awnconsulting

The Tecpro Building,
Clonshaugh Business & Technology Park,
Dublin 17, Ireland.

T: + 353 1 847 4220
F: + 353 1 847 4257
E: info@awnconsulting.com
W: www.awnconsulting.com

EPA ORAL HEARING INTO THE DUBLIN WASTE TO ENERGY FACILITY BRIEF OF EVIDENCE CLIMATE

Report Prepared By

Edward Porter PhD C Chem MRSC

Our Reference

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Cork Office
Unit 5, ATS Building,
Carrigaline Industrial Park,
Carrigaline, Co. Cork.
T: +353 21 438 7400
F: +353 21 483 4617

AWN Consulting Limited
Registered in Ireland No. 319812
Directors: F Callaghan, C Dilworth,
T Donnelly, E Porter
Associate Director: D Kelly

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1.0 Edward S. Porter will say:

1.1 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 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.

1.2 I have been active in the field of chemistry for 17 years, the last eleven as an Environmental Consultant. I have considerable experience in the areas of planning with regard to air quality, assessment of air quality for compliance purposes and air quality mitigation measures in relation to both construction sites and operational developments.

1.3 I am currently Director with responsibility for Air Quality and Climate with AWN Consulting.

Recent Climate Project Experience

- Ringaskiddy Waste-to-Energy Plant Waste Licence & Oral Hearing (2005)
- Carranstown Waste-to-Energy Plant Waste Licence & Oral Hearing (2005)
- M3 Clonee to North of Kells EIS & Oral Hearing (2002)
- South Dublin Outer Ring Road EIS & Oral Hearing (2001)
- Spencer Dock Conference Centre EIS & Oral Hearing (2000)
- Mahon Point Shopping Centre EIS & Oral Hearing (2002)
- Wicklow Port Access & Town Relief Road EIS & Oral Hearing (2003)
- M7/M8 Portlaoise to Cullahill / Castletown EIS & Oral Hearing (2004)

2.0 INTRODUCTION

2.1 AWN Consulting Limited was commissioned to conduct a detailed appraisal of the climatic impacts associated with the Dublin Waste To Energy Facility.

2.2 Available published guidance documents and Directives which are relevant to assessing the climatic impacts from an incineration facility were consulted.

2.4 The climatic impact of the proposed Dublin Waste To Energy Facility was assessed by means of quantifying the release of fossil-fuel derived greenhouse gases (GHGs) and thereafter comparing these releases to those from the alternative waste treatment options such as landfilling and landfilling with anaerobic digestion.

3.0 ASSESSMENT APPROACH

3.1 The approach adopted for the climate assessment firstly involved a detailed consideration of the available published guidance documents and Directives which are relevant to assessing the climatic impacts from a waste-to-energy facility. The key documents consulted in the assessment were:

- IPCC (2006) - 2006 IPCC Guidelines for National Greenhouse Gas Inventories
- EU / AEA (2001) Waste Management Options & Climate Change
- UK DEFRA / ERM (2006) Impact of Energy from Waste and Recycling Policy on UK Greenhouse Gas Emissions
- DEFRA / ERM (2006) Carbon Balances & Energy Impacts of the Management of UK Wastes
- DCMNR (2006) Delivering A Sustainable Energy Future For Ireland
- SEI (2006) Renewable Energy Development 2006
- European Commission (2001) Council Directive 2001/77/EC on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market

3.2 The Intergovernmental Panel on Climate Change (IPCC) updated detailed guidelines on compiling National Greenhouse Gas Inventories have been used in the assessment. The carbon from biogenic sources do not contribute to emission totals considered in the Kyoto Protocol(5).

3.3 In relation to solid waste disposal sites (SWDSs) including municipal landfills, detailed guidelines have been outlined for the calculation of GHG emissions(5). The main GHG emission from SWDSs is methane. Even though the source of carbon is primarily biogenic, CH_4 would not be emitted were it not for the human activity of landfilling the waste, which creates anaerobic conditions conducive to CH_4 formation. Although CO_2 is also produced in substantial amounts, the primary source of CO_2 derives from the decomposition of organic material derived from biomass sources (crops, forests) which are re-grown on an annual basis. Hence, these CO_2 emissions are not treated as net emissions from waste in the IPCC Methodology(5).

4.0 CLIMATE ASSESSMENT

The impact of the Dublin Waste-To-Energy facility on climate and on Ireland's production of greenhouse gases was assessed.

- 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). To assess the potential impact on macroclimate, the net effect of the facility on the generation of these gases in Ireland was calculated.

- When in operation, the facility will treat approximately 600,000 tonnes of waste per annum and export 59MW of electricity to the national grid. If the facility is not built, it is assumed that approximately 600,000 tonnes of this waste will be landfilled in Ireland and 59MW of electricity will be produced in a power station in Ireland.

- Waste in a landfill decomposes and produces gases such as methane and carbon dioxide. The amount of these gases, which would be produced by the decomposition of 600,000 tonnes of waste, was calculated. It was assumed that a landfill gas collection system would capture 75% of the gas and the collected gas would be used for electricity generation. Recent data has suggested that the actual capture rate could be significantly lower than this value[20]. The net emission of gases from the landfill and from the landfill gas electrical generation process was calculated.

- The contribution to the total anthropogenic greenhouse gas emissions, will average 0.14% of the total greenhouse gas emissions in Ireland in 2010 when energy recovery is taken into account over the lifetime of the facility. Moreover, in the absence of the development, greenhouse gas emissions will occur from the landfilling of waste. The contribution to the total greenhouse gas emissions from landfilling 600,000 tonnes of waste, including the generation of power, condensed to a 30-year period, is equivalent to 0.25% of the total greenhouse gas emissions in Ireland in 2010. Thus, a direct comparison between incineration and landfilling indicates a benefit from the scheme of 0.11% of national emissions in 2010. This saving is equivalent to removing over 27,000 cars/annum from the road network [Note1].

- It should be noted that the basis for the calculation is the use of the best environmental technology for landfill gas collection and for the generation of power from this gas. In addition the power generation comparison has assumed the most environmentally advanced technology for fossil-fuel power generation (CCGT) will be exclusively displaced after 2018 rather than, for example, coal or peat fired plants, which would have much higher greenhouse gas emissions.

- Some further alternatives have been investigated and elaborated on further in Section 5. The studies indicate that even allowing for diversion of all residual organic waste to anaerobic digestion (AD) treatment, the Waste-To-Energy facility will be more favourable in climatic terms than these alternatives, ranging between 0.02% to 0.22% of the Kyoto Target, depending on the landfill gas capturing efficiency and the alternative technology employed.

- A district heating scheme will be in operation to avail of the waste heat from the incineration process. The implementation of a district heating scheme will provide even greater climatic benefits that incineration alone. Thus, a direct comparison between incineration with district heating and landfilling with AD (landfill capture rate of 50%)

[Note 1] Based on the most popular car in Ireland in 2005 (Ford Focus 1.4) which emits 160 g/km and based on the average distance travelled (16,000 km/annum) leading to annual total of 2.56 tonnes/annum.

indicates a benefit from the scheme of 0.30% of national emissions in 2010. This saving is equivalent to removing over 70,000 cars/annum from the road network.

