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Energy from waste

A guide to the debate

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Overview

The purpose of this guide is to provide a starting point for discussions about the role energy from waste might have in managing waste. This role will always be dependent on specific circumstances therefore this guide does not attempt to give all the answers. However, it does highlight questions that should be asked, options that are available, and the process for making decisions and influencing them.

The debate around energy from waste is important to a wide range of people with varying levels of interest and knowledge. We have tried to make this guide as relevant to all as possible, addressing the most commonly discussed issues and the rationale underpinning them. However, with an issue as complex as waste, this has inevitably led to some areas requiring discussion in some technical detail which may not be of interest to all readers. This overview therefore highlights the key messages coming from the guide with the main text providing the more in-depth explanations and evidence with hyperlinks for further information.

Changes in the 2014 edition

This revised 2014 version of the guide includes an additional chapter (Chapter 5) which considers the future policy direction for energy from waste. This chapter does not set out any new policy but identifies underlying principles that are likely to continue as key considerations for both government and the sector in the future.

Chapter 1 - Introduction

Energy from waste is about taking waste and turning it into a useable form of energy. This can include electricity, heat and transport fuels (e.g. diesel). This can be done in a range of ways. Incineration is the most well known.

Mixed residual waste – a partially renewable energy source

The guide is mostly concerned with energy from residual waste. This is the waste that is left over when all the recycling possible has been done. This generally means the environmental or economic costs of further separating and cleaning the waste are bigger than any potential benefit of doing so.

When we talk about residual waste we usually mean waste that is a mixture of different things. Part of this residual waste will come from things made from oil like plastics, and part from things that were recently[1] growing and are biodegradable (i.e. break down in landfill) – e.g. food, paper, wood etc.

Only the energy generated from the recently grown materials in the mixture is considered renewable. Energy from residual waste is therefore a partially renewable energy source, sometimes referred to as a low carbon energy source.

The changing nature of energy from waste in the UK

Energy from waste has a poor historical image in the UK. We have been very dependent on landfill and many of the early incinerators were disposal-only plants, which simply burned waste to reduce its volume. This historical image is persistent but outdated. The introduction of landfill diversion targets in the mid 1990s helped drive a new generation of energy from waste plants, designed to meet new strict emissions standards, and provide valuable low carbon energy.

In future we are aiming to prevent, reuse and recycle more of our waste, so the amount of residual waste should go down. However, energy from waste will remain important.

To maintain the energy output from less residual waste resource we will need to

- divert more of the residual waste that does still exist away from landfill and capture the renewable energy
- continue the drive towards better, higher-efficiency energy from waste solutions.

Chapter 2 - Context

The waste hierarchy

In an ideal world all waste would be prevented. However, in reality, for a range of social, economic and practical reasons, this does not happen. Where waste does exist it is usually best to reuse it if possible, and if not, to recycle it. What can't be recycled, the residual waste, could either go to energy recovery or as a last resort, landfill. This general order of preference is known as the waste hierarchy

- prevention
- reuse
- recycling
- recovery
- disposal

The waste hierarchy itself is not inflexible. Where a clearly a better environmental outcome can be shown, it is possible to depart from the hierarchy.

[1] In this context by 'recent' we mean the last hundred years or so as opposed to oil, gas and coal which have been underground for millions of years

The environmental case for energy form waste versus landfill

When considering the relative environmental benefits of landfill and energy from waste, the most important factor is their potential contribution to climate change. Different amounts of greenhouse gases would be released if the same waste was burned or buried.

The balance between the many factors that affect this is complex and much work has been done to understand it that is beyond the scope of this guide. However, there are two simple rules that can help guide our decision making on which route to follow:

- The more efficient the plant is at turning waste into usable energy the better
- The proportion of the waste that is considered renewable is key – higher renewable (biodegradable) content makes energy from waste inherently better than landfill

Energy from waste is therefore better than landfill, providing the residual waste being used has the right renewable content and is matched with a plant that is efficient enough at turning the waste to energy. These considerations should be at the heart of any proposal.

There are rules about when energy from waste can be counted as recovery or disposal in the context of the waste hierarchy. However, if the principles above are followed then even when it is classified as disposal the environmental balance may still favour energy from waste over landfill.

Energy from waste and recycling

There is often concern that energy from waste discourages greater recycling. Government’s goal is to move waste up the hierarchy. Throughout Europe there are examples where energy from waste coexists with high recycling, ultimately delivering low landfill.

At the more local level the risk that energy from waste can compete with, not complement, recycling does exist. However, it is an avoidable risk if contracts, plants and processes are flexible enough to adapt to changes in waste arisings and composition.

Waste infrastructure has a long lifetime and care needs to be taken at the start to ensure systems can adapt to potential long term change and drive waste up the hierarchy, not constrain it. Flexibility of the overall approach to future change should therefore be another key consideration in any proposal.

Energy from waste as an energy source

Energy from waste is not just about waste management.

- The energy it produces is a valuable domestic energy source contributing to energy security.
- As a partially renewable energy source it can also contribute to our renewable energy targets which are aimed at decarbonising energy generation.
- It has the added advantage that it is non-intermittent, so it can complement other renewable energy sources such as wind or solar.

Energy outputs

Most of the energy from waste is currently produced in the form of electricity. However, more and more plants are also looking to use the heat generated. This is known as combined heat and power. More innovative technologies have the potential to also transform the waste into other energy products such as transport fuels or substitute natural gas.

The Government provides a number of different financial incentives to help drive growth in energy from waste, particularly for the more novel technologies and energy outputs beyond electricity. These along with the effective use of heat have the potential to deliver higher overall efficiency and therefore deliver the Government's goal of more energy from less waste.

Chapter 3 - Energy from Waste Infrastructure

An energy from waste solution consists of a number of components: the fuel, the plant, the location etc., and the decisions around these are interlinked.

Waste as a fuel

While waste will differ from one bag to the next, at the scale of an energy from waste plant it is possible to estimate an average composition for the waste. This will define important properties such as the energy available in the waste and the renewable content. These need to be understood to pick the best solution.

Pre-treatments

Some technologies can cope with a wide range of waste composition. However, others need more specific properties, and will therefore require pre-treatment of the waste to transform it into a refuse derived fuel. Pre-treatment requires energy which needs to be considered as part of the overall environmental assessment of the solution. The waste fuel needs to be matched to the technology in terms of both physical properties and environmental impact.

The basic process

All energy from waste plants will have the same basic steps

- A reception area to receive the waste and get it ready for combustion
- A thermal treatment – this essentially releases the energy from the waste
- Conversion to a transportable form of energy – e.g. electricity, heat, fuels
- Emissions clean-up – ensuring waste gases are safe

The overall environmental benefits will depend not only on the thermal treatment but the energy conversion technology to which it is coupled. The important factor to consider is the overall efficiency, net of any energy required to run the process.

Energy from waste technologies and outputs

The most common thermal treatment is incineration; less common are Advanced Thermal Treatments (ATT) such as gasification or pyrolysis. They each have their advantages and disadvantages, with no 'one size fits all' solution. The size and site of the plant will influence the type of technology that is appropriate.

Use of heat significantly increases the overall efficiency of the process and the environmental benefits. Sites with heat customers available should be favoured, along with technologies that can exploit this. Smaller sites may suit the ATTs which can operate at smaller scale.

The most common way to generate energy is to use hot gases from the thermal step to boil water to create steam. This is then fed into a steam turbine to generate electricity and/or used for heating. This is the only route for incineration.

Advanced thermal treatments create a mixture of products from the thermal step that still have a lot of chemical energy stored in them e.g. gases and oils. These can be burnt and used to raise steam as above. However, they also have the potential to be cleaned and burnt directly in gas engines or gas turbines, or converted to transport fuels or synthetic natural gas.

The latter routes have the potential to convert the energy from the waste more efficiently than through steam generation, which makes them attractive. However, they are technically difficult, relatively unproven at commercial scale, and some of the generated energy is used to power the process, reducing the overall benefits.

Emissions

The emissions clean-up step ensures that all the waste gases emitted from the plant meet the very tight limits placed on them by EU legislation. As a result, energy from waste plants contribute only a small fraction of both local and national particulate and other emissions.

Health impacts

The potential health implications of emissions are often a major focus of concern, hence the tight regulation of the emissions and the high priority Government gives to the ongoing process of conducting, evaluating and disseminating high quality science. Public Health England[2] (PHE) has reviewed research undertaken to examine the suggested links between emissions from municipal waste incinerators and effects on health. It notes that modern, well-managed incinerators make only a small contribution to local concentrations of air pollutants. The PHE's view is that while it is possible that such small additions could have an impact on health, such effects, if they exist, are likely to be very small and not detectable.

[2] Formally known as the Health Protection Agency (HPA)

Chapter 4 - Developing an Energy from Waste Facility

The overall process from waste management planning through to having an operational energy from waste facility is one which can take many years and in some cases a decade or more. When trying to understand how this process works it is important that the decisions surrounding energy from waste are not considered in isolation but viewed as part of a long, multifaceted and ongoing process.

Local waste plans

For local authorities the process begins with the development of waste strategies and local plans. We have a 'plan-led' planning system, which means a key deciding factor in whether a proposal is approved will be whether or not it is consistent with local plans. The development and revision of local waste strategies and plans represents perhaps the most important opportunity for the local community to be engaged in the process to determine if energy from waste should be part of their local waste solution, if this might require new infrastructure, and where that might be.

Where does the waste come from – the proximity principle

Councils have a duty to cooperate to ensure that waste needs across their respective areas are handled properly and appropriately. They need to have regard for the proximity principle, which requires all waste for disposal and mixed municipal waste (i.e. waste from households) to be recovered in one of the nearest appropriate facilities. However, this principle must not be over-interpreted. It does not require using the absolute closest facility to the exclusion of all other considerations.

There is nothing in the legislation or the proximity principle that says accepting waste from another council, city or region is a bad thing and indeed in many cases it may be the best economic and environmental solution and/or be the outcome most consistent with the proximity principle.

The ability to source waste from a range of locations/organisations helps ensure existing capacity is used effectively and efficiently, and importantly helps maintain local flexibility to increase recycling without resulting in local overcapacity.

Procurement of infrastructure

The procurement of local authority waste infrastructure is a complex process governed by EU law designed to ensure fairness between bidders. It can be costly and take a significant period of time with limited scope for external communication or consultation.

The apparent step from a broad output-based specification to a clear proposal with only limited scope for modification can give rise to the 'behind closed doors' feel of the process. Identifying and taking opportunities to influence the strategy and specification setting out what the local authority wants prior to procurement starting is vital.

Financing

Financing of energy from waste projects can be difficult with financial institutions, local authorities and waste companies all seeking to minimise their risks. This often leads to a reliance on long term contracts and steers projects towards proven technologies and companies, making it difficult for small companies or innovative technologies to break in.

Government has funded significant infrastructure development through the Waste Infrastructure Grant programme which has helped ensure we are on track to meet landfill diversion targets. Moving forward, it continues to put significant resources into overcoming barriers to delivering further market driven investment, aimed at optimising the role of energy from waste in the hierarchy and as a source of low carbon energy.

Planning applications

Early engagement with the community by developers before submitting a planning application is firmly advocated. Developers need to be responsive to the concerns of the community and many of the issues identified in this guide could be raised; developers should be ready and able to address them. In turn, communities should recognise and be realistic about development constraints such as those around location and costs.

Once a planning application is submitted, views will be sought from the local community and a range of statutory and other consultees. The Waste Planning Authority will consider all the relevant issues and representations and make a decision, normally with the involvement of elected Councillors, in accordance with the local plan for the area as well as any other material considerations (which can include the policies in the National Planning Policy Framework).

Permitting

In the same way that a developer needs planning permission to build a plant, it will require an environmental permit to operate it. The two processes of planning and permitting can happen one after another or at the same time. The Environment Agency is the permitting authority in England.

Construction and operation

Once constructed, the plant will go through a commissioning process to demonstrate it can meet all the requirements of its permit. Only then can it enter operation.

Once commissioned, the operational life of a plant is typically 20-30 years. It will be regularly monitored during that time for compliance with permit conditions including the monitoring of a range of emissions. Breaching any of these limits or permit conditions will result in investigation by the permitting authority and may result in action ranging from a warning for minor breaches if rapidly corrected, to the plant being shut for significant or persistent breaches.

End of plant life

Over the average 25 year planned lifetime of an energy from waste plant, the balance of the many factors that need to be considered to determine if it is the best solution may have changed. Once that planned lifetime has been reached it should not be automatically assumed that extending a plant lifetime beyond that originally envisaged will continue to deliver the same outcomes, although it may do. At this point all options including continued use and/or modification, through to closure and development of a new solution should be considered.

Chapter 5 – Future Policy Direction

Energy from waste is an evolving sector that bridges a number of markets. It also contributes to a number of Government objectives. To develop a clear vision for the future both Government and the sector need to understand and give due consideration to the key principles which underpin policies now and are expected to remain critical in the future.

The Principles Underpinning the Policy

Government would like to encourage developers to consider these principles as a key part of the decision making process around future development of new projects and operation of existing plant. This means that from a sector viewpoint infrastructure proposals, technologies and services that are aligned with these principles should be on a much firmer footing and more robust to future policy than those which are not.

The principles underpinning policy

I. Energy from waste must support the management of waste in line with the waste hierarchy.

II. Energy from waste should seek to reduce or mitigate the environmental impacts of waste management and then seek to maximise the benefits of energy generation.

III. Government support for energy from waste should provide value for money and make a cost effective contribution to UK environmental objectives in the context of overall waste management and energy goals.

IV. Government will remain technology neutral except where there is a clear market failure preventing a technology competing on a level footing.

Energy from waste within the waste hierarchy

The Government sees a long term role for energy from waste both as a waste management tool and as a source of energy. To be consistent with the first principle this long term role needs to be based on energy from waste that at least constitutes recovery not disposal. This should therefore be a key consideration for both new and existing projects. To be classed as recovery, energy from waste facilities must meet the requirements set out in the waste framework directive, for example through attainment of R1 status.

Energy from waste must at the very least not compete with recycling, reuse and prevention and should ideally support them. At the same time recovery through energy from waste needs to be pulling waste out of less environmentally sound disposal routes, particularly landfill but also incineration with insufficient energy recovery. The Government considers there is potential room for growth in both recycling and energy recovery – at the expense of landfill.

The composition of residual waste is by its nature defined by the waste that is prevented or taken out to be reused or recycled. As recycling becomes economic and practical for a wider range of waste types the composition of that which remains will inevitably change. Any long term approach to waste management needs to take into account the fact the picture is not static and be flexible to it. The energy from waste sector needs to think beyond its own boundaries. It must be flexible to changing waste composition or drive recycling and/or collection processes that allow it to manipulate the composition of residual waste (the energy from waste feedstock) without acting as a brake on activities higher up the hierarchy.

Meeting the requirements of the hierarchy will be an important test for any policy or project aiming to increase the waste going to energy recovery and/or the energy produced from it.

Reducing the environmental impacts then maximising the energy

The second principle is about ensuring that energy recovery is the best solution for the residual waste going to it, and then where this is the case that the most is made of the resource it represents. This means understanding and potentially manipulating the nature of the residual waste and ensuring it is suitably matched to the right type of process and energy outputs to minimise the environmental impact. Where this can't be done the impact needs to be mitigated.

A key component of this environmental impact is the relative greenhouse gas emissions. Long term changes in the energy mix being offset by energy from waste have significant consequences for the relative merits of energy from waste versus landfill. There is a balance point where as energy decarbonises, increasing efficiency alone is no longer sufficient to ensure in carbon terms energy from waste is better than landfill, with the biogenic content of the waste feedstock becoming critical.

This is particularly important for electricity only generation as electricity is expected to decarbonise most rapidly, and within the lifetime of existing energy from waste infrastructure. To properly meet the second principle moving away from this balance point is critical for the long term sustainability of mixed waste energy recovery.

Maximising the efficiency of existing electricity only plants will delay reaching the balance point. However, the sustainable lifetime of an electricity only plant may still be limited, and extending it beyond that originally envisaged may not be beneficial. This could be addressed by removing more fossil material from the waste stream thus avoiding the use of waste with insufficient biogenic content to deliver environmental benefits.

Energy outputs such as heat and transport fuels are expected to decarbonise much more slowly than electricity. In addition delivery of heat from energy from waste can be done at much higher efficiencies than electricity only. Plants that operate in combined heat and power (CHP) mode will therefore be able to continue to be superior to landfill, with longer plant lifetimes and using waste streams with a much wider range of biogenic content into the foreseeable future. A key consideration therefore needs to be focussing on development of energy outputs beyond electricity, both for new plants and ensuring existing plants that are ‘CHP ready’ become ‘CHP in use’

As a partially renewable energy source focussing outputs on heat and on transport fuels also aids the decarbonisation of these more difficult energy types. There is therefore a consistent rationale across both waste and energy policy for steering waste towards the most efficient plants and increasing focus on these outputs (and by implication moving away from an electricity only energy from waste model).

Unless the energy output can be effectively used then there is no benefit from maximising its production. Ensuring sites for energy from waste are available that allow potential connection to heat customers is an essential part of maximising the benefits. The updated national planning policy “Planning for Sustainable Waste Management” is expected to reflect this, encouraging local authorities to consider siting, through their local plans, energy from waste facilities in areas which allow them to use heat as an alternative or additional energy output to electricity.

The principles would be expected to apply as much to the production of waste fuels as to their use and policy would be expected to reflect this. Therefore the production of RDF should be part of minimising the environmental impacts of waste management. This means: ensuring the hierarchy is applied and the need to maintain biogenic content in the fuel fraction is not done at the cost of potential recycling; encouraging greater understanding of the biogenic content; increasing biogenic content through removal of fossil waste not addition of biogenic waste and ensuring material if exported delivers a better environmental outcome than domestic disposal.

Fossil based residual wastes, e.g. plastics that cannot be recycled, do not decompose in the same way as biogenic material in landfill. For these waste streams conventional energy from waste will almost always deliver a negative carbon balance compared to landfill. However, they represent a potential resource that in line with the hierarchy should ideally be recovered not disposed of. Advanced processing into energy sources that deliver lifecycle benefits compared to use of raw materials offer a potentially sustainable way to do this. If this is not possible the option of conventional energy recovery and carbon pricing exists for non-municipal waste facilities.

Government support for energy from waste

Government has to ensure that it delivers value for money. This includes direct funding through grants, loans, incentives etc. or more indirect methods such as communications campaigns. The cost effectiveness of carbon reduction is one important measure in assessing this.

There is no automatic link between the cost of managing the waste or producing energy and emissions reductions. While waste as a fuel is not encumbered with the carbon cost of its production any processing once it becomes waste, does have an impact. In particular the combustion of mixed waste releases a substantial amount of fossil emissions from what can be an otherwise relatively inefficient process. However, unlike other biomass which is produced specifically for energy production, residual waste has an alternative fate in landfill that has its own negative environmental impact. The assessment is therefore not straightforward but the principle needs to apply.

Technology Neutral

Government tries not to direct towards one technology above any others where there may be a number of technologies existing and developing that might deliver the same favourable outcome. As such the underlying approach will always be one of technology neutrality.

Chapter 1 - Introduction

Purpose

1. Government's main focus is on preventing waste in the first place or, where it does arise, ensuring it is viewed as a valuable resource, ideally reusing or recycling it. However, it is also Government policy that efficiently recovering energy from residual waste has a valuable role to play in both diverting waste from landfill and in energy generation. In recent decades, the use of fossil fuels such as gas, oil and coal have been contributing to climate change and it is necessary to find ways to generate energy through other means.

