

Cover Note

This Financial Impact Assessment was completed in 2009. Since then, it has been decided to delay consideration of a Quality Protocol for unbound uses of PFA until a later date. However, based on 2009 market assumptions (applied to 2006 data), unbound uses of PFA represent just 3% of total PFA produced, and 7% of PFA not sent to landfill. Thus, the effect on the results is small and there is still likely to be a net benefit from a Quality Protocol.

Waste Protocols Project team, March 2010.

Pulverised Fuel Ash

Partial Financial Impact Assessment of a Quality Protocol for Pulverised
Fuel Ash and Furnace Bottom Ash

Contents

Introduction	01
Background	02
Methodology and Options	08
Costs and Benefits to Industry of the Quality Protocol	12
Sensitivity Analysis	14
Conclusions	17
References	18
Specific Impact Tests: Checklist	20
Annex A Assumptions Used in the Analysis	21
Annex B Technical Advisory Group Membership	22
Annex C Greenhouse Gas Emissions Benefits of using PFA	23
Annex D Regulatory Position of the Environment Agency	24
Annex E Admin Burdens	25

Introduction

1. This partial impact assessment focuses on the financial costs and benefits of introducing a Quality Protocol to those involved in the supply of pulverised fuel ash (PFA) and furnace bottom ash (FBA) arising from the combustion of coal with and without co-combustion materials. It excludes costs to regulators, and social and environmental impacts with the exception of carbon dioxide CO₂ emissions. Furthermore, the analysis looks only at the financial costs and benefits to the producers, processors and users of PFA and FBA. The impacts on those involved in the supply of virgin or other secondary materials are not included.
2. The EU Waste Framework Directive is open to interpretation. The Environment Agency currently holds the view that PFA is a waste and continues to be a waste until it is incorporated into a product. This contrasts with the UK power industry, which considers that PFA is not a waste.
3. Application of waste management controls would be inefficient where the human health and/ or environmental risks associated with use of PFA/FBA are sufficiently small to make the costs of compliance disproportionate to the likely benefits.
4. In some cases, the costs of waste management controls and the stigma associated with PFA being classified as a waste are limiting the sales of PFA in end markets. A significant proportion of PFA is landfilled when it could be recycled into a high quality material.
5. A Technical Advisory Group (TAG) made up of industry representatives supported the development of the Quality Protocol and this Financial Impact Assessment. See Annex B for a list of TAG members.

Background

Production of PFA from coal burning

6. The definition of PFA for the purposes of this analysis is:

'...the ash resulting from the burning of pulverised coal as fuel, both with and without co-combustion materials, within coal fired power stations. This ash is extracted from the furnace gas stream by electrostatic precipitators as a fine ash, known as 'fly ash' or PFA, that may contain hollow spherical ash particles, known as 'cenospheres'. The ash is also deposited on the boiler tubes, which subsequently falls to the bottom of the furnace where it is rapidly quenched, which is known as Furnace Bottom Ash (FBA)'.¹

7. The coal-fired power stations in England are in the north west, Yorkshire and Humberside, West Midlands, East Midlands and the south east. The arisings of PFA/FBA are therefore heavily concentrated in these areas.

8. In 2006, UK power stations produced a total of approximately 5.9 million tonnes of PFA.² PFA arisings had risen from 4.4 million tonnes in 2001 as a result of greater use of coal-fired power stations following increases in gas prices [1]. Production peaked in the 1970s at around 16 million tonnes per year.

9. Around 1 million tonnes of FBA are produced in the UK annually. Virtually all this output is used in the manufacture of lightweight concrete blocks (99.9 per cent) [2]. There are no significant stockpiles of FBA other than as short-term production stock. Only a few thousand tonnes of FBA are thought to go to landfill per year.

10. Cenosphere production in the UK is very low – 1,522 tonnes in 2006.

11. PFA can be supplied in various forms [3]:

- **Dry ash.** This material is usually unprocessed. It is normally taken straight out of the precipitator's hoppers. Dry ash is supplied in tankers and is used as a concrete addition for ready-mixed and pre-cast concrete products, aerated block manufacture and grouts.
- **Classified ash.** This is dry PFA that has been processed to remove the coarser particles to enhance reactivity. It is supplied in tankers, and is used as a concrete addition and for aerated block manufacture. However, only a minor proportion of the PFA sold to end markets in the UK is classified.
- **Conditioned ash.** This is PFA that is mixed with an appropriate percentage of water (around 10–20 per cent). It is supplied in tipping vehicles and is used for block manufacture, grout, load-bearing fill and landscaping. Ash destined for landfill is conditioned at the power station to facilitate its transfer. Conditioned PFA may also be recovered from lagoons after they have been drained.
- **Cenospheres.** These unique, free-flowing powders composed of shelled, hollow, minute spheres are generally used as inert filler in industrial applications. Cenospheres may also be used in paint, varnish and plastics.

¹ Definition provided by Lindon Sear, Technical Director, United Kingdom Quality Ash Association (UKQAA).

² UKQAA

12. In addition, PFA is increasingly being processed to remove excess carbon content.³ The carbon content has increased recently due to the fitting of low NO_x burners at some power stations to reduce emissions of nitrogen oxides (NO_x). A plant is also being built to remove the ammonia from PFA arising at power stations that have injected ammonia into their gas streams to improve the performance of their electrostatic precipitators.
13. Approximately half of PFA produced goes to end markets and the other half is either landfilled (as conditioned ash in a monofill or a lagoon containing only PFA waste) or sent to land reclamation sites (landfill tax is not paid for this). The monofills are often on the power station site. The power stations pay the landfill tax and the costs of maintaining their landfill sites. The UK has a large stock of landfilled PFA (60 million tonnes⁴) which could be recovered.
14. There is some evidence that designating PFA as waste is limiting the use of PFA in some applications [1]. A high profile example of PFA not being used because of its designation as waste was during Walsall Borough Council's Bosty Lane contract in 2004. In the end, the contract was completed using virgin material at the cost of an extra £500,000.⁵ This included a 40 per cent increase in vehicle movements due to the increased cement content and mass of sand required.
15. Total ash managers⁶ are often subcontracted by power stations to sell PFA into the end markets and are normally based on the power station site.
16. The average amount paid for PFA is £20 per tonne including transport costs, though PFA can cost up to £25 per tonne [4]. The high value applications are cement, concrete⁷ and aerated block markets. No ash is sold at less than cost [5] and no companies are paid to remove the ash except for disposal.

