Proof of Evidence

Professor C V Howard, Consultant Toxico-Pathologist

On Behalf of Glosvain

In respect of Planning Application

942-03 / GLOUCESTERSHIRE RESIDUAL WASTE

In relation to

Environmental Health Effects

1. Introduction

Professor C. Vyvyan Howard MB. ChB. PhD. FRCPath.

1.1: I am a medically qualified toxico-pathologist specialising in the problems associated with the action of toxic substances on the fetus and the infant. I am Professor of Bioimaging at the University of Ulster and have written a number of papers and book chapters and spoken in a variety of forums to draw attention to the threat posed by environmental pollutants to the developing fetus.

1.2: I am a Fellow of the Royal College of Pathologists, Past President of the Royal Microscopical Society, Member of the British Society of Toxico-Pathologists, Past President of the International Society of Doctors for the Environment and Member of the European Teratology Society. I have recently completed 6 years as a toxicologist on the UK Government DEFRA Advisory Committee on Pesticides.

1.3: A large part of my current research program is the investigation of the fate and toxicology of nanoparticles. My research team has been in receipt of two large EU grants; 'NanoInteract and 'NeuroNano'. I have co-edited a book entitled 'Particulate Matter: Properties and Effects upon Health' published in September 1999 [1]. I have also sat on two EU expert groups considering the threats and benefits posed by nanotechnology and recently addressed the House of Lords Select Committee on Science and Technology investigating the use of nanotechnology in food.

2. Scope of the Evidence

2.1: My evidence will address:

2.1.1: Uncertainty of modelling estimates

2.1.2: The assessment of particulates, in particular PM2.5, and the importance of assessing particulates correctly.

2.1.3: The use body burden vs TDI for dioxins.

2.2: My opinions and conclusions have been informed by knowledge of the peer reviewed scientific literature and national and local policy documents.

3: Detailed Evidence

3.1: Uncertainty of modelling.

The use of dispersion modelling software is complex and involves the setting of many variables, all of which affect the predictions of the model. Some of these have been mentioned by the Applicant in the ES. They have attempted to estimate wind speed, wind direction, atmospheric stability and stack height, average surface roughness length, effects of ground cover, flow over open ground or in urban conditions etc. Although each of these model parameters requires the adoption of assumptions and therefore is associated with uncertainties, for nearly all estimates arrived at there is simply a single figure given in all parts of the ES. For example see Table 4.5 of Volume3 – Air Quality Assessment – Table 4.5 Stack Emission Modelling Results. All values are given simply as mean values without any indication of uncertainty. Additionally, the level of precision given is often unrealistic (see e.g. Table 1.1 of ES Vol 3 Human Health Risk Assessment - value of emission rate for Chromium VI of 0.0000175 g/s). Occasionally data ranges are given – see Appendix B of Stack Emission Dispersion Modelling Results – although obvious errors are included e.g. for Total Chromium Emission Rate the mean value is over 4 times higher than the reported Maximum level). This raises a number of questions. The overall impression is that the ES has been the result of the mechanical application of the ADMS computer package without regard for the way that scientists normally treat physical data. The data are presented as 'facts', the reader is never reminded of the fact that these are only computer modelled estimates. Normally in the peer reviewed scientific literature it is usual (mandatory) to indicate that a reported quantity, say $\boldsymbol{A}$, is an estimate by designating it ***est A*** or with $\hat{\boldsymbol{A}}$.

3.1.1: When presenting scientific research for peer review it is generally required to give an estimate of the level of uncertainty in the data provided. This gives a measure of the uncertainty for individual estimates. The theory underlying the calculation of the Coefficient of Error (CE) is usually well understood and is based on a sound (and published) understanding of the statistical nature of any estimator. It would be expected when submitting a paper for peer review that such measures of uncertainty would be published as an integral part of the data. Absence of statements of confidence in estimates would normally weigh against acceptance for publication.