2. Where there is residual waste (i.e. remaining waste that cannot be economically or practically reused or recycled), our aim is to get the most value from it via energy recovery, where doing so is the best overall environmental option. This can contribute to our renewable energy targets, and help with the move towards a more secure fuel supply.

3. The debate around energy recovery from waste can often be emotive and highly polarised. However, it is a complex area that is not easily or effectively addressed with a simple "it's right" or "it's wrong" approach. There are many subtleties and individual proposals need to be debated using all the available evidence, and with due consideration of the wider environmental impact of managing our waste. Only through full and informed discussion can we deliver energy from waste that uses the right fuel, in the right place, at the right time.

4. The objective of this guide is to provide a credible and consistent reference document, as discussed with a diverse range of stakeholders, to inform discussions and decisions relating to energy recovery from waste. It aims to highlight the key environmental, technical and economic issues and options that should be considered, and also some of the main points where decisions can be influenced.

5. We hope that this guide will go some way to increasing understanding of the role that energy recovery can play in the sustainable management of residual waste and how it relates to other waste management options, including reuse, recycling and disposal.

6. This guide will be relevant to those wishing to engage in the debate about energy recovery, including:
    - members of the public
    - waste and planning officials in local government
    - elected members of local and national government
    - the waste management industry
    - energy intensive industries
    - energy companies
    - developers and technology providers
    - non-governmental organisations, and
    - those looking to finance energy from waste projects.

7. This guide has been developed by Government (Defra, DECC, BIS, HMT, DfT and DCLG) in conjunction with colleagues in the Devolved Administrations and other key stakeholders. These include the Environment Agency, WRAP, the Public Health England, the Food Standards Agency, the waste management and renewable energy industries and non-Governmental organisations. It is intended to be a living document that evolves alongside the policy and evidence.

8. While many of the issues will be generic across all the Devolved Administrations this guide focuses on the situation in England, and many of the more detailed policy statements and processes, particularly in relation to planning and permitting, are specific to England[3]

9. This revised 2014 version of the guide includes an additional chapter (Chapter 5) which considers the future policy direction for energy from waste. This chapter does not set out any new policy but identifies underlying principles that are likely to continue as key considerations for both government and the sector in the future and the implications of them.

Scope

10. As far as possible this guide aims to cover the issues surrounding energy recovery from municipal solid waste (MSW)[4] and any other commercial and industrial waste (C&I) outside the definition of MSW. While there are differences in how the wastes are managed, many of the issues and key considerations will be the same.

11. The guide is mainly concerned with ways to transform residual waste into energy (see definition section below). Not all of the waste currently being treated through energy from waste is residual. While the guide does consider the role of Anaerobic Digestion (AD) to treat residual waste, it does not cover the use of AD with food and other wet wastes where these have been separated at their source. Further information on all forms of AD and Government policy in relation to it can be found in the AD Strategy and Action Plan[5]. Similarly it does not cover energy recovery from waste that has already been disposed i.e. energy recovery from landfill gas.

Definitions used in this guide

Energy from waste

12. The terms ‘energy recovery (from waste)’, or ‘energy from waste’ (commonly abbreviated to EfW) can be used interchangeably and cover a range of different processes and technologies. For the purposes of this guide we shall use the term ‘energy from waste’ to describe a number of treatment processes and technologies

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[3] Further information on specific policies from the Devolved Administrations can be found at:
- for Wales http://wales.gov.uk/topics/environmentcountryside/epq/waste_recycling/?lang=en
- for Scotland http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Waste-1
- for Northern Ireland http://www.doeni.gov.uk/niea/wms.17.pdf

[4] i.e. waste that is household waste or from other sources which is similar in nature and composition to household waste e.g. commercial office waste.

[5] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69400/anaerobic-digestion-strat-action-plan.pdf

used to generate a usable form of energy and which also reduce the solid volume of residual waste. This energy can be in the form of electricity, heating and/or cooling, or conversion of the waste into a fuel for future use e.g. transport fuels, or a combination of these forms.

13. The term incineration is often used erroneously to describe all energy from waste processes but it is only used in this guide to describe a specific type of combustion process.

14. There are a number of different waste management pathways, with some using one or more energy from waste technologies, and others involving pre-treatment processes to prepare the waste feedstock for energy recovery. While specific details will vary between pathways, many of the principles identified in this guide apply to them all.

Pre-treatment of waste

15. Often, waste will go through some kind of pre-treatment (or ‘intermediate’) process where some items that can be recycled are removed, and/or where the remaining material is prepared for use in energy recovery by being converted into refuse derived fuel (RDF)[6] or solid recovered fuel (SRF)[7]. Pre-treatment processes include:
    - Materials Recovery (often at a Materials Recovery Facility (MRF))
    - Mechanical Biological Treatment (MBT) which can include an AD energy conversion process
    - Mechanical Heat Treatment (MHT) including autoclaving.

Conversion Treatments

16. These are processes which convert residual waste or RDF/SRF into a more useable form of energy such as heat or electricity. These processes include:
    - incineration;
    - gasification (including plasma gasification);
    - pyrolysis;
    - anaerobic digestion (from mixed residual waste, often as part of an MBT process).

17. Decisions on how to treat and prepare waste for energy recovery will depend primarily on the waste feedstock to be used and the outputs desired. Chapter 3 examines the processes and the issues surrounding them in more detail.

Residual waste

18. Residual waste is mixed waste that cannot be usefully reused or recycled. It may contain materials that could theoretically be recycled, if they were perfectly separated and clean, but these materials are currently too contaminated for recycling to be economically or practically feasible. It may also be that there is currently no market for the material or it is uneconomic to take to market. An alternative way of describing

[6] The segregated high-calorific fraction of processed municipal waste
[7] As per RDF but produced to a detailed specification in order to meet certain criteria including calorific value, moisture content, density, particle size

residual waste is 'mixed waste which at that point in time would otherwise go to landfill'. Generally energy recovery should be from residual waste.[8]

'Partially renewable' energy source

19. Renewable energy is energy which comes from renewable non-fossil sources. For energy from waste this means things that were recently[9] growing. Residual waste contains a significant proportion of materials like food and wood ('biogenic' materials) and energy from this proportion is considered renewable. However, residual waste also contains wastes from 'fossil' sources (oil etc.) such as plastic. Therefore when energy is recovered from mixed residual waste it is considered to be only a *partially* renewable energy source. This is considered in more detail in Chapter 2.

History

20. Historically, the main treatment route for waste in the UK has been landfill, primarily due to the availability of suitable sites created by past mineral extraction. As a result, the drive to develop and exploit alternative waste management routes has lagged behind that of other parts of Europe. Early incinerators were primarily for disposal although some had energy recovery. They were not favourably perceived by the public at that time. These factors, along with the tighter incineration emission controls brought in during 1989, meant that no new plants were built between 1980 and 1993 and many existing plants closed.

21. In the mid 1990s when the EU began to recognise the potential impact of waste management on climate change, it brought in targets for the diversion of biodegradable waste from landfill. In the UK this led to the development of the landfill tax escalator and, additionally in England, the landfill allowance trading scheme. This helped drive the development of a new generation of energy from waste plants with energy generation in addition to waste management as a key part of their function and business model. All plants burning waste have to meet at least the stringent emissions limit, monitoring, waste reception and treatment standards brought in under the Waste Incineration Directive (2000/76/EC) which has been recast into the Industrial Emissions Directive (2010/75/EU).

Looking forward

22. The Review of Waste Policy in England[10], published in June 2011, set out the Government's ambitions for waste, including that landfill should be the waste management option of last resort and only for wastes where there is no better use. The Devolved Administrations have also published their own strategies on waste[11].

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[8] In addition to residual waste, there are other wastes for which energy recovery represents the most feasible option e.g. low grade wood waste.

[9] In this context by 'recent' we mean the last hundred years or so as opposed to oil, gas and coal which have been underground for millions of years

[10] https://www.gov.uk/government/publications/government-review-of-waste-policy-in-england-2011

[11] The strategies for the Devolved Administrations can be found at

- Towards Zero Waste: The Overarching Waste Strategy Document for Wales http://wales.gov.uk/docs/desh/publications/100621wastetowardszeroen.pdf;
- Scotland's Zero Waste Plan http://scotland.gov.uk/Publications/2010/06/08092645/0

As waste prevention, re-use and recycling efforts improve; residual waste will eventually become a finite and diminishing resource. In the meantime there is an opportunity to retrieve more value from the waste we are currently sending to landfill by diverting it into energy recovery and by employing more efficient technologies to maximise the energy we get out of it.

23. A number of recent reports have set out scenarios for the amount of waste which could be produced in the future and the potential to generate renewable energy from that waste between now and 2020, and beyond[12,13,]. However, estimating such figures is a complex process and the results are highly sensitive to the assumptions used.

24. Table 1 below shows that we have experienced significant declines in waste being generated in recent years, especially from commercial and industrial sources. The decline between 2008 and 2010 is exaggerated because a new methodology for estimating mining waste revised down the total markedly. Exact trends in waste generation are difficult to identify given the periodic nature of collection for waste data from the commercial and industrial sector. Local authority collected waste, for which more regular data is available, has been declining in the UK since 2003. It is predicted that declines will continue going forward, with government modelling suggesting total waste generation will fall gradually in the short to medium term, with the pattern varying by waste stream. The rate of change in waste arising will vary between countries and regions.[14]

Table 1, Chart data: Total UK Waste Generation by Sector, 2004 to 2010 (tonnes)

Industry Sector	2004	2006	2008	2010
Construction	113,198,513	109,545,988	100,999,493	105,560,290
Mining and quarrying	93,882,695	86,779,157	85,962,590	23,091,832
Commercial and industrial	81,381,302	76,121,790	67,305,288	43,342,791
Households	31,007,481	32,466,327	31,539,338	28,948,507
Secondary, sewage and other*	5,806,665	2,140,096	2,748,421	2,110,195
Total	325,276,656	307,053,357	288,555,131	203,055,625

*Other includes healthcare wastes, batteries & accumulators, and wastes containing PCB.

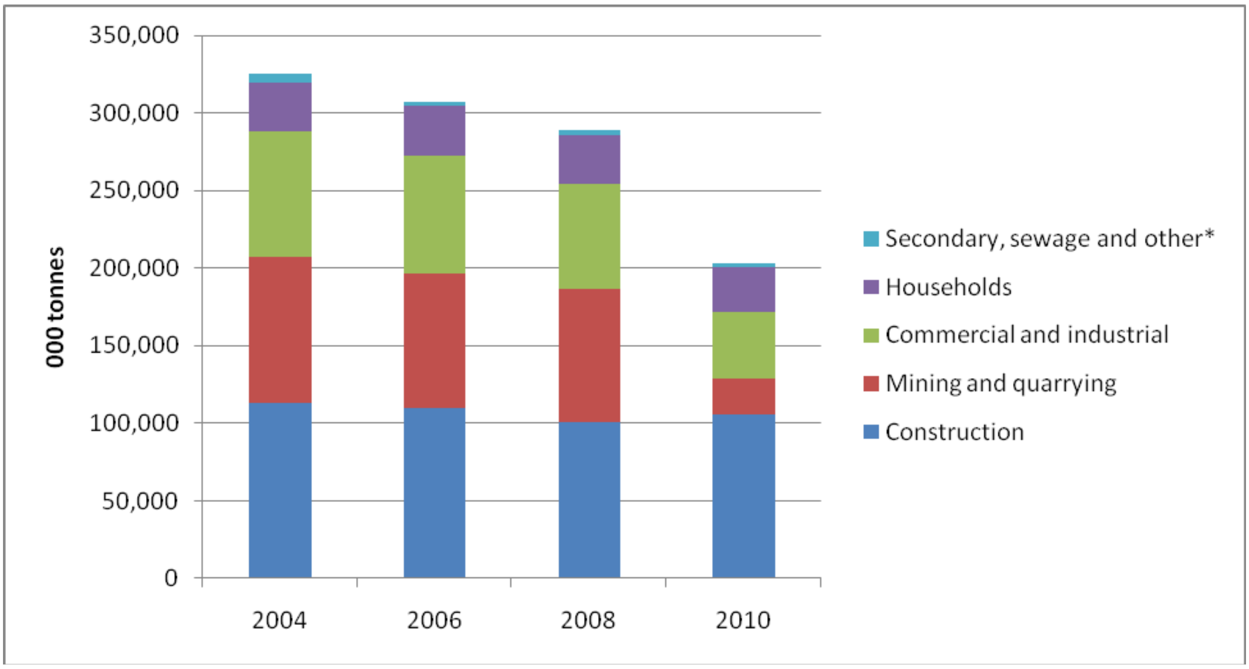
- Towards Resource Management: The Northern Ireland Waste Management Strategy 2010-2050 http://www.doeni.gov.uk/niea/wms.17.pdf

[12] https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/the-renewables-obligation-ro

[13] https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/renewable-heat-incentive-rhi

[14] http://wales.gov.uk/topics/environmentcountryside/epq/waste_recycling/publication/cimsectorplan/?lang=en

Chart 1 - Total UK Waste Generation by Sector, 2004 to 2010 (tonnes)



25. The amount of waste available for energy recovery will not necessarily follow the same trends as the waste being produced, as it is expected the proportion being reused and recycled will increase. While there will be opportunities to divert residual waste that may be destined for landfill into energy recovery, the amount that is available, and its renewable content, will depend on a number of factors, including;

- waste management policy at a local and national level
- the composition of residual waste
- the infrastructure available to treat and process waste
- infrastructure efficiency
- the cost of treating waste in different options
- markets for recyclates and cost of energy.

26. The future policy direction for energy from waste is considered in more detail in Chapter 5.

Capacity and Infrastructure

27. In the UK we have a predominantly market-led approach to infrastructure which should help avoid the development of too much, or too little, energy from waste capacity. However, energy from waste infrastructure can take considerable time (up to 10 years or more) and significant financial investment to develop. Access to residual waste for use in energy recovery can also be problematic, particularly for new technologies or less established companies, as local authority collected waste/household waste is often tied up in long-term waste disposal authority contracts. These complex factors can make it challenging for the waste management industry to respond swiftly to market changes.

28. A recent report by Eunomia[15] suggested that there is currently around 13 million tonnes of residual waste treatment capacity either 'operating' or 'under construction' in Great Britain, estimating around 22 million tonnes capacity gap (per annum) between residual waste arisings and the amount of treatment infrastructure capacity either 'operating' or 'under construction'. The report also suggests that this capacity gap will decrease to just under 11 million tonnes (per annum) by 2020 if the waste treatment capacity that has planning consent (around 12 million tonnes) reaches financial close and begins construction. It also notes that planning consent is being sought for around a further 3 million tonnes of waste treatment capacity.

29. Residual waste treatment capacity varies around the UK. Some regions are closer to foreign export markets for waste as a fuel and therefore can exploit the fact that several EU countries currently have overcapacity with more infrastructure than feedstock. Other UK regions have more available landfill space. Greater landfill availability and strong export markets create competition for waste and reduces the price that energy from waste operators are able to charge in gate fees for incoming waste.

Facts and figures on energy from waste capacity and infrastructure

- Local Authority managed waste going for incineration with energy recovery rose 13% to 5.5 million tonnes in 2012/13 and has more than doubled in the last ten years[16]
- A 2010 survey found only **2%** of commercial and industrial waste was incinerated with energy recovery in England.[17]
- In 2012, **24** energy from waste plants operating in England were treating almost **4 million tonnes** of residual MSW and solid recovered fuel (SRF).
- In 2010, the combustion of the biodegradable component of MSW provided 6.2% of the UK's total renewable electricity generation and 4.7% of total combined renewable heat and electricity generation.[18]
- Waste derived renewable electricity from thermal combustion in England is forecast to grow from the current **1.2TWh to between 3.1TWh and 3.6TWh by 2020.**[19]

[15] Residual Waste Infrastructure Report – High Level Analysis, Eunomia (2011) http://www.eunomia.co.uk/Eunomia_Residual_Waste_Infrastructure_Review_High-level_Version.pdf

[16] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/255610/Statistics_Notice1.pdf

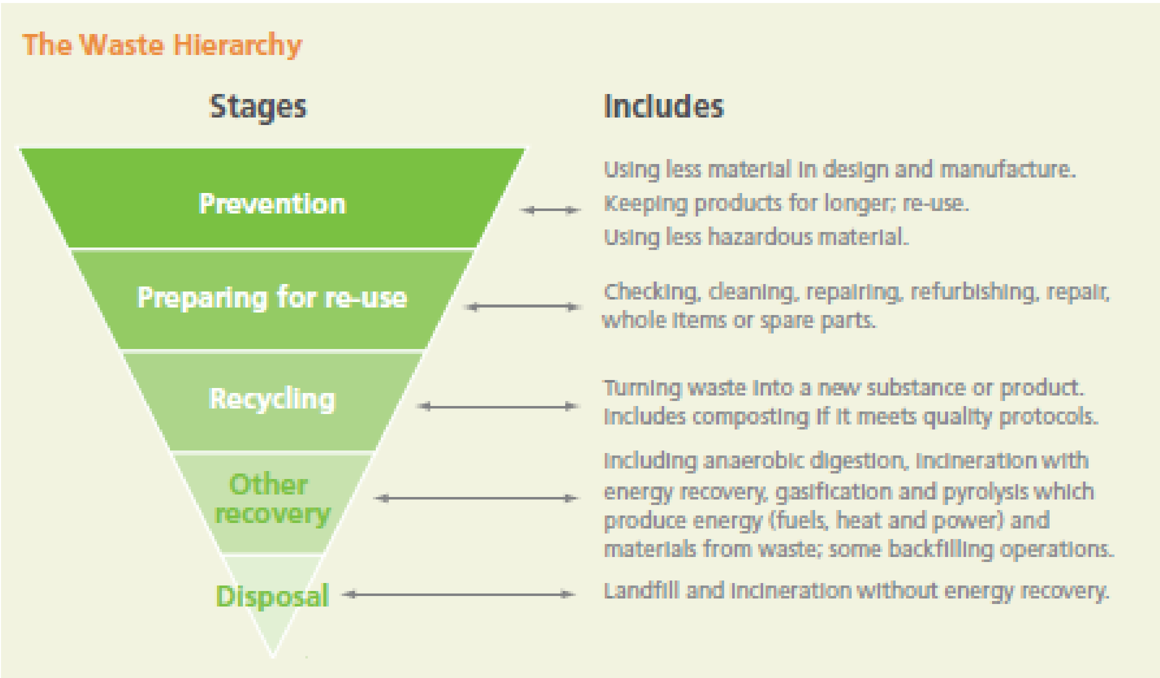
[17] Defra: 2010 survey of commercial and industrial (C&I) waste arisings in England - http://webarchive.nationalarchives.gov.uk/20130123162956/http:/www.defra.gov.uk/news/files/2010/11/1011stats.pdf

[18] Calculations based on figures from Digest of United Kingdom Energy Statistics (DUKES) 2010

Chapter 2 - Context

Energy recovery in the context of the waste hierarchy

30. The waste hierarchy[20] is both a guide to sustainable waste management and a legal requirement of the revised EU Waste Framework Directive[21]. It is enshrined in law through the Waste (England and Wales) Regulations 2011and lays down a priority order of what constitutes the best overall environmental option for managing waste. The hierarchy is applied in the planning system through national waste planning policy.



