Proposed Waste to Energy Facility
at Pigeon House Road, Poolbeg Peninsula, Dublin 4

Brief of Evidence – Human Health

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1. Experience and Qualifications

I am a qualified physician and hold a Ph.D in Food Technology. Currently, I am Head of the Department of Toxicology and Food Chemistry, at the University of Kaiserslautern in Germany, with 25 years experience in the research and teaching of toxicology and with numerous publications to my name on the subject.

I have special expertise in the toxicology of persistent organic pollutants (dioxins, PCBs etc.) and am a Consultant on the topic for the World Health Organization (WHO, Geneva), the European Food Safety Authority (EFSA, Parma), the International Agency for Research on Cancer (IARC, Lyon), the German Senate Commission on Food Safety (SKLM, Kaiserslautern), and the German Federal Institute for Risk Assessment (BfR, Berlin). As well as being a member of a number of professional scientific associations, I am currently on the Executive Committee of EUROTOX and am chairman of its Subcommittee on Education.

I have consulted in 10 environmental impact studies on waste treatment facilities and related projects in Europe.

2. Input to Waste to Energy Project

I have been involved in the planning of the Waste to Energy Facility in Dublin since 2002. During that time, I have participated in several open days and public meetings in the Poolbeg area and a number of other public meetings and consultations. I have also attended a number of scientific conferences on waste management in Ireland where I have given lectures and participated in discussions on toxicological aspects of waste management with special emphasis on the toxicological impact of thermal treatment of waste.

For the purpose of the EIA, I conducted a Literature Review of the published scientific articles on the human health impacts of incineration and co-edited this aspect of the chapter on human health which appears in the EIS[1].

[1] *Chapter 13 of the EIS*

3. Summary of methodology used and suitability of alternative methodologies

3.1. The assessment methodology

The potential human health risks of the project were assessed using a toxicological approach. The approach involved a literature review of studies regarding the possible health effects of thermal treatment facilities, an analysis of health-related data from the vicinity of the projected plant, an analysis of current exposure levels and a prediction of additional exposure levels as a result of emissions from the facility.

For the purpose of the literature review, I carried out extensive literature searches. Having done so, I considered the available peer-reviewed literature on health aspects of waste management (including thermal treatment) and additionally, a number of non peer-reviewed publications. Having analyzed all the available literature, various other reports and health information in respect of thermal treatment in other countries, it was my aim to provide an overview of what is known about possible health hazards from thermal waste treatment facilities. Further, a number of other reports were also made available to me including amongst others, reports on levels of selected contaminants (air, soil etc.) in the Dublin area and on dioxin levels in Irish food items.

Current and predicted exposure levels were assessed as part of an air quality assessment[2], which:

a) evaluated the current exposure levels of the people living in the vicinity of the proposed facility, to selected relevant pollutants, by establishing current ambient air quality in the vicinity; and
b) evaluated their predicted additional levels of exposure due to emissions from the plant.

The current and predicted levels of the various pollutants were then assessed against the currently available limits, as published in local, national and international legislation and guidelines. The result of the assessment established that all relevant pollutants will be well within accepted limits (see, e.g., EIS, Table 8.59) and as such, pose no toxicological risk to people in the vicinity.

In addition, with respect to dioxins, an uptake study was prepared[3]. The study was based on current baseline data (collected as a result of soil sampling, ambient air monitoring and published data regarding the dioxin levels in Irish food) and predicted baseline data (obtained as a result of air modelling based on emissions at maximum operating levels). Again, the outcome of that study was that the increase in dioxin levels will be imperceptible and well within the accepted

[2] Carried out by Dr Edward Porter
[3] This study was prepared by Dr Fergal Callaghan

relevant daily limits; namely the Tolerable Daily Intake for Dioxins which was set by WHO in 1999[4].

Both of the above assessments were conservative in their approach and in my opinion, together with the literature review, were an appropriate and accurate means of assessing the potential toxicological risks to human health as a result of emissions from the facility.

