Programme Area: Bioenergy

Project: Energy From Waste

Title: WP1.3: Final Waste Report

Abstract:

The objective of the Distributed Energy (DE) Programme is to increase the up-take of DE through the development of integrated systems in order to reduce through-life costs, improve ease of installation and increase efficiency in the combined generation of heat and electricity. Within this programme framework the Energy from Waste project seeks to quantify the opportunity for the use of UK Waste arisings as a fuel to be used in the combined generation of heat and electricity.

The UK generates around 330 million tonnes of waste per annum, of which around 90 million tonnes is energy bearing.Government legislation seeks to incentivise the diversion of waste from landfill through the existing landfill tax and landfill diversion targets. In parallel the UK is committed to reducing its GHG emissions by 80% by 2050 and supplying 15% of its energy demands from renewable sources by 2020. These drivers lead to a requirement for technology solutions which enable wastes to be used as a cost effective, low carbon and indigenous energy resource for the UK. The Energy from Waste FRP was commissioned to address these requirements and identify potential opportunities for a large scale demonstration project.

Context:

The Energy from Waste project was instrumental in identifying the potential near-term value of demonstrating integrated advanced thermal (gasification) systems for energy from waste at the community scale. Coupled with our analysis of the wider energy system, which identified gasification of wastes and biomass as a scenario-resilient technology, the ETI decided to commission the Waste Gasification Demonstration project. Phase 1 of the Waste Gasification project commissioned three companies to produce FEED Studies and business plans for a waste gasification with gas clean up to power plant. The ETI is taking forward one of these designs to the demonstration stage - investing in a 1.5MWe plant near Wednesbury. More information on the project is available on the ETI website. The ETI is publishing the outputs from the Energy from Waste projects as background to the Waste Gasification project. However, these reports were written in 2011 and shouldn't be interpreted as the latest view of the energy from waste sector. Readers are encouraged to review the more recent insight papers published by the ETI, available here: http://www.eti.co.uk/insights

Purpose: Arising IP
Restrictions: No additional restrictions

ETI Executive Summary

Programme: Distributed Energy

Project Name: Energy from Waste

Deliverable: DE2001 / WP1.3: Final Waste Report

Introduction

The objective of the Distributed Energy (DE) Programme is to increase the up-take of DE through the development of integrated systems in order to reduce through-life costs, improve ease of installation and increase efficiency in the combined generation of heat and electricity.

Within this programme framework the Energy from Waste project seeks to quantify the opportunity for the use of UK Waste arisings as a fuel to be used in the combined generation of heat and electricity.

The UK generates around 330 million tonnes of waste per annum, of which around 90 million tonnes is energy bearing, this could provide 1 to 5% of UK energy [depending on collection rates and efficiency gains]. Government legislation seeks to incentivise the diversion of waste from landfill through the existing landfill tax and landfill diversion targets. In parallel the UK is committed to reducing its GHG emissions by 80% by 2050 and supplying 15% of its energy demands from renewable sources by 2020. These drivers lead to a requirement for technology solutions which enable wastes to be used as a cost effective, low carbon and indigenous energy resource for the UK.

The Energy from Waste FRP was commissioned to address these requirements and identify potential opportunities for a large scale demonstration project in this area.

The objective of the project is to provide the following outputs:

- Detailed analysis, characterisation and mapping of UK waste arisings to be used as the basis for the subsequent technology assessment and economic analysis within this Project.
- Assessment of the available Energy from Waste technologies for the whole energy value chain from waste input to power and/or heat output and identification of gaps / opportunities in this value chain.
- Identification of combinations of technologies for development and related technology improvement opportunities to fill gaps in the value chain.

- Clear UK benefits case for development and deployment of the identified technologies. The benefits will be judged against criteria agreed with the consortium at the beginning of the project under the headings of Affordability / GHG Reduction / Energy Security / Robustness

The project is split into 4 work packages, represented schematically below. This report is the final report in work package 1. It summarises the findings of the work carried out by Cranfield University to provide an understanding of the UK waste arisings, the composition of these materials and the associated energy potential.

