APPLICATION

By

Donegal County Council

to

Environmental Protection Agency

for

Waste Licence Review

W0024-02

Ballynacarrick Landfill Site,
Ballintra County Donegal

ATTACHMENTS TO SECTION G

Resource Use and Energy Efficiency

ATTACHMENTS TO SECTION G RESOUCE USE AND ENERGY EFFICICENCY

CONTENTS

ATTACHMENTS TO SECTION G

Attachment G.1 Raw Materials, Substances, Preparations

Data and safety sheets for insecticide and pesticide used on site are included. These are not stored on site.

Attachment G.2 Energy Efficiency

Energy Audit has been included.

APPENDIX G

Data and Safety Sheets

Energy Audit

BEFORE USING ANY PRODUCT READ THE LABEL CAREFULLY.

Issue No: LEAF83200 Date: July 1989

Sorex Limited, St. Michael's Industrial Estate, Widnes, Cheshire. WA8 8TJ.
Telephone: 051-420 7151. Telex: 627329 SOREX G. Fax: 051-495 1163.

SOREX

BRODIFACOUM BAIT BLOCKS

PRODUCT SAFETY DATA SHEET

PRODUCT BRODIFACOUM BAIT BLOCKS CODE BROD83200

INTENDED USE FOR USE ONLY AS A RODENTICIDE

Approved under The Control of Pesticides Regulations 1986 for the control of rats and mice.

Approval number : MAFF 04590

HAZARDOUS COMPONENTS

Common Name	Chemical Name (IUPAC)	CAS No :	% m/m
brodifacoum	3-3-(4'-bromobiphenyl-4-yl)-1,2,3,4-tetrahydro-1-naphthyl-4-hydroxycoumarin	(56073-10-0)	0.002

COMPOSITION

A wax-bound bait containing 20ppm (0.002% m/m) brodifacoum, a purple warning dye, flavouring agent and stabilisers on a cereal base.

PHYSICAL/CHEMICAL CHARACTERISTICS

Appearance	:	A briquette shaped wax-bound block, purple in colour with no significant odour.
Flash point	:	Not applicable.
Flammability	:	Non-flammable but combustible.
Solubility	:	Formulated product : insoluble in water. Technical material : <10mg/litre in water (pH7) Moderately soluble in organic solvents.

ENVIRONMENTAL HAZARDS

Brodifacoum bait blocks are hazardous to mammals, including domesticated animals, and birds if ingested

Access to bait by non-target animals should be prevented.

HEALTH HAZARDS

Occupational Exposure Limit : Not yet established.

Toxicity Data : Acute oral LD_{50} to rats is 13,500mgkg^{-1} (by extrapolation).

Health Hazards : Hazardous if ingested, but large quantities would need to be ingested to produce a toxic effect. Practically non-hazardous by skin contact.

Precautions :

AVOID ALL CONTACT BY MOUTH.

WASH HANDS AND EXPOSED SKIN before eating, drinking or smoking, and after work.

DO NOT LAY BAIT where food, feed or water could become contaminated.

PREVENT ACCESS TO THE BAIT by children, domesticated animals, particularly dogs and birds.

DO NOT USE OUTDOORS.

REMOVE ALL REMAINS OF BAIT after treatment and burn.

SEARCH FOR AND BURN ALL RODENT BODIES. DO NOT PLACE in refuse bins or on rubbish tips.

KEEP IN ORIGINAL CONTAINER, tightly closed, in a safe place under lock and key.

EMPTY CONTAINER COMPLETELY and dispose of safely.

FIRST AID

Ingestion	:	Do not induce vomiting. Rinse out mouth. If swallowed, obtain medical advice immediately.
Skin contact	:	Wash off with soap and water.
Eye contact	:	Flush thoroughly with water.
Inhalation	:	Unlikely to occur.

GUIDE TO DOCTOR

Brodifacoum is an indirect anticoagulant. Vitamin K1 (phytomenadione) is antidotal. Poisoning is unlikely unless large quantities have been ingested.

Symptoms : Clinical signs are unlikely to occur until 18h after ingestion, thereafter they may develop rapidly. Clinical signs result from an increased bleeding tendency and include: an increase in prothrombin time, bruising easily with occasional nose or gum bleeds, blood in stools or urine, excessive bleeding from minor cuts and abrasions, pale mouth and cold gums, anorexia and general weakness. In severe cases of poisoning include haemorrhage (usually internal), shock and coma.

Medical Advice : In case of suspected poisoning, determine prothrombin times not less than eighteen hours after consumption. If elevated, administer vitamin K1 and continue until prothrombin times normalise. Continue determination of prothrombin time for three days after withdrawal of antidote and resume treatment if elevation occurs in that time.

For comprehensive medical advice on the treatment of poisoning, contact the nearest Poisons Information Centre or Sorex.

STORAGE AND TRANSPORT

Storage : This product is subject to the Food and Environment Protection Act, 1985, and The Control of Pesticides Regulations, 1986, made under it.

Store in original container under cool and dry conditions in a secure, well ventilated place, inaccessible to children and animals and away from foodstuffs, animal feedstuffs and products which may have an odour. Prevent attack by grain pests.

Transport U.K. : This product is non-hazardous under The Classification, Packaging and Labelling of Dangerous Substances Regulations, 1984.

EMERGENCY PROCEDURES

Fire : This product is non-flammable, but is combustible. In case of fire, extinguish with water spray, CO_2, foam, or dry powder.

Avoid run-off into water courses.

Self-contained breathing apparatus should be worn by fire-fighting personnel.

Spillage : Any spillages should be cleared up immediately. Sweep up any spillages and dispose of safely (see below). Wash surfaces with detergent solution.

DISPOSAL

Product : Incinerate under controlled conditions, or arrange disposal through Local Authority (Environmental Health Department) or reputable waste disposal contractor.

Do not dispose of product in domestic refuse.

Pack : Do not re-use packs. Empty completely, puncture or crush them and dispose of safely.

Do not dispose of the pack in domestic refuse.

BIO-INDUSTRIES GROUP©2002
CLEANING THE ENVIRONMENT NATURALLY

MATERIAL SAFETY DATA SHEET
(COMPLIES WITH C.O.S.H.H. REGULATIONS)

Date of Preparation 17/02/2002.

1. PRODUCT INFORMATION

1.1 Product Identifier:	BIOKILZ
1.2 Description:	Permethrin water based micro emulsion
	UN-NO. 1993 (from the concentrate)
1.2.1 IUPAC Name:	3-phenoxybenzyl (1RS, 3RS; 1RS, 3SR)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate)
1.2.2 Product Type:	A synthetic pyrethroid insecticide containing 0.25% w/w concentrate , with cis:trans isomer ratio 25:75
1.3 Supplier:	Bio-Industries Ltd, Unit 66d Heather Road, Sandyford Industrial Estate, Dublin, Ireland.
1.4 Emergency Tel:	01-2941025
1.5 Application:	Insecticide for flying insects & crawling insects
Approval	HSE 7198 March 2001 UK

2. COMPOSITION & INFORMATION ON INGREDIENTS

2.1 INGREDIENTS:	Permethrin { 93% technical grade} (Xn, R22; N, R50, R53)
	Alkylaryl Sulphonate (Xi, R36/38)
	Petroleum distillates (R10)
2.2 Cas No.	00052645-53-1

3. HAZARD IDENTIFICATION

TOXICITY:

Acute oral, rat:	not measurable
Acute dermal, rat:	not measurable
Inhalation:	not measurable

May cause transient irritation of the eyes, skin and mucous membranes.
Very toxic to aquatic organisms. May cause long-term adverse effects in the aquatic environment.

4. FIRST AID MEASURES

4.1 Eye: Wash eyes with water for atleast 15 minutes. Seek medical advice immediately.
Symptoms: Transient eye irritation may occur.

4.2 Skin: Remove any contaminated clothing and shoes (and launder clothes before reuse). Wash off skin immediately with soap and plenty of water.

Seek medical advice if irritation occurs/persist.

Symptoms: Transient eye irriation may occur.

4.3 Ingestion: Not applicable
4.4 Inhalation: Not applicable

5. FIRE FIGHTING MEASURES

5.1 Non Flammable Product; water based emulsion.

6.0 ACCIDENTAL RELEASE MEASURES : Not necessary

7. HANDLING AND STORAGE

7.1 Storage : Keep in original container-tightly closed. Do not expose to temperatures exceeding 60 degrees Centigrade. Store under cool, dry, well ventilated conditions. But below 0 degree Centigrade.
Keep out of reach of children. Keep away from food, drink and animal feeding stuffs.

7.2 Shelf life: More than 2 years at temperatures not exceeding 35 degrees centigrade (see individual concentrate container for expiry date)

7.3 Recommended packaging materials: See specific packaging of the bottles.
7.4 Precautions: No specific precautions.

8. EXPOSURE CONTROLS AND PERSONAL PROTECTION

Ventilate area where product is handled.

Occupational Exposure Limit: Not applicable.