31. This order (prevention, preparation for reuse, recycling, other recovery and disposal) means that energy from waste is generally considered to have an environmental performance inferior to recycling but superior to disposal through landfill or combustion without energy recovery.

32. In a perfect world all waste would be prevented and the hierarchy would be unnecessary. However, in reality a range of social, economic, practical and technological reasons mean that different waste streams are currently best dealt with

[19] Taken from the Defra Waste Review https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69401/pb13540-waste-policy-review110614.pdf

[20] https://www.gov.uk/waste-legislation-and-regulations
[21] http://ec.europa.eu/environment/waste/framework/revision.htm/

at different levels of the hierarchy – including through energy recovery. Also for specific wastes sometimes it is better to depart from the hierarchy altogether[22].

33. It is readily acknowledged that many waste materials that could theoretically be recycled are not currently, and go to energy recovery or landfill. It is important that the presence of energy recovery as an option does not diminish efforts to overcome the range of barriers to capturing and recycling these. However, it is equally important that while those barriers do exist, energy from waste is used effectively to ensure those materials do not go to a worse environmental fate in landfill. In the long term, all waste should be treated at its optimal level in the hierarchy in environmental and economic terms.

34. In this context energy from waste needs to support, not compete with, both increased diversion from landfill *and* increased recycling whilst also ensuring waste reduction and reuse are not compromised. The next section focuses on the fate of residual waste, as defined in Chapter 1, and RDF/SRF (i.e. waste following pre-treatment) and the interaction with the other management routes in the waste hierarchy.

Energy from waste and landfill

35. The combustion of waste was historically used primarily as a tool for reducing the volume of solid residual waste requiring disposal and as such, combustion itself, was considered a disposal route on a par with landfill. So why can energy from waste now be considered above landfill in the waste hierarchy? The answer lies in the environmental impact of the carbon contained within the waste and the energy produced by the process.

36. The Climate Change Act established a legally binding target to reduce the UK's greenhouse gas emissions by at least 80% by 2050, compared to levels in the base year of 1990. In 2007, direct greenhouse gas emissions from waste amounted to nearly 23 million tonnes of carbon dioxide equivalent, or around 4% of total UK emissions - around 90% of these emissions were from landfill.

37. Both landfill and combustion of untreated mixed waste will result in the release of carbon into the atmosphere but for the same bag of waste they do so in different ways, in different amounts, with different potential impacts. Landfill produces carbon dioxide (CO_2) and methane (CH_4) in roughly equal proportions whereas energy from waste produces carbon dioxide only[23]. Both these gases contribute to global warming, although methane is around 25 times[24] as damaging as carbon dioxide. While waste management impacts on the environment in many ways and the hierarchy reflects all of these, the scale of the climate change potential tends to dominate all other issues. Therefore, the route which produces the lower volume of

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[22] Guidance on the hierarchy https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69403/pb13530-waste-hierarchy-guidance.pdf Wales have published separate guidance http://wales.gov.uk/topics/environmentcountryside/epq/waste_recycling/publication/hierarchyguide/?lang=en

[23] Controlled biological processes like Anaerobic Digestion also emit methane but unlike landfill this is captured in a closed system not released into the atmosphere. Equally not all the methane produced by landfills is released the majority, about 75%, is captured.

[24] Based on IPCC guidance.

greenhouse gas emissions, (usually expressed as carbon dioxide equivalents[25]), is generally placed higher in the waste hierarchy.

38. To illustrate such a comparison of greenhouse emissions let us consider the potential fate of a current typical 'black bag' of residual waste – one route where it is sent to landfill and another when it is used in energy recovery.

39. A typical black bag of residual waste will contain a mixture of different things, such as paper, food, plastic, clothes, glass and metal. Some of these wastes, e.g. food, will originally have come from biological sources, i.e. plants, and the carbon stored in them is known as biogenic carbon. Some of the waste materials, e.g. plastics, will have been made from fossil fuels such as oil and the carbon stored in them is known as 'fossil carbon'. Some of the wastes, e.g. clothes, will contain a mixture of biogenic and fossil carbon (e.g. cotton/polyester mixes) while other wastes will contain little or no actual carbon (e.g. metals). We need to understand if the carbon in the waste is biogenic or fossil in origin for two reasons: (i) they behave differently in landfill (plastic does not generally decompose) and (ii) biogenic and fossil carbon are counted differently in terms of how they are calculated to contribute to global warming[26]. Of the waste in our typical black bag, currently[27] somewhere between one half and two thirds will contain biogenic carbon.

40. Considering the energy from waste route, if our black bag of waste were to go to a typical combustion-based energy from waste plant, nearly all of the carbon in the waste would be converted to carbon dioxide[28] and be released immediately into the atmosphere. Conventionally the biogenic carbon dioxide released is ignored in this type of carbon comparison as it is considered 'short cycle', i.e. it was only relatively recently absorbed by growing matter. In contrast, the carbon dioxide released by fossil-carbon containing waste was absorbed millions of years ago and would be newly released into the atmosphere if combusted in an energy from waste plant.

41. The energy from waste plant will generate some energy (in addition to whatever it uses to run itself). This energy substitutes for energy that would otherwise need to be generated by a conventional gas-fired power station[29], thereby saving the fossil carbon dioxide that would have been released by that power station. This means that in our comparison some of the fossil carbon dioxide released by the energy from waste plant can be offset by the saving from the gas fired power station, reducing the

[25] Carbon dioxide equivalents are used as a way of comparing the effect of different gasses. Carbon dioxide is given a global warming potential of one, while a given unit of methane will be 25 carbon dioxide equivalents.

[26] The atmosphere cannot distinguish between CO_2 released from a biogenic source versus a fossil source. However, in terms of considering overall climate impacts it is important they are accounted for and treated differently to avoid double counting. The IPCC have agreed conventions for doing this which are applied here.

[27] The composition of waste changes over time as consumption patterns, reuse, recycling and separate collection practices change.

[28] <3% would remain in the ash.

[29] A gas fired power station (Combined Cycle Gas Turbine - CCGT) is a reasonable comparator as this is the most likely technology if you wanted to build a new power station today. When conducting more detailed assessments the energy offset should be calculated in line with DECC guidance using the appropriate marginal energy factor https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

overall impact. The more efficiently the energy from waste plant converts the waste to useful energy, the greater the carbon dioxide being offset and the lower the net emissions.

42. Alternatively, considering the landfill route, all the fossil carbon stays in the ground and doesn't break down. The fossil carbon is sequestered, as is potentially up to half of the biogenic carbon depending on the exact conditions in the landfill. However, some of the biogenic material does break down with the carbon converted to a mixture of carbon dioxide and methane, known as landfill gas. A large proportion of this landfill gas would be captured and burnt, generating energy and offsetting power station emissions. Burning landfill gas produces biogenic carbon dioxide which, as for energy from waste, is considered short cycle. Crucially however, some of the methane would escape into the atmosphere. As a very potent greenhouse gas even a relatively small amount of methane can have dramatic effect and be equivalent to a much larger amount of carbon dioxide.

43. For our average current black bag of waste, once the energy offset is taken into account, the net carbon dioxide equivalents from the methane released from landfill would be greater than the net carbon dioxide released from a typical energy from waste plant. All of this means that for this example, energy recovery from residual waste has a lower greenhouse gas impact than landfill. It would therefore be considered higher than landfill in the waste hierarchy and the preferred option for managing residual waste in terms of minimising potential climate change impact.

44. These arguments are of course simplified and whilst these are the key issues, in reality there are many more factors being balanced than those outlined above[30]. There is significant debate on how a number of issues are handled that mean it is important to consider things on a case by case basis. These include: changing biogenic content of residual waste over time; how the biogenic carbon dioxide is counted; the fact that not all the biogenic material breaks down in landfill; the level of landfill gas capture; the impact of recycling metals from ash generated by energy from waste; the impact of pre-treatments on stabilising waste and how to allow for the fact that the landfill gas is released over many years.

45. However, even when these factors are taken into consideration, in carbon terms, currently energy from waste is generally a better management route than landfill for residual waste. While it is important to remember this will always be case specific and may change over time, two rules apply:
    - the more efficient the energy from waste plant is at turning waste into energy, the greater the carbon offset from conventional power generation and the lower the net emissions from energy from waste;
    - the proportion and type[31] of biogenic content of the waste is key – high biogenic content makes energy from waste inherently better and landfill inherently worse.

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[30] Recent modelling work has considered the impact of a number of these factors. The implications of this work are discussed in more detail in chapter 5 and the modelling can be found at http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=19019&FromSearch=Y&Publisher=1&SearchText=wr1910&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

[31] Some wet wastes e.g. food are not particularly suitable for energy from waste.

46. Energy from waste will therefore be a better environmental solution than landfill provided the waste being used has the right biogenic content and a plant is efficient at turning that waste into useable energy. The life of the plant is usually 25-30 years and the biogenic content of the waste will change in that period. It is also possible to treat waste to increase biogenic content e.g. removing plastics. Ensuring that the waste and efficiency of plant are sufficiently matched for the entire life of an energy from waste plant is key to the debate over whether energy from waste is the most appropriate management option. It may be that the plant itself can be updated, upgraded or refurbished to keep pace with the changing nature of the waste. To understand fully the relative benefits of energy from waste against other solutions a full life cycle assessment (see below) for the specific circumstances will be required. The Waste Resource Action Programme (WRAP) have developed an interactive guide[32] which provides information to help decision making for the development of energy from waste facilities.

Recovery or disposal – the meaning of R1

47. As described above the Waste Framework Directive (WFD) sets out the waste hierarchy and enshrines it in law. It requires that a waste management route defined as recovery should be used ahead of an alternative that is classified as disposal. Exceptions can be made (see below) but this general principle makes it important to know whether a process is considered recovery or disposal.

48. Historically the Waste Framework Directives have included annexes which set out lists of what are considered to be recovery or disposal operations. Each is given a number and a letter: R for recovery, D for disposal. In the current directive the classifications of particular relevance to energy from waste are:
    - R1 – Use principally as a fuel or other means to generate energy
    - D10 – Incineration on land

49. What this means is that where waste is burnt as a fuel to generate energy it can potentially be considered a recovery operation (R1) but where the purpose of incineration is to get rid of waste, it is considered D10 and hence disposal. All municipal waste incinerators were and are deemed as disposal activities (D10) unless and until they are shown to meet the requirements of R1. This is why the term R1 often crops up in the debate about how good an energy from waste plant might be and how it compares to other options.

50. For municipal solid waste, which includes all the waste collected from households, the EU has gone further by defining what it considers to be sufficient for recovery status under R1. The WFD includes a formula relating to the efficiency of the combustion plant. A municipal waste combustion plant can only be considered to be a recovery operation under R1 if it generates energy *and* the plant meets the efficiency thresholds calculated using the R1 formula[33].

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[32] http://www.wrap.org.uk/content/energy-waste-development-guidance-0

[33] The R1 formula calculates the energy efficiency of the municipal solid waste incinerator and expresses it as a factor. This is based on the total energy produced by the plant as a proportion of the energy of the fuel (both traditional fuels and waste) which is incinerated in the plant. It can only be considered recovery if the value of this factor is above a certain threshold. It is important to note that the calculated value arrived at via the R1 formula is not the same as power plant efficiency which is typically expressed as a percentage.

51. This helps ensure that all plants which want to be classed as recovery in the EU will meet a minimum standard of environmental performance. As waste can only cross national boundaries for recovery not disposal it also ensures only the more environmentally sound plants can compete internationally for waste derived fuel.

52. The requirement to apply the R1 formula means that lower efficiency municipal energy from waste plants are classed as disposal (D10) even if they are generating useable energy. However, with the right combination of overall efficiency and biogenic content in the waste, an energy from waste plant which does not qualify for R1 status may still be a better environmental option than landfill. Similarly, in line with the right fuel, right technology argument set out above, a plant meeting the R1 formula does not in itself necessarily mean it is the best solution for all waste streams.

53. R1 status is not mandatory for energy from waste plant[34] and will not be part of an environmental permit. Irrespective of whether the plant is classed as a Recovery (R1) plant or Disposal (D10) plant, operation under the Environmental Permitting Regulations requires that plants recover as much energy as practicable[35].

54. The distinction between having R1 status or having a plant being classified as a disposal facility is important for planning purposes and in the application of the proximity principle. It is therefore important that operators strive towards demonstrating that energy from waste is a recovery operation according to the WFD definitions. Interested operators should contact the relevant competent authority[36] who, based on an application from the operator, will assess whether or not a municipal solid waste combustion facility meets or exceeds the threshold and can be considered a recovery operation.

Waste exports for energy recovery

55. The UK has a long-standing policy of self-sufficiency for waste disposal and the UK Plan for Shipments of Waste[37] prohibits the export of waste for disposal. Waste may be exported for recovery, which can have advantages over managing it within the UK. For example if current lack of appropriate infrastructure means the alternative UK treatment route is more costly or environmentally worse.

56. Although exports of waste for recovery from the UK are generally permitted, in line with EU law, the export of mixed municipal waste[38] (in other words "black-bag waste") for recovery is not allowed unless it has undergone some form of pre-treatment. Such

Environment Agency guidance on R1 can be found at https://publications.environment-agency.gov.uk/ms/C7xJLZ

[34] Although Wales require any plant that is part-funded by the Welsh Government should at least comply with an R1 factor of 0.65.

[35] The Environment Agency will shortly be publishing guidance on its requirements for CHP readiness under environmental permitting.

[36] The Environment Agency in England and Wales, the Scottish Environment Protection Agency in Scotland and the Northern Ireland Environment Agency for Northern Ireland.

[37] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69546/pb13770-waste-shipments.pdf

[38] coded 20 03 01 in the European Waste Catalogue

pre-treated waste derived from municipal waste, such as refuse derived fuel, may only be exported for recovery (e.g. to an R1 classified plant) to other OECD (Organisation for Economic Co-operation and Development) countries, in compliance with the EU Waste Shipments Regulation[39]. Within this context a free market operates for the recovery of waste and waste derived fuels.

57. In recent years there has been an increase in exports. Our domestic capacity for dealing with SRF and RDF has not matched the expansion in material going through MBT, and the overcapacity of energy recovery infrastructure in some EU countries has created a competitive market for this material to be exported. In 2012 963,944 tonnes of RDF was exported.[40] While such exports are permissible, the energy recovered from the waste does not contribute to UK renewable energy targets and is effectively a lost resource to the UK. The Government is keen to support domestic RDF and SRF markets, where they can provide better environmental outcomes, to ensure that the UK benefits from the energy generated from UK waste.

Recycling and energy from waste

58. The potential for energy from waste to consume materials which could otherwise be managed higher up in the waste hierarchy is a legitimate concern. This applies to prevention and reuse but is most commonly identified in relation to recycling. This is not a fundamental issue arising from energy from waste as a process, but rather as a result of opportunities not being taken to separate and remove materials from residual waste. Provided the right action is taken to ensure separation and pre-treatment options are optimised, it is a risk that can be effectively addressed. Energy from waste can and should support, not compete, with effective recycling.

59. Government's aim is to get the most energy out of residual waste, rather than to get the most waste into energy recovery. This reflects the desire to move waste up the waste hierarchy and the drive to prevent, reuse and recycle in the first instance.

60. All Member States are working towards reducing the waste they send to landfill and meeting Waste Framework Directive targets to reuse, recycle or compost 50% of waste from households by 2020. Experiences in Europe show that high rates of recycling, composting and energy from waste can and do coexist. In 2010 Austria achieved 70% recycling (including composting) alongside 30% waste which was incinerated; Germany achieved 62% recycling alongside 38% incineration; while Belgium achieved 62% recycling alongside 37% incineration. This compares to the UK with 39% recycling and 12% incineration. While some EU countries are currently experiencing overcapacity in energy from waste, it would seem that rather than reducing recycling rates, this has led to the importation of material for energy recovery from other states with insufficient recovery capacity, diverting even more waste from landfill across the EU as a whole.

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[39] http://www.environment-agency.gov.uk/static/documents/GEHO1105BJVS-e-e.pdf
[40] Source: Environment Agency. Provisional figures for 2013 show an increase to 1,586,946 tonnes http://www.letsrecycle.com/news/latest-news/energy/rdf-exports-top-1.5m-tonnes-in-2013

61. However, overall national trends do not necessarily reflect what is happening at the local level i.e. from the perspective of waste collection and disposal authorities. It is therefore essential that communities and planners have an integrated approach to energy from waste and recycling, and make decisions based both on waste composition and volumes expected to arise and any local collection issues.

62. Energy from waste infrastructure has a long lifetime and changes in the composition and biogenic content of residual waste over time can affect both how efficiently a plant operates and its relative environmental impact. However, this does not have to mean maintaining a certain biogenic content or energy value at the expense of improved recycling. For example, introduction of separate collection of food waste for composting might reduce the biogenic content of residual waste. To balance this and maintain biogenic content, removal (by recycling) of fossil fuel components such as plastics would also be needed, ensuring the biogenic content remains sufficiently high with only the genuinely residual waste remaining. Hence the need to optimise the residual waste being used by energy from waste plant could potentially support and drive greater recycling across a range of materials.

63. The concern is that such changes would never take place as they would reduce the overall volume of waste going to the plant, with the need to 'feed' the plant undermining the case for such recycling and prevention initiatives. Indeed it is a commercial reality that such projects do require a minimum guaranteed throughput to be viable. However, such problems could be avoided by including flexibility within the design of the system and contracts around it, setting realistic capacity requirements, and by plants being allowed to accept and seek out waste from other sources (i.e. commercial contracts or joint working with other authorities) to make up any shortfall. At present 50% of commercial and industrial waste goes to landfill presenting a significant opportunity for those authorities and plants able to exploit it.

Departing from the waste hierarchy

64. Article 4(2) of the revised Waste Framework Directive allows Member States to designate specific waste streams where it is possible to depart from the waste hierarchy in order to deliver the best environmental outcome (e.g. treated waste wood going to energy from waste). However, this has to be justified by life-cycle analysis on the overall impact of generating and managing these waste streams. Life Cycle Analysis (LCA) is a conceptual approach that considers upstream and downstream benefits and trade-offs associated with goods and services. LCA takes into account the entire life cycle, starting with the extraction of natural resources through material processing, manufacturing, marketing, distribution, use, recycling and waste treatment to the disposal of remaining waste. For instance, LCA showed that for food waste, wet or dry anaerobic digestion is better than other recycling and recovery options (see page 6 "Departing from the Waste Hierarchy" of Defra's Applying the Waste Hierarchy Guidance of June 2011).[41]

65. Other considerations - namely the general environmental protection principles of precaution and sustainability, technical feasibility and economic viability, protection of

[41] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69403/pb13530-waste-hierarchy-guidance.pdf

resources as well as the overall environmental, human health, economic and social impacts – can also be taken into account[42]. These other factors are better considered on a case-by-case basis. Further information on application of life-cycle thinking to waste management options is set out in the Waste Hierarchy Evidence Paper[43] published by Defra.

