WRAP

Final Report

Guidance for on-site treatment of organic waste from the public and hospitality sectors

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Front cover photography: Green Johanna, from Housing 21 case study

Executive summary

The purpose of this document is to provide guidance to and aid decision making of managers, facilities managers and others within public sector organisations (including schools, hospitals, universities, prisons) and hospitality sector organisations (including hotels, restaurants, pubs and cafés) who are considering treating organic waste such as food and/or garden-type wastes on-site. There are a range of technologies that can be used to treat organic waste; those included in this guidance break down organic waste by composting and anaerobic digestion. These produce a compost or digestate (compost-type product) that can be beneficial to plant growth and/or improves soil structure. Anaerobic digestion also produces renewable energy.

For these technologies, an organisation will need to have gardens or grounds on which to use the compost or digestate product.

This document provides information and advice that will help you decide whether to invest in on-site treatment and what types of technologies are potentially suitable for your set of circumstances. The list of technologies described in this document is not intended to be exhaustive and other technologies may be available on the market. All information was gathered in good faith for this project. Other sources of information / suppliers may be available from www.ciwm.co.uk, www.r-e-a.net , www.adbiogas.co.uk or www.wrap.org.uk.

The guidance document contains summary information on the following:
- the environmental, financial and social benefits of treating organic waste on-site;
- how you might identify and quantify the amount of organic waste your organisation produces, in order to estimate the capacity of treatment facility required;
- the micro-scale technologies available for treating up to 100 kg/week of organic waste. This is the amount of waste that is likely to be produced by a café or restaurant. These technologies include wormeries, mini-digesters and composting bins;
- small-scale technologies capable of treating over 100 kg/week of organic waste. This includes manually operated in-vessel composters, automated (electric powered) in-vessel composters and anaerobic digestion systems;
- health and safety issues and applicable legislation;
- factors that influence the cost of operating on site technologies;
- an overview of the Decision Tree.

An excel decision tool supports this document. This contains a Decision Tree and Technology Matrix which, through answering a sequence of questions, identifies the technologies that appear to best suit your needs. However, having used the document and the excel decision tool, you may determine that having your organic waste collected for treatment off-site better suits your circumstances.

A series of case studies describing how organisations from the public and hospitality sectors are using different types of technologies to treat their waste on-site are provided alongside this document.

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1.0 **Introduction**

The purpose of this document is to provide guidance to and aid decision making of managers, facilities managers and others within public sector organisations (including schools, hospitals, universities, prisons) and hospitality sector organisations (including hotels, restaurants, pubs and cafés) who are considering treating organic waste such as food and/or garden-type wastes on-site. There are a range of technologies that can be used to treat organic waste, those included in this guidance break down organic waste by composting and anaerobic digestion, resulting in a compost-type product that can be beneficial to plant growth and/or improves soil structure and in the case of anaerobic digestion renewable energy.

- Composting is a process that takes place in the open air or within an enclosed container in the presence of oxygen to produce compost that can be beneficial to plant growth and/or improved soil structure.
- Anaerobic digestion takes place in an enclosed system in the absence of oxygen to produce a digestate, which can be used similarly to compost, and renewable energy.

For both these technologies, an organisation will need to have gardens or grounds on which to use the compost or digestate product. It assumes that organisations will require small scale technologies that will operate under exemptions from *The Environmental Permitting (England and Wales) Regulations 2010.* The guidance does not include technologies that dispose of waste to sewer or thermal treatment technologies.

The guidance contains:

- A summary of the benefits of treating organic waste;
- A summary of the micro-scale (treating up to 100 kg/week) and small-scale (treating over 100 kg/week) technologies that are available to treat organic waste on-site;
- Summary of associated health and safety issues and legislation;
- Information on factors that influence the cost of operating on-site technologies;
- A decision tool to help you decide which technology would best suit your circumstances; and
- A series of case studies describing how organisations are using different types of technologies to treat their waste on-site.

The focus of the guide is on technologies that can be used to treat organic waste on-site. It does not cover technologies that are operated commercially by waste companies collecting from multiple premises and treating the waste centrally. However, having used the decision tool, you may determine that having your organic waste collected for treatment off-site best suits your circumstances.

1.1 Reasons for Treating Organic Waste

There are a wide variety of reasons for improving the management of organic waste through the use of a treatment technology, rather than sending the waste for disposal to landfill, or to sewer. The reasons that could motivate you to treat waste on-site include improved environmental performance, financial benefits and social & educational rewards.

1.1.1 *Environmental Reasons*

Environmental benefits of installing an organic waste treatment technology on-site, include:

- Reducing your organisation's carbon/environmental footprint through a reduction in the amount of waste sent to landfill and a reduction in any associated waste transportation. Diverting one tonne of food waste from landfill via on-site composting will save approximately 335 kg of carbon dioxide (CO_2) equivalent emissions;
- Production of compost or digestate for on-site use to improve soil quality resulting in reduced use of non-renewable peat is used to replace a potting compost and environmental impact of producing compost off-site e.g. energy, transportation;

- Improving sustainability practice by providing a closed-loop solution (i.e. turning your own waste into a product you use on-site);
- If anaerobic digestion is used:
    - production of a valuable product such as biogas for energy generation, displacing fossil based alternatives (e.g. provision of heat and electricity for local use, electricity to the national grid). Diverting one tonne of food waste from landfill via anaerobic digestion will save you approximately 465 kg CO_2 equivalent emissions annually;
    - production of a valuable biofuel product such as biodiesel fuel for use in vehicles or biomass for energy generation, displacing fossil based alternatives;
- Increasing awareness of food waste among staff, customers, students, etc. with the potential for encouraging added benefits of increased recycling and waste reduction.

In a strategic sense, a guiding principle in the selection of waste management options is the "waste hierarchy"[1]. This has been adopted in EU and UK law. The "waste hierarchy" ranks waste management options according to what is best for the environment. It gives top priority to preventing waste in the first place. When waste is created, it gives priority to preparing it for re-use, then recycling, then recovery, and last of all disposal (e.g. landfill). All organisations have a duty to apply the "waste hierarchy" when considering their waste management option[2].

1.1.2 *Financial Reasons*

The potential financial benefit may be a key reason for considering on-site treatment. These benefits may occur as a result of:

- reduction in waste collection and disposal costs;
- reduction in fuel or compost expenditure, and;
- income potential from sale of fuel and electricity from anaerobic digestion technologies.

You will need to undertake an overall cost assessment to determine how these potential benefits compare with costs that you would incur in purchasing and managing a technology on an annual basis. Further information on cost factors is provided in Chapters 6 and 7.

1.1.3 *Social and Educational Reasons*

A key motivation for treating waste on-site is often the social and educational benefits it brings to an organisation. These may include:

- Improving environmental credentials and image, which can in turn attract a new, or reinforce an existing customer base, or student intake;
- Delivering educational curriculum learning outcomes for students and providing purposeful employment for prison inmates;
- Increasing awareness of food waste problems and encouraging green credentials and ethos, including waste reduction and recycling.

1.2 The Importance of Treating Organic Waste

Typically, organic wastes produced in the hospitality and public sectors are disposed of in landfill sites or, in the case of food waste, sometimes macerated in kitchens and disposed to sewer. When organic waste decomposes in a landfill site, quantities of methane gas are produced which contributes to climate change (see Box 1). By producing valuable products, such as compost and biogas from the organic waste, this diverts organic waste away from landfill sites.

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[1] *https://www.gov.uk/waste-legislation-and-regulations*

[2] *https://www.gov.uk/government/policies/reducing-and-managing-waste*

Box 1: Climate Change and Managing Food Waste

The majority of food wastes in the UK are disposed of in landfill sites. The nature of organic material means that as it decomposes it produces the greenhouse gases methane (CH_4) and carbon dioxide (CO_2), which contribute towards the Global Warming Effect, generally referred to as 'Climate Change'.

Climate change effects are demonstrated by a rise in the average annual global temperature. This is considered to be responsible for greater instability of weather patterns. In the UK the impacts of climate change may be felt with increasing frequency if action is not taken to reduce greenhouse gas emissions to a manageable level. Potential impacts include:

- Localised flooding.
- Rising sea levels changing the shape of the UK's coastline.
- Increased frequency of extreme weather patterns and associated disruption.

The UK government's chief scientist Professor Sir John Beddington has expressed (March 2013) that there is a "*need for urgency*" in tackling climate change, warning that "*the* [current] *variation we are seeing in temperature or rainfall is double the rate of the average. That suggests that we are going to have more droughts, we are going to have more floods, we are going to have more sea surges and we are going to have more storms*. These are the sort of changes that are going to affect us in quite a short timescale."

2.0 On-site Organic Waste Treatment Methods

Most organic treatment technologies involve the 'break down' of organic wastes, also referred to as decomposition. The decomposition of organic wastes can occur either aerobically (in the presence of oxygen contained within air) or anaerobically (in the absence of oxygen). Technologies that operate aerobically are termed composting and those that occur anaerobically are termed anaerobic digestion. The majority of technologies available are enclosed (i.e. take place within a container) limiting the potentially unpleasant odours created during the decomposition of wastes.

2.1 Composting

Composting is the natural breakdown of organic materials, such as garden and food wastes, by micro-organisms known as fungi and bacteria in the presence of oxygen and water. The resulting material is a nutrient rich, dark coloured compost, or humus, which can be used as a soil fertiliser, and therefore reduces the need to buy costly chemical fertilisers for use on gardens and open land.

Benefits of On-Site Composting

- Diverting one tonne of food waste from landfill via composting will save approximately 335 kg of carbon dioxide (CO_2) equivalent emissions
- Provides a useful end product for use on land
- Can reduce costs associated with waste disposal and compost purchase

Before the waste is added to the composting unit, some preparation may be necessary to remove unsuitable materials (e.g. plastic food packaging) and to shred/chip waste to increase the surface area of the waste and speed up the composting process.

Basic composting goes through four general stages of treatment, however the period of time it takes to compost can vary across each technology depending on the types of wastes treated, temperatures reached and manufacturer's instructions.

The four stages are as follows:

1) Material begins to warm as bacteria and fungi start to grow, feeding off the waste.
2) If the correct conditions are present (such as the mix of food and garden waste, air, moisture etc.) the process will rapidly heat up. The optimum mix is the relative proportions of different organic waste types that result in the composting process operating most effectively. Regular mixing is important to add oxygen, evenly distribute new additions of waste and to maintain high temperatures.
3) Cooling occurs once much of the material has been digested by micro-organisms. At this stage the material can vary in terms of how it looks, smells and feels depending on the initial mix. Small amounts of shredded cardboard or sawdust can help to soak up excess moisture. Conversely, adding fresh garden clippings or a sprinkling of rain water can add moisture to a dry mix.
4) Final maturation of the compost occurs through further breakdown by micro-organisms plus small invertebrates such as worms. This is necessary to make the compost more stable and suitable for applying to gardens. If applied too early, it can contain acid compounds that can burn leaves or kill very sensitive plants. Mature compost will have an earthy smell, be a rich brown colour, likely to contain some fibrous material and it will be difficult to identify the original organic waste.

