energy from waste

extracting value through innovative infrastructure

Waste represents an important opportunity for organisations and communities to secure resilient energy supplies for the future. In a modern consumer society, waste material can be considered a renewable resource, just like wind, the sun or heat from the earth. The technologies now available can use almost every kind of waste as a fuel, converting it to electricity, heat or refrigeration.

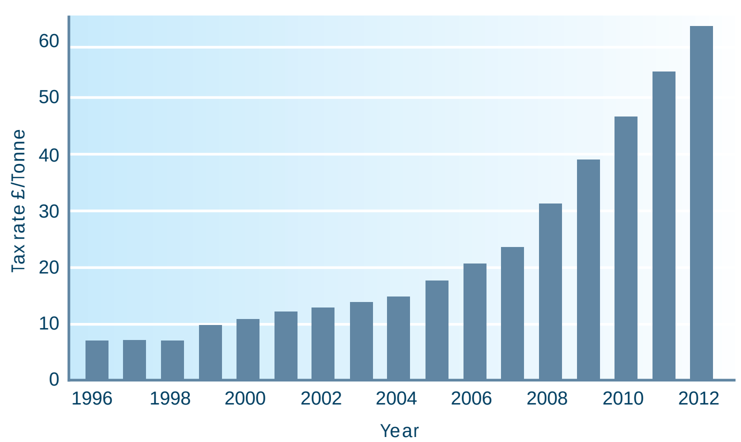
the value of waste

To understand the full potential of waste-to-energy, we need to think of it as a virtuous circle. The UK produces around 114 million tonnes of commercial, industrial, household and agricultural waste every year,[1] and transporting this to landfill is a one-way process, with no benefit and no value. Waste-to-energy is a cycle that uses technology to convert 'useless' waste into useful energy, generating economic and social advantage.

As well as being environmentally damaging, waste is an expensive business. Waste that produces greenhouse gas emissions currently attracts landfill tax at £48 per tonne, with further increases set (see figure 1). Household waste, which largely falls into this category, averages around one tonne per household a year, so the tax bill for the UK's 27 million homes already amounts to some £1.3bn per annum. Adding landfill gate fees, collection and removal costs gives a total disposal figure around £100 per tonne, which is expected to rise by 10-18% over the next five years.

Waste-to-energy infrastructures can potentially eliminate this cost, reduce energy bills and carbon output, and generate revenue through the sale of surplus energy. The economics are complex and each case must be evaluated individually, but with the right design to optimise performance, and the right contractual model to reduce financial risk, the investment is likely to produce positive returns. Waste-to-energy technologies will help the UK meet its landfill diversion and renewable targets and will also become a key component of a decentralised energy strategy.

Figure 1: Landfill tax increases



waste-to-energy infrastructures

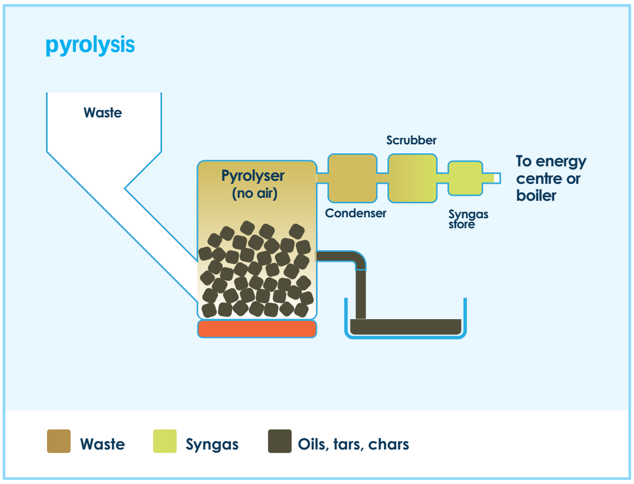
There are currently over 170 waste-to-energy infrastructures operating in the UK,[2] deploying a range of combustion and non combustion-based technologies to generate energy from a variety of waste types.

Most waste that goes to landfill is combustible, so has great energy potential. It needs to be processed in clean, efficient ways that involve no loss of heat, or emissions, to the environment. Non-combustion-based technologies, on the other hand, do not involve high temperatures and are suitable for different kinds of waste.

The government is highly supportive of these developments, with between £9bn and £11bn to be invested in public sector waste initiatives by 2020. The next few years are therefore likely to see a major expansion of waste-to-energy facilities in the UK, as is already happening in many European countries.

Some of the more advanced thermal technologies promise very high levels of efficiency but, as with any emerging technology, there are unknown factors. Amongst around 20 such plants operating in the UK,[3] failures have been experienced, especially in the processing of municipal solid waste.

MITIE has worked with specialist consultants to investigate the potential causes, applying techniques such as computational fluid dynamic modeling to better understand the process. As a result, we have successfully validated the use of these technologies for specific waste streams and work is in progress to accommodate the more variable nature of mixed wastes.



