as the digestion technology itself is likely to be unaffected.

132 Control will be placed on the wastes they can accept and how the products are handled. We are not aware that any of the existing suppliers will be compromised by infrastructure issues, though all suppliers are likely to have initial investments to make to meet the requirements of the Quality Protocol and access to the capital may be a constraining factor. However, those that cannot upgrade due to lack of resources will be overtaken by new players as the market will be increasing through other actions (e.g. ROCs) and the supply of new entrants is likely to outstrip the number of companies unable to develop.

133 Depending on the details of the Quality Protocol, some waste suppliers with materials that do not comply may face reduced competition for their organic waste treatment needs as non-compliant processors will become less prominent and landfilling of these wastes will become more likely.

Will introduction reduce suppliers' incentive to compete vigorously?

134 There are several market sectors to consider.

135 Equipment suppliers will see the UK as an expanding market and any expansion will encourage this competition. The majority of suppliers are from outside the UK and there are unlikely to be capacity constraints that might reduce their enthusiasm.

136 Plant operators and developers may see increased demand. Competition for the waste supply will be geographically bounded and, as more plants are built, the area of natural capture will reduce. This will increase the competition for the most favourable wastes and those wastes that cannot comply with the Quality Protocol are likely to see fewer options for their waste treatment needs.

6.0 Conclusions

137 Introduction of a Quality Protocol would be welcomed by the anaerobic digestion industry as it will aid marketing and provide security to the existing users of digestate. In the short term, however, this is not expected to be reflected in the price paid for the digestate. This means that the principal costs of implementing the Quality Protocol will fall on the digester operators and the benefits will fall to the users of the digestate in terms of fertiliser benefits and unquantified benefits from the organic matter in soil, and to the wider community from the global warming benefits. The challenge in marketing is to transfer the real benefits into a value for the digestate.

138 Overall for a 10-year period, AD operators will benefit directly from reduced marketing costs (£3.71 million) and avoided regulation cost (£4.98 million). The cost of complying with the Quality Protocol will be £13.47 million, giving an estimated net cost of £4.78 million. The benefit to digestate users is estimated to be £3.75 million from avoided nitrogen fertiliser use; industry will also save £1.64 million from avoided landfill costs. The value of the other nutrients (principally P and K) has not been evaluated but, where additional organic waste/residues are applied to land, these will provide further financial and carbon savings.

139 The benefit to environment is much more substantial with the carbon benefit estimated at £5.79 million (range £5.65 million to £5.99 million).

140 AD operators face a challenge to gain additional income to offset the higher costs. The main routes will be to:

- encourage digestate users to pay more for the digestate to take account of its fertiliser value;
- get municipal waste and corporate waste suppliers that value their CSR requirements to pay more through gate fees.

141 In both cases, this is a modest change as an increase in digestate value of 43 pence/tonne (range 21 pence/tonne to 75 pence/tonne) would pay the additional value of the fertiliser. However, these small variations are statically insignificant in terms of the gate fees or digestate price given:

- the generic assumptions made of equality of pricing for composting and digestion; and
- the level of precision in the model.

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8.0 List of acronyms

AD	anaerobic digestion
BAU	Business As Usual
CAD	centralised anaerobic digestion
CHP	combined heat and power
C&I	commercial and industrial
CSR	corporate social responsibility
CV	calorific value
DM	dry matter
FIA	Financial Impact Assessment
kt	kilotonnes
LATS	Landfill Allowance Trading Scheme
MSW	municipal solid waste
NPV	Net Present Value
NVZ	Nitrate Vulnerable Zones
QP	Quality Protocol
ROCs	Renewable Obligation Certificates
SMEs	small and medium enterprises
SPC	Shadow Price of Carbon
STW	sewage treatment works
TAG	Technical Advisory Group

Annex A: Assumptions used in the analysis

- The base year is 2006 and all costs are based to this year. Fixed costs such as the landfill tax are deflated at 2.5 per cent.
- NPV values are assessed on a discount rate of 3.5 per cent.
- The scheme is modelled to start in 2008/09 and costs are assessed over a period of 10 years.
- The LAWRRD model was used to estimate the amount of waste collected separately in future years for biological treatment from municipal sources. The LAWRRD model[16] is a national model of waste management in England used to derive Landfill Allowance Trading Scheme (LATS) trading estimates.
- The assumptions used in the LAWRDD model are as for the base case in the modelling in *Waste Strategy for England 2007*, although the changes in landfill tax announced in the latest Budget are used. The results show there will be modest increases in green waste collection and composting (reflecting the mature nature of these collections) while biowaste collections will increase substantially and account for two-thirds of the increase between 2004 and 2019 (Table A3).

