Waste Planning Practice Guide

Supplementary Document to Technical Advice Note 21: Waste

This supplementary guidance aims to provide planning officers and local authority members with an understanding of the different types of waste infrastructure which may come forward as a development proposal. The information contained within this supplementary guidance does not form Welsh Government policy. The guidance is not exhaustive, and will be subject to review as new technologies are presented to the market. It is envisaged that the guidance will be a 'living document'.

Contents

Abbreviations

AATF	Approved Authorised Treatment Facility
ABPR 2011	The Animal By-Products (Enforcement) (No. 2) (Wales) Regulations 2011.
AD	Anaerobic Digestion
ADQP	Anaerobic Digestion Quality Protocol
ATAD	Autothermal Thermophilic
ATT	Advanced Thermal Treatment
BMW	Biodegradable Municipal Waste
BOF	Basic Oxygen Furnace
CA Sites	Civic Amenity Site
CBM	Compressed Biomethane
CHP	Combined Heat and Power
CV	Calorific Value
DAF	Dissolved Air Flotation
DCF	Designated Collection Facility
DCWW	Dwr Cymru Welsh Water
EAF	Electric Arc Furnace
EEE	Electrical and Electronic
ERF	Energy Recovery Facility
EWC	European Waste Catalogue
FiT	Feed-In Tariff
HCI	Household, Commercial and Industrial
HRT	Hydraulic Residence Time
HWRC	Household Waste Recycling Centre
IVC	In-Vessel Composting
MRF	Materials Recovery Facility
MSWI	Municipal Solid Waste Incinerator
NRW	Natural Resources Wales
MBT	Mechanical Biological Treatment
OWC	Open Windrow Composting
PPM	Parts per Million
PPP	Public Private Partnership
ROCs	Renewables Obligations Certificate
RDF	Refuse Derived Fuel
SR	Standard Rule
TPA	Tonnes per Annum
TSF	Tailings Storage Facility
WEEE	Waste Electrical and Electronic Equipment
WID	Waste Incineration Directive

Introduction

This supplementary guidance aims to provide planning officers and local authority members with an understanding of the different types of waste infrastructure which may come forward as a development proposal.

The information contained within this supplementary guidance does not form Welsh Government policy. The guidance is not exhaustive, and will be subject to review as new technologies are presented to the market. It is envisaged that the guidance will be a 'living document'.

Land use planning and environmental permitting have separate but interconnected functions. Planning determines whether a development is acceptable or suitable on the land whilst permitting determines if an operation can be managed to prevent or minimise harm to human health and the environment. Where a waste facility is being proposed, early engagement of Natural Resources Wales (NRW) in the planning process and close continual liaison is advised. Where appropriate, parallel tracking of the planning permission and environmental permit is encouraged.

The number of different types of waste facilities permitted by the regulator is extensive, with over 60 different recognised types of waste facility permitted through the use of standard[1] or bespoke permits. A similar number of 'exempt' facility types also exist[2]. For the purpose of this guidance, these have been grouped into higher level facility types.

Each chapter of this guide provides detail on a category of waste facility. The guidance splits facilities into the following broad categories:

1. Energy recovery infrastructure
2. Biological waste treatment infrastructure
3. Physical and physico-chemical waste treatment infrastructure
4. Specialist waste treatment infrastructure[3]
5. Waste collection infrastructure

Under each of these broad categories, a number of distinct facility types are discussed. For each identified facility type, the following information is presented:

- A generic introduction to the facility type

[1] Standard rules have been developed by the regulator (EA/NRW) for certain types of regulated facility, as provided under Reg.26 Environmental Permitting (England and Wales) Regulations 2010, SI 2010 No.675. Standard Rules Permits set out a generic set of rules which an operator must comply with where they operate a standard facility.
[2] An exempt facility is any waste operation which does not require an environmental permit under the EP Regulations 2010, as amended. Exemptions can involve the use, treatment, disposal and storage of waste. Whilst they do not require the regulator to issue a permit, exempt facilities must still be registered with the NRW.
[3] 'Specialist waste treatment infrastructure' is a 'catch-all' category for facility types that do not easily sit elsewhere within the guidance.

- A generic discussion on the function of the facility. This discussion considers the following questions :
    - What wastes does the facility accept?
    - What does the facility do with these wastes?
    - What technologies does the facility employ to manage these wastes?
    - What are the facility outputs and markets?
    - Are there alternative options to the use of this facility type?

- A generic discussion on the form of the facility. This discussion considers the following questions :
    - What sort of site does the facility occupy? (ie. In building / open site / combination)
    - How large is the facility?
    - What utility requirements does the facility have – grid access (incoming/outgoing) / gas supply / water supply / sewer connection.
    - What transport connections are needed?
    - What planning land-use classification will the facility have?

- A generic discussion on the benefits of the facility. This discussion considers the following questions :
    - What environmental benefits does the facility bring compared to other options for managing waste?
    - What economic benefits does the facility bring?
    - Are there significant employment benefits from developing this facility type?
    - Will the facility bring societal benefits?

- A generic discussion on the impacts of the facility. This discussion considers the following questions :
    - What emissions does the facility have?
    - What are its impacts on sensitive human receptors?
    - What are its impacts on sensitive ecological receptors?
    - What is the sensitivity of the facility type to adjacent development?
    - What contingencies should be considered in conjunction with the facility development? (ie. Will flooding be an issue? Are fires a likely issue? Will the facility contain safety-critical systems?)

- Further information
    - Photograph(s) of a typical facility type
    - 'Best practice' examples for a typical facility type

Chapter 1: Energy from Waste Infrastructure

1.1 Municipal Solid Waste Incinerator

1.1.1 Introduction

These refers to the reception, pre-treatment (where applicable) and use to recover energy of residual municipal waste and associated wastes (such as 'Refuse Derived Fuels') in a combustion process with a number of outputs, the main one of which is energy.

Operations undertaken in Municipal Solid Waste Incinerator (MSWI) facilities include the:

- Reception of residual wastes (from kerbside 'black bag', civic amenity sites, 'bulky waste' collections and commercial 'trade waste collections')
- Storage of waste and raw materials used in the incineration process
- Pre-treatment of waste where required
- Loading of waste into the process
- Thermal treatment of the waste
- Energy recovery (i.e. through the use of a boiler) and conversion of the heat energy to electricity.
- Cleaning and discharge of flue gases following combustion
- Management of flue gas residues
- Management of Incinerator Bottom Ash (IBA) residues, including screening for metal recovery
- Air emission monitoring and control
- Wastewater control and treatment

MSWI facilities are generally operated by commercial operators, and will be located on sites with B2 or sui generis permissions, either as stand-alone facilities, or ancillary to other waste management operations (i.e. in connection with the operation of associated waste treatment facilities.)

1.1.2 Function

MSWI facilities primarily accept mixed municipal wastes collected from households and similar wastes collected from commercial and industrial premises.

Reception and pre-treatment

Waste is first received in a waste reception area, located inside a building. It is commonly tipped into a bunker for sorting and loading by a grab[4], although some facilities tip waste onto a floor for manual sorting and loading onto a conveyor.

The waste will first be prepared to remove contrary objects which may cause problems with the MSWI[5]. Where waste is unloaded onto a floor and manually

[4] The bunker is a waterproof concrete structure.

sorted, these items will be removed by hand or machine. Where waste is deposited into a bunker, the grab operator will select inappropriate items and remove them to a quarantine area to deal with these items separately. In both instances, incoming waste will be mixed with existing wastes (by machine or by grab) to ensure that the waste feed to the MSWI is homogenised. This ensures a balanced calorific value, particle size distribution and composition of the waste to be presented to the MSWI. The waste will then either be loaded onto a conveyor and fed directly to the combustion hearth of the MSWI, or in the case of a bunker fed system, will be introduced into a feed hopper. At this point, the waste stream will pass to the thermal treatment stage.

Calorific Value (CV)

The CV of the waste is dependent upon its composition. Average calorific values of residual wastes therefore vary, but are typically around 10MJ/kg for unsorted residual wastes. CV could vary significantly over the course of the life of a waste facility. Variations in the CV of incoming waste for combustion can arise as a result of a number of factors including bans of certain wastes to incineration and improvements in recycling, for example. These would affect directly the composition of the waste and therefore it's CV. The design throughput of a facility is directly related to its CV.

This means that whilst a facility may be *capable* of treating, for example, a maximum of 250,000 tonnes of waste annually at a CV of 10MJ/kg, the annual throughput could be less than this if the CV rises over time. It is important to recognise this differential at the planning stage. Flexibility and adaptation of the facility is needed over the longer time to manage the changing waste feedstock as reuse, preparation for reuse and recycling increases.

Combustion

Combustion takes place above the grate in the incineration chamber. As a whole, the incineration chamber typically consists of a grate situated at the bottom, cooled and non/cooled walls on the furnace sides, and a ceiling or boiler surface heater at the top of the chamber. As municipal waste generally has a high volatile content, the volatile gases are driven off the grate, and only a small part of the actual incineration takes place on the grate itself.

Combustion air is added at various places in the combustion chamber. Primary combustion air is generally taken from the waste bunker. This lowers the air pressure in the waste reception hall, and eliminates most odour emissions from the bunker area. It is blown by fans into areas below the grate. Secondary air is blown into the combustion chamber at high speeds – i.e. via injection lances. Its purpose is to ensure mixing of the combusting gases, and to ensure complete combustion. Some operators also utilise tertiary air, using recirculated flue gases.

The design of the combustion chamber is linked to the grate type. Each supplier has their own combination of grate and combustion chamber, the precise design

[5] For example, used gas canisters may be manually removed from the incoming wastes.

of which is based on the individual performance of the system and their specific experiences. European operators of MSWI have found no fundamental advantage or disadvantage for the various differing designs of combustion chamber. For all chambers, the combusted gases are passed over a series of baffles and then to a heat exchanger.

A number of variants of MSWI exist:

Table1(a) – Variants to MSWI

Thermal Treatment Variant	Description
Fixed Grate	These have a fixed grate, which is occasionally agitated to remove ash.
Moving grate	These have a combustion hearth with a grate which moves through a stepped, reciprocating, rocking or travelling action, thus continuously agitating the waste to ensure optimum combustion.
Rotary kiln	These have a combustion hearth which is downwards-inclined, and which waste enters with a tumbling action, to ensure optimum combustion.
Fluidised bed	Air is blown vertically through the waste at a high rate, agitating the waste mass to ensure optimum combustion.

All of the above variants work on the same basic principle. They combust a feedstock in a primary combustion hearth in an excess air environment. They are designed to operate with a feedstock of a given calorific range (typically 8-12 MJ/kg) and to achieve a combustion 'residence time' for combustible gases of at least 2 seconds at a temperature of at least 850^{o}C to ensure compliance with relevant controls set under the Environmental Permitting (England and Wales) Regulations 2010[6].

The energy recovery stage

Combustion is an exothermic process, being a reaction that releases energy. The majority of the heat energy produced during combustion is transferred to the flue gases, with the remainder heating the combustion chamber surfaces (by radiant heating), the grate and combustion residues.

The cooling of the flue gases from the combustion process allows the recovery of energy from the hot flue gases, and the cleaning of the flue gases before they are released to atmosphere. The flue gases are used to heat water in a boiler. The purpose of the boiler is to cool the flue gases, and to transfer the heat from the flue gases into a fluid (usually water) which is transformed inside the boiler into steam. The characteristics of the steam (the required pressure and temperature) are determined by local energy requirements and operational limitations. The

[6] The EP Regulation 2010 transposed, amongst other things, Article 6(1) of Directive 2000/76/EC on the incineration of waste. This Directive has been recast by Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control), in particular Article 50(2) which maintains the above temperature requirement.

design of the boiler will depend on the steam characteristics, and also on the flue gas characteristics – in particular, their corrosivity and potential to foul the boiler heat exchanger.

Cooling will generally take place over the length of the boiler, and boilers are divided into zones. The incoming flue gases are used for 'superheating' – this is the boiler zone closest to the combustion zone, and it is where steam produced further back in the boiler is taken to the design temperature and pressure to feed a set of turbines.

Further back in the boiler is the 'evaporation' zone. This is the boiler zone where hot water is heated to produce steam at low temperature and pressure to pass to the 'superheater' zone. At the back of the boiler lies the 'preheat' or 'economiser' zone. This is the boiler zone where the now cooled stack gases are used to take water up to its boiling point prior to its passage to the 'evaporation' zone. After passing through the boiler, the cooled stack gases pass through a flue gas abatement system prior to discharge to atmosphere through a flue stack (see 'Flue gas abatement' below).

The superheated steam produced in the 'superheater' zone is passed to a steam turbine set, where it is used to power the turbine to produce electricity. In the process, the steam condenses back into water ('condensate'). This is then fed back to the 'preheat' zone within the boiler, and passes around the heating loop again. The incoming combustion gas stream as it enters the 'superheater' zone will be at a temperature of between $850^{o}C$ to $1100^{o}C$, dependent on the calorific value of the fuel being combusted. The combustion of wastes with a higher calorific value (i.e. above about 14MJ/kg) starts to present problems for operators due to the pressures and temperatures experienced at the superheating stage, and also due to the deposition of salts on the boiler heat exchanging surfaces.

Continual mixing of a large volume of input wastes helps to homogenise the waste and reduce impacts on combustion infrastructure as a result of high or fluctuating CV.

Flue gas abatement

After energy extraction, the now cooled flue gases are abated prior to discharge. Abatement can be 'wet', 'semi-wet' or 'dry'.

'Wet abatement' – in a wet abatement system, the flue gas is passed through a spray column where it is passed through a sodium hydroxide (NaOH) solution to neutralise acid stack gases. The gas stream then passes through a de-NOx stage (where urea is added to reduce levels of oxides of nitrogen – NOx) before passing through a particulate removal stage prior to discharge to atmosphere. Particulate removal can take place through the use of a bag filter, an electrostatic filter or a cyclonic filter, or indeed a combination of these. Activated carbon may also be introduced into the gas stream prior to the use of a particulate filter to absorb any volatile heavy metals. Wet systems give rise to a liquid residue which requires treatment, and also a particulate. Semi-wet and dry systems do not give rise to a liquid residue. They do give rise to a particulate, as for wet systems.

'Semi-wet abatement' – in a semi-wet system, a sorption agent is added to the flue-gas flow in an aqueous solution (i.e. as a lime milk or a slurry). The water solution evaporates, and the reaction products are dry. Once the stack gases are neutralised, urea is again added prior to the flue gas passing through a particulate removal stage prior to discharge to atmosphere (as above.)

'Dry abatement' – in a dry abatement system, a dry sorption agent (such as lime or sodium bicarbonate) is added to the flue gas flow. As above, the gas stream is passed through a de-NOx stage before passing through a particulate removal stage. In a dry system, the addition of lime and activated carbon are sometimes combined.

Outputs from MSWI

Table 1(b) – Outputs from MSWI

Outputs	Explanation
Electricity	Generated from the utilisation of steam. Most electricity produced by MSWI is sold to the grid, although some is used for onsite processes (known as "parasitic load".)
Heat	If an MSWI is optimised for electricity production, the heat remaining after the use by the turbine sets is 'low grade', i.e., hot water at c. 40-60^{o}C rather than steam. It has limited uses in this form. Where some 'high grade' heat (ie. water at greater than boiling point and more than 1 bar pressure) is bled off the system prior to the turbine sets, then a significant amount of thermal energy can be provided, allowing for the direct supply of process heat for industrial processes or blended with 'low grade' hot water to provide 'intermediate grade' (ie. hot water at boiling point) for district heating. The supply of 'high grade' steam to process users requires direct extraction of steam prior to the turbine sets. The supply of intermediate and high grade heat from MSWI will result in a reduced electricity production as a result of this.
Flue gas abatement residues	Collected as dry residues (i.e. bag filter residues from 'dry' or 'semi-dry' abatement) or as wet treatment residues (i.e. slurries from the treatment of wet abatement liquors). Flue gas abatement residues are commonly sent for disposal to land. They account for roughly 1-4% by weight of the incoming waste tonnages.
IBA residues	IBA is collected from the base of the combustion hearth, and is quenched by a water spray in the process. It is then screened to remove metals, which are recycled separately. IBA accounts for approximately 18-25% by weight of the incoming waste tonnages.

	Once metals have been removed, IBA is matured and then used as an aggregate replacement material in bound applications.

1.1.3 Form

The processing of mixed municipal waste through MSWI with energy recovery can be undertaken at a range of scales, but facilities are generally of a significant size due to economic factors. Examples currently exist in the UK of plants ranging from 26,000tpa to 700,000tpa, with facilities of up to 850,000tpa in development[7]. Currently, the UK has around 30 operating facilities, of which one is in Wales. Around 11 further facilities are currently in construction in the UK, one of which is in Wales.

MSWI facilities are reasonably compact. Existing facilities in England demonstrate that a facility handling around 275,000tpa may be expected to have a land take of between 3 to 4Ha, with stack heights typically around 80 to 90m for a facility of this size. MSWI facilities are scalable, and the size of the facility will be directly linked to its throughput. Land take for facilities which have ancillary operations (i.e. such as pre-treatment processes and processes for the treatment of IBA) may be larger than this. MSWI facilities may be located on sites across a number of buildings – they are 'in-building' facilities, as they require a waste reception area, a thermal treatment process the facility to sort and store outputs.

The calculation of stack heights is based on modelling which takes account of the throughput of the facility, its location and surrounding topography and the dispersion required to meet with national standards at adjacent sensitive receptors.

Buildings which may house MSWI facilities can be similar in appearance and characteristics to energy generating processes. The location of MSWI facilities on land previously used for general industrial activities or allocated in development plans for such (B2) uses should be considered.

Table 1(c) – Requirements of MSWI

Requirements	Explanation
Three-phase electricity	As a significant user of power
Site for the development of a power island	As a significant exporter to the grid, generally 33kv
Connection to the sewer	To deal with wash down water, condensate, office arisings and for discharges from flue gas treatment as applicable.
Water Supply	For wash down and cleaning, supply office buildings and to raise steam for the process. They may require on-site water treatment capacity to produce conditioned feed water for boilers.
Road Access / Multi modal	Receipt of wastes and removal of outputs.

7 This is towards the upper end of the scale for European facilities.

transport links	

1.1.4 Benefits

Table 1(d) – Benefits of MSWI		
Environmental	**Economic**	**Societal**
Environmental performance is reliant upon the efficiency of the process[8].	The median gate fee for energy recovery facilities is less than that for landfill or for Mechanical Biological Treatment (MBT)[9].	Capture of heat from MSWI processes can allow the development of district heating networks, thus allowing for more affordable heating for domestic consumers. This can have a direct and positive benefit in terms of reducing fuel poverty.
Good environmental returns where ATTs operate in high efficiency CHP modes	Employment levels vary between facilities, depending upon size, treatments undertaken and technologies. A facility of 50,000tpa would employ 2-6 workers per shift and would operate 24 hours.	
Diverts residual waste from landfill	Co-location of MSWI with significant industrial heat users can provide good synergies, and help protect employment opportunities in the longer term as a result of this increased security for industrial consumers.	
A source of renewable energy (due to the biogenic component of the residual waste – this will vary over time as recycling effort improves)	MSWI provides long-term security in respect of waste disposal and recovery costs.	
Produces outputs	MSWI provides long-term	

[8] Research undertaken by the Environment Agency using WRATE lifecycle assessment tool in 2006 and 2010. Further detail can be found at www.walesregionalwasteplans.gov.uk
[9] WRAP (2013) Comparing the cost of alternative waste treatment options: Gate Fees Report 2013. Available online at: http://www.wrap.org.uk/content/wrap-gate-fees-report-2013

capable of replacing primary materials e.g., waste as fuel and IBA as secondary aggregate	security in respect of energy generation costs.	

1.1.5 Impacts

The primary potential sources of emissions from MSWI facilities are associated with:

- The reception and pre-treatment of wastes
- Emissions from the thermal treatment of wastes
- Impacts from the disposal of flue gas abatement residues

Table 1(e) – Planning Issues for MSWI

Planning Consideration	Explanation	Mitigation
Noise and vibration	• Reception, mechanical processes of pre-treatment	• Appropriate design, location and enclosure; • Seek advice from NRW on impacts
Odour	• Organic materials are a component of residual waste and may give rise to odour, particularly when decomposition has begun	• Undertake reception and pre-treatment processes in a dedicated reception area, kept under negative pressure and which mechanically vents extracted air to a filter or is used as feed air for the MSWI combustion process; • Seek advice from NRW on impacts.
Dust	• Component of residual waste	• Undertake reception and pre-treatment processes in a dedicated reception area, kept under negative pressure and which mechanically vents extracted air to a filter; • Seek advice from NRW on impacts.
Air emissions	ATTs may emit (dependent on the waste treated): • Hydrogen chloride (HCl) • Hydrogen fluoride (HF) • Sulphur Dioxides (SOx) • Nitrogen Dioxides (NOx) • Heavy Metals • Carbon Monoxide	• Emission limits are controlled through the environmental permit • Maintenance of appropriate temperature control and combustion residence times are a key control • Use of air abatement

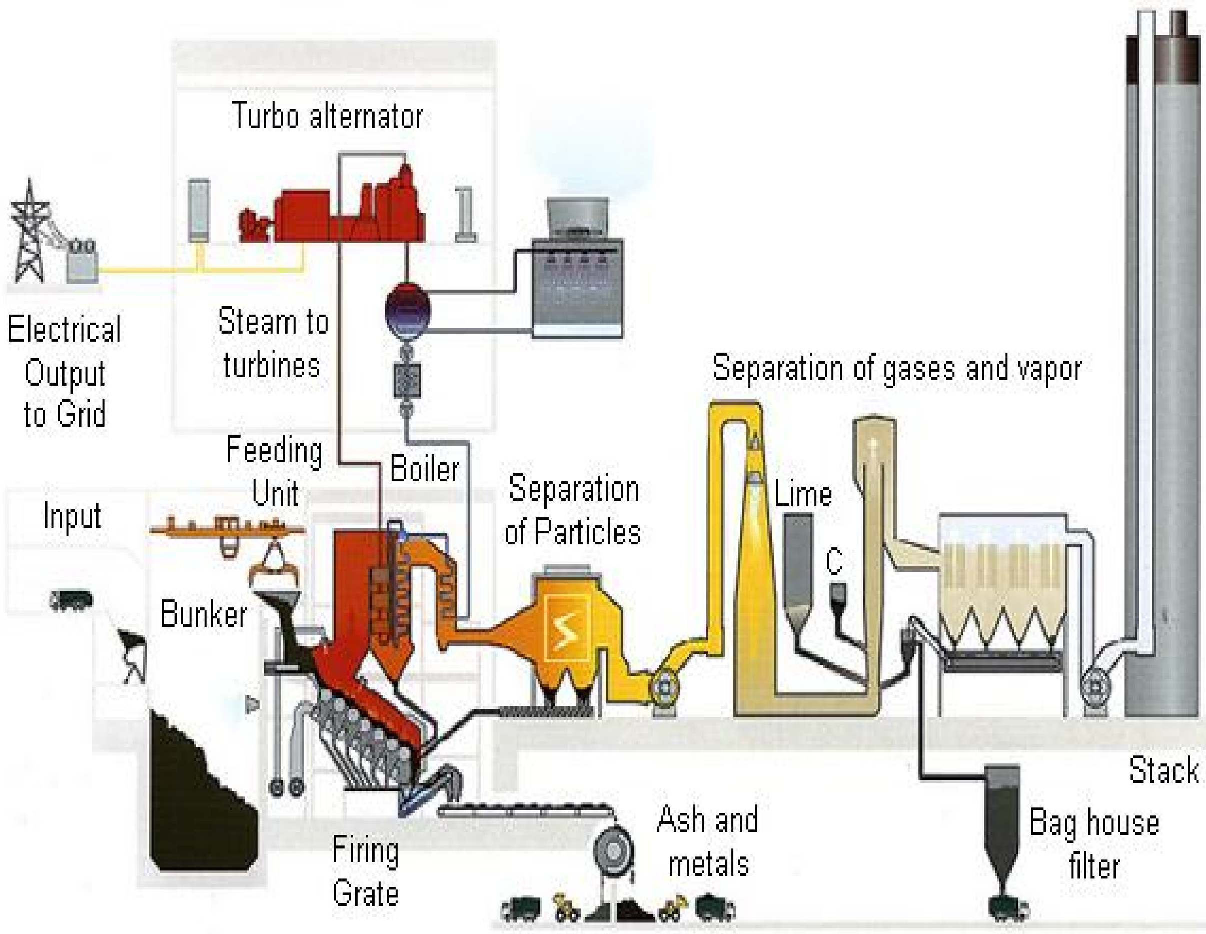
	• Volatile organic compounds • Particulates • Dioxins and Furans	equipment is a key control • Air dispersion modelling will be undertaken as part of any environmental assessment process • Dispersion to ensure appropriate ground level concentrations of emissions after abatement will rely on an appropriate discharge stack height
Bioaerosols	Associated with the reception of residual waste prior to treatment	Bioaerosols are not a significant issue from MSWI facilities barring their production at the point of waste reception. They can be controlled through appropriate mechanical air extraction and the use of this air (after filtration) in the combustion process.