3.1.2: Overall uncertainty is normally stated in the form of a 'confidence envelope' which is a statistical method for setting limits that state the probability of the estimate lying within the bounds of the confidence envelope (CI). For example if a 90% CI is presented for a particular estimate it means that there is a 10% chance that the estimate will be outside the bounds of the CI and a 90% chance that it will fall within. Such statements allow the reader to form an opinion as to how much 'weight' they can responsibly put upon each estimate. This would also feed into considerations of the seriousness of consequences if the model predictions would prove to be inaccurate.

3.1.3: To be able to make a CI it is necessary to be able to sub-sample from an underlying frequency distribution of the variate. In other words you need to have an idea about the way that what you are measuring varies. For example human weights vary a lot between individuals and if you plot them out you will generate a "bell curve" with most measurements being in the middle and very small or very large values being much less frequent. We call this a frequency distribution curve and it is required to have one based on data or to assume one to be able to produce a CI. With estimates arising from physical measurements, this frequency distribution will become evident from an analysis of variance of the actual data. The more variable the measurements for a particular variate (in this case per pollutant) the wider the CI would tend to be, which would mean the less confidence the person interpreting the data would have. All this is described in undergraduate textbooks of standard statistics.

3.1.4: The ES submitted by the Applicant in relation to the Proposed Development provides only single estimates for environmental concentrations of various pollutants, without any associated CI. The reason for this is that the models do not appear to have been 'parameterised'. They do not have enough information to allow for an understanding of the variability of what is being modelled and therefore a CI cannot be estimated. It is not that such could not be obtained, for example, by studying existing plants over prolonged time frames. However it does explain the reluctance of such computer modellers to respond to requests for CIs. It remains, therefore, a serious weakness in the data as presented and puts into questions the use of such models as a means of justification for the granting of licenses for plants that have the potential to cause human and environmental hazard.

3.1.5: I will return to this topic in Section 3.2, where I estimate that the Applicant's model prediction for PM 2.5 concentrations appear to be conservative by a factor of up to 100-fold, without consideration of the additional contribution from secondary particle formation, which is completely ignored in the updated ES.

3.2: The assessment of particulates, in particular PM2.5.

3.2.1: PM2.5 is injurious to health and 'there is no recognised threshold below which there are no health effects' [2]. While the AOL for England has been set at 25 micrograms per cubic metre it should be noted that Scotland has set a more stringent target for PM2.5 of 12 micrograms per cubic meter - to be achieved by 2020 under The Air Quality Standards (Scotland) Regulations 2010. This is indicative of a continuing downward ratcheting of PM2.5 environmental levels in the future.

3.2.2: 'Exposure to PM2.5 reduces life expectancy by around six months averaged over the whole of the UK. For those individuals who are particularly sensitive the reduction in life expectancy could be much greater. For instance, if 10% of the population is affected then the loss of life expectancy for these individuals would rise to an average of around 6 years. Whilst it is not straightforward to compare health risks, it is estimated that eliminating exposure to man-made PM2.5 would yield greater benefits than eliminating road traffic accidents or exposure to passive smoking' [2].

3.2.3: Incinerators emit an aerosol of fine and ultrafine particles. Collection efficiency by bag filters for particles of less than 1 µm down to about 0.2 µm is low. Although very high capture rates, based on gravimetric indices, are generally claimed, the majority by number of ultrafine particles will pass through and current standards do not take into consideration the sizes of the particles emitted by an incinerator. Thus modern plants with their very high gas fluxes are guaranteed to produce an ultrafine particulate aerosol. This point is covered in detail in Section 4 of my Statement of Evidence to An Bord Pleanála over the proposed Waste to Energy Plant at Ringaskiddy in June 2009 (hereinafter referred to as Howard (2009) Ringaskiddy)