Energy from waste as a partially renewable energy source

66. The UK is legally required by the EU Renewable Energy Directive (RED) to source 15% of its total energy from renewable sources by 2020. This will require an annual output of around 227 TWh (terawatt hours) of renewable energy by 2020. Energy from the biogenic part of mixed residual waste is seen as one of a number of technologies that either have the greatest potential to help the UK meet the 2020 target in a cost effective and sustainable way, or offer great potential for the decades that follow (as discussed in the UK Bioenergy Strategy[44]). The RED also requires Member States, by 2020, to source 10% of renewables in road and rail transport. The RED encourages biofuels produced from waste feedstocks by double counting the contribution they make towards the national transport target, although not the overall target. Energy from waste as defined in this guide is not the only way waste contributes to renewable energy targets. Anaerobic Digestion is the best available means of dealing with separately collected food waste producing renewable energy and a valuable fertiliser. Energy from landfill gas capture and from anaerobic digestion of sewage sludge also contribute to the achievement of renewable energy targets.

67. Energy from residual waste is only partially renewable due to the presence of fossil based carbon in the waste, and only the energy contribution from the biogenic portion is counted towards renewable energy targets (and only this element is eligible for renewable financial incentives). If the waste is pre-treated to separate out the biogenic fraction then this can be considered wholly renewable. Waste treated to give greater than 90% biogenic content is considered to be on a par with biomass for many of the incentive schemes, although as it is still a waste derived fuel, it remains subject to all the environmental controls relating to waste[45].

68. As an energy source, energy from waste has a number of potential advantages beyond its renewable content including:
    - energy security
    - non-intermittent nature
    - variety of potential energy outputs

Energy security

69. The UK faces a growing dependency on imported fossil fuels. In 2011, 41% of oil supplies and 26% of gas supplies came from imports, and by 2020, the UK could be

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[42] In accordance with Articles 1 and 13 of the revised Waste Framework Directive
[43] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69404/pb13529-waste-hierarchy-summary.pdf
[44] https://www.gov.uk/government/publications/uk-bioenergy-strategy
[45] Unless it has achieved end of waste status which can be the case for e.g. waste wood.

importing nearly 50% of its oil and 55% or more of its gas. During 2011, household electricity prices increased by around 16% and household gas prices by 25%, mostly due to global fossil fuel prices.

70. Generating energy from waste rather than from these fossil fuels, as with other renewables, provides a domestically-derived energy source and gives the UK greater fuel security, greater energy independence and protection from fossil fuel price fluctuations. At a more local scale, where energy-intensive industries use waste as a fuel, they can directly benefit from this same independence from fossil fuel price fluctuations.

Non-intermittent energy source

71. One of the issues with many sources of renewable energy such as wind or solar is their intermittent nature, if the wind is not blowing or the sun is not shining, they are not generating. Energy from waste, like biomass, can be used to generate constant planned amounts of energy 'base load'. However, as managing the waste on a continuous basis is also a key role, energy from waste plants cannot generally be switched on and off to meet demand peaks in the same way as gas, for example. There is potential for energy from waste plants with a greater degree of flexibility that could be suitable for providing peakload electricity such as those that could provide biogas or pyrolysis oil, which could be stored and used when needed.

Energy outputs

72. Energy from waste processes can either convert the waste to energy within the plant e.g. electricity and heat, or convert it to 'transportable' energy-rich commodities such as transport fuels, substitute (or synthetic) natural gas (SNG) for injection into the grid, hydrogen, or simple chemicals that could be used to make new materials. As noted, the greater the *overall* efficiency with which the waste is turned into useful energy, that is 'exportable' energy net of any energy required by the process to create it, the better the environmental performance of energy from waste.

73. Indirect generation of energy, such as burning waste to create steam to create movement in a turbine to generate electricity, is generally less efficient than direct energy generation e.g. burning a fuel to create movement, such as in a car engine or gas turbine. However, it will often require energy, 'parasitic load', to create the fuel for direct generation so the balance in terms of overall efficiency can be less clear and needs to be considered in determining the relative value and environmental benefit of the outputs. The level of financial risk associated with different outputs also varies as some technologies are less mature than others. The different energy products face a variety of barriers and Government provides a number of incentives to support them described below.

Electricity

74. The conventional way to generate electricity from waste is through direct combustion, with the heat used to produce steam to drive a turbine. This is indirect generation with an overall efficiency of 15-27%. Modern plants tend to be at the top end of this range. Steam generation from gasification is no more efficient than from incineration and due to lower operating temperatures, steam pressure and parasitic loads (i.e. energy

required to run the plant) the overall process may be less efficient than conventional incineration.

75. Processes such as gasification and pyrolysis produce a combustible synthesis gas (often abbreviated to syngas) which can either be used to raise steam as described above or more innovatively can be cleaned up for direct generation in a gas turbine or engine. Gas turbines or engines can provide greater efficiency in the energy generation step than steam turbines and thus there is potential for gains in overall efficiency if parasitic load, especially from the syngas clean-up, can be minimised.

Renewables Obligation (RO)

76. The RO is currently the Government's main policy instrument for supporting large scale renewable electricity in the UK. It places a legal obligation on electricity suppliers to purchase a steadily rising proportion of their electricity from renewable sources each year or pay a penalty. Suppliers demonstrate that they have met their obligation by surrendering Renewables Obligation Certificates (ROCs) received from renewable electricity generators, to Ofgem. The number of ROCs awarded to renewable generators differs between technologies, which are grouped into bands. Only the renewable fraction of waste is rewarded with ROCs and this proportion can either be measured, or for municipal waste, can be 'deemed' at 50% if agreed with Ofgem.

77. The bands of support vary by technology, according to a number of factors including their costs, relative maturity and potential for future deployment. Electricity-only energy from waste is not supported under the RO because such energy from waste plants are already well established and economically viable. Energy from waste with CHP (see below) receives 1ROC/MWh while the Advanced Thermal Treatments, such as gasification and pyrolysis receive 2ROCs/MWh (degressing to 1.9ROCs/MWh in 2015/16 and 1.8 ROCs/MWh in 2016/17). More efficient energy from waste, generating more electricity from the same waste, inherently receives greater support because ROCs are awarded per megawatt hour of electricity generation[46].

78. The Electricity Market Reform White Paper in 2011 set out proposals for a new support scheme for all low carbon electricity to replace the Renewables Obligation (RO). Support will be provided through long-term "Contracts for Difference". This will provide greater price certainty for low carbon generation which should ensure a long-term and viable return for investors, while reducing costs for consumers. Between the introduction of Contracts for Difference (CfDs) (from 2014) and the RO closing to new applicants in March 2017, new renewable generation will have a choice between the two mechanisms[47]

Heat

79. As with electricity, the conventional way to generate exportable heat from waste is through the direct combustion of waste, or syngas from gasification or pyrolysis, in a

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[46] For more information and guidance on the RO, which is administered by Ofgem, please see http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Pages/RenewablObl.aspx

[47] https://www.gov.uk/government/policies/maintaining-uk-energy-security--2/supporting-pages/electricity-market-reform

boiler system to produce steam. With further technological advances, syngas could be upgraded to methane to inject into the gas grid as a replacement for natural gas, with the heat generated directly in domestic boilers. This is potentially a more efficient process as the heat is produced in a high efficiency boiler at the point of need. The most efficient process, up to 90%, is to burn the waste in cement kilns where the heat is used directly in the process. There is a limited market for this approach. One of the most significant challenges for heat is finding the long term customers required to support the infrastructure costs.

Renewable Heat Incentive

80. This scheme provides a guaranteed long-term continuous income stream for renewable heat generators and producers of biomethane. This ensures that renewable heat is commercially attractive when compared to fossil fuel alternatives, in order to encourage the uptake and reduce reliance on fossil fuels. Phase 1 of the scheme is targeted at non-domestic heat users in the industrial, business and public sectors and covers use of municipal waste and biomass[48].

Combined heat and power (CHP)

81. Instead of generating electricity and heat separately, using a Combined Heat and Power (CHP) unit can give overall efficiencies in excess of 40%. This process captures and uses the waste heat produced during electricity generation. It is most economic when there is a continuous heat demand, such as on industrial sites in continual operation, or through district heating systems in mixed-use community developments, such as offices, retail space and homes.

82. In steam generating plants there is an inherent trade off between heat and electricity; the more heat produced the less energy available for electricity generation. Use of low grade 'waste' heat from the generating process will only marginally affect electricity production whereas supplying high grade heat to an industrial process could result in a significant reduction in generating capacity. The relative value of electricity and heat is therefore an important factor in determining how CHP plants operate and the incentives form part of this balance. Plants using gas engines are not affected in the same way.

83. Many energy from waste plants are built 'CHP ready' but a lack of heat customers, due to location or the relative cost of alternatives, meaning they operate in the less efficient electricity-only mode.

Transport fuels

84. Transport fuels can also be produced from waste. In this case the waste is converted into a fuel, with the energy ultimately released directly in the vehicle engine to create movement. Transport fuels are therefore potentially a more efficient use of the energy in the waste, provided creating the fuel itself does not require too much energy.

85. Syngas produced from the processes of gasification can be used to manufacture biomethane for use as a transport fuel. Other transport fuels such as hydrogen,

[48] https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/renewable-heat-incentive-rhi

ethanol, synthetic diesel or jet fuel can also be made from syngas. The process of pyrolysis can produce an oil (called pyrolysis oil) instead of a combustible gas. In the future, it may be possible to upgrade pyrolysis oil to produce petrol and diesel using oil refining techniques.

86. The greatest challenge is ensuring the syngas produced is pure enough for the chemical reactions required to make the fuel to work. This purification or ‘gas clean-up’ step can be energy intensive and reduce the overall efficiency of the process.

Renewable Transport Fuel Obligation (RTFO)

87. The RTFO obliges fossil fuel suppliers to produce evidence that a specified percentage of their fuels for road transport in the UK comes from renewable sources. Biofuel suppliers are awarded Renewable Transport Fuel Certificates (RTFCs) for the volume of renewable fuels they supply. These can in turn be sold on to any fossil fuel suppliers who have not supplied enough biofuel to meet their obligation for the year. In December 2011, the RTFO was amended to award two RTFCs per litre of waste derived liquid fuel or kg of gaseous waste derived fuels.

Chapter 3 – Energy from Waste Infrastructure

88. So far we have considered the history and policy context of energy from waste. At a more practical level there are a number of physical considerations required to deliver energy from waste including: waste as the fuel; a plant; a site to put it on etc. The decisions around these interlink, e.g. the type of waste fuel affects the technology that can be used, the throughput of waste dictates the scale of the plant, and the location both affects, and is affected by, the size and type of plant. This chapter will look at some of these factors and how they relate to each other in a bit more detail.

Fuel

89. Residual waste, i.e. the waste remaining once any recyclates have been removed, is the primary fuel for energy from waste. This can include municipal waste (waste from households and the household-like component of commercial and industrial waste) and/or commercial and industrial (C&I) waste. Municipal waste is collected by local authorities and collection regimes vary. Some authorities opt for separately collected recyclates whereas others might collect all the recyclates together (known as co-mingling) and sort afterwards. In either case the remaining black bags (or wheelie bins) form the residual waste. Other authorities may opt for less separation by householders and so collect a greater proportion of mixed waste and use some kind of mechanical sorting system to remove recyclates and leave the residual waste.

90. 'Black bag' waste may contain many different components including: food, garden waste, paper/card, glass, metals, plastics, textiles, wood and WEEE (waste electrical and electronic equipment). There will be significant differences in the composition of waste from one bag to another, between different locations and across seasons.

91. When brought together and mixed in the quantities required for an energy from waste plant these differences tend to even out and it is possible to estimate an average composition of waste for broad categories, such as household waste or commercial C&I waste. Source-segregated collections or higher recycling would change the relative proportions of different waste streams and thus the composition of the residual stream going to energy from waste. Similarly, C&I waste has a different composition. The composition of waste matters because it affects many of the overall properties of the waste including both the calorific value (CV) and the biogenic content of the fuel.

92. The calorific value of a fuel is a measure of how much energy is available per tonne of waste. The higher the CV, the more energy can potentially be captured from the waste. Different waste components have different individual calorific values i.e. food waste tends to have a relatively low value due to its high water content while plastic has a much higher one. Differing proportions of these will therefore change the overall calorific value.

93. Some technologies can cope with a broad range of calorific values and water content of their waste fuel; others require much more specific levels to operate efficiently. As noted in the context chapter the biogenic content of waste also affects the technologies that are suitable to deliver environmental benefits. Therefore having a

good understanding of composition in terms of CV and biogenic content is essential for designing an energy from waste solution.

Pre-treatments

94. Some authorities may choose to use some kind of pre-treatment on their residual waste to extract more recyclables and produce a fuel with a more specific CV and/or biogenic content. Types of pre-treatment include;

- Mechanical sorting plant
- Mechanical Biological Treatment (MBT)
- Mechanical Heat Treatment (MHT)

95. Pre-treatments generally use mechanical sorting and processing techniques to remove recyclates, remove moisture, and shred and/or homogenise the waste to create some kind of refuse derived fuel (RDF) or solid recovered fuel (SRF) [49]. In addition some, such as MBT, can remove biogenic material (e.g. food waste) for biological treatment which can be composted to stabilise the waste or used in anaerobic digestion to recover energy.

96. The removal of moisture, recyclates and organic matter (where applicable) will tend to increase CV of the refuse derived fuel. Generally mixed municipal waste has a CV of about 10 MJ/kg whereas RDF will have a value in the range 11 to 15 MJ/kg. Advanced conversion technologies generally require a more homogenous feedstock and so usually will require some form of pre-treatment prior to use.

97. Pre-treatment facilities require energy. When comparing possible energy from waste routes it is important to consider the impact of any pre-treatment required on the overall energy balance. Life cycle analysis can be used to determine if the energy used in separation can be offset by the carbon savings from the additional recyclable material collected. Pre-treatment facilities are sometimes co-located with energy from waste facilities and supplied by the electricity and/or heat generated on site from the waste.

98. Pre-treatment facilities can be set up to deliver different outputs depending on their principle purpose. Outputs from pre-treatments can include:

- Recyclates - glass, metals, plastics
- RDF/SRF – e.g. to tight specifications for high quality SRF for use in the cement industry
- Compost like output (CLO) or digestate from MBT or MHT plants - to partially/fully stabilise the biodegradable element of the waste

[49] Whilst SRF is a form of RDF, RDF (a generic term) is not always SRF. SRF has to meet technical specifications set out by the European Committee for Standardisation (CEN) - CEN/TS 15359 Solid Recovered Fuels. See http://www.cen.eu/CEN/Sectors/TechnicalCommitteesWorkshops/CENTechnicalCommittees/Pages/Standards.aspx?param=407430&title=CEN/TC+343 for further information.

- ‘Floc’ or fibre (the biodegradable elements of the waste stream) from MHT which has a number of potential uses including as a fuel

99. The markets for some of the outputs are well established, others less so. The recyclates removed in pre-processing can vary in quality which can affect their value. Generally recyclates from an MBT plant are of lower quality than from separately collected waste streams as they will be contaminated with bits of food and other materials, although technology used for separation is continually improving. Some MHT processes can produce higher quality recyclates as some materials can be ‘steam cleaned’ by the process. However, the process itself tends to be much more energy intensive.

100. Anaerobic digestion (AD) is one of the treatments that can be the ‘biological’ part of a mechanical biological treatment process. The organic-rich segment of the waste is separated and sent to an AD plant. This results in a partially stabilised digestate material and biogas (a mix of methane and carbon dioxide) which can be upgraded for use as a substitute for natural gas or converted into transport fuel. Most commonly biogas is used to fuel boilers or gas engines and produce heat or electricity, some of which may be used to power the rest of the MBT process.

101. Unlike digestate produced from anaerobic digestion of source segregated food waste which can be used as a fertiliser replacement on agricultural land, floc, digestate and CLO from residual waste, although a source of organic matter, cannot currently be used as a fertiliser replacement because they come from mixed waste. It has been possible to develop a series of tests (a Quality Protocol) for digestate from anaerobic digestion of source segregated food waste that demonstrates it is safe to use on land and can be declared ‘end of waste’. However, it is much more challenging to do this for anaerobic digestion from residual waste. Literally anything could have been mixed in the residual waste so a much larger battery of additional tests would be required to rule out all possible contaminants which would make it uneconomic. Therefore there is no parallel quality protocol for digestate from mixed waste. Such outputs are still classified as waste, although they can still be used for the restoration of landfill caps or brownfield sites.

102. To accompany this guide we have published updated Waste Technology Briefs which give more detailed information on the pre-treatment technologies[50].

[50] Waste technology briefs for the different pre-treatment technologies can be found at:

- Mechanical Biological Treatment (MBT) of Municipal Solid Waste https://www.gov.uk/government/publications/mechanical-biological-treatment-of-municipal-solid-waste
- Mechanical Heat Treatment of Municipal Solid Waste https://www.gov.uk/government/publications/mechanical-heat-treatment-of-municipal-solid-waste
- Advanced Biological Treatment of Municipal Solid Waste https://www.gov.uk/government/publications/advanced-biological-treatment-of-municipal-solid-waste

Energy from waste - the basic process

103. Energy from waste plants are complex and exist in many different configurations. However, they can usually be broken down into four basic components:

- A reception area to receive the waste and get it ready for combustion
- A thermal treatment – this essentially releases the energy from the waste
- Conversion to a transportable form of energy – electricity, heat, fuels
- Emissions clean up – ensuring waste gases are safe

The reception area

104. As the name suggests this is where the waste arrives at the plant. It will be enclosed to prevent smells escaping with shutter doors to allow trucks to deliver their loads.

105. The reception area will include some form of waste holding area, generally a very large pit, capable of holding several days' waste. This serves two purposes: to ensure there is always a stockpile of waste available to keep the plant operating; and equally to ensure there is somewhere to put waste deliveries should the plant temporarily shut down for any reason. Waste from the holding area is transferred to the thermal treatment.

The thermal treatment

106. We are all familiar with a burning candle but not necessarily with what is going on when it burns. There are actually two steps. Heat from the flame melts the wax and vapourises it. This hot wax vapour then reacts with the oxygen in the air. It is this reaction which creates more heat. This in turn melts and vapourises more wax, sustaining the cycle. Of course it doesn't just spontaneously burn. It needs a bit of heat from a match to get things going.

107. In simple terms the thermal treatment step in an energy from waste process is essentially the same. In an incinerator, heat (in this case usually from a natural gas burner rather than a match) gets things going, breaking down the waste into gases. These gases then react with oxygen in the air, creating more heat, and the cycle becomes self sustaining (and the gas burner can be switched off). The heat can then be used to boil water and make steam in the conversion step.

108. The advanced thermal treatments, gasification and pyrolysis, are slightly different. The first step is the same - heat converts the waste to gases - but in the second step the amount of oxygen is restricted so the gas cannot fully react. While some heat is produced, enough to keep the cycle going, the gases from the waste still contain a lot of chemical energy. This chemical energy can then be used in the conversion step.

The conversion step

109. This step takes the product of the thermal treatment, be that just heat from an incinerator or the gases from gasification, and turns it into a more useable form of energy.

110. The most common conversion step is to use the heat from the thermal treatment step to boil water and make high pressure steam. This steam can then be used drive turbines which generate electricity. It can also be piped outside the plant to provide a source of heat for other industries, offices or homes.

111. The gases from gasification can also be burnt to create steam and electricity in this way. However, the chemical energy in those gases can also potentially be used in a number of other ways. If it is burnt directly in a gas engine (very like a large car engine) or gas turbine (similar to a jet engine) it can be used to generate electricity directly, missing out the steam step where a lot of the energy is wasted. This is therefore potentially a much more efficient way of converting the chemical energy to electricity. That chemical energy can also be converted using catalysts to synthetic natural gas, transport fuels or chemicals, again at higher efficiency.