Current and future PFA, FBA and cenospheres utilisation in the UK

17. PFA could be sold in new markets such as a binder in road construction, in ground stabilisation applications, capping etc.
18. Annual utilisation of PFA rose until 2004 when it was over 60 per cent, but fell back in 2005 mainly due to a reduction in the amount going to grouting applications (Figure 1). Market applications of PFA are summarised in Table 1.
19. Virtually all FBA is used in lightweight concrete block manufacture, where FBA is a direct replacement for expanded clay.
20. Cenospheres are used in plastics, paints and for other similar applications.

³ The standard for concrete restricts the maximum carbon to 7 per cent as measured by loss on ignition (LOI). Higher LOIs lead to problems with colour and the performance of some chemicals (e.g. air entraining agents) in the concrete.

⁴ Communication with the TAG.

⁵ Estimate by David Oliver of Walsall Metropolitan Borough Council and Chris Sakalas of High Point Rendell (consultants).

⁶ Examples include Pro-Ash, CEMEX and ScotAsh.

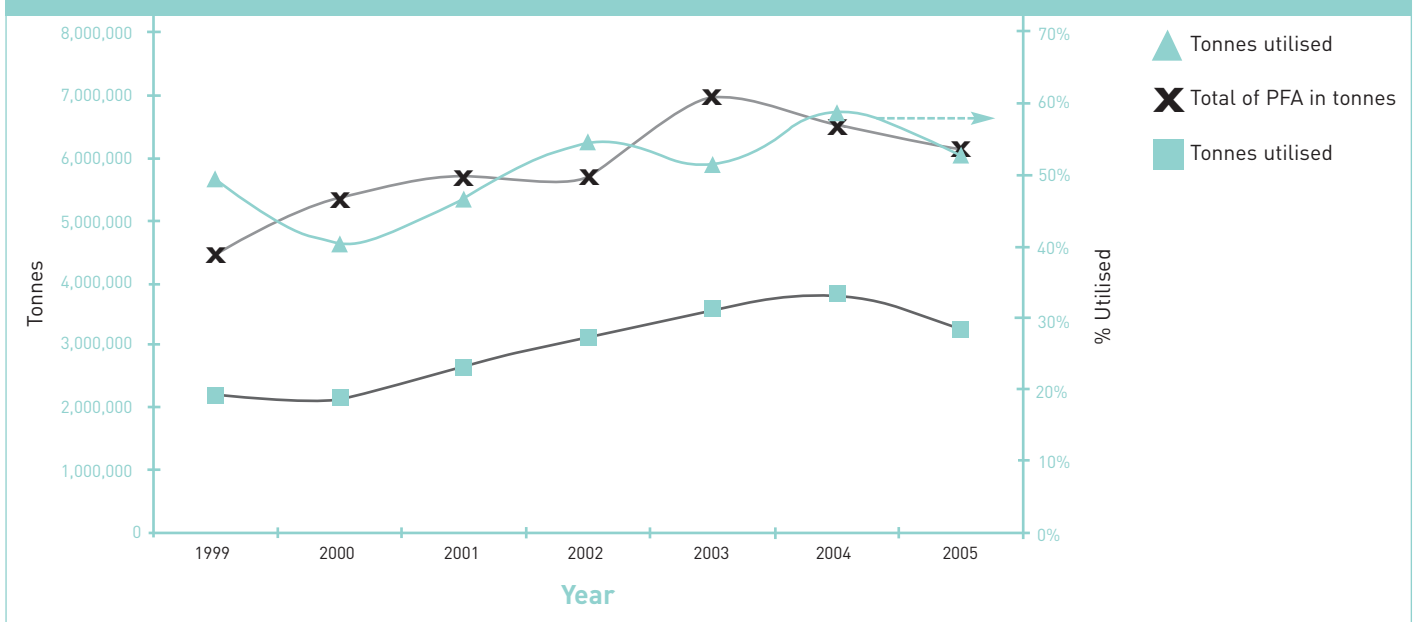
⁷ Personal communication from UKQAA.

Table 1: Market applications of PFA

Product	Details
Aerated and non aerated concrete 'breeze' block manufacture	All aerated concrete blocks contain 80+ per cent PFA. Demand depends on the housing market.
Cement (raw and blend) manufacture	PFA is a partial alternative to Portland cement. The increased use of PFA by cement companies is a direct result of increased pressure on cement companies to reduce their CO ₂ emissions. About 12 million tonnes of cement are produced annually in the UK. Of that, 5 per cent could be PFA used as a 'minor additional constituent'; 27 per cent could be added to around 30 per cent of the cement produced in the UK. For example, a total of 1,572,000 tonnes of PFA could be used in cement manufacture, in principle, in the UK without difficulty.
Concrete addition at the concrete plant	Replaces part of the cement component in concrete. Usage has reduced in the last two years. This is partly due to the growth in the share of market by ground granulated blastfurnace slag (GGBS) and PFA's increased carbon content. UK production of ready mix concrete was 22.4 million m ³ in 2005.*
Fill and ground remediation	PFA competes with virgin aggregates. Price is the determining factor. In 2005, 5.17 million tonnes of sand and gravel were used for fill.*
Grouting	Few materials can compete with PFA for grouting. There is an underlying and consistent market for grouting for housing and industrial plots. Once in a while there are massive one-off jobs requiring hundreds of thousands of tonnes that distort the market. In the absence of waste controls, PFA will always be preferred. It is lightweight, easy to handle, mix and pump and provides good strength. Virgin substitutes do not bind as well as PFA with cement. Greater quantities of cement would be needed. This would add to the monetary cost and the cost to the environment. In addition, virgin substitutes are around twice the price of PFA.
Other uses such as sintered lightweight aggregate (Lytag)	There is currently zero production in the UK; 70,000 tonnes of PFA derived lightweight aggregate is imported from Poland each year.

* UKQAA and Joint Environmental Programme (JEP) response to the questionnaire 'Questions for the PFA TAG to aid the Financial Impact Assessment'.

