GHG emissions from Waste – A guide for Jersey

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Introduction

A key component of Jersey's current waste management operation is its energy recovery[1] facility at La Collette. The process of waste incineration in this way allows for the generation of electricity through steam turbines. The electricity is sold to the Jersey Electricity Company (JEC) and fed back into the distribution network.

The La Collette energy recovery facility contains two boilers, with moving grates for waste incineration, each of which have a maximum capacity of 7.5 tonnes per hour and energy generation of 9.2 MJ/kg. Abatement technology is installed: selective non-catalytic reduction (SNCR) using urea for the treatment of nitrogen oxides (NO_X), dry flue gas desulphurisation using lime and activated carbon for the treatment of hydrogen chloride (HCl) and sulphur oxides (SO_X) and a fabric bag filter for the removal of particulate matter (PM)[2].

The facility is permitted to incinerate municipal waste which includes:

- Combustible construction and demolition waste
- Offcuts from the wood industry including particle board and veneers
- Packaging waste
- Non-hazardous combustibles from end of life vehicles and waste electrical and electronic equipment
- Bulky waste
- Sludge, oil or oily water from oil/water separators
- Absorbents, filter materials, wiping cloths and protective clothing
- Anaerobically treated sewage sludge

Although Energy recovery by waste incineration is the primary treatment option in Jersey, it is one of several solid waste management practices that could be adopted. This document aims to give a simple overview of common practices, with a focus on their comparative climate impact in terms of greenhouse gas (GHG) emissions. Jersey Government may then use this information for future waste policy and decision making.

Specifically, this report also considers the secondary impacts of waste products from composting. This follows a query concerning whether potential carbon sequestration benefits of applying compost to land would outweigh the in-process emissions and / or those of alternative waste treatment options. This type of secondary activity is not easily quantified or reflected in existing national level emissions inventories such as the UK National Atmospheric Emission Inventory (NAEI)[3].

Short commentary is also provided on co-impacts of waste management practices. It should be noted that this is intended as a guide for policymakers, and in-depth consideration of feasibility and local impacts within Jersey's geographical and economic context has not been undertaken.

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[1] Energy recovery is often referred to as "energy from waste" (EfW). For the purpose of this report, "Energy recovery" is used throughout in line with Jersey's commonly applied terminology.

[2] https://www.gov.je/SiteCollectionDocuments/Government%20and%20administration/C%20Energy recovery%20Variation%20Working%20Plan%20Rev%206%20%28size%20595kb%29%2020150112%20DM.pdf

[3] https://naei.beis.gov.uk/

Current waste sector GHG emissions in Jersey

Jersey's GHG emissions are accounted for as part of the UK NAEI. Emissions from the La Collette energy recovery facility are included under the inventory category 1.A.1.a.i – public electricity & heat production. The only other waste treatment category currently included in the Jersey inventory is 5.D.1 - domestic wastewater treatment. Biological treatment of waste (anaerobic digestion and composting) is undertaken in Jersey but not at a large enough scale to be estimated as part of the inventory at this stage. Landfill of waste is not currently undertaken in Jersey. 2017 GHG emissions (as CO_2 equivalent) are estimated to be 0.023 megatonnes (Mt) for category 1.A.1.a.i and 0.011 Mt for category 5.D.1.

The La Collette energy recovery facility incinerates both MSW ("black bag waste") and "bulky waste". The MSW portion is sorted before incineration, whilst the bulky waste is shredded to reduce the size to manageable dimensions. The composition of the MSW is outlined in **Table 1.** The majority of MSW received is food waste (31.2%), paper and cardboard (30.1%) and plastic (15.8%). The bulky waste (**Table 2**) is mostly wood waste (50%) and plastic (14.1%).

Table 1: Composition of "Black bag" waste received at the La Collette energy recovery facility.