3.2. An alternative assessment methodology – the epidemiological approach

The question of whether residents living in proximity to waste storage and/or treatment sites demonstrate adverse health effects has been the subject of a number of epidemiological studies. During the course of the literature review, I considered these studies in detail. Having done so, I concluded that a major drawback of most of these studies is that they rely upon medical and/or epidemiological data only and fail to analyze the toxicological properties of the substances or chemicals which they claim could be responsible for the observed health problems. In some cases, the studies failed to even identify what substances or chemicals they say are responsible for the observed health effects.

The inherent unreliability of a solely epidemiological approach is apparent from the investigative methodology frequently employed to assess the possible health effects of *hazardous* waste sites, namely:

a) *They first list the major substances stored at the site and classify the cohort living in the vicinity as 'potentially exposed'.*

The scientific weakness of such an approach is enormous since the presence of a chemical on a storage site may or may not be related to (an undefined level) of exposure.

b) *The next step in the process is the collection of public health data about the vicinity. Such data may be collected from public databases or sourced through investigations with local physicians or questionnaires handed out to cohort members.*

The disadvantages of this approach are as follows:

- First, it can be difficult to find an appropriate control group. For example, the socioeconomic status of an individual is one of the most important determinants of health.

[4] This was set after scientific progress which allowed for the refinement of the risk assessment process in relation to dioxins.

As such, it is vital that the socioeconomic status of the people who comprise the control group is comparable to the people residing in areas where the waste treatment facility is located. In many studies, this is not the case.

- Secondly, the risk estimates are highly imprecise because in many instances the frequency of certain disease or health defects is low and shows a high rate of fluctuation over time. In addition the prevalence of estimated 'potential exposure' is also low.

Many authors of epidemiological studies dealing with the health effects of waste treatment are well aware of the drawbacks of these studies as described above[5] but nevertheless do not hesitate to publish their 'findings'. The only substantial conclusion from such studies usually is, that 'more studies are needed'. The motivation for such statements remains obscure.

4. Toxicological Impacts

4.1. Description of potential toxins produced as a result of incineration

The thermal treatment of waste is almost exclusively performed as an incineration process under aerobic conditions, i.e., forced oxygen (air) supply. These conditions are known to produce a variety of *potentially* toxic or harmful gases and solids. Council Directive 2000/76/EC, Annex V, Air Emission Limit Values[6] lists the most relevant hazardous chemicals formed. A short description of these chemicals and their potential toxicological effects is set out below.

The most relevant of the gases formed are:

- hydrogen chloride (HCl)
- hydrogen fluoride (HF)
- carbon monoxide (CO)
- sulfur dioxide (SO_2)
- nitrous and nitric oxide (summarized as NO_x)

The above gases have the potential, at high levels, to acutely or chronically affect the human respiratory system and/or exert systemic toxic effects. For example in the case of CO, the oxygen supply via the blood stream can be affected because certain amounts of CO can block the function of the hemoglobin molecule.

[5] *In certain case, these reports also list the failings of an epidemiological assessment extensively in their papers e.g. Orr et al, 2002*

[6] See also page 255 of the EIS

A number of organic compounds with low or negligible volatility at room temperature are other typical by-products of the incineration of organic waste. Of these, some of the halogenated polycyclic aromatic compounds such as the polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) are known for their marked toxicity giving rise to endocrine effects, enhanced tumor formation, and/or developmental effects observed in certain types of experimental animals when applied at certain dose levels.

In addition, some of the inorganic compounds formed are non-volatile at room temperature including salts and oxides of toxic metals such as cadmium, arsenic, and lead. These metals can exert specific toxic effects including, effects on the kidney, skin, hematopoietic system and the central and peripheral nervous system. In addition, they have also been shown to cause tumor formation.

Particles can exert toxic effects including effects on the respiratory system and on cardiovascular functions. They are assessed as particles in general (dust) or as sub-fractions which are, e.g., classified according to their size. The PM_{10} fraction comprises, e.g., all particles with an average diameter of 10 µm or below, irrespective of their chemical composition.

