STRATEGIC INFRASTRUCTURE DEVELOPMENT

APPLICATION TO AN BORD PLEANÁLA

(REG NO. PL04.PA0045)

ORAL HEARING

RINGASKIDDY RESOURCE RECOVERY CENTRE,
RINGASKIDDY, COUNTY CORK

WITNESS STATEMENT OF DR. EDWARD PORTER

AIR QUALITY AND CLIMATE

1. Qualifications and Experience

My name is Edward Porter. I hold a Bachelor of Science degree (1st Class (Hons)) in Chemistry (1991) from the University of Sussex and a Ph.D. in Chemistry (Air Quality) from University College Dublin (1997). I am a Charter Chemist and a full member of the Institute of Air Quality Management (MIAQM) and the Royal Society of Chemistry (C Chem MRSC), a requirement of membership being that I am active in the field of professional chemistry and satisfy the Society's requirements with regard to level of qualifications and experience.

I have been active in the field of air quality and climate for 23 years, the last 19 years as an Environmental Consultant. I have considerable experience in the areas of planning of proposed developments with regard to air quality and climate, assessment of air quality for compliance purposes and air quality mitigation measures in relation to both construction sites and operational developments. I am currently Director of Air Quality and Climate with AWN Consulting. My experience includes:

- Dublin Waste To Energy Facility (2008)
- Ringaskiddy Waste Management Facility (2009)
- Slane Bypass (2010)
- M11 Gorey to Enniscorthy (2009)
- College Proteins Meat & Bone Meal CHP (2009)
- Carranstown Waste Management Facility Expansion (2012)
- Drehid MBT Facility (2012)
- M7 Widening (2013)
- N5 Castlebar to Westport (2014)
- National Children's Hospital (2015)
- Dun Laoghaire Cruise Berth (2015).

2. Role in the Project

My role in the project involved undertaking the air quality appraisal of the proposed development. I prepared the Air Quality Chapter (Chapter 8) and Climate Chapter (Chapter 9) of the Environmental Impact Statement [EIS]. The EIS was submitted to An Bord Pleanála [the Board] with the application for planning permission in January 2016.

In assessing the air quality impacts of the proposed development the following methodology was adopted:

- The receiving baseline environment was characterised through site specific monitoring and detailed analysis of EPA data;
- The most appropriate criteria for evaluating the significance of air quality impacts was determined through reference to national guidance documents (where available) and international best practice;
- The potential air quality impacts were quantified using industry standardised calculation methods;
- The impact of the proposed facility was determined by comparing the calculated levels against the adopted criteria;
- Where necessary specific mitigation measures have been recommended to control the impacts of the development in order to ensure that impacts will be within the adopted criteria, and;
- The residual impact of the proposed development has been presented.

In assessing the climatic impacts of the proposed development the following methodology was adopted:

- Available published guidance documents and Directives which are relevant to assessing the climatic impacts from the facility were consulted.
- The most appropriate criteria for evaluating the significance of climatic impacts was determined through reference to national guidance documents (where available) and international best practice;
- The potential climatic impacts were quantified using industry standardised calculation methods;
- The impact of the proposed facility was determined by comparing the calculated levels against the adopted criteria in the context of international agreements such as the 2015 Paris Agreement and the EU "*2030 Climate and Energy Policy Framework*", and;
- The residual impact of the proposed development has been presented.

2.1 Conclusion of Air Quality Assessment

The conclusions of Chapter 8 of the EIS may be summarised as follows:

- A review of site-specific monitoring data and a review of representative EPA data

has found that the region currently experiences good air quality.

- Based on the emission guidelines outlined in Council Directive 2010/75/EC, detailed air dispersion modelling has shown that the most stringent ambient air quality standards for the protection of human health and the environment are not exceeded either as a result of operating under maximum or abnormal operating conditions.
- The modelling results, using both the USEPA regulatory model AERMOD and the more advanced CALPUFF model, indicate that the maximum ambient GLC generally occurs at or near the facility's southern and south-eastern boundaries. The spatial impact of the facility is limited with concentrations falling off rapidly away from the maximum peak. For example, the short-term limit values at the nearest residential receptor will be less than 17% of the short-term ambient air quality limit values. The annual average concentration has an even more dramatic decrease in maximum concentration away from the facility with concentrations from emissions at the proposed facility accounting for less than 1% of the limit value (not including background concentrations) at worst case sensitive receptors near the facility.
- In the surrounding areas of Cobh, Carrigaline and Monkstown, levels are significantly lower with the concentrations from emissions at the proposed facility accounting for less than 1% of the annual limit values for the protection of human health for all pollutants under maximum operations of the facility.

2.2 Conclusion of Climate Assessment

The conclusions of Chapter 9 of the EIS may be summarised as follows:

- The main greenhouse gases, with climate change potential, which will be emitted by the facility, are carbon dioxide (CO_2), methane ($CH_{4)}$ and nitrous oxide (N_2O).
- If the facility is not built, the waste will either be landfilled in Ireland or exported for incineration abroad. Organic waste in a landfill decomposes and produces gases such as CO_2 and methane CH_4. A landfill will continue to emit gases for over 100 years, long after the landfill has been closed. By incinerating the waste, prior to landfill, the emission of these gases will be avoided.
- If the facility is not built, 18.5MW of electricity will be produced in a power station in Ireland. The emission of combustion gases from the production of 18.5MW of electricity in a combined cycle gas turbine power station was calculated. The net emissions of greenhouse gases from the facility, when the emissions from the generation of 18.5MW of power in a fossil fuel power station have been subtracted, will amount to 0.07% of EU 2020 Strategy GHG Emissions Target.

3. Submissions and Responses

In preparing this witness statement, I have considered each of the observations submitted to An Bord Pleanála by various parties in relation to the air quality and climate impact appraisal of the Ringaskiddy Resource Recovery Centre. I have addressed each of them below.

3.1 Observations have been made by Professor V. Howard on Behalf Of CHASE on a range of matters.

On behalf of CHASE, Professor Howard makes a number of submissions in relation to the air quality appraisal set out in the EIS. Each of these submissions is set out below and the developer's response is made directly thereunder.

