Mercury emissions from crematoria

Consultation on an assessment by the Environment Agency's Local Authority Unit

Department for Environment Food and Rural Affairs

SCOTTISH EXECUTIVE

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

Introduction

Background

This consultation paper comprises a paper produced for Defra by the Environment Agency's Local Authority Unit (LAU) with their technical assessment of the case for tackling mercury emissions from crematoria.

Crematoria have been regulated under Part I of the Environmental Protection Act 1990 since 1991. Substantial improvements have been made through the requirement to use Best Available Techniques Not Entailing Excessive Cost and the statutory government guidance on BATNEEC for crematoria (known as process guidance note PG5/2). The controls have not, however, so far addressed emissions of mercury.

Defra asked the LAU to produce a paper in order to inform decisions on whether to specify gas cleaning of mercury emissions in the next revision of the statutory guidance (which will also serve as guidance on Best Available Techniques under the successor Pollution Prevention and Control Act 1999 regime).

Conclusions of the LAU technical assessment

The LAU paper reaches the following conclusions (copy of paragraphs 65-74):

- it can be roughly predicted that, without intervention, mercury emissions from crematoria in the UK will increase by two thirds from 2000 to 2020. A plateau or slight rise in emissions would follow to 2035 or so, then followed by a decrease back to 2000 emission levels around 2055.
- by 2020 crematoria would emit between 11 and 31% of the UK mercury emissions to air. The upper figure is consistent with UK emissions as reported to UN/ECE and EU.
- the mass of mercury emitted is more important than the species of mercury emitted.
- the health concerns arise from the long distance transport of mercury. Levels around crematoria are below those at which they are believed to give rise to health concerns.
- BAT - gas cleaning by a dry sorbent and filter system or equivalent is recommended as the best available technique for the removal of mercury from crematoria emissions to air for England and Wales.
- available - national emission standards that require gas cleaning at new or large crematoria are in place in Austria, Belgium, Germany, The Netherlands, Norway Sweden and Switzerland. Denmark, France and Great Britain do not have standards that require gas cleaning. Gas cleaning is therefore clearly "technically available".

- NEEC -. In 1998/9, publicly owned crematoria received an average surplus over cost of £67 per cremation, adult cremation costs ranged from £100 to £360 per cremation, and a funeral with cremation averaged £1215 and burials £2048. Gas cleaning (at around £55 per cremation) is unlikely to affect the viability of the majority of crematoria.
- the civil / building costs will vary substantially from site to site. Costs per cremation can increase sharply for the 3 smallest crematoria and due to site constraints for all sizes of crematoria and implementation proposals should take that into account.
- the cost of abating mercury by gas cleaning crematoria exhausts in the UK is higher than other abatement costs that industry bears. However past and current practice should not prevent changes in assessing excessive cost, considering that by 2020 crematoria will be by far the biggest single contributor to national mercury emissions unless steps are taken and that due to its long range transport, mercury is of international concern and that some countries have introduced gas cleaning of mercury at some crematoria.
- if crematoria close rather than upgrade then some co-ordination of closure and any new provision would be necessary to maintain a service to the nearby communities.

Consultation

Because of the recognised sensitivities of regulating crematoria for air emissions, and because of the potentially significant implications of the decision whether or not to require gas cleaning, Defra, the Welsh Assembly Government and the Scottish Executive consider it important to obtain the views of interested parties in the technical assessment which will underpin such a decision. To that end, you are invited to submit views on the attached paper to reach the Department no later than **7th August 2003**. We would welcome any comments you have to make, but in particular we would be pleased to have comments on the following:

1. **the factual content of the LAU's paper and the conclusions drawn therefrom**

2. **the need for action to address mercury emissions and the timescale within which action should be taken**

3. **the techniques that could be used to tackle mercury emissions and the fixed and running costs associated with installing them**

4. **the consequences of requiring gas cleaning or any other technique, including evidence to support any contention that a significant number of crematoria would have to close as a result**

There will be further consultation on any draft revision of the BATNEEC/BAT statutory guidance as regards mercury emissions from existing crematoria before a decision is finally taken on the guidance.

This consultation paper is also available at :
www.defra.gov.uk/corporate/consult/current.htm

Responses

Responses to this consultation paper should be sent by: **7th August 2003, to:**

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If you have any queries about this consultation paper, please contact Carl Woodward on 020 7944 6334 or carl.woodward@defra.gsi.gov.uk

Consultees should note that it may not be possible to consider responses which arrive after the deadline. In your response please explain who you are, and where relevant who you represent and include you r name and address. Please note that copes of your response will be deposited and made publicly available in the Defra library unless you specifically ask for your response to be treated as confidential. All responses will be included in any statistical or other summary of the results.

Code of Practice on written consultation

1. This consultation paper has been produced in accordance with the consultation criteria of the code of practice on written consultation. In accordance with the Cabinet Office Consultation Code, for matters relating to the consultation procedure itself, a consultation co-ordinator has been appointed. The co-ordinator is Lewis Baker and his contact details are lewis.baker@defra.gsi.gov.uk. Further details of the consultation guidelines are available on the Cabinet Office website at: www.cabinet-office.gov.uk/servicefirst/2000/consult/code/content.htm .

The consultation criteria:

a. Timing of consultation should be built in the planning process for a policy or service from the start, so that it has the best prospect of improving the proposal concerned, and so that sufficient time is left for it at each stage.
b. It should be clear who is being consulted, about what questions in what timescale and for what purpose.
c. A consultation paper should be as simple and concise as possible. It should contain a summary, in two pages at most, of the main questions it seeks views on. It should make it as easy as possible for readers to response, make contact or complain.
d. Documents should be made widely available, with the fullest possible use of electronic means (though not to the exclusion of others) and effectively drawn to the attention of all interest groups or individuals.
e. Sufficient time should be allowed for considered responses from all the groups with an interest. Twelve weeks should be the standard minimum period for a consultation.
f. Responses should be carefully an open-mindedly analysed and the results made widely available with an account of the views expressed, and reason for decision finally taken.
g. Departments should monitor and evaluate consultation, designate a consultation co-ordinator who will ensure the lessons are disseminated.

