An Assessment of the Environmental Impact of Management Options for Waste Wood

Tasks D - G: Technical and Economic Issues
Hierarchy, and WID-Compliant Plant Availability
Executive summary

In this report, we combine and summarise the activities undertaken to produce an issues hierarchy for the management of waste wood across nine different management routes. We have also made efforts to relate the resulting issues to wider aspects of waste wood management, in particular looking at national arisings of waste wood, and their impact on the largest issues faced. Within this report, we also examine the availability of Waste Incineration Directive (WID)-compliant plant in the UK, and examine some of the key drivers within the WID-compliant combustion industry.

The work had five main elements:

1. Setting out the Market Structure

Our work has indicated that the clean, dry, uncontaminated fractions of waste wood are very effectively re-processed and recycled. Demand for this waste wood is increasing, while supply is limited and this is generally forcing prices up. Green wood sources (arboricultural wastes) have limited markets, mainly because of the dispersed nature of arboricultural activities and the relatively high moisture content of the wood. It is probable that energy recovery would be a good outlet for this source of waste wood if the supply could be aggregated sufficiently and if the material could be stored for drying to a more appropriate moisture content. Contaminated waste wood has very limited recycling and re-use markets and is the fraction most likely to go to landfill or incineration. The levels of contamination also mean that Waste Incineration Directive (WID) emissions limits apply to combustion of this wood waste stream, which means that many energy recovery plants would not be able to take this waste. Our conclusions are that the only market for this wood waste stream is energy recovery, but that, unless the wood is source segregated, new structures need to be in place to separate and process this wood waste stream. The economics of this use requires in depth analysis.

2. Examining the Availability of WID-compliant Combustion Plant in the UK and Long-term Fuel Supply Contracts

The data sources show a total of 503MW of installed capacity, with a further 1.7GW currently in the scoping, planning, or construction stages. One issue faced in the assessment of available capacity has been the fact that WID compliance is not a recorded factor in many of the data sources. Energy from Waste (EfW) is a major contributor to the installed capacity, although not all EfW capacity is taken up by biomass combustion, and so this must be taken into account when looking at total capacity.

Financiers (both equity and debt) are likely to require new biomass plant to be WID compliant to ensure that it is capable of taking the widest possible range of fuels that can be procured through a mix of the spot markets and medium to long term contracts. Secure access to fuels will determine whether a plant is financeable or not. WID compliance will increase the potential to gain a mix of biomass material and contract types.


Each pathway was assessed and scored in terms of a series of key issues, such as technical, practical, economic and commercial issues. The results of this assessment show that there are a large number of issues associated with most routes. However there are a smaller number of highly complex issues that affect a number of routes, principally those involving energy recovery and Grade D waste wood.


The overall value of the final disposal/energy recovery options are largely governed by three key factors:

1. The value of electricity, which comprises market price and the incentives offered under the ROO
2. The gate fee paid for wood waste at the site, and
3. The capital expenditure on the plants.

The assessment found that MSW to Energy from Waste (EfW) is the most economically attractive route for waste wood management. This is because EfW plants are built to incorporate the air pollution control equipment needed to deal with waste in general and will not require addition air pollution
control (with additional costs) required for the contaminated grades of waste wood. Therefore the internal rate of return of using waste wood in EfW is more favourable. This is reflected in the analysis of the number of EfW WID-compliant plant in the planning and construction phases. However, this analysis was done for all grades of waste wood and does not reflect the economic value to the waste wood re-processor of the cleaner grades of waste. For these grades there is more value in re-processing (recycling). However, if these grades are subsequently burnt (after re-processing) then this value is not realised by the combustion plant operator.

5. Assessing the Issues Hierarchy

Major issues were identified via the issues assessment. Examining these in more detail has shown that many of them affect a large number of routes, and are very difficult to mitigate. The major issues identified were:

- Permitting and Planning (EfW)
- Site Suitability (All combustion plant)
- Technology Status (Grade C and D sorting and separation)
- Technology Status (Gasification)
- Environmental Impacts and Greenhouse Gas Balance (Landfill and Grade D Storage)
- CAPEX (All combustion plant)
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## Appendices

Appendix 1: List of WID-compliant Combustion Plant in the UK (supplied as separate Excel file)

Appendix 2: Detailed Issues Matrix (supplied as separate Excel file)
1 Introduction

Earlier Tasks in the project identified a range of management options for waste wood, and in agreement with Defra and the Steering Group, nine routes were identified for assessment of their technical and commercial issues in this Task (see Table 1.1). The routes were chosen so as to give a good spread across the various sources and grades of waste wood, and management options.

Table 1.1 Routes for Issues Assessment

<table>
<thead>
<tr>
<th>Route number</th>
<th>Route</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRADE A</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Pre-Consumer - Energy Recovery</td>
</tr>
<tr>
<td>8</td>
<td>Pallets - P/board - Energy Recovery WID</td>
</tr>
<tr>
<td>10</td>
<td>Pallets - P/board - Animal bedding - Composting - Landscape</td>
</tr>
<tr>
<td>GRADE B</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>C&amp;I (a) - Panelboard - Energy Recovery WID</td>
</tr>
<tr>
<td>18</td>
<td>C&amp;I- energy recovery</td>
</tr>
<tr>
<td>GRADE C</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Civic Amenity - Landfill</td>
</tr>
<tr>
<td>25</td>
<td>MSW to Energy from Waste.</td>
</tr>
<tr>
<td>GRADE D</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Demolition - WID Gasification</td>
</tr>
<tr>
<td>29</td>
<td>Railway sleepers -energy recovery WID.</td>
</tr>
</tbody>
</table>

In this task we first outlined the current market (Section 2) and the availability of WID-compliant plant in the UK (Section 3). We then considered the technical, practical, environmental, economic, commercial and social issues associated with each element of the above routes (Section 4) and then undertook a cost/benefit analysis of each route to determine economic influences (Section 5). The results from the two assessments were then used to develop an issues hierarchy (Section 6), which also takes account of the wider context of waste wood management. Our conclusions and recommendations are set out in Section 7.
2 Current Market Structure

The waste wood market has been examined in detail for Defra (Defra 2008) and our work has not shown a great change in the structure of the market since that analysis, except that the market has grown and international considerations are becoming more important.

Essentially there are a number of organisations that are key to the production of waste wood and a number of organisations that are important in the aggregation of this supply and its re-processing to forms that are suitable for re-use, recycling or energy recovery:

- **Producers**: wood processing industry, including furniture manufacture; packaging and pallets; construction and demolition; other industrial and commercial sources; and mixed waste producers, i.e. from the municipal waste stream.
- **Aggregators**: Recyclers and re-processors (who sort, segregate and process the waste wood for subsequent markets)
- **Users**: panel board manufacture; energy generation; animal bedding; horticultural use.
- **Treatment, energy recovery or disposal** of waste wood that cannot be recycled or recovered: landfill and energy from waste.

Currently the interaction of these sectors is dictated by market conditions (including the price or gate fee paid for waste wood and the value of the re-processed product), which are influenced by:

- Government policy on waste recycling and renewable energy (which influence the price paid for segregated and processed waste wood);
- Regulations on waste treatment and disposal (which influence the funds available to segregate and re-process waste wood);
- Regulations and agreed protocols on spreading of compost on land (which influence horticultural use);
- Demand for waste wood products in the various markets, which could also be expressed as a function of price of waste wood on the market;
- Supply of waste wood products, which in turn is related to economic activity in sectors that produce waste wood (construction, paper, pulp, timber processing and furniture and other wood based product manufacture).
- Quality of waste wood supplied (see Defra 2008 or the Task A report for this current work).

The current market for **Grade A (and potentially B)** waste wood (i.e. dry, uncontaminated waste wood) is not at ‘equilibrium’, in that demand is exceeding supply both for re-processors and (potentially) for users. This is resulting in increased prices along the whole waste wood supply chain for the clean, dry, easily segregated fractions of waste wood. Re-processors have invested in plant to separate and process wood to meet the needs of each of the customers they serve. The net result is an efficient and effective, commercial industry that is attracting new entrants and faces a number of pressures on margins. This sector does not, on the whole, process wet wood residues such as arboricultural wastes or garden waste from civic amenity waste or mixed or contaminated waste wood.

The main increasing demand for waste wood is dominated by the energy and panel board sectors; in addition (though less significant) the demand for (high quality) animal bedding is increasing. As indicated above the net result is that the price of re-processed waste wood is going up in all markets. In addition there is a growing export market to supply waste wood energy plants elsewhere in Europe. This means that the re-processors are trying to meet increasing demand. However, their supply (from waste wood producers) is limited, hence the upwards pressure on prices.

A further impact of this market is that the re-processing industry is examining new sources of waste wood (particularly Grade B, mixed grade or grade C, low grade). There are two potential solutions. Firstly current waste wood re-processors are short of supply in a number of UK regions. The industry could expand if it invests in regions outside the current areas, where there may be more supply. However, the current industry is centred in those regions where the best quantity of good quality waste wood is available.

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wood is produced; many of the easy sources of waste wood are already known to re-processors. Thus expanding to new regions would not necessarily produce a large increase in the re-processing of waste wood. Furthermore the influence of economic activity on the production of waste wood is a limit in the current market, as indicated above. Consequently this would not necessarily address the limitations in supply at present.