Issue #1:

Submission:

Professor Howard quotes a paper from 2007 (Aboh et al)[1] which measured $PM_{2.5}$ in a Swedish town (Boras) and found that between 17% - 32% of the total $PM_{2.5}$ was due to "waste incineration and local sources" (ambient concentrations were 6 $\mu g/m^3$ during the survey period which is low).

Response:

In relation to the Aboh et al paper, there are several significant omissions from this paper:

- The assumption is made that there is only five sources of $PM_{2.5}$ (waste incineration and other local sources, oil incineration, biomass burning, long distance transport (LDT) and traffic emissions). This assumes there are no natural sources or sources from the many other possible sources in an urban area. Also there is no definition or context for "other local sources".
- Evidence for the incinerator as the source of the $PM_{2.5}$ was based on mainly the detection of lead without explanation or references. As outlined below, a more complex approach is normally necessary related to the ratio of specific metals to distinguish the incineration from other sources.
- The dataset is based on only 27 daily observations (27 data points) with the authors noting that "stable results are not expected".
- The paper cautions that "*It must be noted that the quantitative contribution from the different sources may be treated only as informative at present, since the number of observations are small compared to the number of variables"*.

A more comprehensive and detailed study, where metal ratios were used to detect emissions from municipal waste incinerators in ambient air, has recently been published in Atmospheric Environment[2]. The study focused on six municipal waste incinerators (MWIs) in

[1] Aboh et al (2007) X-Ray Spectrum. 2007; 36:104 - 110

[2] Font et al (2015) Using Metal Ratios To Detect Emissions From Municipal Waste Incinerators In Ambient Air Pollution Data, Atmospheric Environment, 113 92015) 177-186

the UK using four pairs of metal ratios as tracers for MWI emissions (Cu/Pb, Cd/Pb, Cd/Cu and Cr/Pb) and based on over 12,000 days of data between the six sites. The ratio of these metals from MWIs differ significantly compared to ambient and traffic sources. The study found that the maximum PM_{10} concentration from the MWI was between 0.02 – 0.12 $\mu g/m^3$ which is 2-3 orders of magnitude smaller than background ambient PM_{10} concentrations. The study also concluded that there was no evidence of incinerator emissions in ambient metal concentrations around four of the six incinerators. For two incinerators, metals from the MWIs were detected for 0.2% and 0.1% of the time.

Issue #2:

Submission:

Professor Howard has suggested that although bag (fabric) filters are efficient at trapping PM_{10} / $PM_{2.5}$, they are much less efficient for nanoparticles (< 100 nm).

Response:

Currently, no ambient air quality standards on a worldwide basis are expressed in terms of particle numbers or in terms of size distributions. The USEPA has recently updated its review of health effects from particular matter[3]. The current status of UFP proposed legislation was reviewed at the USEPA Workshop on Ultrafine Particles, February 2015. The USEPA view at the Workshop was stated as:

"Based on uncertainties and limitation in the health evidence and monitoring information, EPA concluded that it was not appropriate at the time of the 2012 review to set a separate standard focused on UFPs."[4]

A second presentation from the USEPA at the Workshop noted:

"Currently available scientific information ***does not provide a sufficient basis*** *for supplementing mass based, primary fine particle standards with standards* ***using a separate indicator for ultrafine particles*** *or a separate indicator for a specific $PM_{2.5}$ component or group of components associated with any source categories of fine particles".*[5]

Research has been conducted over the last fifteen years on emissions from incinerators in terms of particle size and numbers. A paper undertaken in 2001[6] studied the emission of particles from modern municipal waste incinerators including a detailed investigation of particle numbers and particle size distribution. The study concluded that:

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3 USEPA (2010) 2009 Final Report: Integrated Science Assessment for Particulate Matter

4 USEPA (2015) Presentation by Dr. Scott Jenkins (USEPA) "National Ambient Air Quality Standards (NAAQS): Overview Of The Review Process With A Focus On PM"

5 USEPA (2015) Presentation by Jason Sacks (USEPA) "UFP Health Effects Evidence that Informed the 2012 PM NAAQS Review"

6 Zurcher et al "Ultra Fine Particles From Municipal Solid Waste Incineration" Proceedings from Waste-to-Energy State of the Art & Latest News, Malmo, Sweden, 2001

"The removal efficiency for PM_{10} of the flue gas treatment systems in all plants is very good. The number concentration of most plants is in the same order of magnitude as ambient air. According to our measurements we can state that waste incineration plants with up-to-date flue gas cleaning systems are not a relevant source for the emission of ultrafine particles into the environment. Particles above 1 micron are almost completely eliminated".[8]

More detailed recent work has been undertaken and is in Appendix A.

Issue #3:

Submission:

Professor Howard has suggested that the Scottish Parliament $PM_{2.5}$ limit value of 12 $\mu g/m^3$ to be met by 2020 is more appropriate than the adopted regulatory limit of 25 $\mu g/m^3$ used in the assessment.

Response:

The limit of 25 $\mu g/m^3$ is the ambient air quality standard set at EU level. The most recent EU Council Directive on ambient air quality was published on the 11/06/08 which has been transposed into Irish Law as S.I. 180 of 2011. As discussed in Section 8.5.2 of the EIS, the process $PM_{2.5}$ ambient levels from the facility are an insignificant fraction of the ambient air quality standard. The predicted maximum process contribution from the facility is 0.08 $\mu g/m^3$ which is less than 0.3% of the EU limit value and less than 1% of the new Scottish Parliament objective value of 10 $\mu g/m^3$ (Scottish S.I. 162 of 2016).

Issue #4:

Submission:

Professor Howard has suggested that secondary PM_{10} / $PM_{2.5}$ due to NO_X / SO_2 releases from the facility is significant and has been ignored in the assessment.

Response:

The USEPA approved regulatory model, AERMOD, which was used in the air modelling assessment does not have the capability to model the formation of secondary organic compounds downstream of an emission source. In the absence of this ability, the USEPA has published guidance on the near-field single source secondary impacts[7]. The guidance refers to several approaches which have been developed to estimate likely secondary organic aerosol (SOA) formation based on the initial release of $PM_{2.5}$, SO_2 and NO_X from a facility. The USEPA has developed a formula to estimate the formation of SOA based on "offset ratios" which relate the emissions of SO_2 and NO_X to emissions of primary $PM_{2.5}$, details of which are in Appendix B

[7] USEPA (2015) Interagency Workshop on Air Quality Modelling Phase 3 Summary Report: Near-Filed Single Source Secondary Impacts.