1.1.7 Further information

Figure 1 – A typical mass burn incineration facility

This photograph shows the MSWI in Alkmaar, Netherlands (HVC Group). 4 incineration lines process approximately 660,000 tonnes of residual waste per year. The plant generates 50 MW heat (enough for heating 16,000 houses) and 68 MW of electricity (sufficient for a city of 130,000 residents)[10].

Figure 2 – schematic showing a typical MSWI layout



This schematic shows a typical MSWI configured to supply electricity to the grid with acid gas scrubbing and particulate capture. The schematic is from the Waste-to-Energy Technology and Research Council website[11].

[10] http://www.hvcgroep.nl/uploads/Downloads_downloadFile_58a1bd5f0f2c8885d9368dcf3309b6ff.pdf
[11] http://www.wtert.eu/default.asp?ShowDok=13

1.2 Advanced Thermal Treatment (ATT)

1.2.1 Introduction

This refers to the reception, pre-treatment, where applicable, and use to recover energy of residual waste and associated wastes, such as 'Refuse Derived Fuels' (RDF), in a reduced-oxygen combustion process (gasification) or a thermal treatment process in the absence of oxygen (pyrolysis). These treatments have a number of outputs, the main one is energy. Gasification and pyrolysis are known collectively as Advanced Thermal Treatment (ATT).

Operations undertaken in ATT facilities include the:

- Reception of wastes
- Storage of waste and raw materials used in the gasification / pyrolysis process
- Pre-treatment of waste where required
- Loading of waste into the process
- Thermal treatment of the waste
- Energy recovery (ie. through the use of a boiler and steam turbine, gas turbine or reciprocating engine) and conversion of the heat energy to electricity.
- Cleaning and discharge of flue gases following combustion (where applicable)
- Treatment of syngas from gasification or pyrolyser gas from pyrolysis for use in associated or remote combustion operations (where applicable)
- Condensation and treatment of liquid hydrocarbon products for onward use as product (for 'fast' or 'flash' pyrolysis applications)
- Management of flue gas residues (where combustion takes place)
- Management of thermal treatment residues, including screening for metal recovery
- Air emission monitoring and control
- Wastewater control and treatment

1.2.2 Function

ATT facilities may accept combustible wastes from a wide range of sectors, and are not necessarily restricted in the same way that MSWI facilities are to wastes falling within EWC code 20 03 01. It is possible that some of the wastes that the facility receives may be discrete hazardous streams.

Reception and pre-treatment

Waste is received in a waste reception area, located inside a building. Arrangements for reception, pre-sorting and presentation to the ATT facility differ according to facility type and waste received. Some ATT facilities need a pre-treated waste feed where, for example, waste is sorted and size-reduced.

For facilities taking a mixed waste feed rather than a prepared feed, this will be initially prepared to remove contrary objects which may cause problems with the ATT. Where waste is unloaded onto a floor and manually sorted, these items will be removed by hand or machine. Where waste is deposited into a bunker, the grab operator will select inappropriate items and remove them to a quarantine area for dealing with these separately.

Incoming waste may be mixed with existing wastes (by machine or by grab) to ensure that the waste feed to the ATT is homogenised[12]. Facilities taking a prepared feed or those introducing discrete loads (i.e. hazardous streams) will have arrangements for these to be introduced directly to the gasifier / pyrolysis plant.

At this point, the waste stream will pass to the thermal treatment stage.

Thermal treatment

Gasification facilities operate in a 'controlled air environment'[13].This leads to partial combustion of volatile gases released by the waste as a result of the thermal treatment process to leave a syngas. The syngas can then either can then be passed to a secondary combustion chamber and burned directly (to generate heat to drive a steam turbine), or cooled, cleaned and compressed (to drive a gas turbine or reciprocating engine which is technically separate to the operation of the gasifier.)

Gasification processes can be either batch or continuous. Where batch processes are operated, the use of several reactors operating in series allows for semi-continuous or continuous operation.

Pyrolysis facilities operate in a 'starved air environment' – where there is no combustion as there is no oxygen present. This leads to the thermal degradation of organic wastes into a complex mix of gaseous hydrocarbons.

Facilities operating in a manner where the waste is held at an elevated temperature over a prolonged period of time ('slow pyrolysis') will give rise to a pyrolyser gas comprised of simple hydrocarbons. Facilities operating at lower temperatures with a short residence time ('fast pyrolysis' or 'flash pyrolysis' systems) will give rise to gaseous and condensable liquid fractions.

Solids are discharged from the process. These solids include metals together with carbon. In the case of gasification, the level of carbon is small; in pyrolysis it is significant. Larger particles of solids in the thermal treatment reactor are usually discharged as bottom ash and slag. Lighter ash is usually collected when the gas is separated with the use of cyclones and ultimately filters. Volatile

[12] Homogenisation of waste is important to ensure a balanced calorific value, particle size distribution and composition of the waste for presentation to the ATT.

[13] Where the combustion reaction has a stoichiometric ratio of >0 to <1.

metals such as lead, tin, cadmium and mercury will be carried in the gas until such point that the gas is cooled for them to be sufficiently condensed.

A potential issue with the use of pyrolysis facilities is the high carbon residue (known as a 'char'). Where the feedstock is clean (i.e. clean waste wood), the char may find an end market in a diverse range of applications, i.e. as carbon black for use in the manufacture of tyres and other rubber products or as activated carbon for use in filters. However, where the feedstock is mixed, it is often difficult to find an end market for the char. One option for operators is to use a combined pyrolysis/gasification facility, where the char is subject to further thermal treatment through gasification to produce a syngas[14].

Where plasma arc gasification is used, the solids from the process are produced as a vitrified material, similar in appearance to glass. This vitrified material will contain any metals and other inorganic residuals within it. Plasma arc gasification is therefore of interest to operators who wish to treat hazardous materials as it produces a solid output which is inert.

Depending on the thermal treatment process utilised, the gaseous product is managed in a number of ways:

Gasification

The syngas may be combusted directly upon exit from the combustion chamber (in a secondary combustion process) in order to heat a boiler to raise steam to drive a steam turbine (in much the same way as an MSWI facility operates)[15]. Alternatively, the syngas may be cooled, cleaned and condensed and used as the fuel in a separate combustion stage, using a gas turbine, a reciprocating engine or a fuel cell[16]. The gas arising from plasma gasification facilities is treated in much the same way.

Pyrolysis

For conventional or 'slow pyrolysis', the pyrolyser gas may be combusted directly upon exit from the combustion chamber in order to heat a boiler to raise steam to drive a steam turbine. Alternatively, the pyrolyser gas may be cooled, cleaned and condensed and used as the fuel in a separate combustion stage, using a gas turbine, reciprocating engine or fuel cell.

In a 'fast' or 'flash' pyrolysis plant, the pyrolyser gas is condensed (at least partially) to provide a mix of longer chain hydrocarbons for subsequent refining into various grades of liquid fuels.

ATT facilities which involve any combustion of waste with a release to the external atmosphere are, like MSWI facilities, covered by the requirements of the Waste Incineration Directive[17] (see the section on MSWI for further detail). This

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[14] The New Earth Advanced Thermal plant at Avonmouth is an example of a combined pyrolysis/gasification facility.
[15] The Energos gasification facility on the Isle of Wight is an example of an operating plant utilising two stage combustion.
[16] An example of this is the pilot scale REFGAS facility in Shotton, Flintshire.
[17] Directive 2000/76/EC on the incineration of waste OJ 2000 L332.

means that these facilities will usually require a WID compliant permit, although where there is no combustion of waste as part of the thermal treatment process a permit may not be necessary[18]. A number of variants of ATT exist:

Table 1(f) – Variants of ATT

Variant	Description
Fluidised bed gasifier	Used in gasification and combustion. Hot gases are blown through the bed of particles which acts like a moving fluid, with good mixing and heat transfer to incoming wastes. Wastes are pre-treated to remove large material. This technology is suitable for the gasification of refuse derived fuels.
Fixed bed gasifier	There are a range of gasifier types that come under this heading. A typical example is a grate system where the feed passes along the grate and hot gases pass through the bed of waste heating it. The gasifier can be 'downdraught' (where hot gases are blown down through the waste) or 'updraught' (where hot gases are blown up through the waste).
Plasma arc gasifier	Waste is heated by a plasma torch, subjecting it to temperatures in excess of 2200^{o}C.
Rotary kiln pyrolyser	Typically operate at temperatures of between 300 – 850^{o}C, accommodating feed material with a large particle size (up to 200 mm). The kiln is heated externally and waste is fed in from one end of the kiln which slowly rotates creating a tumbling action. This mixes the waste and ensures contact with the heating surface and gases inside the kiln.
Heated tube pyrolyser	Pyrolyser tubes are heated externally and temperatures as high as 800^{o}C are used. The process can accommodate large size feed material. The waste passes through the tube at a set speed to ensure the pyrolysis process is complete.
Surface contact pyrolysers	In a surface contact system, small size feed material is required as a feedstock and significant pre-treatment of incoming wastes is necessary. The process operates at high temperatures. The application of this technology is to maximise the rate of pyrolysis.

[18] For example, a pyrolysis facility which was indirectly heated by natural gas to give rise to a pyrolyser gas would not in itself be classed as requiring a WID-compliant permit if there was no subsequent combustion of the gas as part of the pyrolysis process. However, the subsequent combustion of the pyrolyser gas in a separate energy generation step would require a WID compliant permit unless the gas can be demonstrated to meet the 'end of waste' criteria.

Flue gas abatement

For two-stage combustion processes, flue gas abatement is undertaken in much the same way as for MSWI processes.

For gasification and pyrolysis processes using cleaned and condensed gases, flue gas abatement may be less significant in scale – as these facilities will be using gas turbines or reciprocating engines on a clean gas stream, then the flue gas abatement train may have a lower duty.

Outputs from ATT

The outputs from ATT are as follows:

Table 1(g) – Outputs from ATT	
Output	**Description**
Syngas / pyrolysis gas	Gas left following partial combustion of volatile gases released by waste (syngas). Where there is no combustion and no oxygen present, thermal degradation of the waste leads to the production of a complex mix of gaseous hydrocarbons (pyrolysis gas).
Electricity	Generated from the utilisation of steam (for facilities using conventional steam turbines) or from the direct utilisation of syngas or pyrolysis gas (for facilities utilising gas turbines, reciprocating engines or fuel cells). Most electricity produced by ATT facilities will be sold to grid, although some will be used onsite for process uses ('parasitic load').
Heat	For two stage gasification plants optimised for electricity production, the heat remaining after the use by the steam turbine sets is 'low grade', i.e. hot water rather than steam. It has limited uses in this form. However, if some 'high grade' heat is bled off the system, then a significant amount of thermal energy can be provided at above 100^{o}C and more than atmospheric pressure – thus allowing for the supply of process heat for industrial processes or district heating. The supply of 'high grade' steam to process users requires direct extraction of steam prior to the turbine sets. The supply of high grade heat from two stage gasification will result in a reduced electricity production as a result of this. For gasification plants using reciprocating engines, heat can be extracted from the process without affecting electricity output – 'low grade' heat from engine cooling circuits and 'high grade' heat from engine exhausts. This is also the case where fuel cells are used as the generation step.
Flue gas abatement residues	For two stage gasification plants, flue gas abatement residues are similar to those produced by MSWI facilities. Where gasification and pyrolysis plants produce a syngas / pyrolyser

	gas for combustion in an engine, and abatement is required then this may be through the use of smaller scale abatement options.
Ash residues	For gasifiers, gasification residues are collected from the base of the gasifier, quenched by a water spray in the process and then screened to remove any metals (i.e. if using unscreened MSW as a feedstock), which are recycled separately. The residues from gasification of unscreened MSW are similar to those arising from MSWI facilities. Where RDF is used as a feedstock, ash production will be at a lower level when unscreened waste is the feedstock. For pyrolysers, the char arising from the pyrolysis process will typically be rich in carbon. If unscreened waste is the feedstock, this may need to be sorted to recover metals (pyrolysis offers the option of capturing some metals which would be combusted in standard combustion plant because of the lower temperature at which it operates and the absence of oxygen in the process – for example aluminium foils can be recovered through the use of pyrolysis – these are destroyed in a mass burn incinerator by combustion). The char may be further treated through gasification to recover energy or if clean may be used as a product in its own right.
Condensable fractions	'Fast' or 'flash' pyrolysis offers the option of recovering condensable liquid fractions for further refining, especially where high carbon high calorific value wastes have been processed (waste tyres and waste plastic streams are of interest here.) The condensed product will be subject to further refining, and will have to obtain an 'end of waste' designation before it can be used as a product. Planners should obtain clarification from the regulator (Natural Resources Wales) where operators intend to operate fast pyrolysis facilities for the purpose of producing a condensable by-product of any issues associated with the potential storage of waste products on site, and also of any associated refining issues.

1.2.3 Form

The processing of mixed municipal waste through ATT can be undertaken at a range of scales. Examples currently exist in the UK of plants ranging from 5,000tpa (the REFGAS facility in Flintshire) to 350,000tpa (the Air Products facility in construction in Teesside). Currently, the UK has only a small number of operating facilities, with only two in Wales (the REFGAS facility and a small-scale pyrolysis facility at Rhymney, Caerphilly CBC – the Hudol facility). However, there are several facilities in Wales with planning permission which have not yet commenced construction, and over 50 gasification and pyrolysis facilities in the UK which either have planning permission or are in the planning system.

ATT facilities are reasonably compact. ATT facilities are scalable, and the size of the facility will be directly linked to its throughput. Land take for facilities which have ancillary operations (ie. such as pre-treatment processes to produce SRF/RDF and processes for the treatment of combustion or air treatment residues) may be larger than this. ATT facilities may be located on sites across a number of buildings – they are 'in-building' facilities, as they require a waste reception area, a thermal treatment process and the facility to sort and store outputs. Larger ATT facilities may be of a scale whereby multi-modal transport links should be considered as an option, both for the delivery of waste and the removal of processed outputs.

Buildings which may house ATT facilities can be similar in appearance and characteristics to energy generating processes. The location of ATT facilities on land previously used for general industrial activities or allocated in development plans for such (B2) uses should be considered.

ATT facilities will utilise negative pressure extraction for key areas, and will have access doors that can be closed and sealed to prevent the escape of odours. Air extracted from these areas (notably waste reception areas) may be used as primary combustion air where combustion processes take place.

Table 1(h) – Requirement of ATT

ATT Requirements	Required	May be Required
Three phase electricity supply	√	
Site for the development of a "power island"	√	
Local gas grid connection	√	
Sewer connection	√	
Water Supply	√	
On-site water treatment capacity		√
Road Access	√	

1.2.4 Benefits

Table 1(h) – Benefits of ATT

Environmental	Economic	Societal
The environmental performance of ATT facilities is dependent on the efficiency of the process used by the facility[19].	The median gate fee for energy recovery facilities is less than that for landfill or for Mechanical Biological Treatment (MBT)[20].	Heat capture from ATT processes allows development of district heating, delivering more affordable heating for consumers. This has the

[19] Research undertaken by the Environment Agency using WRATE lifecycle assessment tool in 2006 and 2010. Further detail can be found at www.walesregionalwasteplans.gov.uk

		direct and positive benefit of reducing fuel poverty.
There are good environmental returns from the use of ATT where operated in high efficiency CHP modes	Employment levels vary between facilities, depending upon size, treatments undertaken and technologies	
The use of ATT diverts residual wastes from landfill	Limited number of facilities in operation makes it difficult to provide an accurate assessment. The Teeside facility has a projected staffing level of around 50 employees	
ATT's can provide a source of renewable energy, dependent on the biogenic component of the residual wastes that they treat.	The use of ATT can provide long-term security in respect of waste disposal and recovery costs.	
ATT's can produce outputs capable of replacing primary materials - ie. fuel and aggregate	The use of ATT can provide long-term security in respect of energy generation costs.	
ATT's can lead to the enhanced capture of metals from residual wastes	Co-location of ATT with significant industrial heat users provides synergies, protecting employment opportunities due to increased energy security for industrial consumers.	

1.2.5 Impacts

Table 1(i) – Planning Issues for ATT		
Planning Consideration	**Explanation**	**Mitigation**
Noise	• Reception and processing of waste • Number of vehicular movements	• Appropriate design, location and routing of traffic can mitigate noise impacts; • Advice should be sought from Natural Resource

[20] WRAP (2013) Comparing the cost of alternative waste treatment options: Gate Fees Report 2013. Available online at: http://www.wrap.org.uk/content/wrap-gate-fees-report-2013

		Wales in respect of potential operational noise impacts.
Odour	• The reception of residual wastes may give rise to odour, due to their organic component	• Reception and pre-treatment of incoming wastes should be undertaken in a dedicated reception area, kept under negative pressure conditions and which mechanically vents extracted air via appropriate filtration plant to the thermal treatment stage where odorous volatile compounds are destroyed in the combustion process. • Advice should be sought from Natural Resources Wales in respect of odour impacts.
Litter	• Transportation and movement of waste	• Litter can be mitigated by placing controls on the transportation and movement of wastes such as sheeting HGV's, as well as by good housekeeping.
Dust	• The reception of residual wastes may give rise to dusts, as can their thermal treatment • The management of thermal treatment residues can give rise to dusts	• Controls on the reception of residual wastes to minimise dusts are similar to those for MSWI, in that dusts are best controlled by their reception and pre-treatment in a dedicated reception area, kept under negative pressure conditions and which mechanically vents extracted air via appropriate filtration plant to the thermal treatment stage. • Particulate emissions arising from the thermal treatment of residual wastes will be managed through the use of appropriate air abatement equipment, such as wet, semi-wet or dry scrubbing, including the use of cyclones, bag filtration or

		electrostatic precipitation. • Dusts arising from the management of thermal treatment residues will be managed through mechanical extraction, and the use of appropriate mitigation measures when transporting these materials off site (such as sheeting lorries, or the use of vacuum tankers.)
Vermin	• Associated with the storage of residual waste prior to treatment	• Controls on vermin are similar to those used in MSWI facilities, with the use of baits, traps and sprays.
Air Emissions	• ATTs may emit (dependent on the waste treated): • Hydrogen chloride (HCl) • Hydrogen fluoride (HF) • Sulphur Dioxides (SOx) • Nitrogen Dioxides (NOx) • Heavy Metals • Carbon Monoxide • Volatile organic compounds • Particulates • Dioxins and Furans	• Emission limits are controlled through the environmental permit • Maintenance of appropriate temperature control and combustion residence times are a key control • Use of air abatement equipment is a key control • Air dispersion modelling will be undertaken as part of any environmental assessment process • Dispersion to ensure appropriate ground level concentrations of emissions after abatement will rely on an appropriate discharge stack height
Bioaerosols	• Associated with the reception of residual waste prior to treatment	• Bioaerosols are not a significant issue from ATT facilities barring their production at the point of waste reception. They can be controlled through appropriate mechanical air extraction and the use of this air (after filtration) in the thermal treatment process (where appropriate) or the

		use of a Biofilter.

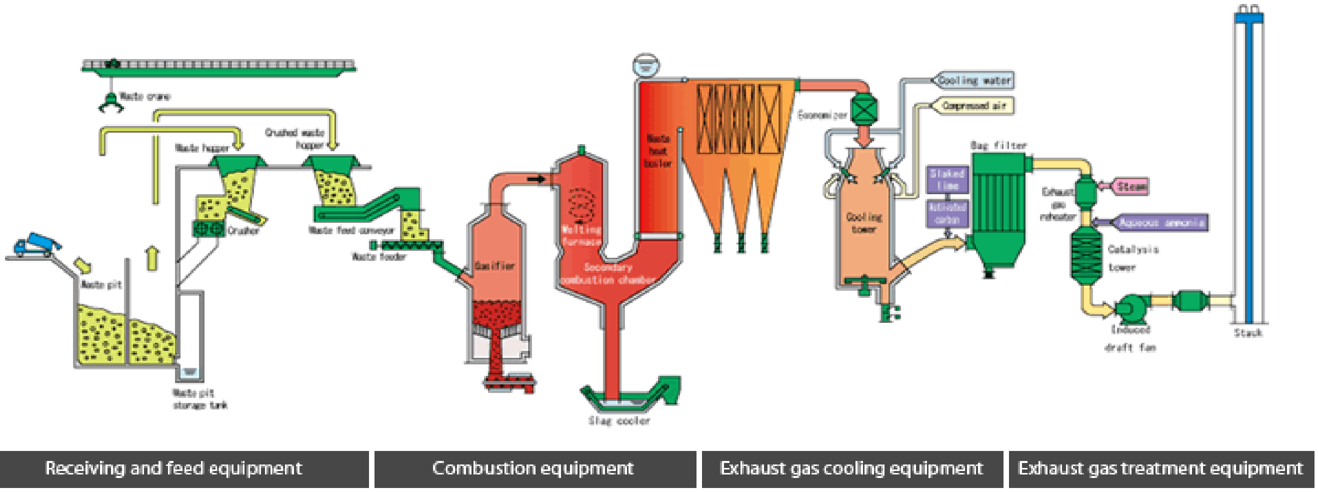
1.2.6 Further information

Figure 3 – A typical two-stage gasification facility

This photograph shows the Forus gasification facility in Stavanger, Norway, which has operated since 2002. It has a capacity of c. 40,000 tonnes per annum, and a CHP output of around 105GW per annum[21].

[21] http://www.energ-group.com/energy-from-waste/our-plants/

Figure 4 – schematic of a typical fluidised bed gasification facility



This schematic shows a fluidised-bed gasifier operated by Kobelco Eco-Solutions Co. Ltd of Japan[22].

Figure 5 – photograph of a small-scale Advanced Thermal Technology facility

This photograph shows the Refgas pilot scale ATT facility in Shotton, Flintshire. It has a theoretical throughput of around 5,000 tpa of RDF, and an output of around 1MW electrical[23].

[22] http://www.kobelco-eco.co.jp/english/product/haikibutushori/ryudo_q3.html
[23] http://www.refgas-uk.com/

1.3 Hazardous waste incinerators

This guidance has not specifically considered planning issues in respect of hazardous waste incinerators, as dedicated facilities for the destruction of hazardous wastes via incineration are now rare in an EU context, with only three significant operating facilities in the UK as at November 2013. The development of any further capacity will be bespoke, and the Welsh Government will consider the provision of further guidance as required.