A second solution is to expand to obtain wood from sectors not previously considered for re-processing. This includes the use of arboricultural wood; green wood from the municipal stream; and to encourage construction and demolition firms working on small sites to separate and recycle more of their waste wood. Green wood is commonly used in the horticultural market. Re-processors have said that their customers will not take this source of waste wood because the moisture content is too high. This means that alternative outlets would probably be required for this waste wood stream – or it would need to be dried and processed into forms that are marketable. Small scale construction and demolition sites are often short of space for separation and would need to be compensated (financially e.g. by lower gate fees) for the time and cost of segregating their waste.

**Pressure to develop grading system for waste wood.**

Most recycling outlets require high grade waste wood (grade A), with low levels of contaminants. In order to provide advice to producers of waste wood and to obtain clarity for the energy market there is a growing pressure to develop a more rigorous grading system for waste wood. However, to date the regulators and re-processors have not been able to agree a protocol that is satisfactory to both their needs. In the mean time re-processors provide a specification to each producer of waste wood, which tend to limit the producers to fractions that can be guaranteed to meet customers’ specification.

**Increased diversion of wood waste from landfill**

To achieve increased diversion of wood waste from landfill will require significant changes, particularly as many of the grades left are among the more contaminated streams. For this wood to be of use to potential end users there is a need to invest in is processing:

- As indicated above, green waste often goes to landfill because it is produced in small quantities over a widely dispersed area and is too moist for many end uses. Investment is required to aggregate this source, and to store, dry and process it.
- Contaminated wood (grades B, C and hazardous wood waste) is a mixed class of waste wood, often contaminated with preservatives or treatments/coatings such as paint, glue, varnishes etc. Currently it is likely that this makes up a large proportion of the waste wood going to landfill and it is likely that it may also be mixed with other materials that are difficult to separate. In its current form this wood is not suitable for recycling or end use. For Grades B and C wood tests to identify some contaminants and therefore allow better separation are required. WRAP has funded work on such tests, but to date no suitable universal test is available. For much contaminated waste wood a visual test is sufficient to demonstrate the contamination (for example MDF, chipboard, painted wood or wood with other coatings are easily spotted) and these waste wood streams are routinely rejected by re-processors. One problem with segregating this wood for energy recovery is that it is difficult to demonstrate the composition of this wood for the purposes of the Renewables Obligation (i.e. to demonstrate that it is 90% biomass). This is because some treatments (e.g. glue, preservatives) may contain fossil carbon, which has to be measured for its contribution to energy content. This means that some wood that might be suitable for energy recovery is rejected because the generator cannot demonstrate its biomass content. This situation may be rectified once work being supported by Defra and DECC on measuring the biomass content of waste is complete.
- Waste wood that is mixed with other waste streams could be separated for recycling. However, initiatives to source separate waste wood and to process it to a form suitable for waste wood re-cycling or recovery will require considerable investment, including increased awareness from the producers, source separation where feasible, processing of the separated fraction etc. Whether or not this investment will result in a useable waste wood fraction is not clear; it is possible that it will only be suitable for energy recovery. The economics of this case need to be examined in detail before investment is made.
- We were not able to uncover what is happening to hazardous waste wood in this work. This grade of waste wood has only two outlets at present: land fill and incineration. However, we were unable to find data that was sufficiently transparent on the fate of this waste wood.

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These conclusions are similar to those of Defra (2008), which concludes (among other things):

- Recycling outlets are well developed and there is limited scope for a significant increase in recycling due to dependence on output from other industries and the contaminated nature of most waste wood; and
- Energy recovery is the most likely method of diverting additional waste wood from landfill.
- There are relatively strong financial incentives for aggregators to collect and process the high grades of waste wood, due to the relatively high demand for such materials from recyclers and increasingly from biomass energy generators.
- There is very low demand for low grades of waste wood from recyclers so aggregators are only incentivised to collect low grades of waste wood where alternative disposal/energy recovery routes exist, for example, if they are close to WID compliant plants.

The significance of WID combustion plant is that they can be used to recover energy from Grades B, C and hazardous waste wood. These would provide an alternative to landfilling for these grades.

We have collated the most recent and relevant information on both operating and planned WID-compliant plant of the following types of WID compliant plants that could recovery energy from waste wood:

- Stand-alone, purpose-built waste wood combustion plants;
- Co-combustion plants: co-combustion with other waste (e.g. sewage sludge) or co-combustion in cement kilns;
- Advanced technology: Gasification of waste wood;
- Energy from Waste plants.

All data is based on published information in the public domain (except where stated).

3.1 Data Sources

Data for this analysis of available and planned capacity has come from a number of sources:

RESTATS

RESTATS, the UK’s Renewable Energy STATisticS database, is a project that has been running for 20 years and over this period has become the primary source of accurate, up-to-date energy statistics of UK renewable energy sources. These cover active solar heating; solar photovoltaics (PV – currently included with wind statistics); onshore and offshore wind power; wave power; large- and small-scale hydro; biofuels (biomass and biowastes, including co-firing); geothermal aquifers. It is thus the most reliable means by which the success of the UK renewables programme can be both measured and monitored.

These data are used by the Department of Energy and Climate Change (DECC), the Statistical Office of the European Communities (SOEC, also referred to as Eurostat) and the International Energy Agency (IEA); UK data are published in the Digest of UK Energy Statistics (DUKES), and also published via the DECC and RESTATS web sites. It has proved particularly valuable in recent years by providing independent statistical evidence in support of various aspects of renewables activities and has been used by Government, industry and various contractors in a range of activities related to related to renewable energy. Further details may be found on: [http://www.restats.org.uk](http://www.restats.org.uk)

REPD

In parallel and complimenting RESTATS, the Renewable Energy Planning Database (REPD) project meets the need to track the progress of potential new projects from inception, through planning, construction and operational stages. These data are required in order to make forecasts about when targets for electricity generation from renewable energy sources will be achieved, as failure to do so would result in financial penalties to the UK. Furthermore, these data help identify where problems may be occurring in policy, incentive mechanisms and in the planning process and provide good quality information to Government to assist in evidence-based policy making.

Released in June 2010, the directory has been researched and prepared by Enagri Ltd, an online company which acts as an information source on bioenergy and energy agriculture (http://www.enagri.info/). The directory contains information on:
- Market Overview
- Biomass Power Plants (operational and planned)
- Co-Firing with Fossil Fuels (operational and planned)
- Energy from Waste Facilities (operational and planned)


The data sheets show listings of biomass generating stations in the UK, split by fuel type for the power station (biomass, AD, Energy Crop, Gasification/Pyrolysis – Gas), biomass type, biomass form, and whether the biomass is a waste. Many of the generating stations are listed more than once as they take a mixture of biomass types.

www.ofgem.gov.uk/sustainability/.../SR%20Master%20report_publish.xls


Article 15 of Directive 2000/76/EC on the incineration of waste (WID) requires Member States (MS) to report on their implementation of, and experience with, the WID in order to facilitate the monitoring of its success as well as to identify any issues that have arisen with its use. The first reporting period for the WID was 2006-2008 and reports, using the questionnaire required by the Directive, were to be submitted in 2009. This report contains the responses of 25 of the 27 Member States, including the UK.

Defra / Environment Agency (2011) Permitted Incinerators

The data show listings of incinerators in three categories:
- Restricted Incineration
- Restricted Clinical Waste
- Restricted Other Energy from Waste

This is data from facilities that the Environment Agency permit. It does not include data from Local Authority permitted facilities, which could be burning waste wood, nor does it include any facilities that are exempt from permitting. The data has not yet been cleared for release and is subject to change. The use of this data has been restricted to this project, and its circulation within the project team has also been restricted.

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3.2 Results

Figure 3.1 Table showing total capacity figures for WID-compliant planned and operational combustion plant in the UK, split by region

<table>
<thead>
<tr>
<th>Region</th>
<th>Planned (MW)</th>
<th>Number of planned plants</th>
<th>Operational (MW)</th>
<th>Number of operational plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Midlands</td>
<td>40</td>
<td>5</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>East of England</td>
<td>461</td>
<td>8</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>North East</td>
<td>55</td>
<td>2</td>
<td>40</td>
<td>1</td>
</tr>
<tr>
<td>North West</td>
<td>308</td>
<td>6</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Northern Ireland</td>
<td>40</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Scotland</td>
<td>63</td>
<td>4</td>
<td>68</td>
<td>5</td>
</tr>
<tr>
<td>South East</td>
<td>226</td>
<td>9</td>
<td>257</td>
<td>12</td>
</tr>
<tr>
<td>South West</td>
<td>278</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wales</td>
<td>82</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>West Midlands</td>
<td>95</td>
<td>5</td>
<td>75</td>
<td>5</td>
</tr>
<tr>
<td>Yorkshire and Humber</td>
<td>112</td>
<td>6</td>
<td>29</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1760</strong></td>
<td><strong>59</strong></td>
<td><strong>503</strong></td>
<td><strong>30</strong></td>
</tr>
</tbody>
</table>

The data sources show a total of 503MW of installed capacity, with a further 1.7GW currently in the scoping, planning, or construction stages. These totals include the full capacity of Energy from Waste plants. There are only 7 plants in operation that are WID-compliant and dedicated to biomass combustion. This would bring the total operating capacity down to 60MW. One issue faced in the assessment of available capacity has been the fact that WID compliance is not a recorded factor in many of the data sources. It has, however, been possible to determine the fuel supply for nearly every installation, therefore giving a good indication of the likelihood of WID compliance for each plant. The vast majority of the identified plants are therefore WID-compliant, but most will be unable to take hazardous waste wood as their permit does not cover hazardous waste incineration. There may be some large-scale waste wood combustion plants that are not currently listed as they are not WID-compliant, but that could probably extend their permit to cover WID combustion, given minor changes in their equipment.