Local Authority Unit - Environment Agency

Assessment for second revision of PG5/2, Process guidance note for Part B Environmental Protection Act 1990, Part 1, and Pollution Prevention and Control Act 1999

Gas cleaning of emissions to air, including mercury, from existing crematoria

A technical case

1. Crematoria and their air pollution controls are authorised by local regulators having regard to the process guidance note PG5/2, first issued in February 91 and revised in August 95 (DOE 1995).
2. This assessment is part of the second revision of process guidance note PG5/2 and has been written by the Local Authority Unit (LAU) of the Environment Agency who draft and consult initially on revisions to the published guidance for England, Wales and Scotland. Revisions are issued by the Secretary of State in England, and by the National Assembly for Wales and by the Scottish Ministers.

Purpose

3. The purpose of this paper is
    - to provide information on the benefits, costs and practicality of removing mercury from the exhaust gases of existing crematoria in Great Britain, and
    - to offer a view on whether gas cleaning of mercury from crematoria exhaust gases is the best available technique not entailing excessive cost (BATNEEC) for local air pollution control in England and Wales.

Update

4. More information is now available since a paper was submitted to DETR by the Local Authority Unit of the Environment Agency in December 2000 on the subject of mercury emissions from crematoria and in particular;
    - a review of emissions from crematoria has been carried out (Edwards 2001) by AEAT on behalf of the Federation of British Cremation Authorities(FBCA) and the Cremation Society of Great Britain and
    - a draft paper from the Netherlands by consultants Tauw Milieu BV (Coenen 1997) on mercury emissions from crematoria and flue gas treatment techniques has also been received by the Local Authority Unit.

Emissions

Mercury

5. The AEAT study (Edwards 2001) measured a number of substances and parameters in cremator emissions from the three main types of cremator in the UK.
6. Mercury emissions were measured from 18 cremations. Most of the mercury in bodies is in dental amalgam fillings (Edwards P 2001), and as the number of fillings varies from person to person, a wide variation of mercury emissions could be expected. The measurements showed 6 cremations with very little mercury and a

considerable variation in emissions from the other cremations. The average emission across all the cremations was 0.9g Hg per cremation.

Discussion of mercury emissions

UK emissions to air of mercury

7. 0.9g of mercury per cremation is less than the calculated emission factor of 3g per cremation that is currently used to estimate UK mercury emissions from crematoria and reported in the National Atmospheric Emission Inventory – (NAEI)
8. Measured values are usually preferred to calculated values for emissions in the NAEI who review the factors from time to time. (NAEI 2001) However due to the limited number of cremations measured and the variation in the number of fillings per cremations, neither the measured nor the calculated emission factors can be discounted.
9. Both the measured and calculated values involve uncertainties. Measured values vary considerably with the size and number of fillings in a cremation and measurements may be within 10% or so of the flue concentration. Uncertainties in the calculated values could act in either direction. According to British Dental Trade Association filling sizes may well have been larger than estimated in the early 90s for those dying in the next 10-15 years as the fillings were put in the 80s. The estimate of the amount of each filling mix that goes to waste in the surgery could be an under or over estimate. If the NAEI estimate was a factor of 2 out in either direction, the range would be from 1.5 to 4.5 g Hg /cremation.
10. The mean value of 3g seems to be a reasonable value to take and the measured values do not overcome the logic of these simple factors. That amount of mercury is going somewhere whether or not the monitoring technique managed to capture it. NAEI are continuing to use the calculated value (3g) in their National Atmospheric Emissions Inventory. (Passant, 2002)
11. So the percentage of UK mercury emissions arising from crematoria can be calculated as part of a range.
    The top of the range is calculated from,
    - the calculated emission factor of 3g, x 446,000 cremations ie1.34 tonnes ,
    - the NAEI total for UK mercury emissions to air in 2000 8.55 tonnes of mercury, (which uses the 3g factor and 1.34tonnes from crematoria)

    The bottom of the range is calculated from
    - the measured emission factor of 0.9g x 446,000 cremations, ie 0.4 tonnes (and consequently a lower total UK emission)
    - and a lower figure for total UK mercury emissions to air of 7.6 tonnes (ie which uses the NAEI data, but allows for the 0.9g factor and 0.4 tonnes from crematoria)

    Those calculations give a range of mercury emissions from cremations as 5.3%-15.7% of UK mercury emissions to air in 2000. (0.4 – 1.34 tonnes mercury). The upper figure from the range is submitted to UN/ECE and EU as UK emissions of mercury to air.

Trends in mercury emissions

12. There are two reasons why crematoria are responsible for a rising proportion of UK mercury emissions to air
    - The number of amalgam fillings present at cremation is rising.
    - Other mercury emissions are falling or are steady

Increase in amalgam fillings at cremation

13. The British Dental Association consider that the population of the UK can be considered roughly as three cohorts:
    - the very old with no teeth
    - those with heavily restored teeth
    - the fluoride toothpaste generation

    The Adult Dental Health Survey 1998 (Office for National Statistics, 1999) provides the data for this view. Extracts from the survey are reproduced in the Appendix. The FBCA have pointed out that after rising, mercury emissions will in time fall.

Tauw Milieu

14. The study by Tauw Milieu BV (Coenen P, 1997) for the Netherlands reported a prediction of a doubling of mercury emissions from crematoria from 1995 to 2020 for the Netherlands. The prediction from 2000 to 2020 was for a 68% increase. The reason for the predicted doubling is the decreasing number of older people with no teeth. The study also reports a fall in the number of fillings in young people, but makes no prediction about when that fall would affect mercury emissions at crematoria.