112. However, gas engines, gas turbines and catalysts like gases with very specific properties otherwise they don't work very well. Waste contains a whole range of things and as a result the gases from the thermal step will often be a mixture of things we do and don't want. There will therefore often need to be a 'clean up' step to either convert the chemicals we don't want to ones we do or remove them all together. This clean up can often be difficult, and energy intensive, reducing the efficiency and reliability of these more advanced conversion steps.

Emissions clean-up step

113. When we have a bonfire, as well as all the heat, there will be a lot of smoke and a pile of ash at the end. The smoke will contain the gases from the reactions with oxygen, primarily carbon dioxide but also a whole host of other chemicals, some of which may be harmful, and lots of small particles. The purpose of the emissions clean-up step in energy from waste is to ensure that unlike a bonfire, where these go straight into the atmosphere, the harmful chemicals and particles are removed and reduced to meet strict emissions limits before the gases go up the chimney. This is why, for example, the total emissions of particles and dioxins from all energy from waste plants in the UK in 2011 were less than those from bonfire night. The clean-up of emissions is discussed in more detail below.

The overall process

114. An energy from waste plant brings these separate steps together. As such the overall environmental benefits will depend not only on the thermal treatment but the energy conversion technology to which it is coupled and how much of the energy it produces is used running the clean-up and other processes. The important factor in assessing any plant is therefore the overall efficiency net of any energy required to run the process.

Energy from waste technologies

115. While the previous section set out the basics, this section aims to give a bit more technical information.

Incinerators

116. There are various types of incinerator. All involve direct combustion of residual waste in the presence of oxygen to produce energy. Temperatures are in excess of 850^{o}C and the waste is mostly converted to hot gasses, primarily carbon dioxide. These hot gases are used to heat water in a boiler to produce steam. The steam is then used to drive turbines to generate electricity, used directly to provide heat, or both (known as combined heat and power or CHP). Any non-combustible materials (e.g. metals,

glass, stones) remain as a solid, known as Incinerator Bottom Ash (IBA) that always also contains a small amount of residual carbon.

117. Energy from waste incinerators can be of variable size – the smallest operating plant in the UK treats about 25,000 tonnes per annum and the largest about 600,000 tonnes per annum. The size of the facility is dependent on a number of factors including: cost, waste catchment area, distance from wider waste sources and site constraints. They tend to have efficiencies in the range 18 to 27% when generating electricity only.

Advanced thermal treatments (ATTs)

118. ATTs tend to use either gasification and/or pyrolysis, although there are a wide variety of technologies within these categories. Typically, but not always, for both gasification and pyrolysis the waste needs to be treated first to give a physically consistent fuel (same shape and size). Typically gasification of waste occurs at temperatures greater than 650^{o}C, in the presence of limited oxygen resulting in partial combustion. This produces a synthesis gas (syngas) containing mainly carbon monoxide, hydrogen and methane. Typically, for pyrolysis, the waste is heated to between 300-850^{o}C in the absence of oxygen. The waste is broken down to produce a gas containing carbon monoxide, hydrogen, methane and a broad range of other volatile organic compounds (VOCs). Parts of this gas mixture may be condensed to form a pyrolysis oil.

119. Advanced thermal treatment facilities currently tend to be smaller (typically 30 - 60,000 tonnes per annum) than incinerators, as many ATTs are at the demonstration phase, although they can be much larger[51]. As with incinerators, they can generate electricity and/or heat by burning the syngas in a steam boiler and turbine system (with efficiencies of 10 – 20% for electricity only). However, the syngas (or pyrolysis oil) also has the potential to be used in other ways which use the energy more efficiently, such as gas engines or gas turbines. The major barrier to this is that the syngas needs to be ‘cleaned up’ to remove small amounts of tar and other chemicals that can damage the engines. This can be technically challenging and/or energy intensive.

Key differences and further information

120. To accompany this guide we have published updated Waste Technology Briefs which give more detailed information on the energy from waste technologies[52]. In general:

- Incinerators
  - are proven technology operating on a commercial scale in the UK and worldwide
  - tend to be larger scale facilities
- ATTs
  - can operate economically over a wider range of scales and are therefore potentially more flexible

[51] Air Products are constructing a 350,000 tonnes per annum 49MW gasification plant

[52] Waste technology briefs for the different energy from waste technologies can be found at:

- Incineration of Municipal Solid Waste https://www.gov.uk/government/publications/incineration-of-municipal-solid-waste
- Advanced Thermal Treatment of Municipal Solid Waste https://www.gov.uk/government/publications/advanced-thermal-treatment-of-municipal-solid-waste
- Advanced Biological Treatment of Municipal Solid Waste https://www.gov.uk/government/publications/advanced-biological-treatment-of-municipal-solid-waste

- o have the potential to generate much greater efficiencies through a range of outputs
- o are much newer technologies for waste with very little currently operating at a commercial scale in the UK, although there are currently several larger scale plants in the planning pipeline and under construction

Outputs

121. Energy from waste facilities produce a number of outputs. These include the desired products e.g. electricity or fuels, and by-products which may have value and/or require careful and costly management e.g. emissions, bottom ash.

Energy outputs

122. The energy outputs from energy from waste have been discussed in more detail in Chapter 2. Electricity is currently the most common commercial output from UK energy from waste plants. Some facilities do produce heat rather than electricity but consumers do need to be local to the facility producing the heat and a distribution system (network) is required to get the heat to them.

123. Many UK plants are combined heat and power enabled but often struggle to find heat customers. Demand for heat (or cooling) can fluctuate considerably so it is often better to produce heat in tandem with power or site plants next to industrial users who are more likely to need consistent supply. Generating heat and electricity together through combined heat and power typically produces much greater efficiencies (in excess of 40%).

By-products

124. These include incinerator bottom ash (IBA), air pollution control residues (APC), pyrolysis char (the solid residue remaining from pyrolysis) and slag or ash from gasification. APC is a hazardous waste which includes material such as fly ash from bag filters and lime used to neutralise acid gases. It could potentially be used in chemical treatment works or converted into aggregates (although this is an energy intensive process). The slag and/or bottom ash can be used as aggregate. Pyrolysis char is a hazardous waste so needs further treatment if it is to be used in some way rather than disposed off. Many facilities will also recover metals from the bottom ash which can then be recycled.

Emissions

125. Emissions are a key concern for many people and are often cited as a source of opposition to new energy from waste facilities. What can be emitted into the atmosphere from an energy from waste plant has for a number of years been tightly controlled under the Waste Incineration Directive (2000/76/EC). There are stringent limits for a number of potential pollutants, as well as demanding operating requirements which help to minimise pollution, that apply to all plants thermally treating waste whatever the technology. These requirements have been recast virtually unchanged into the Industrial Emissions Directive (2010/75/EU).

Flue gas clean-up

126. In order to meet the strict controls, the gases from energy from waste plants will undergo a number of clean-up steps before being released into the atmosphere.

127. Emissions are a key consideration throughout the energy from waste process. A typical plant will have a range of systems including ones to:

- control and improve the quality of combustion - reducing emissions of some pollutants
- remove acid gases (hydrogen chloride, sulphur dioxide)
- remove nitrogen oxides (NO_x)
- remove dioxins
- filter out particulates and particle-bound pollutants such as many heavy metals

128. The result of these systems is that the energy from waste plants are a low source of environmental pollutants and contribute only a small fraction of both local and national total emissions of particles.

129. For example, other much larger sources of small particulates include: vehicle exhausts; paved and unpaved roads; burning of conventional fuels in power stations; wood burning; open burning; industrial activities including grinding and milling; and construction works. They can also be formed by some chemical reactions in the air. Indoor activities, such as smoking, cooking, burning candles/oil lamps and fireplaces also produce these particles.

Health impacts

130. Health issues are always a major focus of the debate around energy from waste and the importance placed on minimising any health risks is reflected in the tight regulations surrounding emissions. It is also reflected in the high priority given to the ongoing process of conducting, evaluating and disseminating high quality science.

131. The Government is advised by the Public Health England (PHE)[53] on the impact on health of emissions to air from energy from waste plants. PHE has reviewed research undertaken to examine the suggested links between emissions from municipal waste incinerators and effects on health. It notes that modern, well managed incinerators make only a small contribution to local concentrations of air pollutants. The PHE's view is that while it is possible that such small additions could have an impact on health, such effects, if they exist, are likely to be very small and not detectable[54].

132. PHE will continue to review any new research findings on the health effects of incinerators published in peer reviewed journals and update its advice as necessary. It is good practice to regularly review the relevant published research to ensure the evidence underpinning regulation and advice is as strong and up-to-date as possible. The conduct and publishing of new research is a key part of an accepted ongoing scientific process to increase the evidence base, and doing so does not necessarily indicate that the level of risk has changed, that the associated advice should be altered, or a more precautionary approach taken.

[53] Previously known as the Health Protection Agency (HPA)
[54] http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1317140238599

133. PHE independently reviews each individual environmental permit application to ensure that the installation does not present a risk to public health. Comments are sent to the Regulator (the Environment Agency) for consideration as part of the permitting process.

134. The Food Standards Agency (FSA) assesses risks to the safety of the food chain. Having carried out detailed assessments of applications for energy from waste plants as part of this regulatory role over a period of about 10 years, the FSA has concluded that properly run, WID-compliant plants will generally have a negligible impact on levels of contaminants in food. In the case of very large energy from waste plants or where the location suggests there may be a high background level of contamination, the FSA may still advise additional measures, e.g. enhanced monitoring, to ensure that food is safe and that there is no risk of non-compliance with contaminants regulations.

Scale and site

135. The choice of site has a critical impact on the acceptability and viability of energy from waste, choice of technology and outputs.

136. While many sites may be relatively straightforward to connect to the electricity grid, a plant aiming to convert and upgrade syngas to biomethane and link up with the gas network may have a more limited choice of sites.

137. If heat is a major output then it is essential that customers for the heat are relatively close by. On average one kilometre of heat pipework can cost about £1m to install. Heat offtake is not common in the UK, unlike many other European countries. In the Nordic counties, for example, energy from waste plants are often sited in urban areas connected directly to the local heat grid. Several plants may feed into one grid to avoid problems with supply during downtimes. In the absence of these heat grids, co-location with industrial or commercial heat users offers a potential alternative solution.

138. Visual impact of energy from waste is increasingly recognised as an important issue and there is a tendency to move away from the big sheds and tall chimney approach towards innovative designs, more in keeping with the local environment. This is also relevant to the scale of the site: smaller scale plants can have much lower visual impact.

139. Transport links are a key concern for local residents and it is an issue which needs very careful consideration. One of the greatest impacts of any waste management site, not just energy from waste, is often not the site itself but the truck movements required to get the waste to the site. This is clearly linked to the scale of the site: all the waste has to get to the facility somehow, so the greater the throughput the greater the transport need. However, a larger facility doesn’t necessarily mean more truck movements. For example, a larger site might benefit from having a railhead or wharf/jetty which would not be economical for a smaller scale facility.

Chapter 4 - Developing an Energy from Waste Facility

140. The aim of this chapter is to set out at a high level the process that is followed when setting up an energy from waste facility, focussing primarily on where and why decisions are made. It is not designed to be a 'how to' guide for the process[55] but rather an explanation of that process, the regulatory framework which surrounds it, the rationale behind it, key players and where it can be influenced. It should be noted that the process described here is not unique to the consideration of energy from waste infrastructure but applies equally to the development of any strategic waste treatment infrastructure.

141. The overall process from waste management planning through to having an operational energy from waste facility is one which can take many years, in extreme cases a decade or more. The infrastructure, and the contracts surrounding them, have an even longer lifetime - 25 years is not an uncommon assumption. When trying to understand how this process works it is therefore vital that the decisions surrounding energy from waste are not considered in isolation but viewed as part of a long, multifaceted and ongoing process.

142. Those making decisions on energy from waste schemes - local authority elected councillors, their officials and other decision makers - may well change during the lifetime of a project. Similarly, the planning framework on which they are basing their decisions may also change. Understanding why earlier decisions have been made, the policies in place at the time and what outcomes they were trying to achieve is critical in reviewing, understanding and making decisions later in the process. It is equally important looking forward to recognise that such change may continue to happen and that projects will need to design in sufficient flexibility to adapt to it.

Options appraisal – Is energy from waste the right answer?

143. This is of course the question at the heart of the energy from waste debate which this guide aims to facilitate. This decision should take into account the issues and information set out in the previous three chapters and assumptions around waste growth and the likely development of activities higher up the hierarchy in environmental, economic and technological terms. It should also consider the principles underpinning future policy development set out in Chapter 5.

144. Whether energy from waste is actually right for the circumstances being considered is the first question the 'waste holder' would have to address. The waste holder for household waste is the waste (county and unitary) disposal authority, working with its local (district or borough) collection authorities; for commercial and industrial waste it would be the company who produces it, or more likely the waste management

[55] WRAP have published a guide for business looking to develop smaller scale energy from waste. http://www.wrap.org.uk/node/10693

company employed to deal with it. The exact process for answering this key question will be different depending on the waste holder, as will the weighting of different factors. Some proposed projects will be driven by technology providers or outputs rather than by 'waste holders', meaning these projects need to answer a slightly different question in terms of finding a source for their waste fuel.

The local authority process

145. For local authorities this decision making process on whether energy from waste is right for the circumstances would be part of the development of their waste strategies (in accordance with the waste hierarchy) and local plans. This provides the potential for advantages in terms of integrating energy from waste with solutions elsewhere in the hierarchy, by ensuring that all options for reuse, recycling and composting can be explored first. However, there are two significant constraints:
    - In areas that are covered by two levels of local authority (which have differing planning responsibilities), management of residual waste which could go to energy from waste would be the responsibility of the county council while the collection regime, which would dictate what is in that waste, is the responsibility of the district or borough council
    - By necessity local authority plans are to some degree limited by the administrative boundaries of the authority, and the timing of processes between neighbouring authorities may not be aligned. This can make it difficult to optimise infrastructure provision

146. Clearly, coordination between different tiers of councils and neighbouring authorities is very important in determining if energy from waste is the best solution. Historically, regional strategies would have been the route to deliver this coordination - in the future the duty to cooperate provision of the Localism Act 2011 is partly aimed at ensuring such coordination exists. This cooperation would commence at the earliest stages of developing waste strategies – which will cover not only household waste but also all other waste arisings in the area.

147. The development and revision of local waste strategies and plans represents perhaps the most important opportunity for the local community to be engaged in the process. The Government has made it clear that an up-to-date Local Plan (see planning section below) is the keystone of the planning system against which individual planning applications will be judged. Therefore, much of what happens later in the development process is influenced by what is identified as strategic policy set out in the Plan. This could include a specific technology being included or excluded. Where the controversial nature of energy from waste and similar waste treatment options is clearly recognised at this stage, with issues highlighted, debated and addressed, and potential sites identified, it can often lead to a much smoother process when specific proposals are made, potentially years later.

148. In developing these strategies the decision to use energy from waste is therefore not taken in isolation but as part of a wider appraisal of options for the full waste management process. This has the benefit of ensuring an integrated solution across the waste hierarchy to deliver the best overall waste management approach. However, it does mean that changing one part of that plan at a later date may potentially have much wider implications on the viability of other parts of the plan.

149. Significant importance should be placed on local authorities having engagement with their communities about the need and locations for waste management infrastructure (including energy from waste) before, during and after options are selected and plans developed.

The proximity principle

150. In considering whether energy from waste is to be part of a waste strategy a key question is whether this would require new infrastructure or if sufficient capacity exists elsewhere. This is where two issues often arise that, if poorly addressed, risk overcapacity at the local level. These are:
    - The proximity principle
    - The idea of a community taking “someone else’s waste”

151. As the proximity principle is often cited, by both sides of the energy from waste debate, as a supporting factor for their arguments, we feel it is worth setting out in some detail here.

152. The proximity principle arises from Article 16, “Principles of self sufficiency and proximity”, of the revised Waste Framework Directive (2008/98/EC), the EU legislation that governs waste management. The principle is often over-interpreted to mean that all waste has to be managed as close to its source as possible to the exclusion of other considerations, and that local authorities individually need the infrastructure required to do so. This is not the case. Indeed the final part of the Article itself states, “The principles of proximity and self-sufficiency shall not mean that each Member State has to possess the full range of final recovery facilities within that Member State”. Clearly if not even the entire country needs to have the full range of facilities, a specific local authority does not have to. While there is an underlying principle of waste being managed close to its source, there is no implication of local authorities needing to be self-sufficient in handling waste from their own area.

153. The proximity principle itself requires mixed municipal waste “...to be recovered in one of the nearest appropriate installations, by means of the most appropriate methods and technologies, in order to ensure a high level of protection for the environment and public health”. This has a number of implications:
    - “one of the nearest” means it doesn’t have to be the absolute closest facility to the exclusion of all other considerations, including cost
    - It may be justified to use a more distant solution if it provides a more appropriate method or technology to ensure overall a higher level of protection of the environment and public health
    - It applies to the network of facilities in the EU – it doesn’t mean a new facility has to be constructed if capacity doesn’t exist in that country. Equally the presence of capacity elsewhere does not preclude the development of a more proximate solution, especially as there is an aim of moving towards self-sufficiency within individual countries. We can export waste for energy recovery where it provides a better solution, but the availability of excess capacity elsewhere in Europe does not preclude us from developing capacity domestically
    - It says nothing about administrative boundaries (except the overall EU border). As such the nearest solutions may all be in administrative areas that are different from those in which the waste arises. Equally it does not imply a facility can only process ‘local’ waste

154. It is these final points that raise the other issue of accepting “other people’s waste”. There is nothing in the legislation or the proximity principle that says accepting waste from another council, city, region or country is a bad thing and indeed in many cases it may be the best economic and environmental solution and/or be the outcome most consistent with the proximity principle. There is an expectation on local authorities to work together (re-enforced by the need to demonstrate that they have done so through the Duty to Co-operate provisions of the Localism Act 2011) to ensure that waste needs across their respective areas are handled properly and appropriately. However, it is recognised that to many, accepting waste from elsewhere does appear wrong and it is often cited in objections to a planning proposal or to demonstrate that a plan is flawed.

155. The concern about accepting waste from elsewhere is often a proxy for more fundamental concerns about the scale of a plant on a given site and the impacts of transporting waste, particularly if it is perceived that taking waste from elsewhere is driving the development of a larger facility in a given community than would otherwise be required to deal with ‘their’ waste. A network of smaller facilities provides potential benefits such as shorter transport distances, proximity to heat users, reduced visual impact and a sense of a community dealing with its own waste. However, in some circumstances a larger plant may be the appropriate solution and there can be benefits from these also. For example: greater efficiencies; economies of scale; the ability to support alternative transport links such as dedicated rail heads; or the availability of large industrial heat customers. Getting the right size plant is a key part of the debate and should not be ignored, but an overemphasis on restricting facilities to ‘local waste’, particularly defining it by administrative ownership of waste and the boundaries and quantities this implies, can lead to sub-optimal solutions in terms of cost, efficiency and environmental impact; and a significant loss of long term flexibility.

156. The ability to source waste from a range of locations/organisations helps ensure existing capacity is used effectively and efficiently and importantly helps maintain local flexibility to increase recycling without resulting in local overcapacity for residual waste. For an existing plant, taking waste from a range of locations should be seen as a positive by keeping the plant running at maximum efficiency. In many places waste from a number of authorities is processed at the same site very successfully.