Personal protective equipment : rubber or PVC gloves should be worn. Masks not necessary.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State	:	Milky emulsion in water
Solubility	:	n.a.
Density	:	0.998-1.000g/ml
Vapour pressure	:	n.a.
Flash point	:	less than 78 degrees Centigrade
Melting point	:	n.a.
Boiling point	:	less than 100 degrees centigrade/0.1mmhg (approx)
Auto-ignition temp.	:	Exothermic decomposition 270-330 degrees centigrades

10. STABILITY & REACTIVITY

Hazardous reaction	:	Avoid strong oxidisers, acids and alkalies
Hazardous decomposition products	:	Combustion or thermal decomposition will evolve toxic and irritant vapours, including oxides of carbon and hydrogen chloride.
Heat stability	:	Do not expose to temperatures exceeding 60 degrees Centrigrades. Prefrential isomer crystallization may occur below 35 degrees Centigrades

11. TOXICOLOGICAL INFORMATION

From the BIOKILZ

Oral LD (Male & Female rat)	:	less than 5000mg/kg
Dermal LD (male & Female rat)	:	less than 2000 mg/kg
Inhalation LC50 (rat) 4hr	:	less than 3942 mg/m3
Irritancy Potential	:	substance is not an eye or skin irritant in primary test
Possible Product Symptoms	:	Transient skin irritation Transient eye irritation

ECOLOGICAL INFORMATION

Do not contaminate ponds, ditches, waterways or ground with the product or used containers. Do not allow to enter drains and sewers.
BIO KILZ is not persistent in the environment. It is destroyed by soil micro-organisms and does not leave residues in the environment or build up in food chains. Very toxic to fish and other aquatic life.

BIO KILZ LC50 (acetone, 96 hr) from BIO KILZ not measurable.

Rainbow Trout	0.019 mg/l
Bluegill Sunfish	0.032 mg/l
Daphnia (EC50, 48 hr)	0.002 mg/l

12. DISPOSAL CONSIDERATION

No specific instructions.

13. TRANSPORT INFORMATION

Not regulated

14. REGULATORY INFORMATION

Labelling: Special label for each country where the product is registered. Refer to any relevant national/international regulations for the protection of man and the environment.

15. OTHER INFORMATION

The information provided in this Safety Data Sheet is supplied in good faith and is accurate at the date of publication. The intention is to give sufficient information about the product and its properties to enable the user to formulate his own procedures for the safe use of the product in terms of health and safety of all concerned and the protection of the environment.

The information will be updated as when appropriate. It is not a specification of the product nor does it list the uses, for which the label on the container should be carefully studied.

In compiling the Safety Data Sheet due account has been taken of all proper and recommended applications of the product of which we are aware and any user must consult us before applying it to any novel or unusual use. The company accepts no responsibility unless the product is used as recommended.

Agrochemicals

Product Safety Data Sheet

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND COMPANY /UNDERTAKING

PRODUCT NAME: 'KLERAT' WAX BLOCKS

Address/Phone No.: College Park House,
20 Nassau Street,
Dublin 2.

Tel. (01) 6795799

EMERGENCY PHONE No. (0044) 622 81 4777 anytime
ICI Ireland Ltd, Dublin (01) 6795799
Poisons Centre, Dublin (01) 379966

2. COMPOSITION/INFORMATION ON INGREDIENTS

Anticoagulant rodenticide bait consisting of paraffin wax blocks, each weighing 20g, containing 0.005% w/w brodifacoum.

MAFF No. : 04746
Product Code : 65484
EINECS No. : 259-980-5 : brodifacoum

HAZARDOUS INGREDIENT (S)	CAS No.	%(w/w)	Symbol	R Phrases
Brodifacoum	056073-10-0	0.005	T+	R26/27/28

3. HAZARDS IDENTIFICATION

Unlikely to cause harmful effects under normal conditions of handling and use.

4. FIRST-AID MEASURES

Symptoms of poisoning are typical of anticoagulants. In severe cases there may be bruising, haematomas of the joints, blood in the faeces and urine. An antidote, Vitamin K1 (Phytomenadione BP), should only be administered under the direction of a doctor who has access to a hospital laboratory. Doctors should refer to the ICI leaflet 'The treatment of Anticoagulant Poisoning', 1988.

INHALATION
Unlikely to be hazardous by inhalation unless heated. Remove patient from exposure, keep warm and at rest. Obtain medical attention as a precaution.

SKIN CONTACT
Unlikely to cause harmful effects under normal conditions of handling and use. Take off immediately all contaminated clothing. Wash skin immediately with water, followed by soap and water.

EYE CONTACT
Immediately irrigate with eye wash solution or clean water, holding the eyelids apart, for at least 10 minutes. Obtain immediate medical attention.

INGESTION
ALL POISONED PATIENTS MUST BE TAKEN TO HOSPITAL IMMEDIATELY.
Refer to the ICI leaflet 'The treatment of Anticoagulant Rodenticide Poisoning', 1988.
Do not induce vomiting.

FURTHER MEDICAL TREATMENT
Gastric lavage may be effective when performed within 4 hours of ingestion.
Doctors should refer to the ICI leaflet 'The treatment of Anticoagulant Rodenticide Poisoning', 1988.

5. FIRE-FIGHTING MEASURES

Keep fire exposed containers cool by spraying with water.

EXTINGUISHING MEDIA

For small fires, use foam, carbon dioxide, dry powder or halon extinguishant. For large fires, use foam or waterlog: avoid use of water jet: Contain run-off water with, for example, temporary earth barriers.

FIRE FIGHTING PROTECTIVE EQUIPMENT

A self-contained breathing apparatus and suitable protective clothing should be worn in fire conditions.

6. ACCIDENTIAL RELEASE MEASURES

Sweep up and shovel into waste drums or plastic bags. Protect against dust. Wash the spillage area with water. Washings must be prevented from entering surface water drains.
Spillage or uncontrolled discharges into water courses must be alerted to the appropriate regulatory body.

7. HANDLING AND STORAGE

7.1 HANDLING

Read the label before use.
Avoid all contact by mouth. Wash hands and exposed skin after use. Avoid contact with eyes. When using do not eat, drink or smoke. Wash face and hands before eating, drinking and smoking. Prevent access to bait by domesticated animals.

7.2 STORAGE

Keep locked up. Keep in original containers, tightly closed, out of reach of children. Keep away from food, drink and animal feedingstuffs.
Storage Life : Physically and chemically stable for at least 2 years when stored in original unopened sales container at ambient temperature.

8. EXPOSURE CONTROL/PERSONAL PROTECTION

When using this product refer to the label for details.

Occupational Exposure Limits

HAZARD INGREDIENT (S)	LTEL 8hr TWA ppm	mg/m	STEL ppm	mg/m	Time mins
Brodifacoum		0.002			

9. PHYSICAL AND CHEMICAL PROPERTIES

Form	: waxy solid
Colour	: dark blue
Odour	: odourless
pH (Value)	: Not available
Boiling Point (Deg C)	: Not available
Melting Point (Deg C)	: >50
Flash Point (Deg C)	: does not flash
Auto Ignition Temperature (Deg C)	: Not available
Explosive Properties	: Not available
Oxidising Properties	: Not available
Vapour Pressure (mm/Hg)	: Not available
Density (g/m/)	: 1.25
Solubility (water)	: Insoluble
Partition Coefficient	: Not available

10. STABILITY AND REACTIVITY

HAZARDOUS DECOMPOSITION PRODUCT (S)

Combustion or thermal decomposition will evolve toxic and irritant vapours.

11. TOXICOLOGICAL INFORMATION

INHALATION
Unlikely route of exposure.

SKIN CONTACT
By consideration of the components of this mixture it is unlikely to be irritant and harmful in contact with skin.
Dermal Median Lethal Dose (>2000mg formulation/kg) (rabbit).

EYE CONTACT
Unlikely to cause eye irritation.

INGESTION
Low oral toxicity.
Oral Median Lethal Dose (approx. 10g/kg- by calculation) (rat).

12. ECOLOGICAL INFORMATION

TOXICITY
This product is toxic to fish, birds and wildlife.

13. DISPOSAL CONSIDERATIONS

Do not contaminate ponds, waterways or ditches with chemical or used containers. Surplus material must be disposed of as detailed in the 'Guidelines for the avoidance, limitation and disposal of pesticide waste on the farm' GIFAP, 1987. Empty containers should not be washed and discharged. Empty containers should not be used for other purposes. Disposal should be in accordance with local, state or national legislation.

14. TRANSPORT INFORMATION

Not Classified as Hazardous for Transport.

15. REGULATORY INFORMATION

Not Classified as Hazardous to Users.
The safety phrases have been assigned by ICI Agrochemicals.
Users should ensure that they comply with any relevant local, state or national legislation.

EEC CLASSIFICATION	: Under the Classification, Packaging and Labelling of Dangerous Substances Regs, 1984, this material is not dangerous for supply or conveyance.
SAFETY PHRASES	: SO53: Do not reuse container, keep tightly closed in a safe place.
	: SO54: See instructions for use supplied separately.
	: DO1: Wash substances from skin or eyes immediately.

16. OTHER INFORMATION

This data sheet was prepared in accordance with Directive 91/155/EEC.

USE : A potent rodenticide, which can kill rodents with a single feed.

'Klerat' is a trademark of an ICI Group company.
Read the label before you buy: use pesticides safely.