Future mercury emissions from crematoria

15. It can be roughly predicted that, without intervention, mercury emissions from crematoria in the UK will increase by two thirds from 2000 to 2020. A plateau or slight rise in emissions would follow to 2035 or so, then followed by a decrease back to 2000 emission levels around 2055. This prediction is based on dental data to 1998 and simple actuarial data. The prediction is set out in the Appendix.

16. Crematoria emissions are expected to increase from 0.4 – 1.34 tonnes in 2000 to 0.68 – 2.2 tonnes in 2020 unless gas cleaning of exhausts is introduced.

Trends of Other Hg sources

17. UK sources of mercury emissions to air include crematoria, zinc ore smelting, coal and coke burnt in power stations, coal burnt elsewhere, chlor-alkali industry, clinical waste incineration, which together accounted for 75% of UK emissions in 1999, and other sources. (Peirce 2002). A more detailed breakdown of sources for 1999 (Peirce 2002) is in the Appendix.

18. Emissions of mercury to air from the named sources excluding crematoria are projected to drop from 5.05 tonnes in 1999 to 1.88 tonnes in 2020. What will happen to the other mercury sources over that period is not clear and here they are assumed to stay constant at 2.16 tonnes. The projection and its basis is set out in the Appendix.

19. By 2020 crematoria are projected to emit between 11 and 35% of the UK mercury emissions to air. The upper figure from the range is preferred as it is based on figures submitted to UN/ECE and EU as UK emissions of mercury to air.

PCDD/F.

20. Mercury abatement would also abate PCDD/F (dioxin and furan) emissions from cremators.
21. PCDD/F (2,3,7,8 substituted polychlorinated dibenzo dioxins and furans) emissions from well-maintained cremators were measured by AEAT (Edwards P, 2001) and found to be much lower than previous measurements made in the early 1990s. The average emission was 61 nanogrammes I-TEQ per cremation and that gives a UK total emission from crematoria of 0.027 grammes I-TEQ. That is **0.008%** of the UK total emission of 325 grammes I-TEQ.

Discussion of PCDD/F emissions

22. From measurements made in the early 1990s about **5%** of UK emissions to air of PCDD/F were attributed to crematoria. (Salway 2002)
23. Current emission levels are similar to PCDD/F emission limits in Waste Incineration Directive 2000/76/EC. That Directive does not apply to crematoria but its emission limits indicate what good exhaust gas treatment can achieve.
24. Consequently gas treatment of cremator emissions for mercury is not likely to make a substantial reduction in the UK emission of PCDD/F. However it would provide a reduction in the emissions of PCDD/F from less well-maintained crematoria.

Mercury releases to the environment

25. The mass of mercury emitted is more important than the species of mercury emitted as all species of mercury emitted from crematoria can be converted into methyl mercury, the most toxic form. This conversion occurs in marine environments, and methyl mercury can then accumulate in the food chain. (eg Lee et al 2000 p.v)

Transport of mercury

26. How far mercury will travel in the air after leaving the crematoria stack before it grounds or enters the sea depends on which chemical species of mercury is emitted as well as the stack dispersion locally. . (Lee et al 2000 p.3)
27. Determining the species of mercury emitted from crematoria by analysis of emissions has not been done. The limited data on species emitted from coal power stations is difficult to apply to crematoria emissions due to the difference in combustion equipment, fuel and air pollution control measures.
28. Mercury in its metallic form has a long atmospheric half-life and is likely to circulate the Northern Hemisphere. The most toxic species of mercury, methyl mercury is not thought to be emitted from crematoria in any measurable quantity due to combustion time and temperature. Mercury in a reactive gaseous form may well be emitted from crematoria, (Lee et al 2000 p.13) and would travel 10s or 100s of kilometres before deposition (Fryer P, personal communication)
29. Measurements for mercury in air around industrial plant, including crematoria, show that levels in air in the UK are below those at which they are believed to give rise to health concerns (Stanger 2001) There are no current air quality limits.

Prevention

30. Measures to prevent mercury being emitted from crematoria, other than cleaning the exhaust gas from crematoria, are not considered in this paper

BAT – Best Available Techniques

Best

31. Both AEAT's report for the FBCA (Edwards 2001 VolB p5) and Tauw Milieu's report for the Netherlands (Coenen 1997, chapter 6), identify wet and dry systems for the removal of mercury from crematoria exhaust emissions. Tauw Milieu also include some systems they consider unproven or uncosted and they do not make a specific recommendation as which abatement system they prefer for crematoria.
32. AEAT's preferred end-of-pipe option for the abatement of mercury for each cremator is a dry sorbent / filter system after exhaust gas has been conditioned, (Cool, capture, collect) together with a draught fan and stack.
33. The system is in common use for cleaning exhaust gases from a wide range of industry and is well understood. Up to 98% reduction in mercury emissions is expected.(Environment Agency 1996)
34. It is possible to have one gas treatment plant for two cremators. Some saving on size and cost (around 30%) is made at the expense of throughput, operational flexibility, and some loss of ease of monitoring and efficiency. Throughput is reduced because loading of the cremators has to be staggered and the length of cremations can be unpredictable. For sites with more than about 1000 cremations a year, the decrease in throughput would be substantial and significant.
35. Wet systems and other dry systems have a number of disadvantages compared to a dry sorbent and filter system. The dry sorbent / filter system or equivalent is recommended as the best available technique for removing mercury from crematoria exhaust gas.
36. Periodic methods for monitoring emissions of mercury are available. BS EN 13211:2001 is suitable.
37. There is currently no continuous measurement method available that can measure total mercury emissions from crematoria, only mercury in metal form. It would also be a matter of consideration whether continuous monitoring, if technically available, would represent BAT from a cost/benefit standpoint.

