Programme Area: Bioenergy

Project: Energy From Waste

Title: Project Framework

Abstract:

This deliverable is number 1 of 3 in Work Package 4. It documents the framework for project delivery and baseline assumptions for the benefits case to be prepared at the end of the project. To this end it specifically covers :

• The Technology Evaluation Criteria to allow the technologies assessed within the project to be compared;
• The financial modelling approach and key assumptions for the calculation of the benefits; and
• The definition of the existing market and baseline technologies to compare against the proposed optimisation and improvements.

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

MEMO

FOR INFORMATION / DECISION
Business confidential

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Date: 9 December 2009

RE: ETI Energy from Waste – Task 4.1 Project Framework Deliverable

1 Introduction

1.1 Purpose

This memorandum is the Task 4.1 Project Framework Deliverable. It outlines the agreed approach to determine:

- Benefits and costs of system improvements (Task 4.2.1) - the benefits and costs associated with the development of the identified technology improvement opportunities; and
- UK Benefits Case (Task 4.2.2) - the benefits to the UK from the commercial deployment of the identified technology improvement opportunities and compare these against technological, environmental and economic factors of the current energy from waste opportunity.

The outcomes of these tasks will inform the ETI strategy and identify future demonstration projects.

1.2 Background

The aim of Task 4.1 is to confirm the project framework and ensure the project scope, project objectives and deliverables are aligned with the ETI objectives and meet their requirements. In addition, to ensure that the dependencies between work packages are understood and the information will be transferred between these work packages.

The Energy from Waste project will focus on power and heat conversion up to 10MWe. The production of transport fuels from energy from waste is excluded however information on the volume and specification of the liquids and gases

produced from the waste processing technologies can be used by the ETI transport team.

Appendix B outlines the agreed technologies and areas that are excluded from the Energy from waste project.

1.3 Workshop

On the 22 September 2009, Caterpillar and EDF Energy held a workshop with the ETI to agree:

- The Technology Evaluation Criteria to allow the technologies to be compared;
- The financial modelling approach and key assumptions for the calculation of the benefits; and
- The definition of the existing market and baseline technologies to compare against the proposed optimisation and improvements.

Appendix C outlines the agree outcomes from the ETI and consortium workshop.

2 Technology Evaluations

The evaluation criteria for the benefits and costs of the system improvements and the UK Benefits case have been broadly developed around the ETI Objectives, i.e.:

- *Affordability* - Does a technology have the potential to be commercially viable?
- *CO_2 Reduction* - What scale of CO_2 abatement is likely to be achieved through mass deployment of a particular technology?
- *Energy Security* - What is the likely impact on UK energy security?
- *Robustness* - How resilient are technologies under different scenarios?
- *ETI Leverage* – Can the skills and capabilities of the ETI contribute to a step-change in technology improvement?

The ETI does not expect ETI leverage to be assessed as part of the UK benefits case deliverable however it is anticipated a discussion will be held with the consortium.

2.1 Task 4.2.1 Benefits and Costs of Technology System Improvements

The benefits and costs associated with the development and implementation of the system improvements will be either at the individual component technology or at the end-to-end system level. Individual component technologies will fall into different categories (i.e. Pre-processing, waste processing, post-processing and power & heat conversion). The system level comprises of all these four categories.

The modelling of technology systems will occur in Work Package 3 (WP3). Component technologies will be modelled in their current state, and then in their developed, improved state, where improvements are identified. System optimisation will determine the best combination(s) of current and optimised technology components to maximise end to end performance (i.e. range of wastes convertible, total efficiency of conversion). This process will identify the component technology and system developments with the greatest impact as measured against the ETI objectives.

The information from WP3 will form the basis of the cost benefit analysis of the development and improvement of the individual component technologies and/or systems and be described on the basis of the following:

1) Scope of the development - Detailed description of technology development including, where appropriate, schematic and or other diagrams. The costs, timeframe and key risks for the development and implementation of the technology developments will be assessed to assist in understanding the benefits of the ETI investing to accelerate the technology improvements.