The length of time to produce compost that is ready to be applied to land can vary depending on the particular technology. In general, open systems (i.e. compost heaps) can produce a finished product within a few weeks to a few months and in-vessel composting (IVC) systems can produce a finished product within a matter of weeks. Locating a compost bin/heap in a sunny spot will help a composter to stay active during colder weather, although it may take longer for compost to be produced than in summer months. In-vessel units can sometimes be insulated using 'jackets' provided by the manufacturer. Some manufacturers of insulated bins recommend they are placed in a shady location in a garden, to avoid over-heating, therefore it is important to always refer to supplier recommendations.

2.2 Anaerobic Digestion

Another way of treating food waste is by using a treatment process called anaerobic digestion (AD). This process involves the breakdown of organic garden and food wastes by bacteria in the absence of oxygen (anaerobic). This type of technology is actively being supplied to the larger scale on-site market in the UK (e.g. breweries, dairies and large scale food manufacturing sites), although is less well established than composting technologies.

Benefits of on-site anaerobic digestion

- Diverting 1 tonne of food waste from landfill via anaerobic digestion will save you approximately 465 kg CO_2 equivalent emissions annually.
- Produces methane gas for renewable energy generation.
- Produces a nutrient rich digestate for use on gardens and landscaping.
- Financial savings can be achieved through the reduction in cost of food waste disposal and compost purchase.

It is more important in AD compared with IVC, that the material is shredded/chipped in order to maximise the surface area available to the micro-organisms in the digestion unit as this increases the speed of digestion. Depending on the AD technology and organic material treated, water may be added and the waste macerated to reach the required consistency. This is particularly important for systems where the waste is run through pumps. The AD process takes place in an airtight container generally known as a digester. Regardless of the system chosen, AD requires a regular feed of waste which is neither too wet nor too dry, however some AD systems can be tolerant of wetter wastes. Typically, AD is ideal for food wastes and does not usually tolerate a large proportion of woody material, which can be a very dry waste. You should seek advice from the technology supplier on suitable feedstock mixes and their relative proportions, as these can impact on the ability for the system to produce a consistent gas output. Bacteria are added to the digester to start the digestion process; this can be achieved through the addition of manure or seeded with bacteria.

The enclosed digester is heated and the digestion process produces a biogas (comprising methane, carbon dioxide and other trace gasses) which can be used to generate electricity and/or heat through a gas engine or combined heat and power (CHP) engine. The digester will need its own power supply to operate (termed a parasitic load), but the surplus can be used on site or potentially exported for use by other organisations. This will have potential implications on where you can practically locate the system. AD also produces a residual sludge or slurry, called digestate, some of which can be recycled back into the process or it may be used whole or further separated into soil conditioner and a liquid fertiliser and applied to land.

The scale of AD systems can vary from a small 'household' scale system (which operate in countries such as India) to large commercial plants of several thousand cubic metres treating food waste from a domestic waste collection round. Small scale units are typically modular or mobile units. Digestion time varies from a couple of weeks to a couple of months.

2.3 Organic wastes suitable for composting or anaerobic digestion

IVC and AD technologies are both suitable for treating uncooked and cooked food waste, of both animal and vegetable origin, as they treat the waste in a closed system and work at a high temperature that sterilises the waste. This includes waste generated during food preparation in kitchens and plate scrapings waste. Food waste cannot be treated in an open system such as a compost heap. There are precise regulatory requirements regarding the treatment of food waste and those relevant to small scale systems are summarised in Chapter 5. Further guidance is available on https://www.gov.uk/dealing-with-animal-by-products and environment agencies in England and Wales.

AD technologies are particularly suited to food wastes. IVC technologies usually require a mix of food and woody type materials. Examples of acceptable wastes include:

- All fruit and vegetables (raw and cooked);
- Meat and fish (raw and cooked);
- Carbohydrates such as bread, pasta, pastry and rice;
- Dairy products and eggs;
- Garden-type waste – quantities dependant on technology type.

Certain wastes take longer to biodegrade than others. Foods that are high in sugars and fats will compost the fastest, followed by leafy matter. Woody wastes such as twigs and leaves contain lignin, a substance that gives vegetation strength and rigidity but does not biodegrade. It is important to get the right mix ratio between carbon and nitrogen containing organic wastes, in order for both composting and AD technologies to work properly. Food and green leafy wastes are rich in nitrogen and brown, drier materials such as cardboard and woody prunings are rich in carbon.

If you have large quantities of green garden waste and leaf litter from grounds maintenance then this is best composted separately in open air composting heaps. For smaller quantities of waste then these can be added to an IVC but it is usually recommended that they are shredded/chipped to increase the surface area, which will assist in help to speeding up the composting time.

Although waste paper and cardboard can be added to IVC units, many technology suppliers recommend that these are only added in small quantities and should be shredded first or are added at the maturation stage of composting.

A normal home compost bin/heap is unsuitable for meat, fish and all cooked food including bread, rice and plate. For further information on waste types that are acceptable or not acceptable for a home compost bin/heap see http://www.recyclenow.com/home_composting/making_compost/.

A 'hot composting' bin is similar in size to a home composting bin but is made of an insulated material which enables the process to work at a high temperature to sterilise the waste. If this temperature is achieved and maintained then uncooked and cooked food waste, of both animal and vegetable origin, can be composted. Note that including cooked food waste brings the potential for attracting vermin unless it is managed according to manufacturer's instructions.

Each technology supplier will be able to provide detailed information on:

- the types of wastes they recommend you can compost/digest using their technology;
- any waste preparation required (e.g. size of vegetables pieces, shredding of paper/woody material);
- the proportions of different waste types (e.g. amount of food waste and sawdust/woodchip required); and
- the waste types to avoid in order to optimise the performance of the system.

3.0 **On-site treatment technologies**

This chapter discusses the range of technologies currently on the market for the treatment of organic wastes that might be produced by establishments such as hospitals, prisons, schools, restaurants and hotels. These are technologies that have a commercial track record and are currently being used by the public and hospitality sectors. The list of technologies described in this document is not intended to be exhaustive and other technologies may be available on the market. All information was gathered in good faith for this project. Other sources of information / suppliers may be available from www.ciwm.co.uk, www.r-e-a.net , www.adbiogas.co.uk or www.wrap.org.uk. Information on alternative technologies that are not included in this guidance are summarised in Appendix 1.

A decision tree has been produced in Chapter 7 which will help your organisation to select the most appropriate and viable solution for your organic waste needs, based on those identified in the production of this guidance. This will allow you to select a suitable treatment technology based on your priorities/requirements, waste production and resources available. Guidance on how you might estimate the quantities of waste you want to treat is provided in Box 2 and Appendix 2.

There are a wide range of examples of technologies used at different establishments in the public and hospitality sectors. To illustrate this, a series of case studies is included alongside this document so that you can compare your requirements with the successful operation of technologies under similar circumstances.

Box 2: How much organic waste do you have?

You will need to estimate how much waste your organisation produces in order to compare different technologies and assess how much it is going to cost you to treat your organic waste on-site. There are essentially three options available to you:

Option 1: Undertake a waste survey to separate and weigh organic waste
Option 2: Estimate the proportion of organic waste within your total waste stream
Option 3: Use proxy data to estimate the amount of organic waste

Option 1: Undertaking a waste survey
A waste survey requires you to separately collect the organic waste in a bin and weigh it. The weight should be recorded over a representative time period, for example, in the middle of term time at a school or a typical week in a restaurant. If your organisation has 'surges' of activity then better data will be obtained from a mid-week survey first (i.e. a less busy day), to allow you to become familiar with the survey methodology. It can then be repeated on a Friday or weekend to capture data from a busy day. The weight data can then be scaled-up in order to estimate the amount of waste you will need to treat per week. This data can also be used to estimate the amount of organic waste produced per pupil, per resident or per diner.

Option 2: Estimating the proportion of organic waste
You can either visually estimate the proportion of organic waste within your total waste stream or you can separate out the organic waste and convert the volume of waste to an estimated quantity of waste produced. Different organic wastes and the way they are collected result in different bulk densities, that is, the quantity of waste that occupies a standard unit of space. Larger quantities of food waste tend to occupy less space than smaller quantities as the weight squashes the waste. The bulk density of food waste ranges between 0.3 and 0.5 tonnes/m3 (WRAP Materials Bulk Density Report, 2010). Alternatively, you can use the following table to estimate the amount of waste you produce. Note that this method is less accurate that option 1.

Bin type used to food collection	Food waste per week	Weight of Food waste per annum
1 large kitchen caddy (10 litres)	5 kg	260 kg
1 mid-sized kitchen bin (30-60 litres)	15-20 kg	780 - 1040 kg
1 full standard wheelie bin (240 l)	60-80 kg	3120 – 4160 kg

Option 3: Using proxy data
If you do not have scales to weigh the organic waste, you can apply sector-specific grossing up factors. These factors are calculated from survey data and enable you to estimate the quantity of waste produced, according to the size and type of organisation. For example, factors are available to enable you to calculate the amount of food waste producer per school pupil or hospital bed. Details of these factors are provided in Appendix 2.

3.1 Micro-Scale Technologies

The term 'micro-scale' is used to describe those technologies that are similar in type to those that may be used in a domestic setting, such as home compost bins and wormeries. These, by their nature are generally restricted to lower volumes of organic waste (up to 100 kg/week), and may be appropriate for smaller commercial or public sector premises such as cafés that produce around 2-3 kg/week of organic waste. 'Micro-scale' technologies are operated manually (e.g. wormeries, Hot Bin).

The micro-scale technologies currently available for treatment of organic wastes are all aerobic, relying on the decomposition of materials in the presence of oxygen found in the air. These can often be used in a modular arrangement, that is, you can increase or decrease the number of units you may need depending on how much waste you produce. For example, you may start off with one composting bin, but then find you need another one to cope with a seasonal increase in waste or a growth in business. This means they are scalable for the majority of small organic waste producers, and can provide a low cost solution for the on-site management of organic wastes. The most commonly used technologies of this type are vermicomposting (i.e. wormeries), windrow or static pile composting (i.e. compost heaps/piles) and compost bins.

3.1.1 *Vermicomposting*

Vermicomposting is a micro-scale technology ideal for treatment of food wastes. The 'wormery' consists of a series of boxes stacked on top of each other and contains specially bred worms that feed off the waste. Within three months a vermi-compost is produced that can be spread to land, and a liquid which is nutrient rich and can be used as a fertiliser. The system is self-sustaining provided adequate waste is added, with worms multiplying provided a stable temperature is maintained in the unit and the waste is not too acidic.

Wormeries are limited in the type of organic materials they accept. Vegetables, tea bags and ground coffee are suitable for the process; however, acidic wastes like onions and citrus peel can only be added in small quantities as they restrict the performance of the worms. Meat and fish are not recommended for this process as the worms will struggle to decompose the material. Further information is provided on the Royal Horticultural Society website[3].