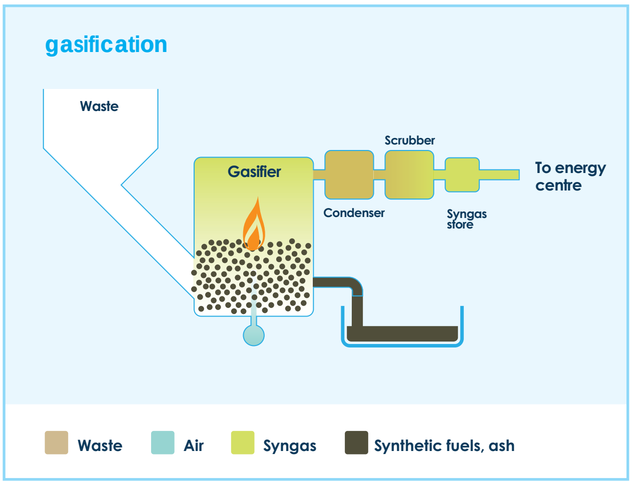
In the pyrolysis process, waste breaks down spontaneously under high temperatures, without oxygen, to produce syngas.

combustion-based technologies

Combustible waste includes paper, plastics, agricultural or animal wastes, rubber, waste oils and hydrocarbons. More than 70% of this is produced by the commercial and industrial sector, the remainder being mainly household waste. It can be converted through thermal waste-to-energy processes, including modern, efficient forms of incineration that capture waste heat, together with more advanced processes including pyrolysis and gasification.

Pyrolysis involves the chemical decomposition of condensed substances that occurs spontaneously at high enough temperatures (typically 200-300°C). It differs from other high-temperature processes in that it does not involve reactions with oxygen (air), water, or any other reagents. In general, pyrolysis of organic substances produces gas and liquid products and leaves a solid residue richer in carbon content which, after suitable clean- up, is converted into a synthetic gas (syngas). Syngas can be used to generate heat and electricity by direct firing in engines, turbines and boilers. Alternatively, it can be reformed to produce liquid fuels such as methanol (CH_3OH) and hydrogen (H), for use in fuel cells or as transport fuel. The syngas can be combusted at higher temperatures than in conventional waste incineration (>700°C), improving the efficiency of the system.

Gasification is similar to pyrolysis, but in this process the fuel, which may be biogenic or fossil-based, is reacted using a controlled amount of oxygen or steam. This produces the syngas through chemical decomposition, as in pyrolysis, but the limited oxygen



In the gasification process, waste is reacted with a small amount of oxygen and/or steam to produce syngas.

introduced into the reactor also allows some of the waste fuel to be combusted. This results in the production of carbon monoxide (CO) and energy, which drives a second reaction that converts further fuel to hydrogen (H) and additional carbon dioxide (CO_2).

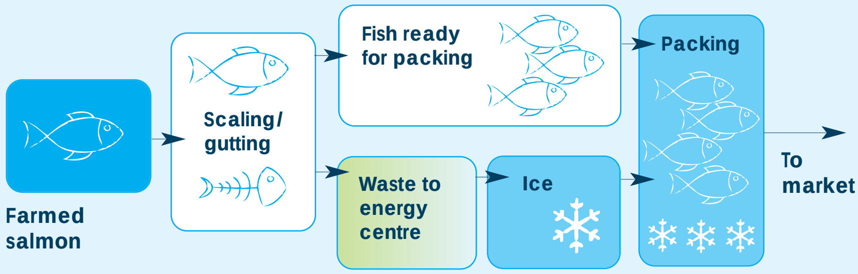
non combustion-based technologies

These processes do not involve high temperatures and are suitable for different kinds of waste. They include biological conversion such as anaerobic digestion, (AD), which utilises bacterial microorganisms, in the absence of oxygen, to break down organic waste materials such as waste paper, grass clippings, leftover food, sewage and animal waste. This produces a gas containing methane (CH_4) and carbon dioxide (CO_2), known as Biogas, which is increasingly used for the production of heat and electricity, or can be injected back into the natural gas grid. The nutrient-rich solid and liquid residues from the AD process can be used as compost and fertilisers.

MITIE is designing and installing waste-to-energy infrastructure across a range of applications, using techniques such as computational fluid dynamic modelling to validate and develop the technologies.