2) Material impact of the developments - Description of the likely operational impact of development on technology and system performance in terms of the technology evaluation criteria outlined in Table 1.

3) Technology Acceleration – Assessment of current state of technology or system in relation to the NASA Technology Readiness Level (TRL) scale based on commercial deployment and where possible an assessment of the current rate of development of the technology. An assessment will also be made of how the proposed development(s) will accelerate the development rate and increase the technology TRL score through overcoming technical barriers to market deployment.

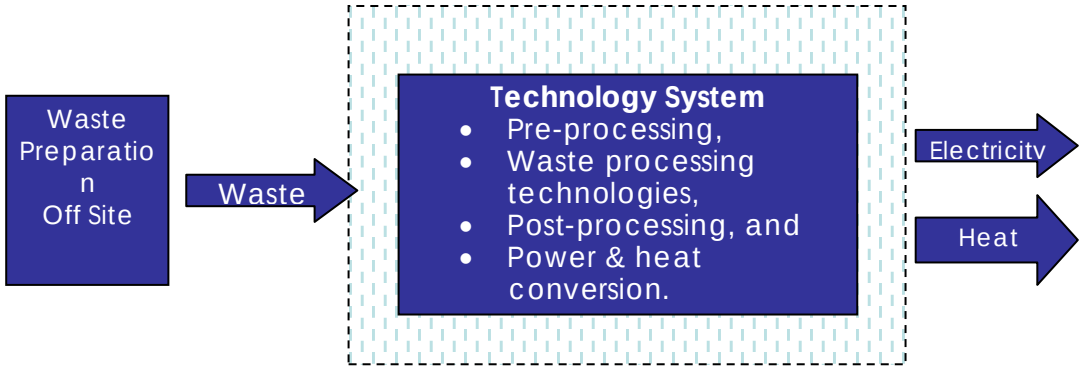


Figure 1 – Technology System Improvement Modelling boundaries

2.2 Task 4.2.2 UK Benefits case

The UK Benefits Case is essentially targeted at the board and is a holistic assessment of the program area (EFW), in terms of its overall potential to impact on the ETI core focus areas i.e. 80% greenhouse gas reduction, energy security, affordability, robustness and additionality. as outlined in Section 2.3, Table 1

The UK benefits case will integrate the findings of the project from Waste Assessment (WP 1), the Technology Assessment (WP 2) and the Technology Performance Modelling and Assessment (WP 3) in order to assess the benefits to the UK of the commercial deployment of the identified technology improvement opportunities. It will compare the 3-5 selected technology system improvements based on commercial assessment for energy from waste plants. A comparison between the improved technology systems and an existing baseline will not be undertaken, unless it becomes clear later in the project that a simple baseline needs to be set in

terms of clarifying the opportunity space to the ETI Board for setting the context not for detailed comparison.

The development of the UK benefits case and the assessment of the commercial deployment will be undertaken using a 3 stage approach:

- Preparation of a sorted waste stream that is transported to site i.e. "Ideal Waste Stream" for each selected technology system;
- Assessment of a generic energy from waste plant for each of the selected technology system improvements;
- Aggregation into the UK benefits case.

The outcomes of the UK benefits case will inform the ETI strategy and identify future demonstration projects.