Wormeries can vary in size from about 75 litres capacity up to as much as 1,000 litres. A wormery with a capacity of 300 litres will treat 7-8 kg of food waste per week, which is approximately the amount produced by a large family or small business such as a café. Prices generally start at about £50 for smaller models, with the largest models costing as much as £700. UK based suppliers include Original Organics and Wiggly Wigglers.

3.1.2 *Compost Bins*

Compost bins are a widely used and are long-standing, proven methods for the treatment of organic wastes. Typically they consist of a plastic or wooden container where organic waste is placed and allowed to naturally degrade over time. They are placed outdoors, directly on the soil and require some maintenance to turn the composting waste periodically to make sure it is sufficiently aerated and to potentially adjust the proportions of waste added. A mixture of green and brown[4] materials is required for optimal efficiency, and will allow

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[33] http://apps.rhs.org.uk/advicesearch/Profile.aspx?pid=726

[4] Green materials are rich in nitrogen and are generally 'wet' materials; brown materials are rich in carbon and generally 'dry' materials. If there are too many brown materials the composting process will be slow. Too much green waste (e.g. composting only grass clippings) is likely to generate a 'wet' mix through which air cannot circulate properly, providing insufficient oxygen, which can cause both odours and an unsatisfactory compost output.

relatively high temperatures to be reached. This will enable the composting process to complete effectively, to produce a high quality compost output with a good nutrient balance ready for application to land, such as flower and vegetable beds.

- Typical "brown" materials include cardboard, egg shells and woody clippings.
- Typical "green" materials include grass, weeds and vegetable peelings.

For further information see http://www.recyclenow.com/home_composting/making_compost/.

Similar to wormeries, compost bins are restricted to accepting organic waste of a plant origin, such as uncooked vegetable food waste and garden waste. Compost bins are not suited for meat, fish and diary wastes. This is because the entire contents of the bin does not reach and maintain a temperature of 60^{o}C, which is necessary to sterilise meat, fish and diary wastes. Compost bins start from as little as £20, and will generally have a capacity in the range of 200 to 350 litres, capable of treating approximately 10 kg of waste per week. In typical home composting bins, compost is usually produced within 6 to 12 months depending on how often it is turned.

3.1.3 *Thermal Compost Bins*

A variation available on the market is a compost bin which accelerates the composting process by maintaining higher temperatures within the composting unit (e.g. the Hotbin, Green Johanna). The units are made from an insulated engineered material which allows the process to reach and maintain a temperature of 60^{o}C. The increased temperature, when compared with standard compost bins, allows all food wastes to be treated by the process (i.e. meat, dairy and carbohydrates as well as vegetable and fruit waste). Including cooked food waste brings the potential for attracting vermin unless it is managed according to manufacturer's instructions.

The amount of time the waste remains in the bin is typically 90 days. After this, it is recommended that the compost is placed in a maturation bin to produce a finished compost product. By way of example, a Hotbin has a total capacity of 200 litres, which is roughly 5 kg of organic waste each week, and costs ~£130. Note that you still need to have your own garden/land on which to use the resulting compost to comply with environmental legislation.

You need to have a minimum of 5kg of waste per week to operate a Hotbin at a temperature of 60^{o}C. If you have insufficient waste, it should be operated as a normal composting bin.

3.1.4 *Mini Home Digesters*

Mini digesters are partially buried static units that utilise heat from the sun to accelerate the decomposition process. Usually the unit is made up of three main parts; a basket that is dug into the ground where the unit will be located, with typically an inner cone and a slightly larger outer cone. The effect of having two cones is that air circulates around the unit and therefore creates heat to help the composting process. A mini home digester utilises natural bacteria, however where the bacterial activity is insufficient, the process can be aided through the addition of accelerants.

Most mini home digesters can accept all types of food wastes, including bones, and will result in outputs of water, carbon dioxide and a small amount of liquid residue which requires emptying roughly every two years. Unlike with AD units there is no useable compost like product or energy production from this process. An established example on the market is the Green Cone, which on average will accept 2-3 litres of food waste each day. Green cones are available commercially in the price range of £75 to £100 per unit.

3.1.5 *Windrow or 'Static pile' Composting*

Open air composting can be done at a number of scales, ranging from a simple compost heap for the smallest amount of organic waste up to windrow style composting for larger establishments. A windrow is a triangular shaped pile of organic waste placed in a line along one axis. This approach is best suited if you have lots of garden or grounds maintenance waste such as grass and hedge clippings. It is illegal to compost in the open meat, fish and other animal related food because of the risk of transmitting infectious diseases like foot and mouth to farm animals.

Windrow composting consists of long piles of organic waste which is periodically turned (in rotation) to reactivate the organisms to keep the process going. As a result they need a lot of outdoor space and a non-porous concrete pad to ensure that any liquid produced from the degradation process, called leachate, can be collected and does not drain into the soil below. Static pile composting would require a compost 'heap'; however this should also be periodically aerated in order to maintain the biological process and to prevent it from going anaerobic, either manually with a fork or using a tractor with a bucket attachment (sometimes referred to as a front end loader) where there are large quantities of waste. You will need to register for an exemption from the *The Environmental Permitting (England and Wales) Regulations 2010* if you propose to store or treat up to 80 tonnes of waste at any one time. Above this quantity of waste you will need a waste permit. An exemption is not required for household scale activity.

3.2 Small-Scale Technologies

The term small scale is used to refer to technologies suitable for serving a single organisation that produces over 100 kg of organic waste a week. Some of the technologies described are available in different sizes, the smallest suitable for a primary school through to the largest of which may be more suitable for a cluster of businesses, a large hotel or a large hospital which would produce more organic waste.

3.2.1 *In-Vessel Composting*

In-vessel composting (IVC) systems are a robust method of treatment which will accept a wide range of organic wastes, including all kitchen or canteen food wastes, garden waste and cardboard waste. The waste to be treated is mixed together in a vessel (i.e. an enclosed metal or plastic container), usually with the addition of an absorbent material like wood pellets or sawdust, to produce a nutrient rich compost material. As the waste is enclosed within a vessel, the composting process can be controlled by a number of methods, including:

- forced aeration – i.e. pumping air through the waste;
- increasing or decreasing the water content of the material; and
- raising or lowering the temperature within the vessel.

These allow optimum conditions to be maintained that support the micro-organisms involved in the composting process.

Small scale, on-site IVC systems are either manual or automated operations. Generally the manually operated vessels will handle a smaller amount of waste (600 to 20,000 litres per annum of organic waste – approximately between 300 to 10,000 kg of food waste assuming a bulk density of 0.5 tonnes/m^3), whereas automated vessels will operate at larger scales, requiring a covered area and a power supply.

Regardless of the system chosen, IVCs require a regular input of waste (i.e. at least weekly) which is neither too wet nor too dry. An input that has too much moisture (e.g. contains a lot of wet materials such as juice, soups and green grass) can cause the process to lose heat and become anaerobic, producing a slimy and smelly product. Inputs that are too dry (e.g. predominantly paper, autumn leaves) will compost very slowly and will look very similar after a few weeks of being in the vessel. If the vessel is being used to treat food waste only, a dry bulking agent such as sawdust will also need to be added to the vessel to achieve a suitable waste density and consistency for the technology to operate. This means that the capacity of the system required will need to take into account the combined quantities of food waste and bulking agent.

IVC and open windrow systems are covered by environmental legislation, with larger facilities requiring environmental permits. However, exemptions are available for smaller scale technologies (treating under 80 tonnes of waste at any given time) allowing on-site management of organic wastes and use of compost outputs (see Chapter 5). It is likely that all systems operating at individual hospitality or public sector sites will fall under this exemption.

Case studies of IVC technologies being used in the public sector (in hospitals, prisons and schools) and hospitality sector (in hotels, restaurants and leisure centres) are available alongside this document.

3.2.2 *Manually Operated In-Vessel Composters*

There are a range of manually operated IVCs available on the market, varying in size from ones capable of handling waste arisings equivalent to those from a small household, to ones which can be used by a small canteen. Two brands have a strong presence in this market, Ridan and Joracompost. Profiles of the models available from these suppliers are detailed below.

Table 1: Ridan Manual IVC

Product Range:	The Small Ridan, The Medium Ridan, The Large Ridan		
Power Supply:	None required.		
Power Requirement:	Manual operation by turning handle five turns daily.		
	The Small Ridan	*The Medium Ridan*	*The Large Ridan*
Dimensions:	2.1x1x1.5 m	2.4x1.1x1.6 m	2.5x1.2x1.7 m
Capacity: per annum of food waste	4,160 ltr	10,400 ltr	20,800 ltr
Costs excluding VAT plus delivery cost:	£1,575	£2,250	£3,400
Spatial Requirement:	Flat hard standing.		
Weekly Maintenance:	Emptying of composted material as required.		
Operational Requirements:	For food waste a 50:50 split of waste and woodchip, sawdust or wood pellets is required. Turning is required at least daily.		
Time in Vessel:	Minimum of two weeks to pass through vessel. Maturation boxes are recommended for subsequent improvement of output.		
Output:	A compost like output which requires maturation to produce an optimal useable product.		
Maturation Period:	Recommend maturation for 2-3 months.		
Support:	Assembly and instructions are included in price.		
Market Penetration:	Well established.		
Examples:	In use in schools, colleges and prisons		
Notes:	The composter will accept meat, fish, dairy, vegetable and garden wastes.		

THE LARGE RIDAN

Table 2: Joracompost Manual IVC

Product Range:	JK125, JK 170, JK 400		
Power Supply:	None required.		
Power Requirement:	Manual operation by turning handle when waste is input.		
	JK 125	*JK 170*	*JK 400*
Dimensions:	0.95x0.84x0.84 m	1.16x0.89x0.89 m	1.17x0.8x1.3 m
Capacity: per annum of food waste	624 ltr	1,560 ltr	4,680 ltr
Costs including VAT plus delivery cost:	£299	£389	£995
Spatial Requirement:	Located off the ground on a non-porous standing, in a frost proof location. Covered housing not required.		
Weekly Maintenance:	Requires a short clean each week to ensure holes are unblocked.		
Operational Requirements:	Add one part wood pellets to 10 parts waste, or 1 part sawdust to 3 parts waste.		
Time in Vessel:	8 weeks. Each chamber if filled over a four week period, and then matures for a further 4 weeks.		
Output:	Compost output, roughly 40% volume of input materials.		
Support:	Manual and assembly instructions provided. 1 year warranty on parts.		
Market Penetration:	Well established.		
Examples:	Numerous schools, restaurants and hotels.		
Notes:	The composter will accept meat, fish, dairy, vegetable and garden wastes. Compost output is ready to use directly from unit.		

THE JORACOMPOST JK125

3.2.3 *Automated Operation In-Vessel Composters*

There are a number of automated in-vessel composters available on the market. Some are established and have been operating for over 20 years, whereas some are less established in the UK market specifically. Profiles of the models available from a range of suppliers are detailed below.