1.4 Non-hazardous and hazardous waste co-incinerators

This guidance has not specifically considered planning issues in respect of co-incinerators. The WID Directive defines a co-incineration plant as *'any stationary or mobile plant whose main purpose is the generation of energy or production of material products, and:*

- *which uses waste as a regular or additional fuel, or*
- *in which waste is thermally treated for the purpose of disposal.'*

A co-incinerator is therefore a facility which primarily exists to serve a purpose other than incineration, but which nevertheless provides some capacity for the thermal treatment of wastes.

Wales has, at present, more co-incineration capacity than it does incineration capacity. However, the use of this capacity is dependent on market conditions and the availability of suitable wastes as feedstocks. Examples of co-incineration facilities are cement kilns (at Aberthaw, Vale of Glamorgan, and Padeswood in Flintshire), and CHP facilities serving industrial processes (such as the UPM facility in Shotton, Flintshire).

As such, co-incineration facilities will be subject to planning considerations associated with their main duty or duties, although development control applications made in respect of such facilities will need to consider issues associated with the thermal treatment of wastes.

Chapter 2 Biological waste treatment infrastructure

2.1 Anaerobic digestion (AD)

2.1.1 Introduction

AD refers to the biological treatment of segregated liquid, semi-liquid or solid food and other household, commercial or industrial organic wastes, or a combination of these wastes (co-digestion) in an anaerobic environment using microbial action. Some facilities co-digest these wastes with agricultural wastes and residues.

The purpose of AD is to reduce the organic content of the wastes and produce biogas for energy generation (utilising the methane component of the biogas) and digestate. Examples exist within the UK of AD being used to treat residual wastes, however this is generally undertaken as part of a Mechanical Biological Treatment (MBT) process (See section 4.1)

Operations undertaken in AD facilities may include the following functional elements:

- reception
- depackaging
- size reduction
- sterilisation (either pre or post digestion)
- biological treatment of organic wastes
- capture of biogas
- cleaning of biogas (where required)
- use of biogas to generate electricity and/or heat on-site, or upgraded (significant removal of CO2) and compressed/liquefied for use off site as a fuel, or for injection into the natural gas grid
- the storage of digestate
- the dewatering of digestate (optional) and
- further on-site treatment of the digestate (further separations or further treatment/maturation through aerobic treatments)
- the consignment of digestate to offsite uses.

They are generally operated by commercial operators and will be located on sites with B2 or sui generis permissions, either as stand-alone facilities, or ancillary to other waste management operations, for example in connection with the operation of MBT facilities.

2.1.2 Function

The exact type and configuration of an AD plant will depend on the type of wastes treated. On-farm facilities can accept slurries, manures, crops and crop-residues only, although there is no technical reason why commercial, industrial or municipal wastes could not be treated at AD facilities located on farms.

AD facilities permitted under bespoke permits will accept a wider range of waste types. These may not all be food-related, although barring contaminants and packaging, they will be organic in nature. The design and treatment stages included within an AD facility are dependent on the waste being treated, and whether or not there is a requirement to treat this waste in accordance with controls set out in the Animal By-Products (Wales) Regulations (ABPR) 2006, as amended[24].

(These controls are not applied through the Environmental Permitting regime, but through registration with the appropriate regulator for the ABPR – the Animal Health and Veterinary Laboratories Agency (AHVLA) and specified local authority officers (Trading Standards officers in Wales) are responsible for enforcing animal by-products legislation.)

There are generic treatment steps which are common to all facilities. AD facilities can be broadly categorised as either 'Wet Digestion' or 'Dry Digestion' facilities.

Wet Digestion

Wet digestion systems are designed to process a dilute organic slurry with typically <15% total solids. For substrates with >15% total solids, this slurry is created by adding fresh water, re-circulated process water, or another organic waste with a lower total solids percentage to the incoming waste stream (i.e. co-digestion).

Waste is first received in a waste reception area. This is generally in-building for wastes which need to be depackaged or which have particular containment issues – i.e. may give rise to odour. Buildings should be enclosed and operated under negative pressure with the exhaust appropriately treated before discharge. Some facilities can accept wastes which are pumped directly in by tanker or direct from an industrial process (where depackaging is not required) and the use of a reception building is not always necessary.

Where waste is required to be depackaged, the incoming material is passed through a mechanical process to separate the organic substrate from its packaging. The depackaging residue is captured for later recycling/recovery (following treatment) or disposal. Other pretreatment of the incoming waste may also be required. To condition solid wastes into a slurry of adequate consistency and devoid of coarse or heavy contaminants can be a complex operation involving screens, pulpers, drums, presses, breakers, and flotation units.

After pre-treatment (if required), the organic material is either passed directly to a reactor vessel (or digester) or to a holding tank. Once fed to a holding tank, the organic substrate is then either fed to one or more reactor vessels directly (for facilities which thermally sterilise digestate after the digestion process has taken

[24] The Animal By-Products (Wales) Regulations 2006, SI 2006 No. 1293. Amended by the Animal By-Products (Amendment) Regulations 2009, SI 2009 No.1119 and the Animal By-Product (Enforcement) (No.2) (Wales) Regulations 2011, SI 2011 No.2377 (W.250).

place, or where sterilisation is not required – i.e. for non-ABPR facilities), or enters the reactor vessel via a pre-sterilisation vessel[25].

Once in the reactor vessel, the substrate is retained for a given time period (its 'Hydraulic Residence Time' or 'HRT') to ensure that digestion has taken place. The HRT can vary from a matter of hours for certain fast-digested wastes (e.g. wastewaters) in reactors (called 'high rate') where microbes are allowed to be retained, or instead to several weeks/months for suspended microbial systems for more solid wastes requiring greater hydrolysis efforts[26].

Higher additional energy (and cost) is required to maintain the digester at thermophilic temperatures, and an advantage will only occur if the retention time is significantly reduced as compared to mesophilic systems. Another drawback of thermophilic systems is their greater sensitivity to operational and environmental conditions. The majority of facilities in the UK are mesophilic systems.

Material in wet digesters requires continuous or periodic mixing to ensure sufficient contact between organic material and the microbial population, to prevent layers forming within the digester, and to achieve consistent stabilisation of the organic material. The size of the reactor vessels themselves can vary significantly depending on the type of system, its HRT and the waste treated. Digestion is very scalable, with small systems capable of a high throughput of specific waste streams. The form of the reactor vessel can have a number of variants[27]. However, in all forms of reactor, the same generic principles apply, the reaction process itself is a means of stabilising the organic matter and of generating biogas from the organic material.

Biogas is generated by the bacteria used in the AD process. It is captured in the headspace of the reactor vessel, where it is either stored directly above the vessel, in an on-tank store, or captured and stored remotely. (Biogas utilisation is discussed below.) After digestion, the substrate is passed to a digestate holding tank. For plants which sterilise the digestate after the digestion process, it will first pass through a sterilisation vessel. The digestate is then periodically removed from the digestate store for subsequent utilisation. The digestate typically consists of a liquid with a small amount of fibre.

Digestate can be spread directly to land as a product if it is produced in plants which meet the appropriate treatment standard (BSI PAS 110 (2010) (currently under review). For economic and / or practical reasons some facilities may dewater digestate, treat the liquid fraction prior to discharge to sewer, with only the solid fibre going on to further use on land. Work by WRAP Cymru has

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[25] This typically uses waste heat from the facility, and is capable of taking the incoming waste to a temperature of at least 70^{o}C, where it is held at this temperature for a period of not less than one hour.
[26] The temperature of the reaction vessel varies according to whether the digester is maintained at 'Mesophilic' or 'Thermophilic'.
[27] Single stage reactors operating as 'Continuous Stirred Tank Reactors' or 'Plug Flow Reactors' or more complex multi-stage reactors. See: http://www.walesadcentre.org.uk/Technologies/SingleMultistageSystems.aspx.

assessed that there is ample agricultural and horticultural land in Wales to accept digestate produced in Wales[28].

Dry Digestion

Dry AD systems digest a waste stream of 15 – 40% total solids. The physical characteristics of the wastes at such high solids content impose technical approaches in terms of handling, mixing and pre-treatment. Transport and handling of the wastes is carried out with conveyor belts, screws, and powerful pumps especially designed for highly viscous streams.

The pre-treatment, handling and mixing equipment for dry digestion is more expensive than the centrifugal pumps used in wet systems, however this additional cost is offset against the smaller vessels required for digesters and reduced storage requirement due to the lower water content of the substrate.

A pre-treatment which is necessary before feeding the wastes into the digester is the removal of coarse impurities which can be accomplished via trommel screens and shredders. Heavy inert materials such as stones which pass the screens or shredder need not necessarily be removed from the waste stream. Due to their high viscosity, the fermenting wastes move via a plug flow inside the digesters. Plug flow operations need specialised mixing arrangements, as mixing the incoming wastes with the fermenting biomass is crucial to guarantee adequate inoculation with bacteria and to prevent localised overloading and acidification.

Whilst dry systems may still require the addition of water (or co-digestion with low solid wastes) to achieve a total solids content of around 30%, dry systems use considerably less water as part of the process than wet systems. This in turn leads to lower energy requirements for in-plant needs, because less energy is needed for heating process water and for de-watering AD digestate.

Dry digestion systems normally operate at thermophilic temperatures so that bacterial metabolism is faster in order to deal with the high organic loads.

Biogas capture arrangements are similar to those for wet systems, although storage generally takes place in a remote store rather than in a store sited on top of a reactor vessel. Instead of pumping the digestate to a holding tank, it is usually passed to a storage pit through the use of a screw auger. Composting of the digestate can be used for further maturation.

Batch Process

A variation of dry digestion can take the form of a batch process where organic material is placed in a gas tight 'bunker', with some adjustment of moisture content and initial treatment of the material achieved through 'percolating' a liquid

[28] WRAP Cymru. (November 2012) Assessing the cost benefits for production and beneficial application of anaerobic digestate to agricultural land in Wales. (OMK007 – 203).

through the waste mass[29] . The waste mass itself is not usually mixed in these systems.

Biogas

The biogas produced by AD typically contains 55-65% methane (CH_4), 34-44 % carbon dioxide (CO_2) and smaller quantities of hydrogen sulphide (H_2S), ammonia (NH_3) and water vapour (H_2O). Trace amounts of hydrogen, nitrogen, oxygen, and siloxanes may also be present.

Biogas production from organic wastes can vary in different digestion systems with different feedstocks, loading regimes, total solid content percentages, mixing efficiencies, operating temperatures and retention times among other parameters affecting production rates.

Source segregated biodegradable municipal wastes (BMW) are high energy wastes, with industrial processes producing 70-170 m^3 of biogas per tonne of waste (wet weight or on as received basis). Agricultural slurries tend to give lower yields in comparison. Biogas production can be enhanced by mixing low-energy substrates such as agricultural slurries or sewage sludge with higher energy wastes e.g. grass & maize silage and rape seed cake. Co-digestion of a number of feedstocks can deliver a recipe for improved biogas yield and process stability.

In many smaller scale AD plants the biogas is burnt directly in boiler systems to produce heat for heating the digester and buildings. However, for many applications the quality of the biogas has to be improved before use.

Biogas upgrading

Prior to use, biogas generally requires ‘upgrading’. The main upgrading required before the biogas is utilised in most gas engines is the removal or reduction of hydrogen sulphide (H_2S) to levels below 250 ppm to prevent engine corrosion[30]. A biogas de-sulphurisation unit is a common feature of most anaerobic digestion plants. The processes used for hydrogen sulphide removal are fairly well developed and include; biological de-sulphurisation, iron oxide treatments or water scrubbing. Further upgrading is required if the biogas is to be added to the gas networks or utilised as a transport fuel.

Biogas utilisation

Biogas can be used to generate heat and power. It can be used as a transport fuel or injected directly into the gas distribution networks. Further details of each method are discussed below.

<u>On-site electricity and heat requirements</u>

The most common biogas utilisation route involves the burning of the biogas in Combined Heat and Power (CHP) engines, producing electricity and heat. In these cases, the electricity and heat produced is usually in excess of all AD

[29] This percolate is usually re-circulated in the process.
[30] This should be reduced further when considering Health and Safety issues.

process requirements. For example, electricity is required for lighting, macerating, pumping and other necessary applications.

Heating is required to keep the digester at the required temperature and to heat, and in some cases, to pasteurise the incoming waste stream.

Vehicle Fuel

Biogas as a transport fuel has been demonstrated in countries including Sweden, Germany, Spain, France, Switzerland, Austria and others. In the UK a number of trials are being carried out by councils and supermarket chains with vehicles powered by compressed biomethane (CBM). However, before it can be used as a vehicle fuel, biogas is typically upgraded, to approximately 97% methane.

The benefits of using upgraded biogas (biomethane) as a vehicle fuel include:

- Can be produced from waste and a wide range of energy crops
- Reduced reliance on foreign fossil fuels
- Lower emissions (air quality benefits)
- Vehicle noise reduction
- Low carbon fuel
- No blending with other fuel is required

Utilisation by Local Gas Networks

Alternatively, upgraded biogas can be injected into the existing gas distribution infrastructure (gas grids). In the UK there are 8 gas distribution networks covering separate geographical areas. Biogas must comply with gas quality requirements set out in the Gas Safety (Management) Regulations 1996[31]. Key components to be removed from biogas are hydrogen sulphide (H_2S), water, CO_2 and siloxanes. There are also restrictions on O_2 levels due to possible network corrosion effects and safety. The gas must also meet a minimum calorific value and 'Wobbe Index' value. Enrichment with propane to match the calorific value and combustion stability of natural gas may also be necessary.

For health & safety considerations, an odorant is usually added to give the biogas a characteristic smell on the lower pressure gas mains.
Despite the technology already being deployed in many other countries in Europe, injection of biomethane derived from AD into the gas grid is still in its infancy in the UK. The UK is ideally suited for this technology since it has a good natural gas distribution infrastructure with a dense coverage.

The advantages of upgrading biogas for injection into the gas grid include:

- Renewable gas can be delivered using existing gas distribution infrastructure
- Low transportation costs by pipelines
- Distribution network has a very dense coverage

[31] SI 1996 No.551.

- Increase security of gas supply, reducing external dependencies
- Utilised for heating at efficiency rates in excess of 90%
- Low 'fossil' carbon dioxide emissions when compared with natural gas.

2.1.3 Form

AD sites can be compact, and examples exist at a small scale which fit entirely into shipping containers or small steel-frame buildings[32]. Such facilities could be easily incorporated into existing waste sites or operated in conjunction with industrial processes. These systems are generally intended for the treatment of relatively low masses of waste (i.e. <2,500 t/yr).

More commonly, AD facilities are constructed at such a scale as to require their own site, or a separate area of a larger waste management / industrial / farm facility. This needs to be secure, and with areas of impermeable paving / bunding to contain spillages. There will be a need for buildings to house plant and equipment (including control gear) although not all AD facilities necessarily require a waste reception building (some industrial facilities have waste conveyed directly to the digestion vessel(s) via pipework or through tanker discharge points).

Wet systems require comparatively larger digesters than dry systems, more and greater capacity water pumping and piping/valving, more extensive digestate storage and / or de-watering, higher capacity wastewater treatment facilities and more energy is required to heat the larger volumes.

Reactor vessels and digestate holding tanks can vary considerably in size. Again, for micro-scale facilities, these can be in the order of a few cubic metres. For large-scale facilities with a long residence time, reactor vessels can be several thousand cubic metres in volume, and digestate holding tanks can be of a similar size.

Table 2(a) below demonstrates the range of plant, equipment and structures that an AD plant may contain (this is dependent on scale and waste treated):

Table 2(a) – Anaerobic digestion – generic plant, equipment and structures		
Plant, equipment and structures	Will contain /require	May contain /require
Reception building, housing : • Waste depackaging unit • Pre digestion processing and mixing • Pre-pasteurisation unit		X
Main building(s) housing: • Office • Control unit • Odour control system	X	

[32] For example, the All Waste Services facility at Llangadoc. See: http://www.allwasteservicesltd.com/anaerobic-digestion.

• Pump system • Pre digestion processing and mixing • Pasteurisation • CHP unit / Boiler / Biogas Upgrading Unit and storage • Welfare facilities		
Weighbridge		X
Vehicle cleaning area		X
Feedstock storage / mixing vessel(s)		X
Fermenter / Digestion vessel(s)	X	
Separate gas storage vessel(s)		X
Digestate store(s)	X	
Digestate / Wastewater Treatment Plant		X
Gas cleaning and upgrade equipment		X
Gas compression equipment		X
Bunding for tanks, vessels and pipework runs	X	
Sewer connection	X	
Incoming electricity grid connection	X	
Outgoing electricity grid capacity		X
Connection to natural gas grid		X

2.1.4 Benefits

Table 2(c) – Benefits of AD

Environmental	Economic	Societal
Reduces energy use	Production of heat, electricity or biomethane produced for on-site use and/or exported	Surplus heat or digestate could be utilised by local communities / groups.
Greenhouse gas savings	Financial incentive schemes for renewable heat, electricity or transport fuel	Many facilities are built with a visitors centre to enable local groups to view the facility and learn more about how it operates.
Reduces risk of pollution and environmental harm	Market development for nutrient rich digestate	
Nutrient rich biodigestate	Increase on farm revenues	
Decrease overall environmental burdens associated with agricultural practice	Provide business diversification	
Reduce impacts associated with slurry management in rural locations	Provision of vocational training for staff	

	A facility of 50,000tpa will employ approximately 15 people.	

2.1.5 Impacts

AD is an enclosed process. Potential sources of emissions are most likely to be associated with activities prior to and post the anaerobic digestion stage, such as:

- The reception and pre-treatment of wastes
- The storage / separation of treated digestates
- The combustion of biogas

Table 2(d) – Planning Issues for AD

Planning Consideration	Explanation	Mitigation
Noise/Vibration	• Mechanical processes involved in the reception and treatment of wastes, such as transfer pumping, shredding, depackaging etc.	• Appropriate design, location and enclosure of such plant • Advice should be sought from NRW on noise impacts
Odour	• Particularly those wastes that need to be depackaged, or which may have already begun to decompose • Digestates held in storage can produce biogas. Venting of storage tanks to atmosphere can give rise to odour impacts and methane and ammonia emissions.	• Dedicated reception and pre-treatment of incoming wastes • Reception area maintained under negative pressure. with mechanical vents to extract air to a suitable filter; • Collect gases from the headspace of the enclosed digestate storage tanks and mix these with the biogas that is generated at the anaerobic digestion stage • Advice should be sought from Natural Resources Wales in respect of potential odour impacts
Vermin	• Presence of food waste	• Vermin are controlled through standard control techniques (ie. baits/traps etc.) and good housekeeping
Air Emissions/ Bioaerosols	• Receipt of wastes	• Bioaerosols are controlled through the receipt of incoming wastes in reception buildings

		with negative air extraction.
Access	• For transport of waste onto site and removal of material	

An AD plant taking segregated food waste with a throughput of 20-25,000 tonnes per annum (equating to approximately 55-70 tonnes a day) will typically produce enough biogas to power a gas engine with a gross output rating of 1MWe, for example.

2.1.6 Further information

Figure 6 – photograph of a simple vertical flow anaerobic digestion facility

This photograph shows a food waste digester at the Llwyn Isaf former landfill site located to the south of Caernarfon. The plant has a capacity to process 11,000 tonnes of local authority collected food waste per year. This will generate around 3,500 MWhr per year of renewable electricity for the national grid and around 10,000 tonnes of biofertiliser for use on local farmland. The plant also provides a local facility to recycle food waste from commercial customers in the area. The large domed structure is the biodigester with integral gas store (gas is stored within the roof of the tank.) The two large vertical tanks are digestate storage vessels, and the smaller vertical tank is a buffer tank. Pre-processing (including depackaging activities) takes place in the building to the rear of the three vertical tanks.

Case studies describing various AD plants in Europe can be found at:
http://www.walesadcentre.org.uk/Default.aspx

Case studies specifically describing AD plants that upgrade biogas to produce biomethane can be found at:
http://www.bio-methaneregions.eu/

Planners should also note the document *'Country Specific Conditions and Barriers to Implementation for anaerobic Digestion Plants in England and Wales'*
http://www.fedarene.org/wp-content/uploads/2013/10/BMR_D2.1.2_Framework_Country_SWEA.pdf

2.2 In-vessel composting (IVC)

2.2.1 Introduction

This refers to the biological treatment of segregated liquid solid food and other organic wastes mixed with green wastes in an aerobic environment using microbial action. The purpose of IVC is to produce a compost for use as a fertiliser. Examples exist within the UK of IVC being used to treat residual wastes – however, this is generally undertaken as part of a Mechanical Biological Treatment (MBT) process, and is considered under Section 4.1.

Operations undertaken in IVC facilities include the:

- reception
- depackaging
- sterilisation (during the composting process as a result of biological action)
- biological treatment of organic wastes
- maturing of compost
- consignment of ATAD digestate/compost to offsite uses.

IVCs are generally operated by commercial operators, and will be located on sites with B2 or sui generis permissions, either as stand-alone facilities, or ancillary to other waste management operations (i.e. in connection with the operation of MBT facilities as discussed at Section 4.1, for example.)

2.2.2 Function

The nature of the waste accepted by IVC facilities depends on the exact nature of the permitted activity[33]. Because IVC is a solid waste treatment process, it requires the use of green wastes along with more liquid food wastes to provide a suitable structure to the waste mass to facilitate composting. Waste is first received in a waste reception area, located inside a building.

Where waste is required to be depackaged, the incoming material is generally passed through a mechanical process to separate the organic substrate from its

[33] The standard rules permit 'SR2012/3 - Composting in closed systems' permits the composting of around 55 identified organic waste types.

packaging. Other pretreatment of the incoming waste may also be required. It may be necessary to shred incoming wastes to ensure that they are the right size and composition for the composting process. Wastes may also need to be mixed prior to composting. After pre-treatment, the organic material is passed to a compost vessel.

A number of variants exist:

Table 2(e) – Variants to IVC

Variant	Description
Vertical composter	Waste is passed into cells from above. The waste mass moves slowly down the composter and the compost emerges from the base of the composter after an appropriate residence period. This is a continuous process. Aeration is usually passive in vertical composters. The rate of composting in this continuous process is controlled by adjusting the rate of filling and the rate of emptying.
Rotating drum composter	Waste is passed into the composter at one end of a slowly rotating tunnel angled at a slight incline. After the appropriate residence period, composted organic matter emerges at the other end of the tunnel. This is a continuous process. Aeration is as a result of the turning motion of the drum. As above, the rate of composting is controlled by adjusting the rate of filling and of emptying.
Tunnel composters	These are large-scale rectangular vessels which used forced aeration systems. They can be permanent structures constructed from concrete and steel, or more temporary using concrete push walls and/or special fabrics stretched over steel frames. Tunnels may be single or double ended for loading and unloading, and may be fitted with opening roofs to help load or unload. Typically, composting tunnels are used to process materials in single batches, although some systems operate on a continuous flow using mechanical systems such as moving floors, rotating shafts, and augers, to move the material through the tunnel on a plug-flow basis. Tunnels can be filled manually using wheeled loading shovels or using specialised filling equipment, such as conveyors. Aeration is achieved through blowing air through the base of the tunnel, via aeration channels or pipework. The rate of composting in batch composters is controlled by adjusting the air flow to the composter, whereas for continuous tunnel composters, controlling the rate of filling and emptying also controls the rate. In-vessel composters normally have a number of composting tunnels, allowing sequential filling and emptying, and hence the continuous operation of a batch

	process.
Batch composter	Food and green waste can be batch composted within enclosed buildings in bays or piles, using plant to turn and aerate the compost piles. Aeration is usually provided by the use of dedicated pipework laid under the piles or bays. The use of a large enough building allows for sufficient batches to be composted at the same time to allow for a continuous feed of incoming waste.