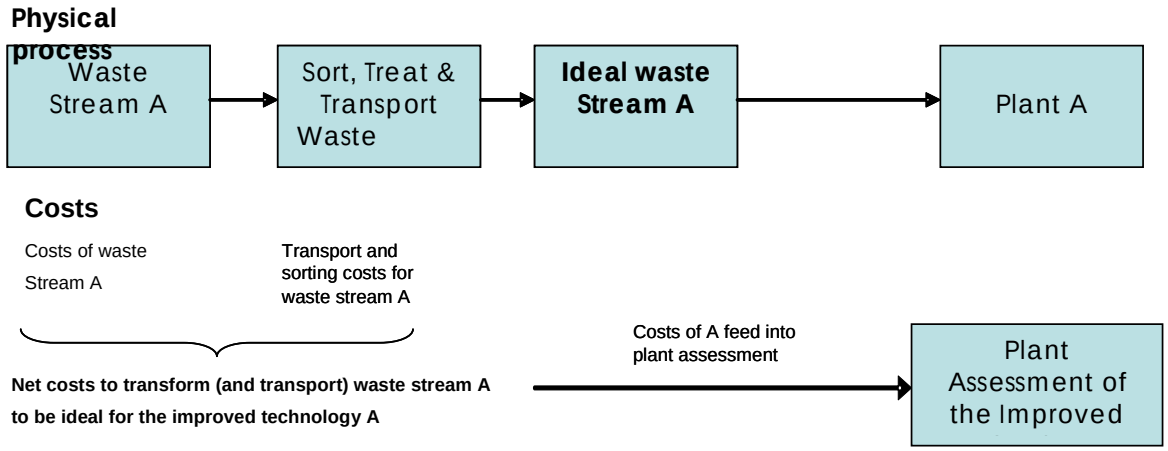
2.2.1 Ideal Waste Stream

To ensure a consistent assessment at the plant assessment level it will be assumed that each plant i.e. any of the 3 to 5 technology improvements, requires a waste stream that is 'ideal' for that plant. The creation of each ideal waste stream and its physical delivery to the plant requires the original waste stream to undergo sorting, treatment and then transportation to the site.

The ideal waste stream assessment for the plants will incorporate an estimate of the differences in cost of acquiring the waste and the landfill fee foregone, and the costs, estimated energy consumption and GHG emissions associated with the sorting and treatment of the waste plus the transportation of the waste to the plant. A simple sensitivity analysis (i.e. +/-10 or 20%) will be undertaken to test the variability and overall impact.

As each plant receives its own ideal waste stream no technology is favoured over another on the basis of the waste stream input to that plant. Other fuels and wastes that can be processed by the technology system will be identified however they will not undergo a full costs, estimated energy consumption and GHG emissions assessment.

The costs and greenhouse gas (GHG) emissions associated with the transport of waste will be based on per mile rate using a standard 44 tonne gross weight truck.



2.2.2 Generic Plant Assessment Methodology

The improved technology systems will be assessed at a plant level. These systems will be treated as a stand-alone fully operational plant set up as a company in its own right. The plant will be assessed against the evaluation criteria outlined in Section 2.3, Table 1 i.e. affordability, GHG reduction, energy security and robustness.

The assessment will include the costs, energy consumption and GHG emissions throughout the process required at an operational plant, including:

- The sorting, treatment and transport of the waste on an appropriate generalised basis;
- The capital, operational and lifecycle expenditure, energy consumption and GHG emissions associated with running the physical plant including balance of plant requirements;
- The overall plant management costs, stand-alone workforce and administration / compliance.

The financial modelling will result in a pre tax and finance cash flow model (and associated profit and loss and balance sheet) that will allow for any of the desired outputs/metrics. The outputs will include, for example:

- Lifetime cost of electricity (£/MWh) and cost of heat (£/MWh);
- Internal rate of return; and
- Net present value.

The cost of electricity and heat generated by the optimised system(s) is intended to enable the ETI to determine the value of subsequent projects to carry out the identified technology developments and demonstrate these on a commercial basis. Therefore it will be assumed that:

- Heat will be modelled to the gate of the plant thus the volume and quality will be outlined. District heating network cost, both capital and operational will be excluded;
- Electricity sold back into the national grid at wholesale market prices.

The greenhouse gas emissions and energy consumption assessment will include the sorting, treatment and transport of waste and the physical plant including balance of plant. The broader environmental assessment as outlined in Table 1 will focus at the plant level.

2.2.3 UK Benefits Case

The UK benefits case will be developed based on evaluating benefits for a generic plant for the selected improved technology. The number of potential sites will be identified using the information generation in work package 1 on the types of "Ideal Waste Stream" used by each improved technology system that is available, specifically the volume and energy content of this ideal waste, and the number of locations there is sufficient waste across the UK.