GLOSSARY

OES	: Occupational Exposure Standard (UK HSE EH40)
MEL	: Maximum Exposure Limit (UK HSE EH40)
ICI	: ICI aims to control exposure in its workplaces to this limit
TLV	: ICI aims to control exposure in its workplaces to the ACGIH Limit
TLV-C	: ICI aims to control exposure in its workplaces to the ACGIH Ceiling Limit
Sk	: Can be absorbed through skin
Sen	: Capable of causing respiratory sensation
MAK	: ICI aims to control exposure in its workplaces to the German Limit

Agrochemicals

The information on this sheet is not a specification; it does not guarantee specific properties. The information is intended to provide general guidance as to health and safety based upon our knowledge of the handling, storage and use of the product. It is not applicable to unusual or non-standard uses of the product or where instructions and recommendations are not followed.

ENERGY AUDIT

FOR

Donegal County Council – Ballynacarrick Landfill Site, Ballintra

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CONTENTS

Executive Summary

This report presents the results of an Assessment of Energy Saving Opportunities at Donegal County Council – Ballynacarrick Landfill Site. This assessment and report are provided by Stephen Kelly of RPS Consulting Engineers. The agreed objectives of the Assessment were to perform an Energy Audit in accordance with the EPA guidance notes on Energy Efficiency Auditing – July 2003 and to identify and prioritise actions that can be taken by the site to save carbon.

Donegal County Council has requested this audit in order to meet the conditions of the Waste Licence and to help prioritise energy saving opportunities on the site. The audit will address specific energy saving opportunities linked to specific mechanical processes on the site as well as a study into the opportunities within the overall Energy management of the site.

The Landfill Site is situated approximately 2 miles from the town of Ballintra, on a hilltop location. The site has been in use for some 20 years with an estimated 4 further years of use in the future. The site uses considerable amounts of energy throughout the year consisting of electricity and Diesel for the machinery on the site. There are 2 small temporary buildings situated near to the entrance of the site consisting of a small office, small kitchen and toilet facilities. There are 4-5 permanent members of staff on the site at any one time. Good housekeeping seems to be evident among the staff, and some energy efficiency opportunities have already been identified and implemented. The agreed objectives of this audit were to formally identify further cost effective energy saving opportunities across all aspects of the site.

The utility supply for the site is currently 150kVA. The table below summarises the main energy types used at the main site and their relative importance.

Utility	**Energy Consumption**		**Cost**		**CO_2 emissions**
	kWh/year[2]	**%**	**€/year**	**%**	tonnes
Utility Electricity	178,750	21	26,372	46	76.9
Diesel Oil - Machinery	679,052	79	30,250	54	169.8
Total Purchased Energy	**857,802**	**100**	**56,622**	**100**	**246.7**

Total annual energy use on the site is approximately 857,802kWh based upon the period Feb-06 to Jan-07.

[2] Delivered

Energy Saving Potential

Within the assessment there is a range of cost effective energy saving opportunities detailed. A summary of these opportunities can be found within the Action plan, which is the focus of this report and can be found overleaf. The site has already made some progress in improving energy efficiency with investment in modern flare monitoring controls. However, there are further opportunities which may lead to further energy savings such as sub-metering and increased monitoring of usage on site and improvements to the control and efficiency of items of on-site Mechanical plant.

The viability of the landfill gas electricity generation opportunity is largely dependant on the cost of the electricity grid connection, which has been estimated at €500,000 for the purposes of the calculation. An accurate cost for the upgraded connection should be sought from the electricity supplier to access the viability of installing a landfill gas generator. If all the prioritised measures are implemented apart from the electricity generation from landfill gas, the aggregated savings from the measures identified represent a 8% reduction in total site energy consumption based on utility electricity and diesel oil or 39% of site electricity consumption. The total annual cost reduction would be worth €7,565 and would translate into direct cost savings. There may be an overlap between some of the recommendations that will lead to smaller aggregate savings than indicated from the summation of all the individual projects.

Preliminary analysis of the likely landfill gas production indicates that, during peak gas production in 2011, 550 m^3/hr landfill gas will be produced which has the potential to generate approximately 890kW of electricity generation and allied with approximately 1150kW waste heat production will be possible. An analysis of power generation potential suggests that an electrical generation only project would have attractive favourable economics with:

- An NPV of €1,288,674 @ a discount rate of 8%
- An NPV of €2,083,653 @ a discount rate of 3.5%
- A theoretical Internal Rate of Return on investment of approximately 22.35%

If it is assumed that CO_2 produced by landfill activities would be produced regardless, then the electrical generation project would displace approximately 17,900 tonnes of carbon over the project 18-year life.

If the project for generation of electricity using landfill gas is adopted the site becomes a significant net exporter of energy, generating revenue for the Council and contributing to a sustainable strategy.

Risks and Uncertainties

The conclusions and recommendations contained within this assessment report are based on observations made during the site survey and data provided by the Client. It is believed that these observations are representative of normal working at the site but this should be confirmed before implementing measures, particularly where they involve substantial capital expenditure. Similarly, it should be noted that the quoted savings and cost figures are budget estimates only and should be confirmed prior to committing to expenditure. In particular the estimate of electricity grid connection costs can have a huge influence on the electricity generation project viability. This aspect should be confirmed as soon as possible.

Action Plan

Priority	Recommendation and key actions	Estimated annual savings			Estimated cost (€)	Payback period (years)	Timescale for completion
		(€)	CO_2 (tonnes)	(kWh)			
1	Improve energy management within the site	2,500	15	35,000	3,000	1.2	3-6 months
2	Introduce additional electricity and oil sub-metering	350	1.05	2,430	350	1.0	3-6 months
3	Improve control of PC's & small electrical equipment	80	0.3	560	0	0	3-6 months
4	High Efficiency Motors & Variable Speed Drives for the Aeration Paddle Motors	4,550	13.8	32,000	13,900	3.0	9-12 months
5	Install generators to run on the LFG output	291,000	1,788	4,157,000	1,036,000	3.5	12-18 months
TOTALS		**298,480**	**1819**	**4,226,990**	**1,053,250**	**3.5**	**-**

1.0 Introduction

1.1 Objectives for the Visit

Energy costs the main site in excess of €55,926 per annum, consisting of electricity and diesel fuel for the site vehicles. The site office utilise mainly electrical heating at a tariff cost of 6.16c/kWh. The electricity and Diesel consumption does not vary a huge amount throughout the year with the summer months responsible for a slightly higher consumption level due to the increased landfill due to the busy tourism season. The agreed objectives for this assessment were to identify cost effective energy saving opportunities across all aspects of the site's activities.

1.2 Site Details

Donegal County Council's Ballynacarrick Landfill site is situated on a hilltop position 2 miles from the town of Ballintra. The site has now been in use for over 20 years. The site is divided into three phases of operation and it caters for the disposal of some 35,000 tonnes of waste per annum. The existing phase, which has now been filled and capped, covers an area of approximately 55,300 m^2. Phase 1, which has recently been filled and capped, covers and area of approximately 14,000 m^2. Phase 2, which has an approximate area of 15,500 m^2, has recently been constructed and waste has started to be deposited within the phase. The existing phase and phase 1 have been capped and have landfill gas extraction pipework in place. Currently the landfill gas is extracted and burned at a flare near to the entrance of the site. There is a total estimated capacity of 165,000 m^3 left in the site, with an estimated 45,000m^3/yr to be filled into the site (Including cover) there is an estimated 3.67 years of capacity left on the site.

There is a leachate lagoon adjacent to the site entrance and offices that is fitted with a 45kW rated motor driving aeration paddle. The Aeration paddle is running at various times throughout the day and accounts for a large proportion of electricity used on the site. There are also 12 leachate pumps on the site in total. There a 6 x 1.5kW pumps, 3 x1.1 kW pumps, 2 x 1kW pumps, and 1 x 4kW pump. The total rated output of the leachate pumps on the site is 18.3kW. These pumps are only run intermittently and therefore they do not contribute a huge amount of the overall electricity usage on site.

Another main site load arises from the landfill gas extraction pump that is situated adjacent to the flare stack. The permanent unit fitted close to the entrance of the site is rated at 7.5kW. The flare is capable of burning a maximum of 550m^3/hr of landfill gas and is run on a continuous basis. The ESB is currently supplying electricity to the site at 150kVA.

The temporary buildings on site, which include a site office, small kitchen area and toilet block, are relatively small in size with an electric heating supply. The nature of the site office is that there is a constant level of access that makes it difficult to maintain adequate space heating. The site office has an approximate floor area of 10m^2 and the separate toilet and kitchen building is of a similar size. Given the small size of both buildings and their respective functions electric heating is appropriate but this should be matched with 7-day timer controls combined with thermostatic over-ride.

Electricity consumption on the site is dominated by the 45kW electric motor driving the aeration paddle in the leachate treatment tank. The other main user of electricity on site is the landfill gas extraction pump which is rated at 7.5kW and is run on a continuous basis. The items of plant using the most electricity on the site will receive particular attention within this report.