16 Brown K, Conchie S, McHenry, P, Wheeler P, van Santen A and Wood D, 2006 The LAWRRD (Local Authority Waste Recycling Recovery and Disposal) Model: A decision support tool designed to assist in waste management policy development. In Proceedings of Waste 2006 (Stratford-on-Avon, 2006).

Compliance costs

Table A1 shows the model input panel for compliance costs.

Table A1: Model input panel – compliance costs

	Value	Units
Application for site exemption		
Admin burdens	£379	
Testing	£200	
Environment Agency costs	£546	
Average size of exemption site	40	ha
Application rate	18	tonnes/ha
Marketing costs		
Average marketing costs per site	50,000	
Size of average site	30,000	tonnes
Reduction in marketing costs associated with QP	50%	
QP compliance cost	1.67	£/tonne
VAT rate	17%	
Inflation rate		
2006-07	2.87%	
2007-08	3.25%	
2008-09	2.75%	
2009-10	2.75%	
2010-11	2.75%	
2011-12	2.00%	
2012-13	2.00%	
2013-14	2.00%	
2014-15	2.00%	
2015-16	2.00%	
2016-17	2.00%	
2017-18	2.00%	
2017-18	2.00%	

Carbon and energy

- Carbon benefits are derived from electricity production only; heat uses are ignored. Emissions from fugitive methane and aerobic degradation as well as nitrous oxide (N_2O) emissions are considered to be similar for wastes and residues applied to land.
- Biogas production from AD of municipal, commercial and agricultural wastes is assumed to be 140, 110 and 15 m^3/tonne processed respectively.
- The CV of methane is 39.75 MJ/m^3. Conversion in gas engines is assumed to be 32 per cent. It is assumed that 80 per cent of the biogas is usefully used and that the rest is flared.
- Where composting is used, an energy use of 75 kWh/tonne is assumed. The CO_2 emission from energy displacement is 0.00049 tonne CO_2 per kWh.[17]
- The CO_2 effect of methane from landfill of C&I waste is 0.097 tonnes per tonne of waste landfilled.

Table A2 shows the model results for compliance costs.

Table A2: Model input panel – energy & carbon

	Value	Units
CV of methane	39.75	MJ/m^3
Efficiency of conversion	32%	
kWh/m^3 methane	3.53	kWh/m^3
Useful gas, i.e. unflared gas	80%	
Energy used in composting	75	kWh/tonne
tonnes CO_2 per kWh	0.00049	tonnes
CO_2 effect of atmospheric CH_4 from avoided landfill of C&I waste	0.0974843	tonnes
tonnes of natural gas used for ammonia production per tonne N	1.08	t CO_2
Cost of carbon (2007)	25.5	£/tonne
Increase in SPC	2%	

17 Fisher K, Collins M, Aumônier S and Gregory B, 2006 Carbon balances and energy impacts of the management of UK wastes. Defra R&D Project WRT 237. London: Defra. Available from: http://www2.defra.gov.uk/research/project_data/More.asp?I=WR0602 [Accessed 18 March 2008].

Municipal solid waste

Table A3 shows the model input panel to MSW and Table A4 the estimates obtained from the LAWRRD model of future composting and biowaste treatment.

Table A3: Model input panel – MSW

	Value	Units
Division of new plant as composting	50%	
QP introduced		
Division of new plant as composting	33%	
Kerbside kitchen and garden composted	131,000	tonnes
Kerbside kitchen and garden digested	50,000	tonnes
Digestate N content	0.50%	
N availability	5%	
Gas production nett of parasitic load	110	m^3/tonne
% methane	60%	

Table A4: LAWRRD estimates of future composting and biowaste treatment

Year	Green waste composting (kt)	Biowaste treatment (kt)	Total (kt)
2004	2,293	90	2,383
2005	2,372	90	2,462
2006	2,407	190	2,597
2007	2,513	206	2,718
2008	2,566	476	3,042
2009	2,586	727	3,313
2010	2,605	894	3,499
2011	2,629	915	3,544
2012	2,642	1,002	3,644
2013	2,655	1,023	3,679
2014	2,669	1,065	3,733
2015	2,681	1,086	3,767
2016	2,713	1,088	3,801
2017	2,744	1,109	3,853
2018	2,766	1,110	3,877
2019	2,786	1,112	3,898

The increase in biowaste treatment will come from composting and AD in roughly equal proportions, i.e. 50:50. With the introduction of the Quality Protocol, the split will move to two-thirds of the new treatment being AD.