The overall UK Benefits case will be an aggregation of generic plant by the number of potential sites multiplied by the generic plant. The ETI requirements of the Benefits Case are set out in Appendix D.

2.3 Evaluation Criteria

The below table outlines the Evaluation Criteria for the Technology System Improvements and the UK Benefits Case that have been broadly developed around the ETI Objectives.

Table 1 – Overview of the Evaluation Criteria for the Technology System Improvements and the UK Benefits Case

	Task 4.2.1 Technology System	Task 4.2.2 UK Benefits Case
General Description	Scope of potential technology developments • Sub-system to which identified development applies • Description of physical incarnation of development • Key risks of the development • Initial cost of the development Improved System Performance • Improved system conversion performance • Improved system waste handling capability	
Affordability	1) Technology System or Individual Technology Component Costs • Capital Expenditure • Replacement Expenditure • Operational Expenditure (not fuel) 2) Comparison of costs to the existing state of that technology system	1) Plant Costs (system including balance of plant etc) • Capital Expenditure • Replacement Expenditure • Operational Expenditure 2) Financial modelling of costs and revenues of technology opportunities • Operational Performance • Plant Cost • Revenues
CO2e Reduction & Environmental	UK GHG emissions reductions from system development • GHG emissions from technology system output • GHG avoided from power generated by other sources (Grid (UK Gov long term projections for 2015, heat at 80% efficient gas boiler) • GHG avoided from landfill (GHG potential of wastes accessible by system)	1) GHG Emissions Levels • Total GHG emissions of the technology opportunities • GHG emissions from plant including technology system • GHG reduction from waste (landfill reduction) • GHG from the transport of the waste

	Task 4.2.1 Technology System	Task 4.2.2 UK Benefits Case
		(generalised). 2) Reduction in waste arising and to Landfill • Reduction in waste compared to BAU 3) Strategic Environmental Assessment • Comparison against existing and future environmental limits - Strategic Environmental Assessment Planning and other key legislative assessment 3) Environmental Performance • Emissions to Air, Water, etc • Residues • Waste 4) Energy balance and energy efficiency across the technology system as a whole
Energy Security	1) Preliminary analysis of the UK waste could be accessed 2) Assessment of potential energy generated by technology systems	1) Generation capacity levels • Generation capacity range • Opportunity in UK for roll - out of technology • Comparison to existing UK electricity generation mix 2) Fuel supply (future trends of waste arising) • Security of fuel supply and supply chain assessment 3) Technology Supply chain • Development of Technology Supply chain – qualitative
Robustness	1) Technology System Diversity • Other end uses and systems in which the improved component technology could be deployed • Other feedstocks which could be processed by the system • Capacity scales and ranges over which	1) Operational Performance • Diversity - Number of fuels the plant can operate on waste and biomass • Plant operational flexibility to meet demand profiles • Length of time taken by plant to adapt to another fuel source

	Task 4.2.1 Technology System	Task 4.2.2 UK Benefits Case
	component technologies and systems could be operated	• Plant Efficiency - Level of performance per waste type • Plant life - Technical life of plant & equipment 2) Potential for technology scalability • Scalability - Technology ranges

2.4 Financial Assumptions

The key financial modelling assumptions for the commercial assessment are:

- Electricity volumes are modelled to the plant 'gate' and sold to 'the grid' based on a single variable tariff.
- Heat volumes are modelled to the plant 'gate' and assumed valued at a single variable tariff. Heat demand modelling will not be assessed and the associated district heat network cost will not be modelled.
- Renewable subsidies will be modelled but will be assumed as zero in the first instance, as directed by the ETI. A sensitivity analysis will be conducted on the cost of carbon using 3 prices in-line with the treatment of the plant under the EU ETS rules.
- Tariffs for electricity and heat and indexation rates across revenues and costs are to be agreed with the ETI.