Finally, the notion that there may be hazardous chemicals present at relevant levels, other than those listed in the Council Directive, is highly unlikely. There has been no serious scientific attempts by the protagonists of the 'theory of unknown ultra-toxins' to identify those unknown substances or at least to provide realistic suggestions about their possible identity. Furthermore, there are no animal or tissue culture experiments which demonstrate the presence of relevant levels of highly toxic compounds other than those listed in the Council Directive.

4.2. Toxicological impacts of facility

As a preliminary point, it is important to remember when considering the toxicological impact of the facility, that the fact that 'toxic compounds' are emitted is not relevant *per se* because the toxicity of a chemical is not alone dependent on its chemical identity but also on the level or dose. Therefore, any chemical can be 'toxic' but the dose decides if the exposure can cause any harm or not. In this respect, the findings of the EIS show that people living in the vicinity of the facility will have minimal additional exposure to a variety of chemicals, gases etc..

In particular, the air quality assessment indicates that the various potentially hazardous compounds are all emitted at very low levels and as such, the changes in air quality are low and non-detectable. This has also been shown in a number of air quality surveys after comparable facilities

went into operation. Furthermore, even with respect to worst case scenarios (as modelled in EIS), the level of dioxin uptake was below WHO limits.

Finally, as regards the concern that the facility may lead to a higher load of ultrafine particles in the air, there is no scientific evidence to indicate that there was a significantly higher level of such particles in the vicinity of modern thermal treatment facilities or that there has been any adverse health effects as a result of their emission[7]. Other studies on respiratory diseases in the vicinity of a modern thermal treatment facility found no relationship between both, and no impact of the facility on the PM_{10} levels[8]. Measurements of removal of ultra fine particles by a wet scrubber as part of the filter system of a modern facility have revealed a drastic reduction and a study has shown that the levels in the emission gas were similar to those found in ambient air[9].

4.3. Impact of dioxin emissions

Various reports have been prepared in relation to current dioxin levels in the Irish environment and more particularly in the Irish food chain[10]. The essential findings of each of these reports were highlighted in the EIS. In summary, the main conclusions which can be drawn from these reports are as follows:

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[7] *In order to demonstrate this fact, it is worth referring to the results of a 3-year epidemiological study which was carried out by Hazucha et al. in 2002. Here, they tested spirometric lung function once annually among residents in three communities in North Carolina surrounding a hazardous waste, biomedical, or municipal waste incinerator, and among residents in three comparison communities. The average monthly concentrations of particulate matter with diameters of 2.5 µm and less ($PM_{2.5}$), ranging from 14.6 – 31.5 $\mu g/m^3$ in ambient air, in all communities were similar during the 3 years of study supporting the notion that Modern thermal treatment facilities have no measurable influence on the $PM_{2.5}$ load of ambient air. There was no difference in percent predicted forced vital capacity, forced expiratory volume in 1 sec, or forced expiratory flow rate over the middle 50% of the forced vital capacity among members of the 'incinerator communities', compared with 'non-incinerator communities', and there were no significant differences in lung function within the three sets of communities.*

[8] *By Shy et al. (1995) and Lee and Shy (1999)*

[9] *Zürcher et al. (2001)*

[10] *The various reports referred to in the EIS (from paragraphs 13.3.55 to 13.3.83) are:*
EPA Dioxins in the Irish Environment Reports 1995, 2000 and 2004
Dioxins in the Irish Environment An Assessment Based on Levels in Cow's Milk,
(EPA, reports from 1996, 2000, 2001, 2006)
EPA 2003 Dioxin Inventory
Food Safety Authority of Ireland (FSAI) 2002 Dioxin Furans and PCBs in Irish milk,
1991-2000
FSAI 2002 Dioxin levels in farmed salmon, wild salmon and fish oil capsules
FSAI 2003 Waste Incineration

- Dioxins are found in low levels in the Irish food chain and in the Irish environment when compared to other countries. This is likely due to the low level of heavy industry as compared to other countries.
- Dioxin levels in the Irish environment and food chain are well within relevant limits.
- Dioxins levels in Irish milk (which is a good indicator of the presence of dioxins in the environment) have consistently decreased in recent years. This is likely due to a variety of factors including increased regulatory measures for the control of emissions, the prohibition of chlorinated compounds in petrol and technological advances in industry.