Figure 1: % utilisation of UK PFA [5, 6]



Barriers to growth of sales in end markets

21. The limited use of coal in power generation is the key constraint to the supply of PFA in the UK. There is potential for PFA production to fall due to the possible reduction in reliance on coal as an energy supply or new technologies resulting in residues with different properties than PFA.
22. It is very hard to predict how the arisings of PFA will develop over coming years and beyond as the power generation mix is very dependent on Government policy and commercial pressures. Consultation with TAG members suggests that, given recent trends and a high degree of uncertainty, a best guess is to assume that arisings will stay at around six million tonnes a year [5, 6].
23. Over the long term, annual arisings of PFA are likely to fall. However, the quantity of stockpiled material is large compared with annual arisings.
24. A high proportion of PFA is landfilled. There are huge existing stockpiles of PFA and the markets that PFA is supplied into are large (Table 2).

Table 2: UK use of PFA in the cement industry (approximate tonnages) [7]

	Cementitious 'addition'	Component of blended cement
Portland cement	n/a	12.5 million
Ground granulated blastfurnace slag (GGBS)	2 million	Minimal
PFA	500,000	~100,000?
Silica fume	3,000	Minimal
Natural pozzolans	Minimal	Minimal
Limestone fines	<10,000	~50,000

25. There is potential to expand the supply of PFA into end markets. Existing barriers to growth are discussed below.
26. The status of PFA as a waste material has led to stigmatisation of the material and is a significant impediment to future utilisation [8]. The United Kingdom Quality Ash Association (UKQAA) considers the 2005 downturn in the use of PFA in grouting was the direct result of the classification of PFA as a waste [5].
27. PFA products compete on the open market against primary materials and other recycled/secondary materials. Many of these markets are very large and competitive. Cost pressures that increase the sales priced of PFA prices are likely to threaten competitiveness with primary materials and affect PFA utilisation in the UK.
28. The cost of producing concrete using GGBS has fallen and this has affected sales of PFA to this market. GGBS is now ground to a finer level, increasing its reactivity and the need for cement. GGBS has also been subject to aggressive marketing [5].
29. In fill and ground stabilisation applications, PFA competes with virgin aggregates. The market is very price sensitive; the price in turn depends on location and availability.
30. The vast majority of coal-fired power stations are in the Midlands. There is one in the north east and some in Yorkshire. The amount of ash produced in these regions far exceeds demand in the local area. Other regions of the UK are therefore an important market for PFA utilisation. Although haulage costs are a competitive disadvantage relative to virgin materials, increased use of bulk trains has eased the situation.
31. Not all ash is suitable for all applications. The ash needs to be high quality (low carbon and with less coarse material) for use in concrete and block manufacturing. If the carbon content was lower, the ash would be more widely used in these applications. High carbon is not a barrier to the use of PFA as a fill, as high carbon usually means lower density which can be a benefit in an embankment built on weak soils. High carbon may also not be a problem in grouts as BS 3892-3 permits loss of ignition (LOI) values up to 14 per cent.
32. The demand for PFA in the construction industry could be restricted if timber continues to grow in popularity relative to concrete blocks.
33. For FBA, the barrier to growth is the limited amount of FBA available. Virtually all FBA is currently used. Demand outstrips supply. If there is an increase in demand from end users, then the price is likely to rise.

Opportunities for the growth of PFA into end markets

34. Some of the opportunities for growth are outlined below.
 - Large-scale construction in south east England could create market opportunities. The construction sector is likely to remain the dominant market for ash. The European Coal Combustion Products Association (ECOBA) and ACAA in the USA consider the fill application the best prospect for increased high volume ash utilisation [8].
 - Pressure on producers to reduce carbon dioxide emissions could increase the demand for PFA relative to virgin substitutes. This has been the case in cement production.
 - Aggregates are a substantial market for PFA. Total aggregate sales in Great Britain in 2003 were just less than 280 million tonnes [9] and the then Office of the Deputy Prime Minister (ODPM) predicted a total market growth of +1.2 per cent per year [10]. The quantity of recycled and secondary aggregates in 2004 was around 70 million tonnes.

- ODPM forecasts for England were for total aggregate use to rise to around 260 million tonnes and aggregate recycling to increase to 60 million tonnes by 2016. WRAP forecasts growth to 3 million tonnes of PFA and FBA recycled by 2015. ODPM forecast that 23 per cent of the total aggregate market would come from recycled and secondary aggregate production [10], though WRAP forecast that this figure would be 28 per cent [11].
- The availability of sustainable resources will fail to keep up with the growth in total market demand [11]. Thus it is likely a majority of the market will continue to be supplied with virgin materials as a result of the barriers described above. In particular, price including haulage costs is often the deciding factor between choosing virgin materials or recycled/secondary materials.
- Policy, regulatory and fiscal drivers such as the landfill tax and the aggregates levy may increase the incentive to utilise secondary and recycled materials in construction projects. The Sustainable Buildings Task Group has recommended setting a minimum standard for the overall percentage of reused and recycled material used in construction projects.

Methodology and Options

35. The options assessed in the financial impact assessment are:

- Option A – Do nothing.
- Option B – Introduce the Quality Protocol in 2011.

36. With the help of experts from the TAG, two scenarios were developed for the purpose of this financial impact assessment. These scenarios describe:

- how utilisation of PFA might change if the Quality Protocol is not introduced;
- how end uses for PFA could change if the Quality Protocol was introduced.

37. There is obviously a huge amount of uncertainty. The scenarios are an attempt to model what could potentially happen and the benefits that would be derived.

38. See Annex A for the assumptions made in order to carry out the assessment.

Options A – Do nothing

39. This is the baseline. Under this option, the Quality Protocol would not be introduced and the existing waste management controls with respect to PFA would remain unchanged.