Waste Type	Sub Waste Type	MSW Waste Composition (%)	
		Sub total	Total
Paper and cardboard	Newspapers/magazines	10.5%	30.11%
	Other paper		
	Liquid cartons	1.5%	
	Card packaging	8.6%	
	Non-recyclable paper	8.3%	
	Other card	1.1%	
Plastic	Plastic film	6.7%	15.80%
	Dense plastic	9.1%	
Textiles			3.52%
Misc. combustibles	Includes disposable nappies		5.02%
Misc. non-combustibles			0.56%
Glass	Brown glass bottles	3.48%	3.48%
	Green glass bottles	-	-
	Clear glass bottles/jars	-	-
	Broken glass	0.20%	0.20%
Putrescible	Kitchen waste	31.2%	35.15%
	Garden/green waste	3.9%	
Ferrous metal			
Non-ferrous metals	Beverage cans	-	-
	Foil	0.38%	0.38%
Mixed Metallic Wastes			3.01%

Waste Type	Sub Waste Type	MSW Waste Composition (%)	
		Sub total	Total
WEEE (Waste electrical & electronic equipment)		0.80%	0.80%
Batteries		0.04%	0.04%
Wood		0.15%	0.15%
Aggregates		0.37%	0.37%
Other		0.45%	0.45%
Fine particles 10 mm fines		0.94%	0.94%

Table 2: Composition of Bulky waste received at the La Collette energy recovery facility.

Waste Type	Sub Waste Type	Bulky Waste composition (%)	
		Sub total	Total
Other Combustibles	Other Wood	44	72.8*
	Carpet and underlay	7	
	Other combustible	6	
	A and B grade wood	6	
	Furniture	6	
	Pallet wood	3	
	Mattresses	1	
	Insulation foam	1	
	Absorbent hygiene products	0	
	Water based paint	0	
Paper and Card		4.5	4.5
Plastics	Dense Plastic	11.8	14.1
	Plastic Film	2.3	
Other Non-Combustibles		2.5	2.5
Textiles		1.9	1.9
Fine Material		1.2	1.2
Putrescible		1.0	1.0
Ferrous Metal		0.8	0.8
Waste Electrical and Electronic Equipment		0.7	0.7
Glass		0.2	0.2
Potentially Hazardous Waste		0.1	0.1
Non-ferrous Metals		0.1	0.1

* May not equal the sum of component parts due to rounding in source data

Implied emission factors for the La Collette energy recovery facility for CO_2 have been calculated and are presented in **Table 3**. Both total emissions and emissions from non-biogenic waste only are presented. Only non-biogenic CO_2 emissions are counted towards a national total in national inventories, and therefore the UK NAEI.

Data on waste tonnages by MSW / bulky waste were not available in the reference documents[4] to allow for accurate understanding of total waste tonnage by composition. As such, to calculate the non-biogenic / biogenic CO_2 split, it has been assumed that all waste incinerated was MSW.

This is considered conservative, as a significant portion of the bulky waste is of the biogenic portion (as in **Table 2**) and the MSW portion is assumed to make up the greater contribution. Where this leads to uncertainty, it will cause a slight overestimate of the non-biogenic (reported CO_2) component.

Biogenic CO_2: CO_2 that is derived from short-lived biogenic material (plant or animal sources excluding fossil carbon). Biogenic CO_2 emissions are excluded from national totals as they are considered part of the biogenic carbon cycle.

GHGs in the form of methane (CH_4) and nitrous oxide (N_2O) will also arise from the incomplete combustion of waste in the incinerator. The emissions, particularly of methane, can vary greatly depending on the temperature, residence time, and air ratio (i.e., air volume in relation to the waste amount). For La Collette, where temperatures are in the range of ~1,000°C, the methane emissions will be small. However, unless facility data is available to show that methane concentrations in the exhaust gas are equal to, or less than those in the ambient air intake, it is best practice in emission inventories to apply default emission factors for the use of waste fuel in stationary combustion[5].

No facility level data on methane or nitrous oxide emissions are available for La Collette. As such, emissions of these gases have been estimated based on UK NAEI implied emission factors for waste incineration under NAEI category 1A1a (use of MSW for public electricity and heat production).

Table 4 presents the total estimated GHG emissions from La Collette by gas, and aggregated as CO_2 equivalent (CO_2e).