3.2.4 On page 332 of the ES Vol 1 the Applicants state that PM2.5 will constitute only 1/3 of PM10 by mass. This is a much lower value than is usually assumed in other incinerator applications. The latter tend to adopt that 2/3 of the PM10 particles are emitted as PM2.5, as suggested in a report prepared by AEA Energy & Environment (Measurement and Modelling of Fine Particulate Emissions (PM10 and PM2.5) from Wood-Burning Biomass Boilers, (September 2008)). Therefore the Applicants appear to be playing down the amount of PM2.5 that will be produced. Indeed the Applicant's own data supports that a higher proportion of PM10 will be occupied by PM2.5. The background level of PM10 measured is reported as an annual mean average of 26.9 micrograms per cubic metre (Table 13.12) while the annual mean for PM2.5 is reported as 16.5 micrograms per cubic metre (Table 13.12). This means that the proportion of PM10 attributable to PM2.5 is 16.5/26.9 = 61%.

3.2.5: A question concerning the modelling of PM2.5 emissions from the proposed plant arises from the data presented in Para 13.4.15 of the ES. The estimated maximum ground level concentration of PM10 attributable to the EFW plant is given as 0.01 µg/M3, against a background level of 26.9 µg/M3 (from Table 13.12). This means that the Applicant estimates that the overall contribution of the EFW plant to background PM10 is 0.01/26.9 = 0.004 = 0.4%. If 2/3 of PM10 by mass is PM2.5 then the maximal proportion of PM2.5 in the environment attributable to the incinerator would be 0.1/16.5 = 0.006 = 0.6%. If one takes the Applicant's value that only 1/3 of PM10 consisted of PM2.5 then this would be even lower at 0.3%.

3.2.6: However a paper by Aboh et al [3] physically measured the proportion of PM2.5 partially attributable to a modern incinerator in the town of Borås in Sweden and found it to be between 17 and 32%. The town of Borås has no heavy industry and largely has light industry supplying the textile trade in Sweden. This could mean that the Applicant's modelled estimate is at variance with a physically measured result by between 2,800% and 5,300%, assuming that 2/3 of PM10 consists of PM2.5. However if the Applicant's value of 1/3 is adopted this would indicate a discrepancy of between 4,800% and 10,600%. Although there seems to be no dispute over the actual measurements of particle composition made by Aboh et al, there has been debate over the use of principal component analysis to attribute them to sources. However given the level of disparity of the predictions of the Applicant and the physical measurements presented by Aboh there can be little doubt that this paper casts doubt on the unbiasedness of the Applicant's modelling of emissions from the plant. It further reinforces the requirement to state the degree of uncertainty in these estimates, which the Applicant has completely failed to provide particularly so because of the absence of secondary particle formation from any estimate.

3.2.7: Any estimate of PM2.5 presented by the Applicant is an underestimate because of the omission of any consideration of secondary particle formation. Modern incinerators are major sources of NOx and this can form nitrate particles with metals such as lead in the incinerator plume and thus increase the toxicity and availability of PM2.5 emissions (Howard (2009), Ringaskiddy, p16, p20).

3.2.8: Given the uncertainty of the modelling of PM2.5 emissions from the proposed plant, combined with the complete absence of information concerning the expected variability of outputs, it is reasonable to assume that the outputs of PM2.5 will be much higher than implied by the modelling. The only way in which the Applicant can suggest that such an unrealistically minute proportion of the ambient PM2.5 can be attributed to the incinerator is that the measured background level of 16.5 micrograms/M3 is already high and indeed in excess of the Scottish target for PM2.5 of 12 micrograms per cubic meter - to be achieved by 2020 under The Air Quality Standards (Scotland) Regulations 2010. There is no recognised safe level of exposure to PM2.5 and further epidemiological studies continue to inform the debate for further reductions in PM2.5 in the forseeable future.

3.3: The use body burden vs TDI for dioxins.

In this section I will refer to Howard (2009), Ringaskiddy and also the Proof of Evidence of Dr Gavin ten Tusscher, Consultant Paediatrician, in his statement of An Bord Pleanála over the proposed Waste to Energy Plant at Ringaskiddy in June 2009 (hereinafter referred to as (ten Tusscher (2009) Ringaskiddy). Dr ten

Tusscher is recognised as one of the leading authorities on the effects of dioxins on human development.