2.0 Current Energy Use

2.1 Site Energy Consumption and Spend

The site consumes approximately 178,750kWh of utility electricity energy per annum (based on figures provided for the period from February 2006 through to January 2007) costing a total of €26,372. The site also uses diesel oil for site vehicles, using 679,052kWh in the same period costing €30,250. All energy terms are in delivered energy and financial figures exclude VAT throughout the report. The energy used in site vehicles is significantly greater than that due to electricity use.

Utility	Energy Consumption		Cost		CO_2 emissions
	kWh/year[2]	%	€/year	%	tonnes
Utility Electricity	178,750	21	26,372	46	76.9
Diesel Oil - Machinery	679,052	79	30,250	54	169.8
Total Purchased Energy	**857,802**	**100**	**55,926**	**100**	**246.7**

The average unit cost for electricity was 14.75c/kWh including standing charges, while the average cost for Diesel oil was assumed to be 4.45c/kWh.

Consumption figures are given in Appendix 2.

Energy Procurement

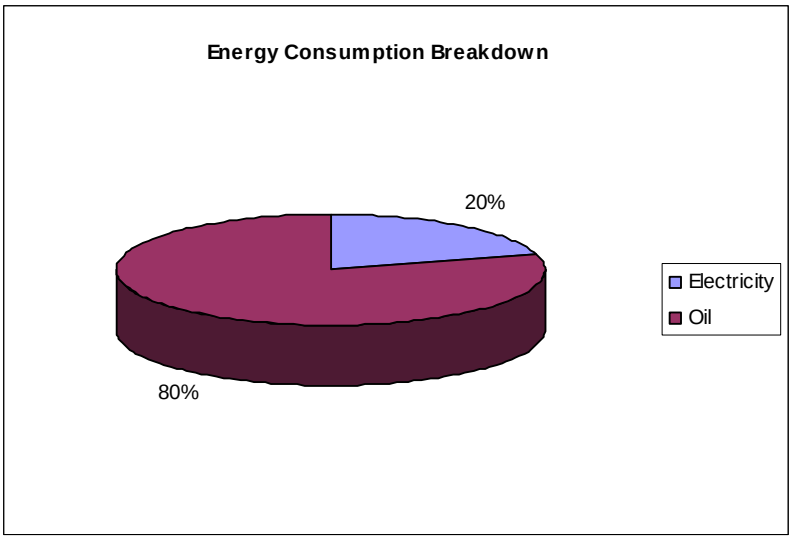
A 'General Purpose – Commercial' electricity purchase tariff is in place with ESB for the site, which is based on a simple flat rate tariff of 15.35c/kWh for the first 4000 units followed by 14.63c/kWh on remaining units. The off-peak rate is 6.95c/kWh. This tariff results in electricity costs that are relatively competitive. The site load is relatively stable due to 24 hour operation.

Diesel oil is purchased from a single supplier but is also at a relatively competitive rate. It may be possible to reduce costs a little by dealing with several suppliers.

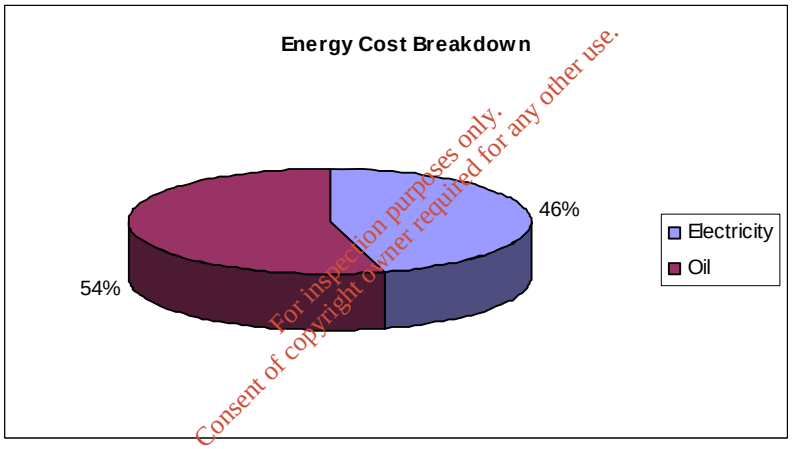
Energy Audit

The following pie chart shows the approximate breakdown of energy consumption on the site for the period Feb-06 to Mar-07.

[2] Delivered



The chart clearly shows how diesel fuel dominates the energy consumption. Similarly we can plot the Energy Cost breakdown as follows.



The average cost of electricity over the period is 14.75c/kWh while that for diesel is 4.45c/kWh. The comparison of the graphs clearly shows the importance of reducing the electricity usage on site as it accounts for 46% of the total energy costs and only contributes 20% of the energy used on the site.

2.2 Benchmarks

Energy performance indicators give a measure of activity based energy use, which can be compared with equivalent benchmarks for other sites. However, energy consumption benchmarks are not generally published for landfill sites.

The current site area has been estimated as 84,800 m^2 and this has been used to calculate the 'Specific Energy Consumption' (SEC) for this site. This is broken down into an electricity specific consumption of 2.1kWh/m^2/year and a diesel specific consumption of 8kWh/m^2/year giving a total of 10.1kWh/m^2/year.

2.3 Energy Management Practices

The existing energy management practices defined in the Energy Management Matrix (see Appendix 1) are as follows:

Energy Policy

Donegal County Council do not have an energy policy for the Ballynacarrick Landfill Site although there is an unwritten set of guidelines.

In order to realise further energy savings, an energy action plan should be developed to encompass the opportunities identified in this report, prioritising energy reduction measures and detailing a time-line for project implementation.

The Good Practice Guide GPG186, 'Developing an Effective Energy Policy' available from the UK Carbon Trust web site provides further guidance on this area.

The site is at Level 1 on the Energy Management Matrix.

Organisation

The Ballynacarrick Landfill Site energy management is the responsibility of Donegal County Council and in particular the manager and staff on site. The Manager has overall responsibility for the energy consumption on site along with many other important responsibilities. A strong link between waste management and energy management exists on the site and as a result environmental and energy strategy may be promoted to a high profile in the improvement of the existing buildings and facilities. The following guide may be of use in further developing the organisation management structure to encompass energy management.

The Good Practice Guide GPG119 'Organising Energy Management', available from the Carbon Trust web site provides further background information.

The site is at Level 1 on the Energy Management Matrix.

Motivation

Ad-hoc contact with staff on energy and space heating issues would be through Informal channels of communication. There is scope to develop a structure that promotes interest and commitment to energy efficiency as part of a comprehensive energy and environmental policy and this should be encouraged.

The site is at level 1/2 on the Energy Management Matrix.

Information Systems

The site currently has no building energy management system and meter data is not regularly collected for either electricity or diesel oil consumption. Cost reporting is based upon invoice data only.

A site such as the Ballynacarrick Landfill Site would benefit greatly from a monitoring and targeting (M&T) programme that can identify the key areas of energy consumption and quickly highlight when consumption unexpectedly increases (allowing reactive maintenance to take place). Due to the amount of continuous electric motor loads it is desirable that a thorough monitoring and targeting programme is used to prioritise maintenance tasks in terms of energy savings (whilst considering conventional factors such as health and safety and staff comfort).

By developing an M&T programme for the site, all areas of waste could be identified and systematically reduced. It is therefore recommended that the electricity half hour data (HHD) should be collected regularly from a sub-meter and analysed for areas of unnecessary consumption. The data should also be compared against manual readings from each of the utility meters to ensure the units are recording on the correct multiplication factor. All data should then be compared with previous periods on a regular basis, prompting maintenance tasks. Close monitoring of leachate aeration and landfill gas extraction loads would also allow energy savings from the other report recommendations to be quantified. The compiled data should also be compared against the respective utility bills on a monthly basis in order to ensure the billing is correct.

Further specific information on this area is included within section 3.0. The Good Practice Guide GPG112, 'Monitoring and Targeting in Large Companies' also provides further help and guidance on this area.

The site is at level 1 on the Energy Management Matrix.

Marketing

Energy efficiency achievements and the sites energy performance could be published internally so that everyone is aware of progress and energy consumption. This would assist in raising the profile of energy efficiency within the Council. Staff do not have a direct interest in plant efficiency but there is an opportunity to improve the level of information on energy efficiency targets and plant performance using a comprehensive energy M&T software system.

The Good Practice Guide GPG084 'Managing and Motivating Staff to Save Energy' available from the Carbon Trust web site provides further background reading on this.

The site is at level 1 on the Energy Management Matrix.

Investment

Some new investment has been made at the Ballynacarrick Landfill Site in recent years in landfill gas extraction plant and monitoring instrumentation. Investment into energy efficient practices and equipment is currently assessed using the same pay back criteria employed for any investment.

Paybacks on energy efficient equipment will become shorter as energy prices increase. As prices have already increased in the region of 50% within the past 12 months, projects that formerly had longer payback periods are now becoming more cost effective.

It is recommended that the Council should earmark sufficient capital to allow a number of energy efficiency projects to be advanced. It is further recommended that the good housekeeping measures identified within this report are undertaken as promptly as possible and the financial savings are ring-fenced for investment in further energy saving projects.

The site is at level 2 on the Energy Management Matrix.