3.2 Observations have been made by Zero Waste Alliance Ireland on a range of matters.

In their submission on the application, Zero Waste Alliance Ireland makes a number of submissions in relation to the air quality / climate appraisal set out in the EIS. Each of these submissions is set out below and the response is made directly thereunder.

Issue #1: That The Facility Is In Contravention of the Stockholm Convention on Persistent Organic Pollutants (POPs)

Response:

In relation to Ringaskiddy Resource Recovery Centre, best available technology (BAT) has been employed in line with the Stockholm Convention[8] and Council Directive 2010/75/EC. Council Directive 2010/75/EC has outlined stringent operating conditions in order to ensure sufficient combustion of waste thus ensuring that dioxin formation is minimised. The Directive has outlined air emission limit values for dioxins which have been set at 0.1 ng/Nm^3. Indaver Ireland is committed, as a minimum, to meeting all the requirements of Council Directive 2010/75/EC. Indeed, due to the advanced post-combustion flue gas-cleaning technology employed, expected average emission values will be significantly below these values. Ringaskiddy Resource Recovery Centre will thus significantly outperform the very stringent limit values imposed by Council Directive 2010/75/EC and thus, in doing so, will fulfil the requirements of BAT as outlined in the Stockholm Convention on Persistent Organic Pollutants.

The EPA has also published the National Implementation Plan in 2012[9] including all sources of POPs for the year 2010. As shown in Figure 5, the major sources of dioxin in Ireland are back-yard burning and heat and power generation. Industrial waste incineration accounted for 0.0093% which does not include the Carranstown Waste Management facility which opened in 2011. Data from Carranstowns' Annual Environmental Report for 2014 and 2015[10] indicates that dioxin emissions averaged approximately 0.0029 g/yr I-TEQ which is 0.018% of the overall total in Ireland of 16.1 g/year I-TEQ in 2010. It is anticipated that the Ringaskiddy Resource Recovery Centre will emit a similar quantity of dioxins and thus will form a very minor part of the overall national total.

Issue #2: Cumulative Impacts Not Taken Into Account

Response:

As outlined in Chapter 8 and in detail in Appendix 8.4, a detailed cumulative appraisal was carried out using the methodology outlined by the USEPA. The impact of nearby sources (Janssen Biologics, Hovione Cork, GSK Ireland, ESB Aghada, Novartis Ringaskiddy Ltd,

[8] UNEP (2001) Stockholm Convention on Persistent Organic Pollutants
[9] EPA (2012) National Implementation Plan For Persistent Organic Pollutants - Ireland
[10] EPA Website: http://www.epa.ie/licsearchdownload/CombinedFileView.aspx?regno=W0167-03&classification=Enforcement

Pfizer Ireland Pharmaceuticals and BGE Whitegate) were examined where interactions between the plume of the point source under consideration and those of nearby sources can occur. Full detail of the cumulative impact assessment and associated results are outlined in Appendix 8.4 and indicate that full compliance with the ambient air quality standards is maintained when all relevant nearby emissions sources are taken into account.

3.3 General Comments

Issue #1: Site unsuitable - by reason of topography, climatic conditions…etc

Response:

The surrounding terrain near Ringaskiddy is characterised by a series of rolling hills as outlined in Table 2. The gradient of terrain features relative to effective stack height is insignificant as shown in Table 2.

Table 2 Significant Terrain Features Relative To Effective Stack Height (Plume Centreline Height)[Note 1].

Terrain Feature Location	Terrain Height (m)	Distance From Stack (m)	Gradient
Hill of Cobh	91	3,000	-
Knocknamullagh (Monkstown)	131	5,500	0.29%
Curraghbinny Woods	74	2,200	-
Doolieve	184	11,000	0.63%
Ballynakilla	191	13,000	0.58%
Ballynaneening	136	5,800	0.36%

Note 1 AERSCREEN estimate final plume height (non-downwash) = 110m (115m OD).

The model used in the assessment, AERMOD, is the current USEPA regulatory model for assessing the impact from complex industrial sources, in both flat and complex terrain[11]. This model is also the model recommended by the Irish EPA[12] for industrial sources and has been used in many previous applications in Ireland.

AERMOD has undergone extensive developmental and independent performance evaluation involving four short-term tracer studies and six conventional long-term SO_2 monitoring databases in a variety of settings[13, 14]. The purpose of the evaluation studies was to be sure that AERMOD had been tested in a variety of types of environments for which it will be used. The types of studies ranged from non-buoyancy releases in flat terrain, buoyant releases in flat terrain, buoyant releases in complex terrain and buoyant releases in mountainous terrain. For example, the Tracy Power Plant (Nevada) study, is in a rural river valley surrounded by mountainous terrain with emissions taking place from a 91m moderately buoyant stack. The Martins Creek study is characterised by complex terrain rising above the stacks (stacks varying from 122 – 183m). Monitoring was carried out on a

[11] USEPA (2005) Guidelines on Air Quality Models, Appendix W to Part 51, 40 CFR Ch.1
[12] EPA (2010) Air Dispersion Modelling From Industrial Installations Guidance Note (AG4)
[13] USEPA (2005) AERMOD Description of Model Formulation
[14] USEPA (2003) AERMOD: Latest Features & Evaluations

mountain 2.5 – 8 km from the facility. The Lovett power plant study again is a buoyant release study carried out in complex terrain (rising to nearly 200 m above stack height)[19].

The overall evaluation for AERMOD indicated that:

- 1.03 is the overall predicted-to-observed ratio for short-term averages (with a range among sites from 0.76 to 1.35)
- 0.73 is the overall pre predicted-to-observed ratio for short-term averages (with a range among sites from 0.30 to 1.64)

The predicted-to-observed ratio did not vary substantially between simple and complex terrain sites.