40. If the Quality Protocol is not introduced and the Environment Agency decided to enforce existing waste controls, the TAG felt the demand for PFA from the grouting market would fall off significantly. This analysis makes the following assumptions:

- The annual quantity of PFA sold for grouting applications would fall to relatively low levels by 2018. It is assumed the quantity would fall to 20 per cent of the 2006 level by 2020 (i.e. an 80 per cent fall). There is considerable uncertainty and this assumption is an attempt to model a worst case scenario. Many grouting contracts are small, ranging from 200 to 1,000 tonnes. The cost of obtaining an Environmental Permit⁸ is relatively high. The UKQAA believes this could kill off the market for contracts of less than 10,000 tonnes [12]. Such contracts make up the majority.
- The quantity of PFA going into fill applications annually would fall by 10 per cent by 2020 from the 2006 level.
- The annual amount going into the other markets would stay at the 2006 level over the period to 2020. In many of these applications, the end users already have to comply with the requirements of Integrated Pollution Prevention and Control (IPPC) and thus do not need to obtain an Environmental Permit to use PFA in their production process. They would still have to comply with IPPC even if the waste classification for PFA was removed.
- The exception is PFA used for the manufacture of lightweight aggregates. This is currently zero and it is assumed it would stay at zero in the baseline.

41. Table 3 presents the assumed tonnes of PFA sold in the grouting, bound and unbound uses in the baseline, and the amount landfilled.

Table 3: Destinations of PFA under Option A (thousands of tonnes)

	2006	2011	2015	2020
Sales to grouting (falls by 80%)	729	520	353	146
Sales to unbound uses (falls by 10%)	192	185	179	172
Sales to bound uses (falls by 10%)	1,997	1,926	1,869	1,797
Landfill disposal	1,876	2,080	2,242	2,445

⁸ The Environmental Permitting (England and Wales) Regulations 2007, which came into force on 6 April 2008, combined the Pollution Prevention and Control (PPC) and Waste Management Licensing (WML) regimes into a single regulatory framework.

Option B – Introduce the Quality Protocol

42. The proposal is to produce a Quality Protocol recognised by, and produced with the support of, industry that defines when PFA (derived from coal production) has been reprocessed to such a level that it is fully recovered.
43. The Quality Protocol sets the point of recovery as when PFA (produced in line with the specification defined by the Quality Protocol) leaves the power station site. Companies downstream of that point (concrete block manufacturers, etc.) will no longer be subject to waste management controls. In addition, they will not face the risk of future requirements should waste controls be applied differently in the future.
44. The Quality Protocol is voluntary. If producers of PFA decide not to comply, the Environment Agency will consider their output to be waste. Purchasers and users of the PFA will then be required to comply with Environmental Permitting Regulations.
45. A primary aim of the Quality Protocol is to provide increased market confidence in the quality of PFA and so encourage greater recycling.
46. The Quality Protocol has three main purposes [13]:
- to provide users with confidence that the manufactured product they purchase conforms to agreed quality standards comparable with equivalent materials of a non-waste origin;
 - to protect human health and the environment by defining acceptable standards for the use of the manufactured product derived from PFA in market applications;
 - to ease the regulatory burden by defining when PFA ceases to be waste and no longer needs to be subject to waste management controls.
47. To comply with the Quality Protocol, the processor must meet and comply with all the requirements of the latest version of an approved standard. Appendix C of the Quality Protocol contains the list of approved standards [13].
48. Providing evidence that processed PFA has been produced in accordance with the Quality Protocol involves [13]:
- retaining copies of supply documentation issued to the customer;
 - providing a Quality Statement as part of this documentation (see the Quality Protocol for more information);
 - keeping records of all inspection and testing carried out in accordance with the appropriate standard;
 - maintaining a record of all Quality Statements issued against each sale of PFA/FBA;
 - retaining specified records for a minimum of two years and making them available for inspection by the regulator (if requested).
49. These requirements are additional to any statutory record-keeping requirements. However, some records may be used to fulfil both a regulatory obligation and evidence of compliance with the Quality Protocol.

50. The TAG felt a Quality Protocol would avoid the current decline in the grouting market and might help to reinstate the lightweight aggregate market in the UK. The TAG also thought a Quality Protocol would be beneficial to the fill market to a certain extent as end users in this market have to register a waste exemption with the Environment Agency. For example, applying to register an exemption under Paragraph 19 of Schedule 3 of the Waste Management Licensing cost £546 per site in 2007/08.⁹

51. If the Quality Protocol is introduced, the following are assumed:

- The total amount of PFA utilised in grouting and fill applications increases to the 2006 level between 20011 and 2020.
- The annual amount going to the other end markets is unaffected by the Quality Protocol.
- PFA competes closely with sand in the grouting market. It is envisaged the Quality Protocol would not lead to an increase in the price of PFA.¹⁰ The assumed price used in the analysis was £20 per tonne, which includes transport costs.¹¹ There is an oversupply.

52. Table 4 presents the assumed tonnes of PFA sold to grouting and fill applications and the amount landfilled under Option B.

Table 4: Destinations of PFA under option B (thousands of tonnes)

	2006	2010	2013	2018
Sales to grouting	729	692	707	729
Sales to fill	192	190	191	192
Sales to lightweight aggregate	63	70	70	70
Landfill disposal	1,876	1,898	1,887	1,871

⁹ On 6 April 2008 the Environmental Permitting (England and Wales) Regulations 2007 came into force. On this date Waste Management Licences issued under the Environmental Protection Act 1990 (as amended) automatically became Environmental Permits and exemptions from the need for a Waste Management Licence registered under Regulation 18 and Schedule 3 of the Waste Management Licensing Regulations 1994 (as amended) came under Schedule 3 of the Environmental Permitting (England and Wales) Regulations 2007. This financial impact assessment (FIA) was completed prior to 6 April 2008 and therefore regulatory compliance cost estimates are based on compliance with the Waste Management Licensing regime. These remain the best available cost estimates and continue to be the basis for this FIA. As such the terminology used in this FIA continues to refer to the waste management licensing regime.

¹⁰ Personal communication from UKQAA.

¹¹ Personal communication from TAG members.

Methodology

53. The impacts of the Quality Protocol were derived by comparing Option A and Option B.
54. For example, the avoided landfill disposal cost as a result of the Quality Protocol is calculated by deducting the landfill disposal cost in Option B from the landfill disposal cost in Option A. This cost is calculated for each year in the 10-year assessment period. These costs are then discounted and summed to derive the Net Present Value (NPV) total landfill cost saving as a result of the Quality Protocol.
55. The benefits and costs are calculated for each year over a 10-year period and then discounted at 3.5 per cent (following HM Treasury Green Book guidance [14]). The analysis is in constant real prices. It is assumed that the prices and costs do not rise in real terms but increase in line with inflation.
56. The analysis is based on 2007 prices and the period of assessment is 2009 to 2018.
57. Costs for climate change benefits are based on the Shadow Price of Carbon (SPC) as set out in Defra guidance [15] at £25.50 and inflated at 2 per cent per year. See also Annex C.