- Thus, the overall annual impact of the Dublin Waste-To-Energy Facility on climate is to produce a net benefit of between 0.02% - 0.22% of the total greenhouse gas emissions in Ireland in 2010. This could potentially rise to 0.30% of this target with the implementation of a comprehensive district heating scheme. In summary, the Dublin Waste-To-Energy Facility will make an important beneficial contribution to Ireland's obligations under the Kyoto Protocol.

5.0 REPLIES TO THIRD PARTY OBJECTIONS – CLIMATE

The Principle Objections Relate To:

- **Waste mix used in the assessment**
- **Electricity credit taken**
- **Contribution of carbon sequestration**

5.1 Response

The concerns outlined above have been responded to in turn below.

Waste Mix

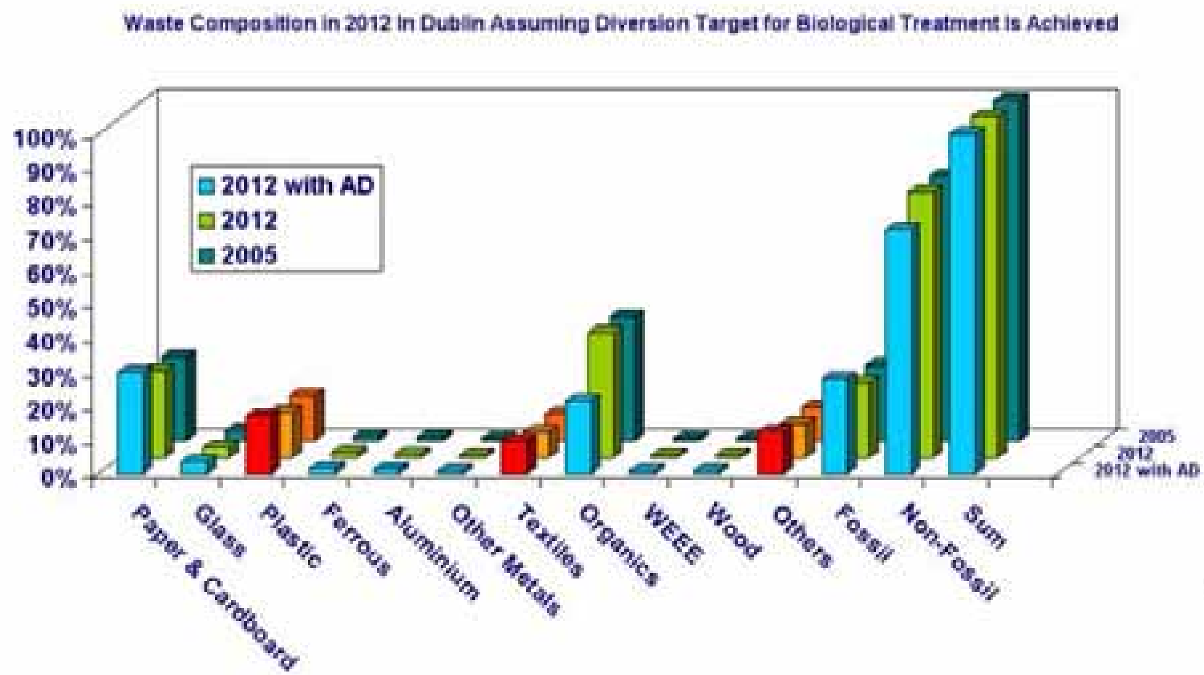
The waste mix which will be treated in the Dublin Waste-To-Energy facility will be residual waste after recycling and biologically treated waste has been extracted. In order to determine what this waste stream is likely to consist of in 2012, several sources of data are available:

- National Waste Report 2005[(1)] (2007)
- Waste Management Plan for the Dublin Region 2005 - 2010[(2)] (2005)
- Programme for Municipal Waste Characterisation Surveys[(3)] (2005)

The National Waste Report includes a breakdown of the municipal waste stream (household and commercial) in 2005 on a national basis. The Waste Management Plan for the Dublin Region 2005 - 2010 details the likely totals of both household waste and commercial waste in 2012. The report also indicates that by 2012, biological treatment facilities will be in place to deal with 90,000 tonnes of household waste and 50,000 - 100,000 tonnes of commercial / industrial waste (it has been assumed that 75,000 tonnes of commercial waste is biologically treated). The steps in deriving the waste mix in 2012 are outlined below:

- Initially individual household and commercial waste fractions in 2012 are assumed to be unchanged from 2005 waste fraction.
- Ratio of household to commercial waste based on Projected Waste Arisings in Dublin in 2012 used to allow for variations between the ratio of household to commercial waste nationally and in Dublin.
- Fraction adjusted to allow for the biological treatment of 165,000 tonnes of waste.

The changes in the waste mix due to the above modifications are shown in Figure 5.1 with detail percentages shown in Tables A1, A2 and A3.



Project
Dublin WTE Project

Reference
08/4030AR02

Figure 5.1
Waste Generation Totals in 2012

awnconsulting

The Tecpro Building, Clonshaugh Business and Technology Park, Dublin 17
T: +353 1 847 4220 F: +353 1 847 4257

Carbon & Fossil Fuel Fraction

The third party appellants have some concerns in relation to the carbon fraction and the fossil fuel fraction of individual waste streams and in particular in relation to plastics and "others" categories.

In relation to the definition of "others", the third party appellants pointed to a subscript in the National Waste Report 2004. The subscript quoted the following:

"Includes cooking oil, mineral oil, batteries, composite packaging, tyres and 70,139 tonnes of residues from mechanical treatment of mixed municipal waste shipped to Germany and Northern Ireland for recovery and recycling respectively." (Table 3, Page 9)(1)

The third party appellant understood that this referred to the fraction of waste that was landfilled. However this definition of "Others" was contrary to an earlier definition of "Others" in the National Waste Report 1998 which stated in a footnote that:

"Note: 'Others' mainly consists of composites, fine elements such as ash, unclassified incombustibles and unclassified combustibles including wood waste". (Table 3.7, Page 30)(1)

An explanation for the confusion can be gleaned from a review of the 2004 Report and earlier Reports 2002 and 2003. Table 3 of the 2004 report refers to both the disposal and recovery of municipal waste but the definition of "Others" does not specify if it applies to disposal, recovery or both. However, in both Table A4 of the 2002 Report and Table A5 of the 2003 Report the definition of "Others" is referred to as "*Waste electrical and electronic equipment, cooking oil, mineral oil, batteries and composite packaging*" exclusively in reference to recovery. It is clear that there are two definitions of "Others", one specific to landfilling and one specific to recovery. The definition of "Others" in terms of landfilling is as defined in the 1998 Report whereas the definition of "Others" in terms of recycling and recovery is as described in the 2002 and 2003 Reports and somewhat confusingly in the 2005 Report. This analysis was confirmed in conversation with the lead author of the National Waste Report 2005 (Odile Le Bolloch (07/11/2007)). The author was also able to provide the breakdown of the recovered waste in 2004 as outlined in Table A4.