An additional evaluation was conducted for AERMOD after the incorporation of the PRIME building downwash algorithm into the formulation[20]. The overall evaluation for AERMOD, incorporating PRIME, indicated that:

- 0.97 is the overall predicted-to-observed ratio for short-term averages using AERMOD.

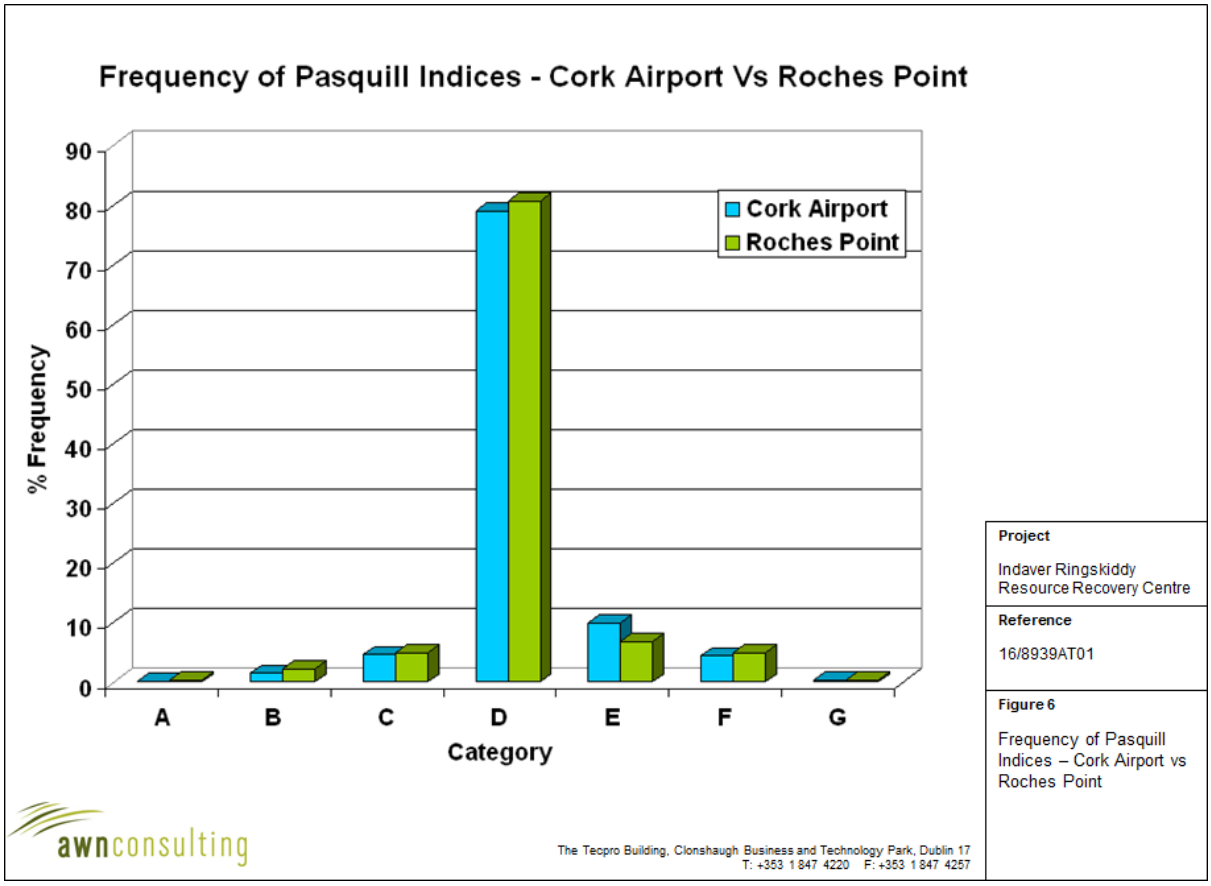
Thus, extensive evaluation exercises have found that AERMOD gives good agreement with observed results regardless of the complexity of the terrain.

Issue #2: Cork Airport Data Not Representative Of Ringaskiddy

Response:

On-site meteorological monitoring was carried out over the period October 2006 - December 2007 in order to determine the site specific nature of the variations in wind speed, wind direction, temperature and humidity. The data for 2007 was used in the CALMET meteorological field as outlined in Chapter 8 of the EIS. AERMOD modelling using site specific wind speed, wind direction and temperature data was also investigated as outlined in Appendix 8.5 of the EIS and indicates that on-site data leads to a slightly lower ambient impact than the use of Cork Airport data.

The differences between the two sites can be explored in a little more detail by looking at the frequency of Pasquill Indices. Pasquill Indices are an indicator of the stability of the atmosphere with categories A-C representing convective (unstable) conditions, D representing neutral conditions whilst E-G representing stable conditions. The inputs into the indices consists of wind speed, insolation during the day (based on cloud cover and time of year) and cloud cover at night. What is apparent from Figure 6 is that both stations are very similar based on data over the period 1961 -1990. Neutral conditions account for almost 80% of the time which is characterized by moderate to high winds and / or cloud cover.



Roches Point was a fully operational station up until 1991. The impact of the facility using Roches Point data from 1986 - 1990 (five years of meteorological data) was also investigated and compared to data using Cork Airport in Appendix 8.5. The results showed that the use of Roches Point data and Cork Airport data gave similar results and indicated that ambient concentrations of all pollutants will be well below the ambient air quality standards.

Issue #3: Generic Letters

- Cause Pollution - dioxins, PCB's heavy metals, dust.
- Stack height not adequate.

Response

The modelling of emissions to air from the Ringaskiddy Resource Recovery Centre indicates that the ambient ground level concentrations will be below the relevant air quality standards or guidelines for all compounds emitted from the facility even under abnormal operating conditions. A detailed cumulative assessment was also undertaken and assessed the impact of background levels of pollutants, traffic-derived sources and other industrial sources in the region. The results showed that the selected stack height is appropriate in ensuring that ambient air quality standards are not exceeded.

Issue #4: Thermal Inversions / Meteorological Considerations

Response

The AERMOD model has the capability of modelling both unstable (convective) conditions and stable (inversion) conditions. The stability of the atmosphere is defined by the sign of the sensible heat flux. Where the sensible heat flux is positive, the atmosphere is unstable whereas when the sensible heat flux is negative the atmosphere is defined as stable. The sensible heat flux is dependent on the net radiation and the available surface moisture (Bowen Ratio). Under stable (inversion) conditions, AERMOD has specific algorithms to account for plume rise under stable conditions, mechanical mixing heights under stable conditions and vertical and lateral dispersion in the stable boundary layer.