Costs and Benefits to Industry of the Quality Protocol

58. Table 5 shows the potential benefits to PFA supply industry and the carbon dioxide savings of introducing the Quality Protocol.

Benefits of the Quality Protocol including sectors and groups affected

59. Possible benefits of the Quality Protocol include:

- Avoided fees and charges for permits and exemptions. Current users of PFA would benefit from not having to pay the fees and charges associated with waste management controls if they purchase PFA that complies with the Quality Protocol. In 2007, the average fee for a Waste Management Licence for grouting applications was £4,500. Fill applications qualified for a Paragraph 19 exemption, which cost £546 in 2007/08.
- Avoided waste regulation admin burdens or the cost of consultancy fees, training and registration for Waste Management Industry Training and Advisory Board (WAMITAB) purposes etc. This evidence base uses the costs of admin burden as calculated following the 2005 Admin Burdens Measuring Exercise undertaken by all government departments. For a Waste Management Licence, this is equal to £9,496. Thus the total cost of a Waste Management Licence for grouting applications is £13,996 (£9,496 + £4,500). Although this value may seem high, it is comparable with an estimate provided by a company consulted by UKQAA which suggested the total cost for each grouting contract would be £13,000. For an exemption, the measurement exercise gives an admin burden cost of £379. The total cost of an exemption (e.g. for fill applications) is therefore £925 (£379 + £546).
- Higher sales of PFA into some end markets relative to the baseline. This could lead to greater revenues for power stations. It is less clear whether the Quality Protocol will have a significant impact on the cement, concrete and block making markets. However, there would be a negative impact on the suppliers of any substitute materials replaced by PFA.
- A lower total landfill tax bill faced by power stations relative to the baseline if the amount of PFA sold increases. Any increase in landfilling costs for power stations could, in principle, lead to higher prices for electricity. However, ash disposal is a very small cost relative to total operating costs and this would barely affect electricity prices to the consumer.
- Society could benefit from a possible carbon dioxide saving relative to the baseline. See Annex C for more details. Costs are calculated using methodology set out by Defra in August 2007 [15].
- In many applications PFA is cheaper than substitutes. Companies that currently purchase virgin substitutes but would switch to PFA if the Quality Protocol is introduced will benefit from a reduction in their production costs. This saving is not calculated here and there is no attempt to quantify it in the analysis.
- There is also the potential for concrete block manufacturers or miscellaneous applications to avoid the costs of complying with waste management controls. In many cases, these will be insignificant because many of the companies require Environmental Permits irrespective of whether PFA is a waste. Therefore this was not taken into account in the analysis.
- Companies that transport PFA will avoid having to register as waste carriers. In 2007 the annual cost of registration was £30 per carrier. This charge is irrespective of how much a company transports and how many vehicles it uses. This saving was not applied in the analysis as it is likely to be insignificant relative to other benefits.

Table 5: Quantified benefits of the Quality Protocol (2007 prices)

	NPV over 10 years (3.5% discount rate)	Average annual value
Avoided waste regulation fees and charges	£8.49 million	£1.26 million
Avoided waste regulation admin burdens	£17.94 million	£2.68 million
Avoided revenue loss	£62.75 million	£7.22 million
Avoided landfill disposal costs	£11.26 million	£1.31 million
Total financial benefit	£100.45 million	£12.46 million
Avoided CO ₂ emissions	£3.58 million (153,000 tonnes)	£0.51 million
Total benefit (financial + CO ₂)	£104.03 million	£12.97 million

Costs of the Quality Protocol

60. The costs of complying with the Quality Protocol, which will fall on power stations, are likely to be relatively low. Many of them will already be operating at or near the standards required. If power stations consider it not worth complying, they can choose not to and continue supplying PFA to market as a waste.
61. Details of the costs of complying with the Quality Protocol will be requested during the public consultation.
62. As noted above:
- suppliers of virgin substitutes may suffer reduced revenue;
 - operators of landfill sites may receive lower landfill gate receipts;
 - the Government could receive lower landfill tax receipts.

Sensitivity Analysis

63. The analysis uses a simple linear model. The benefit estimates in Table 5 are sensitive to the assumptions used. Certain input variables in the model were changed – leaving the other variables constant – and the new values for the benefits were derived. The results are detailed below.
64. Altering the assumed impact of the Quality Protocol on the grouting market has significant effects on the benefit results. The Option A and B scenarios were derived through discussions with the TAG and it is possible that the impacts could be less severe. Table 6 shows the benefits if the amount of PFA supplied to the grouting market falls to 40 per cent by 2020 in the baseline relative to 2006 (all other assumptions staying the same) rather than 80 per cent.

Table 6: Potential benefits when fall in grouting demand is 40% rather than 80%

	NPV over 10 years (3.5% discount rate)	Average annual value
Avoided waste regulation fees and charges	£14.96 million	£1.85 million
Avoided waste regulation admin burdens	£31.78 million	£3.94 million
Avoided revenue loss	£39.94 million	£3.94 million
Avoided landfill disposal costs	£7.17 million	£0.71 million
Total financial benefit	£93.86 million	£10.44 million
Avoided CO ₂ emissions	£1.82 million (77,500 tonnes)	£0.26 million (7,500 tonnes)
Total benefit (financial + CO ₂)	£95.68 million	£10.7 million

65. All benefits are significantly lower in Table 6 apart from the avoided waste regulation compliance cost, which is higher than in the base case. In the baseline of this altered scenario, there would be more grouting companies using PFA and paying fees for permits than in the baseline of the original case. Therefore introducing the Quality Protocol would result in a greater avoided waste controls compliance cost benefit.
66. The total admin burden of a Waste Management Licence is assumed to be £9,496. If this is assumed to be 50 per cent lower, the avoided waste regulation admin burden falls from £17.94 million to £9.14 million. This benefit is therefore very sensitive to the variable. All other benefits are unaffected.
67. The analysis uses a price of PFA of £20 per tonne including transport costs. Reducing the PFA price by x per cent will reduce the avoided revenue loss for the PFA supply chain (power stations, transport companies) by x per cent. All other benefits would be unaffected. Alternatively, increasing the price by x per cent increases the avoided revenue loss by the same factor. As an example, Table 7 shows the impact on avoided revenue loss for an increase and a decrease of 25 per cent relative to the existing assumption.