The composting process needs to ensure that all wastes from wood processing and the production of panels, furniture, pulp, paper and card reach a temperature of at least 70°C for an hour, and that the composting process reduces the particle size of the compost to a maximum of 12mm. There is considerable reliance on the use of temperature monitoring probes within the compost to ensure that the required temperature profile has been met within the waste mass.

For the outputs from an IVC to be considered as a product and not a waste at the end of the treatment process, it is necessary that the compost must be produced in accord with BSI PAS 100:2011 *'Specification for composted materials'*[34], and with the associated Quality Protocol.

The size of the compost vessels themselves can vary significantly depending on the type of system. Composting is scalable, however unlike anaerobic digestion, throughputs are generally fixed and the rate of composting is limited by the PAS100 requirements[35]. Economies of scale dictate the size of in-vessel tunnel composters, with several examples of facility in the 10ktpa to 25ktpa range in Wales. Drum or vertical composters can be smaller than this, as can composting in piles or bays.

After composting, the compost is removed from the vertical compost unit, tunnel, drum or pile and is then commonly stacked on an external pad for maturation. This process can take up to 6-8 weeks, and takes place on a compost pad with integral drainage. The compost can then be removed from site and used as a product where that use is in compliance with the appropriate 'Quality Protocol'. The Welsh Government considers that the application of compost to land in agriculture and horticultural applications brings the greatest environmental benefits. Compost can be used in land remediation applications, and it is also permissible to produce waste-derived compost for domestic uses.

2.2.3 Form

IVCs are generally 'in-building' facilities, requiring a waste reception area, and a composting vessel or vessels. Some vertical composters can be sited as self-contained units sited outdoors, but this is dependent on the ability to deliver to them a pre-processed feedstock, which will need to be treated within a building

[34] See: http://www.environment-agency.gov.uk/business/sectors/142481.aspx
[35] PAS 100 requirements specify that the compost must be retained in the vessel for a certain amount of time.

adjacent to the unit or at a remote location. IVC units can be part of the fabric of the building containing them, or more usually contained within a larger building. IVC's require the provision of paved compost maturation areas with integral drainage, adjacent to the IVC or on a remote site.

Waste reception areas are generally negative pressure extracted, with access doors which can be closed and sealed to prevent the escape of odours. Air extracted from waste reception areas and from the IVC units themselves (where they have a forced air supply) will be extracted and passed to a biofilter unit. The biofilter tends to be sited exterior to the building housing the IVC, typically consisting of a bed of organic material (such as compost mixed with bark to give structure) into which the extracted air is injected from beneath. The biofilter acts as a growth medium for bacteria, which metabolise odorous compounds in the extracted air and reduce the odour potential of extracted air.

IVC's are scalable and the size of the facility is directly linked to its throughput. Due to the restrictions imposed by PAS100, the rate of throughput is fixed, and therefore the larger the throughput, the larger the facility. In Wales, there are examples of fairly compact IVC units. The TEG Vertical Compost Unit at Harlech has a design throughput of 5000 tonnes per annum, and is sited in a building with a footprint of 750m^2, with an external concrete pad for compost maturation with an area of 1200m^2.The Bryn Compost facility at Gelligaer, Caerphilly has a design throughput of 25000 tonnes per annum. It is sited in a building with a footprint of 2800m^2, with an external concrete pad for compost maturation with an area of 4000m^2.

Table 2(f) – IVC Requirements

IVC Requirements	Required	May be Required
Three phase electricity supply	√	
Site for the development of a "power island"		√
Local gas grid connection		√
Sewer connection		√
Water Supply	√	
Road Access	√*	

* Farm sites can be sited on their own land-bank.

2.2.3 Benefits

Table 2(g) – Benefits of IVC		
Environmental	**Economic**	**Societal**
Greenhouse gas savings (not as great as those obtained through AD)	Nutrient rich compost is a marketable product, with a positive value (c. £7-10 per tonne bulked in 2013, but worth more than this if screened, sorted and bagged for sale to smaller domestic consumers.)	Surplus compost could be utilised by local communities / groups in local agriculture/horticulture applications.
Reduces odour and organic loads entering the environment	A medium sized IVC facility (e.g. 25,000 t/yr throughput) treating source segregated food wastes might be expected to employ 2-4, with additional resource input required on a part time / as required basis (e.g. plant maintenance).	Development of local compost facilities at a smaller scale can result in a reduction in waste transportation.
Nutrient rich compost (where standards and quality protocols are followed) which can be used for applications to displace 'virgin' compost.		

2.2.4 Impacts

Table 2(h) – Planning Issues for IVC

Planning Consideration	Explanation	Mitigation
Noise and vibration	• From waste deliveries; • From depackaging, shredding and screening activities; • From operation of fans and air handling units; • Use of plant / machinery	• Appropriate design, location and enclosure of plant; • Enclosure of air handling plant where mounted external to buildings, and use of appropriate shielded ducting; • Noise impact assessment to suggest other mitigating measures as appropriate. • Advice should be sought from NRW on noise impacts.
Odour	• Wastes needing to be depackaged and those already decomposing • High levels of odorous compounds (i.e. Volatile organic compounds); • Maturation of compost • Exhaust air from enclosed systems • Odour from open leachate stores.	• Undertake reception and pre-treatment of incoming wastes in a dedicated reception area, kept under negative pressure conditions and which mechanically vents extracted air to a suitable filter (i.e. a biofilter or activated carbon filter) or similar odour abatement device; • In-vessel composters should vent to atmosphere via biofilters to reduce their impact on sensitive receptors. • Advice should be sought from Natural Resources Wales in respect of potential odour impacts from this activity. • Planners should discuss the sufficiency of the proposed biofilter set with the regulator. • Limit the height and width of maturation piles (on the basis that smaller piles cool more quickly), and planners should consider the use of as large a maturation area as possible with controls on the height of accumulations

Dust	• From general composting activities, and site access/egress by road vehicles	• Composting of wastes in buildings; • Good site construction and landscaping • Distance from sensitive receptors • General housekeeping and maintenance
Air Emissions/ Bioaerosols	• Arising from the reception of wastes • Arising from the composting process • Arising from the maturation of wastes	• Separation from sensitive receptors • Emissions controlled through the use of the biofilter and ancillary filters • Control can be applied to maturation operations to limit bioaerosols through not stacking the compost too high in windrows and turning windrows less frequently.

2.2.6 Further information

Figure 7 – photograph of a tunnel composter

This photograph shows the Penhesgyn in-vessel composting facility at Menai Bridge, Anglesey. This side view of the exterior of the facility does not show the individual compost tunnels, which are accessed through the roller shutter doors to the right. It does however show the exhaust ducting from the tunnels, whereby extracted air from the compost tunnels and the reception area is taken to a biofilter unit, contained within the green container in the foreground.

Figure 8 – photograph of a vertical composter

This photograph shows a vertical in-vessel composting facility at Smithfield Market, Manchester. (http://www.vren.btik.com/Gallery/FairfieldsCompostingPlant)

Vegetable waste is fed via a shredder and conveyor to the top of the unit, where it is evenly laid in piles within each 'cage' (there are three in this unit.) It then composts over time, working its way down to the base of the unit, where it is extracted and removed for maturation. A similar larger facility (under cover) is sited at the Fridd Rasus landfill site in Harlech, and takes local authority household food wastes from Gwynedd County Borough Council.

The 2009 guidance document *'Good Practice and Regulatory Guidance on Composting and Odour Control for Local Authorities'* is a good reference for further information on in-vessel composting[36].

[36] http://archive.defra.gov.uk/environment/quality/noise/research/documents/composting-odour-guidance.pdf

2.3 Open Windrow composting (OWC)

2.3.1 Introduction

Open Windrow Composting (OWC) refers to the biological treatment of green wastes in an aerobic environment using microbial action. The purpose of OWC is to produce a stabilised residue (compost) for use as a fertiliser.

Operations undertaken in OWC facilities include:

- reception
- picking to remove contaminants
- shredding for size-reduction
- piling into static piles or windrows on sealed concrete pads
- biological treatment through composting (including periodic mechanical turning of the windrow or pile for aeration)
- sieving of final product to remove oversize fractions (shredded and reintroduced into the front of the process)
- storage prior to removal from site for agricultural and horticultural applications.

OWCs are operated by commercial operators, and will be located on sites with B2 or sui generis permissions, either as stand-alone facilities, or ancillary to other waste management operations.

2.3.2 Function

There are 27 identified organic waste types permitted for composting in open systems. . These are primarily green wastes from parks and gardens, but also include certain untreated wood wastes, paper, card, compostable plastics, sludge's from the treatment of urban waste water, animal faeces and manures. Wastes which fall under the Animal By-Products (Wales) Regulations 2006, as amended are not permitted as feedstocks for OWC.

Waste is received in a waste reception area. This can be located in a building or it can be handled in the open air. Where waste is required to be depackaged, the incoming material is passed through a mechanical process to separate the organic substrate from its packaging. Shredding or other pre-treatments of the waste may be needed to ensure that they are the right size and composition for the composting process. Wastes may also need to be mixed prior to composting.

After pre-treatment, the organic material is piled in a static pile, or in a long row known as a windrow on an impermeable paved area. Windrows and piles tend to be between 1.5m and 3m in height. The windrows are turned regularly throughout the composting process to improve aeration, to ensure that the material is uniformly composted. Turning is typically every two to three days during the first week or so of composting, and then once a week to once a fortnight. Water may be added to keep the moisture content within the pile at optimum levels. The turning process can give rise to odour and the production of bioaerosols.

Piles can be formed over a perforated pipe or channel, and aeration provided through the use of forced (blowing air) or induced (sucking air) fans. This avoids the need for turning. However, where piles are aerated, they may need to be linked to an extraction system with biofilter to mitigate odour impacts. It is common for aerated piles to be covered with a layer of mature compost to prevent the release of odour.

Synthetic cover options exist for both turned windrows and aerated static piles to retain heat, prevent over-wetting and reduce surface drying[37]. OWC windrows and piles are generally matured in-situ, rather than being removed to a separate location for maturation. As for IVC, this is an extended process, which can take up to 6-8 weeks. The compost can then be removed from site and used as a product where that use is in compliance with the appropriate 'Quality Protocol' (See Section 2.2.2).

The Welsh Government considers that the application of compost to land in agriculture and horticultural applications brings the greatest environmental benefits. Compost can be used in land remediation applications, and it is also permissible to produce waste-derived compost for domestic uses.

2.3.3 Form

It would not normally be necessary for OWC operations to be undertaken within buildings, although small office buildings are generally erected on such sites. Space for at least one week's storage of incoming waste and finished compost is required. Integral sealed drainage is needed for areas where compost is treated, matured, stored and where there may be run-off. This surface captures leachate from the waste and allows it to be treated on site.

OWC is scalable. The land-take of an OWC operation depends on its throughput. A facility treating 25,000 tonnes per annum would have a land-take of around 2-3 Ha.

Table 2(i) – Requirements for OWC

OWC Requirements	Required	May be Required
Three phase electricity supply		√
Local gas grid connection		√
Sewer connection	√	
Water Supply	√	
Road Access	√[38]	

[37] Made from Gor-Tex or similar textiles.
[38] OWCs are generally too small to benefit significantly from the presence of multi-modal transport connections.

2.3.4 Benefits

Table 2(j) – Benefits of OWC		
Environmental	**Economic**	**Societal**
Greenhouse gas savings	Nutrient rich compost product	Surplus compost could be utilised by local communities / groups
Reduces odour and organic loads to water	A significant OWC facility (e.g. 25,000 t/yr throughput) treating green wastes might be expected to employ 2-4 people or more full time employees, with additional resource input required on a part time / as required basis[39].	Reduction of waste transportation distances
Nutrient rich compost substitute		Enhanced health and wellbeing through the participation of composting – the "feel good" factor[40].
Enhanced soil structure		
Improved water and air balance		
Landfill diversion		
Positive impact on climate change		

[39] For example, plant maintenance.
[40] WHIASU, (unpublished) The Health and Wellbeing Impact of Waste Management Technologies: A Guide for Practice at 31.

2.3.5 Impacts

Table 2(k) – Planning Issues for OWC		
Planning Consideration	**Explanation**	**Mitigation**
Noise	• The shredding of wastes prior to composting; • Where forced ventilation is used, in the case of aerated piles, this involves fans and air handling units; • Arising from plant and machinery to turn windrows	• Appropriate siting, design and enclosure of facility; • Enclosure of the fans where necessary and use of appropriate shielded ducting • Advice should be sought from NRW on noise impacts
Vibration	• From mechanical processes	• Appropriate design, location and enclosure of such plant
Odour	• As a result of mechanical turning • OWC can give rise to high levels of odorous compounds, ie. Volatile organic compounds; • Storage of incoming wastes on an open part of the site prior to processing.	• Limit the height and width of piles (on the basis that smaller piles cool more quickly), and planners should consider the use of as large a maturation area as possible with controls on the height of accumulations. • Advice should be sought from NRW on odour impact
Dust	• Composting biodegradable waste • Drying of materials	• Composting of wastes in buildings; • Physical barriers such as mounds and walls • Good site construction and landscaping
Air Emissions/ Bioaerosols	• Arising from the composting process	• Extraction of aerated piles to a biofilter
Road Access	• For transportation of waste to and from the site	• Vehicles should be re-routed away from inappropriate roads.

2.3.6 Further information

Figure 9 – photograph of an open windrow composting facility

This simple OWC uses 'Ecopod' enclosures covering open-windrows on a brownfield site at Bangor-on-Dee. Each pod is 60m long, and produces around 40 tonnes of compost.

(http://ies.bangor.ac.uk/TWIRLS/Composting_Production.php?menu=1&catid=6557&subid=6567)

The 2009 guidance document *'Good Practice and Regulatory Guidance on Composting and Odour Control for Local Authorities'* is a useful reference for further information on in-vessel composting[41].

[41] http://archive.defra.gov.uk/environment/quality/noise/research/documents/composting-odour-guidance.pdf

Chapter 3 Physical and physico-chemical waste treatment infrastructure

3.1 Commingled dry recyclate Materials Facility (MRF)

3.1.1 Introduction

Commingled dry recyclate Materials Facilities (MRFs) are designed to separate co-mingled recyclates into their individual material streams and prepare them for sale in the commodity markets. (A second class of MRF – the so called 'dirty MRF' which handles mixed residual wastes also exists. However, this is generally operated in association with a biological or thermal treatment step to form a Mechanical Biological Treatment facility or Mechanical Heat Treatment facility. These are considered further in Section 4 – 'Specialist Waste Treatment Facilities'.)

3.1.2 Function

Waste materials treated at MRFs are the mixed recyclate fraction collected from household, commercial and industrial activities. Glass is not accepted generally as part of the incoming comingled recyclables accepted by MRFs, although some of the new MRFs accept glass. Where glass is handled, it is separated by an air classifier. The majority of glass recovered in this fashion goes to the aggregates market following treatment by MRF, as it is generally of low quality.

Mixed waste materials are received and stored on a tipping floor in a covered reception area. Pre-sorting involves the removal of contaminants which may cause issues in the sorting process, for example film plastics, oversized cardboard and non-recyclables such as organics and wire. Pre-sorting may take place in a specified pre-sort station, but not always.

After the pre-sort, the fibre streams (paper, card and cardboard) are separated from container streams such as cans and plastic bottles. This is undertaken using a trommel screen. Once separated, the fibre will be sorted into various grades either manually, using disc screens or advanced optical scanners. Steel (ferrous) cans are separated by overband magnets on conveyors. Aluminium (non-ferrous) cans are separated through the use of eddy current separators. Plastics are sorted by polymer using manual and automated techniques, mainly the use of optical scanners. Once sorted and separated, materials may be baled for shipment to market or crushed and loaded loose for transportation (this technique is used particularly for cans and glass).

3.1.3 Form

Each MRF is different and will be able to accept different materials, depending on design. Apart from the actual sorting process, there are certain physical features of a MRF that must be of adequate size to accommodate the volumes of materials anticipated. This includes the capacity for receiving materials, the size of the tipping floor[42], the number of balers, the capacity for storing sorted materials and space for loading sorted materials.

MRFs can occupy large sites, with UK examples occupying sites of several hectares in area, and with throughputs of over a million tonnes per annum. However, large MRF's are more typically sized with throughputs around 250,000 tonnes per annum. The size of the MRF depends upon the capacity and types of comingled material separated, bulked up and transported for onward processing. Adequate room for material storage and for vehicles to operate and access these areas are important considerations. It may be worth providing storage that can cope with periods when materials cannot be moved from site or as capacity increases. There needs to be adequate covered storage for sorted materials to ensure they do not deteriorate in quality.

There is a risk of fire in many MRFs, and this risk can increase depending upon the materials processed and the manner in which they are processed. Paper and timber can ignite readily, plastics and rubber give off toxic smoke. Some materials can become explosive if in a fine condition (e.g. certain dusts).

Siting a reprocessing facility next to an existing MRF ensures local demand for products and limits onward transportation.

Table 3(a) – Requirements of MRFs

MRF Requirements	Required	May be Required
Three phase electricity supply	√	
Local gas grid connection		√
Sewer connection	√	
Water Supply	√	
Multimodal transport access		√

[42]The capacity of the tipping floor is dependent on three key factors: (1) Throughput capacity; (2) Number of balers; (3) Number of shifts.

3.1.4 Benefits

Table 3(b) – Benefits of MRFs		
Environmental	**Economic**	**Societal**
Increases volume of waste recycled	Reduces costs associated with disposal	MRF's can be operated at a small-scale by third sector organisations, benefitting the local community
Improves quality of recycled materials (recyclates)	Some employment opportunities	
Harnessing finite metals and minerals for secondary use	Offers supply of recyclate for local reprocessors	
Landfill diversion		
Improved carbon reduction compared to landfill		

3.1.5 Impacts

Table 2(c) – Planning Issues for MRFs		
Planning Consideration	**Explanation**	**Mitigation**
Noise	• Vehicular Movements • Operation of machinery • Ventilation equipment	• Appropriate design and location of facility • Where possible, operations conducted indoors • Hours of operation • Advice should be sought from NRW on noise impacts and mitigation measures
Odour	• Unwashed containers	• Adequate ventilation and filter systems
Litter	• Arrival of comingled recyclate at site	• Netting of delivery vehicles and general housekeeping
Dust	• Nature of comingled recyclables	• Adequate ventilation and filter systems
Visual	• Look no different from other industrial facilities	• Ensure new facility design is in keeping with the surrounding area

3.1.6 Further information

Figure 10 – A picking line at a typical MRF

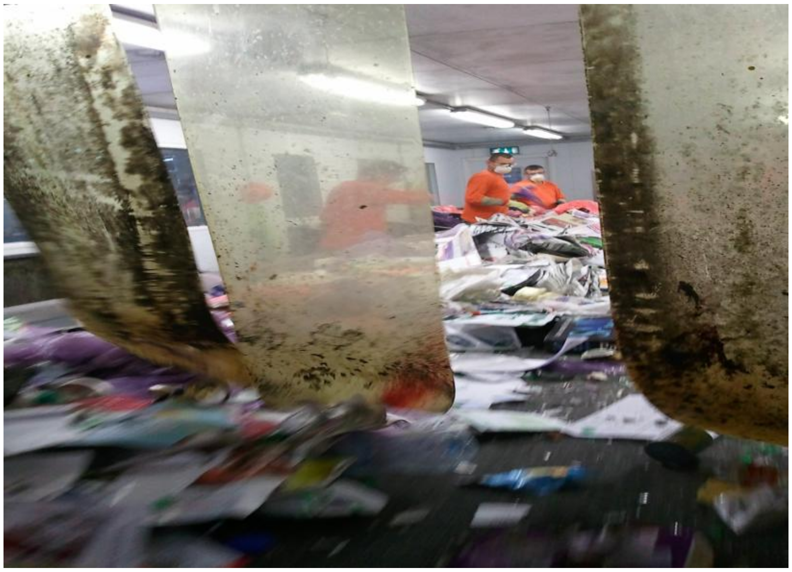

Figure 10 above shows the picking line at a typical MRF. Prior to this point, heavy fractions have been removed, and the pickers are manually sorting paper, card and plastic fractions by picking them from a moving conveyor and dropping them by hand into the appropriate hopper.

Figure 11 – A typical MRF (exterior view)

Fig 11 shows the exterior of a picking cabin, showing bays into which hand-sorted recyclates are deposited. Some MRF's may have more automation, and contain a number of mechanical sortings steps. (This MRF is the HW Martin MRF in Leeds[43].

Fig 12 – Schematic of a typical MRF layout

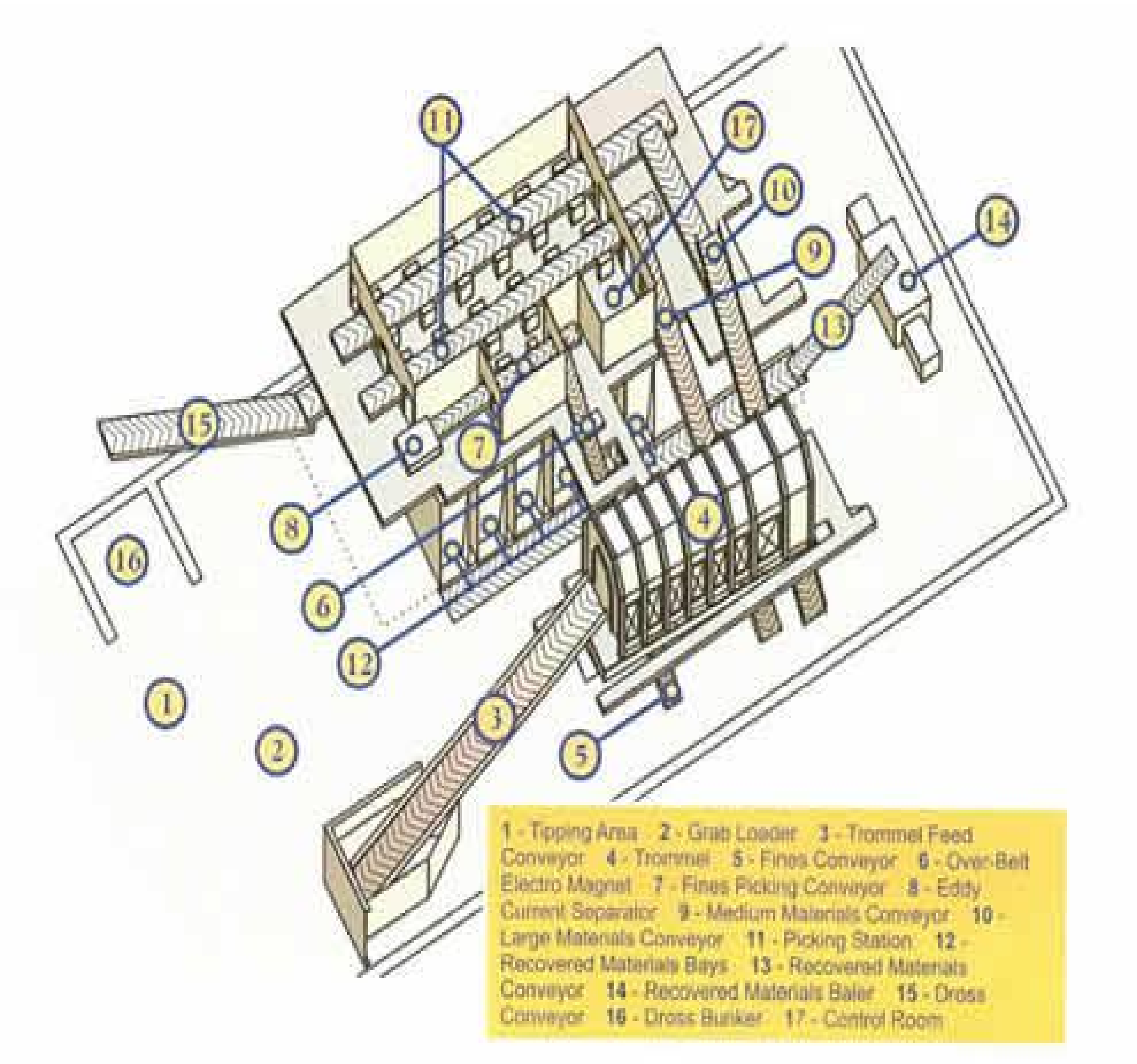

Figure 12 shows a schematic of a typical MRF layout[44].