The modelling results during inversion conditions can be investigated in order to ascertain the ambient ground level concentration under these meteorological conditions. The meteorological features which are evident during thermal inversions are low mixing height, light winds, negative surface energy flux and a positive M-O length. Table 3 shows the ambient air concentrations during these events and also the highest three hours of ground level concentrations in the region of the site over a full year (worst-case modelling year of Cork Airport 2010 reported).

Table 3 Ambient air concentrations ($\mu g/m^3$) during various meteorological conditions using AERMOD and Cork Airport 2010 met data.

Date / Time	Conc. ($\mu g/m^3$)	Location	Wind Speed (m/s) / Direction (°)	Temp (K)	Surface Heat Flux (W/m2)	M-O Length (m)	Cloud Cover (%)	Mixing Height (m)
23:00 16/02/10 (maximum hour)	6.1	800m NW of stack	3.1 / 274	274.2	-8.9	7.2	50	103
01:00 01/09/10 (2nd Highest hour)	5.7	830m NW of stack	3.1 / 120	285.9	-9.1	7.0	30	823
01:00 15/11/10 (3rd Highest hour)	5.6	800m NW of stack	3.1 / 124	276.4	-9.3	6.9	30	103
21:00 02/02/10	3.3	6km SW of stack	2.1 / 34	273.1	-7.7	8.4	30	71
19:00 07/01/10	4.7	2.2 km N of stack	1.0 / 181	273.1	-1.0	2.2	30	71
05:00 18/09/10	0.27	8km NW of stack	1.0 / 237	280.9	-0.8	2.8	90	29

It is evident from the results that the worst-case conditions leading to the highest ambient ground level concentration are generally stable conditions which is characterized by a negative surface energy flux, intermediate wind speeds, positive M-O length and a low-medium mechanical mixing height.

Table 3 also indicates the predicted concentrations under some typical inversion conditions characterized by a negative heat flux, a positive M-O Length, a very low mixing height and

very light winds. The predicted concentrations under these conditions are generally around 5% - 70% of the worst-case ambient concentrations.

Issue #5: Influence Of Wind Turbines On Dispersion

Response

There has been some concern expressed that the nearby DePuy Ireland wind turbine, which is located approximately 400m south of the proposed facility, will have an adverse impact on the dispersion of the plume. A wind turbine, when in operation, has some potential to interact with the plume as the plume passes the region of the turbine. The implications of this have been studied recently by Fletcher and Brown[15]. The study found that there was a small increase in relative concentration in the plume of the order of 5 – 20% over a distance of 1 to 2 turbine diameters downwind of the turbine. Thereafter, concentrations in the plume where seen to fall rapidly to below 30 – 60% of the pre-turbine plume concentration within 4 – 5 turbine diameters. Thus, given the plume concentrations expected at a distance of 400m from the facility, the impact of the DePuy turbine will not be significant and will not lead to an exceedance of the ambient air quality standards in the region.

Issue #6: Cork Harbour Is Polluted / No Information On Existing $PM_{2.5}$ Levels

Response

Ambient PM_{10} and $PM_{2.5}$ monitoring has been undertaken recently under an EPA-sponsored research project (STRIVE)[16] at Tivoli Docks and Haulbowline Naval Base over the period 2007 / 2009.

The average PM_{10} concentration at Haulbowline Naval Base over the period April 2007 – May 2008 was 4.7 $\mu g/m^3$ which is 12% of the ambient air quality standard. The average $PM_{2.5}$ concentration at Haulbowline Naval Base over the period April 2008 – April 2009 was 2.8 $\mu g/m^3$ which is 11% of the ambient air quality standard. These levels at Haulbowline Naval Base are very low and indicate a region of very good background particulate levels with levels similar to rural areas in Ireland.

An extensive baseline survey was also carried out in the region of the proposed Ringaskiddy Resource Recovery Centre over the period August 2014 to July 2015 which supplements the baseline surveys undertaken from November 2006 to February 2007 and from April 2008 to July 2008. The substances monitored over the course of the three surveys were NO_2, NO_X, PM_{10}, $PM_{2.5}$, benzene, SO_2, heavy metals, HCl, HF and PCDDs/PCDFs. The air monitoring program was used to determine long-term average concentrations for these pollutants in order to help quantify the existing ambient air quality in the region. Levels of nitrogen

[15] Fletcher & Brown (2010) *Interaction of an Eulerian Flue Gas Plume with Wind Turbines,* American Institute Of Aeronautics and Astronautics

[16] EPA STRIVE (2011) Composition & Sources Of Particulate Air Pollution in a Port Environment, Cork, Ireland (2006-EH-MS-49).

dioxide (NO_2), PM_{10}, $PM_{2.5}$, SO_2, benzene, hydrogen fluoride (HF) and hydrogen chloride (HCl) were all significantly below their respective limit values. Average concentrations of all metals measured (including nickel, arsenic and cadmium) were also significantly below their respective annual limit values. There are not any EU limits values for background levels of dioxins and dibenzofurans in the air. Levels of these substances were compared to the levels measured elsewhere in Ireland and Europe. The existing levels in Ringaskiddy are comparable with other rural locations in Ireland.

Issue #7: The facility will increase Greenhouse Gas Emissions

Response

The net emissions of greenhouse gases from the facility, when the emissions from the generation of 18.5MW of power in a fossil fuel power station have been subtracted, will amount to 0.07% of EU 2020 Strategy GHG Emissions Target. However, if the facility is not built, the waste will either be landfilled in Ireland or exported for incineration abroad. Organic waste in a landfill decomposes and produces gases such as methane and carbon dioxide. A landfill will continue to emit gases for over 100 years, long after the landfill has been closed. By incinerating the waste, prior to landfill, the emission of these gases will be avoided.