Assume that in-vessel composting and AD (with 2 ROCs) are competitively priced and thus there is no cost penalty associated with the technology shift.

The costs of applying for exceptions from Waste Management Licensing are based on current costs and a site area of 40 ha.

Commercial and industrial arisings

The increase in commercial waste arisings is in line with *Waste Strategy for England 2007* (i.e. rising by 1.16 per cent per year) and is assumed to be all from commercial waste.
The decrease in landfilling (with commensurate increase in recycling) is 15 per cent by 2010 and 20 per cent by 2020.

Starting with an assumed quantity of 25,000 tonne/year being treated by AD, it is assumed that:

- the increase in biowaste treatment will be double the general rate of recycling increase;
- the biowaste treatment will be split equally between composting and AD.

Table A5 shows the model input panel for C&I waste.

Table A5: Model input panel – commercial and industrial wastes

	Value	Units
Arisings of C&I waste, 2002	57,900	kt
Arising of C&I waste, 2020	70,500	kt
% industrial waste arising as % of total C&I	56%	
% commercial waste arising as % of total C&I	44%	
Landfilling of C&I waste	44%	
Recycling of C&I waste	51%	
Landfill tax 2007/08	24	£/tonne
Landfill tax inflator	8	£/tonne
Maximum landfill tax	48	£/tonne
Landfill gate fee	30	£/tonne
Gate fee for AD of C&I waste	47	£/tonne
Additional diversion profile for C&I waste		
2002	0%	
2015	15%	
2020	20%	
Industrial organic waste arisings, 2002	5,300	kt
Commercial organic waste arisings, 2002	7,200	kt
Amount of C&I waste composted, 2004	431	kt
Amount of C&I waste treated by AD, 2004	25	kt
Nitrogen content of digestate	0.50%	
Nitrogen availability	5%	
Division of new capacity		
Composting	50%	
AD	50%	
Additional growth in AD capacity	200%	
QP adopted		
Additional C&I waste to AD	5%	
Gas production	140	m^3/tonne
% methane	60%	

Agricultural residues and wastes

- Arisings of residues and waste will not be unaffected by the introduction of the Quality Protocol.
- The current 202,000 tonnes/year treated through AD will increase at 2 per cent per year due to environmental pressures on the land application of manures.
- The cost of exemptions is be assumed to be £1.67/tonne based on the principles set out in the FIA for the compost Quality Protocol.
- Nutrient losses on land application of manure are 38.4 per cent (Levington Agriculture), first year availability is 30 per cent (TAG comments) and the average N content of the manure is 0.92 per cent (Table 1). P, K, lime, soil fertility, soil moisture retention, erosion protection and workability benefits are ignored.
- The diversion of dry agricultural and food processing residues to combustion processes is beyond the scope of this study and data are currently is unavailable. It is assumed that the Quality Protocol will not alter the amount processed in this way as these dry materials are more technically suited to combustion processes than wet processes such as digestion or composting.
- It is assumed that the Quality Protocol will not influence the introduction of nutrient management schemes using AD.
- The range of costs for an AD plant in relation to the type of waste treated and capacity is indicated in the report for Remade Scotland by Monet (2003):
  - For an on-farm digester, the capital cost is likely to be between £100,000 and £200,000 for a capacity of 3,000 tonnes/year. Annual operating costs should be around £2,000 (without labour).
  - For larger plants treating waste from several farms, capital costs vary from £500,000 for a capacity of 10,000 tonnes/year to £5 million for a capacity of 200,000 tonnes/year. Annual operating costs are likely to be between £31,000 and £530,000.
  - For AD plants treating the organic fraction of source-segregated MSW, capital costs vary from £3 million for a capacity of 5,000 tonnes/year to £12.3 million for a capacity of 100,000 tonnes/year. Annual operating costs range from £127,000 to £935,000.
- The cost of complying with the Quality Protocol are the same as those identified for the compost Quality Protocol, i.e. £1.67/tonne. Although the digestate is unlikely to command higher values in the market, the costs of marketing are assumed to be halved due to the promotional aspects and the acceptance of quality. The costs of marketing are based on a salesperson costing £50,000/year being required to market 30,000 tonnes/year of digestate.