Available Techniques

38. National emission standards that require gas cleaning at new or large crematoria are in place in Austria, Belgium, Germany, The Netherlands, Norway Sweden and Switzerland. Denmark, France and the UK do not have standards that require gas cleaning. Gas cleaning is therefore clearly technically available.

NEEC

39. In this section the following costs for gas cleaning at existing crematoria are estimated.
    - A simple estimate of capital cost for UK
    - Costs per cremation assuming one gas cleaning plant per cremator at crematoria over 978 cremations a year
    - And costs per cremation sharing gas cleaning plant at smaller crematoria
40. A system sharing one larger gas treatment plant between two cremators saves 30% of the capital cost with some restriction of throughput. Sharing a system between three cremators is not thought to reduce costs by much and would considerably restrict throughput. Costs would then increase, as more cremators would then be needed.

41. The capital costs of the gas treatment plant consist of equipment, building and commissioning costs, the running costs include energy, additional maintenance and supervision, and purchase and disposal of sorbent.

    AEAT, based on real cost data, estimates capital costs of installing gas cleaning per cremator at £265,000 and the increase in running costs due to gas cleaning at £8.80 a cremation (Edwards 2001Vol B pp6-8). Most of the UK's 241 crematoria have from 1 to 4 cremators. An average crematorium has 3 cremators, so **a simple estimate of the total capital cost for the UK is £187 million**.

42. From AEAT's figures, the cost per cremation of installing one gas cleaning plant per cremator can be calculated and are given in the table below for crematoria with more than 978 cremation a year.
43. For smaller crematoria ie 978 cremations pa and under cost per cremation can be kept down by sharing gas cleaning plant
    - For 19 small crematoria (978 -700 cremations pa in 1999.), one larger gas cleaning plant is shared between 2 cremators. This can be achieved with some loss of throughput and operational flexibility. There are also slightly higher consequences for abatement failure, and some decrease in abatement efficiency and ease of measurement, but these are not considered to outweigh the cost reduction.
    - 13 plant had fewer than 700 cremations in 1999 and for these a single gas cleaning plant can service two cremators as long as only one is operated at any one time.
44. Using shared gas cleaning plant for smaller crematoria gives costs per cremation which are similar to the costs estimated for the larger crematoria, except for the 3 smallest crematoria. Costs for small crematoria will not be reduced to those in the table where, due to site constraints, a single gas cleaning plant cannot be shared by two cremators.

Table 1 Estimated additional cost per cremation for installing gas cleaning at existing crematoria

Number of cremations in 1999	Number of crematoria, (excluding 3 new in 1999)	Average cost per cremation	Percentage of UK cremations in 1999
Over 978	204	£47 to £67	95%
978 - 700	19	£47 to £63	3.4%
700 – 500	10	£47 to £63	1.3%
Under 500	3	Over £63	0.3%

There were 444,169 cremations in the UK in 1999 (FBCA 2000a)

45. The civil / building costs in the tables above are taken from AEAT's report to FBCA. They are typical costs and will vary substantially from site to site up to the point where it is better value to build on a new site, and consequently the cost increase per cremation will also vary.
46. Periodic monitoring costs for mercury are likely to be between £500 and £1,000 per year per cremator, if carried out at the same time as other periodic monitoring.

47. Continuous monitoring for metals only would cost approximately £22,000 for the first instrument, including the air supply and controller, and about £17,500 for each additional monitor. One monitor per gas cleaning plant would be needed with an expected life of 7-10 years. Installation and running costs are not included here. For an average crematorium, the capital cost is around £60,000 plus installation costs.
48. The publicly owned crematoria received an average surplus over costs of £67 per cremation in 1998-99 according to data submitted to Chartered Institute of Public Finance Accountants (CIPFA) and summarised in Resurgam (vol43 p54). Adult cremation costs range from £100 to £360 per cremation in 1998/9. It would therefore appear that there is scope for the average plant to absorb a reasonable proportion of such costs although, of course, much of the cost will be passed on to the client.
49. The average cost of a funeral was £1215 for a cremation and £2048 for a burial (Office of Fair Trading 2001). A cost increase of, say £55, is unlikely to influence the client or to drive the market towards burials. Gas cleaning is therefore unlikely to affect the viability of the majority of crematoria, although it may cause problems for the 3 smallest plant and sites where site constraints increase costs significantly.
50. Comparing mercury abatement costs with other industries indicates that gas cleaning at crematoria costs more than other industries are currently paying, though willingness to pay is only one criterion among several for judging whether a cost is excessive.
51. Cost per tonne abated is a useful parameter for comparing different techniques and industries.
    - Tauw Milieu report costs equivalent to £31million to £45million per tonne mercury abated over the period 2000 to 2020.
    - Using AEAT's abatement costs with AEAT's measured emission factor of 0.9g leads to a cost of £52million to £58 million per tonne mercury abated for emissions rates at 2000. The cost drops by 40% as emissions rise to 2020 levels
    - Using AEAT's abatement costs with the NAEI calculated emission factor of 3g for emissions leads to a cost of £16million per tonne abated
52. For comparison, the chlor-alkali industry currently propose measures which will save 0.93 tonnes of mercury a year at an estimated cost upwards of £2.15million per tonne of mercury abated (Pierce 2002). Capital costs for the conversion of mercury cells at chlor-alkali works are considerably higher, but direct comparison with crematoria is difficult as that conversion reduces running costs enough to pay for the conversion, but usually not quickly enough for industry to invest in the change.

