# WASTE TO VALUE: TRANSFORMING WASTE INTO EMISSION SAVINGS PRODUCTION

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## ABSTRACT

Climate change and the emerging need to reduce carbondioxide ($CO_2$) and other emissions, call for increased environmental concern on national and global level. Renewable energy has been identified as a would-be significant part of the solution that will prevail on merit and form an important economic component of future infrastructure [1].

Large-scale central power as present today will not be the major thrust of power development indefinitely. Rather, greater use of non-traditional fuels will result in a gradual shift away from fossil fuels to energy sources obtained from factories and homes. Waste heat from industrial processes together with gases from waste biological sources represents significant energy resources that are today frequently neglected. In addition to waste heat, households throw away huge amounts of garbage which can be recovered into biomass materials to fuel the engine/equipment to make power. This paper intends to present an overview of waste-to-energy technologies that could transform waste into renewable energy sources in an economic manner and also provide a cleaner environment.

**KEYWORDS: Waste; Energy; Emissions.**

## 1. INTRODUCTION

Renewable energy are naturally occurring energy which does not run out and does not involve harmful processes, hence minimal amount of pollution and harmful gases are produced. They are sometimes referred to as ‘green energy’, ‘clean energy’, ‘alternative energy’ or ‘sustainable energy’ which denotes their environmental friendliness [2]. Due to growing technologies, there are numerous options to generate renewable energy; these include wind energy, solar energy, geothermal energy, hydro power and biomass energy or energy-from-waste. However this research will focus on energy-from-waste which would help power nations and reduce the need for landfill. Energy-from-waste offers a series of measures and advanced technologies which, if adopted in United Kingdom (UK), could help us reach our targets of an 80% reduction in $CO_2$ emissions by 2050 and producing a third of UK electricity from renewable sources by 2020 [3].

## 2. WASTE-TO-ENERGY

Waste defined as “a combination of materials –our resources for tomorrow. If we extract reusable materials, what is left is residual waste- solid materials containing energy that can be released to light rooms, heat buildings and drive businesses” [4].

Waste to energy is a process of extracting energy stored in waste in the form of fuel, heat or electricity. Waste such as sewage, domestic, commercial, industrial, construction and demolition (which constitute 36% of UK’s household waste) waste can all be utilised in the processes on the condition that they are combustible and/or biodegradable. Waste-to-energy approach solves two germaine issues in our environment of today; waste management and sustainable energy.

According to a report published by the Institution of Civil Engineers and the Renewable Power Association in the UK measuring the potential energy from residual waste, shows that theoretically by 2020, 17% of our electricity may be sourced from waste, though a more realistic percentage should be about 10% [5].

WRAP(Waste & Resource Action Programme), the official Government's recycling agency indicates that colossal quantity of food and drink wasted in the United Kingdom amounts to £17bn annually in these days of recession. The shocking report is a classical exposition of the UK's waste mountain, which hit 18.4 million tons last year. The constituents of this figure includes food, drink, packaging, thrown away by households, distributors, retailers and manufacturers. The report underlined that households produce the vast bulk of food and drink wasted in Britain, throwing away 11.9 million tons every year, at a cost of £12bn coming to two-thirds of the country's total waste mountain. Manufacturers are also culpable wasting five million tons annually, with retailers wasting 1.4 million tons and a further 100,000 tons lost during the distribution process. The environmental cost is compounding the economic impact, with the carbon cost of the wasted food and drink equivalent to an extra 12.4 million cars on British roads [6].

Extracting energy from waste will not therefore only be a cost-effective disposal of waste but will also help to reduce carbon emission, thus reducing climate change. Table 1.0 shows an extract of data summary of UK’s local authority municipal and household waste statistics 2008/09.