Currently the larger proportion of plants are located on the Eastern side of the UK, with the majority of plants located in the South East. There are even some regions without operational plants. However, future planned capacity should provide a much more even distribution of capacity, especially in the South West.

Appendix 1 provides the full list of available capacity in the UK, broken down into planned and operational capacity.

According to a report by Goovaerts et al (2010)\(^4\), in the UK, 159 installations (including 33 new installations) fall within the scope of the WID. The UK accounts for 11% of the total number of reported EU installations within the scope of the Directive.

It is very important to note that the capacity figures for WID compliant plant include a large number of Energy from Waste (EfW) plants (see Appendix 1 for a full breakdown between EfW and Dedicated

Biomass Plant). The main fuel source of these plants is municipal, and, increasingly, commercial mixed waste, and the wood proportion is generally quite low. This means that the total capacity figures need to be read with an understanding that they do not represent 100% WID-able waste wood burning capacity. Figures 3.2 and 3.3 show the operational and planned Waste Incineration Plants (i.e. EfW) from a recent presentation at the latest IEA Bioenergy Task 36 meeting in Rome (November 2010, DECC).

Figure 3.2 Graph showing cumulative operational EfW plants in England (November 2010, DECC)

Figure 3.3 Graph showing cumulative figures for all EfW plants in planning or under construction in England (November 2010, DECC)

3.3 Long term fuel supply contracts and their impact on WID capacity in the UK

The primary driver for the development of WID compliant biomass power plants are the current financial incentives that are available for renewable electricity generation under the Renewables Obligation (RO).

The potential role for fuel contracts is a matter of balancing risk and price, on the basis that long term fuel contracts are likely to be more expensive than procuring material on the spot market, but reduce the risk of not being able to procure the desired amount of fuel.

A WID plant operator must ensure that they can procure the required fuel at an acceptable price to operate the plant to deliver the predicted return on investment. Following consultation with a wood reprocessor it was felt that most of the power plants under development were financed off balance sheet (although risk is reviewed internally as part of the project sign-off).

Many of the larger biomass generators will have medium to long term supply contracts for a proportion of their wood supply, and it is highly likely that they would be burning a combination of virgin wood and treated wood. They will then supplement this with short term—or on the spot buying to make the most of lower prices when available. Combustion plants may also have facility to store significant volumes of fuel on site and so allow the short term buying to function so they can generally avoid peaks in the market.

It would therefore be reasonable to assume that medium to long term fuel contracts for WID material are likely to help secure project finance by offering predictable fuel costs (for a greater proportion of their fuel), therefore providing increased certainty of the returns from a WID plant. To enable the development of medium to long term contracts, a price point of mutual benefit would need to be reached by both the fuel supplier and the WID plant operator which mitigates the risks to both parties.

An added complication affecting the margin that WID plants make, is the uncertainty of the incentive framework, meaning that income from energy generation can be eroded both by increasing fuel prices and changes in subsidies/incentives.

Following discussion with wood re-processors, there are a number of challenges that are present which mean that it is currently difficult for wood processors to offer this type of contract. A key issue is gate fee volatility for material coming into waste aggregators/re-processors. The price that material is offered to WID plants operators combined with the gate fee for material into the site, must cover the cost of processing, haulage and margin. Currently the gate fees for material are quite volatile and can be locally distorted by large demand in a specific area or by European market prices. The barriers to movement of material are also low and the haulage cost of moving material also means that if demand is high enough in a specific area the price point will be exceeded where it is economic to move fuel.

The waste wood supply chain is fragmented. Generally it is not operated on contractual basis and where contracts are in place they are generally short <12months. Fuel aggregators and processors are therefore unlikely to be able to offer longer fuel supply contracts when the contract they have for receiving material are so short and ‘back to back’ contracts are not in place.

It was noted that potentially very large waste management companies might be able offer medium/long term contacts where their operation was linked to public waste management contracts. This would be due to a lower perceived risk to these operators due to the breadth of the operation and waste management contract.
4 Issues Assessment

The identified management options for waste wood were compared in terms of a number of key issues that are important to their sustainability and environmental impact. Comparison of these issues then enabled us to rank the management options to form a ‘hierarchy’ of waste wood management routes.

Defining the Assessment

The assessment for each route was done in three stages:

Stage 1 defined each management route in terms of a number of key, common steps, to allow comparison between the routes. This was done by condensing the detailed flow charts of each route from the Life Cycle Assessment (LCA) into a series of more manageable steps (see example in Figure 4.1). The grade of wood at each stage of the route was also included, as some routes see a change in the grade of wood after a certain stage. For example, once pre-consumer waste wood (grade A) has been processed into panelboard, and then discarded at a later date, the grade of the waste wood decreases from A to B or C.

Figure 4.1 Flow charts showing the stages from the LCA and the condensed stages of Route 3 (see Appendix 2 for all other routes)
Stage 2 defined the factors against which the performance of the routes could be assessed. These factors ensured that all possible aspects of each part of the route could be addressed, whilst also allowing for comparative assessment across all of the routes.

The categories are listed in Figure 4.2, which shows that a range of technical, environmental, logistical, and economic factors were used.

**Figure 4.2 Table showing the categories of assessment**

<table>
<thead>
<tr>
<th>Assessment Category</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logistics / Storage / Materials Handling</td>
<td>Assessment of issues relating to the transport of waste wood, all handling of waste wood (in any form), storage of waste wood (in any form), and movement of waste wood around the site.</td>
</tr>
<tr>
<td>Site Suitability</td>
<td>Availability of land, proximity to domestic residencies, quality of transport routes, proximity of supply, availability of resources on site (such as grid gas), topography of site</td>
</tr>
<tr>
<td>Technology Status</td>
<td>State of currently used technology, level of further development needed, how near to market are newer solutions?</td>
</tr>
<tr>
<td>Impacts (non CO₂) / waste</td>
<td>Emissions to water, emissions to air (apart from CO2, i.e. NOx, SOx, dust, VOCs), emissions to land, nuisance (odour and noise)</td>
</tr>
<tr>
<td>Greenhouse Gas Balance</td>
<td>Results direct from streamlined Life Cycle Assessment (LCA)</td>
</tr>
<tr>
<td>Permitting / Planning</td>
<td>Planning regulations, environmental permitting, public perception</td>
</tr>
<tr>
<td>CAPEX</td>
<td>Investment needed to create a new site set-up</td>
</tr>
<tr>
<td>Profitability</td>
<td>CAPEX, OPEX, Government Incentives</td>
</tr>
</tbody>
</table>

In stage 3 a scoring system was developed to allow assessment of all of the different factors (see Figure 4.3). The scoring system was developed to allow the key advantages or benefits of each route to be identified; and to also identify those factors where there are likely to be more serious issues:

- A score of 1 is generally a benefit
- A score of 2 or 3 is generally representative of ‘business as usual’ – performance typical of current practice
- A score of 4 or 5 should be seen as an indication of more serious issues.

It was not possible to assess all of the factors on the same basis. While most factors can be assessed in terms of the number of benefits or impacts and the complexity of these, other factors, notably LCA, Capex and profitability could not be assessed in this manner. LCA was assessed by referring to the results of the LCA. Capex was assessed according to the impact it might have on investment. Profitability was assessed in terms of relative potential profit.

Following this methodology, all nine routes were scored on the number and complexity of issues associated with each stage within the route (see example in Figure 4.4). Each score was accompanied by a notation of the reasoning behind the score. Appendix 2 contains the detailed matrix and comments for each route.
**Figure 4.3 Table showing scoring criteria used in the Issues Assessment**

<table>
<thead>
<tr>
<th>Score</th>
<th>Issues</th>
<th>LCA scoring criteria kg CO2 eqv</th>
<th>CAPEX</th>
<th>Profitability</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>1</td>
<td>No issue, possible benefits</td>
<td>less than -200</td>
<td>No barrier/ no investment needed</td>
<td>Very good profits</td>
</tr>
<tr>
<td>2</td>
<td>Simple issue, with many options to resolve it</td>
<td>0 to -200</td>
<td>Internal investment approval likely</td>
<td>Good profits with government incentives</td>
</tr>
<tr>
<td>3</td>
<td>Multiple simple issues, which require multiple options to resolve them</td>
<td>+1 to +10</td>
<td>Challenge to approve investment</td>
<td>Profitable</td>
</tr>
<tr>
<td>4</td>
<td>Complicated issue, with limited options to resolve it</td>
<td>+10 to +100</td>
<td>External capital investment needed</td>
<td>Some profit</td>
</tr>
<tr>
<td>5</td>
<td>Very difficult issue, requiring complex options to resolve it</td>
<td>greater than +100</td>
<td>Raising capital will be a challenge</td>
<td>Risk of losses</td>
</tr>
</tbody>
</table>

**Figure 4.4 Table showing Issues Assessment results for Route 3 (see Appendix 2 for all other routes)**

<table>
<thead>
<tr>
<th>Stages (from LCA)</th>
<th>Practical / Technical</th>
<th>Environmental</th>
<th>Commercial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Logistics / Storage / Materials Handling</td>
<td>Site Suitability</td>
<td>Technology Status</td>
</tr>
<tr>
<td>A Collection, transport and sorting</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>A Wood waste processing site and chipping to biofuel grade</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>A Combustion at biomass plant</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>A Ash disposal</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
4.1 Outcomes of the Issues Assessment

The overall results of the Issues Assessment are shown in Figure 4.5 below. In order to allow comparisons to be drawn between the routes, the issues scores are plotted as a percentage of the total issue scores in each route. This diagram shows which routes have the most level 5 issues; and which are the simplest routes in terms of having most level 1 issues. It is quite interesting that route 23 have the most level 1 and level 5 scores. This route is landfilling and its scores reflect the relative simplicity of the option, together with the complexity and impact of the environmental impacts associated with the route.