The total in Table A4 correlates with the total recovered as indicated in Table 3 of the National Waste Report 2004. It should also be point out, as outlined in the Proposed National Hazardous Waste Management Plan 2008 - 2012(4), that most of the waste types outlined in Table 4 are hazardous wastes and as such cannot be landfilled in a municipal landfill facility or treated in a waste-to-energy facility.

In relation to the carbon fraction and fossil fuel fraction of "Others" which is treated or disposed (i.e. of composites, fine elements such as ash, unclassified incombustibles and unclassified combustibles including wood waste) three main reference sources are available:

- IPCC (2006) - 2006 IPCC Guidelines for National Greenhouse Gas Inventories(5)
- UK DEFRA / ERM (2006) - Impact of Energy from Waste and Recycling Policy on UK Greenhouse Gas Emissions(6) and DEFRA / ERM (2006) "Carbon Balances & Energy Impacts of the Management of UK Wastes"(7).
- EU / AEA (2001) - Waste Management Options & Climate Change(8)

These documents outline the carbon fraction and fossil fuel fraction for each of waste category outlined in Tables A5 - A7. The three sources indicate some variations in carbon fraction and fossil fuel fraction for each source. These variations would not be unexpected as waste streams will vary worldwide. In relation to plastics, "others" and textiles, it would be expected that the UK waste profile would be broadly similar to Ireland and more so that the EU. As the

IPCC data is based on worldwide data, the estimates there should be viewed as less site-specific. In terms of the anthropogenic CO_2 emissions based on the three sources, the variation is less than 10% from the mean of the three data sources. As a best estimate, the average of the UK and EU data has been used to derive the anthropogenic CO_2 emissions from the proposed waste-to-energy facility. This is in line with IPCC methodology which states that county-specific information on the carbon content and fossil fuel fraction should be used (Section 5.2 of IPCC Guidelines)[(5)].

Power Generation

The gross power output of the facility is approx. 65.7 MWe. The internal power consumption for the facility is based on experience from other facilities set at 6.6 MWe. This internal power consumption corresponds to approx. 0.1 MWh/tonne of waste that is thermally treated. The internal power consumption is within the recommendation of BAT63 which states that the average installation electrical demand should generally be reduce to be below 0.15 MWh/tonne of MSW processed. The resulting net power output is thus approx. 59.2 MW.

Fuel Displacement

The proposed facility will export 59.2 MW of power to the national grid when in operation. The key question in relation to the export of this electricity is what fuel / generation system will be displaced and thus what credit can be attributed to the facility in terms of a carbon credit.

The current mix of fuels used to produce electricity in Ireland is shown in Table A9. The dominant primary fuels, on which the generation system currently relies in terms of production, are gas (44%), coal (25%) and oil (13%). Gas and coal accounts for 86% of dispatchable installed capacity and 69% of actual generation in 2005[(10)]. The Government in the Energy White Paper (Delivering A Sustainable Energy Future For Ireland (2007)[(11)]) has set a 33% target for renewable electricity by 2020. Therefore the profile of fuel type by 2020 will be significantly different from the current one.

One pertinent question is what effect increasing renewables (which will be primarily wind power[(12)]) will have on the electricity generation fuel mix. Council Directive 2001/77/EC On The Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market[(13)] states in Article 7 that:

"Member States …. may also provide for priority access to the grid system of electricity produced from renewable energy sources. When dispatching generating installations transmission system operators shall give priority to generating installations using renewable energy sources insofar as the operation of the national electricity system permits".

The ESB has investigated the impact of meeting the targets set in Council Directive 2001/77/EC (13.2% renewables by 2010) in terms of costs, emissions and in terms of capacity[(14)]. At a starting point in this study, the ESB has assumed that electricity from wind power will be a "must take" contract and thus all wind power generation will be accepted onto the National Grid. A study commission by Sustainable Energy Ireland (A Study on Renewable Energy in the New Irish Electricity Market (2004)[(15)]) indicates that wind energy providers will operator as "price takers" and that negative prices in the market are unlikely to occur.

In the recent report from the Commission for Energy Regulation - Report on Ireland's Security of Supply of Electricity (2006)[(10)], the authors state that:

"wind does provide a "fuel saving" opportunity whereby, when it is available and generating, given its current priority dispatch position, it displaces other thermal generation"

A & L Goodbody recently published an article entitled "Into Thin AER: Renewable PPAs, CfDs, and the Transition to the Single Electricity Market (June 2007)[16]". The article investigated the effects of regulation and the Single Electricity Market (SEM) on renewables. In describing the SEM the article states that "*renewable generators are entitled to priority dispatch to the extent they choose to be "price takers*". The article, under the section "Renewable Generators as Price Takers or Price Makers" states:

"*It is a European Union requirement that Member States ensure that renewable generators have priority dispatch. Under the SEM it is proposed that this obligation will be fulfilled through enabling renewables generators to become Price Takers in the market. While still under consultation it is proposed that all Price Takers will be deemed to have submitted a bid offer at a level which ensures dispatch (i.e. zero or the lowest non-renewable plant bid) and will receive whatever the pool purchase price is for credited output.*"[16]

All of these studies thus indicate that wind power will essentially always be accepted onto the Grid in line with the "priority access" enshrined in 2001/77/EC. Thus, the ratio of wind power in the national grid will increase significantly over the next few years and it will displace thermal power in the process.

The second consideration is the mix of generators which are currently operating at margin load and how this will be affected by the increasing use of renewables in the generation mix. As outlined in the SEI publication "Security of Supply in Ireland 2006" (2006)[9], the generator setting the spill price (i.e. the last generator in each half hour from which electricity is drawn to meet demand) is the Aghada gas fired unit AD1 followed by Tarbet oil fired unit TB4. Gas is the dominant fuel setting the spill price followed by oil, coal and peat.

Eirgrid in its study entitled "Wind Powered Generation - An Analytical Framework to Assess Generation Cost Implications"[17] assessed the impact of three levels of wind power penetration. In each of these scenarios, it was assumed that thermal power was displaced as shown in Table A10.