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[43] http://www.hwmartin.com/recycling/case-studies/leeds-materials-recycling-facility/2
[44] http://www.hse.gov.uk/waste/mrf.htm

3.2 Materials Facility for mixed Construction, Demolition and Excavation (CDE) Wastes

3.2.1 Introduction

Materials Facilities for Construction, Demolition and Excavation Wastes ('CDE MRF's') treat specifically wastes arising from the CDE Sector. These are typically bricks, tiles and concrete, soils and stones and other incidental arisings (which may include wood, paper/card, metal and plastic). Dependent on scale, some of these activities may also take place at CDE Transfer Stations (with treatment).

3.2.2 Function

Mixed construction, demolition and excavation (CDE) wastes are tipped into an area and sorted to remove unsuitable materials. They are then loaded into a screen (usually a trommel). This initial pre-sort recovers soil and other fine material accounting for a large proportion of the input stream's weight. The waste may be crushed or shredded to facilitate recovery.

Fractions are separated on the basis of particle size, shape or weight. Fine waste falls through while oversized waste continues on the line. Both material streams may be first introduced onto a hopper spreading the material on the conveyor belt, thereby facilitating subsequent sorting processes. The smaller particles are passed by magnets to remove any metal. Density-separation may be employed to recover incidental light fractions such as small paper and plastic film. This material, referred to as "fluff" or "flock" is most often sent for disposal, or possible conversion to a Refuse Derived Fuel (RDF).

The large fraction emerging from the screen often passes under an overband magnet/eddy current separation, to remove further ferrous/non-ferrous metals. The picking cabin pulls off manually various types of rigid and film plastic, cables and wires, paper, card and wood where presented. Each recovered material is dropped down chutes into separate bays located below the picking shed, for onward movement. Any oversized objects or non-recyclables missed in the tipping area are also removed in the picking cabin.

Construction and demolition waste of suitable quality (ie. free from contamination from incidental wastes) may be pre-sorted on site and will by-pass the MRF's normal processes and be directly tipped into the appropriate bulk storage bay ready for onward shipment to the re-processor, or may be washed and sorted by size in an aggregate washing and sorting facility to give prepared aggregate outputs.

3.2.3 Form

Every CDE MRF differs in its particular layout and combination of manual and automated sorting processes. MRF size is largely controlled by the site location and the type of wastes available. The availability of land is an issue as stockpiling recyclates requires considerable space. Waste from construction and demolition sites is usually transported by road to the MRF.

3.2.4 Benefits

Table 2(d) – Benefits of MRFs for Construction and Demolition Waste		
Environmental	**Economic**	**Societal**
Allows enhanced capture of recyclates from mixed C&D waste streams.	More cost-effective option than disposal of mixed C&D waste to landfill.	Employment opportunities
Allows landfill diversion.	Allows material to be segregated in order to be reprocessed as product (ie. secondary aggregate).	
Increases volume of waste recycled	Reduces costs associated with disposal	
Improved carbon reduction compared to landfill		

3.2.5 Impacts

Table 2(e) – Planning Issues for MRFs for Construction, Demolition and Extraction Wastes		
Planning Consideration	**Explanation**	**Mitigation**
Noise	• Vehicular Movements • Sorting equipment • Mechanical grabs • Forklift trucks • Bulldozers and other plant machinery • Ventilation equipment	• Appropriate design and location of facility (including acoustic barriers.) • Where possible, operations conducted indoors • Hours of operation • Advice should be sought from NRW on noise impacts and mitigation measures
Litter	• From incidental light fractions contained in the C&D arisings such as plastic film, paper etc.	• Use of barriers or netting to prevent light material blowing off site • Good housekeeping
Dust	• Produced by vehicular movements and plant and machinery	• Usually controlled by dust suppression measures (ie. water spray).

3.2.6 Further information

Fig 13 – Aerial view of a typical CDE MRF

Figure 13 shows a typical CDE MRF shown from above[45]

Fig 14 – Aggregate washing plant

Fig 14 shows part of a typical aggregate washing facility – this is the Derwen Aggregates facility in Neath[46].

[45] http://www.bluegroup.co.uk/recycling-systems/recycling-plants/
[46] http://www.cdeglobal.com/case-studies/18/derwen-construction; http://www.derwengroup.co.uk/

3.3 End of life vehicles facility

3.3.1 Introduction

End of life vehicle (ELV) facilities depollute and dismantle waste motor vehicles before further treatment in order to reduce environmental harm and harm to human health. First, hazardous materials and components are removed and segregated from other materials (a process known as 'depollution'.) Secondly, components may be stripped from the vehicle for onward reuse, recycling and treatment, known as dismantling, or the material may be consigned directly for processing.

3.3.2 Function

Vehicles reaching the end of their life (technically, economically or prematurely through accident write-offs) must be consigned to an Approved Authorised Treatment Facility (AATF). Vehicles treated in these facilities include passenger carrying vehicles up to 3,500kg; light goods vehicles up to 3,500kg and three-wheel motor vehicles (excluding tricycles)[47].

ELVs that have not already been depolluted are classified as hazardous/special waste until they have been treated to remove fluids and other hazardous substances and components. Therefore, sites which treat vehicles that have not already been depolluted are listed as hazardous/special waste producers.

The process undertaken at an AATF ELV facility involves two main functions:

1. The recovery of all components and fluids that may be recycled and re-used (e.g. fuels, oils, coolants, ferrous and non-ferrous metal components, etc.), and also
2. The removal of all those elements of a vehicle that are potentially harmful to the environment (e.g. tyres, mercury switches, airbags, etc.).

Treatment operations undertaken at ELV facilities may include:

- Removal and Storage of hazardous wastes
- Removal and Storage of waste oils and fluids
- Removal and Storage of batteries
- Removal and Storage of vehicle shells
- Transfer of waste materials (plastics, metals, glass, tyres, and fully de-polluted vehicles)

Depolluting an ELV involves a sequence of removal and draining activities, for which the vehicle will be put onto a depollution frame or lifting device. Activities include baling, storage, cutting, compacting, fluid and other removals. When all the depollution activities have been conducted the ELV will be classified as non-hazardous and can then be recycled.

[47] There are 4 sets of standard rules for sites accepting less than 75,000 tonnes of waste per annum (apply to recovery including storage of all waste motor vehicles. Standard Rules 2008 No 20 (SR2008No20) Vehicle storage, depollution and dismantling (authorised treatment) facility.

Treatment consisting only of depollution of waste motor vehicles and sorting, separation, grading, baling, shearing, compacting, crushing or cutting of waste into different components for recovery.

3.3.3 Form

Whilst the form of ELV facilities will vary depending on the extent of the operations and treatment conducted at the facility, four main areas can be identified:

1- Depollution bays - These bays are fitted with interceptor drainage systems to eliminate the possibility of ground contamination
2- Dismantling bay - remove useful parts for resale
3- Outside storage areas - depolluted vehicles are then removed to these areas for storage
4- Baling areas - when all of the reusable parts have been removed the vehicle is moved to the baling area where the engine is removed mechanically using an engine ripper

Materials stripped from the vehicle are separated and stored according to their suitability of vehicle components for reuse and recovery, and in particular for recycling. All metal and plastic wastes and other oil-contaminated spare parts arising from the treatment of ELVs should be stored on hard standing or an impermeable surface with a sealed drainage system.

3.3.4 Benefits

Table 3(f) – Benefits of ELV facilities

Environmental	Economic	Societal
Recovery of finite metal resource for further use	Considerable economic gains from recycling ELV – both for sector and metal reprocessors, who rely on sector for feedstock	Provides capacity for the management of ELV. Coupled with the positive value of ELV, the presence of AATF's result in a significant reduction in vehicle abandonment, positively benefitting the local environment.
Recovery of other recyclate streams (polymers, glass etc.)	AATF's are significant employers within waste management sector	
Compliance with ELV Directive		
Diversion of recyclate from landfill		

3.3.5 Impacts

ELVs are considered to be hazardous waste and must be depolluted to certain standards. This has a bearing on the impacts of the facility.

Table 3(g) – Planning Issues for ELV facilities

Planning Consideration	Explanation	Mitigation
Noise	• Shredding, cutting, removing, baling of waste vehicles and parts	• Appropriate design and location of facility • Where possible, operations conducted indoors • Signage • Preventing vehicle movements and plant operation at unsocial hours • Hours of operation
Dust	• From cutting, shredding operations	• Adequate ventilation and filter systems;
Spillages	• Handling and removal of fluids, oils and petrol	• Appropriate storage areas, bunding and impermeable surfaces • Use of interceptors integral to drainage system
Visual		
Contaminated water/ groundwater	• Contaminated rainwater run-off from stored parts and wastes	• Covered storage areas • Impermeable surfaces

3.3.6 Further information

Fig 15 – Photograph of vehicle depollution

Fig 15 shows a mobile vehicle depollution rig in action at a scrapyard in Preston[48].

Fig 16– Photograph of stockpiling of depolluted vehicles

Fig 16 shows depolluted vehicles stockpiled for shredding at a large ELV facility in Manchester[49].

3.4 Metals recycling facility

3.4.1 Introduction

Treatment at Metals Recycling Facilities involve the sorting, separating, grading, shearing, shredding, baling, compacting, crushing, granulating and cutting of ferrous and non-ferrous metals or alloys for recovery.

3.4.2 Function

Recycling Facilities process metal-containing waste, collected by or on behalf of local authorities and from commerce and industry (including the construction and demolition sectors), into vital secondary raw material for the smelting of new metals. Activities undertaken at these facilities may include any of the following:

- Collection, weighing, sorting and distribution of metals: dealing with a wide range of suppliers, including engineering industries; small traders, such as plumbers or vehicle dismantlers; local authority collection sites; and household arisings.
- Shearing – reducing the size of large pieces of metal by cutting
- Baling/compacting – to improve ease of handling and transportation

[48] http://www.letsrecycle.com/news/latest-news/metals/preston-recycling-invests-ps30-000-in-elv-recycling-facility
[49] http://www.letsrecycle.com/news/latest-news/general/lnewsitem.2013-11-05.7873857861

- Shredding – reducing feedstock to a given size fraction; and separating metals from other materials using magnets, eddy current separators and air classification methods.
- Media separation – further separation of any remaining non-ferrous metals using liquid density and hand or mechanical sorting methods

After it has been sorted, scrap metal is sent onward to reprocessors as 'furnace-ready' material. Some metal recycling facilities may not undertake the full range of facilities identified above, and may simply sort and bulk materials for transfer to larger facilities for further processing.

3.4.3 Form

Metal recycling facilities in their simplest form are generally external facilities, requiring a waste reception area with weighbridge, a waste treatment area and storage capacity for the temporary storage of furnace-ready scrap metal. Some metal recycling facilities may also undertake vehicle depollution.

Uncontaminated ferrous and non-ferrous metal wastes or alloys can be stored on hard standing or an impermeable surface. Other wastes must be stored on an impermeable surface with sealed drainage system. Areas where wastes are treated require an impermeable surface with sealed drainage system. Operators are permitted by their environmental permit to temporarily store lead acid batteries in containers with an impermeable, acid resistant base and a cover to prevent water ingress. They are also permitted to store metal filings and turnings in containers with an impermeable base and a cover to prevent water ingress.

Larger metal recycling facilities may have large-scale shredding capacity, and may operate large balers and presses. Metal recycling facilities are scalable, and range from small yards handling low tonnages to nationally significant facilities with throughputs of >100ktpa. Examples of both can be found in Wales.

3.4.4 Benefits

Table 3(h) – Benefits of Metal Recycling facilities

Environmental	Economic	Societal
Allows enhanced capture of recyclates	Allows material to be segregated in order to be reprocessed as product (ie. furnace-ready scrap)	Employment opportunities
Allows landfill diversion.	Supports local reprocessors	
Increases volume of waste recycled		
Improved carbon reduction compared to landfill		

3.4.5 Impacts

Table 3(i) – Planning Issues for metal recycling facilities		
Planning Consideration	**Explanation**	**Mitigation**
Noise and vibration	• Sorting, separation, grading, shearing, separating, shredding, baling, compacting, crushing, granulating and cutting of ferrous metals or alloys and non-ferrous metals	• Appropriate design and location of facility • Where possible, operations conducted indoors • Hours of operation • Advice on mitigation measures should be sought from NRW
Litter	• From shredding and cutting operations	• Good housekeeping
Dust	• Release of particulate matter during treatment operations	• Adequate ventilation and filter systems
Contaminated water/ groundwater	• Contaminated rainwater run-off from stored parts and wastes	• Use of surface water interceptor as part of sealed drainage system. • Use of impermeable surfacing for processing and storage areas.

3.4.6 Further information

Fig 17– Photograph of a metal recycling facility

Figure 17 shows a metal recycling facility in Camborne, Cornwall, operated by SIMS Recycling Ltd[50].

3.5 WEEE Treatment Facility

3.5.1 Introduction

This facility type receives and treats Waste Electronic and Electrical Equipment (WEEE) at Approved Authorised Treatment Facilities (AATF's). Treatment of WEEE includes: preparation for re-use, manual disassembly and manual/automated reduction in the size of material for the production of distinct material streams for recycling, energy recovery and/or disposal.

AATF's may receive WEEE from designated collection facilities (DCF's), Electronic or Electrical Equipment (EEE) distributors through 'take-back' schemes or direct from end-users under a contract with a Producer Compliance Scheme (PCS). Operators of AATFs can issue evidence notes for the treatment of WEEE or reuse of whole appliances that is carried out at AATFs in the UK[51].

Operations undertaken in AATF's include the:

- Reception of wastes
- Storage of waste
- Sorting of wastes
- Preparation for reuse of wastes (where appropriate)
- Manual disassembly of wastes (where appropriate)
- Manual/automated size reduction and sorting of wastes (where appropriate)
- Bulking of final product for dispatch (items prepared for reuse, and recyclate streams.)

AATF's are mainly operated by commercial operators and will be located on sites with B2 or sui generis permissions, either as stand-alone facilities, or ancillary to other waste management operations.

3.5.2 Function

AATF's can accept wastes designated under ten discrete categories, as set out under the Waste Electrical and Electronic Equipment Regulations 2006 as amended. These regulations transpose controls set out under the recast Directive 2012/19/EU on 'Waste Electrical and Electronic Equipment' (WEEE).

The ten categories are detailed in Schedule 2 of the Regulations as:

1. Large household appliances
2. Small household appliances

[50] http://consult.cornwall.gov.uk/portal/planning/waste_guide/waste_guide?pointId=1248947874626

[51] The evidence must relate to treatment being carried out on an AATF, or to further treatment, recovery and recycling carried out at other ATFs.

3. IT and telecommunications equipment
4. Consumer equipment
5. Lighting equipment
6. Electrical and electronic tools
7. Toys, leisure and sports equipment
8. Medical devices
9. Monitoring and control equipment
10. Automatic dispensers

Reception and pre-treatment

Precise guidance on what is and is not classed as WEEE is given in an Environment Agency guidance note[52].

Waste is first received in a waste reception area, usually located inside a building. Arrangements for reception and pre-sorting differ according to facility type and waste received. AATF facilities taking in WEEE items for automated size reduction and sorting may store items outside on dedicated areas with integral drainage. AATF facilities taking a mixture of WEEE with a view to undertaking sorting for preparation for reuse or manual disassembly for parts or enhanced recycling will generally tend to take material and sort this into categories to deal with distinct types of WEEE in a different manner.

Some WEEE items, those containing certain hazardous materials and IT and telecommunications equipment may require pre-treatment. After pre-treatment, the nature of the WEEE treatment process is dependent on the nature of the AATF and the materials handled.

Manual AATF

Where the AATF is largely manual in nature, materials are generally sorted to retrieve those which may be of value for ‘preparation for reuse’ activities. Feedstock retrieved for ‘preparation for reuse’ will be checked and tested, and good items removed for refurbishment and resale. Other items may be dismantled manually to remove good components for spares and repair. Items beyond economic repair are passed for recycling.

Recycling at a manual AATF is generally undertaken through the manual strip-down of WEEE to components, where this is economic to do so. This enables the operator to for example:

- Separate motors and drums (high value metals / alloys) from chassis (lower value metals and polymers) for washing machines/tumble dryers.
- Separate hard drives and circuit boards (higher value) from chassis (lower value metals and polymers) for personal computers.
- Remove CRT screens from televisions for separate treatment.
- Remove batteries from portable items for separate treatment.

[52] See: https://brand.environment-agency.gov.uk/mb/B0CzBe.

The decision to use manual dismantling methods is an economic one. The manual disassembly of WEEE brings higher value outputs, and allows for the enhanced capture of precious metals and other critical raw materials. It less expensive in terms of the equipment needed. Very high reuse and recycling rates can be achieved at manual AATF's, with rates of over 90% noted at Welsh facilities.

Following manual disassembly, the operator has a number of discrete material streams to transfer to other reprocessors for further treatment prior to recycling[53].

Automated AATF's

A few AATF's make use of automated size reduction and sortation methods. Here, material is introduced to a fragmentation stage to reduce it to a given size fraction. This is then passed through a MRF, consisting primarily of overband magnets and eddy current separators and physical treatment options to separate dense plastics from glass and similar inert materials.

The output from an automated AATF will consist of size reduced fractions sorted by material type. This will be transferred to other reprocessors for further treatment prior to recycling.

The decision to use automated dismantling methods is also an economic one. It allows for much higher throughputs than manual methods and is less labour intensive. Recycling rates at automated AATF's are high. However, the enhanced capture of precious metals and other critical raw materials is more difficult, as these tend to be lost within the process. It is also much more expensive than manual methods in terms of plant and equipment needed.

Outputs from AATF's

A typical AATF may produce a number of outputs:

- Items prepared for reuse – the most common items prepared for reuse at AATF's are IT and telecommunications equipment. However, some AATF's refurbish white goods and other domestic WEEE items. There is also evidence that medical equipment is refurbished by AATF's for resale.

- Specific hazardous material streams
    - Electrical insulation oils – can be present in certain items.
    - Radioactive sources – may be present in some items (ie. legacy emergency exit signs may contain tritium, smoke alarms may contain americium etc.
    - Refrigerants – may be present in refrigeration and air conditioning equipment.

- WEEE recyclate streams

[53] For example, CRT screens may go for smelting to recover their lead content, circuit boards may go for incineration in order to recover high-metal content ashes for smelting.

- Ferrous and non-ferrous metal streams – steel, aluminium and copper in the main, with smaller amounts of other non-precious metals.
- Precious and semi-precious metal streams – gold, silver, platinum and rare earth-group metals can be harvested from certain WEEE products.
- Dense polymers – many WEEE products contain significant quantities of dense polymers.
- Glass – a number of WEEE products contain glass.
- Wood – less commonly nowadays, a number of WEEE products have wooden chassis
- Rubber products – WEEE products may contain rubber seals or drive belts

- Non-WEEE recyclate streams (associated packaging etc.)
  - Light and dense plastic fractions – may be used for the packaging of WEEE (ie. film, polystyrene, dense plastic used for ancillary products such as ink cartridges for printers etc.)
  - Paper and card – used for packaging, in equipment manuals etc.
  - Wood – packaging cases etc.

3.5.3 Form

Examples currently exist in the UK of plants with a capacity of up to 100,000 tonnes per annum[54], although most plants are much smaller than this. There are a number of AATF's in Wales, with an estimated 24 at the present time. Of these, the majority are small enough to be operating under environmental permit exemptions, with only half a dozen or so believed to be operating under a permit.

AATF's are scalable and the size of the facility will be directly linked to its throughput, and also a factor of the type of WEEE processed, and the nature of the processing required. Most AATF's are compact, and would fit into a standard small industrial unit. The largest Welsh facility, the SIMS WEEE plant in Newport, is on a site of approximately 12 acres. Large AATF's may be located on sites across a number of buildings and may require a separate waste reception area, and facility to sort and store outputs.

Buildings which may house AATF's can be similar in appearance and characteristics to small manufacturing or warehousing buildings. The location of AATF's on land previously used for general industrial activities or allocated in development plans for such (B2) uses should be considered.

[54] The Sims AATF's in Newport and Daventry.

Table 3(j) – Treatment Requirements for AATFs		
WEEE Treatment Requirements	**Required**	**May be Required**
Three phase electricity access		√
Outgoing three phase electricity grid capacity		
Site for the development of a “power island”		
Natural gas grid connection		√
Sewer connection	√	
Water Supply	√	
On-site water treatment capacity		
Road Access	√	

3.5.4 Benefits

Table 3(k) – Benefits of AATFs		
Environmental	**Economic**	**Societal**
High potential for re-use and preparation for re-use activities	Capturing materials and metals for further processing.	Options for the preparation of reuse of WEEE can bring good community returns, and link into digital inclusion programmes.
Retains finite resources including precious metals within the economy (reduces need for extraction)	WRAP estimates that the material value of WEEE disposed of in the UK at the current time is in the order of £1.4 billion per annum[55].	
	Employment opportunities will depend on the nature and scale of the facility, but there are examples in Wales of manual AATF’s employing over 70 people, with employment at automated plants somewhat less than this	
Allows landfill diversion.	Supports local reprocessors	
Increases volume of waste recycled		
Improved carbon reduction compared to landfill		

[55] http://www.wrap.org.uk/sites/files/wrap/Electrical%20product%20material%20composition%20overview.pdf

3.5.5 Impacts

Table 3(l) - Planning Issues for AATFS		
Planning Consideration	**Explanation**	**Mitigation**
Noise/Vibration	• From the delivery of incoming wastes • Vehicle movements • Shredding and dismantling activities	• Appropriate design, location and routing of traffic • Undertaking of activities within a building • Seek advice from NRW
Air emissions	• Treatment of WEEE may involve the removal of hazardous materials (ie. such as 'degassing' of fridges etc.) This may release emissions into the atmosphere.	• Seek advice from the NRW.

3.5.6 Other information

Fig 18– Photograph of manual disassembly of IT-WEEE at an AATF

Figure 18 shows the manual disassembly of IT-WEEE at the MeTech Recycling AATF in Hirwaun, Rhondda-Cynon-Taff CBC[56].

Fig 19– Photograph of automated disassembly of IT-WEEE at an AATF

Figure 19 shows the SIMS WEEE recycling centre at Daventry, Northants. This facility handles around 75,000 tpa of IT and consumer WEEE, and features a fragmentation plant plus automated sortation capacity[57].

