AEA

MEMORANDUM

To Matthew Farrow, Environmental Services Association

From Mark Broomfield, AEA Technology

Date 4 July 2012

SUBJECT: Welsh Assembly Government Petitions Committee: comments on modelling studies made by Professor Vyvyan Howard

1. AEA Technology was requested to provide feedback on criticisms made by Professor Vyvyan Howard of air quality modelling studies in aural evidence provided to the Welsh Assembly Government Petitions Committee on 29 May 2012. This note summarises the comments made on this issue by Professor Howard and provides a commentary.

Comments made by Professor Howard

2. The issue of air quality modelling studies was raised by Professor Howard during discussion of risk assessment for waste incineration facilities. Professor Howard outlined four stages in risk assessment:

   (a) Hazard identification

   (b) Hazard characterisation

   (c) Exposure assessment

   (d) Risk assessment

3. Professor Howard suggested that hazard characterisation and exposure assessment were inadequate in relation to waste incineration. His criticisms in relation to exposure assessment focused mainly on dispersion modelling studies. Professor Howard highlighted a set of model results provided in an Environmental Statement for a proposed waste incinerator in South Wales. AEA has not seen these model forecasts, and so the information provided by Professor Howard has been taken at face value.

4. Professor Howard commented that the modelled process contribution to PM2.5 levels reported in this Environmental Statement was 0.054 µg/m^3. This corresponds to 0.22% of the air quality standard of 25 µg/m^3, or 0.61% of the estimated background level of 8.8 µg/m^3. Professor Howard contrasted this estimated contribution to the findings set out in a paper by Aboh et al (2007).[1] This study was carried out in Boras, a medium sized city in Sweden with a modern waste incinerator, and indicated that emissions from the waste incinerator contributed 17% to 32% of environmental levels of $PM_{2.5}$.

5. Professor Howard described the results of Aboh et al. as “physical measurements” and contrasted this to the air quality model results which he described as “hopelessly optimistic” and “opinion dressed up in

[1] Aboh IJK, Henriksson D, Laursen J, Lundin M, Pind N, Lindgren ES, Wahnström T, “*EDXRF characterisation of elemental contents in PM2.5 in a medium-sized Swedish city dominated by a modern waste incineration plant*,” X-Ray Spectrometry Volume 36, Issue 2, pages 104–110, 2007

numbers". Professor Howard was critical that the model results comprised a single value with no indication of uncertainty. He concluded that the data demonstrates a large area of doubt with regard to exposure modelling.

Commentary

6. Professor Howard is right to highlight this apparent anomaly and difference between air quality model results and the findings of a study using energy dispersive x-ray fluorescence (EDXRF) techniques. However, for the reasons set out in the following paragraphs, the difference between the two studies is likely to be mainly due to shortcomings in the study by Aboh et al. (2007) rather than shortcomings in dispersion modelling studies. There are also uncertainties in dispersion modelling studies that need to be taken into account.

7. Firstly, Professor Howard described the findings of the Aboh et al study as "physical measurements." The levels of trace elements recorded by Aboh et al. were indeed physical measurements. However, the interpretation of these measurements to give a source attribution was not a physical measurement. A Principal Component Analysis was used to identify source groups which were assumed to be represented by groups of elements. Table 4 from this paper is reproduced below:

Table 4. Estimated percent contributions of PM2.5, normalised to 100%, for the different sets of variables listed in Table 3

	Waste incineration and local sources	Oil incineration	Biomass burning	Long distance transport (LDT)	Traffic emissions
19 variables	32	33	18	16	1
14 variables	28	29	9	23	12
8 variables	17	21	7	41	14
6 variables	24	11	8	51	6

8. This table shows that for the "6 variable" case, the category "waste incineration and local sources" was identified as contributing 24% of levels of $PM_{2.5}$. The previous discussion indicates that this attribution was based on the assumption that waste incineration and other local sources were characterised by emissions of lead. In fact, waste incineration is unlikely to be a significant or dominant source of lead. The Swedish Emissions Inventory indicates that public electricity and heat production accounts for 30% of lead emissions, and only a proportion of this would be due to waste incineration with energy recovery. Additional metals are included in the analyses with more variables, but those which are assumed to be indicative of waste incineration are not specified, and in any case, as for lead, emissions from waste incineration are not likely to be characterised by other trace elements from the lists provided by Aboh et al. It is concluded that the attribution of 17% to 32% of $PM_{2.5}$ as being due to waste incineration is highly uncertain, and in fact the contribution allocated to "waste incineration and other local sources" is likely to be largely due to sources other than waste incineration.

9. Secondly, Professor Howard incorrectly quoted the Aboh et al. paper. He said during the Petitions Committee hearing that "the incinerator" was found to account for 17% to 32% of $PM_{2.5}$. In fact, the category in question is "*Incineration of domestic and industrial waste in the city of Boras together with other local sources.*" In this context, it is important to be aware that Aboh et al. use the term "source" in the paper to mean "source category" rather than an individual point source. The municipal waste incinerator constitutes only one element of this category, and from the discussion in the preceding paragraphs, it is likely to be no more than a minor constituent of this category. This is consistent with a low contribution of an MSW incinerator to environmental levels of $PM_{2.5}$, as suggested by the dispersion model results quoted by Professor Howard, although it does not confirm that the contribution is as low as the dispersion model results suggest.