International drivers

53. There are international drivers for lower mercury emissions as, it is transported across boundaries, there are elevated levels of mercury in marine life across the North Sea, and other countries have introduced gas cleaning at some crematoria amongst other measures.
54. UK has signed up to the OSPAR Hazardous Substances Strategy in which there is an objective to "make every endeavour to move towards the target of cessation of discharges, emissions and losses of hazardous substances by 2020". Mercury is an identified hazardous substance.(OSPAR 2000)

55. There are no current EU limits for mercury in ambient air but there is a draft Directive On Arsenic, Cadmium, Mercury, Nickel And Polycyclic Aromatic Hydrocarbons In Ambient Air.
56. Mercury has now been adopted as a priority hazardous substance under the Water Framework Directive and consultants commissioned by the EC are currently drawing up an inventory of the sources of mercury. This is to inform decisions relating to the Directive's provision to bring forward measures aimed at the cessation or phasing out of emissions, discharges and losses within 20 years. The scope of this Directive (and the extent to which it applies to air emissions, including those from crematoria) will be considered in the development of daughter directives. (Directive2000/60/EC)

NEEC conclusion

57. The cost of abating mercury by gas cleaning crematoria exhausts in the UK is high by comparison with other abatement costs. However past and current practice should not prevent changes in cost assessment, particularly, when by 2020 crematoria will be by far the biggest single contributor to national mercury emissions unless steps are taken and that due to its long range transport, mercury is of international concern and some European countries have introduced gas cleaning of mercury at some crematoria.

Implementation

58. The FBCA survey of members (FBCA 2000b) asked whether crematoria would close rather than install gas cleaning of crematoria exhausts. 23% of replies anticipated closure, lack of capital or space being the main reasons quoted. Since that survey the cost of gas cleaning has been revised upward by AEAT's report.
59. FBCA promised their members confidentiality for survey replies and therefore there is no site specific information about which crematoria anticipated closure, or for what reasons.
60. There may be insufficient space to install gas cleaning at some crematoria. Difficulties include:
    - graves close to the crematorium, (it is usually difficult, slow and costly to move graves),
    - listed buildings or other buildings where changes in character would be resisted by planners, and
    - other site limitations.
61. The main reasons given for closure were lack of space or capital. Whatever the reason, plant may be replaced by private sector operators with more flexible capital-raising ability, on new sites. Most of the new crematoria sites in the last 5 years are privately owned and run. For this reason and because the confidential questionnaire might have been seen as part of a negotiation, it can be assumed that the total number of closures will be less, say 15% rather than 23%. This however is speculative.
62. Costs per cremation can increase sharply due to site constraints for all sizes of crematoria and implementation proposals would have to take that into account.
63. Difficulties about finding capital might be solved by the involvement of the private sector who already own and operate crematoria or by public crematoria who reported surpluses of £67 per cremation.

64. If crematoria close rather than upgrade then some co-ordination of closure and any new provision would be necessary to maintain a service to the nearby communities.

Conclusion

65. It can be roughly predicted that, without intervention, mercury emissions from crematoria in the UK will increase by two thirds from 2000 to 2020. A plateau or slight rise in emissions would follow to 2035 or so, then followed by a decrease back to 2000 emission levels around 2055.
66. By 2020 crematoria would emit between 11 and 31% of the UK mercury emissions to air. The upper figure is consistent with UK emissions as reported to UN/ECE and EU.
67. The mass of mercury emitted is more important than the species of mercury emitted.
68. The health concerns arise from the long distance transport of mercury. Levels around crematoria are below those at which they are believed to give rise to health concerns.
69. BAT - Gas cleaning by a dry sorbent and filter system or equivalent is recommended as the best available technique for the removal of mercury from crematoria emissions to air for England and Wales.
70. Available - National emission standards that require gas cleaning at new or large crematoria are in place in Austria, Belgium, Germany, The Netherlands, Norway Sweden and Switzerland. Denmark, France and Great Britain do not have standards that require gas cleaning. Gas cleaning is therefore clearly “technically available”.
71. NEEC -. In 1998/9, publicly owned crematoria received an average surplus over cost of £67 per cremation, adult cremation costs ranged from £100 to £360 per cremation, and a funeral with cremation averaged £1215 and burials £2048. Gas cleaning (at around £55 per cremation) is unlikely to affect the viability of the majority of crematoria.
72. The civil / building costs will vary substantially from site to site. Costs per cremation can increase sharply for the 3 smallest crematoria and due to site constraints for all sizes of crematoria and implementation proposals should take that into account.
73. The cost of abating mercury by gas cleaning crematoria exhausts in the UK is higher than other abatement costs that industry bears. However past and current practice should not prevent changes in assessing excessive cost, considering that by 2020 crematoria will be by far the biggest single contributor to national mercury emissions unless steps are taken and that due to its long range transport, mercury is of international concern and that some countries have introduced gas cleaning of mercury at some crematoria.
74. If crematoria close rather than upgrade then some co-ordination of closure and any new provision would be necessary to maintain a service to the nearby communities.

Appendix

3 cohorts by age and dental health

75. Evidence for BDA's view that in the UK there are three cohorts by age and dental health (David Turner personal communication) can be seen in the UK Adult Dental Health Survey 1998, extracts from which are reproduced below.