Table A5 shows the model input panel for agricultural wastes.

Table A5: Model input panel – agricultural wastes

	Baseline	Units	Low	High
Agricultural waste AD, 2002	202	kt		
Annual increase in AD through environmental pressures	10%			
QP adopted				
% of agricultural waste by 2020 adopting AD	1%			
Manure N loss	38.4%			
Digestate N loss	18%			
Manure N availability	25%		20%	30%
Digestate N availability	60%		50%	70%
Manure N content	0.92%		0.45%	1.50%
Digestate N content	0.92%		0.45%	1.50%
Value of nitrogen	£425		£342	£500
Arisings of agricultural waste, 2008	88,225	kt		
Arisings of agricultural waste, 2010	86,552	kt		
Arisings of agricultural waste, 2015	84,835	kt		
Arisings of agricultural waste, 2020	83,293	kt		
Biogas production	15	m^3/tonne		
% methane	70%			

Annex B: Technical Advisory Group membership

Annex B Technical Advisory Group membership	
Representative	**Organisation**
Amy Colson/Laura Battle-Welch	BREW Waste Protocols Project Team
Aoife O'Sullivan	Welsh Assembly Government
David Collins	Renewable Energy Association
Emily Nichols/Jane Gilbert	Composting Association (now renamed Association for Organics Recycling)
Iain Notman	Department for Environment, Food and Rural Affairs
Justin French-Brooks	Environmental Services Association
Michael Faulkner	Consultant to BREW Waste Protocols Project Team
Nina Sweet	Waste & Resources Action Programme
Peter Olsen	Scottish Environment Protection Agency
Roger Unwin	Consultant advising WRAP
Sarah Clayton	BREW Waste Protocols Project Team
Suzanne Laidlaw	BREW Waste Protocols Project Team
Tony Osborne	Environment & Heritage Service (Northern Ireland)
Vicky Heslopp	AD Technical Specialist
Victoria Sturt	Environment Agency
Viv Dennis	Environment Agency

Annex C: Admin burden calculations

Admin burdens are the costs to operators of complying with regulations and include the costs of:

- reporting information;
- familiarisation with forms;
- gathering and preparing data;
- inspections;
- meetings;
- form submission;
- settlements.

The cost of these activities to operators is included in the estimate of the cost of complying with waste regulations. This report uses the admin burden associated with Environmental Permit exemptions as calculated under the 2005 Admin Burdens Measuring Exercise undertaken by all government departments.

In this exercise, exemption applications are defined as 'registering to carry out exempt activities relating to recovery or disposal of waste (for example activities relating to waste glass/scrap metal in certain quantities), providing the name of the exempt activity, submitting the name and address of the establishment and submitting the name of the place where the activity will take place'.

The cost per exemption is estimated to be £379.11 at 2007 prices. This is adjusted for the 'business-as-usual factor', which reflects the fact that some of the associated activities (e.g. meetings) would take place irrespective of the regulation.

The calculation of the admin burdens decrease relative to the 2005 admin burdens baseline, reported on page 2 of the impact assessment template, is made relative to the number of applications made in 2005. Therefore these figures exclude any additional admin burden that would occur from the increase in the number of exemptions resulting from market expansion over the appraisal period in the absence of the QP.

The increase in admin burdens associated with the introduction of the QP follow from the costs of certification. This is based on the costs of PAS 100 certification given in the FIA of the Quality Protocol for compost[18] and is presented in the impact assessment template as the average admin burden in constant prices over the appraisal period.

18 The Composting Association, 2006 PAS 100 Quality Protocol Financial Impact Assessment. Final Report to the Organics Technical Team.

Annex D: Current regulatory position

Waste Management Licensing

Anaerobic digestate currently requires a Waste Management Licence to store, transport and distribute as per the Waste Management Licensing Regulations 1994. Under the Exemption Paragraphs in Schedule 3, paragraph 7A, 'Spreading for Agricultural Improvement', digestate is exempt if it meets the test of agricultural benefit. Similarly, under the Exemption Paragraphs in Schedule 3, paragraph 9A, 'Spreading for Land Improvement', digestate is exempt if it meets the test of ecological benefit.