4. Conditions Recommended By Cork County Council

Cork County Council has recommended the attachment of a number of indicative conditions which are contained in its Report received by the Board on the 13th April 2016. The applicant is in agreement with the approach taken by the Council in relation to suggested Condition 24, in regards to air quality / dust matters.

5. Conclusion

In summary, in relation to air quality, detailed air dispersion modelling has shown that the most stringent ambient air quality standards for the protection of human health and the environment will not be exceeded either as a result of operating under maximum or abnormal operating conditions.

The modelling results, using two different advanced air dispersion models, show that the spatial impact of the facility is limited with concentrations falling off rapidly away from the maximum peak. For example, the short-term limit values at the nearest residential receptor will be less than 17% of the short-term ambient air quality limit values. The annual average concentration has an even more dramatic decrease in maximum concentration away from the facility with concentrations from emissions at the proposed facility accounting for less than 1% of the limit value (not including background concentrations) at worst case sensitive receptors near the facility.

In relation to climate, the net emissions of greenhouse gases from the facility, when the emissions from the generation of 18.5MW of power in a fossil fuel power station have been subtracted, will amount to 0.07% of EU 2020 Strategy GHG Emissions Target. The facility will avoid the need to export this waste or alternatively the landfilling of this waste with greater associated greenhouse gas emissions.

APPENDIX A

Recent studiesby an Italian research team[17,18,19] which focussed on a series of modern waste-to-energy facilities in Italy.

One of these papers[9] reviewed emissions from five facilities in Italy with a range of furnaces and flue-gas cleaning technology. The facilities included moving grate, roller-type grate and fluidized bed reactors. In terms of abatement, the technology included wet, semi-dry and dry processes, spray absorber systems and fabric filters. Four of the five incinerators installed fabric filters, the exception being a facility which processed biomass which had a wet scrubber as the preferred abatement technology.

At two of the incinerators, measurements were taken both prior to and after the fabric filter in order to determine the abatement efficiency of the fabric filter in the nanoparticle range. The results from the efficiency test were that fabric filters could achieve an efficiency of 99.99% over the entire measurement range (from 6 nm – 1000 nm). There was a shift in the mode towards lower diameters although even in the range 5 – 40 nm the efficiency was of the order of 99.88%. The efficiency results are shown in Figure 1 below.

In terms of the overall results from the four MSW incinerators, the average concentration ranged from 0.4 – 6.0 x 10^3 particles cm^{-3}. The peak in particle numbers occurred in the range 10 – 100 nm as shown in Figure 2 for the highest emission periods. The study concludes by stating:

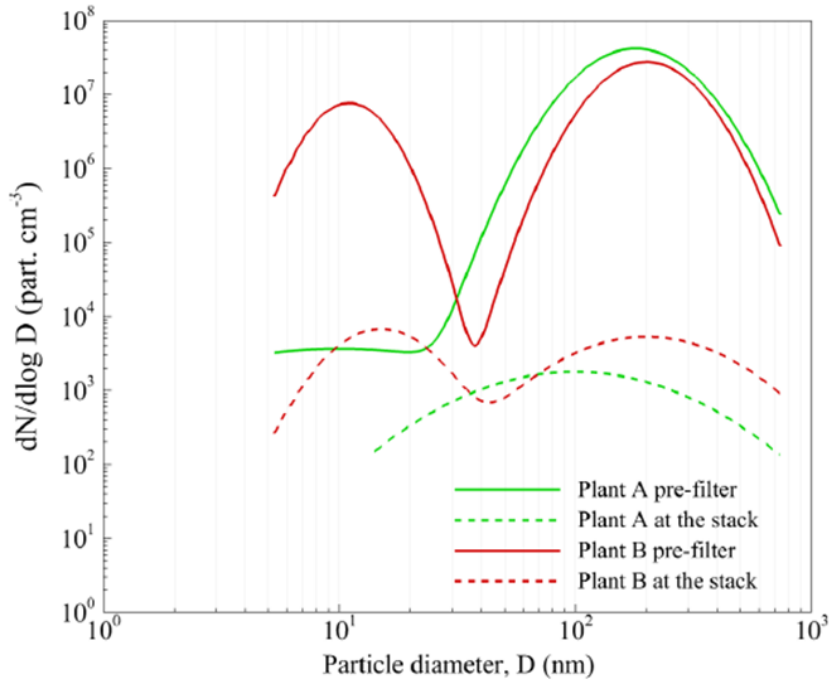
*"**Implications**: The main implication of the study is that the use of a fabric filter in the flue gas treatment section of incinerators is able to guarantee very low concentrations in the stack in terms of UFPs. As regards the incineration plants, a further implication of the proposed study is that an a priori negative social response seems to be unjustified when referred to the ultrafine particle emissions."*[9]

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17 Buonanno et al (2011) Chemical, dimensional and morphological ultrafine particle characterisation from a waste-to-energy plant. Waste Management 31 (2011) 2253-2262.

18 Buonanno et al (2011) Ultrafine particle emission from incinerators: The role of the fabric filter J. Air & Waste Management Assoc. (2011) 2253-2262.

19 Buonanno et al (2010) Dimensional and chemical characterisation of particles at a downwind receptor site of a waste-to-energy plant Waste Management (2010) 1325-1333.



Taken from "Buonanno et al (2012) Ultrafine particle emission from incinerators: The role of the fabric filter J. Air & Waste Management Assoc. (2011) 2253-2262."