Refer to Appendix A attachment for the agreed detailed financial assumptions.

Appendix A Financial Assumptions

Initial financial model assumption list to promote discussion - Waste to Energy: High-level generic plant assumptions
The aim is to derive a cash flow model from which all manner of metric and 'output' could be obtained and presented. Some of which are discussed in the WP4 scoring

Item	Comments/Actions/Owner
Project Length	
Project Start (financial close - date contracts signed)	Assume 2012
Project life	EDF Energy & CPI (WP3): Optimal economic/technical length interaction
	Potentially assume 25 year project life
Electricity and Heat Strategy	
Electricity sales	Assume sales to the grid
Heat sales (demand and customer mix)	Heat modelled to plant 'gate' only - heat demand not modelled
Operational strategy (how much and when run which equipment -> drives elec sales price)	EDF Energy/CPI (WP3): simple capacity factor assumption to be made to derive a te
	EDF Energy/CPI (WP3): Heat demand will not be modelled, so only flexibility of fuel i
Plant flexibility (to meet heat demand profile)	elec output are considered
Generation	
Plant type	CPI (WP3)
Plant heat efficiency	CPI (WP3)
Plant electrical efficiency	CPI (WP3)
Plant availability	CPI (WP3)
Plant capacity	CPI (WP3)
Capex/repex	
Capex equipment	Caterpillar (WP2)
Capex price & spend profile	Caterpillar (WP2)
Capex risk/contingency	Caterpillar (WP2)
Capex useful life (and therefore replacements required, proportion of repex/lifecycle required)	Caterpillar (WP2)
Enhanced capital allowance applied to capex or not	EDF Energy/Caterpillar (WP2)
Pricing (& volumes)	
Gate fee for landfill waste	EDF Energy - with Cranfield & Shanks (WP1)
Volumes for different recyclables	EDF Energy - with Cranfield & Shanks (WP1)
Prices different recyclables	EDF Energy - with Cranfield & Shanks (WP1)
Volumes for compost/organic material (@ different grades)	EDF Energy - with Cranfield & Shanks (WP1)
Prices for compost/organic material (@ different grades)	EDF Energy - with Cranfield & Shanks (WP1)
Standing tariff for heat per customer type	EDF Energy - will model single variable heat tariff at the plant 'gate'
Variable tariff for heat per customer type	EDF Energy - will model single variable heat tariff at the plant 'gate'
Variable tariff for electricity per customer type	EDF Energy - will model single variable electricity tariff ('to the grid') at the plant 'gate
Sales price of electricity to grid	EDF Energy - will model single variable electricity tariff ('to the grid') at the plant 'gate
ROC sales price	EDF Energy - will allow for input in the model (to be modelled as zero at ETI request)
ROC volume	EDF Energy - will allow for input in the model (to be modelled as zero at ETI request)
RHI sales price	EDF Energy - will allow for input in the model (to be modelled as zero at ETI request)
RHI volume	EDF Energy - will allow for input in the model (to be modelled as zero at ETI request)
FiT sales price	EDF Energy - will allow for input in the model (to be modelled as zero at ETI request)
FiT volume	EDF Energy - will allow for input in the model (to be modelled as zero at ETI request)
LEC sales price	EDF Energy - will allow for input in the model (to be modelled as zero at ETI request)
LEC volume	EDF Energy - will allow for input in the model (to be modelled as zero at ETI request)
LECs (or equivalent) end date	EDF Energy - will allow for input in the model (to be modelled as zero at ETI request)
REGO sales price	EDF Energy - will allow for input in the model (to be modelled as zero at ETI request)
REGO volume	EDF Energy - will allow for input in the model (to be modelled as zero at ETI request)
Triad price	EDF Energy
Triad volume	EDF Energy
Connection fees paid into project (heat)	EDF Energy - only model a single variable tariff for heat, thus exclude connection fee
Opex	
Waste transport costs	EDF Energy - with Cranfield & Shanks (WP1)
Sorting costs	EDF Energy - with Cranfield & Shanks (WP1)
Sorted waste transport costs	EDF Energy - with Cranfield & Shanks (WP1)
Tech processing costs	Caterpillar (WP2)
Tech running costs	Caterpillar (WP2)
Tech maintenance costs	Caterpillar (WP2)
Plant running costs	EDF Energy
Plant BOP	EDF Energy
Admin/office costs	EDF Energy
Fuel	
Fuel type	CPI (WP3)
Fuel calorific value	CPI (WP3)
Fuel emissions factors	CPI (WP3)
Waste Cost	EDF Energy - with Cranfield & Shanks (WP1)
Fuel cost (back-up/alternate fuel sources; e.g. gas)	EDF Energy/Caterpillar (WP2) - if Caterpillar state back-up required
Fuel transportation cost	EDF Energy
Heat Network	Excluded
Network loss factors (heat)	Excluded
Capex and opex cost for DE network	Excluded
Greenhouse gases (Savings and other)	
Emissions volumes	CPI (WP3)
Carbon emissions methodology (vs. base case etc)	EDF Energy
Carbon costs applicable	EDF Energy to allow for input
Other emissions	
Other emissions volumes	CPI (WP3)
Cost of prevention of release of other GG	EDF Energy/Caterpillar (WP2)
Financial & modelling	
Upfront costs (costs to close)	All parties
Funding methodology	EDF Energy - model pre finance
Ownership structure	EDF Energy - model pre finance
Finance structure	EDF Energy - model pre finance
Bank debt rate	EDF Energy - model pre finance
Terminal value	Assume no terminal value beyond project life
Tax rate	EDF Energy - model pre tax
VAT rates	Assume UK large business VAT rates - required for accurate initial cash flows
Working capital	EDF Energy - with Shanks for waste and recyclables (WP1)
Capital allowances	EDF Energy - model pre tax so not directly relevant, but useful to include
Interest rate on cash balance	EDF Energy - model pre finance
Interest rate on overdraft	EDF Energy - model pre finance
Indexation	
indexation factors (capex, opex, labour etc)	ETI to provide guidance