The SEI publication "Renewable Energy In Ireland 2005 Update"[12] states that in answer to the question - "*what electricity generation is being displaced by renewable energy generated electricity?*", that:

"*Renewable energy plants are not generally displacing electricity from either "must-run" plants (peat) or from baseload plants (coal fired station at Moneypoint and the combined cycle gas turbine(CCGT) plants). Calculating the PEE (primary energy equivalent) based on the remaining plant provides a more accurate estimate than using the entire plant mix and the approach is known as the Operating Margin Approach. There are clear limitations in this analysis but it does provide useful indicative results. The assumption underpinning this approach is that the renewable plant is displacing the last plants to be dispatched to meet electricity demand i.e. the marginal oil and gas plants.*"[12]

The SEI approach referenced the research paper by Kartha et al (2004) which was published in Energy Policy[18]. The paper entitled "Baseline recommendations for greenhouse gas mitigation projects in the electric power sector" was concerned with the methodology to identify the baseline scenario in relation to greenhouse gas emissions so as to answer the question - "*What is the quantity of net emission reductions relative to what would have occurred in the absence of the proposed project?*". The paper suggests that most projects should use the Combined Margin Approach. This approach is shown below;

Combined Margin = (Operating Margin$_{\text{Year1}}$ + Build Margin$_{\text{historical}}$) /2

Where:

Operating Margin is based on the generation-weighted average emission rate, excluding must run / low running cost facilities. The low-running cost facilities are defined as hydro, geothermal, wind, low-cost biomass and solar. The point is made that renewables are excluded from the calculation as they have no associated fuel costs and further that "*The resulting baseline under these conditions will include an average of all coal, oil, gas and higher-cost biomass resources. It would be a mix of both base load and peaking facilities which is appropriate given that most projects will avoid a mix of both types.*"[18] The current operating margin mix can be derived from data published by the SEI[9]. The frequency of the top eight facilities operating as marginal load over the period July to October 2006 is shown in Table A11 (accounting for 80.8% of the period):

Table A11 indicates that the current marginal operating mix is 53% gas, 28% oil and 19% coal leading to an average fuel emission rate as shown in Table A12:

Base on the SEI future scenarios[9], oil will be phased out over the next few years and will generally be replaced by natural gas. Thus it has been assumed that by 2012, all oil facilities will be decommissioned and have been replaced with CCGT facilities using natural gas as shown in Table A13:

Build Margin approach makes a "best guess" as to what type of electric facility would have otherwise been built (or built sooner) had the project not been implemented. Several methodologies are available including the "single proxy plant method" which is assumed to be a CCGT or the "cohert method" which is based on the average of the 20%, or 5, most recent plants, whichever is greater. In this context, plans are underway for several new CCGT plants. The ESB is constructing a new CCGT in Aghada, Cork at 430MW which should be open by 2010. Other recent additions include the Huntstown facility in Dublin at 345MW CCGT and the Aughinish facility which is 150MW CHP. Two new peat facilities have also recently been opened accounting for 91 and 137MW capacity[15]. Thus a reasonable estimate of the build margin would be to assume the emission rate equivalent to a CCGT which is 400 kg_{CO2eq} / MWh[19].

Thus the combined margin in 2012 will be:

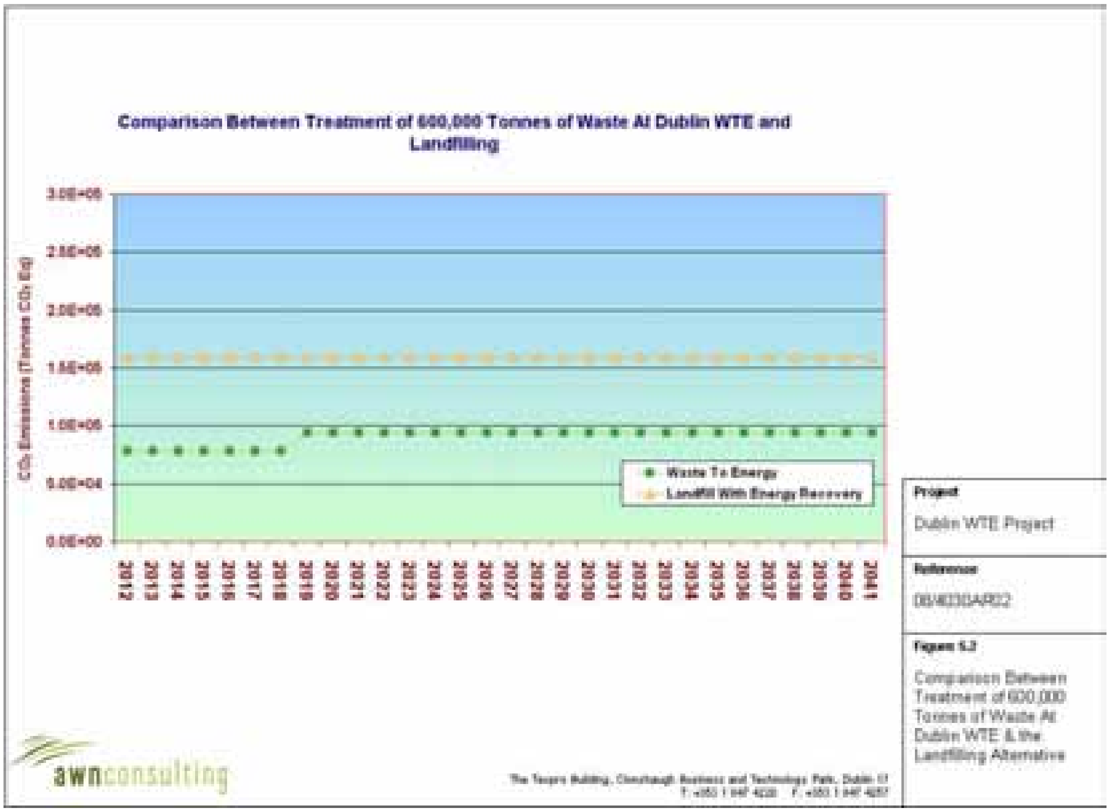
Combined Margin = (Operating Margin$_{Year1}$ + Build Margin$_{historical}$) /2

Combined Margin = (468 + 400) /2 = 434 kg_{CO2eq} / MWh

The research paper suggests that this approach is appropriate for the first seven years of the project. For the period Year 8 - 15 it is assumed that the build margin represents the average of new plant additions during the first seven years of the project. Again, it is reasonable to assume that build margin in this period will be based on CCGT which is 400 kg_{CO2eq} / MWh.

5.2 Net Emissions from 600,000 Tonnes of Waste: Incineration vs Landfilling

Figure 5.2 outlines the anthropogenic CO_2 emissions from Incineration of 600,000 tonnes of MSW compared to the landfilling of the waste (assuming 75% landfill gas capture rate) using the combined margin approach for displaced power.



Result - Assuming the displaced fuel is the combined margin 2012 fuel mix as a starting point and with the fuel mix decreasing to 0.40 tonnes CO eq / MWe which is equivalent to the emissions from a CCGT in 2019, the time series indicates that incineration is more favourable than landfilling in all years. The results are summarised in Table 5.1:

Table 5.1 Anthropogenic CO_2 Emissions Due to Incineration of 600,000 tonnes of MSW vs Landfilling (tonnes CO_2 eq).