[56] http://www.metechrecycling.uk.com/gallery/

[57] http://www.simsrecycling.co.uk/Contact/UK-Locations/Daventry-WEEE-recycling

3.6 Other physical treatment facilities

3.6.1 Introduction

Physical methods of waste treatment include processes not otherwise detailed above where physical methods are used to improve or treat waste, to change them into a form permitting further treatment or utilisation.

3.6.2 Function

This category includes (but is not necessarily limited to):

Wood treatment facilities – here, wood is accepted by grade, and is shredded for onward processing. These facilities may include the use of 360 degree grabs, conveyors and shredders (with metal removal capacity through the use of overband magnets) as well as loading shovels and bays. The purpose of a wood treatment facility is to sort wood by grade and send it for appropriate end-uses which are dependent on the quality of the product. The end uses can include reuse, reprocessing by panel-board manufacturers, recovery as animal bedding or preparation of a fuel for energy recovery.

Tyre treatment facilities – here, tyres are accepted and shredded into crumb for onward processing. These facilities will include the use of 360 degree grabs, conveyors and tyre shredders, as well as overband magnets. They will also use loading shovels. The purpose of a tyre shredder is to separate the components of a tyre (ie. rubber, nylon and metal) and to send each for appropriate end-uses.

Plastic sorting and washing facilities – here, baled plastics are accepted and split for shredding, washing, flaking and sorting. After an initial sort to remove obvious contraries, mixed plastic is shredded and then washed in a series of tanks to remove contaminants such as labels or any residual contents before being flaked and then sorted by the use of optical sorting equipment into polymer grade. The purpose of a plastic sorter is to separate polymers by polymer type to service end markets which seek recycled polymer as a feedstock to replace the use of virgin polymer in their process. Residual materials arising from the process may be sent for lower-value recycling or recovery options, or to landfill for disposal.

Glass recycling facilities – here, glass of various grades is accepted for reduction to cullet. It may be washed and sorted in the process. Cullet is dispatched to end-users dependent on their particular requirements – it may be returned for remelt back to glass, to glass-fibre (for insulation), for use as secondary aggregate, or for niche applications such as the production of shot-blasting substitute.

3.6.3 Form

Facilities which physically treat discrete waste streams can vary in size, from small operations which shred tyres (there are examples in Wales of facilities with throughputs of a few thousand tonnes per annum) to large facilities which manage waste streams such as waste wood (examples exist of facilities with throughputs of over 50ktpa), glass and plastic.

These facilities are very scalable, although economies of scale are linked to the value of the waste stream being processed, and also to the availability of feedstock. Smaller facilities (ie. such as tyre shredding or plastic sorting plants) may be largely in-building. Larger facilities (such as glass sortation facilities and waste wood recycling plants) tend to be largely external in nature.

Buildings which may house smaller physical treatment facilities can be similar in appearance and characteristics to small manufacturing or warehousing buildings. The location of these treatment facilities on land previously used for general industrial activities or allocated in development plans for such (B2) uses should be considered. Larger facilities, with their need for external stockpiling of feedstocks and products may pose additional siting issues.

3.6.4 Benefits

Table 3(m) – Benefits of Other Physical Treatment Facilities

Environmental	Economic	Societal
Retains finite resources within the economy	Capturing materials and metals for further processing, supporting local reprocessors	Physical treatment options can be undertaken by third sector organisations, directly supporting the wider community as a result.
Allows landfill diversion.	Employment opportunities will depend on the nature and scale of the facility	
Increases volume of waste recycled	Supports local reprocessors	
Improved carbon reduction compared to landfill		

3.6.5 Impacts

Table 3(n) – Planning Issues for Other Physical Treatment Facilities

Planning Consideration	Explanation	Mitigation
Noise and vibration	• Sorting, separation, grading, shredding, baling, compacting, crushing, granulating and cutting of wastes as applicable	• Appropriate design and location of facility • Where possible, operations conducted indoors • Hours of operation

		Advice on mitigation measures should be sought from NRW
Litter	• From sorting, shredding and cutting operations as applicable	• Good housekeeping
Particulate emissions	• Release of particulate matter during treatment operations	• Adequate ventilation and filter systems as applicable
Contaminated water/ groundwater	• Rainwater run-off from stored wastes as applicable	• Use of surface water interceptor as part of sealed drainage system as applicable • Use of impermeable surfacing for processing and storage areas as applicable

3.6.6 Other information

Fig 20– Photograph of a wood recycling facility

Figure 20 above shows a wood waste recycling facility. The shredder and grader in the foreground is being used to reduce wood wastes to given size fractions, which are then stockpiled temporarily pending consignment off-site for further uses (which depend on the nature of the material processed[58].)

[58] http://www.swwr.co.uk/process.php

Fig 21– Photograph of a tyre shredding facility

Figure 21 shows a conveyor with tyre shredder. This reduces tyres into crumb, from which metal content can be extracted using overband magnets. The crumb is used for a number of applications, such as impact absorbent surfacing.

(See http://www.creigiautyresrecycling.co.uk/tyredisposal.html)

Fig 22 – Photograph of a plastic sorting facility

Figure 22 above shows an automated plastic sortation facility developed by Bollegraaf Ltd. This is currently operating as a commercial trial plant at Hanbury Recycling, Stoke on Trent. It combines a conveyor belt (on which a mixed plastic feed is deposited) with a Near Infra Red detector. Once scanned, individual items are tracked and grabbed by a number of robotic arms and placed in the appropriate hopper to either side of the conveyor belt. Windows on the side of each hopper allow the operator to check that material is being appropriately separated. This autosorter can operate on its own, or as part of a larger installation (ie. such as an MRF.)

Fig 23 – Photograph of a glass sorting facility

Figure 23 above shows a glass sortation plant at Recresco's Ellesmere Port facility. This allows for the sortation of bottle glass by colour, thus increasing its output value (dependent on market, tolerances for contamination of one colour by another may vary in the glass recycling industry.) The throughput of the plant is around 4000 tonnes per week[59].

[59]http://www.letsrecycle.com/news/latest-news/glass/recresco-to-expand-mixed-glass-sorting-capacity

Chapter 4 Specialist waste treatment infrastructure

4.1 Mechanical biological treatment facility (MBT)

4.1.1 Introduction

This refers to the pre-treatment, sorting and biological treatment of residual municipal waste in a complex intermediate treatment process with a number of outputs. The purpose of MBT is to produce a number of outputs for further processing in associated or remote facilities.

Operations undertaken in MBT facilities include the:

- Reception of black bag wastes
- Preparation through the use of size reduction through one or more of the following:-
  - Shredders, hammer mills, ball mills, wet rotating drums with knives.
- Waste separation through the use of one or more of the following :-
  - Trommel and screens – to sort materials by size.
  - Magnetic and eddy current separators – to remove ferrous and non-ferrous metals. Manual separation – to remove oversize materials, contaminants and plastic streams
  - Wet separators – to sort plastics and organics from inert materials
  - Air classification and ballistic separators – to sort light fractions (plastic and paper)
  - Optical separators – to sort specific polymer streams

- Biological treatment of organic wastes through the use of one of the following:-
  - In-vessel composting – to 'biostabilise' the waste or to process a segregated organic rich fraction.
  - Anaerobic digestion – to process a segregated organic rich fraction
- The consignment of outputs to further uses. These can include :-
  - The provision of low to medium quality recyclate streams for reprocessors – this can include plastic, glass and metal streams.
  - The supply of a light fraction for use as a 'Refuse Derived Fuel' for energy recovery – this includes paper and plastic streams.
  - The supply of a 'bio-dried' organic fraction for use as a 'Refuse Derived Fuel' – this is comprised of organic streams such as food waste, paper/card, wood etc.
  - The supply of a treated organic fraction for use as a 'Compost-like Output' for certain contaminated-land remediation options – this is comprised of wet organic streams such as food waste, paper, card etc.
  - The supply of inert or reject streams for disposal to land.

- The supply of biogas for energy generation options (where the organic waste treatment step uses anaerobic digestion as the treatment option.)

Not all of the above treatment options will be found at any one MBT facility – some can be quite rudimentary, using only simple physical treatment with some low-level biological treatment as a precursor to disposal to land. Others will be far more complex, and each must be considered in context.

MBT plants do one of two things. They either separate wastes or then treat the components as an intermediate step, or they treat the wastes and then separate the components. They are generally operated by commercial operators, and will be located on sites with B2 or sui generis permissions, either as stand-alone facilities, or ancillary to other waste management operations (ie. in connection with the operation of associated energy recovery facilities, or landfill disposal sites.)

4.1.2 Function

MBT facilities primarily accept residual wastes. They accept wastes falling under Chapter 20 of the European Waste Catalogue (EWC)[60]. Waste is first received in a waste reception area, located inside a building. The waste will be initially prepared to remove contrary objects which may cause problems with processing equipment downstream. (For example, bulky wastes such as mattresses and carpets may be manually removed from the incoming wastes.)

The waste will then be loaded onto a conveyor, and will first pass through a bag splitter in order to split refuse sacks and present the contents for treatment. The contents may be size reduced, through the use of shredders or hammer mills or may pass straight to a waste separation step. At this point, the waste stream will generally pass over a series of trommels, to separate the waste fractions by size. Interlaced within the trommels will be magnetic and eddy current separators (to remove ferrous and non-ferrous metals), manual separation points or picking stations (to allow the removal of oversize materials, contaminants and plastic streams), air classifiers and ballistic separators (to separate light fractions).

Sorting may take place at several points within an MBT facility, with separated streams passed back through the process to 'polish' them where required. Once separated, these streams may pass through material-specific routes for further separation – for example, mixed plastic streams may pass through optical separators in order to sort by specific polymer.

The exact configuration of an MBT facility is dependent on the nature of the incoming waste – and also upon what markets the operators seeks for the

[60] Chapter 20 wastes are 'Municipal wastes and similar commercial, industrial and institutional wastes including separately collected fractions'. The main waste stream accepted by MBT facilities are code 20 03 01 wastes – 'Mixed municipal wastes from civic amenity sites, commercial wastes, general factory waste, domestic waste, general commercial waste, general industrial wastes'.

outputs. Different process steps may be added or removed in line with wider market fluctuations. (For example – if polymer prices rise, an operator may decide to place more emphasis on the sorting of polymers by type for recycling. If prices fall, the operator may decide that the use of the commingled polymer stream for energy recovery offers the best economic outcome, and may not wish to expend as much effort on sorting by polymer type.)

This flexibility is attractive to waste operators, and it is for this reason that there are over 300 MBT facilities operating in Europe at the current time. It is thought that there are around 30 operating in the UK, primarily in England. Wales has three such facilities at the current time.

As well as separating dry recyclable materials by type, MBT facilities also separate organic and inert fractions. The organic fractions are comprised primarily of food and green wastes and residual paper and card. The inert fractions are comprised primarily of soils, stones and glass. After separation, the organic fraction is treated through an anaerobic or an aerobic treatment step to biostabilise the material.

Where treatment is anaerobic, the organic fraction is usually passed to a wet anaerobic digestion (AD) process. (See section 2.1 – 'Anaerobic Digestion' for a description of the processes involved.) This process is similar to that used for the treatment of segregated food wastes, with the exception that the process will not meet with the relevant standard (PAS110) or its associated quality protocol, and the outputs therefore remain a waste material. As the resultant outputs will not be used on agricultural land, there is no need to include a sterilisation step in the treatment of organic residual municipal waste by anaerobic digestion. Digestate liquors are normally disposed to sewer following digestion, with the recovered solid fibre treated as for 'Compost-Like Output' (see below).

Where treatment is aerobic, the organic fraction is usually passed to an in-vessel composting (IVC) process, although the use of aerated static piles or windrows within a larger building are also common. Operators may require the addition of shredded green wastes to give an appropriate mix for composting. The process is similar to that used for the treatment of segregated food and green wastes, with the exception that the process will not meet with the relevant standard (PAS100) or its associated quality protocol, and the 'Compost-like Outputs' (CLO) arising from this process therefore remain a waste material.

Outputs from MBT

Dry recyclates – recyclables extracted from MBT are of a lower quality than those derived from separate household collections (ie. Using kerbside sorting or commingled collections sorted at Materials Recycling Facilities), and this therefore constrains their end markets. Almost all MBT facilities will extract metals, but the decision to extract other dry recyclates is dependent on the state of the recycling market (as previously discussed.) Materials extracted may be compromised – for example, glass may typically be extracted as a 'dense fraction' and mixed with other inert materials such as stone and ceramics. As such, the use of this material is limited – it may find an application in recovery for low-value aggregate, although this is dependent on the quality of the inert fraction.

The operator faces a challenge when extracting textiles, paper and plastic to do so in such a manner that the outputs are marketable. Outlets for these residual recyclates are very limited. Few MBT processes attempt to segregate these streams in reality, with operators instead preferring to configure them to blend this 'light fraction' as a 'Refuse Derived Fuel' (RDF), which is used for energy recovery in associated or off-site facilities.

Refuse Derived Fuel
A number of outputs for RDF have been identified by DEFRA. Their viability is dependent on a number of issues – technical barriers for the use of the fuel, market demand for the fuel, commercial drivers around carbon trading, energy costs and renewable energy incentives (as an RDF will have a given biomass content) and the cost of alternative treatment or disposal options (gate fees.)

The six identified options are

- Industrial users for power, heat or both (using Combined Heat and Power)
- Cement kilns
- Purpose-built incinerators with power or power and heat offtakes.
- Co-firing with coal at power stations.
- Co-firing with fuels eligible for Renewables Obligation Certificates (ROC's)[61] or the Feed-In Tariff (FiT)[62] in conventional technologies.
- Use in 'Advanced Thermal Technologies' (ATT) such as pyrolysis and gasification which are 'ROC-eligible'.

At the current time in the UK, RDF is currently utilised at industrial facilities, replacing fossil fuels. Only one dedicated conventional combustion plant (a Welsh facility) uses RDF as a fuel to generate electricity. Other incineration facilities in the UK can and do accept RDF, but it is not their sole fuel.

RDF is also accepted at a number of ATT facilities in the UK, either exclusively or as part of a mixed feedstock.

Organic wastes
As previously outlined, the processing of mechanically separated organic streams can produce a biostabilised output known as 'Compost-Like Output'. The markets for these outputs are dependent on their quality, and also on

[61] The Renewables Obligation Order 2009, SI 2009 No.785, as amended by the Renewables Obligation (Amendment) Order 2013, SI 2013 No.768.
[62] Energy Act 2010, c.27 s.4 and Energy Act 2011, c.16.

legislative/market conditions[63]. This means that the organic output produced by MBT is still a waste, and its application to an end use will not count as a recycling operation.

CLO and residual waste AD digestate has the potential to be used as a source of organic matter to improve certain low quality soils, for specific brown-field site restoration activities, or for use in landfill capping. It is not permitted for application to agricultural or horticultural land. Any activity using this material will still require either a waste permit for its application or registration for an appropriate exemption from permitting. If outlets cannot be found for the CLO, it may have to be disposed of to landfill. Alternatively, it can be dried and used as a fuel in energy recovery operations – however, it is likely to have a low calorific value.

Biogas
Where biogas is captured from the use of AD as the biological treatment component, the markets will be the same as those outlined in Section 2.1 above.

4.1.3 Form

The processing of mixed residual waste through MBT can be undertaken at a range of scales, but facilities are generally of a significant size due to economic factors. In their 2010 Waste Infrastructure report[64], the Environment Agency reported 19 permitted MBT facilities in England, with plants ranging from a permitted capacity of 50,000 tpa to 305,000 tpa. Larger facilities are currently in development in England. In Wales, there are three operational facilities, one of which is small-scale, and the other two are larger than 50,000tpa.

Typically, MBT facilities are generally of a significant size (the largest Welsh MBT facility, with a permitted capacity of c. 140,000tpa occupies a site of around 5Ha in area).

They may be located on sites across a number of buildings, they are ‘in-building’ facilities, as they require a waste reception area, a materials sorting facility and an organic treatment facility. Buildings which may house MBT facilities can be similar in appearance and characteristics to various process industries. The location of MBT facilities on land previously used for general industrial activities or allocated in development plans for such (B2) uses should be considered.

MBT facilities are scalable, and the size of the facility will be directly linked to its throughput.

Where the MBT facility uses AD as its organic treatment step, the operator may require a grid connection in order to introduce biogas to the grid.

[63] CLO or digestate from mixed waste processing will not qualify for the appropriate British Standards (BSI PAS100 and BSI PAS110 respectively), nor will they meet with the associated Quality Protocols.
[64] See: http://www.environment-agency.gov.uk/research/library/data/134327.aspx

Table 4(a) – Requirements for MBTs

Requirements	Required	May be Required
Three phase electricity supply	√	
Local gas grid connection		√
Site for the development of a "power island"		
Sewer connection	√	
Water Supply	√	
Road Access	√	
Multi-modal transport links		√
Parking		√

4.1.4 Benefits

Table 4(b) – Benefits of MBT

Environmental	Economic	Societal
Depends upon the end use of the various outputs from the process[65].	Indications are that in 2013, energy recovery costs have now dropped below those of MBT as further capacity has been made available in the market.	Production of certain recyclate streams could be of benefit to local reprocessors
Environmental outcomes may be equivalent to the optimised recovery of energy directly from residual wastes where MBT is undertaken to produce recyclates and an RDF for use directly in an energy intensive process (ie. A cement kiln) or for substitution of a fossil fuel in an energy generation facility.	A medium sized MBT facility (e.g. 150,000 t/yr throughput) treating source segregated food wastes might be expected to employ 40-50 full time employees, with additional resource input required on a part time / as required basis (e.g. plant maintenance).	Reduce waste transportation distances.
Where MBT was undertaken to produce recyclates and a		Public engagement - facilities are often designed to include a

[65] This conclusion was drawn following lifecycle assessments conducted in 2006 by the Environment Agency, using the WRATE LCA tool. This considered the relative merits of residual waste treatment technologies in support of the First Review of the Wales Regional Waste Plans on behalf of the Wales Regional Waste Planning Groups. Further assessment of residual waste management technologies was undertaken on behalf of the Welsh Government in 2010 in support of the First Review of the Wales Waste Strategy 'Towards Zero Waste', using the WRATE lifecycle assessment tool. Further detail can be found at www.walesregionalwasteplans.gov.uk . There are three plans, one for each region.

biostabilised residue for disposal to land or use in contaminated land remediation, the environmental outcomes were much more modest, and the performance of the MBT facility was bettered by a number of alternative options for the management of residual wastes.		visitor's centre. The enables local groups to view the facility and learn more about how it operates.
		Provides vocational training opportunities for staff.

4.1.5 Impacts

The primary potential sources of emissions from MBT facilities are associated with:

- The reception and pre-treatment of wastes
- Emissions from mechanical sorting and separation
- Emissions from the biological treatment of the organic component of residual waste.

Table 4(c) – Planning Issues for MBTs

Planning Consideration	Explanation	Mitigation
Noise	• Mechanical processes in pre-treatment • Vehicle movements • Traffic noise on local road networks • Air extraction fans and ventilation systems	• Appropriate design, location and enclosure; • Advice should be sought from NRW in respect of potential noise impacts
Odour	• Decomposing waste	• Undertake the reception and pre-treatment of incoming wastes in a dedicated reception area, kept under negative pressure conditions and which mechanically vents extracted air to a suitable filter (ie. a biofilter or activated carbon filter) or similar odour and dust abatement device.

		• Advice on odour impacts should be sought from Natural Resources Wales
Litter	• Where waste contains plastics and paper	• Use of covers on vehicles • Processing undertaken indoors
Dust	• Residual waste composition	• Advice on dust should be sought from Natural Resources Wales
Air emissions/ Bioaerosols	• Biological processing	• Biofilters or thermal based emission systems
Road Access	• Suitable site layout/road configuration	

4.1.7 Further information

Fig 24– External photograph of an MBT facility

Figure 24 shows an external view of the Shanks MBT facility at Hespin Woods, Cumbria. This facility has a design throughput of around 75ktpa[66].

[66] http://www.waste-management-world.com/articles/2011/12/mechanical-biological-treatment-facility-opened-in-cumbria.html

Fig 25– Internal photograph of an MBT facility

Fig 25 shows an internal view of the New Earth Solutions MBT facility at Cotesbach, Leicestershire. This facility has a throughput of 50ktpa[67].

Fig 26 – Schematic diagram of an MBT facility

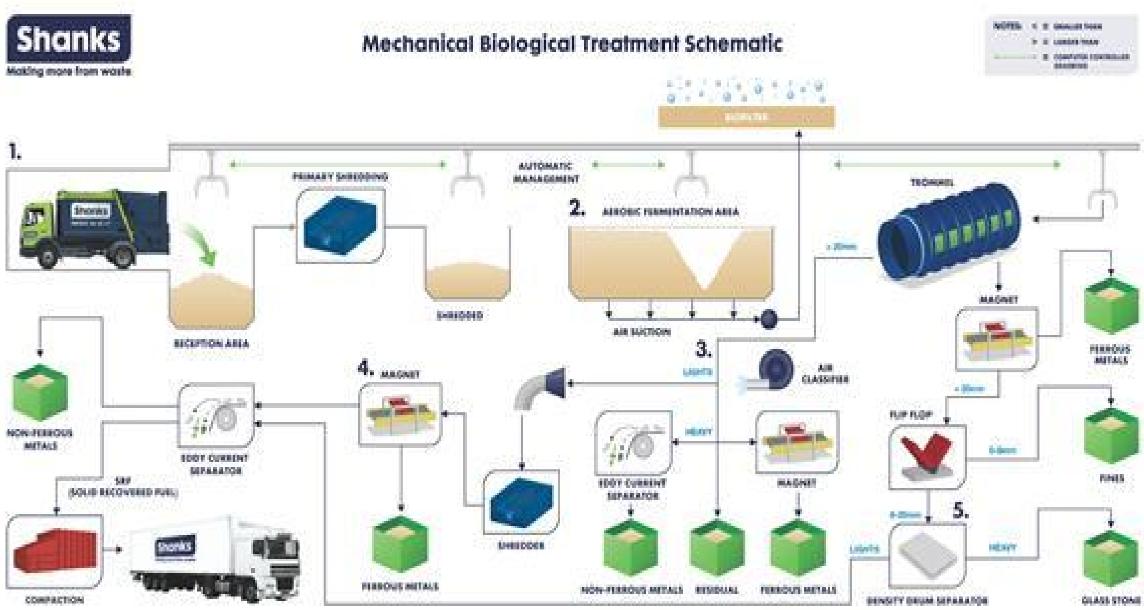

Fig 26 above is a schematic diagram showing the layout of the Shanks Hespin Wood MBT facility[68].

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[67] http://newearthsolutions.co.uk/wp-content/uploads/2011/08/Case-study-Cotesbach-email.pdf

4.2 Mechanical Heat Treatment Facility (MHT) including autoclave

4.2.1 Introduction

This refers to the pre-treatment, sorting and mechanical treatment using heat of residual municipal waste in a complex intermediate treatment process with a number of outputs. The purpose of MHT/Autoclave is to produce a number of outputs for further processing in associated or remote facilities.