Furthermore, the result of the dioxin uptake study which was completed for the EIS was that even in the worst case scenario, the facility will have no significant impact on the dioxin intake of people residing in its vicinity[11].

In light of the conclusions of the various reports referred to above, the existing low levels of dioxins in the vicinity of the site and the outcome of the dioxin uptake study, it is reasonable to conclude that the facility will have a negligible impact on the levels of dioxins in the surrounding environment and that the uptake levels in the area will remain well within accepted levels.

Because the potential adverse health impacts which can arise as a result of dioxin emissions, have been continuously raised as a point of concern amongst the community[12], I wish to address some of the main concerns which have been raised.

4.3.1. Carcinogenic nature of dioxins

One common concern regarding dioxins is that they are potentially carcinogenic and that as a result, there is no uptake threshold at which they are safe. What needs to be understood, however, is that toxicological research does not indicate that any exposure to carcinogenic chemicals results in a relevant cancer risk. Rather, it is clear from all experimental and epidemiological data, that very low exposure to carcinogenic compounds results in no or (not distinguishable) very low additional cancer risk. The difference between 'no' and 'very low' can not be tested by any experimental or epidemiological means because of the variable 'background incidence' of cancer in any human or animal population. Instead, it must be remembered that humans have always and will always be exposed to very low levels of 'carcinogenic chemicals' from a variety of sources such as food, fire, microorganisms, plants etc. The relevance of these very low exposures is more than doubtful.

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[11] *See paragraphs 13.4.9 to 13.4.16*

[12] These were raised at the *various public meetings which have been held in the area, and also, in submissions provided after the lodgement of the EIS.*

The emission limits for potentially carcinogenic chemicals which will apply to the proposed facility, will ensure that an additional cancer incidence in the vicinity of the incinerator **will be absent or not detectable**. Further, my conclusion in this respect is bolstered by the fact that there is no credible report or study which has found that there was an increased cancer incidence in the vicinity of a modern thermal treatment facility as a result of emissions from that facility.

4.3.2. The effect of mixed brominated dioxins

A further concern raised in respect of dioxins is that hazardous brominated or mixed chlorinated-brominated dioxins will potentially be emitted from the facility but will not be subject to specific emission limits or regular monitoring. Whilst it is the case that there is no obligation to regulate or monitor the emission of brominated dioxins, studies indicate that the amounts emitted are very small[13] and further, that no health risk arises in respect of their emission[14]. As such, there is no need for the operators of the facility to adhere to any self imposed emission limits or monitoring regime.

4.3.2. The bioaccumulation of dioxins

A further common question amongst the public is whether or not there is potential for the bioaccumulation of dioxins in the human body as a result of prolonged exposure to dioxins in the atmosphere or in the human food chain resulting from the operation of modern thermal treatment facilities. The answer to this question is negative for a number of reasons.

First and most importantly, any accumulation of dioxins can be easily measured in human blood or adipose tissue. In respect of modern thermal treatment facilities, several studies have analyzed whether dioxins can be found in the blood of the people living in the vicinity of the facilities. However, in each case, the results were always negative and no increased dioxin levels were found to be present in their blood.

Secondly, in spite of the fact that dioxins can, in principle, accumulate in the human body, those levels have been declining dramatically over the last decades and in particular in those European countries with modern thermal treatment facilities. This fact supports the notion of a lack of correlation between dioxin exposures and Modern thermal treatment facilities.

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[13] *Riggs et al., Organohal. Compounds 2, 351-356, 1990*

[14] *Ebert and Bahadir (Environ. Internat. 29, 711-716, 2003) conclude that 'complete and controlled incineration of bromine-containing compounds as usually conducted in municipal waste incinerators, however, show no raised risk'.*

Thirdly, the dioxin exposure of the population in a number of European countries mainly originates from previous and current ‘human activities’. Modern thermal treatment facilities have been found to play only a very minor role (see also Dioxin Inventory of the Irish EPA which estimates the current sources of dioxin in Ireland) in overall dioxin levels in these countries.