**Table 1.0 - Data summary of local authority municipal and household Waste statistics 2008/09**

| Authority Type | Total Household Waste | Household Waste sent for recycling | % of Household Waste sent for recycling |
|---|---|---|---|
| Unitary | 87122.62 | 24023.82 | 27.55 |
| Unitary | 61726.95 | 24735.47 | 40.07 |
| Unitary | 62183.88 | 14252.95 | 22.88 |
| Unitary | 46514.53 | 17349.17 | 37.25 |
| Unitary | 47681.24 | 12820.98 | 26.89 |
| Collection | 26288.62 | 5795.4 | 22.05 |
| Collection | 11719.21 | 4178.07 | 35.65 |
| Collection | 34410.26 | 7968.19 | 23.16 |
| Collection | 42744.5 | 13055.88 | 28.99 |
| Collection | 33219.48 | 9647.83 | 26.79 |
| Collection | 35448.66 | 10714.48 | 33.56 |
| Collection | 21642.89 | 5423.89 | 22.27 |
| Disposal | 254360.9 | 74859.66 | 29.10 |
| Collection | 24665.96 | 7346.16 | 29.78 |
| Collection | 23883.48 | 8371.07 | 35.11 |
| Collection | 20055.51 | 8269.56 | 41.23 |
| Collection | 30426.3 | 8848.6 | 29.08 |

| | | | |
|---|---|---|---|
| Collection | 10287.9 | 2744.2 | 27.05 |
| Collection | 14110.2 | 4912.8 | 35.46 |
| Disposal | 160421.25 | 62314.49 | 38.93 |

Source: Department for Environment, Food and Rural Affairs (DEFRA)

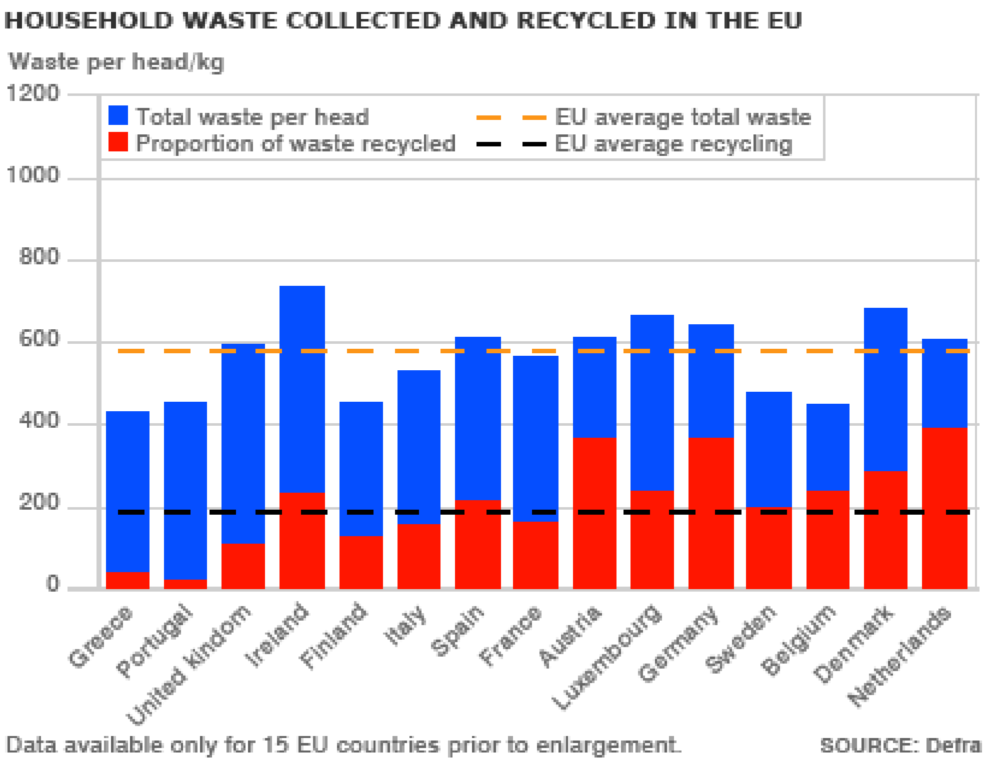


**Figure 1.0 - Analysis of UK waste and recycling amongst the EU countries. (Source: Defra)**

The United Kingdom still produces more waste per head of population than many of its European neighbours, with an average of 592kg above the EU average of 577kg as shown in figure 1.0. It also lags behind in the amount of waste recycled, with a UK average figure of 18% based on these figures, well below the EU average of 36.4%. The Netherlands leads the way in Europe with a national recycling average of 64.4%, more than double the level achieved in England. Greece is the worst offender on landfill, dumping 90% of its municipal waste, with Portugal and the UK dumping about three-quarters of their waste [7].