Operations undertaken in MHT/Autoclave facilities include the:

- Reception of black bag wastes
- Thermal treatment of wastes through the use of one of the following:-
  - MHT – heating of the residual waste in an open vessel at atmospheric pressure using direct or indirect heating to sterilise the waste prior to processing.
  - Autoclave – heating of the residual waste in an open vessel at greater than atmospheric pressure to sterilise the waste prior to processing.
- Waste separation of the sterilised waste mass through the use of one or more of the following :-
  - Trommel and screens – to sort materials by size
  - Magnetic and eddy current separators – to remove ferrous and non-ferrous metals
  - Manual separation – to remove oversize materials, contaminants and plastic streams
  - Wet separators – to sort plastics and organics from inert materials
  - Air classification and ballistic separators – to sort light fractions (plastic and paper)Optical separators – to sort specific polymer streams
- The consignment of outputs to further uses. These can include :-
  - The provision of low to medium quality recyclate streams for reprocessors – this can include plastic, glass and metal streams (Both).The supply of a light fraction for use as a 'Refuse Derived Fuel' for energy recovery – this includes paper and plastic streams (MHT only)The supply of a dry' organic fraction for use as a 'Refuse Derived Fuel' – this is comprised of organic streams such as food waste, paper/card, wood etc. (MHT only)The supply of a wet fibre stream for use in brownfield land remediation (Autoclave only)The supply of inert or reject streams for disposal to land. (Both)

MHT/Autoclave plants, unlike MBT facilities, first treat the wastes using a thermal process, and then separate the components. They do not separate prior to

[68] http://www.shanks.co.uk/image-gallery/schematics

treatment[69]. Not all of the treatment options set out above will be found at any one MHT/Autoclave facility. Each must be considered in context.

MHT/Autoclave are generally operated by commercial operators, and will be located on sites with B2 or sui generis permissions, either as stand-alone facilities, or ancillary to other waste management operations (ie. in connection with the operation of associated energy recovery facilities, or landfill disposal sites.)

4.2.2 Function

MHT/Autoclave facilities primarily accept residual wastes[70]. Waste is received in a waste reception area, located inside a building. The waste will be prepared to remove contrary objects which may cause problems with processing equipment downstream[71]. The waste will then be loaded onto a conveyor, and will first pass through a bag splitter in order to split refuse sacks and present the contents for treatment. The contents may be size reduced, through the use of shredders or hammer mills etc., or may pass straight to a waste separation step. At this point, the waste stream will pass to the thermal treatment stage.

Mechanical Heat Treatment

In a non-Autoclave MHT system, waste is dried using externally applied heat, usually in a rotating vessel, for example, an open ended drum along which heat is applied to the external surface, or alternatively through the centre of the drum. The waste fed to the drum may have been pre-shredded prior to its introduction. The general purpose of this form of MHT system is to dry the waste received and for much of the output to be used as a Refuse Derived Fuel. After heat treatment for a given residence time within the vessel the contents are removed for mechanical separation[72]. Non-Autoclave MHT systems are generally continuous feed systems.

Autoclave

In an autoclave MHT system, waste is heated in a sealed vessel using steam injection or indirect heating[73]. In both instances, the aim is to bring the waste within the vessel up to around 180^{o}C at a pressure of around 5-7 Bar. The vessel is rotated to mix the waste, which stays in the vessel for a given residence time. At the end of the treatment process, the vessel is purged of excess steam (even where steam is not directly injected, water content retained within the input waste flashes off and gives rise to steam inside the vessel), any condensate is drained off, and the vessel is decanted for mechanical separation.

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[69] Oversize wastes and contaminants will be removed.
[70] They accept wastes falling under Chapter 20 of the European Waste Catalogue (EWC). Chapter 20 wastes are 'Municipal wastes and similar commercial, industrial and institutional wastes including separately collected fractions'. The main waste stream accepted by MHT/Autoclave facilities are code 20 03 01 wastes – 'Mixed municipal wastes from civic amenity sites, commercial wastes, general factory waste, domestic waste, general commercial waste, general industrial wastes'.
[71] For example, bulky wastes such as mattresses and carpets may be manually removed from the incoming wastes.
[72] At temperatures >90oC and <180oC and at atmospheric pressure.
[73] For example, using steam to heat the walls of the vessel itself.

Autoclave MHT systems are batch feed systems, as they treat a given quantity of waste at a time in a sealed system. The use of two or more autoclaves in parallel allows for the continuous treatment of waste.

Mechanical separation
After heat treatment, the decanted contents from both MHT and Autoclave will generally pass over a series of trommels, to separate the waste fractions by size. Interlaced within the trommels will be magnetic and eddy current separators, to remove ferrous and non-ferrous metals, manual separation points or picking stations (to allow the removal of oversize materials, contaminants and plastic streams), air classifiers and ballistic separators (to separate light fractions).

Sorting may take place at several points within an MHT/Autoclave facility, with separated streams passed back through the process to 'polish' them where required. Once separated, these streams may pass through material-specific routes for further separation – for example, mixed plastic streams may pass through optical separators in order to sort by specific polymer.

Outputs from MHT
The exact configuration of an MHT facility is dependent on the nature of the incoming waste – and also upon what markets the operators seeks for the outputs. Non-Autoclave MHT facilities are commonly configured to produce a 'Refuse Derived Fuel' – and therefore the processing may be geared towards separating material that has a high calorific value from inert material, rather than for separating material for recycling. Where materials are separated for recycling, the issues are similar to those for MBT (see Section 4.1). The materials removed from MHT generally include glass, metals, plastic and a dried fibre or 'floc'[74]. The issues applying to 'Refuse Derived Fuel' are similar to those applying to RDF from MBT (See Section 4.1)

Outputs from Autoclave
The outputs are therefore a fibre or 'floc', glass, metals, plastics and a reject fraction (inert materials – stones, grit, broken glass etc.)

The fibre produced by Autoclave facilities has a high moisture content. When dried, it can be used as an RDF with a high organic content. Alternative uses for the fibre are to compost this material and use it as a 'Compost-Like Output', as per CLO from MBT (see, Section 4.1.2). The same legislative issues apply to the use of the fibre in this regard as to the use of CLO (see Section 4.1.2). There has also been market interest in using the fibre as a feedstock in AD plants, and also as a feedstock in the manufacture of ethanol from biocellulose. However, neither of these have yet been commercialised in the UK.

Separation Techniques
The separation techniques used at MHT and Autoclave facilities will be similar to those used at MBT facilities. While the recyclate is likely to be cleaner than

[74] This, along with certain plastics, are what comprises the content of the RDF.

materials extracted from an MBT process, there may be quality issues for reprocessors due to fibre / floc / other contrary materials being trapped within containers destined for recycling. In particular, hard plastics, such as plastic bottles tend to deform in these processes around loose material, presenting as hard nuggets containing a core of contamination.

There have been a number of operating MHT and MHT/Autoclave facilities taking residual municipal waste as a feedstock in the UK, primarily in England. Wales has had one example of an operating autoclave (the now closed Davies Bros facility at Tythegston, Bridgend) and one example of a proposed MHT facility with planning permission (the Orchid Environmental facility at Shotton).

4.2.3 Form

The processing of mixed residual waste through MHT/Autoclave can be undertaken at a range of scales, but facilities are generally of a significant size due to economic factors. Examples currently exist in the UK of plants ranging from 75,000 to 320,000ktpa. It is thought that a typical facility with a throughput of c. 100,000tpa would have a footprint of around 2Ha, and so the technology is reasonably compact. Estimated employment figures for a proposed site combining autoclaving and AD in West Yorkshire suggest a staff of around 70 to run the combined facility. Autoclave/MHT only facilities would be expected to employ fewer people than this. The exact number of employees depends on the number of people used on manual picking duties to an extent, as this tends to be a labour-intensive part of the process.

MHT/Autoclave facilities may be located on sites across a number of buildings – they are ‘in-building’ facilities, as they require a waste reception area, a thermal treatment process and a materials sorting facility. Buildings which may house MHT/Autoclave facilities can be similar in appearance and characteristics to various process industries. The location of MHT/Autoclave facilities on land previously used for general industrial activities or allocated in development plans for such (B2) uses should be considered.

MHT/Autoclave facilities will utilise negative pressure extraction for key areas, with access doors that can be closed and sealed to prevent the escape of odours. Air extracted from extracted areas (notably waste reception areas) will be extracted and passed to a biofilter unit. This is generally sited exterior to the building housing the MHT/Autoclave, and typically consists of a bed of organic material, such as compost mixed with bark to give structure, into which the extracted air is injected from beneath. The biofilter acts as a growth medium for bacteria, which metabolise odorous compounds in the extracted air (ie. Volatile organic compounds, hydrogen sulphide etc) and reduce the odour potential of extracted air. More complex options for the treatment of extracted air also exist[75].

MHT/Autoclave facilities are scalable, and the size of the facility will be directly linked to its throughput.

[75] For example, activated carbon packed columns, wet scrubbing columns.

Table 4(d) – Requirements for MHT

Requirements	Required	May be Required
Three phase electricity supply	√	
Local gas grid connection	√	
Sewer connection	√	
Impermeable surfacing	√	
Water Supply	√	
Road Access	√	
Multi-modal transport links		√

4.2.4 Benefits

Table 4(e) – Benefits of MHT

Environmental	Economic	Societal
Impacts depend upon the end use of the various outputs from the process[76].	Indications are that in 2013, energy recovery costs have dropped below those of MBT.	The production of certain recyclate streams could be of benefit to local reprocessors
Landfill diversion	A medium sized MHT/Autoclave facility (e.g. 150,000 t/yr throughput) might be expected to employ 70 full time employees.	The presence of a local MBT facility will cut down on transport of wastes to more distant facilities.
Lifecycle assessment demonstrates that MHT/Autoclave and MBT to RDF scenarios have a similar performance, showing an overall climate change benefit.	Provision of vocational training for staff.	Public engagement - many new facilities are built with a visitors centre to enable local groups to view the facility and learn more about how it operates
Impacts associated with autoclave are greater than for MBT, due to the energy inputs required to drive the process and to dry the 'floc' so that it is suitable for use in energy recovery applications.		Training and upskilling opportunities for employees

[76] This conclusion was drawn following lifecycle assessments conducted in 2006 by the Environment Agency, using the WRATE LCA tool. This considered the relative merits of residual waste treatment technologies in support of the First Review of the Wales Regional Waste Plans on behalf of the Wales Regional Waste Planning Groups. The use of Autoclaves was not fully modelled in the first assessment, due to a lack of representative data. Further assessment of residual waste management technologies was undertaken on behalf of the Welsh Government in 2010 in support of the First Review of the Wales Waste Strategy 'Towards Zero Waste', using the WRATE lifecycle assessment tool. Further detail can be found at www.walesregionalwasteplans.gov.uk. There are three plans, one for each region.

4.2.5 Impacts

The primary potential sources of emissions from MHT/Autoclave facilities are associated with:

- The reception and pre-treatment of wastes
- Emissions from mechanical sorting and separation
- Emissions from the thermal treatment of wastes

Table 4(e) – Planning Issues for MHT

Planning Consideration	Explanation	Mitigation
Noise	• Mechanical processes of reception, pre-treatment	• Appropriate design, location and enclosure; • Seek advice from NRW on impacts
Odour	• Organic wastes are a component of residual waste and may give rise to odour, particularly when decomposition has begun;	• Undertake reception and pre-treatment processes in a dedicated reception area, kept under negative pressure and which mechanically vents extracted air to a filter; • Seek advice from NRW on impacts.
Litter	• Presence of waste paper and plastics may potentially result in the release of litter	• Enclosure of operations within buildings • Ensure all waste vehicles are sheeted • Perimeter fencing • Landscaped areas to trap litter before it leaves the site.
Dust	• Component of residual waste	• Undertake reception and pre-treatment processes in a dedicated reception area, kept under negative pressure and which mechanically vents extracted air to a filter; • Seek advice from NRW on impacts.
Air quality	• Combustion of fuel to raise steam	• Appropriate abatement option e.g., biofilter / thermal oxidiser • Sensitive routing/siting to reduce traffic related air quality effects • Seek advice from NRW on impacts.
Traffic	• HGVs entering and egressing site causing impacts on roads and amenity of local residents	• Routing of vehicles away from sensitive areas • Limiting operating hours • Use of s.106 agreements

4.2.6 Other information

Planners are advised to note the DEFRA publication *'Mechanical Heat Treatment of Municipal Solid Waste'*, published in 2013[77].

4.7 Clinical waste treatment facilities

4.7.1 Introduction

Clinical waste treatment facilities treat waste arising from the medical, dental, veterinary and similar practices. Clinical waste is defined in the Controlled Waste Regulations 1992 as:

> *(a) any waste which consists wholly or partly of human or animal tissue, blood or other body fluids, excretions, drugs or other pharmaceutical products, swabs or dressings, or syringes, needles or other sharp instruments, being waste which unless rendered safe may prove hazardous to any person coming into contact with it; and*
> *(b) any other waste arising from medical, nursing, dental, veterinary, pharmaceutical or similar practice, investigation, treatment, care, teaching or research, or the collection of blood for transfusion, being waste which may cause infection to any person coming into contact with it*.

4.7.2 Function

Clinical waste segregation separates wastes requiring incineration from those that can be treated and those that should be landfilled. In the UK, infectious waste, including healthcare waste/clinical waste, from any source, is prohibited from being sent to landfill unless it has undergone a process of pre-treatment commonly referred to as "rendering safe". The requirements of rendering safe depend on the type of waste treated and on the nature of the contaminants present in the waste. Once rendered safe clinical waste should no longer pose a risk of infection.

There a number of different treatments for clinical waste. These include:

- High temperature controlled combustion
- Gasification and pyrolysis
- Steam sterilisation (often under pressure in an autoclave)
- Microwaving

High temperature controlled combustion

This is the most common treatment. All types of clinical waste can be incinerated. With this treatment the waste will be received into a reception area where it will be fed onto a conveyor (or directly introduced via a hopper), and then conveyed to the incinerator.

[77] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/221040/pb13891-heat-treatment-waste.pdf

Clinical waste is destroyed at temperatures in excess of 1100°C. The gases produced by the process undergo a treatment and scrubbing process prior to the discharge of cleaned gases to atmosphere via a stack. Energy can be recovered from the incineration of clinical waste, although where this is the case it is generally just used within the process (ie. to provide hot water to wash collection receptacles prior to return etc.)

Disinfection

Alternative treatment includes treatment by heat, chemicals and irradiation in order to render clinical waste safe by ensuring that pathogenic agents are eradicated. At present, this mostly relates to treating infectious clinical waste to render it safe by disinfecting it.

Chemical treatment utilises disinfectants. The purpose of disinfection is to render infectious waste safe. The primary consideration should be to prevent releases of harmful substances to the aquatic environment, whether releases are direct or via a sewage treatment works. Chemical disinfection is used commonly in health facilities to kill micro-organisms on medical equipment and is one method for treating health-care wastes. Chemicals are added to the wastes to kill or inhibit pathogens. This type of treatment is suitable mainly for treating liquid infectious wastes.

Solid medical wastes can be chemically disinfected, but they must be shredded first. This practice poses a number of safety problems and the wastes are only disinfected on the surface.

Thermal Treatment

Thermal treatment uses heat to inactivate pathogenic micro-organisms. Heat treatment can be broadly divided into two groups.

1) 'Moist' heat processes that generate steam, including autoclaves, steam augers, and some microwaves
2) 'Dry' heat processes utilising electricity, hot-oil and some microwaves, which rely partially on moisture already within the waste.

Autoclave Treatment

Autoclaving is a thermal process where waste is subjected to pressurized saturated steam for a sufficient length of time to be disinfected (60 minutes at 121°C and >1 bar). Autoclaving is environmentally safe but is not always suitable for treating wastes.

Once wastes have been processed in an autoclave, they are no longer infectious materials and can be incinerated (or used as RDF). Autoclaving is often used for pre-treating highly infectious waste before it is transported outside the premises in which it arose.

Other Clinical waste treatment

Emerging technologies, for example hot alkaline hydrolysis, may have scope to treat other hazardous components of clinical waste, beyond just disinfection. These are not considered within the scope of this guidance.

4.7.3 Form

Clinical waste treatment facilities are generally fairly small scale. The UK has two larger scale hazardous waste incinerators which accept healthcare wastes as a feedstock (facilities at Ellesmere Port, Merseyside, and Fawley, Hampshire), but most clinical waste treatment facilities are smaller than this, with throughputs of a few thousand tonnes per annum. They are generally located in standard small industrial units, and can be co-located with other industry on sites with B2 or sui generis use classes.

Sites will need to be secure, with impermeable surfacing and may require sealed drainage in case of spillages.

Table 4(f) – Requirements for Clinical Waste Treatment facility

Requirements	Required	May be Required
Three phase electricity supply		√
Local gas grid connection	√	
Sewer connection	√	
Impermeable surfacing with sealed drainage	√	
Water Supply	√	
Road Access	√	

4.7.4 Benefits

Table 4(g) – Benefits of Clinical Waste Treatment Facilities

Environmental	Economic	Societal
May permit diversion of waste from landfill dependent on treatment method used	A cost-effective means of managing healthcare wastes	
Permits safe disposal of sterilised wastes to landfill where required		

4.7.5 Impact

Table 4(h) – Planning Issues for Clinical Waste Treatment Facilities		
Planning Consideration	**Explanation**	**Mitigation**
Noise and vibration	•	• Appropriate design and location of facility • Where possible, operations conducted indoors • Hours of operation • NRW to advise on impacts
Odour	• Storage of clinical waste	• Storage in sealed containers
Spillages	• Release of fluids	• Impermeable surfaces with sealed drainage for areas where waste is loaded, unloaded and handled • Provision for disinfection and wash-down of surfaces and collection/disposal of wash-waters
Contaminated water/ groundwater	• Discharge to surface water drains	• Suitable containment of wash waters • Impermeable area/storage in a designated area of a secure building
Air emissions (Bioaerosols)	• Maceration of clinical waste may generate pathogens	• Appropriate use of high efficiency particulate air (HEPA) filters where required • Design of facility to ensure microbiological aerosol containment (particularly where a facility will undertake shredding)
Vermin and Pests	• Infestations caused by the waste material	• Clinical waste should be received in sealed containers • Designated and refrigerated area in a secure building/outside area for anatomical waste and animal carcasses

4.7.6 Other information

Planners should note Health Technical Memorandum 07-01: *'Safe management of healthcare waste'*[78].

[78] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/167976/HTM_07-01_Final.pdf

Chapter 5 Waste collection infrastructure

5.1 Bring banks

5.1.1 Introduction
Bring-banks allow for the separate collection of selected recyclable household wastes in fixed containers at unmanned sites.

5.1.2 Function
The materials collected at bring-banks are typically the main dry recyclates – paper, card, bottle glass, some plastic packaging and metal packaging (steel tins and aluminium or steel cans). Some bring-banks may also accept certain textiles (ie. clothes), cartons (ie. 'Tetrapak') and certain other niche materials (ie. books, footwear, spectacles etc.) which are of interest to third sector organisations.

Bring-banks are collection facilities. There is no sorting or bulking at these facilities. Full containers are collected and swapped for empty containers at given intervals. The materials collected at bring-banks are usually taken off-site for sorting and further bulking at other facilities prior to onward transport to reprocessors.

5.1.3 Form
Bring-banks are outdoor receptacles sited in dedicated areas, open to the general public for the deposit of selected recyclates. Bring-banks are typically sited in locations with road access, which may include temporary parking for users. Bring banks generally have a small footprint.

Bring-banks are sited typically on paved areas. Where this is the case there may be a connection to surface water drainage. They may also be sited in areas where there is artificial lighting to allow for use in the hours of darkness. They do not otherwise require connection to utilities.

5.1.4 Benefits

Table 5(a) Benefits of Bring Banks

Environmental	Economic	Societal
Increases volume of recyclates	Low cost collection method which supplements kerbside collection	Enhance the area where sited
Reduce littering	Local employment benefits	Reduce littering
Landfill diversion		

5.1.5 Impacts
Impacts arising from the use of bring-banks are generally restricted to local nuisance issues only.

Table 5(b) – Planning Issues for Bring Banks		
Planning Consideration	**Explanation**	**Mitigation**
Noise	• Noise from vehicles accessing and egressing the site; • Noise from filling containers • Noise from servicing by the operator	• Appropriate siting and design of containers • Acoustic barriers • Signage • Advice should be sought from environmental health staff in respect of the location of any new bring-banks
Odour	• Due to storage of unwashed recyclates	• Appropriate siting and design of containers; • Regular emptying
Litter	• Due to spillage of wastes brought to site by users	• Regular cleaning regime • Supply of litter bins at bring site
Vermin	• Unwashed food packaging may give rise to vermin	• Use of pest control measures as required

5.1.7 Further information

Fig 27 – A typical bring bank

Figure 27 above shows a typical bring bank, collecting a range of materials.

5.2 Civic Amenity (CA) Sites / Household Waste Recycling Centres (HWRC's).

5.2.1 Introduction

Local Authorities are required to provide CA sites for the deposit of waste by householders. This is established in the Environmental Protection Act, s.51 (1) b:

> *"It shall be the duty of each waste disposal authority to arrange for places to be provided at which persons resident in its area may deposit their household waste and for the disposal of waste so deposited".*

The position in Wales is complex, with a number of sites filling the Civic Amenity site function also permitted to take certain hazardous waste arisings, and some sites undertaking a degree of on-site transfer and treatment operations (ie. physical separation of mixed wastes etc.)

The terms 'House Waste Recycling Centre' (HWRC) and 'Civic Amenity Site' (CA Site) are interchangeable. The facilities considered are those permitted by Natural Resources Wales (NRW)[79]. These facilities handle a range of wastes arising from households. Some local authorities also operate CA sites, which take similar trade waste arisings.

The original purpose of the CA site was to provide a facility to take bulk waste arisings from local householders, and to act, in effect, as a transfer facility to consign these wastes to landfill. The site was a fixed facility that complemented the general kerbside and 'special' collections undertaken by the local authority. Greater legislative control on the operation of sites, coupled with the change to a recycling culture during the mid 1990's led to CA sites evolving into manned secure facilities with an increasing range of recycling options presented for the site users, and increasing controls on trade users. The current CA Sites / HWRC's allow for the user segregated deposit of recyclable materials and mixed municipal wastes in fixed containers at manned sites.

5.2.2 Function

CA sites accept a wide range of wastes, both for recycling or disposal. They commonly include bring-banks within their footprint, but also allow users to deposit materials which cannot be deposited in unmanned bring-banks for recycling. In addition to the main recyclates accepted in bring-banks, these sites commonly accept the following materials for recycling:

- Non-packaging scrap metal (ie. pipe work, structural scrap metal etc.)
- Construction and demolition wastes, including bricks, tiles, stones and concrete, plasterboard and wood
- Waste Electronic and Electrical Equipment (WEEE)
- Waste paint

[79] A13 – Household Waste Amenity Site; SR2008/12 Non-hazardous Household Waste Amenity Site; SR2008/13 Hazardous and non-hazardous Household Waste Amenity Site.

- Waste vehicle oil
- Vehicle batteries
- Household batteries
- Textiles
- Fluorescent light tubes
- Used vegetable oils
- Garden wastes

CA Sites also accept residual waste for disposal from household and commercial sources[80]. Both recyclates and residual waste are bulked at CA sites for onward shipment to reprocessors, either directly or via transfer stations (for materials).

CA sites may use equipment to compact waste (to optimise transport), either in the form of fixed compaction equipment fixed to skips or through the use of mobile plants for example, using a tracked excavator to compact waste in-situ. Apart from the use of compaction equipment, CA sites do not generally handle wastes – these are user segregated and deposited in the appropriate receptacle. Any sorting will be basic hand-sorting by operatives.

The outputs from CA sites are nominally sorted recyclate streams and residual loads. Some recyclate streams may go directly to a reprocessor, but commonly they will be taken to a transfer station for bulking. Residual loads are either taken directly to intermediate treatment facilities, energy recovery facilities or to deposit in landfill or via transfer stations.

The use of CA sites is seen to complement the collection of recyclates, residual wastes and bulky wastes at kerbside, and to offer recycling options for materials not normally collected at the kerbside, for example, waste vehicle oils, used vegetable oils, paints, construction and demolition wastes etc.