Figure 4.5 Graph showing the percentage breakdown, per route, for the Issues Assessment

The full data for this graph and explanations of all scores given in the Issues Assessment can be found in Appendix 2.

A review of the outcomes of the Issues Assessment shows that all routes have elements of simplicity, and elements of complexity. No one route is free from issues, although those routes that contain more contaminated waste wood (Grades C & D i.e. Routes 23, 25, 28 and 29), face a larger proportion of complex issues.

The factors that scored a 5 in the issues assessment are shown in Figure 4.6, together with an indication of which routes were affected. A number of the major issues affect almost all of the routes. These major issues are analysed in more detail in Section 5 of this report.

Major variables when assessing the score to be given for an issue include:

- Scale of combustion plant under discussion. Issues for a 500kW plant would score differently to issues for a 50MW plant;

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6 For detail on what the various routes are see Table 1.1 in this report.
- Using existing combustion plant / landfill etc, vs. building new capacity. In this case, very different issues would be faced. Where this question was raised, specifically regarding EfW and landfill, we have completed an Issues Matrix for each of the two different scenarios.

**Figure 4.6 Table showing all issues scoring 5 in the Issues Assessment**

<table>
<thead>
<tr>
<th>Category</th>
<th>Stage</th>
<th>Routes</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Suitability</td>
<td>Combustion at WID and non-WID biomass plant, EfW plant, and gasification plant</td>
<td>3, 8, 14, 18, 25, 28, 29</td>
<td>Very limited number of large scale combustion plants, timescale for development quite long therefore may be no demand locally</td>
</tr>
<tr>
<td>Technology Status</td>
<td>Grade B, C &amp; D: Collection, transport and sorting</td>
<td>8, 10, 14, 18, 23, 25, 28, 29</td>
<td>No agreed methodology to separate grades out from collected waste wood which means that it all needs to be classed as a total grade, depending on the main source for collection (i.e. Grade C from CA sites)</td>
</tr>
<tr>
<td>Technology Status</td>
<td>Gasification and Combustion at WID biomass gasifier plant</td>
<td>28</td>
<td>Highly complicated technology, especially when using the gas in CHP engines. Many issues to overcome before this is an established technology for electricity generation</td>
</tr>
<tr>
<td>Impacts (non CO₂) / Waste</td>
<td>Transport and disposal in landfill</td>
<td>23</td>
<td>Many issues, odours, noise, visual obtrusion, long term restrictions upon redevelopment</td>
</tr>
<tr>
<td>Impacts (non CO₂) / Waste</td>
<td>Grade D: Collection, transport and sorting</td>
<td>28, 29</td>
<td>A number of issues such as CCA treatments, non-recyclable waste arisings, traffic movement disturbances</td>
</tr>
<tr>
<td>Greenhouse Gas Balance</td>
<td>Transport and disposal in landfill</td>
<td>23</td>
<td>See LCA results</td>
</tr>
<tr>
<td>Permitting/Planning</td>
<td>Combustion at EfW plant</td>
<td>25</td>
<td>Most plants are over 5 MW thermal capacity and will be visually obtrusive and create significant lorry movements. They will also have to comply with AQ regulations. All combustion plants scored a 4 or more for planning issues, although at the time of writing this report it was felt that there was a stronger anti-incineration lobby in particular.</td>
</tr>
<tr>
<td>CAPEX</td>
<td>Combustion at WID biomass plant, EfW plant, and gasification plant</td>
<td>8, 14, 18, 25, 28, 29</td>
<td>A WID biomass plant is a significant expense and is likely to require external capital to enable it to proceed.</td>
</tr>
</tbody>
</table>
5 Economic Assessment

This task assesses the relative economics of the nine routes which have been pre-selected earlier. Used wood, classed as grade A and B in particular, can find several uses before its residual value needs to be recovered in the final disposal/energy recovery option. The options considered here are based on energy recovery by combustion, landfill or gasification or by composting. Use of the wood prior to these options is primarily governed by market opportunities alongside those of the final disposal options and it is not the intention to discuss interlinks or the conditions that will drive options one way or the other.

For the purpose of providing a comparative analysis, and on similar basis to the GHG analysis, we have worked through each option in turn and have examined the economics of the options in the light of the economic incentives offered by the UK Government.

5.1 Approach

In order to do this, we first divided each route into its separate processing segments (e.g. collection, delivery, chipping board manufacture etc) and then selected those around which the economic analysis of the final disposal/energy recovery options is based. Given the nature of the energy recovery options, having large capital investment with a limited plant life, we have adopted a simplified discounted cash flow analysis to assess the net benefit (or cost) of the relevant options. In doing this a number of simplifying assumptions are made, which are highlighted below.

The overall aim here is to indicate the parameters which are likely to drive decisions but to also elucidate their merits across all of the option routes. Towards the end of this section we have also undertaken a sensitivity analysis of some of the key economic parameters, including the ROC price, gate fees and capital cost on the options.

All values are then presented on the basis of one tonne of wood waste arriving at the final point of disposal.

5.1.1 Technical and economic assumptions

- The wood waste arrives at the final point of disposal/energy recovery on which a market gate fee is paid. To the operator of the plant this can be an income stream if a gate fee is paid (i.e. negative fuel cost) or can be expenditure (i.e. as fuel cost to the plant).

- The nine routes with their respective processing capacity, throughput, and calorific value are given in Figure 5.1 below. The table also provides ash production levels, as well as the fuel cost, conversion efficiency and fly ash disposal fee – as used in the analysis.

- Where appropriate, transport cost of wood is assumed\(^7\) to be £0.17 per tonne and km.

- As far as ash from any incinerator or combustion scheme is concerned, approximately 25% is collected as fly ash and 75% is collected as bottom ash. The latter can find ready applications or can be disposed at inert landfills; so its value ranges from £15 (credit) to around -£35 (cost) but for the purpose of this analysis it is considered to be cost neutral to the energy recovery plants. In contrast, the fly ash is the most troublesome to manage and is assumed to be disposed, as hazardous material, at £150 per tonne, including £48/t as the landfill tax.

- Plant availability is assumed to be 90% for all options except for landfill (in Route 23) and the gasification option (in Route 28). As for the gasification option, the plant availability is assumed to be 80% although this can vary depending on the year of operation since start up (normally ramps up to 50% in the first year, 60-65% in the second etc expecting to reach as high as 90% with some of the large scale plants).

\(^7\) Personal communication, Chris Hoy, Dec 2010
- No heat is recovered from any of the energy recovery options. If heat were added (i.e., a fully operational Combined Heat and Power (CHP) plant) it would add further economic and environmental value to these routes. However, adding CHP adds at least an additional 20% to project development costs and is dependent on having a guaranteed heat load, which may add risk to the project. For this reason we have not included CHP in our basic assumptions.

- Electricity price (or cost) is as assumed to be 4 p/kWh.

- Income from electricity ROC is valued at 4.5 p/kWh, which is multiplied by the uplift factor of 1.5 for routes 3, 8, 14, 18, 25 and 29 (factor for dedicated biomass scheme under the Renewable Obligation Order 2009), by the factor of 2 for the gasification option in route 28 and a factor of 0.25 for the landfill gas energy scheme in route 23.

- The electricity generated will not attract the Climate Change Levy, which in effect acts as a credit at 0.47 p/kWh.

- Compost (from Route 9) is sold at £50 per tonne.

- The discount factor used in the analysis is 6% and all costs and prices should be read as for the year 2010.

- The capital costs of the plants are estimated from published information (DECC, 2010) and guidance received in discussion with technology experts. The latter have helped to re-examine some of the capital and operating costs in the light of the current context. The project team also brought a great deal of the knowledge and experience needed and have contributed through internal discussions.

- Any cost related to site purchase, foundation or development is not included.

- The operation and maintenance cost of these plants are taken as a percentage of the capital cost, which for the waste to energy plants are taken at 4.67%; that for gasification plant is taken at 5% (estimated); and for composting is taken as 15% (recently observed by the project team for In-Vessel Composting systems). In addition, a variable entity is added to reflect the handling cost which will vary by volume of throughput. This is charged at £1 per tonne for all plants except the composting plant, landfill and the gasification plant which are charged at £2, £0 and £1.5 per tonne of wood handled.