157. As set out in the Waste Review 2011 for England, it is not unreasonable that the community hosting a facility, and receiving a proportionately greater share of the impacts, should also receive a greater share of the benefits. Equally if opting for a number of smaller more costly solutions, the community should be aware of and be prepared to accept any related extra costs. While these trade-offs could be addressed once a specific proposal is made, considering them in the early stages of planning and waste policy development has the potential to deliver better overall outcomes.

Procurement

158. The procurement process for local authority waste infrastructure can seem to the outsider a very closed process that takes a significant amount of time and money, and which at the end suddenly produces a fully formed proposal with little or no apparent opportunity to influence or debate. This section aims to set out briefly what the process entails.

159. Once the waste strategy and policies have been adopted, the first step in any procurement would be to develop the specification which sets out what it is the local authority wants. This will come out of the waste management strategy and sometimes will not be just for the energy from waste plant but for the delivery of the overall waste management process. Generally the specification would not commit to, or rule out, using specific technologies unless this was stated in the strategy. Instead it will be designed in such a way as to allow bidders to determine the best way to deliver the specified outputs.

160. The aim of the procurement process is to deliver the best outcome for the authority while ensuring a level playing field for the bidders to create sufficient competitive pressure. Procurement of large public contracts is governed by regulations that operate across the EU and has to be open to bidders from all Member States. As such, much of the process itself is very rigid, with all the requirements set out in advance. This is to avoid changes part way through the process, once details of bids are known, that could be seen as favourable to a particular bidder.

161. Given the complexities surrounding waste management facilities, including energy from waste, there is a wide range of advice and support available to help with procurement. Many consultants specialise in this type of process and are often utilised by local authorities. There is also a substantial amount of information and support on the internet both to assist those going through the process, and to explain it in more detail than here. There are communities of expertise and information such as the Waste Improvement Network[56] and government guidance, for example from the Waste Infrastructure Delivery Programme (WIDP)[57].

162. Once an authority has agreed its specification it will be advertised across Europe, and companies will bid for the contract and will gradually be whittled down to two companies who will submit final tenders. These tenders are carefully evaluated and a preferred bidder chosen. It is important that no fundamental changes are made to the bid during this period as this could invalidate the 'fairness' of the procurement process.

163. As with any large infrastructure project, procurement can be costly and take a significant period of time with limited scope for external communication or consultation. It is this apparent, but necessary, step from a broad output-based specification to a clear proposal with only limited scope for modification that can give rise to the 'behind closed doors' feel of the process. This is why identifying and taking opportunities to influence the adopted plans and policies prior to procurement commencing is so vital.

164. The nature of the process also limits the level of engagement the bidders can have with the community in developing and explaining their proposals before contracts are signed, despite a sometimes strong desire to do so.

165. For a merchant plant i.e. that not funded by government (local or national), there is no need for such a procurement process. The plant will be bidding for contracts from

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[56] http://www.win.org.uk/site/cms/contentChapterView.asp?chapter=1
[57] https://www.gov.uk/government/policies/reducing-and-managing-waste/supporting-pages/waste-infrastructure-delivery-programme

private companies or other waste holders. In a sense the merchant plant comes first, then seeks waste to fill it, rather than in the local authority process where the waste exists and the local authority is seeking a solution to manage it. Although, as set out below, it is difficult to finance any plant without certainty as to where the waste is coming from.

166. Most of the remaining process set out below applies to both municipal (local authority contracts) and merchant plants.

Financing

167. The most critical part of any infrastructure project is ensuring the finances are secure. This can be challenging for waste treatment projects, particularly where more innovative technologies are involved. The demands required by project finance can significantly constrain the choices available to a project.

168. There are three main ways to finance energy from waste infrastructure. It is not uncommon for a project to use a mixture of routes.
    - Debt – borrowing money from a bank and paying interest (like a mortgage)
    - Equity – investors putting money into a project with a view to getting a share of the profits or dividends
    - On balance sheet – a company using its own resources to fund the project or to guarantee loans

169. Newer waste conversion technologies often claim higher efficiencies and more flexible outputs, e.g. through clean-up and use of syngas. However, in order to manage their risks, financial lenders, such as the banks or equity investors, are much more interested in having proven track records of full scale operation in the UK, which most of these technologies have yet to achieve. Building a track record for the newer technology is of course difficult to do without finance to build such plants in the first place, leading to a vicious circle that can be hard to break, especially as such technologies are often driven by relatively small companies that cannot follow the on balance sheet route of financing.

170. Financial lenders often want to see long term waste contracts for a project. This is because a primary source of income for an energy from waste project is not just the power produced but the fee charged for accepting the waste – the gate fee. This gate fee is charged on a 'per tonne of waste' basis and contracts usually also include guaranteed minimum tonnages per year. Together this gives the plant a minimum guaranteed source of income which the investors are looking for. Such long term contracts are usually only available for local authority waste. Commercial waste contracts are generally much shorter, making it harder to finance projects taking primarily commercial and industrial waste.

171. Local authorities in their specification for such long term contracts will set tough requirements in terms of guarantees to take waste (operational availability) and company track record (they want to know the company will always be there). This low risk approach is understandable - they are spending public money and they can't have waste piling up if something goes wrong. However, this inevitably makes it harder for smaller companies with innovative (commercially unproven) technologies to

meet the requirements of the procurement specification and steers the larger waste companies towards offering proven technology outcomes.

172. The minimum guaranteed tonnages that tend to form part of waste contracts (known as ‘put or pay’) are often cited as a potential barrier to greater recycling. However, they are a commercial reality required to deliver the finance for many large-scale infrastructure developments including energy from waste plants and are therefore hard to avoid. The potential negative consequences of these requirements can, however, be avoided if contracts provide sufficient flexibility for the local authority or waste contractor to top up with waste from other sources, be that commercial waste or negotiating to accept waste from other authorities. It is where the need for such guarantees is combined with an inability to accept waste from other sources, for contractual, planning or philosophical reasons, that this becomes an issue. Such restrictions on waste sources should therefore be avoided.

173. While these realities of project finance could, if not properly managed, lead to *local* overcapacity, they also make it unlikely that the market will deliver *national* overcapacity. It is very challenging to deliver the finance necessary to build a plant without evidence that the waste will be there to supply it over a long timescale. It is therefore likely that the money to deliver infrastructure will dry up before the waste does.

174. Government has sought to address some of the barriers around financing energy from waste projects in a number of ways. Waste Infrastructure Credits (WIC)[58] has been a key route to support local authorities seeking to develop the infrastructure required to meet landfill diversion targets. When fully operational, the WIC will have helped support the development of 28 infrastructure projects with a total capacity of approximately 5.3 million tonnes and an installed power capacity equivalent to about 290MW.

175. Moving forward, Government continues to put significant resources into overcoming barriers to delivering further market-driven investment aimed at optimising the role of energy from waste in the hierarchy. The Green Investment Bank has waste, including energy from waste, as one of its key investment areas. There will be a particular focus on projects that would struggle to find conventional finance, such as those looking to utilise commercial waste or innovative technologies. However, the Bank will still have strong lending criteria in terms of the robustness of the business case, the expected return on investment and the level of additional private finance leveraged. It will not fund speculative projects.

176. There are a range of other government and industry funding sources available for energy from waste projects ranging from funding towards research and demonstrator level projects from organisations such as WRAP and ETI, to assistance in delivering full-scale plants from sources such as the Regional Growth Funds and the London Waste and Recycling Board.

177. Of course many of the issues surrounding the finance of energy from waste projects are much more complex than set out above. However, these few examples highlight some of the complexities and constraints finance imposes, and particularly how it can

[58] Formally known as the waste Private Finance Initiative (PFI), England only

lead to solutions which on paper look attractive being much more difficult to deliver in reality.

Planning

178. The planning system aims to help ensure that development takes place in a way which balances environmental, social and economic impacts, ultimately securing sustainable development. It is not a system of absolutes and, while there is much that has to be legally considered in the planning process, ultimately decisions come down to a question of balancing the evidence.

179. The planning system has two key elements:
    - Preparing development plans (local plans)
    - Managing development (through determining planning applications)

180. Virtually all planning applications for waste development, including energy from waste facilities, are made to the county council or unitary authority (as the waste planning authority) rather than the district or borough council. Details on this planning regime are set out in this section. However, the largest plants (i.e. facilities that have a generating capacity of more than 50MW) are decided under the regime set out in the Planning Act 2008 by the National Infrastructure Directorate of the Planning Inspectorate[59]. That process is not discussed further in this guide.

Local plans

181. An application for planning permission is both what most people commonly recognise as ‘planning’ and where many people first encounter energy from waste as the result of a specific proposal. However, this stage of assessing development proposals is actually the final stage of a much larger planning process, and much of what happens as part of this application stage will be framed by the earlier steps.

182. We have a ‘plan-led’ planning system, the foundation of which is the preparation of strategic plans by local authorities which set out how land will be used in their local areas. These plans must take account of national planning policy[60] and form the local policy framework upon which decisions on individual planning applications must be made. Planning law requires that applications for planning permission have to be decided in line with the development plan unless material considerations indicate otherwise (this might come into play, for instance, when a local plan is very out-of-date). These local plans will include provision for waste management facilities, and

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[59] see http://infrastructure.planningportal.gov.uk/ for details

[60] The National Planning Policy Framework (NPPF) sets out the Government’s planning policies for England and how these are expected to be applied https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf National planning policy on waste is published separately. Current national planning policy on waste is set out in Planning Policy Statement 10 Planning for Sustainable Waste Management https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/11443/1876202.pdf The Waste Management Plan for England (published in December 2013) https://www.gov.uk/government/publications/waste-management-plan-for-england and PPS 10 together meet the planning requirements of the revised Waste Framework Directive. New waste planning guidance which will replace PPS 10 is due to be published in 2014. Decision makers need to have regard to all these documents when considering planning applications in addition to local authority local plans.

developers should consider the local plan from the outset and aim to develop solutions which are consistent with it.

183. The plan will usually identify potential sites for waste infrastructure. However, some plans will identify broad areas, leaving the identification of a specific site to a later stage, or develop precise criteria to guide the location of energy from waste facilities. Ideally the needs of energy from waste would be specifically considered, particularly in terms of ensuring enough sites are included with good potential for use of heat through combined heat and power (CHP). Doing so will ensure that if energy from waste is adopted, sites are available to maximise heat offtake and therefore improve its environmental benefits.

184. When energy from waste projects are proposed, their potential location and other attributes will be strongly influenced by these plans and other policy, such as the presumption in favour of sustainable development, contained in the National Planning Policy Framework. More information on what goes into these plans and the planning process can be found on the Planning Portal[61]

185. It is vital that the local community is fully engaged in developing these local plans, otherwise a significant opportunity to shape proposals for future energy from waste and other facilities will be missed. Where the importance of these early steps has not been recognised, it is not surprising that communities often feel faced with a ‘fait accompli’ when it comes to a specific proposal being submitted. Similarly, some developers feel frustrated that despite doing their best to meet the requirements set out in these plans, which are supposed to reflect local desire and need, they meet significant opposition.

186. It is an important local authority role to ensure communities are fully aware of the implications of these early stages of the planning process and are engaged in shaping them. Also that these plans are up-to-date reflecting current local requirements and effectively integrated with wider local and national waste management strategies.

187. This early step in the process of developing local plans is critical to shaping proposals. This is especially pertinent given the emphasis placed by Government on an up-to-date Local Plan being the keystone of the planning system against which individual planning applications will be judged.

Planning permission

188. Planning permission is required prior to any energy from waste plant being constructed. Discussions between an energy from waste developer and the waste planning authority would have commenced significantly ahead of the submission of an application for planning permission. The aim of these discussions would be for the developer to understand the local situation and requirements of the Local Plan so any application can effectively address these and maximise the chance of being passed.

189. It has long been best practice for developers also to consult directly with the community to understand their needs and concerns. It is important to have clear expectations from both sides as to what can be achieved. Developers need to be responsive to the concerns of the community, while the community needs to

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[61] www.planningportal.gov.uk

recognise the limitations of the development and the constraints within which it is being proposed. Many of the issues identified in this guide could be raised and developers should be ready and able to address them. If done early enough these discussions can help influence important aspects such as the design and visual impact of the facility, transport links etc. and local knowledge can be exploited to the benefit of both the developer and the community. This consultation and engagement should also be considered a long-term, ongoing process.

190. The planning application for an energy from waste plant itself is likely to be extensive and detailed. Once a planning application is submitted, views will be sought from the local community and a range of statutory and other consultees. The Waste Planning Authority will consider all the relevant issues and representations, and make a decision, normally with the involvement of elected Councillors, in accordance with the local plan for the area as well as any other material considerations (which can include the policies in the National Planning Policy Framework). Community Infrastructure Levy payment may also be required, which allows local authorities to raise money from developers to fund a wide range of infrastructure that may be needed as a result of development e.g. new or safer road schemes, flood defences, green spaces etc.

191. If an application is refused it is possible for a developer to appeal the decision to the Planning Inspectorate. It is not possible for a third party to appeal against the granting of a planning permission, although it can be challenged in the courts through judicial review. However, for a challenge to be successful the court would need to be satisfied that the decision maker had made an error in law in reaching their decision, e.g. misinterpreting or misapplying policy, or failing to take account of an important consideration.

192. Whilst waste planning authorities are responsible for making planning decisions on waste infrastructure, the Secretary of State has the power under section 77 of the Town and Country Planning Act 1990 to 'call-in' planning applications (for example, if they conflict with national policies on important matters) and determine them him or herself. Planning appeals can also be 'recovered' for decision by Ministers. The decision of the Secretary of State on whether to grant planning permission following an appeal or the call-in of an application is informed by the report of an Inspector, who nearly always holds a public inquiry into the proposal, and the evidence provided to him or her.

Permitting

193. In simple terms, while planning permissions are required to build an energy from waste plant, environmental permits are required to operate it. However, there are inevitably some overlaps in this definition. It is possible for a project to gain one approval and not the other as they examine different aspects of the project. However, as there would be no point in building a plant that can’t be operated, environmental permits like planning permission need to be obtained prior to final construction and the two processes can happen in parallel.

194. The Environment Agency (EA) is the regulatory authority for Environmental Permits in England and the system is governed by The Environmental Permitting (England and Wales) Regulations 2010. As permits relate to operation of the plant, it will be the organisation in charge of day-to-day operation who applies. This applicant may be

different from the planning applicant. The Environment Agency has developed some guidance on how planning and permitting fit together[62].

195. Environmental permits contain conditions to protect the environment and human health. Energy from waste permits can set controls on a range of factors including:
    - Waste inputs – type, quantities, annual throughput
    - Process controls – how activities on-site will be managed e.g. flow of waste to ensure complete combustion
    - Emissions limits – air, land and water
    - Performance monitoring – ongoing measurement of activity

196. As with planning applications, there would be an opportunity for interested parties, including the public and a number of statutory consultees, to comment on the application. These comments are considered alongside the information in the application before a final decision is reached. More information on the permitting process can be found on the Defra website[63].

Building and Commissioning

197. Once all the necessary permissions, finance and contracts are in place, construction can commence. At this stage an energy from waste facility is like any other major construction project, as are the issues and regulations that surround it. The construction itself is monitored by the relevant authority to ensure it is complying with permissions, is to the appropriate standards, and that the site and boundary are safe for workers and the environment. It is best practice that engagement with the community continues throughout the construction phase to ensure any issues are identified and addressed. Especially if there are any changes to the design or construction timetable that might affect local residents e.g. through noise or traffic movements.

198. Commissioning is the next important step in the process. This is the step where the facility is tested to verify it functions according to its design specifications. Various factors are examined at this stage including for example:
    - Monitoring of the combustion conditions to ensure they operate as designed to meet emissions limits
    - Continuous or regular monitoring of a wide range of emissions themselves to ensure they meet or beat allowed limits
    - Monitoring of noise levels in the local environment to ensure it complies with permits.

199. Any issues that arise are addressed and retested. Commissioning can be a lengthy process as the functioning of the plant is optimised. Only if the plant can be demonstrated to meet all the necessary permitting conditions will it be allowed to enter full operation.

[62] https://brand.environment-agency.gov.uk/mb/EX9lFH
[63] https://www.gov.uk/government/publications/environmental-permitting-guidance-core-guidance--2

Operation

200. Once fully commissioned the plant will enter its operational phase, which can typically be 20-30 years. Many plants include visitor or educational centres to ensure long-term involvement and engagement with the community throughout operation.

201. During its operation the plant will be monitored on an ongoing basis through a range of processes to ensure it is compliant with its environmental permits.

202. There will be limits set for the emissions for a range of substances. These will often include continuous monitoring limits i.e. at any given point the level of a substance must not exceed a given level; 'spot checks' where a substance is measured and a given limit must not be exceeded; and periodic limits e.g. the total emissions in a day, a month, a year, must not exceed certain levels.

203. Many plants will publish their emissions statistics on a regular basis and some will make real time monitoring information available in visitor centres or even on the web.

204. The EA regulates municipal energy from waste plants and all but the smallest incinerators (which are regulated by the local authority). It aims to ensure operators comply with their environmental permits, which implement requirements of the Industrial Emissions Directive[64].

205. The Industrial Emissions Directive sets mandatory emission limit values (ELV) and monitoring requirements. Plants must measure a number of parameters at a range of intervals, many continuously. Emissions measured include:
   - total particulate matter (TPM)
   - sulphur dioxide (SO_2)
   - oxides of nitrogen (NO_x)
   - hydrogen chloride (HCl)
   - carbon monoxide (CO)
   - total organic carbon (TOC)
   - hydrogen fluoride (HF)
   - heavy metals
   - dioxins
   - furans

206. Additionally, the EA can require operators to measure ammonia and nitrous oxide continuously, and often does so. The EA can also require operators to measure dioxin-like polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAH), and particulate matter, i.e. PM_{10} and $PM_{2.5}$. Operators must also measure other parameters, such as the concentration of oxygen, and furnace temperature.

207. The operator must stop burning waste if the continuous emission monitoring systems break down and cannot be fixed within a limited time. Permits set reporting requirements to demonstrate compliance, e.g. with emission limit values. All

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[64] Prior to January 2013 equivalent controls were applied through the Waste Incineration Directive (WID)

emissions data must be reported to the EA, which checks compliance and places it on public registers.

208. Many other factors are regularly assessed and monitored ranging from noise and odour to the regular maintenance and calibration of the monitoring equipment itself.

209. Breaching any of these limits or environmental permit conditions will result in investigation by the permitting authority and may result in action ranging from a warning for minor breaches providing they are rapidly corrected, to the plant being shut for significant or persistent breaches.

210. Breaching any permit condition, including an emission limit value, must be reported to the regulator without delay. The first priority in such situations would be quickly to take the steps to assess whether there will be any impact on the environment and/or human health.

End of plant life

211. Most plants will be built with a minimum planned lifetime - this will usually be related to the length of the contract or the period for return on investment. However, the minimum planned lifetime is not necessarily the same as the physical lifetime of the plant and many plants will have the potential to operate for longer.

212. Over the average 25 year planned lifetime of an energy from waste plant, the balance of the many factors that need to be considered to determine if it is the best solution may have changed. In assessing the benefits and impacts, they should be considered over its whole lifetime and with an awareness of the context in which the original decisions were made. However, once that planned lifetime has been reached it should not be automatically assumed that extending a plant lifetime beyond that originally envisaged will continue to deliver the same outcomes, although it may do. At this point all options including continued use, modification, through to closure and development of a new solution should be considered.