Table 7: Avoided revenue loss under varying price assumptions

Price equals £20/tonne	Price lowered by 25%	Price increased by 25%
£62.75 million*	£47.10 million	£78.45 million

* From Table 5.

68. If it is assumed the average grouting job is 2,000 tonnes rather than 1,000 tonnes, avoided waste management fees and charges become £4.34 million over 10 years and avoided admin burdens become £9.10 million. Doubling this variable almost halves the avoided waste regulation compliance cost. The other benefits are unaffected.
69. If the average fill job (a type of unbound application) is 10,000 tonnes instead of 5,000 tonnes, the avoided waste management fees and charges become £8.42 million and admin burdens become £17.88 million over 10 years. The results are less sensitive to changes in this variable because the analysis is based on an exemption cost which is much lower. The other benefits are unaffected.
70. The analysis assumes that current compliance with waste management controls is 100 per cent. If this was lowered to 50 per cent, the cost of waste management fees and charges would be £4.24 million and admin burdens would be £8.97 million over 10 years.
71. Consideration of all these sensitivities together implies a minimum overall benefit (excluding CO₂ costs) of £44.95 million and a maximum of £242.2 million over 10 years. In the lower figure, the price of PFA sold is assumed to be 25 per cent lower and, in the higher figure, the price is assumed to be 25 per cent higher.
72. The avoided cost of CO₂ emissions is £3.59 million. If the shadow price of carbon was 5 per cent lower or higher, the avoided cost would range from £3.41 million to £3.77 million.
73. At the same time as the 2009 budget, HM Treasury announced a consultation on planned changes to landfill tax arrangements. The most notable proposal was to move several materials including PFA currently under the inert rate of taxation to the active rate. The proposals would be contained in the 2010 Finance Bill. At the same time, the Chancellor announced that the landfill tax escalator would remain in place until 2013, bringing the active rate of taxation to £72 per tonne. No announcement was made about how the tax would change beyond this point. These changes are still under consultation, so it is not possible to accommodate these changes into the main estimates. However, we can carry out some illustrative analysis:
- There is a transitional period where the change is delayed for year after the 2010 Finance Act is implemented. The Act will be implemented immediately after it is passed. Thus, the active rate of landfill tax will be applied to PFA from 2011.
 - The landfill tax escalator will end in 2013. However, the tax will be increased to account for inflation from 2014 to 2020. The effects of inflation mean that the tax will be worth £67.08 per tonne in real terms by 2013.
 - Assuming that approximately 2,000,000 tonnes of PFA are landfilled in 2011, the total tax at 2011 alone will increase from £4.6 million to approximately £103 million in 2007 prices.
 - Avoided landfill costs (including the operational cost of disposal) of the Quality Protocol increase from £11.26 million at 2011 to £137.32 million 2020, an increase of £126 million in 2007 prices.

However, the effect of the increase in landfill tax will have a dramatic impact on the economics of PFA utilisation. Thus, rather than just amending the landfill tax assumptions in the analysis, it would be necessary to revisit the assumptions about PFA utilisation and prices. The effects are likely to be very wide ranging, and given the timing of the announcement, are outside the scope of this analysis.

Impact on Small Firms and Competition Assessment

74. The main companies affected by the introduction of the Quality Protocol are power stations and end users of PFA. The costs of complying with the Quality Protocol will fall on the power stations, which are not 'small firms'. The Quality Protocol would not create any barriers to entry into this market and would not reduce the number of processors. Any compliance costs will be very small relative to normal capital and operating costs. Many of those companies that choose to comply will already be operating to near or at the standard required. Existing processors will face the same compliance costs as new entrants.
75. End users will benefit from reduced waste management compliance costs and greater assurance of quality.
76. Small firms can often be disproportionately impacted by waste management controls. The Quality Protocol allows for PFA and FBA to cease to be waste and therefore no longer need waste management controls and so should disproportionately benefit smaller firms.
77. The Quality Protocol will not reduce the range or quality of the input materials available to end users and is unlikely to raise the price of PFA. On the contrary it should increase the available options and provide greater assurance of quality.

Compensatory simplification (offsetting)

78. Following the introduction of the Quality Protocol, it will not be necessary for businesses to comply with existing waste management controls if the materials they are using meet the required standards. Thus, compensatory simplification measures are not relevant to the analysis.

Enforcement, sanctions and monitoring

79. Where this Quality Protocol is not complied with (e.g. the PFA is not processed to an approved standard or not used according to the appropriate code of practice), the producer/user must comply with the relevant waste management controls and may be committing an offence if they do not do so.
80. Even if the Quality Protocol is complied with, the material may become waste again and subject to regulatory waste controls if, for example, it is at any stage:
 - disposed of;
 - stored indefinitely with little prospect of being used;
 - used in a way that poses a risk to human health or the environment.

Conclusions

81. The Quality Protocol is in line with the Government's risk-based approach to regulation and reduces the regulatory burden on industry. It is also in line with the Government's sustainability policy and commitment to encourage recycling and reduce disposal to landfill.
82. The Quality Protocol should provide a number of private sector and social impacts. Given the assumptions used in the model it could provide the impacts summarised below.
- Higher revenues (relative to the baseline) for power stations and those that supply PFA to market are forecast to be £62.75 million NPV over 10 years. However suppliers of substitutes could suffer corresponding losses.
 - There is the potential to avoid 2.6 million tonnes more PFA being disposed of to landfill relative to the baseline over 10 years. This would result in lower landfill tax costs of £11.26 million NPV over 10 years for power stations. These savings will be even higher depending on the outcome of HM Treasury's landfill tax consultation.
83. There is likely to be an overall gain for society in terms of lower CO₂ emissions, environmental gains from less material being landfilled and a reduced waste regulation burden.