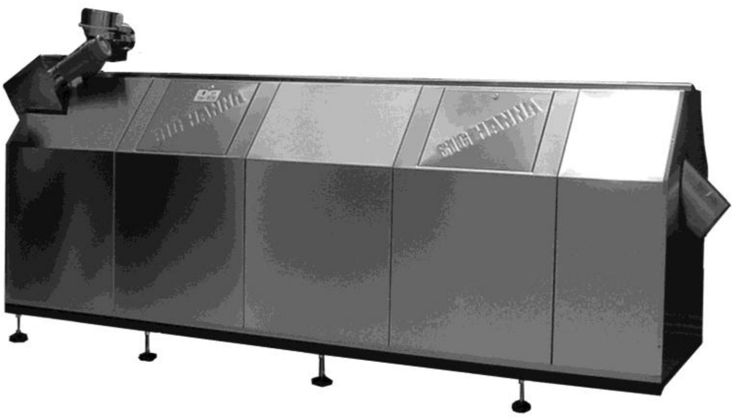
Table 3: Joracompost JK5100

Power Supply:	400v16A 3-phase
Power Requirement:	17.5 kWh/week
Dimensions:	3x1.24x1.51m
Capacity:	36,400ltr per annum of organic waste.
Cost:	£19,995 (+ VAT) including delivery, installation, commissioning and training.
Spatial Requirement:	Requires an extra 1m length and 0.5m width for operation and feeding. Frost proof location on non-porous standing.
Weekly Maintenance:	None. Requires sharpening of grinder blades every six months.
Operational Requirements:	Add one part wood pellets to 10 parts waste, or 1 part sawdust to 3 parts waste. Requires manual transfer between chambers.
Time in Vessel:	4 weeks. 2 weeks in feeding chamber, followed by 2 weeks in maturation chamber.
Output:	Equivalent to 20% volume of input material.
Support:	Training is offered. 12 month warranty provided.
Market Penetration:	Limited market coverage.
Examples:	Isle of Eriska Hotel, National Trust sites (x5).
Notes:	The composter will accept meat, fish, dairy, vegetable and garden wastes. Compost output is ready to use directly from unit.

THE JORACOMPOST JK5100

Table 4: BigHanna IVC

Product Range:	T40, T60, T75, T120, T240, T480					
Power Supply:	230v10A 1-phase up to 400v16A 3-phase					
Power Requirement:	7-35 kWh/week					
	T40	*T60*	*T75*	*T120*	*T240*	*T480*
Dimensions:	1.94x0.88 x1.47 m	2.32x1.08 x 1.55 m	2.83x1.08 x1.55 m	3.82x1.08 x1.55 m	4.8x1.4 x2.07 m	6.32x2.2 x2.32 m
Capacity: per annum of organic waste	5.2 tonnes	13 tonnes	16.9 tonnes	26 tonnes	62.4 tonnes	124.8 tonnes
Costs including VAT plus delivery cost:	£8,350	£15,000	£16,500	£18,900	£34,250	£84,000
Spatial Requirement:	An additional ~1.5m lengthways and widthways. Housed on non-porous hard standing. Indoors or outdoors.					
Weekly Maintenance:	30 minutes including cleaning.					
Operational Requirements:	For best performance requires daily feeding. Twice weekly removal of compost output.					
Time in Vessel:	6-10 weeks					
Output:	Compost (c. 10% input) and condensed water.					
Maturation Period:	Compost maturation of 3 months for optimum output.					
Support:	1 year parts and labour warranty. Training, demonstration, delivery and installation included in price.					
Market Penetration:	Well established					
Examples:	HM Prison service (over 50% of prisons), Eden Project, Glenmore Lodge Training Centre.					
Notes:	The composter accepts meat, fish, dairy, vegetable and garden wastes. Operational in 25 countries. First UK installation in 1991 and still operational. Estimated 25 year lifespan. Some parts require change periodically.					



THE BIG HANNA T120

Table 5: Rocket IVC

Product Range:	Rocket A500, Rocket A700, Rocket A900, Rocket A1200			
Power Supply:	240v13A 1-phase (x2 for larger units).			
Power Requirement:	12-30 kWh/week			
	A500	*A700*	*A900*	*A1200*
Dimensions:	2.5x0.7x1.3 m	3.0x0.9x1.6 m	4.0x1.0x1.9 m	7.0x1.4x1.8 m
Capacity: per annum of food waste	15,600 ltr	36,400 ltr	91,000 ltr	364,000 ltr
Costs including VAT plus delivery cost:	£12,954	£17,934	£27,570	£59,940
Spatial Requirement:	No extra spatial requirements. Housed on non-porous hard standing, under cover.			
Weekly Maintenance:	Weekly removal of leachate. Fortnightly removal and clean of leachate filter and drain.			
Operational Requirements:	For best results requires daily feeding of a 50:50 mix of food waste and woodchips.			
Time in Vessel:	14 days			
Output:	Compost (roughly 15% input volume) and a small amount of leachate.			
Maturation Period:	Compost maturation of at least 1 month for optimum compost output.			
Support:	1 Year warranty standard, with an option of an extended warranty and service package. Price includes delivery, installation support and manuals.			
Market Penetration:	Well established			
Examples:	Warwickshire County Council Schools. River Cottage Restaurant. University of Bradford. University of Salford. Warren House Conference Centre.			
Notes:	The composter will accept meat, fish, dairy, vegetable, garden and animal wastes. Life expectancy of machine if serviced is 20 years plus.			

A500 ROCKET

3.2.4 *AD technologies*

Experience in the use of on-site AD systems in the public and hospitality sector is limited. It has been used successfully at HMP Guys Marsh Prison and on sites with comparable quantities of waste such as food manufacturing premises. The scale at which AD systems operate means that it is only worth considering on-site for very large public sector or hospitality organisations, such as a hospital or hotel, or in partnership with other organisations i.e. receiving waste from similar organisations or farms.

In undertaking this research we identified two technologies that were providing small scale units, powerQUBE and SEaB Flexibuster. Both use a shipping container to house the AD unit and are available in different capacity modules.

Table 6: powerQUBE

Product Range:	3.2, 7, 11, 15			
Power Supply:	Not required. Small requirement to process electricity supply to grid.			
Power Requirement:	15% of generated capacity.			
Dimensions:	Either 1 or 2 20' shipping containers dependent upon model – 6.1x2.44x2.44 m			
	powerQube 3.2	*powerQube 7*	*powerQube 11*	*powerQube 15*
Capacity: per annum of organic waste	132 tonnes	289 tonnes	454 tonnes	619 tonnes
Costs including VAT:	£79,248	£133,230	£193,610	£244,940
Weekly Maintenance:	On-going general maintenance to ensure operation.			
Operational Requirements:	Recommended to use 10-20% slurry alongside waste input.			
Residence Time:	40 days.			
Output:	In CHP mode: 19,200kWe, 42,000kWe, 66,000kWe, 90,000kWe per annum. Biogas production: 222,170MJ, 485,998MJ, 763,711MJ, 1,041,424MJ per annum. Digestate output equals waste input.			
Support:	Training provided. 5 year warranty on digester. 1 year warranty on CHP. 1 year technical support.			
Market Penetration:	Limited.			
Examples:	1 unit taking food manufacture wastes. 1 treating farm wastes. No operational public /hospitality sector as yet. Company is proposing to expand into these areas.			
Notes:	Digester can accept meat, fish, dairy, vegetable, garden and animal wastes. Housed in a standard shipping container. Scalable in size, meaning a 3.2kW unit can be upsized to a 7kW unit if required. Requires maceration and thermal pre-treatment to meet ABPR standards.			

POWERQUBE

Table 7: SEaB FlexiBuster

Product Range:	MUCKBUSTER® and FLEXIBUSTER
Power Supply:	Grid connection.
Power Requirement:	15-30% of electric and 60-70% of heat generated.
Dimensions:	3x 20ft containers (6x2.44x2.8m) up to 7 x 20ft containers (6x2.44x2.8m).
Capacity:	0.5 – 3.5 tonnes/day.
Cost:	£115,000 to £450,000.
Spatial Requirement:	$80m^2$ to $400m^2$. Hard standing to place container. Water connection, gas connection or bottled gas for start-up, internet connection, electrical connection and fowl sewer connection.
Weekly Maintenance:	Requires a service roughly every 8 weeks.
Operational Requirements:	Low contamination feed stock if possibile. No pre-treatment required. Only loading required on-site.
Residence Time:	15 days.
Output:	100-500 tonnes per annum liquid fertiliser. 8-65kW electricity, 16-130kW heat Mulch (used for animal bedding).
Support:	Training provided. 20 year life cycle. 2 year manufactures warranty (5 years possible when extended warranty purchased).
Market Penetration:	Limited.
Examples:	University of Southampton Science Park (see case study in Appendix), Lancaster Brewery treating wet spent grain.
Notes:	Digester accepts meat, fish, dairy, vegetable, garden and animal wastes. Housed in a standard shipping container. Scalable in size.

SEAB UNIVERSITY OF SOUTHAMPTON SCIENCE PARK

3.3 Emerging technologies

The following technologies are not commercially or technically demonstrated in the UK for the public and hospitality sectors. Some are in use treating food manufacturing wastes or are still in the pilot stage of development.

3.3.1 *Thermophilic Aerobic Digestion*

Thermophilic Aerobic Digestion (TAD) is a method of composting which produces a pelletised end-product which is ready for direct application to land as a soil fertiliser. The output material will be in the range of 30% volume input wastes. The process is faster than IVC technologies and can produce an end product within a week under the correct circumstances. This technology can accept all food wastes, and does not require the addition of supplementary materials to aid the process.

There is one such technology unit available in the UK market at present, marketed as the ASM EcoHero, which has a facility at London Zoo. It operates as a batch system, so unlike IVC technologies waste requires storing before input into the vessel. The system requires a power input, and operates a five-stage process:

1. Blending phase.
2. Accelerated Thermophilic Aerobic Digestion phase.
3. Drying phase.
4. Sanitising phase.
5. Pelletising phase using a rotary drum.

3.3.2 *Anaerobic Digestion*

Clearfleau have developed a small AD unit, housed in a 40 foot shipping container similar to other processes currently available, which is capable of handling up to 70,000 litres of waste per day. A pilot model of the technology has been successfully operated for over three years. The technology is principally designed to operate treating liquid wastes, so would potentially be most suitable to commercial industries like breweries etc. This technology is under early development and may have a greater presence in the market over coming years. The potential for adoption of this technology has, as yet, not been fully explored.

3.3.3 *Digesters / Dehydrators*

Food waste digesters/dehydrators are a process which utilises natural microorganisms to quickly breakdown food waste. The process results in a grey water discharge[5] which can be disposed though the sewer system within 24 hours. The technology is capable of handling up to 180kgs of food waste per day and its benefits include the reduction of costs associated with waste collection and disposal, and space requirements needed for storage of food waste. There are no useable compost, fertiliser or energy products from these processes.