- Capital cost contribution per tonne of wood is derived by assuming two years as construction and commissioning period, during which the capital is fully paid: 50% in year 1 and 50% in year 2. The plant operation begins at the start of year 3; for 20 years. The capital cost contribution is then the discounted Capex divided by the discounted throughput of the plant.

In assessing the costs for gasification (route 28) we have assumed that the plant works efficiently. However, discussions with a developer working on gasification of waste wood indicated that these plants are still in development phase, with considerable modifications required for different feedstocks. This means that the developer can face additional expenditure to ensure that the plant operates efficiently. This cost is not included here as we have assumed that all of the plants examined are commercial operational plants. However, in the short term developers of gasification plant may see higher capital and operating costs than estimated here.

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8 Gasification refers to what is defined as advanced gasification under the RO.
9 Study for DECC entitled ‘Interaction between different incentives to support renewable energy and their effect on CHP: RO & RHI’ by AEA (Reference URN 10D/545; ED43634); January 2010.
10 Personal communications with Jeremy Stambough (AEA) and Des Mitchel (OgenUK); December 2010.
5.1.2 Key Results

Figure 5.2 gives the outcome of the economic analysis, which is also illustrated in Figure 5.3. These show that Route 25 is the most economically attractive one as it will provide the greatest income worth around £157 per tonne of wood waste; i.e. after the capital and operating costs have been paid for but excluding site purchase and development cost. On similar basis, the following is the prioritised order of the nine routes:

<table>
<thead>
<tr>
<th>Route</th>
<th>Income per tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route 25</td>
<td>£157 per tonne</td>
</tr>
<tr>
<td>Route 28</td>
<td>£134 per tonne</td>
</tr>
<tr>
<td>Route 29</td>
<td>£130 per tonne</td>
</tr>
<tr>
<td>Route 23</td>
<td>£119 per tonne</td>
</tr>
<tr>
<td>Route 3</td>
<td>£106 per tonne</td>
</tr>
<tr>
<td>Route 8</td>
<td>£97 per tonne</td>
</tr>
<tr>
<td>Routes 14&amp;18</td>
<td>£92 per tonne</td>
</tr>
<tr>
<td>Route 10</td>
<td>£23 per tonne</td>
</tr>
</tbody>
</table>

These net benefits, expressed per tonne of wood, can be viewed in a different way to examine the resilience of the routes. Error! Reference source not found. shows the maximum price that could be paid per tonne of wood (in contrast to the gate fee paid to the operator) to make the net benefit zero. It shows, for instance that for Route 3 (pre-consumer wood to energy recovery), that the gate fee of £20 per tonne (income) would have to become a cost (i.e. paid to receive the wood) of £86 per tonne before the route becomes loss making. Such values are high for routes that recover greater value from its products, energy in particular.

The overall impact of ash disposal on the economics of thermal routes is negligible and is not commented on further.

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11 These options vary only by the wood journey prior to its arrival at the energy recovery plant; for the purpose of this analysis they are identical.
### Figure 5.1 Table showing basic technical and economic factors

<table>
<thead>
<tr>
<th>Route</th>
<th>Route 3</th>
<th>Route 8</th>
<th>Route 10</th>
<th>Route 14</th>
<th>Route 18</th>
<th>Route 23</th>
<th>Route 25</th>
<th>Route 28</th>
<th>Route 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant capacity, basis (kW)</td>
<td>15,000</td>
<td>15,000</td>
<td>(50,000)*</td>
<td>15,000</td>
<td>15,000</td>
<td>N/A</td>
<td>15,000</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td>Plant capacity (t/y)</td>
<td>88,000</td>
<td>99,000</td>
<td>50,000</td>
<td>106,000</td>
<td>106,000</td>
<td>-</td>
<td>99,000</td>
<td>22,000</td>
<td>44,000</td>
</tr>
<tr>
<td>Capital cost (£ million)</td>
<td>£38</td>
<td>£38</td>
<td>£5</td>
<td>£38</td>
<td>£38</td>
<td>N/A</td>
<td>£38</td>
<td>£18</td>
<td>£15</td>
</tr>
<tr>
<td>Calorific value (MJ/kg)</td>
<td>17.3</td>
<td>17.3</td>
<td>N/A</td>
<td>16.1</td>
<td>16.1</td>
<td>N/A</td>
<td>17.3</td>
<td>16.1</td>
<td>16.1</td>
</tr>
<tr>
<td>Calorific value (MWh/t)</td>
<td>4.8</td>
<td>4.8</td>
<td>-</td>
<td>4.5</td>
<td>4.5</td>
<td>-</td>
<td>4.8</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Fuel/Feed cost (£/t)</td>
<td>-£20</td>
<td>-£20</td>
<td>-£20</td>
<td>-£20</td>
<td>-£20</td>
<td>-£88</td>
<td>-£80</td>
<td>-£40++</td>
<td>-£80</td>
</tr>
<tr>
<td>Fuel cost (£/MWh)</td>
<td>-£4.2</td>
<td>-£4.2</td>
<td>-</td>
<td>-£4.5</td>
<td>-£4.5</td>
<td>-</td>
<td>-£16.7</td>
<td>-£8.9</td>
<td>-£17.9</td>
</tr>
<tr>
<td>Conversion efficiency – electrical</td>
<td>28%</td>
<td>25%</td>
<td>N/A</td>
<td>25%</td>
<td>25%</td>
<td>30%</td>
<td>25%</td>
<td>35%</td>
<td>20%</td>
</tr>
<tr>
<td>Ash production (% of input)</td>
<td>1.58%</td>
<td>1.56%</td>
<td>N/A</td>
<td>1.72%</td>
<td>1.73%</td>
<td>N/A</td>
<td>1.84%</td>
<td>2.18%</td>
<td>1.37%</td>
</tr>
<tr>
<td>Fly ash disposal fee (£/t)</td>
<td>£150</td>
<td>£150</td>
<td>N/A</td>
<td>£150</td>
<td>£150</td>
<td>N/A</td>
<td>£150</td>
<td>£150</td>
<td>£150</td>
</tr>
</tbody>
</table>

+ Assumed capacity for composting plant
++ Assumes gate fee of £80 per tonne wood but roughly half of this is spent in rendering it suitable fit for the gasification plant, as such the net is £40 per tonne.

### Figure 5.2 Table showing outcome of the economic analysis

<table>
<thead>
<tr>
<th>Route</th>
<th>Route 3</th>
<th>Route 8</th>
<th>Route 10</th>
<th>Route 14</th>
<th>Route 18</th>
<th>Route 23</th>
<th>Route 25</th>
<th>Route 28</th>
<th>Route 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital cost contribution (£/t)</td>
<td>£42.51</td>
<td>£37.96</td>
<td>£9.80</td>
<td>£35.48</td>
<td>£35.48</td>
<td>£3.13</td>
<td>£37.96</td>
<td>£76.70</td>
<td>£33.39</td>
</tr>
<tr>
<td>Fuel cost (£/t)</td>
<td>-£20.00</td>
<td>-£20.00</td>
<td>-£20.00</td>
<td>-£20.00</td>
<td>-£20.00</td>
<td>-£88.00</td>
<td>-£80.00</td>
<td>-£40.00</td>
<td>-£80.00</td>
</tr>
<tr>
<td>Operating cost (£/t)</td>
<td>£21.27</td>
<td>£19.09</td>
<td>£17.00</td>
<td>£17.91</td>
<td>£17.91</td>
<td>£1.00</td>
<td>£19.09</td>
<td>£40.65</td>
<td>£16.92</td>
</tr>
<tr>
<td>Income (£/t)</td>
<td>-£150.54</td>
<td>-£134.41</td>
<td>-£30.00</td>
<td>-£125.64</td>
<td>-£125.64</td>
<td>-£35.02</td>
<td>-£134.41</td>
<td>-£175.90</td>
<td>-£100.51</td>
</tr>
<tr>
<td>Ash disposal cost (£/t)</td>
<td>£0.66</td>
<td>£0.69</td>
<td>N/A</td>
<td>£0.65</td>
<td>£0.65</td>
<td>N/A</td>
<td>£0.69</td>
<td>£0.00</td>
<td>£0.52</td>
</tr>
<tr>
<td>Net benefit (£/t)</td>
<td>-£106.10</td>
<td>-£96.67</td>
<td>-£23.20</td>
<td>-£91.60</td>
<td>-£91.60</td>
<td>-£118.89</td>
<td>-£156.67</td>
<td>-£98.55</td>
<td>-£129.68</td>
</tr>
</tbody>
</table>
Figure 5.3 Graph showing components of the discounted expenditure and income per tonne of wood waste, by route
5.2 Sensitivity Analysis

In this section the effects of changes in in three parameters (namely ROC value, capital cost and discount rate) on the net benefit is analysed.