References

1. *Survey of arisings and use of alternatives to primary aggregates in England 2005: other materials*, Department for Communities and Local Government, 2007. Available from: <http://www.communities.gov.uk/publications/planningandbuilding/surveyother2005> [Accessed 6 August 2008].
2. *The sustainability and environmental issues of using PFA in comparison with virgin materials*, Lindon Sear, UKQAA.
3. *Technical Report on the manufacture of products from pulverised fuel ash (PFA) and furnace bottom ash (FBA)*, Environment Agency and WRAP, 2009.
4. *PFA from Didcot Power Station*, Report No. SRL/PFA/001.2, 28 August 2006.
5. UKQAA response to the questionnaire 'Questions for the PFA TAG to aid the Financial Impact Assessment'.
6. Neil Bowmer response to the questionnaire 'Questions for the PFA TAG to aid the Financial Impact Assessment'.
7. *Sustainable concrete: how can additions contribute?* Paper by Denis Higgins (Cementitious Slag Makers Association) to 'Concrete for a Sustainable Future', Institute of Concrete Technology's annual technical symposium held March 2006. Available from: <http://www.sustainableconcrete.org.uk/PDF/ICT%20Convention%202006%20-%20paper%20-%20Higgins.pdf> [Assessed 7 August 2008].
8. *Technology status review of ash utilisation from coal based plants*. Presentation at DTI Conference Centre in June 2004 by UKQAA and Hatterall Association.
9. Sustainable development report 2007, Quarry Products Association. Available from www.mineralproducts.org/sus_report01.htm
10. National and Regional Guidelines for Aggregates Provision in England, 2001–2016 ODPM, 2003.
11. *Sustainable waste management and recycling: achieving the potential of recycled aggregates*, John C Barritt, WRAP, 2004.
12. 'Meeting with Ben Bradshaw MP Parliamentary Secretary (Commons) (Local Environment, Marine and Animal Welfare)'. Issues relating to the classification of coal fired power station ash products as wastes under the Waste Management Regulations – by Lindon Sear, UKQAA.
13. Draft *Quality Protocol for the production of pulverised fuel ash (PFA) and furnace bottom ash (FBA) for use in construction and manufacturing*, Environment Agency and WRAP, 2008.
14. *The Green Book*. Appraisal and evaluation in central government. 3rd edn. HM Treasury, 2003.
15. *How to use the Shadow Price of Carbon in policy appraisal. Interim Guidance*, Department for Environment, Food and Rural Affairs (Defra), 2007. Available from: <http://www.defra.gov.uk/environment/climatechange/research/carboncost/index.htm> [Accessed 7 August 2008].

Other key references:

Environmental legislation and by-product materials – the UK perspective, Lindon Sear, UKQAA.

Consultants (& contractors) who will not use PFA, Lindon Sear, Technical Director, UKQAA, March 2007.

The sustainable use of resources for the production of aggregates in England, WRAP, 2006. Available from: http://www.aggregain.org.uk/templates/temp_agg_publication_details.rm?id=2298&publication=3337 [Accessed 7 August 2008].

Specific Impact Tests: Checklist

Use the table below to demonstrate how broadly you have considered the potential impacts of your policy options.

Ensure that the results of any tests that impact on the cost-benefit analysis are contained within the main evidence base; other results may be annexed.

Type of testing undertaken	Results in Evidence Base?	Results annexed?
Competition Assessment	Yes	No
Small Firms Impact Test	Yes	No
Legal Aid	No	No
Sustainable Development	No	No
Carbon Assessment	Yes	Yes
Other Environment	No	No
Health Impact Assessment	No	No
Race Equality	No	No
Disability Equality	No	No
Gender Equality	No	No
Human Rights	No	No
Rural Proofing	No	No

Annex A: Assumptions used in the Analysis

The following assumptions were made in order to undertake the analysis.¹²

Assumptions applying to both options:

- Arisings of PFA do not increase over the assessment period.
- Constant real prices are used in the analysis. The impact of inflation is removed.
- The cost to power stations of maintaining their landfill sites is £3 per tonne.
- The amount of PFA sent to temporary stockpiles is 145,523 tonnes per year over the period, i.e. the same amount as stockpiled in 2006.
- That 29 per cent of the PFA not sent to end markets or stockpiling goes to land reclamation, i.e. no landfill tax is paid but it is assumed the power station is unable to sell PFA to this route.
- The admin burden associated with a Waste Management Licence is £9,496 per licence at 2007 prices, as indicated by the 2005 admin burdens measurement exercise. The average cost of a licence is £4,500. See Annex F for details of admin burdens calculations.
- The cost of Waste Management Licences exemptions admin burdens is £379.11 per licence in 2007 pounds, as indicated by the 2005 admin burdens measurement exercise. Registration costs £546. See Annex F for details of admin burdens calculations.
- There is no increase in the price of PFA as a result of the Quality Protocol. The figure of £20 per tonne used in the analysis includes transport costs.
- An average fill site uses 5,000 tonnes of PFA. Fill sites need a waste exemption costing £546 each.
- The average grouting job is assumed to be 1,000 tonnes. It is also assumed that every year there is one grouting job of 100,000 tonnes.¹³
- If one tonne of PFA is replaced by sand in grouting, then the extra CO₂ emissions would be 0.05 tonnes. The amount of CO₂ saved per tonne of PFA used in fill is 0.023 tonnes. See Annex C for the calculations.
- The inert rate of the landfill tax stays constant at £2.50 per tonne over the assessment period. It is quite possible that the landfill tax will be increased. If so, the presented avoided landfill disposal cost would be an underestimate.

Assumptions used in Option A (baseline):

- If the Quality Protocol is not introduced, the amount of PFA going to grouting will fall to 20 per cent of the 2006 level by 2020. The decline is linear.
- The quantity of PFA sold into the fill market will fall by 10 per cent by 2020 from the 2006 level. The decline is linear.
- No PFA is currently sold for lightweight aggregate production. In the baseline, it stays at zero throughout the assessment period.
- The quantity of PFA sold into the other end markets each year stays the same as the 2006 level throughout the 10-year period.

Assumptions used in Option B (Quality Protocol introduced):

- All coal-fired power stations will follow the Quality Protocol.
- The Quality Protocol is enforced and monitored effectively.
- The amount of PFA produced in the UK going to the grouting and fill markets falls after 2006 until the Quality Protocol is introduced in 2009. It falls at the same rate as in Option A. From 2009 onwards, the annual quantity sold into both markets rises linearly until it regains the 2006 levels by 2020.
- The amount of PFA going to the other end markets stays the same as the 2006 level. This is the same as in Option A.