3.3.4 *Vertical Composting Units*

Vertical Composting Units (VCU) are continuous aerobic composting units which can handle up to 10 tonnes of waste per day. Typically units measure 2.5 metres in diameter by 4.5 metres in height. The process follows a 'plug-flow' arrangement, whereby a mixture of waste and bulking agent (typically wood or garden waste ~15-50%) is fed into the top of the unit and air is drawn through the mixture to accelerate the composting process. The temperature of air increases as it moves up the vessel due to the biological processes of micro-organisms degrading the waste material. Average temperatures at the top of the VCU can reach 70°C. As waste decomposes it moves down the vessel. Typical retention times for wastes in these units can be anywhere between 4 and 14 days. VCUs are proven to be

[5] *A cloudy water that contains food-derived impurities*

capable of delivering an Animal By-Products Regulation and Publically Available Specification (PAS100) compliant compost end product, and are available from VCU Europa for the UK market. Maturation in recommended for a high quality useable product from this process.

4.0 **Health & Safety**

4.1 Collecting and carrying waste before treatment

The waste you are going to treat by composting or anaerobic digestion will need to be collected at the point of production and transferred to the point of treatment. This will require the provision of suitable caddies or bins for food waste. Green waste such as grass, clippings and leaves may need to be stored in a designated area or bin prior to treatment. The manual handling risk of emptying bins will need to be assessed, taking into consideration who will be undertaking this task, the size of bins required, the distance to the treatment area and how frequently they will need to be emptied. For example, if kitchen staff are to empty the bins, there will be a maximum weight they can physically lift. You should refer to health and safety advice provided by your organisation and guidance on manual handling and preventing trips/slips from the Health and Safety Executive and the Waste Industry Safety and Health (WISH) Forum[6]. For hygiene reasons, anyone handling waste or bins should wash their hands afterwards.

4.2 Preparation of waste before treatment

Green waste may require preparation (i.e. shredding/chipping) before treatment, in order to make the material more even in size and to increase surface area which will assist in speeding up the composting time. Preparation should also include the removal of any items that are not suitable for treatment e.g. large branches, plastic bags. The processing poses similar risks to normal grounds maintenance work. The use of and training in the use of shedding equipment and personal protective equipment (PPE) to handle green waste should be provided, such as gloves and eye protection where size reduction activities are being undertaken.

4.3 Treatment process

Composting is a natural process taking place all around us (e.g. plant decay) and as such, the emissions from these processes are present in the air we breathe. These emissions are sometimes called bioaerosols and are complex mixtures of airborne micro-organisms and their products. Bioaerosols cannot be seen and they do not smell.

Evidence suggests that emissions from large, centralised sites that operate commercially present a relatively low risk to the health of people living nearby. The risk of exposure drops to normal levels within 250 metres of commercial sites. The Environment Agency requires that all new composting environmental permit applications within 250 metres of workplaces or dwellings to carry out a Site Specific Bioaerosol Risk Assessment (SSBRA) in support of their application. Before granting a permit they need to be satisfied that the SSBRA shows that bioaerosols can, and will, be maintained no higher than acceptable levels at the sensitive receptors.

Greater concentrations of bioaerosols are found in large scale composting sites compared to small-scale facilities. Small-scale facilities are exempt from environmental permitting (see section 5.1) and do not need to undertake a SSBRA. Public Health England states that there have been occasional reported illnesses associated with bioaerosols produced in the domestic garden, but the risk of becoming ill from handling composting is low. Properly controlled aerobic composting processes such as small IVC and small scale open air composting will not significantly raise background levels of these emissions. Sometimes, emission levels can be higher - particularly during any turning operations, such as the mixing of compost – so exposure to micro-organisms, their spores and by-products can be a greater risk.

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[6] *Manual handling at Work http://www.hse.gov.uk/pubns/indg143.pdf; http://www.hse.gov.uk/waste/wish.htm*

Possible exposure risks include:

- Inhalation;
- Skin contact or absorption;
- Injection (exposure through the skin, via cuts, abrasions or puncture wounds);
- Ingestion (usually hand-to-mouth).

The risks can be reduced with IVC processes as the composting takes place in an enclosed system. Some methods to reduce risk and exposure to bioaerosols include:

- If a person has allergies or is prone to infections, avoid or have minimal exposure to compost;
- Wear gloves when handling waste and compost;
- Wash hands after handling waste and compost;
- Not eating when undertaking composting to mitigate against ingestion or inhalation of bioaerosols.
- When in contact, or near compost, recognise potential allergy symptoms in people such as shortness of breath, wheezing, irritation of the eyes/nose/throat, nausea or headaches.

Bioaerosols are most likely to be released during operations that agitate the compost, including the sieving of final product prior to use. Consideration should be given to minimising the generation of dusts for example through the use of enclosed sieves or damping the compost prior to sieving. These risks are reduced for processes that handle low volumes of waste as there is less exposure to this material, however staff should be provided with operating and health &safety guidance as bulleted above.

If the composting process is not managed properly, for example it is not aerated sufficiently or the mix of wastes added is not monitored (e.g. too much wet waste), there is a potential that conditions can become anaerobic. This can result in strong unpleasant odours, but is categorised as a nuisance rather than a health risk. Some input waste materials are more likely to result in odour and as you get used to your composting system, it may be necessary to vary the input mixture to achieve the right balance of waste types.

The risk of odour can be reduced by optimising the performance of the system (e.g. control of input material, getting the right ratio of carbon and nitrogen-rich waste materials), careful monitoring and regular mixing of the waste in the composter to help maintain oxygen levels. Consideration should be given to the siting of processes to avoid placing them too close to activities or buildings which may be sensitive to odour (e.g. guest hotel rooms, a school classroom), and minimising the quantity and duration of storage of wastes for treatment prior to the process.

Further guidance is available from the Health and Safety Executive (HSE) from www.hse.gov.uk/waste/composting. In addition, the Association for Organics Recycling (AfOR) provides advice in 'Health and Safety at Composting Sites: A Guide for Managers' which is available from www.organics-recycling.org.uk.

5.0 **Relevant Legislation**

This section covers three areas of legislation:

- Waste permitting;
- Use of compost;
- Animal by-products.

5.1 Waste permitting

The legislation covering the storage, treatment, disposal and use of waste is *The Environmental Permitting (England and Wales) Regulations 2010*[7]. These are designed to ensure waste is managed in a safe, secure and environmentally sound manner.

The legislation is regulated by the Environment Agency[8] (in England) or Natural Resources Wales[9] (in Wales). It is likely that for most organisations wishing to treat their own waste on-site, the capacity of facility required will be covered by an exemption from the regulations, as shown in Table 8 below.

However, an organisation will still need to register this exemption with the appropriate regulator. All non-domestic waste management operations should be registered as an exemption. Your local regulator office can provide you with advice on how to make an application. Guidance on how to estimate the quantities of waste you want to treat is provided in Chapter 2. Although the registration of exemptions is currently free, a registration is only valid for a period of three years when it may be renewed.

Prior to registering an exemption, you should review the criteria and restriction associated with the exemption to ensure that your operation can comply. If your operation cannot be managed within the terms of an exemption an environmental permit would be required which is a more costly and time consuming process to obtain. In the event you feel your operations would require a permit, you should in the first instance contact the relevant regulatory body.

5.1.1 *Exemptions for the treatment of organic waste*

The table below summarises the exemptions available for small scale biological treatment technologies. Further guidance on this is available from http://www.environment-agency.gov.uk/business/topics/permitting/115578.aspx.

You will need to consider the residence time in the IVC/AD unit in order to calculate the total amount of waste that will be present at any one time at the place of production. For example, the smallest AD units will treat about 350 -500 kg per day of waste, with residence times ranging from 15 to 40 days. This would equate to a maximum of 7.5 to 14 tonnes organic waste treated by the unit at any one time. Assuming 0.5 tonnes of food waste takes up 1 m^3 of space, these small units would hold an estimated 15 - 28 m^3 of food waste at any one time and therefore fall under an exemption. Units treating between 1 and 1.5 tonnes per day are likely to require an environmental permit. It is unlikely that a single organisation from the public and hospitality sector would produce this amount of organic waste, although this may be the case if a unit is to serve a cluster of organisations.

[7] *SI 675, 2010 The Environmental Permitting (England and Wales) Regulations 2010*

[8] *www.environment-agency.gov.uk*

[9] *www .naturalresourceswales.gov.uk*

Table 8: Organic waste treatment exemptions in England and Wales

Exemption Number	Treatment Process	Applicable Volumes	Relevant Restrictions	Types of activities included
T23	Aerobic composting and associated prior treatment	Store or treat up to 80 tonnes of waste at any one time at the place of production and the resultant compost is to be used at that place; Store or treat up to 60 tonnes of waste not at the place of production and the resultant compost is used at a different place than where it is composted.	Restricted to no more than 10 tonnes of: ▪ paper or cardboard ▪ canteen or food wastes within the total volume.	A school composts kitchen and garden waste in its grounds; An allotment association composts their old plants and trimmings; A community composting group brings locally produced vegetable peelings and garden waste to a central point for composting, prior to use back in local gardens.
T25[10]	Anaerobic digestion (at premises not used for agriculture and burning of resultant biogas)	50m^3 of waste at any time.	Minimum retention period of 28 days Biogas must be used to produce power in a sub 400kW appliance.	A business or organisation, such as a hotel, prison or hospital digesting their own food waste producing digestate for use on the gardens and biogas to generate electricity.
T26	Treatment of food waste in a wormery	6 tonnes annually of paper, cardboard or food waste.	Vermicompost must be used to treat land.	Composting of food waste from an office canteen.

5.2 Use of compost produced

The finished compost/digestate produced by these processes is normally classified as a waste, which means its use is also controlled under the environmental permitting regulations. Therefore, you may need to register with the Environment Agency (in England) or Natural Resources Wales (in Wales) for an exemption to spread the compost or digestate to land. It is recommended you contact the relevant agency to gain clarification on the necessity of such an exemption.

There are two exemptions covering the spreading of compost onto land – one for agricultural land (Exemption U10) and the other for non-agricultural land (Exemption U11). These exemptions allow the compost to be used for spreading on gardens, playing fields, agricultural land etc., which can result in savings on avoided purchase cost of commercially produced compost. Both allow the spreading of up to 50 tonnes per hectare of compost in a 12 month period.

The Compost Quality Protocol (QP) has been produced by WRAP and the Environment Agency and sets out "end of waste criteria" for compost, which means that where compost is produced and used in accordance with the QP it is no longer classified as waste. This enables the compost produced to be used without the need for an exemption. A similar QP exists for the digestate output from anaerobic digestion. Both QPs are voluntary and certification is required to demonstrate compliance with the QP. Further information on the

[10] Note that T25 and T26 both use the term 'kitchen waste' instead of 'food waste'.

Compost Quality Protocol is available from:
http://www.wrap.org.uk/recycling_industry/quality_protocols/.

This QP may be of interest if you propose to use the compost or digestate off-site (e.g. if you have too much to use on-site) and you wish to benefit from spreading as a non-waste and thus avoid having to apply for exemptions for spreading to land. You should note that there is a cost associated with achieving compliance.

5.3 Animal by-products legislation

The EU Animal By-Products Regulation[11] (ABPR) was introduced in 2001 to prevent the infection of farm animals from food and catering waste. It permits the treatment of low risk animal by-products and catering waste which contains meat or comes from premises handling meat in approved composting premises.