Total tooth loss

76. "In the past it was fairly common for adults to lose all their teeth at an early age. Today it is rare for younger adults to lose all their teeth. The people who were affected by early tooth loss are now in the older age groups and account for the majority of the edentate population"

Table 2 Percentage of adults with no teeth, 1978-98

age	percentage of adults with no teeth, 1978-98		
	1978	1988	1998
16-24			
25-34	4	1	
35-44	13	4	1
45-54	32	17	6
55-64	56	37	20
65-74	79	57	36
over 75		80	58

(Office for National Statistics. 1999 Table 3)

Heavily restored teeth

77. For 1998 *"Adults aged 45-54 had the highest average number of teeth with sound restorations (10.8). The older age groups had fewer teeth with sound restorations because they had fewer teeth overall, whereas the younger adults had fewer teeth with sound restorations because they had more sound untreated teeth. Dentate adults aged 65-74 had on average…..8.1 teeth with sound restorations. The comparable figures for dentate adults aged 25-34 were….. 7.1"*

Table 3 Number of sound restorations in dentate adults 1978-98

age	number of sound restorations in dentate adults 1978-98		
	1978	1988	1998
16-24	8	5.5	2.9
25-34	9.8	10	7.4

35-44	8.9	11.1	10.1
45-54	7.1	9.6	11.1
55-64		7.1	9
65-74	4.8	5.7	8.2
over 75		3.7	6.5

(Office for National Statistics. 1999, from Table 8)

The fluoride toothpaste generation

78. Adults in the 16-24 age band in 1998 have significantly fewer fillings than the same age group in 1978 who are part of those with heavily restored teeth (2.9 fillings v 8.0 fillings).

Predicted rise, plateau and fall for mercury emissions from fillings.

79. Predictions of a rise plateau and fall in future mercury emissions are based on

- Most mercury emitted from cremations is attributed to dental amalgam fillings
- data from the UK Adult Dental Health Survey 1998(Office for National Statistics 1999)
- UK Government Actuary's Department's Interim Life Tables 1997-1999, and from a Tauw Milieu bv study from the Netherlands about mercury emissions from crematoria.(Coenen 1997)

Rise

80. From 2000 to 2020 the rise is assumed to be the same as the Netherlands. The reason in both countries is the fall in the number of older people with no teeth.

Plateau

81. In the UK from 1978 to 1998 the average number of sound restorations for adults with teeth stays at a similar level during adult life as that age group ages.

The number of sound restorations in 1978 in each age group is broadly the same across the 10 year age bands; 16 to24, to 34 to 44 to 54 years (8.0, 9.8, 8.9, 7.1 from the table above). 20 years on, the pattern is repeated for the 35 to 74 year olds in 1998. (10.1, 11.1, 9.0, 8.2 from table 2 above)

Fall

82. 16-24 year olds in 1978 had an average of 8.0 sound fillings. In 1988 the 16 to 24 year olds had 5.5 sound restorations on average, and in 1998 16 to 24 year olds had 2.9 sound restorations on average.

The average life expectancy of a UK 20-year-old in 1999 was 55.95 years for a male and 60.61 for a female.(Government Actuary's Department). And so around 2055 the number of fillings cremated can be expected to be significantly below the number in 2035.

In 1998 about half of the over 65s had teeth and they averaged about 7.3 fillings each, an average across the whole age band around 3.6 fillings

The 16-24s in 1998 will be 71+ in 2055. Assuming very few lose all their teeth (see paragraph 'Total tooth loss' above), and assuming they keep the same number of fillings throughout their lives then they will average 2.9 fillings, which is broadly the same level as the current over 65s.

Uncertainty - Changes in Dental Practice

83. As dental practice has changed considerably over the last 30 years or so, there is considerable uncertainty in making predictions over the next 50 years. For example, white fillings are currently being offered as a mercury free alternative to amalgam fillings, though the British Dental Association prefers amalgam fillings for the bearing surfaces of teeth.

UK heavy metal emissions to air 1999

Table 4 UK heavy metal emissions to air 1999, ranked in order of size of emissions

Source	Mercury (tonnes)	Mercury (% of total emissions)	Mercury cumulative %
Power stations (coal/coke)	1.56	18.2	18.2
Chlor-alkali process	1.41	16.5	34.7
Cremation	1.34	15.7	50.4
Industrial combustion (coal)	0.85	9.9	60.3
Other sources	0.56	6.6	66.9
Domestic combustion (coal)	0.43	5.1	72.0
Clinical waste incineration	0.37	4.3	76.3
Primary lead/zinc	0.29	3.4	79.7
Cement	0.24	2.8	82.5
Electric arc furnaces	0.21	2.5	85.0
Foundries	0.21	2.4	87.4
Domestic combustion (solid smokeless fuel)	0.17	2.0	89.4
Non-industrial combustion (coal)	0.14	1.6	91.0
Industrial combustion (other than coal coke oil or gas)	0.13	1.5	92.5
Power stations (other than coal coke oil or gas)	0.11	1.3	93.8
Sinter plant	0.09	1.0	94.8
Blast furnaces	0.08	1.0	95.8
Refineries	0.07	0.8	96.6
Glass	0.06	0.7	97.3
Industrial combustion (coke)	0.06	0.7	98.0
Coke production	0.05	0.5	98.5
Basic oxygen furnaces	0.04	0.4	98.9
Domestic combustion (wood)	0.03	0.3	99.2
Non-road transport	0.02	0.2	99.4
Secondary lead	0.02	0.3	99.7
Industrial combustion (oil)	0.01	0.1	99.8
Non-industrial combustion (oil)	0.01	0.1	99.9
Power stations (oil)	0.01	0.1	100.0

Domestic combustion (oil)	0.00	0.0	100.0
Municipal solid waste incineration	0.00	0.0	100.0
Total	**8.55**	100	

The data for Table 4 is from Peirce et al (2002 pp8, 9) sorted by size of emission with the addition of a cumulative total.

Simple projection of mercury emissions to UK atmosphere 1999-2020

Table 5 shows a simple projection of mercury emitted to UK atmosphere for 1999 to 2020. The emission data for 1999 is taken from Table 4 and the projections are based on Table 6 below. The projections are shown by sector in Figure 1, and as annual totals in Figure 2.