AD is particularly suited to wet organic or biodegradable material and is commonly used for effluent and sewage treatment. The UK produces about 100 million tonnes of food, farm and other organic waste each year, which could generate up to 7% of the renewable energy required by 2020.[4]

Figure 2: waste-to-energy in salmon farming

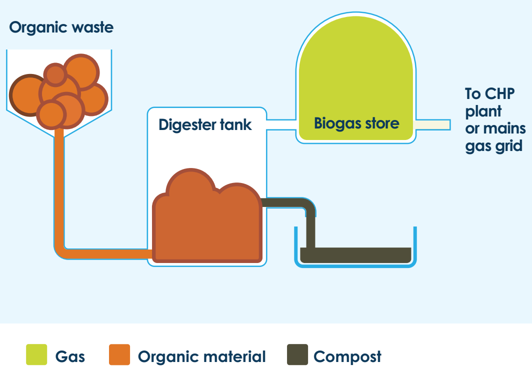


waste-to-energy in action

MITIE is evaluating, designing and installing waste-to-energy infrastructure across a range of different applications. We are developing a facility for general waste material that combines pyrolysis and gasification with a further process of oxidisation, producing a very high temperature gas that drives an electricity turbine. Each of these plants will deliver over 27,000 MWh of electricity a year - enough to power 27 million 100-watt light bulbs for ten hours - and will offset 14,600 tonnes of CO_2 from grid-based generation. In another new venture, we will build, operate and maintain a gasification plant to process waste wood, with a local high-technology manufacturing plant purchasing the heat and power under a 10-year agreement.

We have developed innovative approaches to convert organic waste to energy. One proposal was for a plant processing 32 tonnes a day of food waste from catering production. This would reduce energy and waste costs per meal produced by 50%, and the output of CO_2 emissions per meal by more than 30%. Another proposal utilised organic waste generated by a fish farming business to power the gutting and cleaning process and produce ice for packing and transport (see Figure 2). This facility would divert 1,500 tonnes of waste from landfill or incineration every year, saving the client £120,000 in energy and transportation costs and 500 tonnes of CO_2 emissions per annum. Some types of waste are hazardous and carry proportionately higher costs of conventional disposal: from £250-£800

anaerobic digestion



In anaerobic digestion, organic waste is broken down by bacteria, without oxygen, to produce Biogas.

per tonne. This can make the economics of waste-to-energy particularly attractive. We are currently working with a large NHS Trust hospital in London to convert clinical waste into heat that can be pumped back into the hospital's network to reduce heating costs and avoid landfill gate fees.

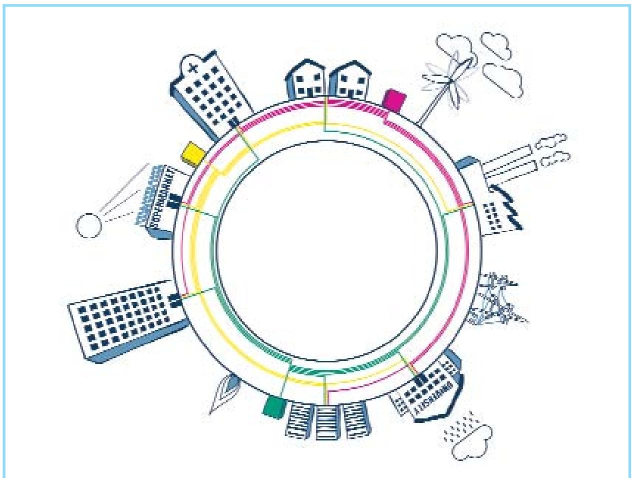
waste-to-energy in context

Waste-to-energy technologies are deployed as part of decentralised energy developments that can benefit both public and private sector organisations, and their local communities. Other core technologies that may form part of the infrastructure include combined heat and power (CHP) or biomass energy centres, and heat pump and heat recovery systems. For maximum advantage, the technologies will be evaluated, combined and customised to meet the specific output requirements for the site. Getting everything to work together in the most efficient way is key to effective deployment. Decentralised energy infrastructure offers energy resilience by enabling organisations and communities to take greater control of their own energy provision, reducing traditional dependence on the grid. Ultimately, one can envisage a situation where the main sources of energy can become local, with grid supplies reserved for contingencies.

Funding for waste-to-energy and other energy infrastructures can be based on a wide range of contractual arrangements. Availability-based contracts, for example, are increasingly attractive because they transfer the risks of owning and operating energy infrastructure from the user to the provider. Performance-based contracts guarantee that the plant and equipment will achieve predetermined outputs in terms of cost, carbon savings or other measures.

Waste-to-energy developments will be key to long-term decentralised energy strategies.

The benefit of this kind of development lies in optimising output through energy conversion assets that take into account the current and future requirements of an organisation and the opportunity to distribute surplus energy to other local users. In this way, the full value of decentralised energy infrastructure can be realised.



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For more information on waste-to-energy and other decentralised energy technologies, visit www.mitie.com/communityplatform.

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2 www.renewables-map.co.uk, July 2010
3 Advanced Thermal Treatment of Municipal Solid Waste, DEFRA, 2007
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