Figure 5.5 illustrates this as a result of the changes in ROC market value, by 50% decrease and 50% increase compared to the base case (of 4.5 p/kWh). The red line represents the baseline modelling described above. The figure shows that the greatest effects are felt by those routes generating high levels of electricity. As such it is led by Route 28 (demolition wood – gasification), which will provide a net benefit up to £204 per tonne if the ROC value is increased by 50% but it goes down to £63 per tonne if the ROC value is halved. It should also be mentioned that this route benefits from double ROC value (based on the factor set for the developing technologies such as gasification, in the Renewable Obligation Order 2009); whereas the thermal routes 3, 8, 14, 18, 25, 29 attract 1.5 times the ROCs and route 23 involving landfill gas only 0.25 ROC. It should also be noted that gasification technology for waste wood is not straightforward and there are still technical issues with implementation that can result in significant additional costs that are not modelled here. This is why the Government set the band for ROCs at 2 ROCs/MWh for advanced conversion technologies. In addition there is a further issue if the wood is mixed with other waste in commercial and industrial steam generation, as it would be necessary to demonstrate the renewable content. This has provide a challenge, although methodologies to do this are being developed by the European standards body and DECC and Defra.

Figure 5.6 illustrated the changes in net benefit as a result of 25% variation in the capital cost of the energy recovery plants. Here too, the change is greatest for Route 28, due to its relatively high capital cost (when compared on a per tonne basis). The net benefit varies from £105 per tonne for the plant.

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12 Note that this route includes waste wood in MSW and such a plant would only qualify for ROCs on the biocontent, which is deemed at 50% if burnt in ENW plant at present, if the energy is used for CHP.
13 We have discussed this with a technology provider in this area who has undertaken considerable work on his gasification system to improve operation and decrease the production of residues (tar) from the plant. In doing this he has incurred significant operating costs for his plant.
costing 25% higher (i.e. £22 million) to as high as £163 per tonne for the plant costing 25% less than the base case. Those of other routes can be read from the figure.

Figure 5.7 illustrates the changes in the net benefit as a function of the discount factors of 4%, 6% (base case) and 8%. The changes in net benefits are small compared to those of ROC value and capital cost changes.

**Figure 5.5 Changes in overall benefit as a result of changes in ROC value**

<table>
<thead>
<tr>
<th>Route 3</th>
<th>Route 8</th>
<th>Route 10</th>
<th>Route 14</th>
<th>Route 18</th>
<th>Route 23</th>
<th>Route 25</th>
<th>Route 28</th>
<th>Route 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net benefit @ 50% of current ROC value (£/t)</td>
<td>-£61</td>
<td>-£56</td>
<td>-£23</td>
<td>-£54</td>
<td>-£54</td>
<td>-£115</td>
<td>-£116</td>
<td>-£63</td>
</tr>
<tr>
<td>Net benefit @ current ROC value (£/t)</td>
<td>+£123</td>
<td>+£137</td>
<td>+£129</td>
<td>+£122</td>
<td>+£116</td>
<td>+£100</td>
<td>+£95</td>
<td>+£116</td>
</tr>
<tr>
<td>Net benefit @ 150% of current ROC value (£/t)</td>
<td>-£151</td>
<td>-£129</td>
<td>-£23</td>
<td>-£129</td>
<td>-£122</td>
<td>-£197</td>
<td>-£204</td>
<td>-£160</td>
</tr>
</tbody>
</table>

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14 Percentage changes are equivalent to decreasing and increasing the ROC bandings e.g. 1 ROC = current value, 1.5 ROCs = 150% of current value
Figure 5.6 Changes in overall benefit as a result of changes in capital cost variation

![Graph showing changes in overall benefit as a result of changes in capital cost variation.]

Figure 5.7 Changes in overall benefit as a result of discount factors

![Graph showing changes in overall benefit as a result of discount factors.]

Net benefit (£ per tonne of wood waste)

- Net benefit @ 25% capex reduction (£/t)
- Net benefit (£/t)
- Net benefit @ 25% capex increase (£/t)

Net benefit @ 4% DF
- Net benefit @ 6% DF
- Net benefit @ 8% DF
5.3 Key conclusions

Overall conclusions from the comparative economic analysis of the nine routes are summarised below.

Route 25 is the most economically attractive one as it will provide the greatest income worth around £157 per tonne of wood waste; i.e. after the capital and operating costs have been paid for but excluding site purchase and development cost. This is followed by Route 28 (£134 per tonne); Route 29 (£130 per tonne); Route 23 (£119 per tonne); Route 3 (£106 per tonne); Route 8 (£97 per tonne); Routes 14&18\(^{15}\) (£92 per tonne) and Route 10 (£23 per tonne).

The overall value of the final disposal/energy recovery options are largely governed by three key factors:

1. Value of electricity which comprises the wholesale electricity price and the incentives offered under the ROO 2009;
2. Gate fee paid for wood waste at the site, and
3. Capital expenditure on the plants.

As competition for biomass and wood waste grows, the gate fees paid by waste producers will decline and in some circumstances become a feed cost. In such an event the routes with greater energy recovery, which are also favoured by the Government incentives, will remain more attractive. For instance, Route 28 involving gasification would be able to pay up to £94 per tonne of wood and the thermal routes between £50 and £86 per tonne before they begin to lose money on their investment.

The gate fee variation and net benefit values quoted in this study should be read as indicative values only. This is because they have been derived for the comparative analysis, covered in this study, and following a number of simplifying assumptions that were necessary due to the lack of technical and economic details. Nonetheless the overall conclusions are still valid.

The UK Government’s support for renewable electricity, offered under the Renewable Obligation Order 2009 is currently acting as the main driving force on these options. It contributes up to around £140 per tonne of wood waste in the gasification route. The second most significant factor is the fee paid at the plant for the wood waste, followed by the capital cost of the energy recovery plants. It should be understood that the gasification technology is yet to demonstrated at large scale and will take some time before it is considered mature technology.

Given the high investment costs related to the energy recovery options, availability of finance for them will be affected by the level of ROC values, any variation in the terms of the Government incentives and competition for the wood fuel (i.e. the effect this has on the price of the fuel).

An additional factor to take into account is the price of transport. If the price of transport fuel dramatically increases, this could have an impact on the economics of the routes examined. This would need further examination.

\(^{15}\) These options vary only by the wood journey prior to its arrival at the energy recovery plant; for the purpose of this analysis they are identical.
6 Issues Hierarchy

From the analysis in section 4 it is possible to pull out all of the issues that scored most highly for each route. These are the issues that are likely to be the most complex to address and to provide a barrier to expansion to that route if they are not addressed.

In the following sub-sections, we discuss each of the ‘Score 5’ issues. Where possible, we have grouped the routes and grades of waste wood that they affect, in order to take a more contextual view of the issue.

6.1 Permitting and Planning: Combustion at Energy from Waste Plant

Context

All Energy from Waste (EfW) plants require Environmental Permitting from the Environment Agency to ensure that the conditions of Integrated Pollution Prevention Control regulations are met; and Planning Permission from the relevant Local Authority:

- The Environmental Permit will establish the requirements on the combustion conditions which must be achieved and the limits on the concentrations of pollutants which can be emitted. It is unlikely that an EfW plant would be built to deal mostly with waste wood. They are generally designed for MSW, using the wood as a complement to boost calorific value.
- If planning permission is granted it is usually accompanied by a number of conditions for EfW plants, which might include factors related to the design of the plant to minimise visual impact; limits on operating hours and the number of lorry movements; communication of emissions survey results to the local community; conditions on what types of waste can be treated at the plant etc.

Why is this an issue?

Planning permission is not an easy process for EfW plants, with many developments being delayed for two years or more due to the difficulty of obtaining planning. Key issues in planning include: health impacts for the local population (particularly from particulate and VOC emissions); lorry movements; visual impact; and whether or not the local community needs (or wants) the plant. Public perception of incineration plants can be poor in many areas and careful site selection and communication with the local community is important. This can also be an issue for all types of energy recovery plants.

Environmental permitting should not be so time consuming, but it is important to get it right for both economic and operational reasons. Environmental emissions abatement can be expensive and it must be appropriate to the plant, or the plant will not comply with its permit and could be closed down as a result. Once the plant is built non-compliance solutions are often difficult to install and expensive.

What mitigation actions can be taken?

Mitigation is difficult. For Environmental Permitting, a good knowledge of the impacts of emissions and the ability of abatement equipment to control emissions is important. Early communication with the Environment Agency is important.

For the issues in planning the best solution is to ensure that the site is carefully selected so as to minimise additional visual impacts and the impact of lorry movements. Sites in designated areas are not suitable; nor are sites in remote areas with poor access. In addition communities take a dim view of plants intended to take waste from outside their area, but not from their area. Early communication and consultation with the local community is considered vital to the success of planning applications.
6.2 Site Suitability: All combustion plant

Context
With the introduction of double ROCs for electricity generation from biomass combustion, and the new Renewable Heat Incentive, the drive for building new heat and power plant is anticipated to increase far above the current level. The market for biomass heat and power has developed exponentially over the last 10 years, as discussed in Section 1, although the vast majority of new users coming into the market still do not have a good appreciation of some of the practical aspects of siting a combustion plant. This problem is exacerbated by the slow uptake of biomass systems knowledge in the heating engineer sector.

As indicated in Section 3, although there are a growing number of plants that can take clean waste wood, the number of WID-compliant large scale combustion plants in the UK is limited at present. This limits the potential for diverting low grade waste wood from landfill to energy recovery at present.