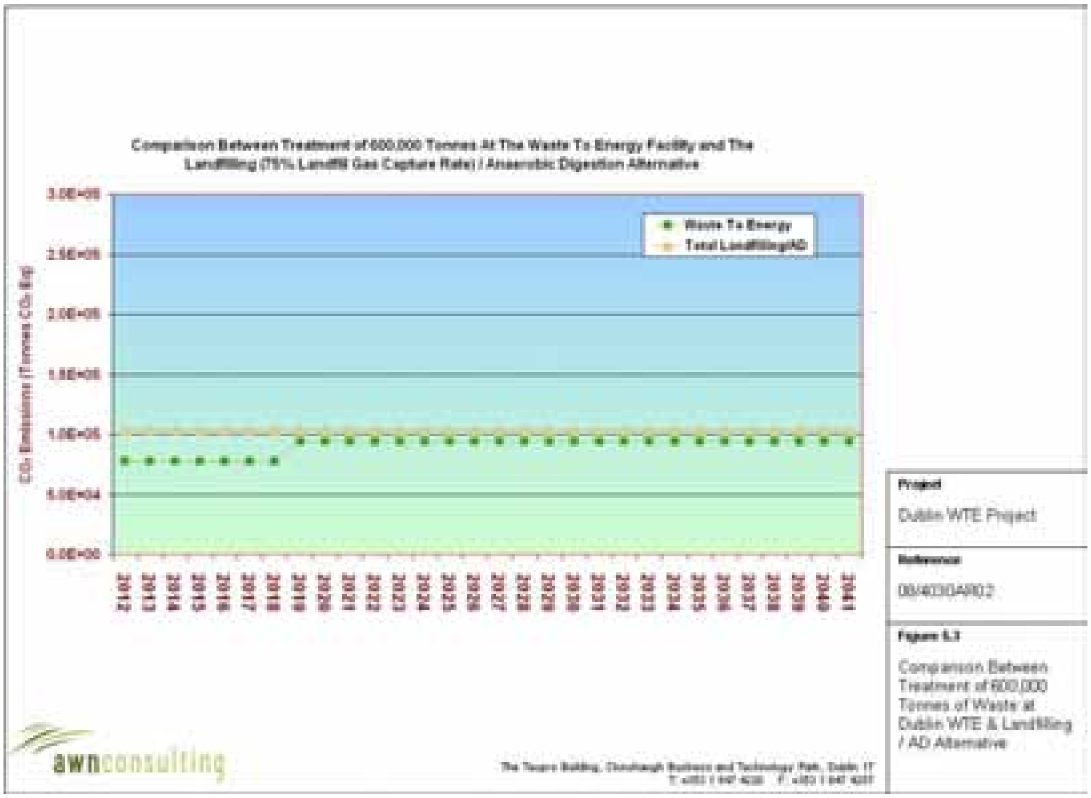
	2012	2041	Overall
Incineration	77,801	93,904	2,704,397
Landfilling	159,467	159,467	4,784,000
Balance	-81,665	-65,563	-2,079,603
% of Kyoto Target(1)	-0.13%	-0.10%	-0.11%

(1) Kyoto Target is 63.032 Mt CO2 Eq.
(2) On an annualised basis.

Summary - The results indicate that incineration is more favourable than landfilling over the lifetime of the facility by 0.11% of the Kyoto target.

5.3 Net Emissions from 600,000 Tonnes of Waste: Incineration vs Landfilling With AD of Organic Waste

Figure 5.3 outlines the anthropogenic CO_2 emissions from Incineration of 600,000 tonnes of MSW compared to the AD of all residual organic waste (assumed to be 144,031 tonnes of waste with a ratio of 90:10 organics:paper) and the landfilling of the remaining waste (assuming 75% landfill gas capture rate).



Result - The time series indicates that incineration is more favourable than landfilling / AD in all years. The results are summarised in Table 5.2:

Table 5.2: Anthropogenic CO_2 Emissions Due to Incineration of 600,000 tonnes of MSW (tonnes CO_2 eq) Compared To AD / Landfilling alternative.

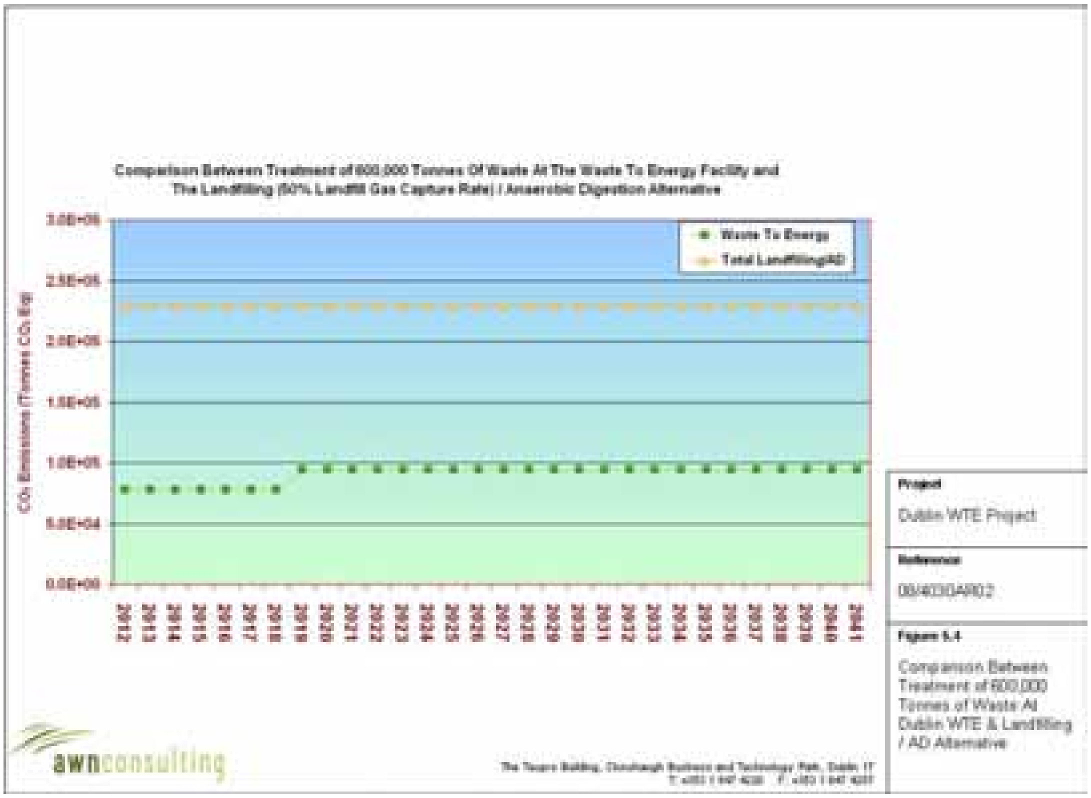
	2012	2041	Overall
Incineration	77,801	93,904	2,704,397
Landfilling	103,692	103,692	3,110,769
Balance	-25,891	-9,789	-406,372
% of Kyoto Target(1)	-0.04%	-0.02%	-0.02%

(1) Kyoto Target is 63.032 Mt CO2 Eq.
(2) On an annualised basis.

Summary - The results indicate that the facility is more favourable than landfilling (assuming 75% landfill gas capture rate) with AD over the lifetime of the facility by 0.02% of the Kyoto target.

5.4 Net Emissions from 600,000 Tonnes of Waste: Incineration vs Landfilling With AD of Organic Waste (50% Landfill Gas Capture Rate)

Figure 5.4 outlines the anthropogenic CO_2 emissions from Incineration of 600,000 tonnes of MSW compared to the Anaerobic Digestion (AD) of all organic waste (assumed to be 144,031 tonnes of waste with a ratio of 90:10 organics:paper) and the landfilling of the remaining waste (with a landfill gas capture rate of 50%).