3.3.1: Polychlorinated dioxins and furans are persistent organo-chlorine pollutants consisting of 75 congeners which are known collectively as 'dioxin-like substances' (the number of dioxin congeners accounts for the disposition of various numbers of chlorine atoms at all possible permutations of positions on the 8 available binding sites on the 2 aromatic rings). The congeners have differing toxicities and there is a system of relating the amount and comparative toxicity of each congener to the toxicity of the most toxic congener, tetra-chloro- dibenzo-p-dioxin (TCDD) in toxic equivalent units (TEQ) to lead to an estimate of the overall hazard. Dioxins are not made intentionally but are formed during the manufacture of organo-chlorine products, such as PVC, and again subsequently during their destruction by combustion. They are amongst the most toxic substances known. This is the class of substances which is usually addressed in pollution modelling for incinerators. (ten Tusscher (2009) Ringaskiddy, p4).

3.3.2: There are also 13 'co-planar' polychlorinated biphenyls (PCBs) which have dioxin-like activity (ten Tusscher (2009) Ringaskiddy, p4). In addition there are a number of other organic compounds which are universally present which also have some dioxin-like properties. These include, for example, polychlorinated naphthalenes.

3.3.3: The level of organo-brominated wastes in the waste stream is increasing. This is because of the widespread use of brominated flame retardants over the past decades, for example in furniture, carpets and electronics. These will lead increasingly to the formation of polybrominated and chloro-brominated dioxins, of which there are over 5,000 possible congeners. These are not routinely measured or modelled as part of the pollutant emissions from waste incinerators (Howard (2009) Ringaskiddy, Section 4.9). Therefore any estimates offered of dioxin emissions from the proposed plant are underestimates. This will also apply to any discussions about the current body burdens of dioxins in the local population.

3.3.4: The half-life of dioxin in the body is estimated at between 7 and 12 years (ten Tusscher (2009) Ringaskiddy, p5). This means that they are extremely persistent (a drug is normally metabolised and excreted within 48 to 72 hours) and because they are fat soluble they accumulate in the body's fat stores. Because they accumulate more rapidly than they can be excreted the concentration of dioxin-like substances tends to increase with age. The amount of dioxin in an individual is referred to as the 'body burden'.

3.3.5: Scientific studies into the effects of dioxins on health are performed by measuring body burdens (USEPA, 2001; ten Tusscher (2009) Ringaskiddy, p12), from which the 'dose' can be inferred, and measuring this against outcome. The determinant of harm is the concentration of the toxicant within the body. The Amsterdam and Rotterdam studies, amongst others, have clearly demonstrated that adverse effects on human health have been associated with current 'background' levels of dioxin-like substances, particularly with respect to the amount of dioxin passing from mother to child across the placenta and subsequently in the breast milk. The list of adverse effects includes changes to the immune system, disruption of thyroid hormones and neuro-behavioural effects. This is particularly the case when it is established that breast fed babies will be receiving ~70 times the amount of dioxin an adult will consume for the duration of their breast feeding.

3.3.6: Tolerable Daily Intake (TDI) of a substance is defined as the amount of a substance that can be consumed every day of an individual's life, without harm. The setting of a TDI is a pragmatic political decision which is informed by science. The setting of a TDI is a regulatory public health measure designed to reduce overall hazard levels within a population. A TDI does not inform directly about the distribution of body burdens of persistent organic pollutants which are affected by many factors including: age, diet, pregnancy, lactation, occupation etc.

3.3.7: The approach adopted by the ES in assessing the impact of emissions from the Proposed Development on human health is based on "Tolerable Daily Intake" ("TDI") for a number of "receptors". The Applicants undertake the assessment of TDI using a model (fact-free) in order to assess the predicted contamination rate on the surrounding countryside. This process involves calculating TDI by undertaking a calculation based on the following hypothetical criteria:

-various hypothetical persons;
-the hypothetical point of maximal ground level contamination; and
-the hypothetical uptake into the food chain.