One of the major factors affecting the installation of new plants, (apart from financing capital costs), is that there are multiple practical issues to overcome, relating to the siting of a new combustion plant (including those that use Grade A waste wood as a fuel, and therefore do not need to be WID-compliant). These are similar to the factors impacting EfW plants:

- Suitable transport links for fuel delivery;
- Access to a suitable electricity connection (most biomass boilers require a three-phase supply which can be a major issue if the proposed plant is located in a rural area);
- Proximity of fuel to combustion unit;
- Obtaining planning permission for plant.

The net effect of these issues is an increase in the timescale for development.

The lengthy requirements for planning generally mean that the timescale for development is relatively long, which means that firm commitments for fuel supply and the use of the heat/electricity generated need to be in place at an early stage, especially if external funding needs to be secured.

Why is this an issue?

The major issue for build of new plants is the planning stage, which can hold up development of a plant for some time, often years. We have already discussed these issues in relation to EfW plants; and the issues for WID–compliant plant taking waste wood are likely to be very similar. Issues with planning include traffic movements, odour, noise and emissions to air. Public perception of combustion plant is often poor and consultation to re-ensure the local population is necessary and frequently difficult step. As for EfW plants, careful site planning, good communication and provision of information and good community relationships can have a significant impact on decreasing the length of time it takes for planning permission to be granted.

Once the plant is in the build stage there may be other issues relating to the site and the nature of biomass that may increase the timescale of development of the plants.

What mitigation actions can be taken?

Small-scale heat generation (50kw – 2MW): It is important to pass on lessons learnt and disseminated through schemes such as the Department of Energy and Climate Change (DECC) Bio-Energy Capital Grants Scheme (BECGS) and the Biomass Energy Centre, emphasise the need for thorough research and preparation prior to plant development. There is also a need for education of both the heating sector as an industry, and of the end-user market, as many of the problems that installations experience have been seen at other locations.

Large-scale power generation (3MW – 200MW): Careful site selection is very important for large scale plants. Even plants situated in industrial areas or in ports have faced local opposition (e.g. the Prenergy plant at Port Talbot)16.

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16 See, for example, [http://www.bbc.co.uk/news/uk-wales-south-west-wales-12171409](http://www.bbc.co.uk/news/uk-wales-south-west-wales-12171409)
6.3 Technology Status: Sorting of Grade B, C and D

Context
There are two elements to this issue:

- There is no UK-wide agreed classification system for grading waste wood (as discussed under Task A of this project). This means that the lines between what is classed, for example, as Grade B or Grade C waste are blurred. This creates issues for sourcing at site; and means that it is difficult to provide guidance for producers of waste wood.

- The second element is that there is no agreed methodology to separate different grades once the waste wood has been collected. This means that the total load is classed as a single grade, depending on the main source for collection (i.e. Grade C from CA sites). Although work on development of a test for contamination is progressing, agreement between the regulators (Environment Agency) and re-processes may prove difficult.

Why is this an issue?
The industry believes a large amount of wood has to be treated as Grade C, in case it contains contaminants. With better sorting and classification it might be possible to obtain more higher grade wood to the benefit of all involved in the supply and use of waste wood.

What mitigation actions can be taken?
This will continue to be an issue for the foreseeable future. As many in the industry point out, the new European methodologies being developed to test for contamination are not necessarily relevant to the UK as we use many different chemical treatments which are not included in the testing methodologies.

Trade Associations, such as the Wood Recyclers Association (WRA), are working alongside WRAP and the Environment Agency as part of a working group to create a Quality Protocol for management of waste wood (currently limited to Grade A and some Grade B waste wood). BSI are also developing PAS111 (Specification for the requirements and test methods for processing waste wood). The first draft has now been published for comment (http://drafts.bsigroup.com). Again, this deals mainly with the cleaner end of the waste wood spectrum. Expansion of both the Quality Protocol and PAS111 to cover Grades C and D waste wood would be a useful step towards mitigating this issue, although this will probably be very difficult to achieve.

6.4 Technology Status: Gasification

Context
Gasification is a technology that is used throughout many European countries, including Sweden and Germany but not widely. It has been proposed as a better option than waste combustion for many years but it has failed to achieve wide scale acceptance and combustion remains the default technology choice. The process converts a solid feedstock to a fuel gas by reaction with an oxidant such as air. This gaseous fuel can then be burned in a controlled manner in a burner, boiler, turbine or engine.

The advantages of gasification are:

- That the intermediate gaseous fuel produced in the gasification reactor can be burned in engines or gas turbines to generate electricity at a higher efficiency than possible with a steam turbine cycle.

- The gaseous fuel when burned as a flame in a burner or boiler will give more controlled combustion and lower emissions than direct combustion of the solid fuel.

- Cleaning pollutants from the relatively small fuel gas stream before combustion is more cost effective than from the larger post combustion flue gas stream.

Experience to date suggests that producing gas and burning it in a boiler or process kiln with limited or no cleaning is a very reliable process with many references in Europe. These include some 12 district heating stations in Finland, lime kilns in Sweden and Austria and two co-firing power plant in Finland and Belgium where waste is gasified and the resulting gas burned in coal fired power stations. There is not reason why such installations should not be replicated in the UK for waste wood or mixtures of waste wood and SRF.
Using the produced gas in an engine or turbine has been much more problematic, particularly at small scales suitable for waste wood-based CHP. There is one trouble-free commercial plant that we are aware of in Denmark. There are successful demonstration projects in Austria and Denmark and one commercial installation in the UK using waste wood that is working through commissioning problems.

The advantages of gasification have been recognized in the Renewable Obligation where 2 ROCs are paid for electricity generated by advanced gasification.

**Why is this an issue?**

Combustion-based CHP using a steam turbine is an expensive option with a low electrical efficiency at small sizes where matching heat loads can be found. Higher efficiencies can be obtained but at much larger sizes where only industrial complexes would have sufficient heat load.

In a steam cycle the heat and electricity efficiency are linked, taking more heat radically reduces the power output and hence the revenue from ROCs.

Gasification with engine-based generation offers a route with a high electrical efficiency that can be applied at relatively small scale. In addition, the electricity production is decoupled from heat production giving much more flexibility.

Many issues need to be overcome before gasification becomes an established technology for electricity generation:

The technology for linking engines and gas turbines to gasification processes is largely unproven in commercial application which reduces its attractiveness to the waste management industry despite the advantages.

**What mitigation actions can be taken?**

The lessons learnt in Europe need to be transferred to new projects in the UK.

Demonstration projects need support as does further underpinning research on the underlying processes.

Many other countries are supporting work in this area and it would be most efficient for the UK to join collaborative projects and information sharing.

### 6.5 Environmental Impacts and Greenhouse Gas Balance

**Context**

The main environmental impact examined quantitatively in this work was life cycle assessment of the GHG emissions. Other factors such as odour, noise and visual impact were also considered, but on a qualitative basis.

**Why is this an issue?**

There are two reasons why this is important. The first is that the Waste Strategy for England and Wales (2007) aims to ensure that the way we manage our waste is environmentally beneficial, including the reduction of net greenhouse gas emissions from waste management. Additionally, the revised Waste Framework Directive (2008) says that the first objective of waste management policy should be to minimise the negative effects of the generation and management of waste on human health and the environment. In order to ensure that this is taken into account in waste management this principle has been incorporated into the waste hierarchy in the revised Waste Framework Directive, such that improved reduction in GHG emissions is a reason for using energy recovery above recycling in some specific instances where the environmental impact can be demonstrated to be lower with energy recovery.

The second reason why environmental performance is important is that Government incentives for supporting renewable energy are driven by a desire to decrease carbon emissions in the UK and to ensure that the UK meets EU renewable energy targets. Therefore, it is important that the greenhouse gas emissions from the recovery of energy from waste wood are better than the alternatives for energy production, particularly than fossil fuel generated energy. There is also an important role that energy recovery from UK resources can make towards energy security in the UK. However, the aims of this project are to compare different pathways for the management of waste wood, so for this project we are also interested in comparing pathways that include energy recovery with those that do not.
For waste wood environmental impacts are related to the composition of the wood, the treatment and processing of the wood, the level of transport required and the relative greenhouse gas emissions of the different management routes.

Composition of the wood. Grade A waste wood is by definition untreated wood, which is chemically the same as virgin wood. All other grades of wood have had some exposure to contamination or are treated in some way, often with glues, preservatives and/or coatings, paints or varnishes. Hazardous wood grades may be treated with wood preservatives containing chromium, cadmium and arsenic (CCA), which may be leached out. Suitable landfill sites should include good leachate management and treatment, which should prevent pollution of water courses.

Processing of wood. Processing is a necessary stage in the recycling of wood waste, but it may have some environmental impact, such as noise, odour or dust emissions.

Transport. Our analysis showed that all routes involve some transport; some routes involve more transport than others, particularly those routes with most stages. However, the impact of this transport is not of great significance compared to other environmental impacts from the management pathways.

Greenhouse Gas (GHG) emissions. In our analysis the disposal of wood to landfill had the highest GHG emissions, by a significant margin. Even accounting for energy recovery from landfill the net emissions from a tonne of wood waste going to landfill was found to be around one tonne of CO₂ equivalent, the net emissions of a route comprising of civic amenity to landfill is +1250 kg CO₂ equivalent/tonne of wood waste.

Our analysis showed that the greatest impacts were from two issues related to waste wood management: landfill disposal; and collection sorting and storage of Hazardous waste wood.