To provide further analysis, **Table 5** presents emissions of air pollutants from the facility. The data are based on that provided by the La Collette energy recovery facility which has continuous environmental monitoring systems (CEMS) on their two stacks, monitoring both air quality pollutants and CO_2 as a concentration. This can then be converted to annual emissions using the flue gas volume and can be considered high accuracy.

[4] Bulky waste composition for 2017 data taken from: Waste compositional analysis Jersey Commercial Bulky Waste, Resource Futures, 2017. MSW composition is from 2013.
[5] IPCC 2006 Guidelines, Volume 5, Chapter 5

Table 3: Implied emission factor for incineration at the La Collette energy from waste facility

Average CO_2 Emissions (mg/Nm^3)[1]	Annual CO_2 Emissions (kg)[2]	Annual Waste Incinerated (metric tonnes)[1]	Implied Emission Factor (kg/tonne)	Non-biogenic Implied Emission Factor (kg/tonne)
20	9000	75,000	0.120	0.025

1. Values on average CO_2 emissions, average flue gas volume and annual amount of waste incinerated received from the La Collette facility.
2. This value has been calculated based on an average flue gas volume of 37,000 m^3 per hour and 6000 annual hours of operation.

Table 4: GHG emissions from La Collette energy from waste facility

Annual CO_2 Emissions (kg)	Annual CH_4 Emissions (kg)	Annual N_2O Emissions (kg)	Total GHG emissions (as kg CO_2e)	Notional lifetime landfill CH_4 Emissions (as kg CO_2e)*
9,000	15,000	1,845	957,945	20,257,675

Note: AR4 global warming potentials used (methane = 25, nitrous oxide = 298)
* Notional methane emissions if the 75,000 tonnes of waste incinerated at La Collette was landfilled. The waste would decay and release methane over decades in a landfill.

Table 5: Air pollutant emissions from the La Collette energy from waste facility

Pollutant	Annual Pollutant Emissions (tonnes)	Average Yearly Concentration (mg/Nm^3)[2]	Daily average emission limit values (mg/Nm^3)[3]
Carbon Monoxide (CO)	3.9	8.59	50
Hydrogen Chloride (HCl)	3.8	8.44	10
Nitrogen Oxides (NO_X)	83.5	185.45	200
Particulates (Dust)	0.29	0.65	10
Sulphur dioxide (SO_2)	6.5	14.47	50
Volatile Organic Compounds (NMVOC)	0.43	0.97	-

2. Annual emissions calculated based on an average flue gas volume of 37,000 m^3 per hour
3. Daily average emission limit values for waste incineration from Annex VI of the Industrial Emissions Directive

Comparative GHG intensity across solid waste management practices

Implied emission factors were calculated for landfill, composting and anaerobic digestion based on the 2017 UK inventory[6]. These are presented alongside the IEF estimated for this report from the La Collette energy recovery facility (**Table 6**). These give an idea of the comparative GHG intensities of the treatment options. The UK

[6] https://naei.beis.gov.uk/reports/reports?report_id=981

inventory is assumed to be the most comparable to Jersey, and therefore can be used to predict and compare emissions that may arise from the utilisation of alternate waste management practices.

Emission factors from the International Panel on Climate Change (IPCC) Guidebook[7] are also given where available for additional context and verification.

Table 6: Implied emission factors for landfill, composting and anaerobic digestion

Waste management practice	Pollutant	Implied emission factor UK inventory (kg/tonne)	Emission factor IPPC (kg/tonne)	Estimated (kg/tonne)
La Collette energy recovery facility	*CO_2e*			*12.8*
Landfill	CH_4	10.8	-*	
	CO_2e	270.1	-*	
Composting (wet weight basis)	CH_4	4.0	4.0	
	N_2O	0.24	0.24	
	CO_2e	172.0	-**	
Composting (dry weight basis)[1]	CH_4	-***	10	
	N_2O	-***	0.6	
	CO_2e	-***	-**	
Anaerobic digestion	CH_4	0.8	0.8	
	CO_2e	20.0	-**	

* There is no single EF for landfill as it is estimated using the first-order decay (FOD) method
** The IPCC Guidebook does not provide aggregated EFs as CO_2e
*** The UK inventory uses the EFs for wet composting only
[1] The emission factors for dry waste are estimated from those for wet waste assuming a moisture content of 60% in wet waste

Modern landfills include the recovery of methane emissions using impermeable liners and covering materials with gas extraction systems. This control of the release of emissions from landfill is required under permitting conditions within the UK. The captured methane emissions can be utilised for power generation or flared. The captured and flared methane is not included in these implied emission factors. It is assumed that landfill within Jersey would have similar emission recovery requirements.