Result - The time series indicates that incineration is more favourable than landfilling (50% gas capture rate) with AD. The results are summarized in Table 5.3:

Table 5.3: Anthropogenic CO_2 Emissions Due to Incineration of 600,000 tonnes of MSW (tonnes CO_2 eq) Compared To AD / Landfilling alternative.

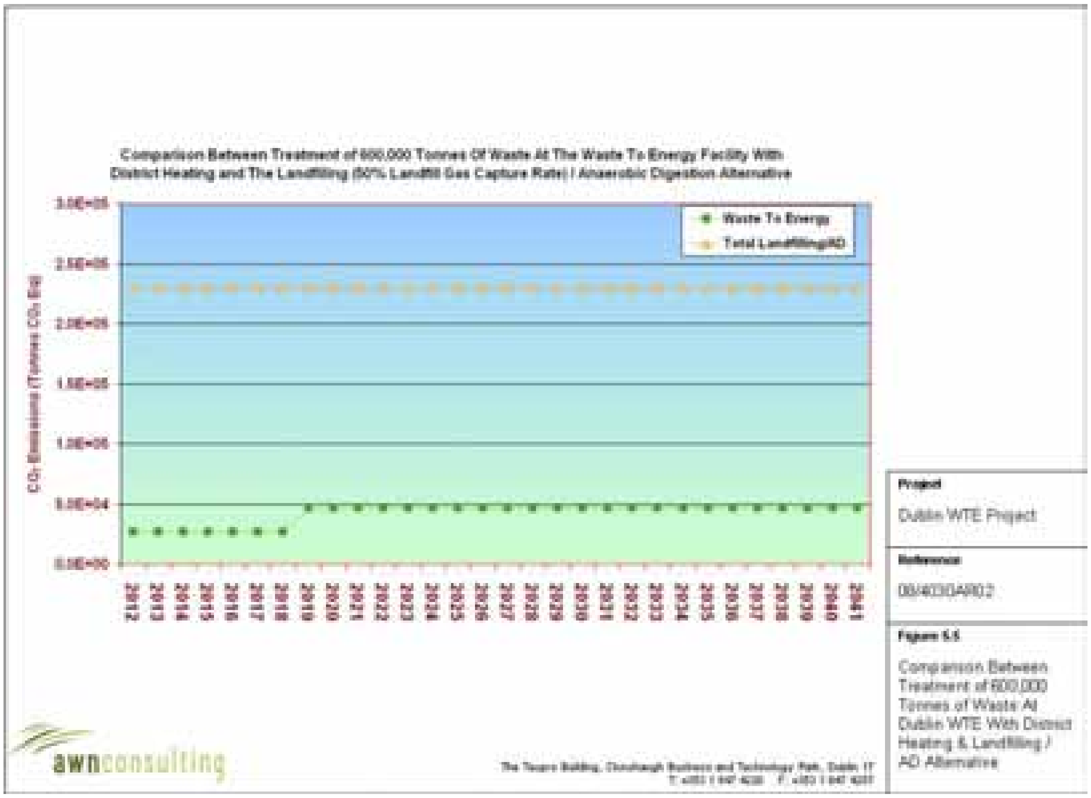
	2012	2041	Overall
Incineration	77,801	93,904	2,704,397
Landfilling	230,059	230,059	6,901,769
Balance	-152,258	-136,155	-4,197,372
% of Kyoto Target(1)	-0.24%	-0.22%	-0.22%

(1) Kyoto Target is 63.032 Mt CO2 Eq.
(2) On an annualised basis.

Summary - The results indicate that incineration is more favourable than landfilling (50% gas capture rate) with AD over the lifetime of the facility by 0.22% of the Kyoto target.

5.5 Net Emissions from 600,000 Tonnes of Waste: Incineration With District Heating vs Landfilling With AD of Organic Waste (50% Landfill Gas Capture Rate)

Figure 5.5 outlines the anthropogenic CO_2 emissions from Incineration of 600,000 tonnes of MSW (with district heating) compared to the AD of the organic waste (assumed to be 144,031 tonnes of waste with a ratio of 90:10 organics:paper) and the landfilling of the remaining waste (with a landfill gas capture rate of 50%).



Result - The time series indicates that incineration with district heating is more favourable than landfilling (50% gas capture rate) with AD. The results are summarised in Table 5.4:

Table 5.4: Anthropogenic CO_2 Emissions Due to Incineration of 600,000 tonnes of MSW (with district heating) (tonnes CO_2 eq) compared to AD / Landfilling alternative.

	2012	2041	Overall
Incineration	26,708	46,813	1,263,652
Landfilling	230,059	230,059	6,901,769
Balance	-203,351	-183,246	-5,638,117
% of Kyoto Target(1)	-0.32%	-0.29%	-0.30%

(1) Kyoto Target is 63.032 Mt CO2 Eq.
(2) On an annualised basis.

Summary - The results indicate that incineration is more favourable than landfilling (50% gas capture rate) with AD over the lifetime of the facility by 0.30% of the Kyoto target.

5.6 Sequestration / Biogenic Fraction of Waste

The Intergovernmental Panel on Climate Change (IPCC) has recently published updated detailed guidelines on compiling National Greenhouse Gas Inventories. The guidelines are designed to estimate and report on national inventories of anthropogenic greenhouse gas emissions and removals in order to ensure compliance with the Kyoto Protocol. Anthropogenic refers to greenhouse gas emissions and removals that are a direct result of human activities or are a result of natural processes that have been affected by human activities(5). The quantity of carbon from natural cycles through the earth's atmosphere, waters, soils and biota is much greater than the quantity added by anthropogenic GHG sources. However, the focus of the UNFCCC and the IPCC is on anthropogenic emissions because it is these emissions that have the potential to alter the climate by disrupting the natural balances in carbon's biogeochemical cycle, and altering the atmosphere's heat-trapping ability. The carbon from biogenic sources such as paper and food waste was originally removed from the atmosphere by photosynthesis, and under natural conditions, it would eventually cycle back to the atmosphere as CO_2 due to degradation processes. Thus, these sources of carbon are not considered anthropogenic sources and do not contribute to emission totals considered in the Kyoto Protocol(5).

In relation to solid waste disposal sites (SWDSs) including municipal landfills, detailed guidelines have been outlined for the calculation of GHG emissions(5). The main GHG emission from SWDSs is methane. Even though the source of carbon is primarily biogenic, CH_4 would not be emitted were it not for the human activity of landfilling the waste, which creates anaerobic conditions conducive to CH_4 formation. Although CO_2 is also produced in substantial amounts, the primary source of CO_2 derives from the decomposition of organic material derived from biomass sources (crops, forests) which are re-grown on an annual basis. Hence, these CO_2 emissions are not treated as net emissions from waste in the IPCC Methodology(5).