Animal By-Products Regulations

The EU Animal By-Products Regulation (EC 1774/2002) has been applied since 1 May 2003 and enforced since 1 July 2003. It permits the use of composting and biogas treatments for catering wastes and other low-risk (Category 3) animal by-products through a time temperature regime with a maximum particle size limit.

For composting or anaerobic digestion (biogas) plants that treat only catering waste and specific categories of animal by-products that are allowed to undergo treatment of this kind (e.g. animal manures), the Regulation allows Member States to specify their own process standards at national level.

The operator of a biogas or composting plant must keep records of animal by-products and catering waste received on the premises, and records of the treatment process.
If consignments of compost or digestion residues are for use on agricultural land, the operator must ensure that they are labelled or accompanied by documentation that draws the recipients' attention to the regulatory requirements.

Nitrates Directive & Nitrate Vulnerable Zones

The EU Nitrates Directive (91/676/EC) is an environmental measure designed to reduce water pollution by nitrates from agricultural sources and to prevent such pollution occurring in the future. The Directive requires Member States to implement one of the following two options:

1. To apply agricultural Action Programme measures throughout their whole territory; or

2. To apply Action Programme measures within discrete Nitrate Vulnerable Zones (NVZs).

The UK has designated specific NVZs. Action Programme measures apply only in NVZs; they promote best practice in the use and storage of fertiliser and manure, and build on the guidelines set out in the *Code for Good Agricultural Practice for the Protection of Water*.[19]

In December 2006, the NVZ whole farm organic manure loading limit for any areas of the farm not in grass dropped from 210 kg N/ha/year to 170 kg N/ha/year.

Landfill Directive

The Landfill Directive (1991/31/EC) encompasses the requirements of Articles 3 and 4 of the Waste Framework Directive (75/442/EEC). It also presents the technical requirements for landfills covered by the Integrated Pollution Prevention and Control (IPPC) Directive (96/61/EC). The Landfill Directive has 19 Articles and three Annexes covering general requirements, Waste Acceptance Criteria, and control and monitoring.

Central to the Directive is the requirement (Article 5) that all Member States must introduce measures to reduce the quantities of biodegradable municipal material going to landfill to 35 per cent of 1995 levels by 2016. Up to four years' derogation from this target is possible for countries currently landfilling >80 per cent of wastes.

19 See http://www.defra.gov.uk/farm/environment/cogap/index.htm

Landfill Allowance Trading Scheme

Local authorities responsible for waste disposal have been allocated decreasing allowances for the maximum amount of biodegradable municipal waste they can landfill each year until 2020 by the Landfill Allowance Trading Scheme (LATS). They can trade allowances with each other, sell allowances if they have diverted more waste from landfill (e.g. recycling), or buy more allowances if they are likely to exceed their own allocation. Local authorities can also bank unused allowances or borrow from their future allocations.

UK Renewables Policy

The primary instruments for the development of renewable capacity in the UK are the Non Fossil Fuel Obligation (NFFO) Orders for England and Wales, and for Northern Ireland (NI-NFFO) and Scottish Renewable Obligation (SRO) Orders. In addition to these instruments, the following measures have driven UK renewables policy since 2000:

- all electricity suppliers in Great Britain supplying a specific proportion of electricity from renewables receive Renewable Obligation Certificates (ROCs), a premium on the price of electricity;
- electricity generated from renewables is exempt from the Climate Change Levy;
- programmes with capital grants and funding for research and development into new and renewable energy initiatives.

The EU Directive on the production of electricity from renewables (Directive 2001/77/EC) proposed that Member States adopt national targets for renewables to achieve an overall EU target of 12 per cent of energy and 22.1 per cent of electricity generated from renewables after 2010. Under this Directive, the proposed UK 'share' of the EU target is 10 per cent of UK electricity from renewables by 2010.

Waste & Resources Action Programme

February 2009

The Old Academy
21 Horse Fair
Banbury, Oxon
OX16 0AH

Tel: 01295 819 900
Fax: 01295 819 911
Email: info@wrap.org.uk
www.wrap.org.uk

Helpline freephone
0808 100 2040

Environment Agency

www.environment-agency.gov.uk
Tel: 08708 506 506
E-mail: enquiries@environment-agency.gov.uk

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