2.5 Organisational Issues Affecting Energy Use

The main issue affecting energy use on the Ballynacarrick Landfill Site is the ESB utility electricity connection and distribution around the site to supply the landfill gas extraction pump loads, aeration paddle motors and leachate pump systems etc.

3.0 Energy Saving Opportunities

This site is administered by a management team with reasonable knowledge of energy efficiency and waste avoidance. As a result some of the normal opportunities for improved energy efficiency have been adopted. The site has chosen to use electricity for space heating and this is appropriate given the small space heating load. The use of diesel fuel in vehicles, earth moving equipment etc is by far the largest source of energy consumption on the site and up to four times more energy is used in this manner than in the form of utility electricity.

The following recommendations have been prioritised in terms of ease of implementation and potential energy/cost savings. Most measures requiring capital investment have a payback within 3 years (with the majority having a much shorter payback period). Note; all carbon savings are in tonnes.

Priority 1	**Improve Energy Management within the site**			
Cost Saving € per year	CO_2 Savings Tonnes/year	Energy Savings kWh/year	Cost €	Payback Years
2,500	15	35,000	3,000	1.2

Detail:

The site has been proactive in taking the initiative to explore energy efficiency further and has had some success in implementing measures to date. It is recommended that the recommendations of this report are studied and plans made to implement the best opportunities. The key areas to address are summarised within the following paragraphs:

Energy Policy/Action Plan

Part of developing an energy policy involves the identification of energy use and the setting of targets for energy consumption reductions. In order to ensure the targets are met it is recommended that a new energy policy is developed reflecting this objective and endorsed by senior management. It is further recommended that the reduction targets be established for the medium term (up to the next 10 years) to enable energy reduction projects to be planned and prioritised within the budget for each financial year.

In order to realise the energy savings, a detailed action plan should be developed, prioritising energy reduction measures, identifying who is responsible for delivering the savings within the site (or who is responsible for managing outside consultants/contractors) and detailing a time-line for project implementation. The action plan within this report should be used as a starting point and should be developed further, depending on the level of investment available and the required level of savings.

Monitoring & Targeting

For a site such as the Ballynacarrick Landfill Site, a monitoring and targeting (M&T) programme can identify the key areas of energy consumption and quickly highlight when consumption unexpectedly increases (allowing reactive maintenance to take place). Due to the amount of electric motors used on the site it is essential that a thorough monitoring and targeting programme is used to prioritise maintenance tasks in terms of energy savings (whilst considering conventional factors such as health and safety and staff comfort). Ballynacarrick Landfill Site does not have manual monitoring capability using utility meters and additional automated monitoring and target setting software would be useful to identify trends away from peak efficiency.

By developing an M&T programme for the site, all areas of waste could be identified and systematically reduced. It is therefore recommended that the electricity meter readings are automatically entered into a database with associated spreadsheet for target setting analysis. All data should be corrected in order to establish a standard performance figure for the site. The

electricity half hour data (HHD) should be obtained from sub metering and analysed for areas of unnecessary consumption with additional sub-metering where possible. All data should then be compared with previous periods on a regular basis, prompting maintenance tasks. Close monitoring of performance would also allow energy savings from the other report recommendations to be quantified. The compiled data should also be compared against the respective utility bills on a monthly basis in order to ensure the billing is correct.

Staff Awareness Campaign

The staff at the Ballynacarrick Landfill Site have a limited level of control of space heating and natural ventilation but are key to implementing an energy reduction strategy within the site. Historically there is motivation for energy efficiency but it is recommended that a comprehensive energy awareness campaign is renewed to include:

1. Briefing new staff as part of a staff induction programme
2. Briefing staff on the environmental and financial costs of wasting energy and explaining what they can do to help
3. Maintaining a 'switch-off' campaign, concentrating on all equipment, heating, lighting, computers, monitors etc that can be switched off when not required.
4. Undertake regular 'walk-round' surveys to determine the effectiveness of the staff awareness campaign

Rationale:

Comprehensive energy management is essential in ensuring the site achieves energy savings in line with its internal targets. It is therefore necessary to develop a suitable energy policy action plan and monitoring & targeting programme.

Risks:

If energy consumption is not monitored closely the effects of the various initiatives cannot be quantified. It is therefore vital that energy management is maintained as a high priority for the site.

Next Steps:

In order to improve energy management within the next 3-6 months the following steps should be taken:

1. **Develop a new energy policy with targets.**
2. **Adopt the Action Plan within this report & develop as necessary.**
3. **Decide what outside help is needed to install an automated M & T Programme**
4. **Analyse figures & use findings to influence the Action Plan.**
5. **Nominate a member of management to develop a new site wide energy awareness campaign.**

Relevant Publications:

GPG 084 - Managing & Motivating Staff to Save Energy
GPG 112 - Monitoring & Targeting in Large Companies
GPG 186 - Developing an Effective Energy Policy
GPCS 375 - Effective Energy Management at ICI Paints, Slough

Priority 2		**Introduce electricity sub-metering**		
Cost Saving € per year	CO_2 Savings Tonnes/year	Energy Savings kWh/year	Cost €	Payback Years
350	1.05	2,430	350	1.0

Detail:

In addition to meters for the main utility supplies, sub-metering of separate loads will provide a detailed framework for setting targets and monitoring progress. Ballynacarrick Landfill Site should consider metering electrical supplies to the aeration paddle motor and landfill gas extraction pump motor as these are the key consumers of energy and detailed information is important.

Rationale:

When undertaking an initiative to reduce energy costs it is important to have frequent and accurate consumption data along with information on the factors that influence energy usage. Provision of this information must be efficient in the time it takes to process and the data obtained must be readily available for further scrutiny in the form of charts etc. Ideally the figures provided should give a performance measure for the current week and for the year to date whilst comparing both of these with the "target" values that take into account appropriate factors.

Risks:

There are minimal risks involved within this project as senior management should be involved and committed before it proceeds. Some expenditure is required for improved metering and the expedient use of outside assistance. Some risk exists if the initiative is not fully maintained and followed through.

Next Steps:

In order to implement this recommendation within the next 3-6 months the following steps should be taken:

1. **Determine validity & what help is needed to establish an automated M&T system.**
2. **Identify and install additional metering where this can provide benefit at low cost.**
3. **Devise and implement a reporting system, costs centres and controls that best suit the site budget management.**

Relevant Publications:

GPG 231 – Introducing information systems for energy management
GPG 326 - Good Practice Guide to Energy Metering
GPG 125 – M&T in small and medium companies
GPG 112 - Monitoring & Targeting in Large Companies

Priority 3		**Improve control of PC's & small electrical equipment**		
Cost Saving € per year	CO_2 Savings Tonnes/year	Energy Savings kWh/year	Cost €	Payback Years
80	0.3	560	0	0.0

Detail:

The site has several computers and a number of pieces of electrical office equipment (such as copiers, scanners, printers, etc), many of which are used throughout the working day. It was noticed during the walk-round survey that some of the equipment was operating despite minimal

use by staff. In addition, the majority of computer screens had been left in screen saver mode. Although the screen savers do reduce the overall energy consumption during short breaks, both computers and screens should be turned off when the PC is not due to be used for any significant period (i.e. during lunchtimes and at the end of the working day). The following recommendations for improvement are made:

Improve staff awareness

Staff should be informed of the cost of operating a computer unnecessarily and encouraged to switch off when not in use. Posters and stickers providing information on this area are available, free of charge, from the Carbon Trust and SEI web sites.

Improve control of small electrical equipment

Throughout the office buildings there is a variety of small electrical equipment, which is left on stand-by mode when not in use. Although developments have resulted in electrical equipment consuming less energy in stand-by mode, this is an area where small energy savings can easily be achieved and demonstrates management's commitment to environmental issues. Staff should be prompted to switch off equipment when not required (through an energy awareness campaign) and simple time switches should be fitted to equipment within communal areas (such as the water heaters and photocopiers).

Rationale:
Electrical equipment still consumes energy whilst in 'sleep' or 'saver' mode. Therefore it is prudent to maximise the use of energy saving features and also to switch off equipment when it is not in use for any prolonged period (such as overnight).

Risks:
Some staff may be reluctant to switch off electronic equipment (and especially computers) for fear of losing unsaved data, or disturbing electronic settings. All equipment which can be switched off should therefore be labelled with one colour and all equipment which should be left running should be labelled in a separate colour.

Next Steps:
In order to implement this recommendation within the next 3 months, the following action should be undertaken:
1. Renew the energy awareness campaign, to include specific information on computers and screens.
2. Label all equipment, so that staff understand what can/cannot be switched off overnight.
3. CRT Monitors should be replaced with Flat Screen TFT monitors that consume 50% less energy when monitors are being replaced or new ones bought.
4. Monitor the site's overnight electricity consumption as part of an M & T programme and use the data to provide feedback on the success of the 'switch-off' campaign.

Relevant Publications:
GPG118 - Managing Energy Use - Minimising Running Costs of Office Equipment & Related Air-conditioning

Priority 4		**Aeration Paddle Motors**		
Cost Saving € per year	CO_2 Savings Tonnes/year	Energy Savings kWh/year	Cost €	Payback Years
4,550	13.8	32,000	13,900	3.0

Detail:
Modern three phase induction motors are at least 85% efficient in converting electricity to shaft power. The latest single speed induction motors, designated EFF1, can achieve an improvement of a further 4% and should always be specified for replacement drive motors given that an induction motor can consume 100 times its original cost in electricity over its normal life.