The emission factors for composting and anaerobic digestion used in the UK inventory are the default IPCC values[8]. N_2O emissions are assumed to be negligible. Similar to landfills, the methane generated from anaerobic digestion can be used for power generation and the IPCC guidelines outline that it is expected that only between 0 and 10% of methane produced will be emitted as unintentional leakages. The default methane emission factors already account for methane recovery during anaerobic digestion.

[7] https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html
[8] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_4_Ch4_Bio_Treat.pdf

Table 7: GHG intensity of different waste management practices relative to incineration at the La Collette energy recovery facility

La Collette	Landfill	Composting[1]	Anaerobic Digestion
1	21.1	13.4	1.6

[1] The GHG intensity for composting of dry and wet waste will match under IPCC methodologies where dry matter content is removed from activity data (tonnage waste input).

Table 7 outlines a comparison of GHG intensity of the different waste management practices as a ratio relative to incineration at the La Collette energy recovery facility; the CO_2 equivalent has been used and was calculated by dividing the emission factor of the different waste management practices by the emission factor of incineration at the La Collette energy recovery facility. The results show that Landfill is the most GHG intensive waste management practice investigated, at >20 times the emissions per unit of waste processed. This takes into account emissions over the lifetime of waste in landfill, as waste disposed of in landfill continues to emit GHGs over many years as it decomposes. Composting is shown to be approximately 13 times more GHG intensive than the energy recovery facility. Anaerobic digestion is found to be approximately 1.6 times more GHG intensive option on this basis. Of course, the actual GHG intensity of any specific site may vary further, particularly where CH_4 recovery is an option.

Secondary GHG impact of compost applied to land

The data above on comparative GHG intensities only considers the in-process emissions i.e. the emissions that result directly when waste is undergoing transformation / degradation as part of the management procedure. However, it is recognised that waste management systems, and the selection of the "best" option in terms of life cycle GHG emissions, may be significantly impacted by associated emissions. This may include the utilisation of transport networks for waste transfer, or through the onwards use and application of waste products. One such factor is the potential onward GHG impact of compost. This section of the report considers available research, to consider whether there would be positive outcomes for the further promotion of composting as a waste treatment option in Jersey, and the subsequent use of that compost on agricultural land.

Literature

Most of the literature about carbon storage in agricultural soil concerns land use type (e.g. peatland, cultivated land, grassland and crop types)[9,10]; agricultural management techniques such as tillage and crop rotation[11,12] or other factors such as soil characteristics and altitude[13]. There have been few studies into the carbon sequestration and emission effects of mature compost (which contains a high proportion of complex organic molecules) after it has been applied to soil.

9 Kasimir-Klemedtsson et al. (1997) Greenhouse gas emissions from farmed organic soils. Soil Use and Management, 13, 245-25.
10 Paustian et al. (1997) Agricultural soils as a sink to mitigate CO2 emissions. Soil Use and Management, 13, 230-244.
11 Ogle et al. (2005) Agricultural management impacts on soil organic carbon storage under moist and dry climatic conditions of temperate and tropical regions. Biogeochemistry, 72, 87-121.
12 Sperow et al. (2003) Potential soil C sequestration on U.S. Agricultural soils. Climatic Change, 57, 319-339.
13 Leifeld et al. (2005) Carbon stocks in Swiss agricultural soils predicted by lane-use, soil characteristics, and altitude. Agriculture, Ecosystems and Environment, 105, 255-266.