5.2.3 Form

CA sites / HWRC's are manned facilities, subject to control under the arrangements set out through permits (and exemptions for specified waste management activities) issued by the regulator (Natural Resources Wales) under the Environmental Permitting (England and Wales) Regulations 2010 (as amended)[81].

[80] The range of accepted wastes is detailed in the Environment Agency's Standard Rules Permit for CA Sites,, Table 2.2 'Waste Types and Quantities'. Available online at: https://publications.environment-agency.gov.uk/pdf/geho0512bwlv-e-e.pdf.

[81] Environmental Permitting (England and Wales) Regulations 2010, SI 2010 No.675. Amended by Environmental Permitting (England and Wales (Amendment) (No.2) Regulations 2013, SI 2013, No.766; Environmental Permitting (England and Wales (Amendment) Regulations 2013, SI 2013, No. 390; The Environmental Permitting (England and Wales) (Amendment) Regulations 2012, SI 2012 No. 630; The Environmental Permitting (England and Wales) (Amendment) (No.2) Regulations 2011, SI 2011 No.2933; The Environmental Permitting (England and Wales) (Amendment) Regulations 2011, SI 2011 No. 2043; The Environmental Permitting (England and Wales) (Amendment) (No. 2) Regulations 2010, SI 2010, No. 2172; The Environmental Permitting (England and Wales) (Amendment) Regulations 2010, SI 2010 No.676.

They are generally open-air facilities. Some may have covered areas for weather protection, although this is not common. They will require hard paved sites, which can be secured (these are permit requirements.)

There are currently 89 such facilities in Wales. CA sites / HWRC's can vary widely in their cost of development and implementation. They are scalable facilities, which are designed to meet a given throughput dependent on the size of the population served. At the time of writing, there are no Welsh CA sites with a throughput of greater than 25,000 tonnes per annum, and most have a throughput that is considerably lower than this.

These facilities need to be located on sites which:

- are hard paved
- can be secured
- are not prone to flooding
- have the potential for future expansion and re-distribution of containers to allow flexibility for enhanced collection of materials
- are capable of enabling the development of options for basic physical treatment (sorting, compaction, baling etc.) if this is needed.
- are located on sites where the impacts upon sensitive receptors are minimal.

Table 5(c) – Requirements for CA sites / HWRC's

Requirements	Required	May be Required
Three phase electricity supply		√
Sewer connection	√	
Water Supply	√	
Road Access	√	
Parking		√
Signage	√	
CCTV and Security Alarms		√
Ancillary buildings to house site staff	√	

5.2.4 Benefits

Environmental	Economic	Societal
Increases volume of recyclates	Low cost collection method which supplements kerbside collection	Enhance the area where sited
Reduce littering	Local employment benefits	Reduce littering and fly-tipping
Landfill diversion		Some CA sites allow re-use options to be

		developed, which can benefit local communities through offering the sale of second-hand goods.

5.2.5 Impacts

The impacts associated with the use of CA Sites / HWRCs' are potential nuisance impacts, and impacts associated with access and egress by vehicles.

Planning Consideration	Explanation	Mitigation
Noise	• Noise from vehicles accessing and egressing the site; • Noise from filling containers • Noise from servicing by the operator	• Appropriate siting and design of containers • Acoustic barriers • Signage • Advice should be sought from environmental health staff in respect of the location of any new CA Sites/HWRC
Odour	• Due to storage of unwashed recyclates	• Appropriate siting and design of containers • Regular emptying
Dust	• From filling of containers • From access and egress by road vehicles	• Controlled by appropriate siting • Good housekeeping, including road-sweeping if required
Vermin	• Unwashed food packaging may give rise to vermin	• Regular emptying of containers • Good pest control regime
Spillages and litter	• From filling of containers	• Signage • Good housekeeping • Use of bunding and interceptors

5.2.6 Alternatives to the use of CA sites / HWRC's

Alternatives exist for the use of CA sites / HWRC's. Bulky household residual wastes can be collected at the kerbside by local authorities by special arrangement. Some recyclate streams can be deposited at bring-banks, or collected at the kerbside. Private sector companies may collect other streams through skip collections as arranged. However, the CA site/HWRC represents the most convenient and lowest-cost option for householders for the deposit of occasional wastes, and complements existing kerbside collection arrangements.

5.2.7 Further information

Fig 28 – A typical HWRC

Fig 28 above shows a typical HWRC facility (Briton Ferry, Neath Port Talbot CBC). Note the traffic management system (one-way traffic flows through the site, with spaces to park for unloading) and the range of segregated collection containers beyond the public car parking areas. The buildings in the middle house the site staff and site operations.

Fig 29 – A typical HWRC

Figure 29 above shows a smaller HWRC (located in Merthyr). The container at the front of the photograph is dedicated to small household WEEE, with a range of containers for other materials in the background beyond.

5.3 Household, Commercial and Industrial (HCI) Waste Transfer Stations

5.3.1 Introduction

HCI Waste Transfer Stations service the collection of a wide range of hazardous, non-hazardous and inert materials from all sectors (dependent on facility type) as an intermediate waste management facility[82]. Some HCI Waste Transfer Stations also undertake treatment activities. Prior to their transfer to onward reuse/recycling/recovery or disposal operations, operations undertaken in these installations may include the:

- reception
- storage
- manual sorting
- separation
- screening
- shredding
- crushing
- compaction
- bulking, baling and repackaging of wastes

They are operated by commercial operators, and will generally be sited on sites with B2 or sui generis permissions, either as stand-alone facilities, or ancillary to other waste management operations.

5.3.2 Function

The waste streams accepted by HCI transfer stations vary, with some accepting up to 200 separate waste types (as defined by the European Waste Catalogue code).

HCI transfer stations can be (depending on whether or not they have a permit which allows the treatment of waste as well as its transfer) permitted to store, repackage, manually sort, separate, screen, shred, crush, compact, bulk, bale or repackage these wastes prior to onward transfer to other waste management facilities (for further bulking, treatment, recovery or disposal), or reprocessors (for reuse/recycling or recovery.) Operations undertaken at individual HCI transfer stations will depend on the activities allowed under the terms of the environmental permit. HCI transfer stations can move from transfer to treatment activities (and hence seek repermitting), and have done so historically due to economic conditions.

[82] http://www.environment-agency.gov.uk/business/topics/permitting/118404.aspx#Keepingtransfer_of_waste details the different permitted HCI waste transfer operations.

HCI transfer stations use manual techniques to store, sort and bulk waste into discrete streams for onward management, coupled with the use of plant and equipment for the separation, screening, shredding, crushing, compaction and baling of wastes.

Wastes sorted and bulked at HCI transfer stations will be consigned on to a range of different end uses. Some materials may be used directly as product in various applications if they meet the relevant 'end of waste' criteria[83].Other streams may go for further sorting prior to processing (wood, glass, plastic, metal, paper/card, green waste etc.), may be utilised on 'exempt sites' (ie. stone used in construction), or may be sent for recovery including energy recovery (ie. wood to energy from waste facilities as a feedstock) or sent for disposal in landfill.

5.3.3 Form

HCI transfer activities are generally undertaken on open facilities, although some in-building storage and sorting of materials may take place. 'Standard rules' permits allow for the transfer and sorting of specified wastes at open-air facilities, with certain other activities requiring the use of on-site buildings.

Standard Rules Permits have specific restrictions on the location of HCI transfer stations. They are not permitted to operate within 200 metres of a 'European Site' or SSSI, nor within 50 metres of a well, spring or borehole used for the supply of water for human consumption.

Simple HCI transfer activities may be undertaken on areas of hard standing. However, for specified wastes, the use of impermeable surfaces with a sealed drainage system for the storage, bulking, sorting and transfer of these waste types is required. Such facilities may therefore require the provision of areas of impermeable pavement with integral drainage, but not necessarily underlying the whole site. For those sites with asbestos storage capability, further controls will be utilised – for example, the provision of secure storage for lockable containers.

HCI transfer stations can vary in size dependent on throughput – this category of facility ranges between small yards used by sole operators to large sites handling dozens of skip movements a day. Most facilities will typically be <1 Ha in size, although facilities can exceed this.

These facilities do not necessarily require electricity or gas grid connections, although most will have access to mains water and connection to foul sewer (at least for staff amenities), coupled with the sealed drainage arrangements outlined above. HCI waste transfer stations are generally served by road transport rather than rail or intermodal transport options, although these may be applicable for larger facilities.

[83] Article 6, Directive 2008/98/EC on waste and repealing certain directives OJ 2008 L312/3.

5.3.4 Benefits

Environmental	Economic	Societal
Increases volume of recyclates	Low cost collection method which supplements kerbside collection	Enhance the area where sited
Reduce littering	Local employment benefits	Reduce littering
Landfill diversion	Reduce costs to waste producers	
	Reduce costs to waste carriers	

5.3.5 Impacts

Planning Consideration	Explanation	Mitigation
Noise	• Noise from vehicles accessing and egressing the site; • Noise from filling containers • Noise from servicing by the operator	• Appropriate siting and design of containers • Acoustic barriers • Signage • Hours of operation • Advice should be sought from environmental health staff in respect of the location of any new CA Sites/HWRC
Odour	• Receipt of potentially odorous waste types	• Appropriate siting • Regular servicing
Litter and spillages	• Spillage of materials during transfer operations	• Good housekeeping • Litter fences on exposed sites • Bunding and interceptors
Dust	• Access/egress by road vehicles • Emptying of containers • Screening and sorting	• Appropriate siting • Good housekeeping (site cleaning including mechanised washing and sweeping equipment)
Vermin	• Receipt of potentially odorous waste types	• Frequent emptying of containers • Pest control measures

5.3.6 Alternatives to the use of HCI Transfer Stations

Alternatives exist to the use of HCI waste transfer stations. Increasingly, operators are seeking to utilise construction, excavation and demolition wastes on the site of production under the terms of appropriate exemptions (ie. as infill for construction sites). Operators can also send material directly from the site of production to recycling, recovery or disposal options where identified. However, HCI waste transfer stations have a niche within the waste management industry – by separating out materials into discrete streams, they are able to offer cost-effective options for users.

5.3.7 Further information

Figure 30 – a typical HCI transfer station (Greater Manchester)[84]

[84] See: http://acrow.aplant.com/wp-content/uploads/sites/2/2013/03/Manchester-Waste-Transfer-Station-complete.jpg.

5.4 Hazardous Waste Transfer Stations[85]

5.4.1 Introduction

Hazardous waste transfer stations serve to manage the movement of hazardous wastes to onward options for reprocessing and disposal[86].These facilities bulk up small consignments of similar hazardous wastes before consigning the larger loads to reprocessors or disposal options. Clinical waste transfer stations are similar, but accept wastes from the Healthcare Waste Sector only.

Operations undertaken at these installations may include:

- reception
- storage
- repackaging
- shredding (for clinical wastes)
- chemical disinfection (for clinical wastes)
- thermal disinfection (for clinical wastes)
- bulking and repackaging

These wastes will then be transferred to onward reuse/recycling/recovery or disposal operations.
It should be noted that 'Standard Rules Permits' exist only for certain clinical and healthcare waste transfer operations. Other hazardous waste transfer operations require 'bespoke' permits[87].

Hazardous waste transfer stations are operated by commercial operators, and will generally be sited on sites with B2 or sui generis permissions. These can be either stand-alone facilities, or ancillary to other waste management operations (ie. in connection with the operation of landfill sites, for example.)

5.4.2 Function

Hazardous waste transfer stations can accept a wide range of waste types. They serve to manage the flow of these wastes more effectively, and reduce overall reliance upon disposal options.

The collection of hazardous wastes in Wales takes two main forms. A small number of large producers consign significant loads directly to hazardous waste treatment facilities or for recovery or disposal, accounting for the majority of the tonnage handled in Wales. However, the vast majority of hazardous waste

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[85] Clinical waste facilities are discussed below.

[86] Waste will be categorised as hazardous where it has any of the properties listed under Annex III of Directive 2008/98/EC on waste. These properties include: explosive, flammable, toxic, carcinogenic, infectious and corrosive. Clinical waste is defined under the Controlled Waste Regulations 1992, SI 1992 No. 588 as:

> (a) any waste which consists wholly or partly of human or animal tissue, blood or other body fluids, excretions, drugs or other pharmaceutical products, swabs or dressings, or syringes, needles or other sharp instruments, being waste which unless rendered safe may prove hazardous to any person coming into contact with it; and
> (b)any other waste arising from medical, nursing, dental, veterinary, pharmaceutical or similar practice, investigation, treatment, care, teaching or research, or the collection of blood for transfusion, being waste which may cause infection to any person coming into contact with it.

[87] See: http://www.environment-agency.gov.uk/business/topics/permitting/118404.aspx#Keepingtransfer_of_waste.

consignments involve the collection of small loads and their transfer to and from hazardous waste transfer facilities in the first instance.

Some Clinical Waste Transfer Stations include treatment options such as autoclaving (thermal treatment) or sterilisation through the application of disinfecting agents (chlorination or ozonation) to facilitate the onward management of wastes, or are directly associated with disposal options (ie. they operate their own incinerators.) Outputs from hazardous waste transfer stations are bulked consignments of wastes which have been sorted into waste type, but which will still remain hazardous. However, treated clinical wastes may no longer be classed as hazardous but 'difficult' following treatment.

Subsequent destinations for these materials are dependent on material type. Some hazardous wastes may be consigned from transfer stations directly for energy recovery or disposal by incineration or to landfill. Other wastes may be consigned to intermediate treatment options or to recycling options. Direct consignment to energy recovery or disposal by incineration or to landfill are alternatives to Hazardous Waste Transfer Stations for certain material streams.

5.4.3 Form

Hazardous Waste Transfer Stations require secure facilities including dedicated buildings (for waste transfer/treatment operations) and impermeable paving throughout with integral sealed drainage and bunded areas where appropriate. They need to be large enough to allow for the segregation of incompatible waste types in dedicated areas, although can still have a compact footprint dependent on throughput[88].

These facilities will require incoming electricity grid access, a sewer connection and a water supply. They may require access to the local gas grid. They will generally need external and internal lighting. They will require good road access. The relatively small tonnages of hazardous waste consigned within Wales will mean that sites with rail access are uncommon.

5.4.4 Benefits

Hazardous / Clinical Waste Transfer facilities serve a vital role in the bulking up and repackaging of loads in order that treatment options are undertaken in an economically viable fashion, either associated with the transfer facility, or at remote treatment facilities. They reduce costs to waste producers and carriers. They do not offer significant opportunities for employment, with only a few members of staff generally working at such facilities. However, there is a need for skilled technical staff to operate these sites.

5.4.5 Impacts

The impacts associated with the use of these facilities are potential nuisance impacts (noise, odour, litter, dust, spillages, vermin) and impacts associated with access and egress by vehicles (noise, congestion.)

[88] Examples exist in Wales of hazardous and clinical waste transfer operations with a footprint of less than <1 Ha.

5.4.6 Further information

Figure 31 – a typical hazardous waste transfer station

Figure 31 above shows a typical hazardous waste transfer station[89]. Note the bulking and palletising of grouped wastes prior to onward dispatch.

5.5 Inert Waste Transfer Stations (including treatment)

5.5.1 Introduction

Inert waste transfer stations service the collection of inert wastes only (primarily from construction and/or demolition activities) as an intermediate waste management facility[90]. Operations undertaken in these installations include the:

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[89] http://www.csg.co.uk/transfer_station.php

[90] Inert waste is defined in Article 2(e) of Directive 1999/31/EC on landfill as: waste that does not undergo any significant physical, chemical or biological transformations. Inert waste will not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm human health. The total leachability and pollutant content of the waste and the eco-

- reception
- sorting and
- bulking
- crushing (for aggregate)

of inert wastes prior to their transfer to onward recycling/recovery or disposal operations.

They are operated by commercial operators, and will generally be sited on sites with B2 or sui generis permissions, either as stand-alone facilities, or ancillary to other waste management operations (ie. in connection with the operation of landfill sites).

5.5.2 Function

Inert waste transfer stations are used to manage a restricted range of materials[91]. Activities are generally undertaken on open facilities, although some in-building storage and sorting of materials may take place. Inert transfer stations use manual techniques to store, sort and bulk waste into discrete streams for onward management.

Wastes sorted and bulked at inert transfer stations will be consigned on to a range of different end uses. Some materials may be used directly as product in building applications if they meet the relevant ‘end of waste’ criteria.

Other streams may go for further sorting prior to processing (wood, glass, plastic etc.), may be utilised on ‘exempt sites’ (ie. stone used in construction), or may be sent for recovery including energy recovery (ie. wood to energy from waste facilities as a feedstock) or sent for disposal in landfill.

5.5.3 Form

Inert waste transfer stations are usually open-air facilities, although open metal-framed buildings with internal bays may be used to provide protection from the weather for staff engaged on sorting activities. These facilities are not generally required to have an impermeable pavement underlying the whole site. They can vary in size dependent on throughput. This category of facility ranges between small yards used by sole operators to large sites handling dozens of skip movements a day. Small facilities (ie. Handling less than 5,000 tonnes per annum) will typically be <1 Ha in size.

Inert waste transfer stations are generally served by road transport rather than rail or intermodal transport options, although these may be applicable for larger facilities. These facilities do not necessarily require electricity or gas grid

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toxicity of the leachate must be insignificant and in particular not endanger the quality of surface water and/or groundwater.

[91] The ten discrete waste streams that these facilities are permitted to handle, as defined by the European Waste Catalogue code entry, are outlined in the Environment Agency’s Standard Rules Permit for Inert Waste Transfer Stations with a throughput of less than 75ktpa. See: http://publications.environment-agency.gov.uk/PDF/GEHO0512BWJI-E-E.pdf.

connections, although most will have access to mains water and connection to foul sewer (at least for staff amenities.)

5.5.4 Benefits

Inert and excavation waste transfer stations are of significant importance to the construction industry and also to the householder. They serve to manage the flow of inert wastes more effectively, and reduce overall reliance upon landfill – as increasingly the capture of recyclable materials takes place at these facilities. Sited sympathetically, they can enhance the area in which they are sited and reduce costs to waste producers and carriers by providing alternatives for targeted materials to deposit to land.

5.5.5 Impacts

Planning Consideration	Explanation	Mitigation
Noise	• Noise from vehicles accessing and egressing the site; • Noise from sorting and transfer operations	• Appropriate siting and design of containers • Acoustic barriers • Waste reception arrangements • Advice should be sought from environmental health staff in respect of the location of any new CA Sites/HWRC • Hours of operation
Litter and spillages	• Incidental litter within inert wastes (ie. plastic film)	• Good housekeeping
Dust	• Vehicle movements, waste handling and crushing activities (where applicable)	• Undertake work within building • Damping down the site • Using wheel wash facilities • Water mist on conveyor systems • Good housekeeping

5.5.6 Further information

Figure 32– a typical inert waste transfer station

Figure 32 above is a photograph of an inert waste transfer station in Bynea, Llanelli[92].

[92] http://www.skipsolutions.co.uk/assets/images/gallery/DSCF1184.jpg.

Glossary

Term	Definition
Air Classifier	Materials are sorted in a chamber using a column of rising air. The air drag on the objects supplies an upward force which counteracts the force of gravity and lifts the material to be sorted up into the air. The objects in the moving air column are sorted vertically by size and shape.
Approved Authorised Treatment Facility	A waste treatment site that has an environmental permit or registered exemption to undertake the treatment of certain waste material.
Baling	The process of compacting waste materials for onward transport to reprocessors. Baling reduces the volume and floor space needed for the material, improves storage and reduces the costs of transportation.
Bin Washing Machine	An industrial machine requiring water and power which cleans and sterilises waste storage containers.
Bioaerosols	Aerosols made up of bacteria and fungal spores produced in the breakdown of organic material. They become airborne as a result of evaporation or turbulence.
Biofilter	A method of odour treatment, using moist organic materials to adsorb and biologically degrade an extracted air-stream containing odorous compounds. Cooled and humidified process air is typically injected through a grid of perforated pipes into a bed of filtration media.
Biogas	Produced from organic wastes and comprises a mixture of methane and carbon dioxide with other trace gases. Can be used to generate heat and power, used as a transport fuel or injected into the gas distribution network.
Bulking	Storing and compacting waste material in sufficient quantities to make transportation, recovery and transportation efficient and cost effective.
Calorific Value	The calorific value of a fuel is the heat available from that fuel when it is burned. This is expressed as heat units per unit of fuel weight or volume (ie as MJ/Kg.)
Char	Solid residue high in carbon content left following waste treatment through the thermal treatment of pyrolysis
Compaction	The process of compressing waste material to reduce its volume and size. This reduces the floor/storage area required for the material prior to onward processing.
Crushing	The size reduction of waste materials such as glass, wood and construction and demolition materials such as bricks.
Depackaging	A process which allows waste to be separated from packaging, for example packaged food products, to allow

	separate processing of the packaging and its contents.
Dewater	The removal of water from solid material or soil by wet classification or a similar solid-liquid separation processes.
Digestate	Nutrient-rich material produced by anaerobic digestion, comprised of undigested solids and a liquid fraction that can be used for agriculture and horticultural applications.
Exothermic	A reaction that releases energy.
Flue gas	The gas entering the atmosphere from a flue, which is a pipe for conveying the products of a combustion reaction.
Incinerator Bottom Ash (IBA)	The ash left on the combustion grate when waste is burned in an incinerator. It is sorted to remove metals and conditioned prior to use as a secondary aggregate, or is disposed of to landfill. IBA arisings typically represent 18-25% of the input tonnage to a municipal solid waste incinerator, depending on waste composition.
Maturation	A biological process to aerobically degrade residual organic content in fresh composts and solid anaerobic digestates to produce a more stable output.
Mesophilic	Operated at an ambient temperature of around 35-40^{o}C
Mixed Municipal Waste	Mixed municipal waste or residual municipal waste includes those mixed wastes collected by third parties from commercial and industrial sectors as well as from private households.
Municipal Solid Waste Incinerator (MSWI)	A facility where residual municipal waste is used as a fuel in an energy recovery process, being combusted in an excess air environment to generate heat, used to raise steam to drive steam turbines for the generation of electricity. Waste heat may also be captured at MSWI facilities to provide heat to domestic, commercial or industrial consumers through the use of district heating networks.
Overband Magnet	Operates by material on the conveyor passing underneath the magnet. Ferrous metal is attracted to the surface of the magnet. The overband magnet is a continuously moving belt which wipes its surface clean of the ferrous metal.
Pre-treatment	Includes sorting to change the characteristics of waste to reduce waste volume including hazardous returns, facilitate the handling and enhance its recovery.
Reception Building	The area of a waste facility where certain waste is accepted, sorted and pre-processed.
Residual Municipal Waste	Waste remaining after recyclable or compostable material has been removed from the waste stream.
Screening	Used for the separation of diverse waste fractions. This can be achieved using trommel screens, disc screens or screening drums, depending upon the type of material.
Separation	The process of sorting different waste materials into their

	material types.
Shredding	Used to size reduce waste materials. There are different types of shredder including the cross-flow shredder, which uses a system of beating the waste until it breaks down into smaller parts and the single-shaft shredder, which employs the more traditional blade system to cut waste particles down. Shredding breaks down the waste into smaller parts for sorting for recycling and recovery.
Silo	Container for holding material.
Syngas	Composed of hydrogen and carbon monoxide
Thermophilic	Operated at an elevated temperature of around 55 ^{o}C
Trommel	Material is fed into the drum the rotation lifts it up and is aerated as it falls back down. This action is repeated with each rotation along the drum. The finer material passes through the screen openings while the larger materials tumble towards the exit at the rear of the drum.
Wobbe Index	An indicator used to express the heating characteristics of a combustible gas.

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