Investigation of the efficiency of the aeration paddle motors on the leachate lagoon to determine their efficiency at aerating the leachate
It is possible that a system could be devised that utilises the oxygen content of the leachate pond water to control the rate of rotation of the aeration paddle motors. This could have a significant influence on the energy consumed by the aeration paddle motor that is rated at 45kW. As the power absorbed by the paddle follows a cubic relationship with shaft speed small reductions in rotational speed can lead to large energy savings. A variable speed drive controller would be required in this application. Variable speed drives are electronic devices that control the supply of electricity to the motor. Typically, reducing the speed of rotation by 50% reduces the input energy demand by over 85%. Alternatively, a blower system for oxygenation of the leachate may be more efficient and should be investigated.

Rationale:
The measures proposed above could significantly reduce the energy consumed by the aeration paddles.

Risks:
No risks are anticipated with this upgrade as the control system would ensure that oxygen levels were maintained at adequate levels.

Next Steps:
In order for this recommendation to be implemented within the next 12-15 months, the following steps should be taken:

1. **Prioritise work within the site Action Plan**
2. **Carry out a detailed study of the efficiency of the aeration motors as part of the M&T programme**
3. **Schedule for the work to be completed**

Relevant Publications:

GPG 2 – Energy savings with motors and drives

Priority 5		**Install generators to run on the LFG output**		
Cost Saving € per year	CO_2 Savings Tonnes/year	Energy Savings kWh/year	Cost €	Payback Years
291,000	1819	4,157,000	1,036,000	3.5

Detail:
The evaluation of the economic case for landfill gas utilisation in electricity generation is examined in detail in Section 4 of this report. A business case is made for the phased installation of 1 x 1MW generator that has been sized to mirror the peak projected landfill gas production rate over the eighteen year life of the site. At present this gas is being flared to atmosphere with total loss of the considerable energy content.

Rationale:
A simple economic analysis has been completed on the basis of the assumptions made for the costs of up-rating the electricity connections to the site. An export price of €70/MWh has been assumed for the electricity exported to the grid. Simple payback occurs in four years and the evaluation is summarised in Table 2 at the end of Section 4. A Net Present Value of €1,288,674 can be achieved with a discount rate of 8% whereas this increases to €2,083,653 with a discount rate of 3.5%. The project has a theoretical Internal Rate of Return of 22.35% and the electrical generation project would displace 17,893 tonnes of carbon over the 18-year life.

Risks:
The main risk to this project exists around the cost of upgrade of the grid to accept the peak electricity production rate of 886 KW. A sum of €500,000 has been assumed but this could be a significant under estimate. It is recommended that ESB be engaged to provide a detailed estimate in this respect. The project has the capability to absorb a higher connection cost.

Next Steps:
In order for this recommendation to be implemented within the next 12 months, the following steps should be taken:

1. **Prioritise work within the site Action Plan**
2. **Commission a grid connection estimate from the ESB**
3. **Commission a detailed study of the proposal**
4. **Schedule for the work to be completed**

4.0 Landfill Gas and Renewable Generation Opportunities

The two main constituents of landfill gas, CO_2 and methane are both potent greenhouse gases and treatment must ensure that combustion takes place at a temperature higher than 1000°C. Currently all the gas is passed to a flare for combustion treatment prior to issue to atmosphere. Power generation from LFG is usually achieved most cost effectively using reciprocating engines. This is simply because the mechanical efficiency achieved by these engines is high and the overall electrical generating efficiency achieved is good because parasitic loads are relatively low[1].

Typically for engines of 1MW(e) or above, the gross mechanical output may be close to 40% and the electrical output 35% or more. Waste heat is rejected from the engine cooling water, the intercoolers if the engine is super or turbo charged and the exhaust from the engine. In many cases it is possible to recover 40% or so of the original input energy as useful waste heat depending upon the design.

Heat is recovered from the landfill gas generator in two ways. The waste heat rejected from the engine cooling water, the intercoolers and lubrication system is recovered with a series of heat exchangers. This heat can generally be recovered at a maximum of 90°C, although adaptations may allow a higher recovery temperature. The waste heat in the exhaust gases, exhausted at more than 500°C may be recovered separately, by cooling these to 180°C in the case of landfill gas, and recovering the heat at higher temperatures if required.

At this site where there is apparently the potential to develop a maximum of 886kW or more of electrical power, there is therefore also potential to recover up to 1135kW of waste heat that could potentially be distributed and used for developments on the site.

Under some circumstances, a distributed heat network can provide an efficient and cost effective means of energy distribution and a reduction of primary carbon emissions. This is often the case where primary energy efficiency may be improved with the use of combined heat and power or where heat is distributed from a centralised renewable or low carbon source. In this case there is the potential to generate electricity on the site but very limited potential application of the resulting waste heat. Only in the circumstances of additional site development would this be possible. Unfortunately there is no available land or prospect of such development so all waste heat must be dumped to atmosphere.

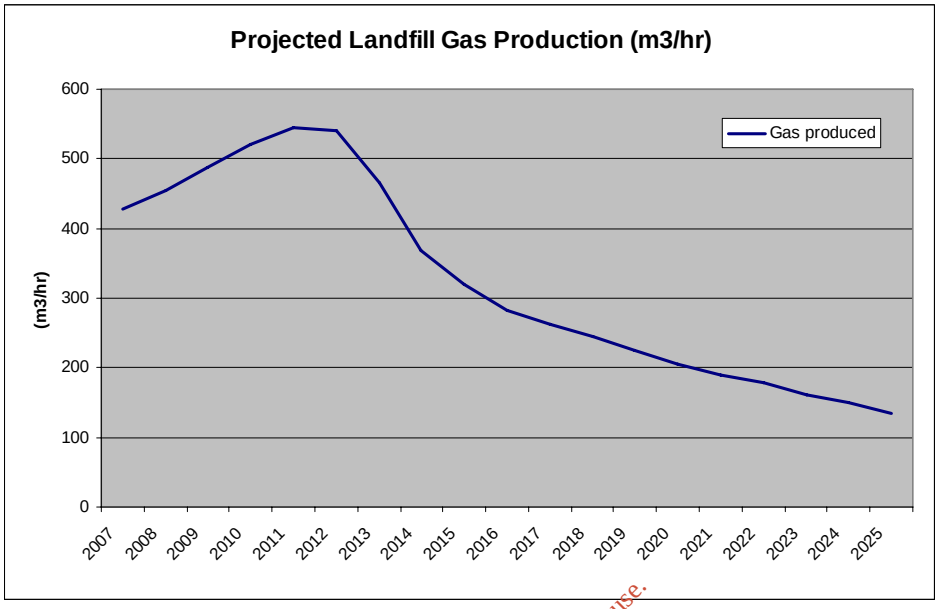
4.1 The quality, quantity & duration of gas generation.

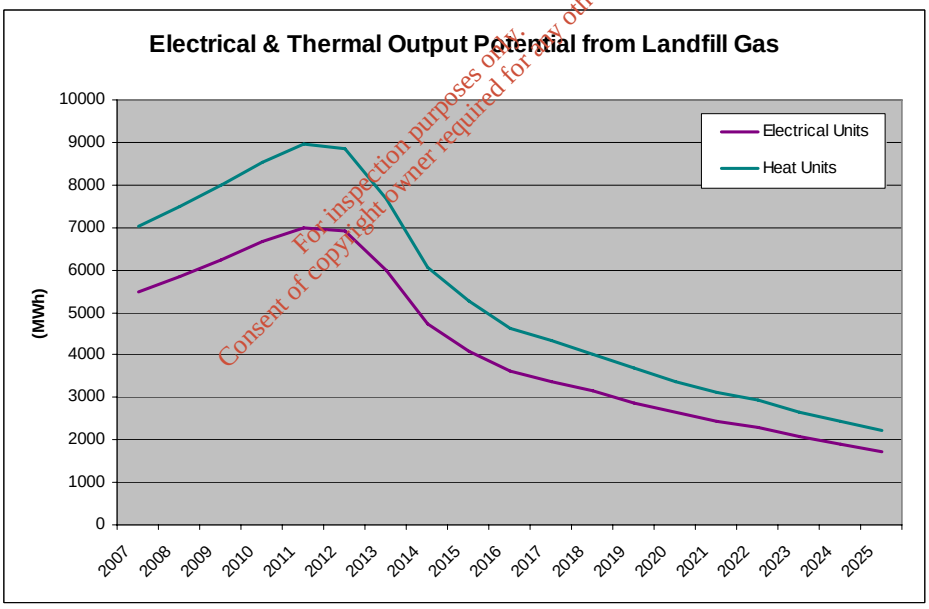
LFG is a by-product of the largely anaerobic bio degradation of organic material dumped in landfill waste. Gas quality depends on the constitution of the waste and in particular the organic or putrescent content. However the methane content has been measured at approximately 37.5% by volume and the net calorific value therefore approximately 15MJ/m^3.