Table 5 Projected emissions of mercury to UK atmosphere, in tonnes, by sector

	Crematoria	Primary lead/zinc	Coal/Coke: Power	Coal: industry, non-industrial + domestic	Chloralkali	Clinical Waste Incineration	Other	Total	named sources (ie excl 'other') as percentage of total		Crematoria as percentage of total
1999	1.34	0.29	1.56	1.42	1.41	0.37	2.16	8.55	75%		15.7%
2005	1.55	0.29	1.36	1.25	1.41	0.12	2.16	8.14	73%		19.0%
2010	1.77	0.29	1.16	1.07	0.00	0.12	2.16	6.57	67%		26.9%
2015	1.98	0.29	0.96	0.89	0.00	0.12	2.16	6.40	66%		30.9%
2020	2.20	0.29	0.76	0.71	0.00	0.12	2.16	6.24	65%		35.3%

Table 6 Basis for projections by sector

Sector	**projected change**	**basis for projection**
Crematoria	66% increase 2000 to 2020:	Coenen 1997 and this paper
Primary lead/zinc	steady	assumed maintenance of recent improvement
Coal/Coke: Power	50% decrease 2000 to 2020:	assumed continued decline in coal burnt
Coal: industry, non-industrial + domestic	50% decrease 2000 to 2020:	assumed continued decline in coal burnt
Chlor-alkali	cessation of mercury emission by 2010	effects of OSPAR Recommendation
Clinical Waste Incineration	66% decrease by 2005	decrease by date of Waste Incineration Directive
Other	steady	assumed steady

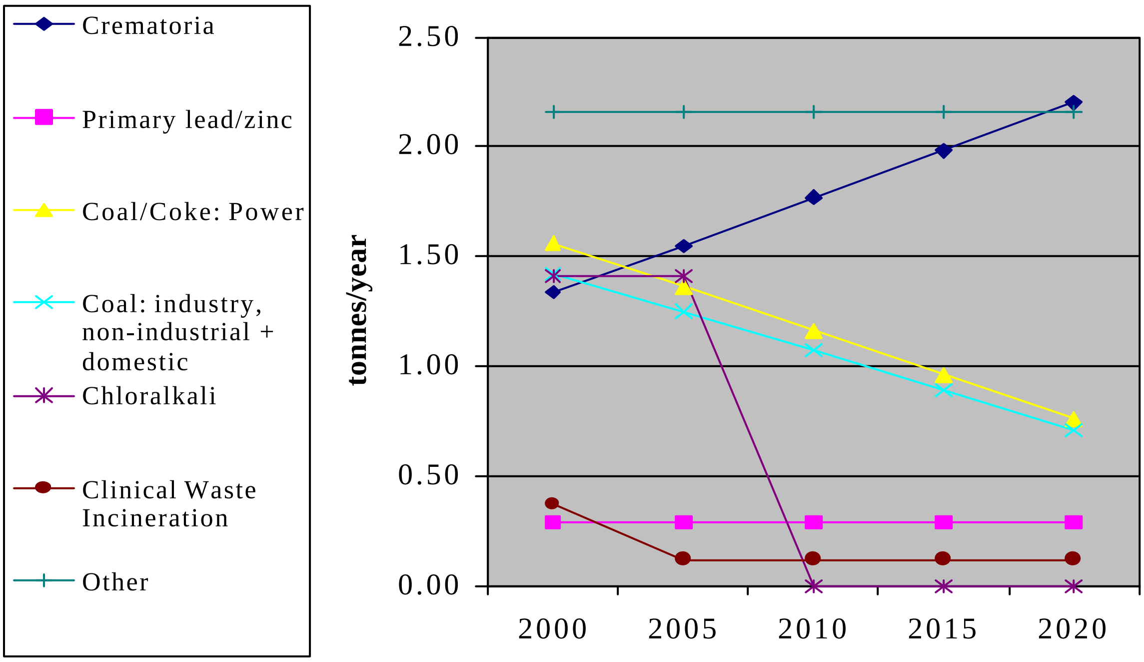

Figure 1 Simple projection of emissions of mercury to UK atmosphere, by sector

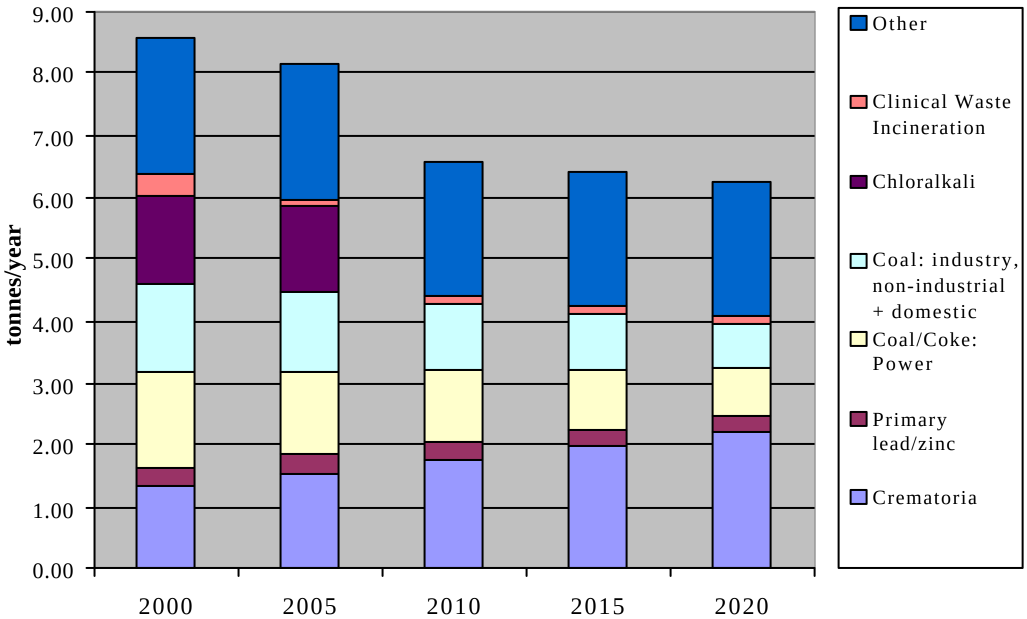

Figure 2 Simple projection of total mercury emissions to UK atmosphere

Cost of gas cleaning per cremation calculation

The additional cost per cremation of installing gas cleaning at existing crematoria is calculated by adding the annual costs and dividing them by the number of cremations. The figures in table 1 (repeated below) assume