The term catering waste means *'all waste food including used cooking oil originating in restaurants, catering facilities and kitchens'*. In England, these wastes must be treated under an authorisation granted by Defra's Animal Health and Veterinary Laboratories Agency (AHVLA) section. In Wales, the relevant authorisation body is the Office of the Chief Veterinary Officer for Wales.

The ABPR however, does allow the composting of small quantities of catering waste to take place without the need for an authorisation, for example at schools, universities, hospitals and prisons, if certain conditions are met[12]. Note that exemption under the Environmental Permitting Regulations is still required. To comply with the relevant exemption under ABPR you must:

- Produce the compost on the private grounds belonging to the establishment where the catering waste is produced;
- Not keep ruminant animals or pigs on the same land. If you keep birds such as chickens, then the composting area must be designed to prevent the birds gaining access.

Approval by the AHVLA is not required if the compost/digestate is to be used on the same premises where the catering waste originated. A risk assessment based scoring system has been produced by Defra/AHVLA to allow for the off-site use of compost and digestate, where the assessment demonstrates there is no risk to public or animal health[13].

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[11] *EC/1069/2009, enacted through The Animal By-Products (Enforcement) (England) Regulations 2011*

[12] *See section 6(f), page 5 of the Defra guidance on Controls on Animal By-Products, version 4 Nov 2011. Although this is a Defra document it is endorsed by the Welsh Government.*

[13] *http://www.defra.gov.uk/ahvla-en/disease-control/abp/compost-biogas-manure/home-small-site-composters-anaerobic-digestion-ad-plants/*

6.0 **Cost Factors**

Actual costs will be unique to each organisation reflecting their particular set of circumstances. Factors influencing cost including technology choice, availability of staff resources to manage the facility and existing waste management costs, all of which need to be assessed to determine whether on-site treatment is affordable. Likewise, affordability is an organisation-specific issue, dependant on what payback period is acceptable or whether the primary motivation for on-site composting is environmental rather than waste management cost savings. This section describes the factors you should consider and how they impact on the overall cost, affordability and cost benefits of a treatment technology. A table showing the cost information you would need to obtain is provided at the end of this chapter, to assist you in calculating the overcall costs and savings of treating your organic waste on-site.

6.1 IVC costs

6.1.1 *Capital costs*

The cost of purchasing the treatment technology (i.e. the in-vessel composter or the anaerobic digester) is usually the largest cost. The actual cost will depend on technology choice and the size of system required. The larger IVC units with an electric motor and control panels will be more expensive than a unit that is turned by hand. However, they are suitable for larger quantities of waste and can offer a high degree of process control, potentially saving staff time and therefore costs. IVCs that require a power supply will need to be housed undercover and placed on a non-porous surface such as a concrete floor, therefore additional capital outlay may be required for a new or upgraded installation area. There are also items of capital expenditure relating to the collection of organic waste, maturation of the compost and the storage of the finished product. Depending on your circumstances, it may be necessary to purchase kitchen caddies and wheeled bins. After the waste has been treated, in most systems the compost is still 'active' (particularly those that are manual and/or where the residence time in the composting unit is short) and will need a period of maturation before it can be used. This stage can be carried out in a maturation bin, which are usually sold by the supplier, or in an outside bay.

6.1.2 *Financing Options*

The affordability of treating your waste on-site is likely to be influenced by how the technology is paid for, whether you have sufficient funds available to make a one-off payment or you need to spread the cost over a number of years.

As an alternative to a one off capital purchase, some suppliers offer a buy/lease option to spread the investment cost. Payments are usually quarterly and, after a period of years, you will own the unit. Public sector organisations should also consider whether there are opportunities to purchase an IVC at a discounted price through a central purchasing organisation, such as the Eastern Shire Purchasing Organisation (ESPO) and the Yorkshire Purchasing Organisation (YPO).

Grants to subsidise the purchase of composting units are available, particularly for the public sector and community organisations. For potential sources of funding and how to make an application see local authority websites, Bid Lottery Fund, the Big Society and Wales Council for Voluntary Action website. The scale of community grants usually range from £300 to £10,000.

6.1.3 *Utility costs*

Automated composting units will require an electricity supply to power a motor which will turn the waste. In some technologies there are blades which grind/macerate the waste, making the waste more even in size and reduce the water content. Suppliers of IVC technologies state that between 7 and 35 kWh/week of electricity is required, depending on the capacity of the unit operated. This cost is often viewed by suppliers (and even by users) of the technologies as very low or insignificant. Based on current average costs of electricity, then costs could range from £55 to £220 per year, not taking into account any standing charges or increased charging[14]. Having a separate meter for monitoring electricity consumption will help keep track of the actual running costs and the operating efficiency of the composting unit. This on-going cost will need to be included within the annual costs of operating a technology.

6.1.4 *Maintenance costs*

Manually operated composters such as the Ridan and Jora will include a 1 years warranty and will provide extended warranties. These technologies are not particularly complex and have limited moving parts, but should undergo a regular safety check to ensure, for example, the equipment is fixed firmly to wall and there is no rust damage.

When purchasing an automated IVC, a 1 years warranty and service agreement is normally included in the purchase price. After that, there is usually a cost for each additional year's maintenance and warranty. This can range between £500 - £1,100 per annum, and would include the replacement of defective parts and labour. The higher cost in the range usually includes an annual service but, if excluded, this could cost in the region of an additional £400 per year.

If your organisation does not have the technical skills in-house or time resources available then it may be beneficial to take out the annual maintenance and warranty agreement. Some universities, technical colleges or organisations with electrical maintenance engineers may be able to undertake the maintenance themselves.

6.1.5 *Operational labour costs*

The majority of organisations will usually find that the tasks of collecting the organic waste, operating the equipment and handling the compost can be incorporated into the job descriptions of existing staff e.g. kitchen staff, porters at universities, grounds maintenance staff. In such cases, additional labour costs should not be incurred. Feedback from organisations that provided information for the Case Studies suggests that it can take a small period of time to provide the necessary training and generate staff buy-in. However, once engaged in the benefits of composting, concerns around additional workloads are usually overcome. Greater environmental awareness in staff as a result of composting has also shown to improve recycling rates of other materials such as food packaging, whereas previously this was regarding as 'too difficult'.

For large automated IVC units, feedback suggests that it is usually best to have one individual responsible for loading the organic waste, monitoring its operation and emptying out the compost. This improves the operating efficiency as they learn what organic feedstock proportions work best, the residence times required for the compost (i.e. how long the waste has to remain in the unit) and can detect any minor faults in the process. In total, it may take about 1 hour a day to manage a large IVC unit and this time will need to be accounted for.

6.1.6 *Additional feedstock costs*

In order to get the best mix of organic waste for the composting process, many suppliers recommend that you add sawdust or woodchip to the input waste. This is particularly the case if your main input is food waste and you do not have access to more woody material

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[14] *http://www.comparethemarket.com/energy/electricity/ - assuming 12p/kWh.*

such as garden clippings. The proportion of sawdust or woodchip you will need to add may be up to 50% of the total waste, depending on how wet your other waste inputs are and manufacture recommendations. This can often be obtained free of charge, such as from a local tree surgeon or sawmill. If a larger quantity is required then the cost may be in the region of £100-200 per annum.

6.2 IVC savings

6.2.1 *Waste management*

The main cost saving incurred by on-site treatment is the avoided cost of waste collection and disposal. How much you save depends on how much organic waste you expect to treat on site and what impact this will have on your existing waste management arrangements. For example, if your organic waste is currently collected together with all other waste in the same bin(s), you will need to estimate by how much this waste will reduce if you take out the organic materials. Usually, an organisation is charged by a waste company or a local authority per lift (i.e. charged for each bin emptied). The frequency of collection, the size of the bin and the type of waste collected (e.g. black bag waste, materials for recycling) will also influence the cost. Sometimes there are other costs such as bin rental, or you may purchase trade waste sacks in advance and present these for collection. You may need to contact the organisation that provides your waste management service for a more detailed breakdown of costs. Example collection costs for comparison purposes are as follows:

- Hospitality wastes - average cost of food waste collected for AD from London restaurants - £14 per 240 litre bin lift[15];
- University of York – quotes for collection of food waste for AD - £9 -11.50 per lift;
- WRAP benchmark data – general waste -£7 (outside London), £8.50 (London) per 240l bin lift (2013)
- WRAP benchmark data – food waste -£9 (outside London), £18 (London) per 240l bin lift; (£5-14 per 120l bin lift) (2013);

[15] *LCS Consulting Report for the London Development Agency, taken from the report Too Good to Waste, Restaurant Food Waste Survey Report, 2010, Sustainable Restaurant Association*

6.2.2 *Compost Value*

A 'compost calculator' has been produced by WRAP to enable you to see the financial values of the key nutrients in compost and biofertiliser, when compared to inorganic fertilisers. The values are based on current market prices for fertilisers and the typical nutrient content of composts and digestates, using the recommended RB209 approach for compost and research into digestate nutrient contents[16]. If you buy inorganic fertiliser for use in grounds maintenance and would switch to using the material produced from your on-site facility, then this would be a useful tool to compare the potential cost savings you could make through avoided purchase. By way of example, the financial value of nutrients in compost produced from green garden waste and food waste is £7.29/tonne of compost. More information can be found on http://www.wrap.org.uk/content/compost-calculator .

6.3 AD costs

The small-scale AD technologies market is still in its early development and consequently there is limited cost data available.

6.3.1 *Capital costs*

AD units are more expensive than the large IVC units and normally have a larger capacity. This cost can be offset by income received from the sale of electricity, heat and renewable energy financial incentives. Small scale AD units that are currently available for public and hospitality sector are housed within a steel container. Equipment purchase can start from ~£80,000 for the smallest units currently available on the market (handling from about 130 tonnes food waste per annum). This quantity of waste could be produced by a large hospital or large hotel of around 150 rooms.

As for IVC, you would need to take into account the purchase of the unit, construction of any housing and any bins needed for the collection of organic waste. Warranty and extended warranty arrangements are offered by the technology providers (two years typical warranty, with an option to extend to five years), or servicing/maintenance arrangements can be agreed.

6.3.2 *Financing Options*

Many suppliers offer a leasing model whereby equipment is hired to the customer at a fixed annual rate. Given the high start-up costs for AD this may be a more attractive route for organisations. Annual equipment leasing options may be available starting from ~ £5,000 per annum (for units capable of handling about 250 tonnes of food waste per annum). A significant benefit of AD is the production of biogas which has income potential. You will need to establish with the supplier who is the recipient of this income as it may vary with leasing options.

6.3.3 *Maintenance costs*

Suppliers usually remotely monitor the AD system which removes the need for organisations to be highly skilled in operating and identifying faults in a unit. This service is included within the purchase/lease price. Therefore, it should only take an organisation roughly 30 minutes a day to perform routine safety checks and load/unload material.

Units will require maintenance and routine servicing. A typical service pack contract would include operation support (for both equipment/mechanical failure and operational problems/irregularities) and maintenance/servicing of the unit, costing in the order of £6,500 per annum.