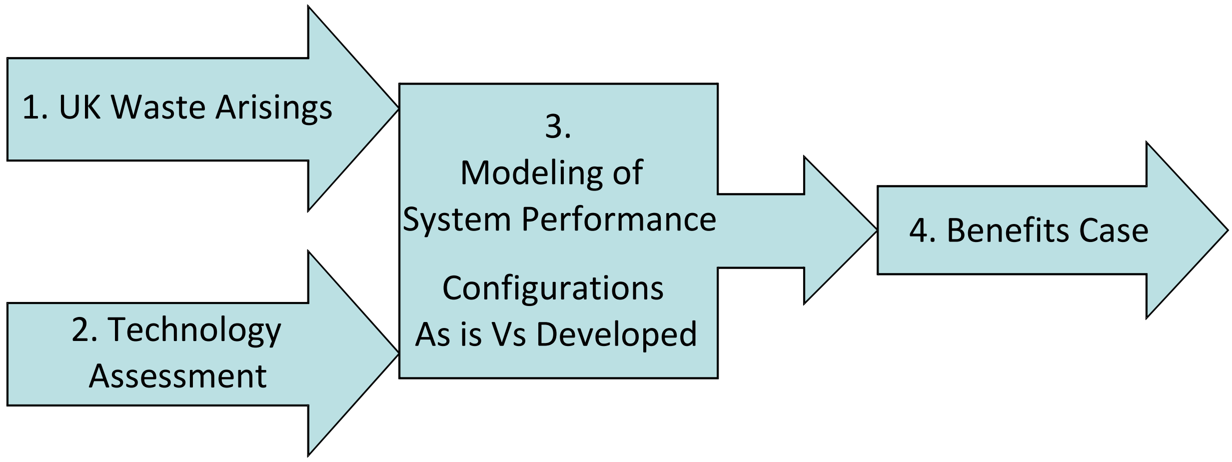

Fig 1 : Energy from Waste Project Structure

Basis of Designs

The objective of Work Package 1 (WP1) is to collect the available data on waste arisings and composition within the UK and to then convert this into a value for its fuel potential. This draws information from a number of sources, including completed and on-going waste studies plus a sampling programme of waste from a number of UK sites.

The WP1.2 report highlighted the available data and identified the areas in with the level of data and understanding was limited, presented in table 1 below;

Sector type vs data	Ag	M&Q	SS	DrMt	MSW	Com	Ind	C&D
	<1%	30%	<1%	5%	9%	11%	13%	32%
Energy	H	L	H	L	H	H	H	M
UK Arisings	L	H	L	M	M	H	H	H
Data Quality	M	M	H	L	H	L	L	M

Table 1 : UK waste arisings and data priorities for fuel analysis

This highlighted that the Commercial and Industrial (C&I) and Construction and Demolition (C&D) waste streams were not well characterised. As such these waste streams were prioritised for investigation within the project. A number of different approaches and sources of data were used to fully characterise these waste streams, including sampling of 5 Shanks Waste Management sites across 4 seasons.

The data sources & approaches used are described below:

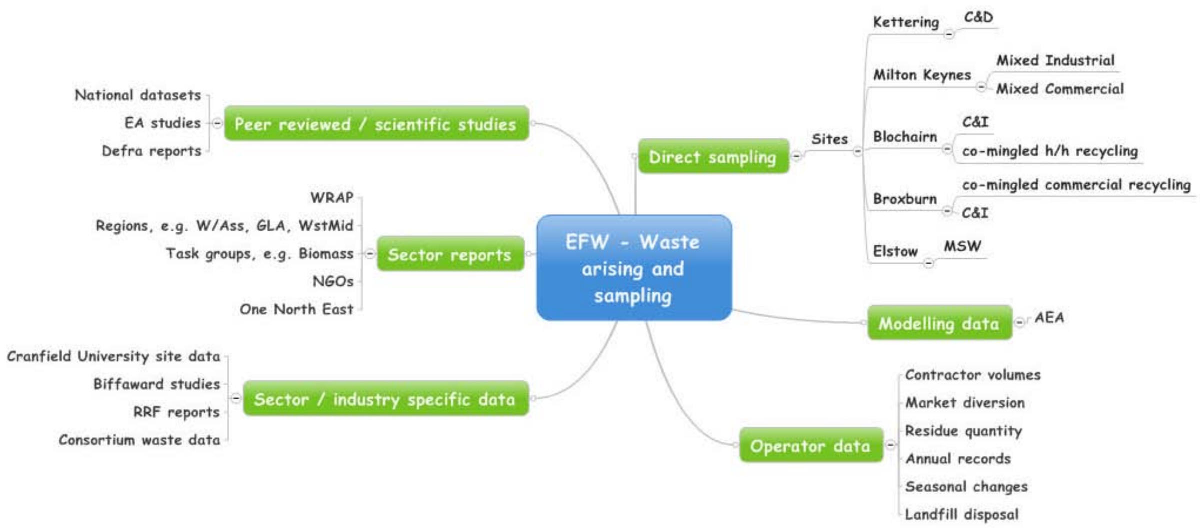

Fig 2 : Data Sources / Approaches Used for Waste Characteristion

For the sampling of waste from the Shanks sites, extensive details of the approach followed are giving in the deliverable, refer to section 3. In summary the following actions were taken:

1) Detailed hand sort of waste carried out
2) 30 images of the waste were taken for visual compositional analysis
3) For each detailed sort at least 1 representative sample was sent to an external laboratory for proximate and ultimate analysis to determine properties such as
    a. Moisture content

b. Calorific value

c. Elemental composition

Under the leadership of Cranfield an analysis of the findings from the various data sources and from the sampling was conducted.

It should be highlighted that in addition to the above methods the team at Cranfield also tested a prototype Image Analysis method under development as part of an MSc project, details of the method are provided in Appendix B of the report. The objective of the Image Analysis work is to determine if an automated approach to waste assessment is feasible as an alternative to manual, hand sorting. Initial findings from the Image Analysis approach are encouraging and further work is planned to develop it further.

Results summary

A summary of the UK waste arisings is provided below

			England		N.Ireland	Scotland	Wales
		02/03[1]	06/07[2]	08/09[1]	06/07[2]	06/07[2]	06/07[2]
C&I	Total ['000 t]	67,900	58,658	48,018	1,560	8,093	3,573
	% recycled		48.7	52	52.3	46	57.5
MSW	Total ['000 t]		29,144	27,333	1,053	2,134	1,785
	% recycled		30.9	37.6	29	30	34
C&D	Total ['000 t]		89,600		1,715	11,804	12,167
Agricultural	Total ['000 t]		2,590		28	370	32

Table 2 : Summary of UK Waste Arisings for Each Waste type ([1] AEA models, [2](DEFRA 2010))

Detailed results of the elemental analysis of the various waste streams, together with the seasonal variations by site are contained within section 4 of the report

		Season					Net CV
		1	**2**	**3**	**4**	**Average**	**[MJ/kg]**
Physical composition (% weight)	Paper	16.5	11	23.5	27.4	19.6	14.4
	Card	15	17.9	12	15	15.0	14.8
	Wood	16.1	19.5	6.8	4.8	11.8	16
	Metals	7.6	3	2.7	2.3	3.9	0
	Glass	3	1.2	1.7	0.9	1.7	0
	WEEE	0.7	0.1	0.3	0.9	0.5	0
	Textiles	2.8	8.7	7.4	2.1	5.3	20.7
	Dense Plastics	10.4	8.2	11.2	12.6	10.6	35.2
	Plastic Film	10.4	11	14.1	21	14.1	41.3
	Organic Dines	14.8	15.3	17.2	8.6	14.0	8.1
	Inert / Agg / Soils	2.8	1.4	1.5	1.8	1.9	0
	Misc. Comb		2.8	1.6	2.6	2.3	10
Proximate	Total Moisture %	40.1	17.6	16.5	10	21.1	
	Ash %	13.4	9.1	7.3	16	11.4	
	Volatile Matter %	41.7	60.4	70.3	69.7	60.4	
	Gross Calorific Value kJ/Kg	8,306	11,850	18,365	18,543	14,380	
	Net calorific Value kJ/Kg	5,796	8,707	17,070	14,644	11,374	
Ultimate elemental analysis	Carbon %	52	41.5	54.1	56.6	51.1	
	Hydrogen %	6.5	4.3	2.8	0.4	3.5	
	Nitrogen %	0.8	1.2	0.6	0.2	0.7	
	Oxygen %	40.3	52.6	42.3	42.2	44.4	
	Sulpur %	0.2	0.2	0.1	0.2	0.2	
	Chlorine %	0.2	0.2	0.1	0.4	0.2	
	Sample Count	6	4	5	5		

Table 3 : Average Properties of C&I Wastes for Each Season of WP1

Key findings

Key findings of the study are:

1) The MSW and C&I mixed waste streams consist of large amounts of different components which have the potential for energy recovery, such as paper, card, plastics, organics [food and green waste] and textiles.

2) The findings show that up to 70% of C&D wastes by weight is inert, i.e. material that is not biodegradable and of no energy value.

3) The C&I wastes were observed to contain higher quantities of paper and card than MSW, which is due to the differences between the recycling targets and policies relating to these two waste streams.