¹¹ Assumptions were derived from communications with members of the TAG.

¹² Personal communication from UKQAA.

Annex B: Technical Advisory Group Membership

Organisation	Representative	Type of member
Association of Electricity Producers (AEP)	Andy Limbrick	Attending
Department for Business, Enterprise and Regulatory Reform (BERR)	Jonathan Thomas Kerry Vitalis	Attending Attending
Environment Agency	Scott McFarlane Andrew Hitchings	Attending Attending
Joint Environmental Programme (JEP)	Neil Bowmer Richard Busby	Attending Attending
UK Quality Ash Association (UKQAA)	Lindon Sear	Attending
Waste Protocols Project Team	Suzanne Laidlaw Michelle Steer Hana Leithgoe Sarah Clayton Nicola Content Ahlim Hashm (RPS)	Attending Attending Attending Attending Attending Attending
Waste & Resources Action Programme (WRAP)	John Barritt	Attending
National Industrial Symbiosis Programme	Nizar Ghazireh	Attending
Aggregate Industries	Andrew Swain	Invited member
Ash Solutions Ltd	Les Drury	Invited member
Environment Agency	Clare McCallan Kathryn Harris	Corresponding Corresponding
Environment Agency Wales	Becky Favager	Corresponding
Scottish Environment Protection Agency (SEPA)	John Harris	Corresponding
Veolia	Sarah Moseley	Corresponding
Welsh Assembly Government (WAG)	Aoife O'Sullivan	Corresponding

Annex C: Greenhouse Gas Emissions Benefits of using PFA¹⁴

Grouting

The normal substitute for PFA in grout is sand. However, sand has proved to be not as good technically as PFA. This is due to the particle shape, density and chemistry of PFA compared with natural aggregates.

The issues to consider are that [5]:

- PFA is less dense than virgin aggregates and requires ~13 per cent more material;
- 25 per cent more Portland cement is needed to compensate for the pozzolanic effect of PFA;
- problems with bleeding must be addressed.

If one tonne of PFA is replaced by sand, the extra CO₂ emissions would be 0.05 tonne.

The calculation is as follows:

- Mass of sand required = $1 \times 2.6/2.3$ (to compensate for differing densities).
- CO₂ emissions associated with producing 1 tonne of sand = 23 kg or 23/1000 tonnes.
- Increased Portland cement content for 1 m³ of 10:1 grout = 25% x 115 kg = 28.75 kg or 28.75/1000 tonnes.
- For every tonne of Portland cement replaced by PFA, there is an overall reduction of 0.86 tonnes of CO₂.
- 1.031 tonnes of PFA are used in every 1 m³ of grout.
- Tonnes of CO₂ emissions from using sand = $1 \times 2.6/2.3 \times 23/1000 = 0.026$
- Tonnes of CO₂ for using extra Portland cement = $1/1.031 \times 28.75/1000 \times 0.860 = 0.024$
- Total CO₂ emission benefits of using 1 tonne of PFA in grouts instead of sand = 0.05 tonnes.
- The above assumes CO₂ emissions attributable to PFA production are zero.

The Shadow Price of Carbon is calculated according to Defra guidance [13].

Fill and ground stabilisation

When PFA is used as a fill material, it is a direct replacement for virgin aggregates. The quantity of CO₂ emitted for every tonne of virgin aggregates produced varies considerably depending on the aggregate type. The median figure is 23 kg of CO₂ per tonne of aggregate or 0.023 tonne of CO₂ [5].

Annex D: Regulatory Position of the Environment Agency

Use	Current legislative control*	Current regulatory approach
Aerated concrete blocks	<p>If <20,000 tonnes of waste ash is stored at place where blocks are to be manufactured, Paragraph 13 exemption of Schedule 3 of the Environmental Permitting Regulations (England and Wales) 2007 (EPR) applies.</p> <p>If >20,000 tonnes, an Environmental Permit is required.</p>	PFA ceases to be waste at the point the block is made. At this point, the blocks can be stored and sold as products with no waste management controls.
Cement	Cement blending and manufacturing plants are required to be registered under IPPC Part B.	PFA ceases to be a waste at the point it is blended into the cement mix or used as raw feed.
Concrete as a Type II addition	Covered under an Environmental Permit (previously covered under PPC).	PFA is likely to cease to be waste at the point it is blended into the cement mix or used as a raw fill material.
Fill material	Covered by Paragraph 19 exemption of Schedule 3 of the Environmental Permitting Regulations.	PFA ceases to be waste at the point it is incorporated into the structure.
Grouting	An Environmental Permit is required.	PFA grout does not cease to be waste until incorporated into a structure. It is unlikely that a Paragraph 19 exemption will apply and therefore an Environmental Permit is required.
Sintered lightweight aggregate (Lytag)	Requires a Permit; the Environment Agency is considering why Paragraph 13 exemption does not apply.	
FBA for the manufacture of lightweight concrete blocks	Covered by Paragraph 13 exemption of Schedule 3 to the Environmental Permitting Regulations.	FBA ceases to be waste at the point it is incorporated into a block. The blocks can be stored and sold with no waste management controls.

* The Environmental Permitting (England and Wales) Regulations 2007 came into force in April 2008.

Annex E: Admin Burdens

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.

This evidence base uses the admin burden associated with Waste Management Licence exemptions and Waste Management Licence applications as calculated under the 2005 Admin Burdens Measuring Exercise undertaken by all government departments. The use of these figures is compulsory in impact assessments carried out by government departments and agencies.

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 amount of applications that were made in 2005. Thus, 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 Quality Protocol.

While steps have been taken to ensure its accuracy, the authors cannot accept responsibility or be held liable to any person for any loss or damage arising out of or in connection with this information being inaccurate, incomplete or misleading. This material is copyrighted. It may be reproduced free of charge subject to the material being accurate and not used in a misleading context. The source of the material must be identified and the copyright status acknowledged. This material must not be used to endorse or used to suggest WRAP's endorsement of a commercial product or service. For more details, please refer to our Terms & Conditions on our website – www.wrap.org.uk

**Waste & Resources
Action Programme**

November 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



www.environment-agency.gov.uk

Tel: 08708 506 506

E-mail: enquiries@environment-agency.gov.uk