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[16] *Defra Fertiliser manual*

6.3.4 *Additional feedstock costs*

Whilst these technologies are suitable for the hospitality and public sector, we would recommend that you contact the technology supplier to establish what proportion of waste types will enable the production of biogas to run smoothly.

6.3.5 *Income Potential*

AD systems will always have a higher capital cost than equivalent IVC systems, due to the nature of the technologies and need for energy recovery equipment. AD will derive an income stream through sales of renewable energy (electricity or biogas and/or heat) and associated renewable energy financial incentives (Feed In Tariffs and Renewable Heat Incentive). Some technologies may have different capital costs and varying residence times, and as a consequence may differ in income from biogas due to the quantities generated in the process. For larger scale operations there may be potential for biogas to be used to fuel vehicles on site, these would attract road transport renewable energy incentives (RTFCs).

The amount of biogas generated will be related to the nature of the feedstock, the residence time[17] in the digester and other operational variables. The smallest on-site AD units will treat between 350 and 500 kg of organic waste per day (i.e. 130 to 180 tonnes per annum); the amount of electricity they produce will depend on the capacity of the gas unit and how efficiently it operates (i.e. by way of example, a system with a 4 kW capacity engine operating for 8,000 hours a year, around 90% availability, will produce in the order of 32,000 kWh of electricity per annum.

All on-site small scale AD plants will have a capacity of 250 kW or less and therefore be entitled to the highest Feed in Tariff (FIT) incentive. It is estimated that AD facilities with a 250 kW capacity would be suitable for treating up to around 15 tonnes per day of food waste (around 5,500 tonnes per annum).

The Renewable Heat Incentive provides an income for generators of renewable heat. All on-site AD system will have a rating of less than 200 kW and will be eligible for RHIs.

More information is provided in Box 3 on renewable energy incentives.

[17] *Residence time = the amount of time the waste is held within the digester*

Box 3: Renewable energy financial incentives

Feed-in Tariffs (FITs)

Since April 2010, Feed-in Tariffs (FITs) have provided a guaranteed price for a fixed period to small-scale electricity generators. FITs are intended to encourage the provision of small-scale low carbon electricity. Only AD facilities with less than 5MW capacity, completed after 15 July 2009, are eligible for FITs. The Government offers preliminary accreditation for AD, with a guarantee that the project will be eligible for the tariff payable at the time of accreditation. Each tariff runs for 20 years.

You would receive a tariff income in 2 ways:

- a generation tariff for every kWh of electricity generated – this is for all of energy output, whether used on-site or off-site;
- an export tariff for every kWh of electricity exported to the national transmission network, i.e. electricity surplus to an on-site requirements.

All on-site AD facilities will have an electricity capacity less than or equal to 250kWe and are entitled to the highest generation tariff of 15.16 pence/kWh, as of April 2013. The export tariff is currently 4.64 pence/kWh or you can arrange a separate price with your energy supplier.

The amount of income you receive will depend on how much electricity your AD system generates. There are many factors that influence this including the operational availability of the gas engine, its electrical efficiency and the amount of biogas produced to burn in the gas engine. The quantity of biogas will vary depending on the quantity and composition of organic waste that is being digested. As a very rough working estimate, 100 tonnes of food waste would generate in the region of 25,000 kWh per annum. On current prices, this would give you a generation tariff income of £3,790 (SKM Enviros estimate). In addition to this income you will need to take into account the avoided cost of electricity for any on-site use. It is recommended that you seek advice from a supplier to accurately forecast the amount of income you are likely to receive.

The FITs scheme is administered by Ofgem with whom you will need to make an application, in order to receive the payments from a registered electricity supplier. For more information see http://www.energysavingtrust.org.uk/ and http://www.ofgem.gov.uk .

Renewable Heat Incentive (RHI)

The RHI provides a fixed income (per kWh) to generators of renewable heat, and producers of renewable biogas and biomethane. AD facilities completed after 15 July 2009 are eligible for the RHI. The lifetime of the tariff is 20 years.

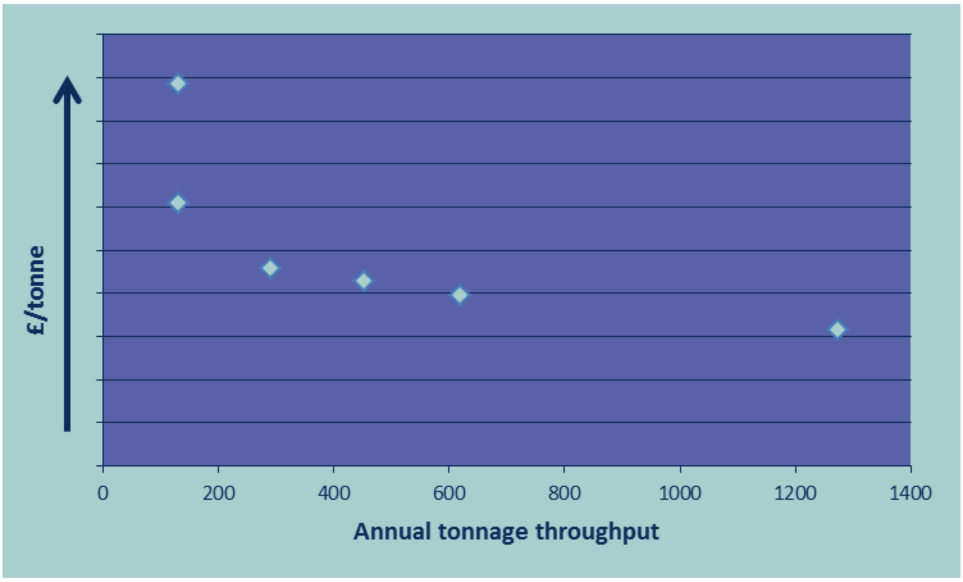
The current RHI for AD is as follows (from April 2013):

- Biogas combustion up to 200 kW scale receives 7.3 p/kWh.
- Biomethane injection to the grid receives 7.3 p/kWh.

6.3.6 *Cost Viability*

There is an economy of scale in the AD equipment market as observed in the technologies reviewed, i.e. the larger the AD facility, provided it is operating at optimum capacity, will have a lower capital cost per tonne of waste than a smaller equivalent technology. The graph below illustrates this point by comparing the capital cost per tonne of organic waste put into the AD processes, against the overall capacity of the plant, using data obtained from suppliers[18]. This clearly shows that as the annual throughput increases the unit cost markedly decreases.

Figure 1: Total capital costs plotted against one year's throughput [19]



One reason identified for the economy of scale shown was a limitation on the smallest CHP units available. For example, in the SEaB Case Study it was observed that the digester only generated enough biogas to service the smallest available CHP unit for 50% of the time. Therefore, the CHP unit was idle for the remaining 50% of the time. This example also necessitated gas storage alongside the digester. Furthermore, it also presents a limitation on the use of electricity and heat from the CHP engine as they are only available for around half of the amount of the time the unit is operational. An optimum AD unit would be scaled to produce biogas matched to an available small-scale CHP engine running 100% of the time.

6.4 Payback periods and financial viability

The payback period and financial viability of composting and anaerobic digestion will vary by technology and the specific circumstances of an organisation. Information provided by suppliers and within the case studies suggests that typical payback periods range from 3 to 9 years. The main factors that will influence this include:

- Economies of scale – as illustrated in the graph above, the larger the facility the lower the capital cost is per tonne of waste;

[18] *It should be noted that a higher capital cost does not necessarily mean a more expensive technology overall, as identified above, overall economic performance will also be factors of the running costs, amount of biogas generated per tonne of input, staff time, maintenance costs etc.*

[19] *Note that the cost per tonne is an illustration of the economy of scale rather than relevant in any other context, as the capital cost itself will be spread over the life of the plant (c. 20 years) rather than the (one) year shown in the graph*

- Financial arrangements – your costs per annum will vary depending on whether you choose a leasing arrangement or capital purchase arrangement. The payback period for equipment will be longer if you choose a leasing arrangement as you will incur additional finance (interest) costs;
- Technology type - manual IVCs are cheaper than automated IVCs, but become impractical when managing over 500 kg of organic waste per week (i.e. you would need several manual units);
- Labour costs - these may be additional to your existing waste management arrangements or not applicable (e.g. if you are a prison, duties can be included in existing work specification);

The following table summarises the cost information you would need to obtain in order to calculate the cost effectiveness of treating your organic waste on-site by IVC or AD.

Table 9: Cost components for IVC and AD

Cost component	Item	Notes
Capital expenditure	Unit	Financing options - one-off payment or paid off over several years (which could include leasing options).
	Hard-standing	May need to resurface an area for an automated IVC or AD facility
	Covered area	Will need a covered area for automated IVC, either within an existing building (e.g. near canteen) or outside
	Caddies/wheeled bins	To collect organic waste
	Maturation/storage area	Outside bay for end product
	Electricity connection	Cost of employing contractor, new cables/metering
On-going costs	Energy use	Suppliers of automated IVC technologies state that between 7 and 35 kWh/week of electricity is required, depending on the capacity of the unit. The parasitic load for AD facilities is 5-10% of output electricity.
	Other materials (woodchip, sawdust etc.) to add to the treatment process	May be up to 50% of the total waste input. May be obtained free, but if a larger quantity is required then the cost may be in the region of £100-200 per annum.
	Operational labour	Estimate 1 hour per day to manage a large IVC unit or AD unit ; cost may be additional or absorbed into existing duties.
	Waste permitting	Time to liaise with Environment Agency and acquire exemptions. Currently no fee for an exemption.

	Maintenance and warranty, including annual service	Usually start with one-year warranty. After that, there is usually a cost for each additional year's maintenance and warranty. This can range between £500 - £1,100 per annum, and would include the replacement of defective parts and labour. The higher cost in the range usually includes an annual service but, if excluded, this could cost in the region of additional £400 per year.
Savings/ revenue	Avoided waste collection and disposal	Calculation of reduced number of bin lifts
	Avoided Compost purchase	Calculate historical use of compost in garden/grounds maintenance
	Energy Incentives and income – from FITs, RHI and sale of energy and heat to grid/local user	Would need to work with AD supplier to determine how much electricity/heat the technology would produce per annum based on your feedstock and calculate: ▪ how much would be used on-site (parasitic loading); ▪ organisations' own energy need and cost savings associated; ▪ potential income from exported energy; ▪ potential income from FITs and RHIs.

7.0 Decision Tree

A Decision Tree has been developed to help organisations decide which on-site treatment technology or technologies identified in this guidance are potentially suitable for their set of circumstances. The tree eliminates those technologies that are potentially unsuitable, based on a sequence of questions on availability of gardens/grounds for spreading the compost/digestate, the amount of organic waste you produce and preferences on technology use.

All information was gathered in good faith for this project. The list of technologies described in this document is not intended to be exhaustive and other technologies may be available on the market. Other sources of information / suppliers may be available from www.ciwm.co.uk, www.r-e-a.net , www.adbiogas.co.uk or www.wrap.org.uk.