Appendix B - Boundaries of the Project

Below is a list of agreed items and technologies that are not included within scope of this project:

- Waste testing (sampling) will only cover waste available at Shanks sites
- Hazardous waste, clinical waste, radioactive etc.
- Non energy bearing wastes
- Waste currently in Landfill – all waste will be collected pre-landfill
- Off-site waste preparation – sorting and separation
- Materials flow, energy use in sorting machinery
- Current gas capture from landfill, uncaptured landfill, landfill gas, landfill gas processing technologies, waste already landfilled
- Sorting of recyclables, processing of recyclables, energy trade-off with recycling processes, recycling trade-off with raw material production, waste reduction, materials re-use
- Direct Incineration/combustion of solid waste
- Technologies, energy recovery using steam power generation as primary generator
- Technologies or systems with capacity for power generation <100 kWe, >10 MWe or equivalent materials throughput
- Manure, whilst an agricultural waste, is only classified as such if it leaves the farm and is not included in this scope
- Technologies not in the tables below including further post-processing of waste derived liquids/gases into transport fuels

For clarity the technologies included in the tables below are included in the scope of the project.

Pre-Processing

Stabilisation		Storage	Size Reduction
Drying	Torrefaction		Milling

Processing

Anaerobic Digestion

Assessment Criteria	Mesophilic		Thermophilic	
	Batch	Continuous	Batch	Continuous

Gasification

Down Draft	Updraft			Plasma
Fixed Bed	Fixed Bed	Fluidised Bed		
		Air	Steam	

Pyrolysis

Rotary Kiln	Surface Contact

Post- Processing

Filter	Cyclone	Oil Scrub	Water Scrub	Electro Static Precipitation	Plasma

Power Generation

IC Engine	Gas Turbine	Fuel Cell

		(Generic, unspecified type)

Appendix C - Meeting Notes

Below are the notes from the workshop on the 22 September with Caterpillar, EDF Energy and the ETI. The ETI presented on their distributed energy programme and Macro DE requirements with the outcomes of the discussion documented below.