Chapter 5 – Future Policy Direction

213. By its nature energy from waste bridges two sectors both of which are evolving. It has its roots firmly in waste management but is becoming of increasing importance to energy generation. Waste management is changing to be much less about how we get rid of things we no longer want and more about managing discarded resources back into the economy. Likewise energy generation is evolving to make best use of renewables, novel fuels and different energy outputs always with an eye to energy security.

214. The Government sees a long term role for energy from waste both as a waste management tool and as a source of energy. Energy from waste is in a unique position to fulfil a range of objectives across a number of Government departments. For Defra it helps divert waste out of landfill, for DECC it is a potential source of low carbon energy, for DCLG it can be a contributor to waste planning objectives and for DfT it is a potential source for a variety of transport fuels. It can also contribute to growth in the waste and energy sectors as well as the construction sector through infrastructure development.

215. In this context, now is a particularly good time to consider the future direction of energy from waste. The need to meet 2020 landfill diversion targets for biodegradable waste has been a major driver for Government waste policy and infrastructure development over the last ten years or so. The landfill tax is a key instrument to meeting the target along with other policies and initiatives, such as part funding the delivery of waste infrastructure and services using Waste Infrastructure Credits (WICs)[65]. We are on track to meet our landfill diversion targets for 2020, and sufficient treatment infrastructure is being delivered to achieve this.

216. There are wider societal and environmental benefits associated with energy generation and use that will drive energy policy and impact on energy from waste. Energy from waste will be subject to policy developed to address these drivers and therefore so will decisions on how best to maximise the energy use from energy from waste. Examples might include renewable energy targets and how these are used amongst electricity, heat and transport fuels. Energy from waste in particular has the potential to deliver low carbon energy in a cost effective way and as a non-intermittent source helps provide energy security.

217. There is therefore a range of policies which waste management and energy generation companies have to navigate. With the average contract life time of an energy from waste plant being 25 years, potential investors need to be mindful of Government's vision for the future.

218. In this Chapter we set out the underlying principles which are driving current Government policy on energy from waste and are likely to remain key considerations for Government and the sector going into the future. We have aimed to interpret the principles into practical considerations for the sector and also set out the implications of new Defra modelling on the future direction of energy from waste.

[65] Formerly known as the Private Finance Initiative (PFI).

The Principles Underpinning the Policy

219. There are four key principles that underpin current thinking on energy from waste and which are expected to remain critical to the development of a sustainable policy into the future. These principles are outlined in the box below.

> I. Energy from waste must support the management of waste in line with the waste hierarchy.
>
> II. Energy from waste should seek to reduce or mitigate the environmental impacts of waste management and then seek to maximise the benefits of energy generation.
>
> III. Government support for energy from waste should provide value for money and make a cost effective contribution to UK environmental objectives in the context of overall waste management and energy goals.
>
> IV. Government will remain technology neutral except where there is a clear market failure preventing a technology competing on a level footing.

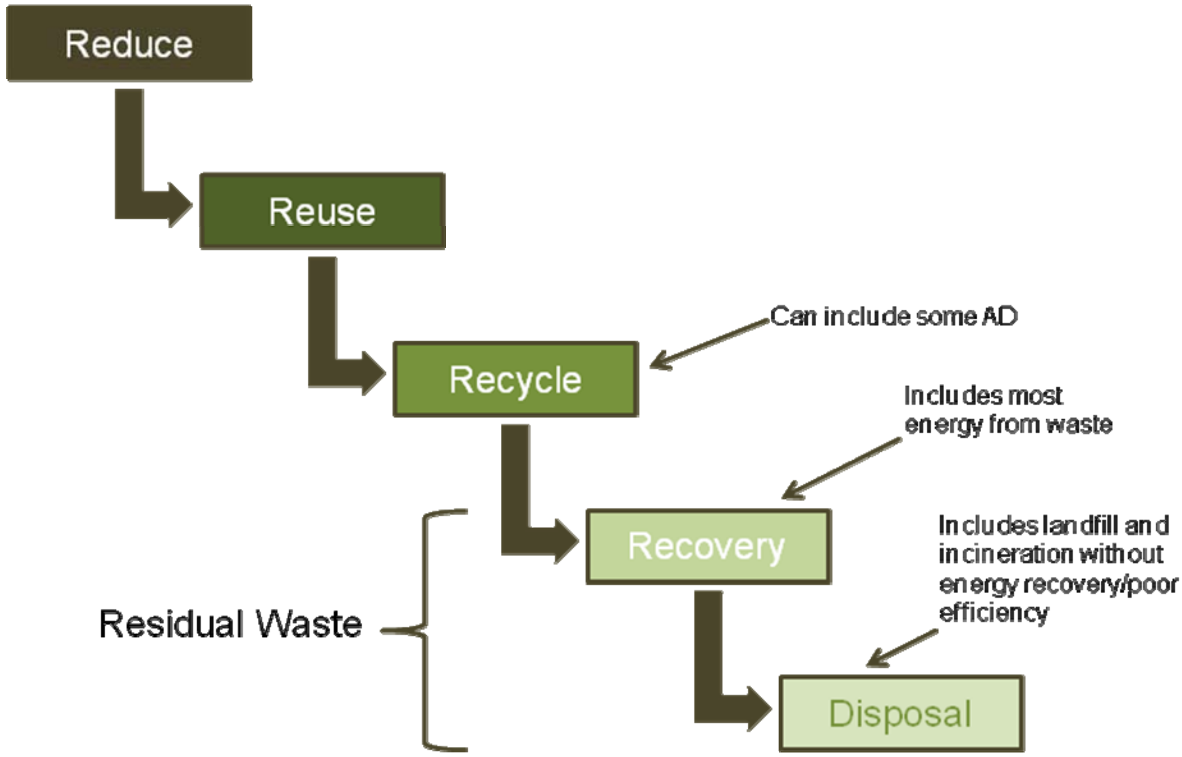
220. Government would like to encourage developers to consider these principles as a key part of the decision making process around future development of new projects and operation of existing plant.

221. This means that from a sector viewpoint infrastructure proposals, technologies and services that are aligned with these principles should be on a much firmer footing and more robust to future policy than those which are not.

222. The following sections look more closely at each of these principles and identify key considerations for the energy from waste industry, and policy making, going forward.

Energy from waste within the waste hierarchy

223. The first principle is “Energy from waste must support the management of waste in line with the waste hierarchy”. The waste hierarchy, illustrated below, has been one of the key themes in waste management policy for a number of years. Its role has developed over that time and it has now become enshrined in law, for more detail see Chapter 2 of this Guide.



Energy from waste as Recovery

224. Energy from waste is generally seen as recovery but in fact it can sit in a number of places within the hierarchy depending upon the feedstock and the efficiency with which it is performed.

225. Anaerobic Digestion of source segregated waste while technically recovery can in certain circumstances count towards recycling targets and actually be better environmentally. Conversely waste incineration where energy is either not recovered or done so inefficiently is classed as disposal.

226. The Government sees a long term role for energy from waste. To be consistent with the first principle this long term role needs to be based on energy from waste that at least constitutes recovery not disposal. This should therefore be a key consideration for both new and existing projects. To be classed as recovery, energy from waste facilities must meet the requirements set out in the waste framework directive, for example through attainment of R1 status[66].

227. Having established the position of energy from waste within the hierarchy it becomes clearer how it must support the management of waste across the hierarchy. It must at the very least not compete with recycling, reuse and prevention and should ideally support them. At the same time recovery through energy from waste needs to be pulling waste out of less environmentally sound disposal routes, particularly landfill but also incineration with insufficient energy recovery.

228. There is an inherent tension between the waste hierarchy and the drive for energy. Maximising energy generation has the potential not only to pull waste out of disposal

[66] http://ec.europa.eu/environment/waste/framework/energy.htm

but also to pull waste down the hierarchy away from uses that on a lifecycle basis are more beneficial. This tension can be overcome, as demonstrated by the number of countries where high recycling coexists with high energy from waste, at the expense of landfill (see Chapter 2). This first principle addresses this tension by ensuring that the hierarchy takes precedence, reflecting its legal status. The approach in the 2011 Waste Review[67] sets out how we should be seeking to "get more energy out of the waste going to recovery rather than more waste in to recovery".

229. Increased prevention, reuse and recycling, does not necessarily mean less waste feedstock for energy recovery. There is a large amount of potentially combustible residual waste still going to landfill that could be utilised in energy recovery. The Government considers there is potential room for growth in both recycling and energy recovery – at the expense of landfill.

230. This consideration is particularly pertinent at the local level where the presence or plan for an energy from waste facility is often perceived as a potential brake on initiatives to optimise local recycling. However, local waste successfully diverted to more beneficial processing higher up the hierarchy can be replaced by participation in the wider waste market through further diversion of other sources from landfill. Thus the need to "feed the beast" to maintain economic energy from waste operation should not impede continuing improvements in prevention, reuse and recycling of the host community.

Why not just recycle everything?

The waste hierarchy does not say everything should be recycled and not go to recovery regardless of cost or practicality.

If material is so contaminated that the resources required to clean and process it for recycling would outweigh the benefits of recycling then it may be better going to recovery.

However, if there is a cost effective, practical route for ensuring that material can be collected in a less contaminated state so that recycling is viable, the presence of a planned or operational energy from waste alternative should not impede doing so.

231. The regulations surrounding the hierarchy do allow for deviation for specific waste streams in order to deliver the best environmental outcome[68], usually through the use of life cycle analysis. This would be consistent with the first principle.

Impact of the hierarchy on the composition of energy from waste feedstock

232. The composition of residual waste is by its nature defined by the waste that is prevented or taken out to be reused or recycled. As recycling becomes economic and practical for a wider range of waste types the composition of that which remains will

[67] https://www.gov.uk/government/publications/government-review-of-waste-policy-in-england-2011
[68] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69404/pb13529-waste-hierarchy-summary.pdf (page 6)

inevitably change. Any long term approach to waste management needs to take into account the fact the picture is not static and be flexible to it.

233. Changes in composition due to enhanced recycling will alter the properties of the residual stream in ways such as calorific value and biogenic content. Energy from waste needs to ensure that its requirements do not act as a brake on such positive changes. Approaches need to be flexible enough to cope with such change or to seek out routes to further manipulate the waste stream to rebalance properties, ideally we should be minimising the fossil content of waste going to energy recovery. This could be through seeking necessary streams from landfill or supporting recycling of other components that redress the balance e.g. removing a greater proportion of fossil plastics to make up for a loss of biogenic material.

234. As discussed below the composition of waste going to energy recovery is key to its environmental benefits and much greater consideration needs to be given to it. In considering waste composition the environmental requirements should be given as much weight as the technical plant requirements. Having a higher calorie fuel may make sense from an energy production viewpoint but if it is due to a higher plastic content creating fossil emissions it may be environmentally detrimental. This consideration needs to extend beyond the plant to the pre-processing and collection regimes that ultimately dictate waste composition and quality.

Summary of key considerations arising from the first principle

235. To be consistent with the principle of energy from waste supporting waste management in line with the hierarchy, key considerations for the long term development or operation of an energy from waste solution are:

- The ability to at least qualify as recovery in the waste hierarchy
- To support and not compete with effective prevention, reuse and recycling and not be a brake on their growth
- Meeting the requirements of the hierarchy will be an important test for any policy or project aiming to increase the energy produced from waste
- The energy from waste sector needs to think beyond its own boundaries working with partners along the supply chain. It must be flexible to changing waste composition or drive recycling and/or collection processes that allow it to manipulate the composition of residual waste (the energy from waste feedstock) without compromising the above.

Reducing the environmental impacts then maximising the energy

236. The second principle is “Energy from waste should seek to reduce or mitigate the environmental impacts of waste management and then seek to maximise the benefits of energy generation”.

237. Policies and processes that influence what we are doing up the hierarchy in line with the first principle will impact on the type of waste remaining in the residual stream. This composition of materials will in turn impact on the optimum solution for that residual waste.

238. This principle is about ensuring that energy recovery is the best solution for the residual waste, and then where this is the case that the most is made of the resource it represents. This means understanding and potentially manipulating the nature of the residual waste and ensuring it is suitably matched to the right type of process and energy outputs to minimise the environmental impact. Where this can't be done the impact needs to be mitigated.

Energy from waste versus landfill

239. There are two main management routes for residual waste – energy recovery or landfill. Pre-treatments such as Mechanical Biological Treatment (MBT) offer an alternative route but in addition to recyclates will result in material that goes to landfill and/or energy recovery. The composition and fate of these outputs, particularly refuse derived fuels (RDF) needs to be considered in the same context as residual waste.

240. Recovery's place above landfill in the waste hierarchy is primarily a function of the relative carbon benefits of the two approaches. However, this is not a simple picture and factors such as the efficiency of the recovery process can affect the relative merits. Hence the adoption by the EU of the R1 formula for municipal waste in order to more clearly identify the processes that currently deliver these benefits.

241. In line with the second principle due consideration needs to be given to whether, by favouring energy from waste over landfill, we are truly reducing the environmental impacts of the management of residual waste and when recovering the energy, we are maximising the energy benefits.

242. Chapter 2 of this Guide set out two general rules for energy from waste to be a better waste management tool than landfill for a specific proposal

- the more efficient the energy from waste plant is at turning waste into energy, the greater the offset from conventional power generation and the lower the net emissions from energy from waste;
- the proportion and type of biogenic content of the waste is key – high biogenic content makes energy from waste inherently better and landfill inherently worse.

243. Looking to the future this is not a static picture. A number of factors including the composition of waste, the environmental impacts of alternative energy sources, and the effectiveness of landfill gas capture, are expected to change and will all have an impact on the relative merits of the two approaches.

244. Ensuring that energy from waste is robust to these changes and maintains its primacy over landfill in the long term will need to be a key consideration for Government policy and industry practice alike.

245. Recent modelling conducted by Defra and published alongside this document[69] has examined these factors further and considered the implications for the long term development of energy from waste. It identifies that there are potential balance points beyond which energy from waste could perform worse than landfill in carbon terms.

[69] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=19019&FromSearch=Y&Publisher=1&SearchText=wr1910&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

There are clear messages in terms of the potential trends as to where the focus needs to be to move away from these balance points and to maximise the potential of energy from waste in the long term.

246. The modelling confirms the two rules identified above but additionally shows that long term changes in the energy mix being offset by energy from waste has significant consequences for the relative merits of energy from waste vs landfill. As energy decarbonises, increasing efficiency alone is no longer sufficient to guarantee maintaining the primacy of energy from waste over landfill in carbon terms, with the biogenic content of the waste feedstock becoming the overriding determinant.

247. The real world implications of this modelling are potentially most pertinent for electricity only generation. Predictions for the marginal electricity mix[70] show significant decarbonisation within the potential lifetime of existing energy from waste plants. There is a risk that such plants may only continue to be better than landfill in carbon terms when using high biogenic content waste streams, potentially greater than that currently found in unsorted mixed municipal waste.

248. Additionally while electricity only plants may be beneficial over their planned lifetimes, the carbon benefits would be expected to be least in the final years, when decarbonisation of the grid is most likely to have occurred. As such extending the lifetime of an electricity only plant beyond that originally planned may not be sustainable.

249. Conversely, other energy outputs such as heat and transport fuels are expected to decarbonise much more slowly. In addition delivery of heat from energy from waste can be done at much higher efficiencies than electricity. Plants that operate in combined heat and power (CHP) mode therefore have the potential to continue to be superior to landfill using waste streams with a much wider range of biogenic content, balancing electricity and heat production over longer plant lifetimes, into the foreseeable future.

250. To address these changes and meet the second principle of minimising environmental impacts key considerations for both new and existing plants going forwards will be:

- Maximising the efficiency of existing plants to delay reaching, and avoid going beyond, any balance point
- The sustainable lifetime of an electricity only plant will be limited and extending it beyond that originally envisaged may not be beneficial
- Focus on development of energy outputs beyond electricity, both for new plants and ensuring existing plants that are ‘CHP ready’ becoming ‘CHP in use’
- avoiding the use of waste in energy recovery with insufficient biogenic content to deliver environmental benefits, or capturing the environmental cost of doing so

[70] This is the energy mix that Government Green Book guidance says should be used for such comparisons https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

251. This last consideration implies developing greater understanding of biogenic content of the residual waste and seeking to match the waste feedstock more closely to the technology and outputs. Where this matching cannot be done with unprocessed residual waste the options are then to manipulate the composition of the waste through increased recycling of fossil components, processing into a refuse derived fuel (RDF) or to ensure the environmental cost is captured[71].

Energy outputs

252. Maximising the benefits of energy generation from the waste that is available for recovery is a key component of the second principle.

253. As noted above the modelling indicates that the need to minimise the environmental impacts of waste management would be best met by those outputs that are decarbonising more slowly and can be produced more efficiently, as these provide the greatest long term energy offset, i.e. heat and transport fuels.

254. Heat and transport fuels are expected to decarbonise more slowly as renewable sources are less common and less well developed. As a partially renewable energy source energy from waste itself can aid the decarbonisation of these more difficult energy types. There is therefore a consistent rationale across both waste and energy policy for increasing focus on these outputs (and by implication moving away from an electricity only energy from waste model).

255. We should seek to drive waste towards those plants and processes which deliver the most efficient conversion of waste to energy. In line with the principle of technical neutrality (see below) any Government intervention would be related to driving the overall efficiency of the process rather than any specific technology.

256. Combustion by its nature produces heat and the capture and use of this inevitably leads to more efficient use of the energy in the waste fuel. This may be the only route for delivering this long term energy offset for conventional mass burn incineration. Advanced thermal treatments (ATT) have the potential to deliver heat or less direct outputs such as transport fuels. These are more challenging to evaluate as while they can ultimately be used in an efficient way, to create motion, they may require additional energy input in their manufacture. Life cycle analysis across the whole process from waste fuel to energy use is needed to help inform the relative merits of the outputs.

257. Unless the energy output can be effectively used then there is no benefit from maximising its production. Ensuring sites for energy from waste are available that allow potential connection to heat customers is an essential part of maximising the benefits. The proposed updated national planning policy “Planning for Sustainable Waste Management” is expected to reflect this[72], encouraging local authorities to consider siting, through their local plans, energy from waste facilities in areas which allow them to use heat as an alternative or additional energy output to electricity.

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[71] See discussion on carbon pricing of energy from fossil waste below

[72] The consultation document can be found at https://www.gov.uk/government/consultations/updated-national-waste-planning-policy-planning-for-sustainable-waste-management. The planning policy forms part of the National Waste Management Plan for England https://www.gov.uk/government/publications/waste-management-plan-for-england

258. To meet the second part of this principle, maximising energy benefits, key considerations are

- Steering waste towards the most efficient plants/outputs on a lifecycle basis and away from less efficient solutions
- Selecting sites that do not limit plants to only generating electricity i.e. sites in urban centres and/or close to heat users should be preferred to remote rural locations where opportunities to utilise heat may be more limited.
- Delivery of wider energy policy goals and regulation

259. DECC is delivering a number of initiatives to support greater development and use of heat[73]. It has set up a Heat Networks Delivery Unit (HNDU) within the Department that will work closely with individual local authorities' project teams in England and Wales to support authorities in developing heat networks.

Refuse derived fuel (RDF)

260. Refuse derived fuel (RDF) is produced by the mechanical processing of mixed waste. There are a range of processes that can be applied to mixed waste to transform it into a fuel.