Studies conducted in California by researchers on the Marin Carbon Project have shown that applying a layer of compost to grassland increases the carbon storage of the soil underneath (excluding the addition of the carbon from the compost). It is thought that this increase is due to a higher water-holding capacity and the "slow release effects of compost decomposition" leading to more vigorous plant production[14].

However, this increase in carbon storage is not applicable to cropland which is considered net zero in terms of carbon. Any increased carbon storage in the form of plant matter is eventually released back into the atmosphere post-harvest.

Current use of compost in agriculture

Currently, the majority of compost products used in the agricultural sector are in the form of soil conditioners[15]. In 2006/7, 53% of compost in the UK was supplied to the agricultural sector (mostly in the form of soil conditioner)[16]. The purpose of soil conditioner is to improve physical qualities of the soils, primarily soil structure.

Jersey's agricultural soils

Jersey contains 4900 ha of cropland and 2800 ha of grassland. In 2017, 19% of total N_2O emissions reported by Jersey were due to agricultural activity such as fertiliser application on soils. There is currently no specific composting data currently being reported. The use of soil conditioner does not greatly overlap with the use of fertiliser, the primary function of which is to supply nutrients[17]. Therefore, there is little scope to calculate any potential reductions in emissions due to replacement of fertiliser use.

Status of GHG impact research

There is little evidence identified that application of mature compost to land in Jersey would offer significant carbon sequestration benefits, although the research on this topic is in its infancy. It is clear that compost offers benefits to soil quality due to its role as a soil conditioner. There is no evidence or literature of carbon benefit from applying mature compost to land that could be implemented and reflected in the Jersey (and UK NAEI) greenhouse gas inventory.

14 https://www.marincarbonproject.org/file/2018-documents/Paper-Summary---Effects-of-Organic-Matter-Amendments-on-Net-Primary-Productivity.pdf

15 K.W. Waldron, E. Nichols, in Handbook of Waste Management and Co-Product Recovery in Food Processing, Volume 2, 2009

16 http://www.organics-recycling.org.uk/uploads/article1769/The_State_of_Composting_and_Biological_Waste_Treatment_in_the_UK_2006-7.pdf

17 https://extension.umd.edu/sites/extension.umd.edu/files/_docs/programs/master-gardeners/Montgomery/2016Novemberconference/HG42_Soil_Amendments_and_Fertilizers.pdf

Co-impacts of solid waste management practices

In addition to analysis of greenhouse gas emissions, **Table 8** outlines some of the co-impacts of the four solid waste management practices including air quality emissions, cost, sustainability and odour.

The cost information is based upon a 2002 European Commission report, and as such the specific values should be treated with caution and are given for comparative purposes only. Supplementary information related to UK legislation is given where appropriate.

Table 8: Co-impact of solid waste management practices

Waste management practice	Air Quality pollutants[1]	Cost[2] €/tonne waste	Sustainability[3]	Odours
Landfill	Particulate matter from waste handling. In addition, small amounts of volatile organic compounds, carbon monoxide, ammonia, nitrous oxides.	Dependant on location but medium to high cost of €10-34 excluding levies. In the UK, landfill tax is set at £91.35/tonne during 2019, and rising in 2020, making this a high cost option.	Tends to be lowest option in hierarchy of options. High land use.	Potential for odour during process.
Incineration (with recovery)	As noted on page three, the energy recovery facility at La Collette has advanced pollutant abatement in place. Where this is not the case, waste incineration practices may give rise to pollutants including dioxins and furans, persistent organic pollutants, heavy metals, sulphur oxides,	More types of waste can be incinerated. Medium to very high cost, €41-66.	Classified as other recovery in the waste hierarchy.	Odours arise from storage only.

	nitrous oxides, volatile organic compounds, carbon monoxide and ammonia. Where these are unabated, they may occur in significant quantities.			
Composting	Ammonia but not considered to be released in significant quantities. However, composting dry waste can increase ammonia emissions due to nitrogen overload. Bioaerosol emissions.	Low to medium cost, including separate collection, €35-75.	Classified as other recovery in the waste hierarchy.	Potential for odour during process especially if waste is high in nitrogen.
Anaerobic digestion	Ammonia, nitrogen oxide and dust	Medium to high cost including separate collection, €80-125.	Classified as other recovery in the waste hierarchy.	Potential for odour during process