- For over 978 cremations a year, 1 gas cleaning system per cremator
- For 978-700 - 1 larger gas cleaning plant serving 2 cremators operating with staggered loading, at 70% of capital cost of 2 single gas cleaning plants
- For 700-500, and under 500, - 1 gas cleaning plant serving 2 cremators but only 1 cremator operating at a time
- A maximum of 700 cremations a year per cremator,
- Capital costs of £180,000 gas cleaning plant, commissioning cost £10,000, civil/building cost £75,000 per single gas cleaning plant
- Capital costs are converted to an annualised cost using an annualisation factor 0.1030 which is suitable for 15 years plant life and 6% discount rate
- An increase in running costs due to gas cleaning of £8.80 per cremation.

(Costs are as in AEAT's report to FBCA (Edwards 2001))

Table 1 (repeated) Estimated additional cost per cremation for installing gas cleaning at existing crematoria

Number of cremations in 1999	Number of crematoria, (excluding 3 new in 1999)	Average cost per cremation	Percentage of UK cremations in 1999
Over 978	204	£47 to £67	95%
978 - 700	19	£47 to £63	3.4%
700 – 500	10	£47 to £63	1.3%
Under 500	3	Over £63	0.3%

The number of gas cleaning plant needed goes up in steps as annual capacity of crematoria increases and so the cost per cremation also increases in steps. The cost is shown as a range in table 1. The step is highest going from 2 to 3 gas-cleaning plant. Some smaller plant can share gas-cleaning plant without affecting annual capacity. Above 2100 cremations a year, each increase is spread over more cremations. Figure 3 shows the steps.

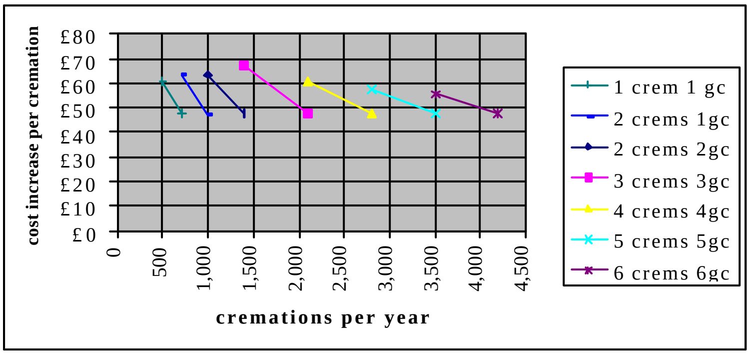

Figure 3 Cost increases per cremation for gas cleaning

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Consultation List

Environmental Industries Committee
British Ceramics Confederation
Quarry Products Association
Department for Trade and Industry
Casting Technology International
Local Government Association
Scottish Environmental Protection Agency
National Society for Clean Air
Wood Panel Industry Federation
Scottish Executive
Society of Motor Manufacturers and Traders
Chartered Institute of Environmental Health
British Coating Federation
Sem Seaborne Film Coating Industry Group
Welsh Assembly Government
Sutton Council
Environment Agency
Falmouth & Truro PHA
Greenwich City Council
Department of Environment (NI)
Sheffield Metropolitan Borough Council
NGS (NI)
Scottish Executive
Scottish Environmental Protection Agency
Friends of the Earth
EA Local Authority Unit
Knowsley Borough Council
NI Pollution Group
Environmental Industries Committee
Consumers Association
Gambica
Combustion Engineering Association
Source Testing Association
British Dental Association
AEA Netcen
Office of Fair Trading
Centre of Aerospace Technology
Prof David Fowler: CEH
Cumbria EP Technical Working Group
Dorset CEHO Pollution Advisory Group
Herts & Beds EP Group
Kent EP Technical Working Group
Wales National Pollution Control Technical Panel
Manchester Area Pollution Advisory Panel
Midland Joint Advisory Committee
Staffs EP Technical Group
Suffolk EP Group
Sussex Branch Pollution Study Group

Wiltshire Branch CIEH Technical Pollution Committee
London Pollution Study Group
Merseyside Chief Officers Pollution Working Group
Northern Centre CIEH EP Committee
Suffolk Air Quality Management Group
Surrey EP Study Group
West Midlands Joint Pollution Group
West Midlands Chief Officers Group
North Wales Pollution Group
Warwickshire EP Council
Yorks and Humberside Pollution Advisory Committee
Bristol, Glos & Somerset EP Committee
Cheshire CEHO Pollution Study Group
Cumbria EP Technical Working Group
Devon CIEH Environmental Protection
Essex EP Study Group
Hampshire & IOW Environmental Control
Kent CEHO Group
Lancs Pollution Officers Group
Cambridgeshire Pollution Group
Cornwall CIEH Pollution Sub Group
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Dorset CEHO Pollution Advisory Group
Glos. Pollution Technical Sub Committee
Herts & Beds EP Group
Kent EP Technical Working Group
Leics EPA Part 1 Working Group
Lincs Pollution Group
London Pollution Advisory Group
Manchester Area Pollution Advisory Council
Merseyside Chief Officers Pollution Working Group
Midland Joint Advisory Committee
Norfolk EP Group
Northamptonshire CIEH Pollution Sub Committee
Nottinghamshire Pollution Working Group
Shropshire & The Marches Pollution Group
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