5. Proposed Mitigation Measures

From a toxicological point of view, various aspects of the possible impact of thermal treatment of waste have to be considered when mitigation measures are taken.

In this context, the main aspect to be considered is the possible impact of toxic stack emissions from the incineration process. However, in order to mitigate this potential impact, state of the art flue gas cleaning technology and regular monitoring and maintenance will be employed so as to reduce the emissions to a level considered as non-hazardous for the residents living in the vicinity of the plant and well within the accepted emission standards.

The proposed facility will be fitted with the most up to date flue gas cleaning technology. This technology is highly efficient and allows the reduction of dioxin levels in the emission gas well below the EU maximum levels of 0.1 ng Toxic Equivalents/m^3. Further, a complete failure of the flue gas cleaning would lead to a worst case scenario comparable to an uncontrolled residential fire which involved the burning of plastics, paper, wood etc. Long-term scientific evidence shows that modern facilities employing modern flue gas technology have no difficulties complying with this regulation and air and soil analyses in the vicinity of modern facilities have not shown any impact on air quality. It can be reliably predicted that this will also be the case in the Poolbeg area.

In addition to the stack emissions, other by-products of interest include bottom ash and flue gas residue. The bottom ash is an inert material which causes no harm when deposited in landfills, or used for certain purposes such as road construction. The flue-gas residue collected during the process of flue gas cleaning is a hazardous material containing dioxins and toxic metals. However, it will be handled as hazardous waste and either deposited safely or transported to an adequate flue-gas residue treatment facility in order to reduce, separate or destroy the toxic constituents.

Having regard to the above factors, I am of the opinion that the mitigation measures proposed are suitable and adequate.

6. Literature review

6.1. Principal Findings

For the purposes of the EIS, I completed a literature review examining the various scientific publications on the potential impact of thermal treatment facilities on human health. However, there are few peer-reviewed studies on modern incinerators due to the fact that many scientists recognise (and as a result, stopped investigating the issue) that the low levels of emissions due to modern flue gas cleaning make it highly unlikely that any increased levels of hazardous chemicals or any adverse health effects related to emissions are present or can be detected. However, it is apparent that the studies which do exist on the topic can be divided into two categories, namely toxicological studies on exposure to hazardous compounds and epidemiological studies on health effects. For the reasons outlined above, I believe that the toxicological is the more appropriate of these two approaches.

The complete literature review was published as an appendix to the EIS[15]. However, it is useful to summarise some of the principal findings as follows:

a) all peer-reviewed publications dealing with this issue, found that there were no increased levels of dioxins in the vicinity of modern waste to energy facilities;

b) although a number of epidemiological studies suggest a causal relationship between old waste to energy facilities and certain adverse health conditions/diseases such as cancer, respiratory diseases, congenital malformations and hormonal changes, most of these studies were hampered as a result of the following:

- The lack of adequate measurements on internal or external exposure; and by
- The likelihood of strong confounders such as urbanization, socio-economic deprivation and other related factors; and

c) whilst there is evidence that higher levels of external dioxin exposure have existed in the vicinity of older thermal treatment facilities without any or insufficient flue gas cleaning, there is no such evidence with respect to modern facilities.

6.2. Main Reports considered

[15] Appendix 13.3

A number of reports were considered for the purpose of the review, and the findings in respect of the most prominent are worth revisiting, including the reports published by Greenpeace[16] and by the British Society of Ecological Medicine[17] on this issue. In respect of these, I concluded that the scientific value of both studies was questionable because both were relatively unselected compilations of all kinds of reports on waste treatment and health which:

- Discussed studies on health effects in relation to facilities without any flue gas cleaning, with inadequate flue gas cleaning, and with modern flue gas cleaning facilities but failed to distinguish between any of the three for the purpose of their results.
- Presented and combined findings from sewage sludge incinerators, hazardous waste incinerators, non hazardous waste facilities and other types of incinerators.