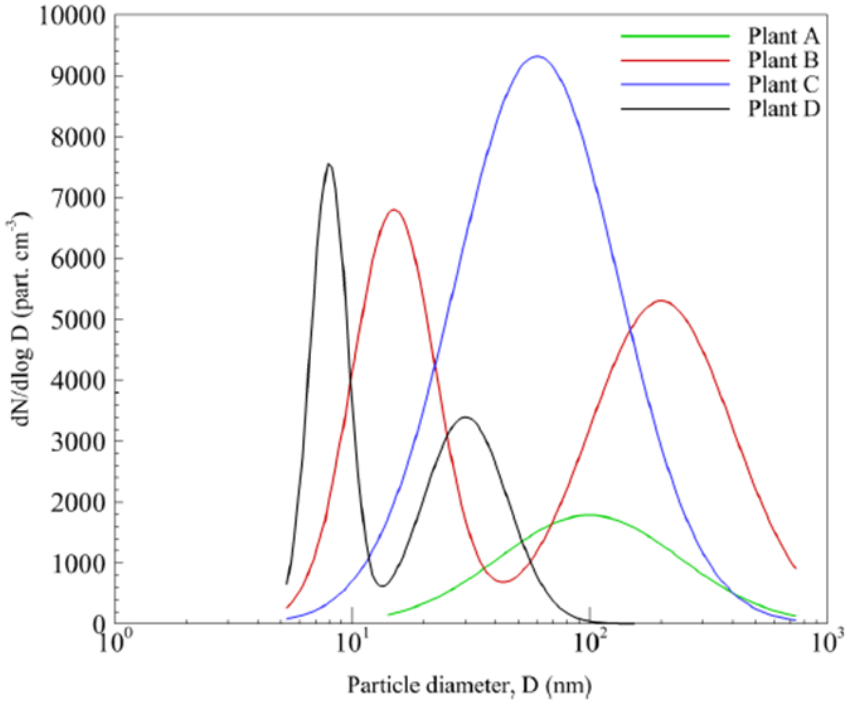
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Reference
16/8939AT01

Figure 1
UFP efficiency of Fabric Filter – Two Modern Incinerators In Italy



Taken from "Buonanno et al (2012) Ultrafine particle emission from incinerators: The role of the fabric filter J. Air & Waste Management Assoc. (2011) 2253-2262."

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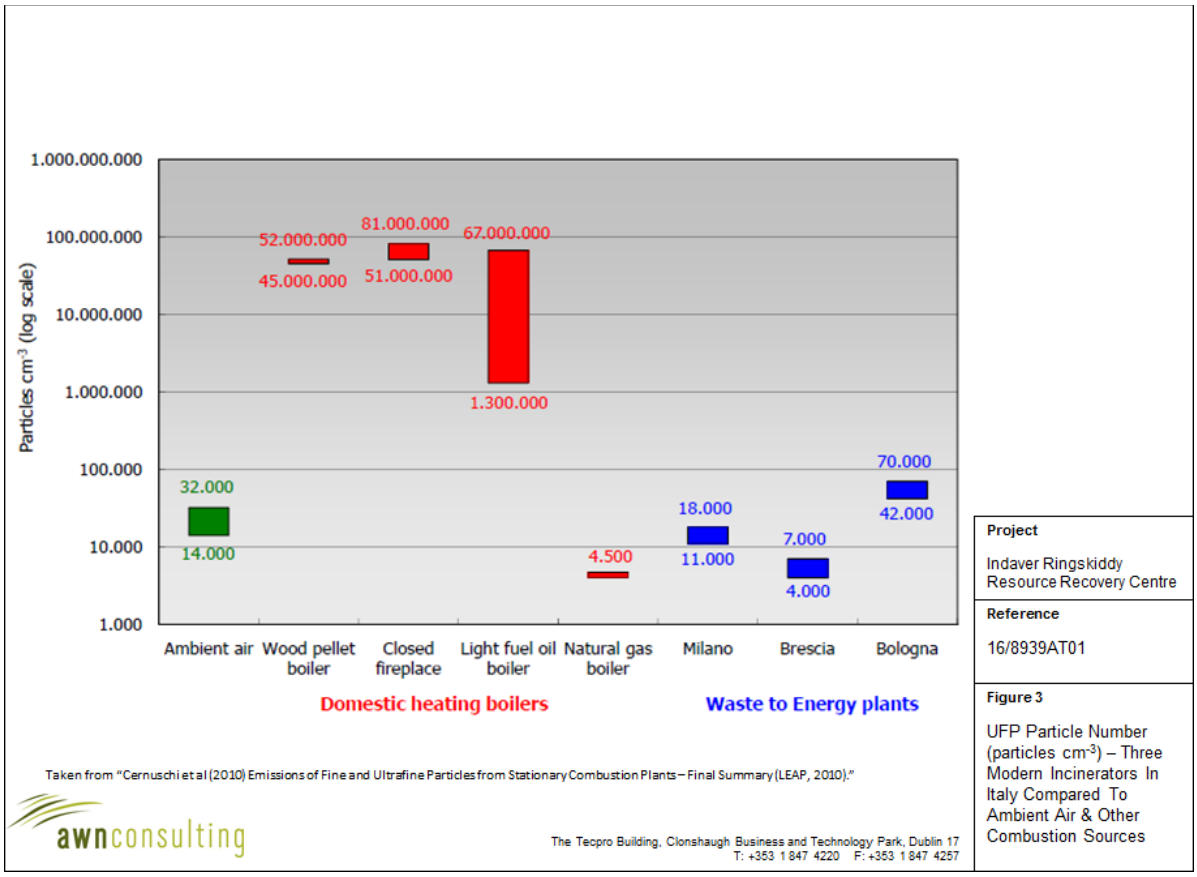
Reference
16/8939AT01

Figure 2
UFP Particle Number (particles cm^{-3}) – Four Modern Incinerators In Italy

Buonanno et al[9] undertook a review of UFPs in ambient air downwind of a waste-to-energy facility in 2010. The facility was a modern moving grate facility with a semi-dry abatement

system (SNCR, spray absorber system and a fabric filter). The average total number concentration was lower than 1.0 x 10^4 particles cm^{-3} with a mode of about 130-170 nm. The study concluded that the results were typical of a rural site and that most of the elements could be attributed to long-range transport from other natural and/or anthropogenic sources.

Another study, by Cernuschi et al (2010)[20], found that emissions of UFP (in terms of particle numbers) from WTE facilities with fabric filters were typically similar to or lower than ambient air as shown in Figure 3. The results were compared to other combustions sources, such as wood pellet boilers, closed fireplaces and light fuel oil boilers, which were typically orders of magnitude higher.