The conclusion reached is that the amount of each type of emission is only a small fraction of the TDI, and therefore it is safe to humans.

3.3.8: The modelling is simplistic in a number of aspects and, indeed, the models adopted are not capable of dealing with many aspects of bioaccumulative persistent organic compounds (POPS). A large proportion of the inhaled dose of dioxins comes as part of the particulate matter, the dioxins forming during the process of particle speciation (Howard (2009), Ringaskiddy, Section 4.6). Given the uncertainties expressed above in Section 2 concerning the levels of PM2.5, on a local basis this could be an appreciable route of entry, particularly as 100% of the inhaled dose of dioxins is assumed to be internalised. Over 80% of dioxins on particles are found on the fine fraction, i.e. that part most difficult to suppress in the flu cleaning process and 50% of the total dioxin burden was found on particles of < 1.1μm, i.e. the most readily respirable particles (Howard (2009), Ringaskiddy, Section 4.8).

3.3.9: Given the hypothetical, rather than fact-based basis on which such calculations have been undertaken, the above modelled estimates will have a degree of uncertainty. Such uncertainty is not discussed by the Applicants, nor is an appropriate sensitivity analysis undertaken. When subsequent derivative estimates are made by combining, by multiplication, previous modelled estimates, then the uncertainty is also multiplied. The failure to provide an assessment in the ES of the size of the confidence envelope for these estimates makes the data unreliable. In assessing the effect of emissions on human health, the ES ought to have assessed the body burden of dioxins, rather than the TDI.

Rather than assessing the effect of emissions on human health taking account of body burden, which would provide a significantly more accurate assessment of the effect of emissions on human health, the ES substitutes an assessment of the TDI. The ES makes the (unstated) assumption that all members of the population will have body burdens of dioxin-like substances that are below a level that would give rise to any cause for concern. An appreciable proportion of the population have body burdens of dioxin-like substances that are associated with adverse effects. Clearly for such individuals any additional dioxin is not 'tolerable' and any additional inputs to the environment cannot be considered to be harmless. Significantly the Updated ES has not assessed the levels of dioxins in the local population (body burdens). The failure to do so renders the conclusions reached unreliable.

Conclusions

In my opinion the assertion by the Applicant that the plant will be safe is based upon a flawed risk assessment which is unreliable because there is no statement about the confidence that can be put in certain key modelled estimates, particularly concerning PM2.5 emissions, which appears to be appreciably underestimated. There is no debate amongst the scientific community about the fact that the PM2.5 emissions will cause harm, only about how much harm.

The approach to appraising potential harm from dioxins is not based on a knowledge of current body burdens of local receptors but on a simplistic model of the likely additional amount of dioxin which will be added to the intake of local receptors.

Given the known fact that some members of the population already have body burdens, which on current scientific knowledge are considered too high, the Applicant has, in my opinion, adopted an unreliable approach. This is the more so because some routes of exposure have not been considered.

The overall impression is that the ES has been produced as a generic exercise by the routine application of a commercial computer modelling package (ADMS) by operatives with little regard for the norms of data reporting and even less insight into the weaknesses and limitations of modelled data and the attendant uncertainties.

Public concern over these inadequacies is, in my opinion, understandable and justified.

References

[1] Maynard R L & Howard C V (Author/Editors). Particulate Matter: Properties and Effects upon Health. (Bios Scientific Publishers, Oxford UK, 1999, ISBN 1-85996-172-X) 184

[2] SNIFFER REPORT (2010). PM2.5 in the UK

[3] Aboe I J, Henriksson D, Laursen J, Lundin M, Pind N, Lindgren ES and Wahnstro¨m T (2007). EDXRF characterisation of elemental contents in PM2.5 in a medium-sized Swedish city dominated by a modern waste incineration plant *X-Ray Spectrom.* **36**: 104–110