The analysis of historic waste records has been conducted by the site using a recently installed monitoring system with the conclusion that the gas quality and the net calorific value at this site will not be significantly different from the figures quoted above.

The projected gas flows have been modelled using software designed for this predictive task. Simple calculations based upon waste quantity, quality and time illustrate model variations in peak flow conditions of 20% reached in 2011 depending upon the half-life assumed for waste degradation. However, using the GASSIM software the gas production is projected to be 428 m^3 in 2007 rising to a peak production rate of 545 m^3 in 2011. This profile is assumed for CHP electricity and heat calculations in this report. In practice this would allow maximum power generation of approximately 886 kWe at peak flow in 2011 and commencing at 696kWe in 2007.

Currently approximately 430 m^3/h of landfill gas is being burned in the flare on site. From interpretation of the data provided by the Council it is concluded that the minimum production profile will be similar to that modelled below:





4.2 Buying & Selling Renewable Energy

Electricity value. The indicated ReFIT supported export price is 7c/kWh and this has been used in the supporting calculations. It may be possible through negotiation with other energy supply companies to get up to 7.2c/kWh for net exported energy. If the Council were to go outside the support mechanism it should be possible to get the Best New Entrant, (BNE) price which in 2006 stood just under 7.3c/kWh. While this is better than the supported figure there is no guarantee of this rate. On this basis a basic purchase price for electrical units of €70/MWh has been assumed in all the calculations. The new Single Electricity Market commencing in Nov 2007 may produce a change to these figures. It may also be possible to obtain a 4.0c/kWh carbon saving premium but this has not been assumed in these calculations.

The grid connection cost to be able to export the full production of electricity from the generators is the largest unknown in this assessment. It is frequently sufficiently large as to make the overall project only marginally viable. We have assumed a grid connection cost of €500,000 however this is just a estimate. It would be worth getting a grid connection pre-feasibility study done by the ESB for the site costing €730 which will provide a proper estimate of the grid connection cost to be able to export up to 1MW. The current supply line is limited to 150kVA, this is still only a small amount of the required full export capacity. The grid connection cost has a very significant influence on the viability of renewable electricity generation.

Heat value. Heat energy only has a value if there is a 'buyer' available at the site. This is not feasible unless there were plans to develop sections of the site as a business park or other activity with a need for heat. Thus the heat value has been assumed to be zero in the calculations contained in this report with the assumption that the heat will be dumped to atmosphere.

4.3 The Projected Heat & Power Outputs

To assess the potential for the site, the modelled gas predictions have been adopted. The performance as anticipated in the feasibility study has been considered. The landfill gas is assumed to have a net calorific value of 15MJ/m^3 comprising of 37.5% methane. The performance of the Jenbacher JGC 320 (1048kWe) generator has been used to model gas consumption, electrical power outputs and heat outputs. There are many manufacturers who produce gas fired reciprocating engines, Deutz, Caterpillar and Jenbacher etc. to name but a few. It is easier to continue this report using the published performance of one particular model for the purposes of comparison. A Jenbacher JGC 320 is used. The engine performance of different manufacturers is generally similar and in using the Jenbacher models as an example there is no implied preference or endorsement of this specific equipment.

The standard specification for the engines used to model electricity and heat production for this site is as follows based upon nominal engine performance at 75% part load:

Fuel gas	kWh/Nm^3	Part Load 75%
Energy Input	kW	2.047
Gas Volume @ 37.5% CH_4	Nm^3/h	585
Mechanical Output	kW	821
Electrical Output	kWe	798
Specific Fuel Consumption	kWh/kWh	2.49
Electrical Efficiency	%	39.0%

The projected heat and power outputs are illustrated in Table 1 below.

Year	Gas Produced (m^3/hr)	Electrical Output (kWe)	Gas Burnt (m^3/hr)	Thermal Output (kW)	Electrical Units (MWh/yr)	Electrical Units Value (€)	Heat Units Produced (MWh/yr)	Potential CO2 Emission reduction (Tonnes)	Primary Carbon Reduction (Tonnes)
2007	428	696	428	892	5483	383833	7030	4555	1242
2008	455	739	455	948	5829	408046	7473	4842	1321
2009	487	791	487	1015	6239	436744	7999	5183	1413
2010	520	845	520	1083	6662	466339	8541	5534	1509
2011	545	886	545	1135	6982	488759	8952	5800	1582
2012	540	878	540	1125	6918	484275	8869	5747	1567
2013	466	757	466	971	5970	417911	7654	4959	1352
2014	369	600	369	769	4727	330921	6061	3927	1071
2015	320	520	320	667	4100	286978	5256	3405	929
2016	282	458	282	587	3613	252899	4632	3001	818
2017	263	427	263	548	3369	235860	4320	2799	763
2018	245	398	245	510	3139	219717	4024	2607	711
2019	224	364	224	467	2870	200884	3679	2384	650
2020	206	335	206	429	2639	184742	3384	2192	598
2021	190	309	190	396	2434	170393	3121	2022	551
2022	179	291	179	373	2293	160528	2940	1905	520
2023	162	263	162	337	2075	145282	2661	1724	470
2024	149	242	149	310	1909	133624	2447	1586	432
2025	135	219	135	281	1730	121069	2217	1437	392
Total		**10018**		**12844**	**78983**	**5528803**	**101260**	**65606**	**17893**

Table 1: Projected Heat & Power Outputs

4.4 Simple Economic Analysis

Each 500m^3/h of gas generates revenue of €446,880 per year. For this simple analysis the €70/MWh price of exported electricity has been used. Simple payback occurs in 4 years. The NPV and IRR are relatively attractive as illustrated in Table 2 at the end of Section 4. However attention is drawn to the sensitivity of the analysis to the cost of grid connection. The estimated €500,000 may be a significant under-estimate.

4.5 Other uses for Landfill Gas

If generation of electricity from the landfill gas is determined not to be viable the following sets out other possible uses of the LFG.

Gas Scrubbing

There are two reasons for treatment of LFG:

1. Due to the large proportion of carbon dioxide (around 60% CO_2) in the make up of landfill gas the calorific value is low when considered by volume (for example untreated LFG has a CV of 13-15MJ/m^3, as compared with 38-40MJ/m^3 for treated gas). By removing the contaminants the volumes of gas that need to be managed are reduced. Whilst the net energy content of the LFG is the same as the treated gas, the volume of the treated gas is greatly reduced and combustion is more

efficient. This results in an increase in efficiency and a reduction in capital cost as plant size is significantly reduced.

2. In addition to the carbon dioxide, LFG contains hydrogen sulphide and other trace chemicals such as aromatic hydrocarbons that are toxic and environmentally damaging, as well as reducing engine life were the LFG to be used directly for power generation.

There are various existing techniques suitable for gas treatment:

1. MEA – Monoethanolamine may be used to remove CO_2 from the LFG.
2. Kyrosol Process - Uses chilled methanol to remove the CO_2 and other contaminates.
3. Gaseous filtering - A molecular level membrane is used to remove the CO_2.

Sulphur dioxide and water vapour are removed as part of the process. It is possible that CO_2 & SO_2 or its derivatives may have commercial value. Processing and compressing the gas requires electrical energy. To get 98% methane, 5-10% of the energy value in the gas is used. This processing cost could be significantly reduced if the electricity required was produced on site using a proportion of the landfill gas.

The estimated total processing power requirements for gas scrubbing is typically 10% of the energy content of the gas. Thus for 500m^3/h of raw LFG the removal of the CO_2 and contaminants would account for 208kW. This electrical load can be generated using 53.6 m^3/h of the 187.5m^3/h of scrubbed gas assuming a generator efficiency of 35% leaving a net scrubbed gas production rate of 133.9m^3/h.

The scrubbed gas will have an energy content of 38-40MJ/m^3. The gas may be used to generate electricity in more efficient smaller generator arrangements or it may be compressed to produce Compressed Natural Gas (CNG) which may be used as a transport fuel as a substitute for petrol and diesel within the Councils fleet of vehicles.

Gas Compression

The use of CNG as a transport fuel would require conversion of the vehicles to include a CNG tank and fuel injection systems. Companies specialising in such conversions are becoming more common and the use of LPG for transport use is already well established. Compressed Natural Gas has less environmental impact than petrol or diesel use as it burns more cleanly than fossil fuels. The main reductions are in NO_x, SO_x and particulate emissions. To be used as vehicle fuel the LFG would be processed to 98% methane as identified above. Once compressed the gas can be stored or transported as required.

At present the market for alternative vehicle fuels is relatively small in Ireland. The market is quite mature in France and other European countries. The gas could be used to offset the fuel used by Donegal County Council's vehicle fleet. This would have three benefits: firstly the fuel bill is significantly reduced and secondly the Council is seen to be promoting environmentally sound policies. Finally the vehicle emissions would be reduced.

Let us consider continuing the processing to include gas compression. The power required to compress 133.9m^3/h of the scrubbed LFG from 1bar to 200bar has been estimated as about 5% of the energy in the gas or a power of 22.3kW. The compression must take place in three separate stages and the electrical load can be supported from the use of 5.7 m^3/h of the 133.9 m^3/h of scrubbed gas leaving a net volume of 128.2 m^3/h which is compressed to CNG at a production rate of 0.64 m^3/h or 1.42MW of CNG. It should be noted that in volume for volume terms at 200bar CNG has just 25% of the calorific value of petrol so larger storage volumes are required for the same vehicle range.