A recent review undertaken by a team lead by Roy Harrison in the UK[21] stated the following in terms of UFPs from incinerators:

"However, the work of Buonanno et al. (2008, 2009a, 2011) and Angelucci et al. (2010) indicates that the flue gas treatment used on current technology incinerators is highly efficient, reducing nanoparticle concentrations in stack gases to levels comparable with ambient air. Consequently, the UFPs associated with MSW incineration are likely to be considerably smaller in quantity compared with a major source such as road traffic emissions."[11]

[20] Cernuschi et al (2010) Emissions of Fine and Ultrafine Particles from Stationary Combustion Plants – Final Summary (LEAP, 2010)

[21] Kumar et al (2013) Nanoparticle emissions from 11 non-vehicle exhaust sources – A Review. Atmospheric Environment **67** *2013* 252 - 277

APPENDIX B

The ratios, which are discussed in a recent report[22] are as follows:

SO_2 to Primary $PM_{2.5}$ offset ratio: 40:1
NO_X to Primary $PM_{2.5}$ offset ratio: 100:1

and the formula used to derive the equivalent primary $PM_{2.5}$ is:

Total Equivalent Primary $PM_{2.5}$ (tpy) = Primary $PM_{2.5}$ (tpy) + SO_2 (tpy)/40 + NO_X (tpy)/100

Thus, in relation to the Ringaskiddy Resource Recovery Centre the emissions of SO_2, NO_X and primary $PM_{2.5}$, based on the maximum emission limits outlined in the IED, are:

SO_2 Emissions = 62.2 tonnes/yr
NO_X Emissions = 249 tonnes/yr
Primary $PM_{2.5}$ Emissions = 12.4 tonnes/yr
Total Equivalent Primary $PM_{2.5}$ (tpy) = 12.4 + 62.2/40 + 249/100 = **16.5 tonnes/yr**

The total (primary and secondary) $PM_{2.5}$ concentration can then be estimated by multiplying the AERMOD concentration for primary $PM_{2.5}$ by the emissions ratio:

Total $PM_{2.5}$ ($\mu g/m^3$) = Primary $PM_{2.5}$ ($\mu g/m^3$)* Total Equivalent Primary $PM_{2.5}$ (tpy)/ Primary $PM_{2.5}$ Emissions (tpy)

Total $PM_{2.5}$ ($\mu g/m^3$) = 0.083 $\mu g/m^3$ * (16.5/12.4) = **0.110 $\mu g/m^3$**

Thus, the process contribution from the facility increases from 0.083 $\mu g/m^3$ to 0.110 $\mu g/m^3$ when secondary organic aerosol formation is taken into account as shown in Table 1:

Table 1 Dispersion Model Results – Total Dust (referenced to $PM_{2.5}$)

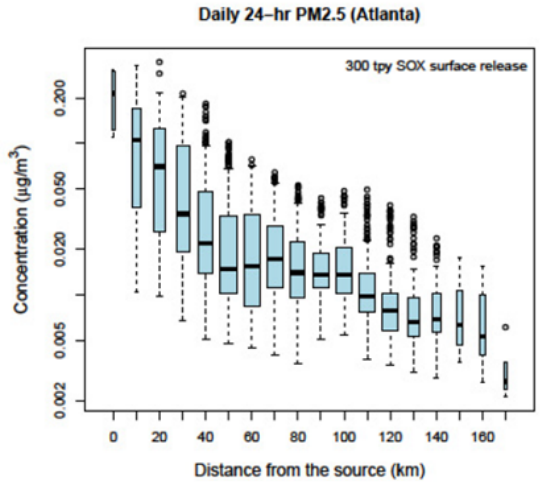
Pollutant / Scenario	Averaging Period	Process Contribution ($\mu g/m^3$)	Background ($\mu g/m^3$)	Predicted Emission Concentration ($\mu g/Nm^3$)	Limit Value[(1)] ($\mu g/Nm^3$)
$PM_{2.5}$ / Maximum	Annual mean	0.083	12	12.08	25
$PM_{2.5}$ / Abnormal Operation[(2)]	Annual mean	0.090	12	12.09	25
$PM_{2.5}$ / Maximum Including SOAs	Annual mean	0.110	12	12.11	25
$PM_{2.5}$ / Abnormal Operation[(2)] Including SOAs	Annual mean	0.120	12	12.12	25

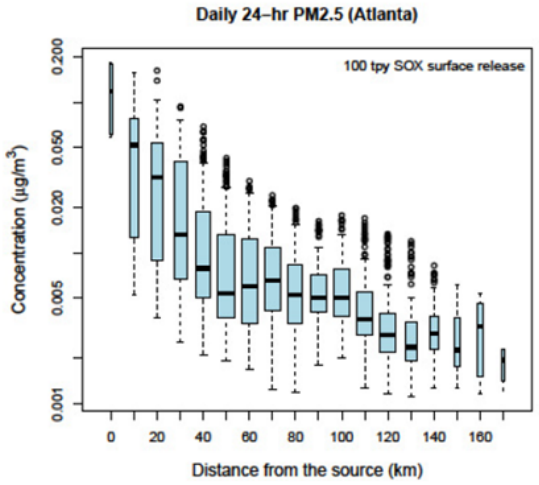
(1) Council Directive 2008/50/EC
(2) Abnormal operation scenario - 30 mg/m^3 for 3% of the time (assumed to occur for one 24-hour period once per month).

Thus, taking into account secondary aerosol formation, the predicted ambient $PM_{2.5}$ concentration will increase by 0.1% of the ambient air quality standard.

[22] NACAA (2011) $PM_{2.5}$ Modeling Implementation for Projects Subject to National Ambient Air Quality Demonstration Requirements Pursuant to New Source Review

The USEPA report[12] also discussed the formation of secondary $PM_{2.5}$ with distance downwind based on photochemical modelling of a hypothetical source emitting 100 and 300 tpy of SO_2 (as outlined above the Ringaskiddy facility will emit 62.2 tonnes per annum of SO_2 (68.5 US tpy)). As shown below in Figure 4 the formation of secondary $PM_{2.5}$ peaks near the source at a concentration of approximately 0.15 $\mu g/m^3$ for a 100 tpa SO_2 release and decreases away from the source.





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Figure 4

Maximum 24-hr $PM_{2.5}$ sulphate ion formation downwind of a hypothetical source emitting 100 and 300 tpa of SO_2.

Taken from "USEPA (2015) Interagency Workshop on Air Quality Modelling Phase 3 Summary Report: Near-Filed Single Source Secondary Impacts"

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