General

- Distribute the ETI presentations discussed yesterday. [AK] - Complete and attached.
- Caterpillar to liaise with the ETI [Mark] on the approach for developing future capex costs.
- Energy from Waste is focused on power and heat conversion up to 10MWe. The production of transport fuels from energy from waste is excluded however information on liquids and gases produced from the waste processing technologies can be used by the ETI transport team.
- Heat will be modelled to the gate of the plant thus as a product and the volume and quality outlined. This will allow the data to be used by ETI.
- Confirm WP1 will be documenting current usages of waste by waste type. This should be presented in table that can then be used and added to in the UK benefits case. Table should outline waste type, volume, CV, current usage (technology & volume), timeframes for usage, and appropriate technical assay information (ash content, silica, water, halides, alkalis, etc) TBC

Technology System - Evaluation Criteria

- Technology system has 4 individual component technologies – Pre-processing, waste processing technologies, post-processing and power & heat conversion.
- Update the Technology System Assessment Criteria to align with the ETI objectives – Affordability (Capex / Opex), CO2e reductions, Energy security, Robustness. [BS / ZvR]
- Baseline comparisons will be based on the status of the existing technology system / sub-component
- Benefits technology improvement should incorporate benefits of the ETI investing in acceleration of the technology improvements - Qualitative assessment of the R&D timescale. Further work is required to understand how this is evaluated, but is will be undertaken by the ETI. [BS]

UK Benefits case - evaluation criteria

- The UK Benefits Case is essentially targeted at the board and is a holistic assessment of the program area (EFW), in terms of its overall potential to impact on the ETI core focus areas (80% GHG reduction, energy security, affordability, robustness and additionality). The Project must generate and compile sufficient data, analyse it and present it in such a manner as to enable the ETI to make decisions at the end of the Project regarding future programme scope. The requirements are aligned as stated in the RFP and the presentation material attached. The costs modelling and financial assessment underpinning this will be developed based on evaluating benefits for a generic plant for the selected technology, determining the number of potential sites and no. potential sites x generic plant.
- Comparison will be between the 3-5 technology system improvements not an existing baseline for UK benefits case, unless it becomes clear later in the project that a simple base-line needs to be set in terms of clarifying the opportunity space to the board for setting the context not for detailed comparison.
- Affordability criteria

    - This will be predominantly a cost based assessment- capex and opex. ~~Detailed~~ DH network costs and modelling to be excluded.
    - Review approach being undertaken for development of capex and opex costing beyond 2010 by ETI (in terms of inflation index) based on the Energy Systems Model (ESM). [AK]
    - Develop a high level model of the costs of preparing targeted waste, transport to site. Transport Document on overview of this approach. [AW]
    - Undertake a Generic commercial assessment of plant – operational cash flow however excluding financial incentives and based on ETI price / revenue curves only if they are all ready established within the ESM. [AK to confirm]. Assessment of financial viability given today's incentives useful as context for board (on-going discussion closer to project conclusion)
- CO2 reduction & Environmental
    - Energy consumption is embedded within the black-box component models. CPI will provide information on CO2 emissions and energy consumption at a systems level. [BS to inform CPI of this requirement].
    - Transport of waste will be undertaken on per mile (costs, energy and CO2e). EDF Energy and Cat believe this should be done using a standard 40 tonne truck. To be discuss and confirmed with Shanks. [BS/ FSP]
- Energy Security
    - Security of fuel supply - Waste stock availability should incorporate seasonality and the sheet updated. [FSP] Complete
    - Technology supply chain assessment should be revisited. It is unclear how this assessment would be undertaken. Generally if there is a market the supply chain will develop.
    - Robustness
    - Diversity should incorporate commentary on the fuels the plant can operate beyond waste (e.g. biomass). [FSP] Complete
    - Circulate the draft deliverable for Task 4.1 Monday 28 September. [FSP]