- **Landfill**: The grades of wood going to landfill tend to be Grade B, C and the hazardous grades. These are the grades that contain contaminants and preservatives. Wood preservatives in hazardous waste wood grades may contain chromium, cadmium and arsenic (CCA), which may be leached out. In our analysis, the disposal of wood to landfill also had the highest GHG emissions, by a significant margin. Even accounting for energy recovery from landfill the net emissions from a tonne of wood waste going to landfill was found to be around one tonne of CO₂ equivalent, the net emissions of a route comprising of civic amenity to landfill is +1250 kg CO₂ equivalent/tonne of wood waste.

- **Collection, sorting and storage of Hazardous waste wood**: A number of issues such as CCA treatments, non-recyclable waste arisings, traffic movement disturbances. Also, where large stockpiles of hazardous waste wood are stored outside, runoff from the piles may include creosote and fine particles of paint from contaminated wood. This run off can be the result of water sprayed on to the stockpile to mange dust.

What mitigation actions can be taken?

**Landfill**: Suitable hazardous waste landfill sites should include good leachate management and treatment, which should prevent pollution of water courses. The best course of mitigating GHG emissions from landfill is diversion from landfill for all waste wood grades. This is a topic that will be investigated further in the final stage of this project.

**Collection, sorting and storage of Hazardous waste wood**: Correct management of the run off e.g. through bunding of the site and controlled drainage of the water, is needed to avoid pollution of water courses.

### 6.6 CAPEX: All combustion plant

**Context**

In comparison to installing a fossil fuel powered boiler or engine, the costs of installing a biomass combustion plant, or Energy from Waste incinerator are high per unit capacity. Typically, a biomass powered system will cost around 6 or 7 times more than the fossil-fuelled alternative per MW of generation capacity.

**Why is this an issue?**
Even given the development of the bioenergy market, and the technology, over the last 10 years, the majority of currently operating plants have required finance and are not economic without Government incentives.

Funding for plant burning Grade A waste wood for heat generation has mostly come from central government capital funding programmes, such as the Bio-Energy Capital Grants Scheme, and RDA funding schemes, such as ones run by Yorkshire Forward and RegenSouthWest.

Finance for waste wood power generation plant has generally come from:
- Off balance sheet – for example utilities may consider this finance.
- Private equity or project finance – developers of such plants have to assure their investors that the plants will be developed, and that there is a fuel supply. The investment is financed on the basis of the return from the RO.

What mitigation actions can be taken?

The Government has introduced a Renewable Heat Incentive. Payments are made based on the amount of heat generated, and according to the type of technology and size of scheme. It is unlikely that biomass-fuelled plants will ever be comparable in price to fossil-fuel systems, but with rising fossil fuel costs combined with incentive schemes, combustion of biomass from waste and virgin wood is predicted to increase far more rapidly than has previously been seen.
7 Conclusions

In this report, we combined and summarised the activities undertaken to produce an issues hierarchy for the management of waste wood across nine different management routes. We also made efforts to relate the resulting issues to wider aspects of waste wood management, in particular looking at national arisings of waste wood, and their impact on the largest issues faced. Within this report, we also examined the availability of Waste Incineration Directive (WID)-compliant plant in the UK.

The work had five main elements:

1. Setting out the Market Structure

Our work has indicated that the pre-consumer grades of waste wood, which are clean, dry and uncontaminated, are very effectively re-processed and recycled. Demand for this waste wood is increasing, while supply is limited and this is generally forcing prices up. Green wood sources (arboricultural wastes) have limited markets, mainly because of the dispersed nature of arboricultural activities and the relatively high moisture content of the wood. It is probable that energy recovery would be a good outlet for this source of waste wood if the supply could be aggregated sufficiently. Contaminated waste wood has very limited recycling and re-use markets and is the fraction most likely to go to landfill or incineration. The levels of contamination also mean that Waste Incineration Directive emissions limits apply to combustion of this wood waste stream, which means that many energy recovery plants would not be able to take this waste. Our conclusions are that the only market for this wood waste stream is energy recovery, but that, unless the wood is source segregated, new structures need to be in place to separate and process this wood waste stream. The economics of this use requires in depth analysis.

2. Examining the Availability of WID-compliant Combustion Plant in the UK and Long-term Fuel Supply Contracts

The data sources show a total of 503 MW of installed capacity, with a further 1.7 GW currently in the scoping, planning, or construction stages. One issue faced in the assessment of available capacity has been the fact that WID compliance is not a recorded factor in many of the data sources. Energy from Waste (EfW) has been a major contributor to the above figures, although not all EfW capacity is taken up by biomass combustion, and so this must be taken into account when looking at total capacity.

The potential role for fuel contracts is a matter of balancing risk and price, on the basis that long term fuel contracts are likely to be more expensive than procuring material on the spot market, but reduce the risk of not being able to procure the desired amount of fuel. It would be reasonable to assume that medium to long term fuel contracts for WID material are likely to help secure project finance by offering predictable fuel costs (for a greater proportion of their fuel), therefore providing increased certainty of the returns from a WID plant.


The results of the issues assessment show that there are a large number of issues within most routes, however there are a smaller number of highly complex issues that affect a number of routes, principally those involving energy recovery and hazardous waste wood.

Major variables when assessing the score to be given for an issue include:

- Scale of combustion plant under discussion. Issues for a 500kW plant would score differently to issues for a 50MW plant;
- Using existing combustion plant / landfill etc. vs. building new capacity. In this case, very different issues would be faced. Where this question was raised, specifically regarding EfW and landfill, we have completed an Issues Matrix for each of the two different scenarios


The overall value of the final disposal/energy recovery options are largely governed by three key factors:
1. Value of electricity which comprises market price and the incentives offered under the ROO
2. Gate fee paid for wood waste at the site, and
3. Capital expenditure on the plants.

The assessment found that MSW to Energy from Waste (EfW) is the most economically attractive route for waste wood management. This is reflected in the analysis of the number of EfW WID-compliant plant in the planning and construction phases.

5. Assessing the Issues Hierarchy

Major issues were identified via the issues assessment. Examining these in more detail has shown that many of them affect a large number of routes, and are very difficult to mitigate. The major issues identified were:

- Permitting and Planning
- Site Suitability (All combustion plant)
- Technology Status (Grade C and D sorting and separation)
- Technology Status (Gasification)
- Environmental Impacts and Greenhouse Gas Balance (Landfill and Grade D Storage)
- CAPEX (All combustion plant)

In conclusion, the work undertaken for Tasks D – G on this project has touched upon many different subjects and debates. In the main, it has attempted to open up and discuss issues that exist in the industry of managing waste wood, and also to note the factors that make discussion of issues difficult, such as the impact of scale on the severity of an issue. The main conclusions of the report are detailed above, and show that it is possible to pin-point a number of major factors that influence the management of waste wood. These include:

- Finance and incentive schemes;
- GHG emissions and Environmental Permitting;
- Planning permission and public perception;
- Dissemination and industry engagement.

We propose that these factors will form a structural basis for the next phase of the project, discussed in the following section of this report, where assessment of the potential situation regarding each one of these factors will change depending on the policy or market scenario being assessment.
8 Next Project Stages

The final Task on this project is to look at various future scenarios for both policy and market. The proposed scenarios are:

- **Business As Usual**: Policy drives import of biomass for combustion, large amounts of waste wood go to landfill.
- **Green waste policy A**: Restrictions on the landfilling of waste wood results in the need to develop alternative treatment for waste wood options that cannot be recycled.
- **Green waste policy B**: In this scenario we examine policy options which would reduce the amount of waste wood going to landfill, without restrictions on landfilling of such wastes. Such policies include increased taxes on the landfilling of specific types of waste; development of policies in favour of energy from waste, encouraging waste wood that cannot be recycled to go to energy recovery instead.
- **Green energy policy**: Concern about the sustainability of biomass and conflicts with alternative land use result in pressures to include energy from biomass wastes in renewable legislation; to be eligible for these incentives SRF is developed to contain high biomass content.
- **Green accelerator**: combined environmental and policy options.
- **Market 1**: High fossil fuel prices lead to increased interest in relatively clean biomass wastes such as waste wood grades A, B and C.
- **Market 2**: Examine the impact of good (unconstrained) biomass fuel supply on energy from waste wood.

We will use the scenarios to examine which are the best scenarios for different mixtures of fuels (waste wood, SRF and biomass) for combustion/CHP for energy from waste wood. We will also examine which policies/mechanisms would be most effective in stimulating energy recovery from waste wood and SRF in terms of policy cost, quantity of waste wood diverted from landfill and the logistics required.

The scenarios will be examined on three timescales: 2015, 2020 and 2030. The purpose of this is to see if the timescale over which management options of policies were introduced would make a difference to the relevant markets.

This report will be submitted in late February 2011.

All task reports will be written into a final report, which will be submitted to Defra and the Steering Group during March 2011. The project will complete in April 2011, with the report being published by Defra late in Spring 2011.
Appendices

Appendix 1  List of WID-compliant Combustion Plant in the UK (supplied as separate Excel file)
Appendix 2  Detailed Issues Matrix (supplied as separate Excel file)
Appendix 1 - List of WID-compliant Combustion Plant in the UK

See attached excel spreadsheet.
Appendix 2 - Detailed Issues Matrix

See attached excel spreadsheet