Further, a recent French report on the issue which was published subsequent to the completion of the literature review has also been considered[18] for the purpose of this brief. This report was commissioned by the French Department on Environmental Health for the purpose of assessing the cancer risk of people living in the vicinity of the municipal thermal treatment facilities. For the purposes of this study, cancer incidences in certain areas were analysed from 1990 to 1999. The study focussed on dioxin output from modern facilities. However, a major drawback of the study is that dioxin levels in air, soil or water were not measured but estimated on the basis of release and distribution models. No attempts were made to verify these models, i.e. to do sample analysis to make sure that the estimates are correct. Furthermore, no blood sampling occurred in the cohorts analyzed for cancer.

The analysis found an excess cancer risk of a few percent for a number of cancers including all cancers combined (in women), mammary cancer, liver cancer, lymphoma and soft tissue sarcoma.
A major confounder in this study is the urban-rural slope in cancer incidence. It is well known, that rates of all cancers combined and of a number of cancer localisations are more abundant in urban than in rural areas. Since the study includes communities with over 10,000 inhabitants, it compares apples with pears. Modern thermal treatment facilities are frequently located in the vicinity of big cities which per se have a higher cancer rate. This effect is unrelated to the facilities but is due to different environmental and lifestyle factors in big cities or areas with high population density. The only way to solve this dilemma is to analyze the levels of the accused 'toxic chemical' in environmental samples or in humans. This has been done several times in the past for dioxin in the vicinity of modern thermal treatment facilities. Neither the air or soil in the

[16] Greenpeace report on incineration and human health (2001)
[17] Fourth Report of the British Society of Ecological Medicine on the "Health effects of waste incinerators"
[18] *Etude d'incidence des cancers à proximité des usines d'incinération d'ordures ménagères(2007)*

area or blood samples taken from inhabitants of the area, indicated elevated dioxin levels. This is almost certainly due to the fact that modern gas cleaning technology reduces the output of dioxins to levels well below 0.1 ng per cube meter of flue gas.

Also, the French study investigated cancer incidences in the 90's. It mentions the fact that since the assumed period of exposure of the cohorts (before 1990), the gas cleaning technology and emission limits for Modern thermal treatment facilities have been improved dramatically. At the end of the study it is claimed that as 'the study is based on a previous situation, the results cannot be applied to the current situation in the vicinity of Modern thermal treatment facilities which are much better controlled and environmentally friendly'.

Finally, a number of submission to the Board refer to what they claim is a report by WHO recommending that no further incinerators be built. However, to my knowledge, no such report exists. Rather, WHO Europe has published that '*The incineration of waste is an hygienic method of reducing its volume and weight which also reduces its potential to pollute*'[19].

In summary, there is not a single peer-reviewed study showing that modern thermal treatment facilities release hazardous substances at a level causing any harm to the people in the vicinity. Monitoring studies have shown that emissions from modern facilities are within the strict EU limits and their contribution to background levels is negligible. No study has shown any adverse health effects in the vicinity of a modern facility which are traceable to that facility. As a result, it is my strong professional opinion, that modern thermal treatment facilities can be regarded as safe facilities which have a negligible, non-relevant impact on the environmental and health situation in their neighbourhood.

7. Conclusion

In summary, it is my professional opinion as a toxicologist, that the proposed facility will have no negative health impact on the residents in the Poolbeg area. The reason for my opinion is this regard has been already outlined in this brief, but may be summarised as follows:

[19] (http://www.euro.who.int/eprise/main/who/progs/hoh/publications)

- It is clear from the available literature that there is no scientific evidence to suggest that adverse health impacts can be attributed to emissions from modern thermal treatment facilities, where such facilities adhere to relevant emission limits.

- The toxicological risk assessment which has been carried out in respect of the current facility indicates that any rise in the levels of various regulated pollutants will be negligible and that the predicted increases in exposure levels will be well within relevant limits,

- The mitigation measures envisaged for the current project are adequate and sufficient.