3 Appendix D –ETI Requirements for the Benefits Case

4 High-Level Benefits Case

4.1 Benefits Case

This has to be robust to present to the ETI Board in order to set the context and case for further investment into the Energy from Waste Arena. The report should highlight areas of investment opportunity for technology acceleration in-line with the TRL's the ETI operates under. This must include the areas covered by the FRP

- **A)** Clarity on overall opportunity space for energy from waste (total waste vs useable waste, key drivers/costs (transport, etc), CO2 reduction, energy security, robustness, including grid connection, etc
- **B)** Assessment of current technology landscape and developments (UK and internationally)
- **C)** Opportunity space for improvements (including technology acceleration) and quantification of where to play and at what cost...
- **D)** Linked technologies

4.2 Minimum Benefits Case Requirements

- Align with requirements as set in the Waste to Energy FRP
    - As per RFP

Assumptions behind data and conclusions must be made available to the ETI in order for data to be interfaced into the 2 ETI energy models, as follows:

- Ability to interface to Cost of Energy Model Break-down
- Ability to interface with the UK Energy Systems Model (ESM)
    - Availability of resources broken down to appropriate granularity at a spacial (GIS) level to align with UK ESM
    - Clarity on potential conversion technologies efficiency, carbon abatement, capital and operating costs
    - Clarity on underlying issues associated with Energy from Waste processes, including separation, preparation, transportation, aggregation and pre-processing (e.g. costs of transport on a per km basis, carbon abatement/build-up across the value chain buckets, energy efficiency, etc)
    - Probability curve in terms of built-up costs, efficiency and carbon improvements from 2020 to 2050 for each component/value-bucket

4.3 ETI's Core Value Requirements

- **Affordability** – Does a technology have the potential to commercially viable and have an impact in the 2020 to 2050 timescale?
- **CO2 Reduction** – What scale of CO_2 abatement is likely to be achieved through mass deployment of a particular technology?
- **Energy Security** – What is the likely impact on UK energy security?
- **Robustness** – How resilient are technologies under different scenarios?

4.4 Sensitivity Analysis

- The Benefits Assessment must align with the time-frames expected for impact (e.g. 2020 to 2050 landscape)
- Although incentive mechanisms are clearly important in the near term, incentives such as RHI, ROC's, landfill credits, etc may not exist in the 2020-2050 landscape, hence it is important to build the Cost/Benefits case up on "naked" data in terms of actual costs in terms of the sensitivity analysis/scenario building.

4.5 Scope of Energy from Waste Projects (from FRP)

- Identification of the opportunities for development of the chosen combinations of technologies, complete with a quantified analysis of the interactions and trade-offs between the selected component technologies.
- Assessment of the potential benefits (particularly CO2 emissions reduction, increased affordability and security of energy supply, waste landfill reduction, etc) which could be derived from the further development and deployment of the identified technologies.
- The Project must generate and compile sufficient data, analyse it and present it in such a manner as to enable the ETI to make decisions at the end of the Project regarding future programme scope. The Participants shall review with the ETI, at least at each relevant stage gate, whether this criterion has been met for the work to date and whether it is expected to be met by the detailed plans for forthcoming work.

4.6 Work Package 4: UK Benefits Case

This Work Package shall assess the potential benefits to the UK which could be derived from the further development and deployment of the identified technologies and opportunities. For each opportunity, the assessment shall include:

- Scope for potential improvements
- Materiality of the impact of such improvements on CO2 emissions, affordability and security of energy supply, waste landfill reduction, etc
- Summary of any subsidiary benefits identified
- Present status of technology development, preferably measured against the NASA
- Technology Readiness Level (TRL) scale, and acceleration potential
- Preliminary economic analysis to show how much of the UK opportunity for Energy from Waste could be accessed.

4.7 Deliverables:

Report detailing the UK benefits case for development and deployment of each of the identified technology opportunities.