Similarly, in relation to incineration, a large fraction of the carbon in waste combusted (paper, food waste) is derived from biomass raw materials which are replaced by re-growth on an annual basis. Thus, these emissions should not be considered as net anthropogenic CO_2 emissions in the IPCC Methodology(5). On the other hand, some carbon in waste is in the form of plastics or other products based on fossil fuel. Combustion of these products, like fossil fuel combustion, releases net CO_2 emissions. Thus, in estimating emissions from waste incineration, the desired approach is to separate carbon in the incinerated waste into biomass and fossil fuel based fractions and thereafter to use only the fossil fuel fraction in calculating net carbon emissions(5). Other relevant gases released from combustion are net GHG emissions including CH_4 and N_2O. The IPCC Guidelines does state that if incineration of waste is used for energy purposes, both fossil biogenic CO_2 emissions should be estimated. Only fossil CO_2 should be included in the national emissions under Energy Sector while biogenic CO_2 should be reported as an information item also in the Energy Sector(5). For informational purposes the biogenic carbon emissions from the operation of the waste to energy facility are outlined below in Table 5.5:

Table 5.5: Biogenic CO_2 Emissions Due To The Operation of The Dublin Waste to Energy Facility

Scenario	Biogenic CO_2 Emissions (Tonnes CO_{2Eq} / Annum)
600,000 Tonnes Incinerated (Residual Waste)	375,583

Greenhouse gases have different efficiencies in retaining solar energy in the atmosphere and different lifetimes in the atmosphere. In order to compare different greenhouse gases, emissions are calculated on the basis of their Global Warming Potential (GWPs) over a 100-year period, giving a measure of their relative heating effect in the atmosphere. The GWP100 for CO_2 is the basic unit (GWP = 1) whereas CH_4 has a global warming potential equivalent to

21 units of CO_2 and N_2O has a GWP100 of 310. Thus the issue of the lifetime of gases in the atmosphere has already been taken into account in the calculation of the GWP100.

In line with IPCC methodology, all greenhouse gas fluxes are treated as though they take place instantaneously. Although landfill emissions occur over decades the total emissions are what is important so the phasing of emissions within the 100-year time horizon can be ignored[(5)].

The UK DEFRA has recently commissioned a report, undertaken by AEA Technology, entitled "The Social Costs OF Carbon Review"[(21)]. The report investigates the social cost of methane emissions and indicates that the social cost of methane emissions will increase much faster than CO_2 emissions. The report further states that "*This is because of the short atmospheric lifetime of methane; any methane emitted today will have disappeared from the atmosphere before the most severe climate change impacts start. This implies that given a choice today between emitting 1 tonne of methane now , or at some time up to 60 years in the future, we should opt to emit it now*." In this context, the emission of methane from landfills which can occur over a period of greater than 100 years will have greater social costs than instantaneous emissions of greenhouse gases such as the emissions associated with the proposed Dublin WTE Project.

5.7 Summary

Using the 2006 IPCC methodology rules[(5)], incineration of waste at the Dublin WTE facility is a better climatic option than the alternative landfilling of this waste. The incineration of waste at the Dublin WTE facility is also a better option than anaerobically digesting all organic waste with the remaining waste landfilled using a realistic landfill gas capture rate of 50% which is a rate more typical of the real world[(5,20)] and even when using the aspiration 75% gas capture rate. The incineration of waste at the Dublin WTE facility becomes even more favourable when district heating is taken into account.

In summary, incineration of mixed MSW is a more favourable option from a climate perspective, under the IPCC rules, both currently and into the foreseeable future than either landfilling alone or the option of landfilling of inert material with the AD of biogenic material.

5.8 REFERENCES

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APPENDIX 1

Table A1: Composition of Household and Commercial Waste Landfilled In Ireland In 2005[1]

Material	Household		Commercial		Total	
	(%)	(tonnes/annum)	(%)	(tonnes/annum)	(%)	(tonnes/annum)
Paper	19.2%	229223	35.0%	220734	24.7%	449957
Glass	3.7%	44173	1.5%	9288	2.9%	53461
Plastic	13.8%	164754	12.2%	76669	13.2%	241424
Ferrous	1.5%	17908	1.0%	6296	1.3%	24204
Aluminium	1.4%	16714	0.6%	3566	1.1%	20281
Other Metals	0.4%	4775	1.2%	7746	0.7%	12521
Textiles	11.0%	131326	2.5%	15464	8.0%	146790
Organics	36.2%	432182	37.3%	235331	36.6%	667512
WEEE	0.8%	9551	0.4%	2761	0.7%	12312
Wood	0.9%	10745	0.5%	3194	0.8%	13939
Others	11.1%	132520	7.8%	49145	10.0%	181664
Total Fossil Fuel[1]	24.9%	296677	17.3%	108974	**22.2**	405651
Total Non-Fossil Fuel	75.1%	897194	82.7%	521220	**77.8**	1418414
Total	100%	1,193,871	100%	630,194	100%	1,824,065

Note: "Others" mainly refers to composites, fine elements such as ash, unclassified incombustibles and unclassified combustibles including wood wastes.

(1) Derived from plastics (100%), Others (50%) and Textiles (50%) only.

Table A2: Composition of Household and Commercial Waste Projected To Arise In Dublin In 2012 and Assuming the Individual Household and Commercial Waste Breakdown Remains Unchanged[1,2]

Material	Household		Commercial		Total	
	(%)	(tonnes/annum)	(%)	(tonnes/annum)	(%)	(tonnes/annum)
Paper	19.2%	86775	35.0%	104354	25.5%	191129
Glass	3.7%	16722	1.5%	4391	2.8%	21113
Plastic	13.8%	62370	12.2%	36246	13.2%	98616
Ferrous	1.5%	6779	1.0%	2976	1.3%	9756
Aluminium	1.4%	6327	0.6%	1686	1.1%	8013
Other Metals	0.4%	1808	1.2%	3662	0.7%	5470
Textiles	11.0%	49715	2.5%	7311	7.6%	57026
Organics	36.2%	163608	37.3%	111255	36.7%	274863
WEEE	0.8%	3616	0.4%	1305	0.7%	4921
Wood	0.9%	4068	0.5%	1510	0.7%	5578
Others	11.1%	50167	7.8%	23234	9.8%	73401
Total Fossil Fuel[1]	24.9%	112311	17.3%	51518	21.9%	163829
Total Non-Fossil Fuel	75.2%	339643	82.7%	246412	78.2%	586055
Total	100%	451954	100%	297930	100%	**749884**

Note: "Others" mainly refers to composites, fine elements such as ash, unclassified incombustibles and unclassified combustibles including wood wastes.

(1) Derived from plastics (100%), Others (50%) and Textiles (50%) only.