4) The C&I and MSW materials both contained large quantities of film plastic, which yielded the highest CV of all components analysed [39,000 kJ/kg].

5) The potentially recyclable materials present in the residual wastes, in particular C&I, is of importance. The plastic materials contribute significantly to the CV of the overall

material, and as the proportion of these materials are policy and economically driven, being able to understand future recycling trends would be important.

6) The economics of recycling plastics or recovering energy from these materials has been compared. It was concluded that where both heat and electricity is recovered and exported it is economically favourable (due to the increase in overall efficiency) to recover the energy, however where only electricity is recovered in a typical incinerator (e.g. moving grate) facility it is more economically favourable to recycle the plastic.
7) Many recyclable materials, such as plastics and paper, cannot be continuously recycled due to the degradation and/or contamination of the materials as they are reprocessed. As a result, there will always be ‘recyclable’ materials within the residual stream.
8) It is anticipated, and shown in the AEA models used throughout WP1, that paper, card, dense plastics, glass and metals will predominantly contribute to higher recycling rates in 2050. Around 90% of each from the forecasted total residual arisings will need to be removed from the residual C&I stream in order to meet total C&I recycling targets of 70%.
9) As the moisture content impacts on the net CV of the waste materials caution is required when considering these materials as potential fuels. Wastes of higher moisture content would require drying prior to use as a fuel and, in cases where grinding and pre-sorting are required, increase the costs of preparing the material prior to energy recovery. Therefore consideration could be given to waste containers and the collection schemes, including the collection vehicles used, to prevent the addition of rain water to the material before arrival at the treatment facility.
10) The ultimate analysis of the wastes indicates that, on a dry basis, the elemental content is consistent for all wastes assessed as part of this project.
11) The film and dense plastic materials indicate a significantly higher net CV [39,000 and 33,000 kJ/kg respectively] than the other components. Film plastic, however, is not commonly source-segregated for recycling collections. The chlorine and sulphur content of these plastic streams are not higher than other materials, and so further consideration should be given to the environmental emissions resulting from the use of these materials as a fuel.
12) Paper and card yield the lowest net CV [14,400 kJ/kg] of the analysed waste components. These were also present in relatively high proportions in the C&I fractions shown in Table 3. As paper and card are commonly recycled (especially for MSW streams) consideration should be given to the benefits of recycling this material and the potential impacts on the fuel value of the overall waste stream.
13) Waste arisings are variable, as is the composition. A number of factors can explain the fluctuations and growth in waste arriving at the sites, such as adverse weather

[flooding and snow], site building work, changes in contracted collections, economic impacts etc.

14) The fluctuations in quantities and composition of waste arriving are a result of seasonal and economical changes. These variations pose a risk, which should be considered in the design of energy from waste facilities.

15) The level of pre-processing required for the use of waste materials as a fuel is dependent on the energy recovery technology and the associated tolerances; a higher level of pre-processing required results in a high cost, and possibly a higher quantity of waste material [i.e. inert from C&D wastes]. Therefore variability in the waste composition can be offset by adaptable processing of the waste to yield consistent fuels.

Further work

This deliverable is the final deliverable in Work Package 1, it is used as an input into the WP3 (Modelling of System Performance) and WP4 (Benefits Case). The report makes a number of recommendations where further work could be performed, outside the scope of work of the current project, namely:

1) A major driver behind the use of certain materials as a fuel is the commodity value. This is the financial benefit of separating a specific waste component for reuse. Certain components, such as specific plastics, provide a financial incentive to the waste treatment operator. However if the market value of the recyclate was to drop or the energy value was to increase due to technological advance, then the ongoing separation of that recycled material may no longer be profitable and as a result would remain in the mixed waste stream, available as a fuel. As such further research is recommended on the environmental impacts of recycling plastics or use in energy recovery; this could take the form of a lifecycle analysis and compare the differences between CO2 emissions.

2) The understanding of the content, energy value and elemental composition of residual C&I wastes has been developed and enhanced. However a more detailed understanding of the wastes arising from specific industrial sectors would allow a greater insight into the impacts of specific commercial activities on the energy value of C&I wastes. The inclusion of the outputs from the survey of C&I undertaken by Defra would be highly complementary to the data obtained within this project.

References

Council of the European Union (2000). "Directive 2000/76/EC on the Incineration of Waste." Official Journal of the European Communities L 332: 91-111.

Defra. (2010). Survey of commercial and industrial waste arisings 2010- final results. London, UK.

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