It is estimated that for each 500m^3/h of landfill gas the use of CNG for vehicle fuel could offset 1.144 million litres of diesel and be worth €1.258 million a year after taking out production costs. Excise duty would be liable on this fuel reducing the net worth. See Table below:

Basic Assumptions and Reference Data

Make up of Landfill Gas	
Assumed proportion of methane CH_4	37.5%
Carbon dioxide proportion	60%
Calorific Value of Methane	40MJ/m^3
Calorific Value of Carbon Dioxide	0MJ/m^3
Calorific Value of Landfill Gas (raw)	15MJ/m^3
Calorific Value of Landfill Gas (scrubbed) – 98% Methane	38.6MJ/m^3
Density of scrubbed LFG @ 1atmosphere, 15°C	0.68kg/m^3
Annual operating period	
Assumed basic Landfill Gas Production Rate	500m^3/h
Plant availability	90%
No days available	328.5days
No operating hours	8000 per annum
Energy Costs and Values	
Electricity (purchased)	14.8c/kWh
Electricity (exported to the grid)	7.0c/kWh
Petrol at the pump price (2006)	€1.10/l
Petrol Calorific Value by mass	45GJ/t
Density	730kg/m^3
Petrol Calorific Value by volume	32850MJ/m^3
	9.13kWh/l

Value of Landfill Gas used to Generate Electricity

Electricity	
Reference Hourly production LFG	500m^3
Electrical Output – kWe Net after accounting for availability	655
Assumed proportion of methane CH_4	37.5%
Peak Electrical Output -MWe	1.66MWe
Electrical Value of exported units	7c/kWh
Equivalent Net Annual Value	€920,250

Value of Compressed Natural Gas used to displace Petrol/Diesel in Transport

Equivalent Energy Content of LFG	
Reference Hourly production LFG	500m^3
Assumed proportion of methane CH_4	37.5%
Production of scrubbed and compressed LFG	128.2m^3/h
Production of scrubbed and compressed LFG	87.2kg/h
Calorific Value of 1hour's supply of scrubbed gas	4849MJ
(NB figures assume partial use of LFG energy content to	

generate electricity to support the process of scrubbing & compression)	
Equivalent quantity of petrol	0.110tonne/h
	110kg/h
	0.143m^3/h
Equivalent Quantity Petrol	143l/h
Equivalent Annual Net Volume of Petrol	1,144,000l
Equivalent Net Annual Value	€1,258,400

Table 2: A Preliminary Assessment of Cash Flow for Landfill Gas Electrical Generation

Year	Year No.	Gas Produced (m^3/hr)	Electrical Output (kWe)	Gas Burnt (m^3/hr)	Gross Energy input (MJ)	Thermal Output (kW)	Electrical Units Value (€)	Engine Maintenance (€)	Net revenue Flow (€)	Grid Connection Costs (€)	CHP Purchase (€)	Gas Collection (€)	Cumulative Cashflow (€)
2007	0	428	696	428	6420	892	383833	55640	328193	-500000	-1036000	-150000	-1357807
2008	1	455	739	455	6825	948	408046	59150	348896				-1008911
2009	2	487	791	487	7305	1015	436744	63310	373434				-635477
2010	3	520	845	520	7800	1083	466339	67600	398739				-236739
2011	4	545	886	545	8175	1135	488759	70850	417909				181170
2012	5	540	878	540	8100	1125	484275	98800	385475				566645
2013	6	466	757	466	6990	971	417911	60580	357331				923976
2014	7	369	600	369	5535	769	330921	47970	282951				1206927
2015	8	320	520	320	4800	667	286978	41600	245378				1452305
2016	9	282	458	282	4230	587	252899	36660	216239				1668544
2017	10	263	427	263	3945	548	235860	34190	201670				1870213
2018	11	245	398	245	3675	510	219717	31850	187867				2058081
2019	12	224	364	224	3360	467	200884	29120	171764				2229845
2020	13	206	335	206	3090	429	184742	26780	157962				2387807
2021	14	190	309	190	2850	396	170393	24700	145693				2533500
2022	15	179	291	179	2685	373	160528	23270	137258				2670758
2023	16	162	263	162	2430	337	145282	21060	124222				2794980
2024	17	149	242	149	2235	310	133624	19370	114254				2909234
2025	18	135	219	135	2025	281	121069	17550	103519				3012753
Total			**10018**		**92475**	**12844**	**5528803**	**830050**	**4698753**	**-500000**	**-1036000**	**-150000**	

NB This analysis is derived using estimated prices and budget quotations. The NPV and IRR can be considered as preliminary and indicative only. A detailed engineering and infrastructure analysis would be required to develop costs and confirm the economic case.

The simple model indicates that:

- **An NPV of €1,288,674 can be achieved with a discount rate of 8%**
- **An NPV of €2,083,653 can be achieved with a discount rate of 3.5%**
- **The project would have a theoretical IRR of approximately 22.35%**
- **The electrical generation project will displace 17,893 tonnes of carbon over the 18-year project life**

Appendix 1: Energy Management Diagnostics

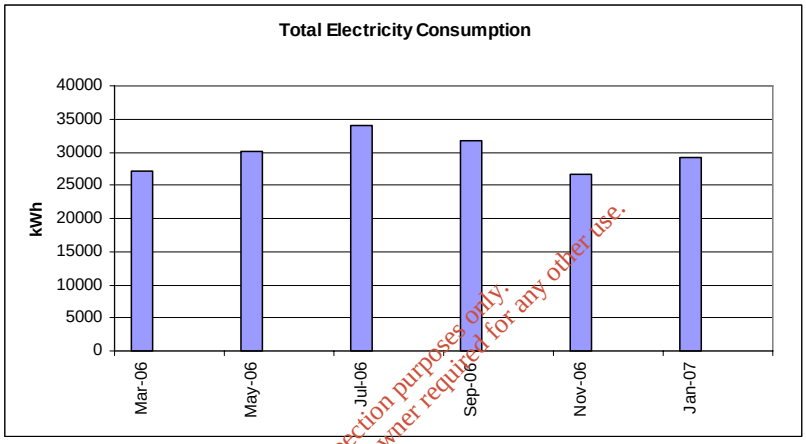
Energy Management Matrix

This matrix shows an overall appreciation of energy management for the survey site. The shaded cells represent current achievement levels and highlight key areas where improvement can be made.

Level	Energy Policy	Organising	Motivation	Information systems	Marketing	Investment
4	Energy policy, action plan and regular review have commitment of top management as part of an environmental strategy	Energy management fully integrated into management structure. Clear delegation of responsibility for energy consumption.	Formal and informal channels of communication regularly exploited by energy manager and energy staff at all levels.	Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking.	Marketing the value of energy efficiency and the performance of energy management both within the organisation and outside it.	Positive discrimination in favour of 'green' schemes with detailed investment appraisal of all new-build and refurbishment opportunities.
3	Formal energy policy, but no active commitment from top management.	Energy manager accountable to energy committee representing all users, chaired by a member of the managing board.	Energy committee used as main channel together with direct contact with major users.	M&T reports for individual premises based on sub-metering, but savings not reported effectively to users.	Programme of staff awareness and regular publicity campaigns.	Same pay back Criteria employed as for all other investment.
2	Un-adopted energy policy set by energy manager or senior departmental manager.	Energy manager in post, reporting to ad-hoc committee, but line management and authority are unclear.	Contact with major users through ad-hoc committee chaired by senior departmental manager.	Monitoring and targeting reports based on supply meter data. Energy unit has ad-hoc involvement in budget setting.	Some ad-hoc staff awareness training.	Investment using short-term payback criteria only.
1	An unwritten set of guidelines	Energy management is the part-time responsibility of someone with limited authority or influence	Informal contacts between engineer and a few users.	Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department.	Informal contacts used to promote energy efficiency.	Only low cost measures taken.
0	No explicit policy	No energy management or any formal delegation of responsibility for energy consumption	No contact with users.	No information system. No accounting for energy consumption.	No promotion of energy efficiency.	No investment in increasing energy efficiency in premises.

Appendix2: Energy Data

	Mar-06	May-06	Jul-06	Sep-06	Nov-06	Jan-07	Total
Electricity							
Winter Peak							0
Winter day	27183					29083	56266
Summer Day		30183	33983	31683	26635		122484
Night							0
Evening & Weekend							0
Total kWh	27183	30183	33983	31683	26635	29083	178750
Cost	4050.00	4642.00	4639.00	4534.00	3926.00	4581.00	26372.00
Cost/kwh	0.1490	0.1538	0.1365	0.1431	0.1474	0.1575	0.1475



Diesel							
Litres	9825	11021	12683	10605	9747	8820	62701
kWh	106405	119357	137357	114852	105560	95521	679052
Cost	4788	5384	6132	4988	4660	4297	30250
Cost/kWh	0.0450	0.0451	0.0446	0.0434	0.0441	0.0450	0.0445