## 2.1 Types of Waste-to-Energy Technologies

There are many wastes to energy technologies. Waste to energy technology includes combustion, pyrolysis, gasification, anaerobic digestion, fermentation, and esterification.

- **Combustion**: This is the burning of waste in controlled incinerators to fuel boilers using feedstock produced in a "mass burn process" to create energy. The inside of the boiler's combustion chamber is filled with metal pipes, which are filled with water. The water in the pipes is heated and turns into steam when the waste is burnt. The steam is then used to drive the steam turbine generator to produce electricity. The most efficient output is to produce combined heat and power (CHP) i.e. electricity plus heat that can be exported for industrial or commercial use. The type of waste that can be used in this way include municipal solid waste (MSW), commercial and trade waste, industrial waste, clinical or hospital waste, wood waste. Electricity generating waste plants can typically process between 20,000 and 600,000 tonnes of waste per year, from which they can generate between 1 and 40 MW of electricity [8]. Figure 2.0 below shows a typical waste-to energy process.

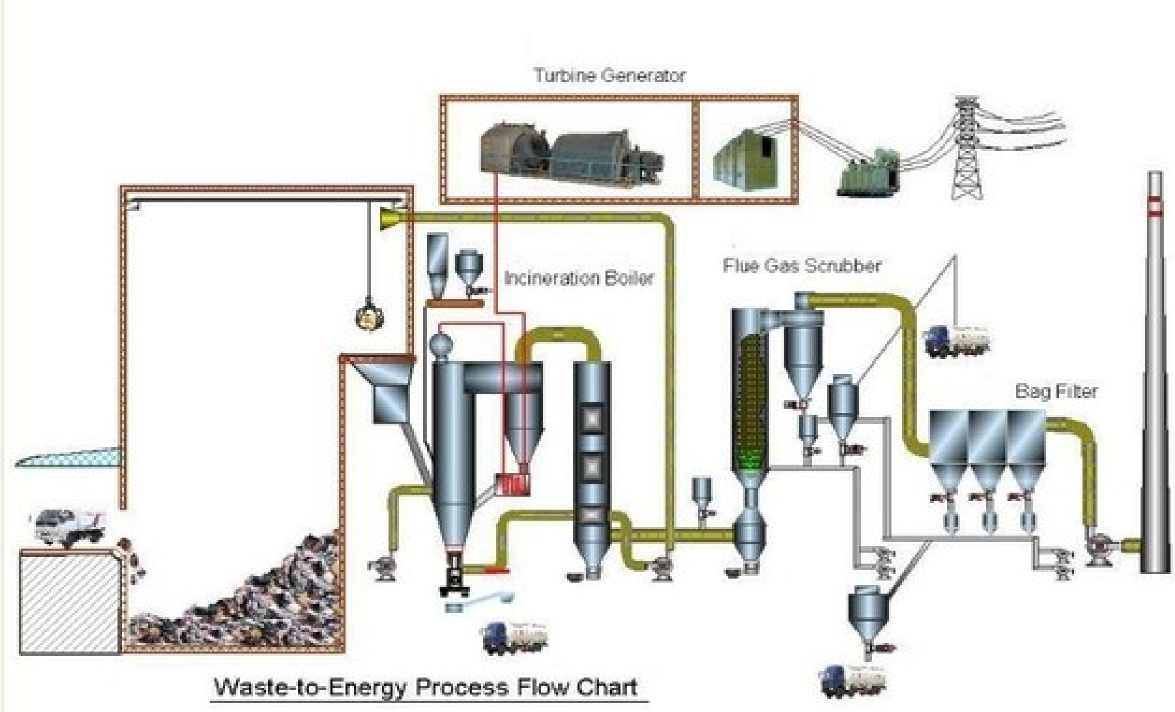


**Figure 2.0 – A typical Waste-to-Energy Mass-burn Facility** [9].

- **Pyrolysis and Gasification**: These are some of the most effective waste to energy technologies around today. Pyrolysis is a thermal process where high temperatures (of around 500ºC) is applied to break down waste without oxygen The process generates three end products; char (or ash), bio-oil and a synthetic gas. The solid char contains a combination of valuable carbon and mineral materials, which can be processed further to release this energy. The bio-oil is useful in fuelling power stations and the gas is a clean fuel with a high calorific value. Gasification is similar to pyrolysis_because the same three products are generated but with a higher temperature of 2000ºC being involved and unlike pyrolysis uses using controlled amounts of oxygen and water in the process. Gasification produces a gas called syngas, which can be used as an alternative to fossil fuels in generating electricity. These two technologies can be performed together to maximize the cost effectiveness. Pyrolysis needs an outside heat source, and this is supplied by the gasification process, making both processes together self sustaining. This reduces the cost of the process, making them both more cost effective. Waste to energy in this manner can create several forms of energy.
- **Anaerobic digestion** is another possibility with waste to energy technology that is available today. Anaerobic literally means 'without oxygen' which is the main difference between this process and composting. Waste decomposition happens rapidly in the absence of oxygen due to the bacteria that thrive in these conditions. Anaerobic digestion is a

process similar to composting which can treat all of our organic material. Organic waste is taken to a specialised plant and placed in an enclosed chamber for 10-25 days under controlled conditions. The waste is put in specially constructed digesters, and no oxygen is allowed in. The waste to break down much faster, releasing greenhouse gases including large amounts of methane. This process can also create heat from the large amounts of microbial activity as the biomass is decomposing. This process produces biogas and a solid material called a digestate. Biogas is a gas, which can be used as a fuel to make electricity. Many sewage treatments use this process and the gas produced is used to heat and power the plant. The digestate can be separated out into fibre and liquor. The liquid is useful as agricultural fertilisers and the solid as used as soil conditioner [10].