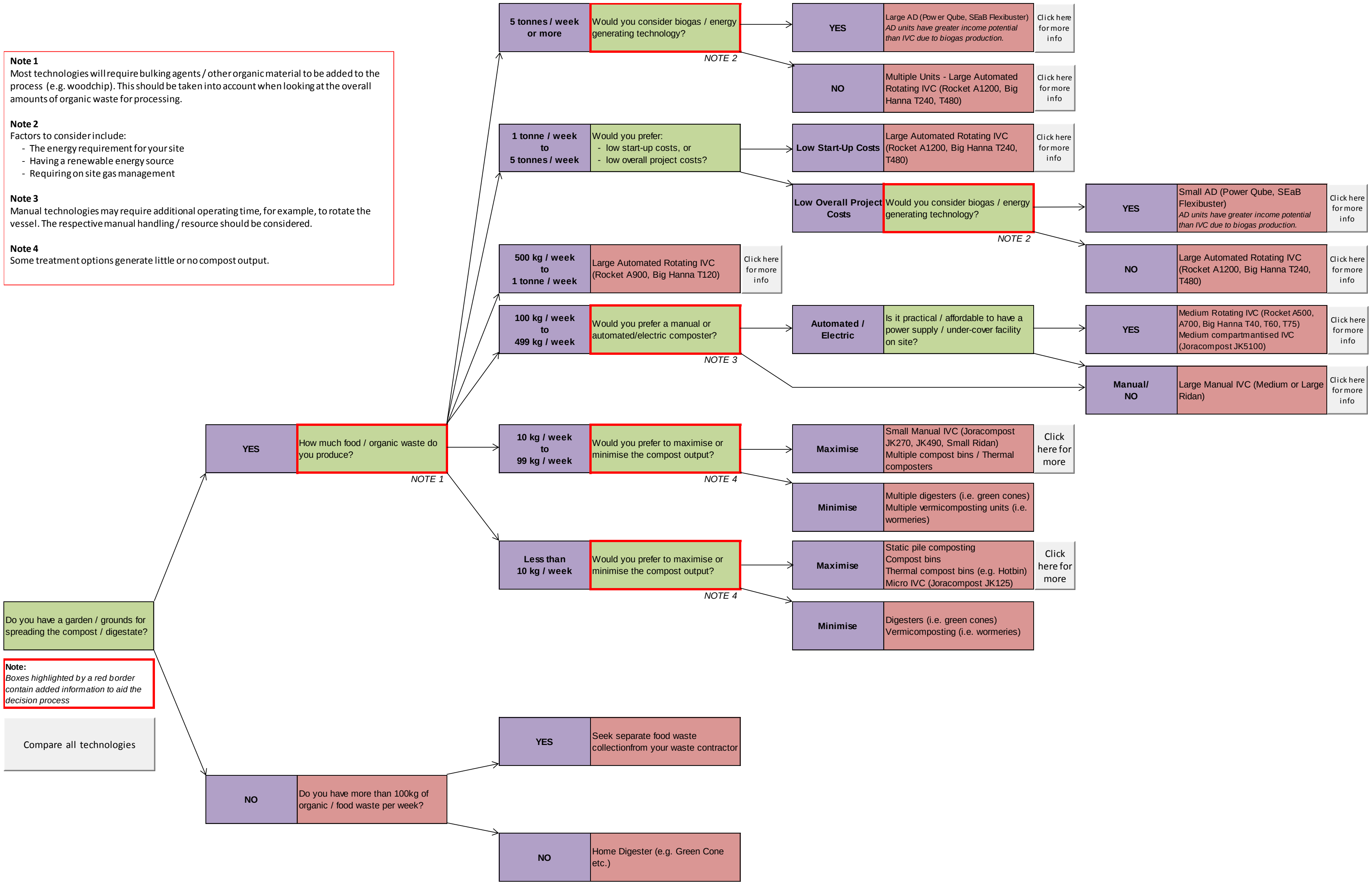
This tree is provided below and is also available in an interactive excel spreadsheet format which is linked to a matrix of information on the different technologies. When using the electronic format, you will be guided to data on only the technology types and capacities that will most likely suit your circumstances based on how you have answered the questions in the decision tree.

Note 1
Most technologies will require bulking agents / other organic material to be added to the process (e.g. woodchip). This should be taken into account when looking at the overall amounts of organic waste for processing.

Note 2
Factors to consider include:
- The energy requirement for your site
- Having a renewable energy source
- Requiring on site gas management

Note 3
Manual technologies may require additional operating time, for example, to rotate the vessel. The respective manual handling / resource should be considered.

Note 4
Some treatment options generate little or no compost output.



Appendix 1: Alternative Technologies for Treating Organic Waste

Waste Cooking Oil to Biodiesel
Waste vegetable oil from kitchens and canteens can be recycled into a useable Biodiesel in a process which takes anywhere between 1 day and 2 weeks to complete. The biodiesel product can be used as a direct substitute for traditional diesel, and therefore can offer significant environmental and economic gains. The majority of equipment developers claim that they have achieved payback periods of less than 2.5 years for their customers through reduced fuel costs.
The process involves feeding used cooking oil into a vessel in batches. Dependent on the model used these batches can start from as little as 150ltr units, however much larger models are available if there is sufficient used cooking oil supply. Operating costs are marketed at roughly 15-20p per litre of diesel produced, which fares favourably when compared with the purchase price of standard diesel. A small amount of the input waste is converted into glycerol (often about 5%) which can be composted / digested or collected for treatment and disposal.

Box A
Turning Waste Cooking Oil into Biodiesel
The University of Wales, Newport
The Caerleon Campus of the University of Wales is located on the outskirts of the city of Newport and caters for over 10,000 students and staff. Since 2010 the University has turned 2,500 litres/year of used vegetable cooking oil into biodiesel to improve their environmental credentials. The equipment cost £7,500 to purchase, takes up $14m^3$ of floor space, and can process 150 litres of oil in one batch (one batch takes two weeks and requires 8 man hours).
The university powers many of its campus maintenance vehicles and machinery including tractors, road sweepers and generators, along with the campus post van and various mini busses, with its own eco-friendly biodiesel.
Key benefits have included:
- "At least £3,000 per year" transport and fuel cost savings.
- Biodiesel produced at 20p per litre achieving cost savings of 84% verses road diesel and 60% compared to agricultural diesel.
- Pay back achieved in 2.5 years.
- 85% carbon emission savings from university fleet.

Blunsdon House Hotel, Wiltshire
Adopted a similar scaled system to the University of Wales example, also with a 2.5 year payback. A number of further points are raised:
- Biodiesel doesn't contain antifreeze, so should be blended with diesel during the winter months.
- Biodiesel will destroy rubber, so engines must have the right specifications.

A 150ltr sized unit is available from numerous manufacturers in the UK, with prices ranging from £1,000 up to £3,500. Prices of the technology have been reducing over the last few years, and when coupled with inflating fuel prices, this means the payback period for this technology is likely to be falling. Box 2 provides short case studies of biodiesel production in the hospitality and public sector.

Waste Cooking Oil to Combined Heat and Power
Combined heat and power (CHP) technologies are available which convert waste cooking oils into electricity and heat through a generator which can be used on site. The technologies have the benefit of offsetting traditional power supplies of gas and electricity. Models of the technology available in the UK are capable of processing waste oils in the range of 150 litres up to 10,000 litres each week.

Dryers
Food waste dryers are a process which produces a dried powder/granular output which can then be collected for further treatment offsite through anaerobic digestion or composting. The process claims to reduce waste volumes by 90%, and therefore cut collection costs accordingly. Models are available ranging in size from 30kg per batch (up to two operations daily) up to 12 tonnes per day. Numerous models are available in the UK and have been used to reduce food waste volumes and stabilise products to reduce odours and mean they can be stored for up to 60 days without degrading further. Examples of where the process is used include Royal Navy ships, where storage for food waste is limited. The process requires a power input and air vent.

Rendering
Rendering is a process that converts waste animal tissue into stable, value-added materials. This material can include the fatty tissue, bones, and offal, as well as entire carcasses of animals. The rendering process simultaneously dries the material and separates the fat from the bone and protein. A rendering process yields a fat commodity (yellow grease, choice white grease, bleachable fancy tallow, etc.) and a protein meal (meat and bone meal, poultry by-product meal, etc.). Rendering is only suitable for organisations which generate large quantities of specific wastes because of the feedstock property requirements necessary.

Maceration
Under some circumstances, such as for catering and food waste, it is possible to macerate waste using kitchen grinders or industrial scale macerators. The waste is then tankered off-site or sent as sewage to the sewage treatment works.

Water UK reports that macerators are typically installed in commercial kitchens, hospitals, care homes, domestic premises and other premises, although the actual scale of use is unknown. A recent survey of the hospitality sector, found that whilst the use of macerators was the most prevalent in-house treatment method, only 7% of those who responded to the survey used this technique.

Similar technologies are often used at the front end of some IVC or AD processes as a pre-treatment method to render the waste into a pumpable form and/or homogenise the waste, for example Brown's Hotel in London utilise a maceration/dewatering technology to reduce their food waste in order to facilitate efficient collection and handling. This food waste is then collected by a specialist contractor for treatment at a centralised food waste treatment facility.

Appendix 2: Sector grossing up factors

Public Sector Data

Education Sector
Food waste per pupil per year (tonnes)

	fewer than 300 pupils	300 to 399	400 or more
Primary School	0.0139	0.0134	0.0099

	fewer than 800 pupils	800 to 1199	1200 or more
Secondary School	0.0112	0.0069	0.0056

	fewer than 800 pupils	800 to 1199	1200 or more
Independent School	0.0131	0.0070	0.0056

Nurseries	0.004
Universities	0.0011
Further education college	0.0040

Prisons
Food waste per prisoner per year (tonnes)

Prison	0.1958

Hospitals with primary catering units
Food waste per HD bed per year (tonnes)

fewer than 250 HD beds	250 or more HD beds
0.6671	0.2868

Care homes
Food waste per care home place per year

Care home	0.1080

Staff Canteen
Food waste per canteen per year (tonnes)

Canteen	2.909

Hospitality Sector Data

Pubs

Size band: number of employees	Tonnes food waste per site per year
0 to 4	1.23
5 to 9	3.78

10 to 19	7.60
20 to 49	10.05
50 to 99	21.73

Restaurants

Size band: number of employees	Tonnes food waste per site per year
0 to 4	0.83
5 to 9	2.91
10 to 19	7.44
20 to 49	9.01
100 to 249	21.30
250 or more	36.62

Quick service restaurants

Size band: number of employees	Tonnes food waste per site per year
0 to 4	1.43
5 to 9	5.00
10 to 19	5.42
20 to 49	7.03
50 to 99	6.01
100 to 249	15.47

Leisure

Size band: number of employees	Tonnes food waste per site per year
size 1 to 10	5.92
size 11 to 25	6.03
size 26 to 50	8.11
size 51 to 100	4.65
size 101 to 200	5.10
size 200 or more	8.51

Hotels

Size band: number of employees	Tonnes food waste per site per

	year
0 to 4	2.51
5 to 9	4.27
10 to 19	6.80
20 to 49	6.31
50 to 99	16.37
100 to 249	30.80
250 or more	94.25

Waste & Resources Action Programme
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