1. https://www.eea.europa.eu/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/5-waste
2. Economic analysis of options for managing biodegradable municipal waste (2002): https://ec.europa.eu/environment/waste/compost/pdf/econanalysis_finalreport.pdf. Given this costing is from a report produced in 2002, these costings should be treated as representative only
3. https://ec.europa.eu/environment/waste/publications/pdf/Making_Sust_Consumption.pdf

Summary

Currently, Jersey's waste management operations consist primarily of the energy recovery facility at La Collette, which treats MSW and additional bulky waste. Small amounts of green waste and sewage sludge are composted and treated through anaerobic digestion respectively. This document explores the potential impacts of alternative waste management practices in terms of in-process GHG emissions. GHG intensities are presented for landfill, composting and anaerobic digestion and are compared with current emissions that have been calculated on the basis of reported data from La Collette. The GHG intensity of La Collette is found to be lowest, with anaerobic digestion found to be approximately 1.6 times move intensive, while the intensity of composting and landfill are around 13 and 21 times greater respectively. It is noted that the actual GHG intensity of any specific site may vary further, particularly where methane recovery is an option. However, this analysis is indicative and is not intended to reflect detailed feasibility of options in Jersey e.g. due to transport infrastructures, geographies and economic factors.

A more detailed review of the impacts of compost application to soils reveals that although there is potential for increased productivity, it is likely that annual crop harvest means there would be no net increase in carbon sequestration. Furthermore, as compost products are not suitable for use as a direct fertiliser replacement, the current emissions due to agricultural fertiliser application in Jersey are not expected to be reduced. The literature in this area is in its infancy, but there is no evidence or literature of carbon benefit from applying mature compost to land that could be implemented and reflected in the Jersey (and UK NAEI) greenhouse gas inventory.

The co-impacts of air quality pollution, cost, sustainability and odours were also compared. Incineration with energy recovery (such as La Collette) can produce emissions of many air pollutants, although these are significantly reduced through abatement technologies. Incineration can have sizable cost, comparable to that of composting. The pollutant releases, particularly for air pollutants, can however be significantly abated in comparison with unabated incineration plant. Composting and anaerobic digestion produce the fewest air pollutants, while anaerobic digestion can have the highest cost of all the methods. Landfill is generally the cheaper option, but scores lowest in terms of sustainability and also has the potential to produce many pollutants.

Recommendations

This project has collated and presented improved emissions data from La Collette energy recovery facility in Jersey. Currently, the UK NAEI is using outdated input data and non-specific emission factors. It is recommended that the data acquired during this project be collected across the necessary timeseries (1990 – current year minus 2) where available. This should coincide with an annual procedure / agreement to ensure the ongoing provision of emissions data to the UK inventory compilers. This will allow for accurate representation of Jersey's waste sector emissions in the national level reporting.

The report also puts into context other waste treatment options for Jersey. Data on utilisation of current small-scale practices e.g. composting should be tracked to allow for understanding of GHG impact should the popularity of such practices increase in future years. In addition, researching the implications of compost application in Jersey would improve the understanding of secondary impacts such as soil conditioning and fertiliser use.

About the authors

Aether provides world experts in environmental data analysis and interpretation, and is at the forefront of greenhouse gas and air quality pollutant emissions calculation and review

Richard Claxton has many years' experience in the compilation of emission inventories and projections both internationally and in the UK. During this time, Richard has also managed and been involved in the compilation of the emissions data for the UKs Overseas Territories and Crown Dependencies (OTsCDs). Richard is a qualified waste sector expert under the UNFCCC and has taken part in the annual inventory review of numerous Annex I Parties.

Lucy Garland has experience of inventory compilation through her work on the UK NAEI (including OTsCDs) and is also supporting Richard on waste sector projects and inventory compilation.

Holly Zhang has also supported on the production of this report. A recent graduate, Holly is adept at literature review and has a firm grounding in emissions data and analysis.

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