- **Fermentation**: This which can take biomass and create ethanol, using waste cellulosic or organic material. In the fermentation process, the sugar in the waste is changed to carbon dioxide and alcohol, in the same general process that is used to make wine. Normally fermentation occurs with no air present.
- **Esterification**: can also be done using waste to energy technologies, resulting in biodiesel. Its cost effectiveness will depend on the feedstock being used, and all the other relevant factors such as transportation distance, amount of oil present in the feedstocks, and others. No matter the category all waste to energy technology can be developed to be cost effective when implemented correctly.

### 2.2 Choosing waste-to–energy technologies

There are factors to consider in choosing waste-to-energy technology, these are:

- **Cost Effectiveness**. Some of the technologies are cost effective while some are not. Some technology use physical waste-to-energy technologies which process solid waste (such as municipal solid waste, construction & demolition waste ) mechanically to produce suitable forms to be used as fuel, others use thermal which uses heat or combustion to treat waste or biological waste-to-energy technologies which uses microbial activity to produce fuels from waste. Any method used must be cost effective for the success of the project. The cost of creating the energy must not be too high and the project must be well implemented with all necessary infrastructure put in place for efficiency. Waste to energy technology can be extremely cost effective and efficient when implemented correctly [11]
- **Location**. Situating the waste-to-energy plant in the right place can help to bring down the significant cost of energy production. Waste –to- energy plant should be set up in a location that meets all the needs and will bring maximum economic returns. For example, for power generation a combined heat and power (CHP) plant should be located as close as possible to residential or commercial areas to maximise economic opportunities by supplying them captured ‘waste’ heat to meet their heating needs.
- **Availability of Waste**. The waste chosen must be in abundant, readily obtainable and cheap; otherwise the cost of creating the energy will be too high. Latest survey shows that every year UK households throw away the equivalent of 3½ million double-decker buses (almost 30 million tonnes), a queue of which would stretch from London to Sydney (Australia) and back [12]. Since we produce over 300 million tonnes of waste per year, enough to fill London Albert Hall in less than two hours, it shows abundance of waste. For a combined heat and power plant which is a thermal waste-to-energy technologies; local waste wood from construction & demolition, sustainable wood, the biomass fraction of municipal solid waste or the agricultural waste supply is the preferred fuel. While sewage/food waste wet biomass is best suited for anaerobic digestion, a biological waste-