261. The principles would be expected to apply as much to the production of waste fuels as to their use and policy would be expected to reflect this. Therefore the production of RDF should be part of minimising the environmental impacts of waste management. Care needs to be taken to ensure that the overall environmental benefits of the separation process, and the application of the hierarchy are not compromised.

262. Within this context RDF production can potentially be used to manipulate the biogenic content of waste fuels. Increasing the biogenic content of refuse derived fuels could theoretically be done either by the addition of biogenic material into the RDF stream or greater removal of fossil based waste from it. The latter approach of removing additional fossil based material (i.e. plastics) for recycling would be most consistent with the principles

263. Unless it can be clearly demonstrated there is an overall environmental benefit in doing so (as an exception to the hierarchy) biogenic material that might otherwise have been separated and more beneficially processed in a different way (e.g. through AD) should not be left in or added to the RDF.

264. Unlike untreated mixed municipal waste RDF can be exported for recovery operations elsewhere in the EU (see Chapter 2 of this guide). The requirement to direct the RDF to a recovery rather than disposal operation is consistent with the principles outlined above. There is also an underlying principle of free trade to which the UK adheres.

265. There is currently no minimum specification for RDF, it is a catch all term for waste that has been processed in some way to make it a suitable fuel. There is therefore some blurring in the boundary between what is mixed municipal waste and what is truly RDF. The specification for the fuel is usually dictated by the end user using a

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[73] https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/heat-networks

range of parameters[74]. These can include biogenic content but more usually focus on the physical and chemical properties required to optimise operation of their particular plant.

266. The same issues raised by the modelling apply equally to energy recovery outside the UK. The use of heat from energy recovery is much more widespread in the major RDF import markets. However, it is not universal. There is therefore a risk that RDF with insufficient biogenic content could be exported for recovery. This could lead to the export of material for what is nominally recovery but in environmental terms the handling of waste in that way is worse than domestic disposal to landfill. This would be inconsistent with the principle of minimising the environmental impact of waste management.

267. Defra will be issuing a call for evidence in 2014 to investigate the extent to which there is an environmental case for intervention in RDF markets, including exports.

268. To adhere to the principles key considerations for the production and use of refuse derived fuels are:

- Ensuring the hierarchy is applied and the need to maintain biogenic content in the fuel fraction is not done at the cost of potential recycling
- Encouraging greater understanding of the biogenic content
- Increasing biogenic content through removal of fossil waste not addition of biogenic waste
- Ensuring material if exported delivers a better environmental outcome than domestic disposal

Recovery of energy from fossil waste streams

269. As outlined above, long term policy will need to be consistent with ensuring energy from waste remains superior to landfill. For mixed or primarily biogenic wastes the balance of emissions of methane from landfill and those from energy from waste provides the key driver. The primary routes for managing the relative impacts are through the careful choice of the technology and energy outputs to match the available fuel, or where this is not possible, modifying the fuel to have sufficient biogenic content.

270. Fossil based residual wastes, e.g. plastics and synthetic rubbers that cannot be recycled, do not decompose in the same way as biogenic material in landfill. For these waste streams conventional energy from waste will almost always deliver a negative carbon balance compared to landfill. However, they represent a potential resource that in line with the hierarchy should ideally be recovered not disposed of.

271. Clearly it would not be consistent with the principles just to mix the fossil waste stream with higher biogenic content material prior to combustion, as doing so would just increase the environmental impacts of burning the latter.

[74] WRAP have recently produced a specifications system for waste derived fuels http://www.wrap.org.uk/sites/files/wrap/WDF_Classification_6P%20pdf.pdf

272. There are two options for managing the environmental impacts of such waste streams used for energy recovery[75]

- advanced processing into energy sources that deliver lifecycle benefits compared to use of raw materials
- conventional energy recovery and carbon pricing.

273. An example of the former approach would be taking waste plastics and transforming them into transport fuels. Car and truck engines are an efficient way of turning fuel into useable energy (in this case movement). Creating the fuel from waste is an energy intensive process, but so is creating diesel from crude oil, and overall there may be a environmental benefit from using the waste compared to the virgin alternative.

274. Not all fossil waste streams could undergo this type of processing. The alternative option is therefore more conventional energy from waste technology. However, this alone is unlikely to be efficient enough to deliver carbon benefits over landfill.

275. The concept of carbon pricing exists to allow activities to occur where there are strong reasons to do so but negative carbon impacts. For energy from waste the EU Emissions Trading Scheme (EUETS) is the primary instrument available[76]. An example of where this approach has been used is management of automobile shredder residue. The Environment Agency has agreed a standard for energy from this material to be classed as recovery based on a combination of minimum process efficiency and sufficient scale to be captured by EUETS. This ensures that the resource is not lost but the carbon impacts are suitably priced and not ignored.

276. To adhere to the first and second principles when considering energy from primarily fossil waste streams key considerations are:

- Encouraging recovery of the resource rather than disposal
- Disincentivising mixing with biogenic rich waste streams that could otherwise move up the hierarchy
- Supporting energy recovery processes that deliver overall lifecycle benefits compared to raw materials
- Ensuring recovery captures the environmental cost of the process where this is greater than landfill

Government support for energy from waste

277. The third principle states that "Government support for energy from waste should provide value for money and make a cost effective contribution to UK environmental objectives in the context of overall waste management and energy goals".

[75] There may be other routes for recovering the material beyond energy production but these are not considered here

[76] Mixed municipal waste is currently excluded from EUETS. However as a mixed waste stream with a generally high biogenic content it should be possible to deliver overall benefits through output selection and feedstock manipulation

278. The second principle is concerned primarily with the key considerations for the development and operation of energy from waste, and how Government might set the policy framework to ensure energy from waste maintains its overall benefits. This third principle is about how and where Government chooses to support energy from waste where there is a direct associated cost.

279. There are two aspects to this. Firstly it is a general principle that Government has to ensure that it delivers value for money. This includes direct funding through grants, loans, incentives etc. or more indirect methods such as communications campaigns.

280. Secondly, one of the key drivers for energy from waste is to reduce the overall environmental impacts of waste management and energy production. However, there are many potential routes to do this and there is no automatic link between the cost of managing the waste or producing energy and emissions reductions.

Value for money

281. The drive for government intervention is usually to address a specific market failure or to incentivise a certain type of behaviour. As such the measure of value tends to be specific against that outcome.

282. In order to deliver value for money Government support is also inherently finite. Support may be limited in different ways, e.g. budget or meeting a specific target, but there will be a limit. This is not to say that achieving beyond this limit is not a good thing that government might support from a policy perspective, but the rationale for providing funding to do so will not be as strong. Otherwise the same limit will be reached but more money will be spent.

283. An example of this is the Waste Infrastructure Delivery Programme (WIDP) programme. This was set up specifically to deliver our commitments to the EU Landfill Directive for the diversion of biodegradable municipal waste from landfill. Waste recycling and treatment infrastructure (including energy from waste) was one way to deliver this. However, it was not a specific goal of the programme to develop more infrastructure than needed to satisfy the requirements of the Landfill Directive. The combination of the financial support provided through the WIDP programme in the form of WICs and other drivers (such as the landfill tax) means we are on track to deliver against these commitments.

284. Therefore the rationale for additional government funding to deliver the target is no longer there and a number of projects have had the provisional offer of funding withdrawn. This does not mean there is no need for, or benefit to be derived from, more waste infrastructure, including more energy from waste. There is still plenty of waste that needs to be dealt with and in the case of energy from waste, a large unexploited energy potential. However, the previous rationale for the WIDP programme providing funding through the specific mechanism of WIC has been met. Therefore continued development of the sector would be consistent with government policy, but would be expected to be market driven.

285. Energy incentives are subject to similar constraints. Here the aim is to provide a more level playing field between renewable technologies and to attract investment in the renewable sector as a whole. However, as technologies become more established it would be expected that the market failures which the incentives aim to correct would gradually disappear. As a result there is an expectation that costs will reduce to a level where no incentives are required.

Cost effective environmental benefits

286. As set out in the UK Bioenergy strategy[77], Bioenergy should be supported when it "offers equivalent or lower carbon emissions for each unit of expenditure compared to alternative investments which also meet the requirements of the policies". Waste as a form of bioenergy needs to adhere to this approach.

287. The strategy notes that "A bioenergy source that had a low cost per unit of energy might still be a very expensive way of reducing carbon if significant emissions are associated with its production. Bioenergy policies must therefore assess the cost effectiveness of bioenergy in reducing carbon emissions as well as producing energy compared to alternative options".

288. For conventional biomass these calculations need to include factors such as land use change[78] and the processes required to turn the biomass into a useful fuel. While waste as a fuel is not encumbered with the carbon cost of its production[79] any processing once it becomes waste, does have an impact. In particular the combustion of mixed waste releases a substantial amount of fossil emissions from what can be an otherwise relatively inefficient[80] process. Residual waste has an alternative fate in landfill that has its own negative environmental impact. The assessment is therefore not straightforward but the principle needs to apply.

Technology Neutral

289. The fourth principle states that "Government will remain technology neutral except where there is a clear market failure preventing a technology competing on a level footing".

290. Government tries not to direct towards one technology above any others where there may be a number of technologies existing and developing that might deliver the same favourable outcome. As such the underlying approach will always be one of technology neutrality.

291. Government policy sets the desired outcomes and potentially outputs but does not dictate the technology required to deliver them. This is not to say that policy cannot be a steering force, for example a desire for much greater utilisation of heat and greater efficiency may favour technologies that can deliver this over those which can't.

292. In the same way Government would not expect to favour a given technology, neither should it be blinkered to new or innovative technologies coming forward. For example local authorities should not assume that established technologies are the only possible solution to meet their needs.

293. Where there are seen to be significant market failures Government may choose to intervene to correct these. Energy from waste covers a number of potential markets which to a degree operate independently of each other e.g. waste, electricity,

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[77] https://www.gov.uk/government/publications/uk-bioenergy-strategy

[78] Most of the energy incentives require either reporting or mandatory meeting of sustainability criteria in order to meet an incentive, but Wastes for solid biomass are exempt from sustainability criteria. For the Renewable Energy Directive waste is zero rated up the point of production of the waste

[79] in carbon accounting these fall to the original purpose of the material before it became waste.

[80] Typical conversion efficiency of waste fuel into usable electricity is 25% compared to >70% for natural gas to electricity in CCGT

transport fuels. The degree to which any intervention distinguishes between technologies may well depend upon the market within which the intervention is operating.

294. For example, within the waste market Government policy is driven by the desire to drive waste up the hierarchy. As outlined above maintaining primacy of energy from waste over landfill relates to the efficiency of the plant, the biogenic content of the waste and the energy being offset. If these parameters are equal policy would not be expected to incentivise e.g. conventional combustion technologies over ATT. This is the case in the waste market where there are no differential incentives. However, from an energy perspective, as a source of renewable energy, the relative costs and maturity of the technologies are different. ATTs cannot currently compete with generators in the energy market place without additional support; hence they are eligible for greater energy incentives than conventional energy from waste.

Summary

295. For a number of years the primary purpose and driver for energy from waste in the UK has been to divert biodegradable waste from landfill. However, over time both the sector and the policy which steers it have evolved. The overall hierarchy has become much more important, with waste being pushed up to higher uses such as reuse and recycling and with energy from waste itself needing to cement itself more firmly as recovery. Equally the drive for renewable energy and energy security has increased the importance of energy from waste to the energy sector. This has come together in the approach set out in the 2011 Waste Review of more energy out of waste rather than just more waste into energy recovery.

296. The first two principles set out above recognise energy from waste's fundamental role in the waste hierarchy. They also recognise that as application of the hierarchy succeeds the volumes and composition of waste going to energy from waste from current sources will reduce and change. The sector will need to ensure more waste is pulled out of landfill or new sectors such as commercial and industrial waste are better exploited to maintain feedstocks. With diminished or changing feedstock energy from waste must evolve both to deliver its potential as a partially renewable energy source and as demonstrated by recent modelling, to maintain its environmental benefits over landfill. This will require much wider utilisation of heat or other higher energy outputs both for new and existing plants.

297. The third and fourth principles highlight that direct Government support for energy from waste, be that infrastructure, communications or energy incentives, will be driven by the need to correct market failures, where those failures are preventing government from reaching its stated goals. The support will be focussed to enable those goals to be reached but achieving beyond them, while often desirable, will be left to the market. As energy from waste bridges a number of different markets the level of intervention may be different across the markets.

298. Energy from waste developments and operations need to give proper consideration to the principles set out above and recognise some of the limitations they imply. By doing so they are likely to be much more robust to any future policy changes than those which are not consistent with delivery of these principles.

Glossary of waste related terms and acronyms

Advanced Thermal Treatments (ATT) – are systems which incorporate emerging technologies which use heat to decompose waste in limited oxygen prior to energy extraction. These systems include pyrolysis and/or gasification processes.

Anaerobic Digestion (AD) – is a series of processes in which microorganisms break down biodegradable material in the absence of oxygen. It is used for industrial or domestic purposes to manage waste and/or to release energy. Much of the fermentation used industrially to produce food and drink products, as well as home fermentation, uses anaerobic digestion.

Biogenic - material within the waste stream that has come from biological sources and was recently growing. In this context recently means the last hundred or so years. Examples include food, paper, garden waste, wood. See also 'fossil'

Calorific Value (CV) – is a measure of the amount of energy contained within the waste that could be potentially released when it is completely combusted under specific conditions. It is a measure of heating power and is dependent upon the composition of the waste.

Combined Heat and Power (CHP) – is the use of a heat engine or a power station simultaneously to generate both electricity and useful heat.

Compost Like Output (CLO) – is the bio-stabalised organic fraction of mixed waste as a result of processing through MBT or MHT. As such it will be less likely to decompose and produce methane in landfill.

Energy from waste (EfW) – is the process of creating energy - usually in the form of electricity or heat but also potentially biofuels - from the thermal treatment of a waste source via technologies such as incineration, Anaerobic Digestion, Gasification or Pyrolysis.

Fossil – material within the waste stream that has come from sources such as coal, oil and natural gas which have been locked underground for millions of years. Examples include plastics made from oil

Gasification – is a process that converts organic or fossil based carbonaceous materials at elevated temperatures with controlled amounts of oxygen into carbon monoxide, hydrogen, carbon dioxide and methane. It is a well-known technology, although its advanced use with a mixed waste feedstock has not been proven on a commercial scale.

Incinerator Bottom Ash (IBA) – is a form of ash produced in incineration facilities. This material is discharged from the moving grate of municipal solid waste incinerators. Following combustion the ash typically has a small amount of ferrous metals contained within it. This ash can be processed to standardise the material and remove contaminants in order for it to be used as an aggregate.

Materials Recovery Facility (MRF) – is a specialised plant that receives, separates and prepares recyclable materials for marketing to end-user manufacturers. Generally, there are two different types: clean and dirty MRFs.

Mechanical Biological Treatment (MBT) – is a type of waste process that combines a sorting facility with a form of biological treatment such as composting or anaerobic digestion.

Mechanical Heat Treatment (MHT) – is an alternative waste treatment technology. This technology is also commonly termed Autoclaving. MHT involves a mechanical sorting or pre-processing stage with technology often found in a material recovery facility. The mechanical sorting stage is followed by a form of thermal treatment. This might be in the form of a waste autoclave or processing stage to produce a refuse-derived fuel pellet. MHT is sometimes grouped along with mechanical biological treatment. MHT does not however include a stage of biological degradation (anaerobic digestion or composting).

Mega watt (MW) – is a unit of power i.e. the rate of energy conversion. One megawatt is equal to one million watts.

Megawatt hour (MWh) – is a unit of energy equal to 1,000 kilowatt hours of electricity used continuously for one hour.

Municipal Solid Waste (MSW) – is commonly known as refuse or rubbish and is a waste type consisting of everyday items that are discarded by the public. It covers household waste and household-like commercial and industrial waste (e.g. from offices or hotels).

Poly Aromatic Hydrocarbons (PAH) – are a group of organic compounds which are from incomplete combustion of carbon-containing materials such as oil, coal, gas etc. They are often absorbed onto particles of soot emitted from combustion sources.

Pyrolysis – is a thermo-chemical decomposition of organic material at elevated temperatures in the absence of oxygen. Pyrolysis typically occurs under pressure and at operating temperatures above 430 °C (800 °F).

Renewable Heat Incentive (RHI) – is Government scheme owned by the Department of Energy and Climate Change (DECC) and administered by Ofgem which provides a continuous financial support over twenty years to any organisation that installs an eligible renewable heating system. Technologies such as biomass boilers and energy from municipal solid waste (MSW) are supported.

Renewables Obligation (RO) – is a scheme owned by the Department of Energy and Climate Change (DECC) and delivered by Ofgem and is the main support scheme for renewable electricity projects in the UK. The RO places an obligation on suppliers of electricity to source an increasing proportion of their electricity from renewable sources (see also Renewable Obligation Certificates).

Renewable Obligation Certificates (ROCs) – is the green certificate issued for eligible renewable electricity generated and supplied to customers within the UK by a licensed supplier. ROCs are issued by Ofgem to accredited renewable generators. Different technologies receive different numbers of ROCs for each megawatt hour (MWh) of eligible renewable output generated.

Renewable Transport Fuel Certificate (RTFC) – Certificates are used by obligated suppliers as evidence of meeting their obligation. One renewable transport fuel certificate is awarded for every litre of biofuel supplied under the RTFO.

Renewable Transport Fuel Obligation (RTFO) - was introduced by the Department for Transport (DfT) in 2008 and places an obligation on owners of liquid fossil fuel intended for road transport use to ensure that either a certain amount of biofuel is supplied or that a substitute amount of money is paid. There is a requirement under the RTFO in the UK on transport fuel suppliers to ensure that 4.71% percent of all road vehicle fuel is supplied from sustainable renewable sources during the 2012/13 accounting year.

"R1" Recovery status – is the definition in the revised Waste Framework Directive for a 'recovery' operation. For municipal waste incinerators this is based on a calculation of a plant's efficiency in converting tonnages of municipal waste to energy. Plants operating at or above the stipulated thresholds can be classified as 'recovery operations' for the purposes of the waste hierarchy. Incinerators operating below the threshold are classed a 'disposal'. There is currently no requirement for municipal waste incinerators to achieve R1 status or have their performance assessed against the R1 formula in the Environmental Permitting Regulations 2010 (EPR). For Non-municipal waste incinerators designation as R1 depends on criteria set by the Competent Authority, this is the Environment Agency in England

Refuse Derived Fuel (RDF) – is a fuel produced by shredding and dehydrating municipal solid waste (MSW) via a process such as MBT (see above). RDF consists largely of combustible components of municipal waste such as plastics and biodegradable waste.

Solid Recovered Fuel (SRF) – is a fuel produced by shredding and dehydrating solid waste via a process such as MBT. SRF can be distinguished from RDF in the fact that it is produced to reach a specific quality standard.

Steam autoclaving – is a form of solid waste treatment that uses steam (at temperatures of up to 160°C) pressure and agitation/mechanical means to separate the organic fraction of waste, and separate and sterilise recyclates such as plastics, glass and tin etc in a mixed waste stream.

TeraWatt hours (TWh) – is a unit of energy, especially electrical energy, equal to the work done by one terawatt acting for one hour and equivalent to 3,600 joules.

Volatile Organic Compounds (VOC) – are organic chemicals that have a high vapour pressure at ordinary, room temperature conditions. Their high vapour pressure results from a low boiling point, which causes large numbers of molecules to evaporate or sublimate from the liquid or solid form of the compound and enter the surrounding air.