Table A3: Composition of Household and Commercial Waste Projected To Arise In Dublin In 2012 and Allowing for the Biological Treatment of 165,000 Tonnes of Waste (assumed to consist of 90:10 organic:paper)[1,2]

Material	**Household**		**Commercial**		**Total**	
	(%)	**(tonnes/annum)**	**(%)**	**(tonnes/annum)**	**(%)**	**(tonnes/annum)**
Paper	21.5%	77775	43.4%	96854	29.9%	174629
Glass	4.6%	16722	2.0%	4391	3.6%	21113
Plastic	17.2%	62370	16.3%	36246	16.9%	98616
Ferrous	1.9%	6779	1.3%	2976	1.7%	9756
Aluminium	1.7%	6327	0.8%	1686	1.4%	8013
Other Metals	0.5%	1808	1.6%	3662	0.9%	5470
Textiles	13.7%	49715	3.3%	7311	9.7%	57026
Organics	22.8%	82608	19.6%	43755	21.6%	126363
WEEE	1.0%	3616	0.6%	1305	0.8%	4921
Wood	1.1%	4068	0.7%	1510	1.0%	5578
Others	13.9%	50167	10.4%	23234	12.5%	73401
Total Fossil Fuel[1]	31.0%	112311	23.1%	51518	28.0%	163829
Total Non-Fossil Fuel	69.0%	249643	76.9%	171412	72.0%	421055
Total	100%	361954	100%	222930	100%	584884

Note: "Others" mainly refers to composites, fine elements such as ash, unclassified incombustibles and unclassified combustibles including wood wastes.

(1) Derived from plastics (100%), Others (50%) and Textiles (50%) only.

Table A4: Breakdown of the category "Others" which was recovered in 2004 (EPA, 2007 (Private Communication).

Waste Type	**Tonnage Recovered**
Composite Packaging (Tetra Pak)	992
Waste Oil	22,287
Cooking Oil	4,530
Refuse Derived Fuel (RDF)	70,139
Tyres	35
Batteries	5643
Total	**103,626**

Type	Waste Totals	Waste Fraction	Total Carbon Content (wet)	Fossil Carbon Fraction	CO_2 Emissions (Tonnes/Annum)
Paper	179142	29.9%	31.9%	0.0%	
Glass	21659	3.6%	0.3%	0.0%	
Plastic	101164	16.9%	51.3%	100.0%	190,290
Ferrous	10008	1.7%	0.0%	100.0%	
Aluminium	8220	1.4%	0.0%	100.0%	
Other Metals	5611	0.9%	0.0%	100.0%	
Textiles	58500	9.7%	39.9%	50.0%	42,792
Organics	129628	21.6%	13.5%	0.2%	128
WEEE	5048	0.8%	0.0%	100.0%	
Wood	5722	1.0%	42.5%	0.0%	
Others	75298	12.5%	21.8%	50.0%	30,094
Total	600000	100.0%			**263,305**

Table A5: Anthropogenic CO_2 Emissions From Incineration of 600,000 tonnes of MSW (tonnes CO_2 eq) Based On UK Guidance[6,7]

Type	Waste Totals	Waste Fraction	Total Carbon Content (wet)	Fossil Carbon Fraction	CO_2 Emissions (Tonnes/Annum)
Paper	179142	29.9%	33.0%	0.0%	
Glass	21659	3.6%	0.0%	0.0%	
Plastic	101164	16.9%	61.0%	100.0%	226,271
Ferrous	10008	1.7%	0.0%	100.0%	
Aluminium	8220	1.4%	0.0%	100.0%	
Other Metals	5611	0.9%	0.0%	100.0%	
Textiles	58500	9.7%	39.0%	50.0%	41,827
Organics	129628	21.6%	19.0%	0.2%	181
WEEE	5048	0.8%	0.0%	100.0%	
Wood	5722	1.0%	42.5%	0.0%	
Others	75298	12.5%	24.0%	29.0%	19,216
Total	600000	100%			**287,494**

Table A6: Anthropogenic CO_2 Emissions From Incineration of 600,000 tonnes of MSW (tonnes CO_2 eq) Based On EU Guidance[8]

Type	Waste Totals	Waste Fraction	Total Carbon Content (wet)	Fossil Carbon Fraction	CO_2 Emissions (Tonnes/Annum)
Paper	179,142	29.9%	41.4%	1.0%	2,719
Glass	21,659	3.6%	0.0%	0.0%	
Plastic	101,164	16.9%	75.0%	100.0%	278,202
Ferrous	10,008	1.7%	0.0%	100.0%	
Aluminium	8,220	1.4%	0.0%	100.0%	
Other Metals	5,611	0.9%	0.0%	100.0%	
Textiles	58,500	9.7%	40.0%	40.0%	34,320
Organics	129,628	21.6%	16.2%	0.2%	154
WEEE	5,048	0.8%	0.0%	100.0%	
Wood	5,722	1.0%	42.5%	0.0%	
Others	75,298	12.5%	2.7%	100.0%	7,454
Total	600,000	100%			**322,849**

Table A7: Anthropogenic CO_2 Emissions From Incineration of 600,000 tonnes of MSW (tonnes CO_2 eq) Based On IPCC Guidance[5]

Waste Type	Tonnage of Waste (based on 600,000 tonne facility)[1]	Tonnes CO_2 eq / 600,000 Tonnes of Waste
Plastics	101,164	208,280
Textiles	58,500	42,310
Others	75,298	24,655
Organics	129,628	154
Total CO_2 Emissions		**275,399**
Total GHG Emissions		**283,343**

Table A8: Anthropogenic CO_2 Emissions From The Incineration of 600,000 tonnes of MSW (tonnes CO_2 eq) Based On The Mean Carbon Content and Fossil Carbon Fraction Using Both UK and EU Data.

Table A9: Breakdown by Fuel Type of installed electricity plants in Ireland in 2006[9].

Fuel Type	MW	% of Total Installed MW	% of Actual Generation Output
Gas	3111	45%	44%
Coal	858	13%	25%
Oil	1014	15%	13%
Dispatchable Hydro	508	7%	7%
Peat	346	5%	10%
Non-dispatchable[1]	1007	15%	8%
Total	6843		

(1) Non-dispatchable includes wind (12%) and hydro, biomass, CHP and industrial generation (accounting for 3%)

Table A10: Number of Thermal Plants Displaced By Wind[17].

Wind (MW)	Displaced Thermal Plant			
	235 MW CCGT	**67.3 MW OCGT**	**29.9 MW OCGT**	**Total MW**
1500	1	1	1	332
2500	1	2	2	429
3500	1	3	2	496

Table A11: Generators Operating At Margin Load in 2006[9].

Generator	MW	Fuel	% of Time[1]
Aghada CT1	269	Gas	20.1
Tarbet 4	241	HFO	14.3
Poolbeg C	474	Gas	12.4
Moneypoint 2	305	Coal	9.2
Tarbet 3	241	HFO	8.1
Moneypoint 1	305	305	6.4
Poolbeg 2	115	Gas	5.8
Poolbeg 1	115	Gas	4.5

(1) Accounts for 80.8% of the period with 19.2% of the period due to an additional 24 generators.

Table A12: Fuel Mix Operating At Margin Load in 2006[9].

Fuel	% of Time	Emission Rate[19] (kg_{CO2eq} / MWh)
Gas	53.0%	400
Oil	27.7%	550
Coal	19.3%	750
Average	100%	**509**

Table A13: Assumed Fuel Mix Operating At Margin Load in 2012[9].

Fuel	% of Time	Emission Rate[19] (kg_{CO2eq} / MWh)
Gas	90.7%	400
Oil	0%	550
Coal	19.3%	750
Average	100%	**468**