to-energy technologies. However transportation distance to the waste-to-energy plant and traffic implications of fuel delivery needs to be considered for cost effectiveness.

- **Scale**. The size of waste-to-energy plant needs to be appropriately considered, which in turn determines the scale of application. Plant output capacity, conversion level efficiency, and targeted customers, commercial viability, funding, financial sustainability and the phasing of development is crucial in establishing economic viability.
- **Regulations**. The regulations and policies for waste-to-energy technologies can be complex. Irrespective of commercial viability, any waste-to-energy plants in UK are required to meet regional or local planning policies depending on the scale. One method may be allowed at one end, and at the other end disallowed due to air-quality concerns or classification of by products of particular waste-to-energy technologies.
- **Future proofing**. In order to keep-up-to-date with the continuous emergence of new more efficient and environmental friendly waste-to-energy technologies or meet the increasingly tough demands of the Climate Change Act on $CO_2$ emission compliance, whatever technology chosen should allow for future modification or upgrade with minimal disruptions.

### 2.3 Benefits of Waste-to Energy

Waste-to-energy offers a series of benefits if adopted, these includes:

- It provides dual benefit in electricity production if a Combined Heat and Power (CHP) plant is used, leading to leading to the production and delivery of more than one service and associated prime energy efficiency gains. The inevitable 'waste' heat from the electricity generation process can be captured to heat buildings or existing nearby industries, rather than requiring additional gas, oil or electricity to generate it.
- United Kingdom produces over 300 million tonnes of waste per year. These wastes if seen as 'resource' could be utilised in energy production, which would help to power the nation and other benefit such as volumetric reduction of waste and can help to reduce environmental effect of land filling. The biodegradable waste sent to landfilling when it decays produces methane, a potent green house gas that contributes to climate change [13]. Latest report indicated that UK will require the organic fraction of landfilled waste to be reduced by 25% in 2010, 50% in 2013 and 65% in 2020 because it is running out of suitable landfill sites and partly because of the European Landfill Directive (2002).
- Waste -to –energy technologies if fully adopted across the UK could help us reach our targets of an 80% reduction in $CO_2$ emissions by 2050 because it is a renewable energy and a third of UK electricity can also be produced from renewable sources by 2020.
- It is a far more sustainable option for the future than fossils fuels which is scarce and expensive. For common household waste streams such as paper, glass and metal, recycling incurs lower environmental costs than production from virgin materials [14].
- Due to the fact that waste-to-energy can be produced locally, it therefore can benefit local communities and businesses as well as stimulate local economies in these times of economic recessions.

## 3. CONCLUSION

Waste-to-energy as a renewable energy will significantly reduce our use and dependence on fossils fuels thus minimizing the amount of toxins, environmental degradation and harmful pollutants released in our environment, because fossils fuels are the biggest single contributor to climate change. As such any increase in energy demand of whatever form supplied from fossil fuels and will therefore escalate and not alleviate, climate change. On the other hand, waste-to-energy utilises a renewable resource as fuel which does not require mining or drilling and will therefore, make a significant contribution to alleviating climate change. A typical example is the ongoing British Petroleum oil spills at the Gulf of Mexico which is among the biggest oil spillage in the world with tens of millions of gallons spilled to date.

Adopting waste-to-energy in meeting future energy demand will provide us with a cleaner and more sustainable environment and also will help to create and sustain dozens of jobs.

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