10. Thirdly, the authors of this paper produced a subsequent paper at a conference.[2] The full paper is not available, but the abstract for this conference paper is available. The abstract states that: "*Even with the relative small data set the source 'wind radar plots' together with selected variables indicate that the identification of some of the (point) sources might be possible.*" This indicates that the authors considered that identification of point sources using EDXRF data combined with meteorological data

[2] Laursen J, Aboh IJK, Henriksson D, Lindgren ES, Lundin M, Pind N, Wahnström T, "*Urban $PM_{2.5}$ aerosol source identification by factor analysis of elemental composition related to meteorological data*," IOP Conf. Series: Earth and Environmental Science 6 (2009).

was no more than a possibility. This is consistent with the interpretation of the results of Aboh et al (2007) outlined above.

11. Fourthly, research into environmental levels of fine particulates in the vicinity of a waste incinerator in Italy has been carried out by Buonanno et al. (2010).[3] Levels of particulate matter were found to be low in the Italian context. An analysis of the elemental composition of particulates indicated that sources other than the EfW facility accounted for all the elements present. In a separate study of fine and ultrafine particles on the surface of foodstuffs in Italy, the authors concluded that "*little evidence is found for particles whose origin could be attributed to industrial combustion processes, such as waste incineration*".[4] Similarly, Morishita et al. found that waste incineration facilities made a minimal contribution to $PM_{2.5}$ levels in urban environments in the United States.[5,6] These findings are consistent with a minimal and non-detectable contribution of waste incineration to environmental levels of ultrafine particulate matter. More significant sources included road traffic, industrial sources and secondary particulates.

12. Fifthly, Professor Howard described the use of modelling as "an opinion dressed up in numbers" and suggested that model results should be supported by data. In fact, dispersion models are supported by data, and there is an extensive programme of model validation. Details of an international programme of model validation are available via www.harmo.org. Provided a dispersion model is used appropriately, it can be considered as being supported by scientific data. For the reasons discussed above, the information in Table 4 of Aboh et al. (2007) does not constitute a physical measurement, but is also in the category of a model result supported by data.

13. Professor Howard makes a valid point in relation to uncertainty in the model forecasts. All models are subject to uncertainty, and it would be appropriate for an environmental statement or other air quality model report to include a discussion of uncertainty. We have not been able to review the document quoted by Professor Howard to determine whether such a discussion is present. Relevant factors may include:

    (a) The ability of a model to reproduce environmental concentrations when source parameters are accurately represented in the model.

    (b) The ability to accurately represent the source parameters in the model

    (c) The representativeness of meteorological data used in the model for the study area

    (d) Additional uncertainties introduced by factors such as buildings and complex terrain where relevant

    (e) The possibility of formation of secondary particulates following emission from the proposed facility.

14. These uncertainties are typically addressed in a modelling study by adopting a worst-case or conservative approach. This approach is designed to ensure that model forecasts are more likely to be over-estimates than under-estimates of the levels that will arise in practice. Again, we have not been able to verify whether this approach was adopted in relation to the study quoted by Professor Howard.

15. Sixthly, if we take at face value Professor Howard's contention that the model may be under-estimating the contribution to $PM_{2.5}$ by a factor of 100, this would result in a highly implausible conclusion with regard to other pollutants. A typical modelled process contribution to levels of nitrogen dioxide would be 1 $\mu g/m^3$. Multiplying this by 100 would suggest that a waste incinerator could on its own result in an exceedance of the air quality standard for nitrogen dioxide over a wide area. Such exceedances are not observed in practice: the evidence of continuous nitrogen dioxide monitoring and diffusion tube surveys

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[3] Buonanno G, Stabile L, Avino P, Vanoli R, "*Dimensional and chemical characterization of particles at a downwind receptor site of a waste-to-energy plant,*" Waste Management 30 (2010) 1325–1333

[4] Giordano C, Bardi U, Garbini D, Suman M, "*Analysis of particulate pollution on foodstuff and other items by environmental scanning electron microscopy*," Microsc Res Tech. 2011 Oct;74(10):931-5.

[5] Morishita M, Keeler GJ, Kamal AS, Wagner JG, Harkema JR, Rohr AC , "*Identification of ambient PM2.5 sources and analysis of pollution episodes in Detroit, Michigan using highly time-resolved measurements,*" Atmospheric Environment 45 (2011) 1627-1637

[6] Morishita M, Keeler GJ, Kamal AS, Wagner JG, Harkema JR, Rohr AC , "*Source identification of ambient PM2.5 for inhalation exposure studies in Steubenville, Ohio using highly time-resolved measurements,*" Atmospheric Environment 45 (2011b) 7688-7697

is that urban nitrogen dioxide levels are highly correlated with road traffic sources. This further suggests that dispersion model forecasts do not grossly under-estimate the contribution to environmental levels of incinerator emissions as suggested by Professor Howard.

Conclusion

16. Professor Howard makes a number of relevant points with regard to the modelling of emissions from waste incineration facilities. It is recommended that measurements of trace components of $PM_{2.5}$ in emissions from waste incineration facilities should be made as suggested by Professor Howard earlier in his evidence to the Petitions Committee, building on work published by Buonanno et al. (2011).[7] It is recommended that uncertainties in dispersion model forecasts should be clearly set out.

17. Professor Howard suggested that model forecasts are "*hopelessly optimistic … naïve and don't match reality … an opinion dressed up in numbers.*" It is concluded that there is no basis for this opinion, and in fact dispersion model forecasts are supported by scientific evaluation, and are consistent with the data presented by Aboh et al. (2007). Decision-makers can have confidence in properly carried out dispersion modelling studies for use in environmental impact assessment and risk assessment.

AEA Technology Ref. ED57607002
4 July 2012

[7] Buonanno G, Stabile L, Avino P, Belluso E, "*Chemical, dimensional and morphological ultrafine particle characterization from a waste-to-energy plant,*" Waste Management 31 (2011) 2253–2262