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APPENDIX A: Measured criteria

This appendix presents the results of the assessment of the 21 measured criteria for each of the nine scenarios; these cover environmental objectives, economic objectives, social objectives, deliverability, and waste policy. The landscape and townscape criteria, three criteria covering deliverability, one of the two factors covering economic factors, and one criteria for social objectives are non-measurable criteria, and these are discussed in Appendix B. The assessments were conducted using the Environment Agency's WRATE software, AEA's wasteflow model, or professional judgement (based on comparative data for waste treatment plants).

A1. Minimise impact on population and human health

The assessment criteria cover the following:

- Minimising nuisance from noise, odour, dust, litter and vermin generation
- Minimising local transport impacts
- Minimising the health impact of waste treatment facilities.

A1.1 Minimise nuisance

Nuisance such as a higher noise level, odour, dust and generation of litter and vermin may increase in the proximity of waste treatment facilities and waste disposal sites. The impact of noise, dust etc may have the potential to cause harm to human health and the environment if acceptable levels are exceeded. Therefore the level of potential nuisance from waste treatment and disposal sites, and its impact on nearby residents, is an important factor to consider, particularly when considering a planning application for a waste management facility.

As planning issues are normally specific to individual facilities, the assessment was conducted by allocating performance scores to each type of facility used (these scores have been generated through consultation with waste management professionals and planners to derive a professional judgement of the potential of a particular facility type to cause a problem). The performance scores for each facility were then totalled to determine the overall performance score for each scenario. The main differences between the scores for each scenario are due to the impacts from the residual management (landfill, MBT, EfW or ATT) facility and treatment of source segregated organic waste through windrow, IVC and AD.

The scores are based on the amount of waste that is handled in these facilities, and thus reflect the impacts from dealing with this waste.

A1.2 Minimise noise level

The noise issues for all of the scenarios are shown in Table A.1. A landfill site will generate noise due to the mechanical equipment required to compact the waste, but this will be less than a processing facility. Processing plants which include pre-treatment activities such mechanical separation, e.g. MBT generally have a higher potential for noise problems than thermal treatment facilities, e.g. EfW and ATT.

Table A.1: Noise and vibration potential for each scenario

Scenario	Noise potential	Normalised score
Sc 1- Base Case	32.00	1.00
Sc 2- MBT-Aerobic	34.34	0.47
Sc 3- MBT-RDF on site	36.13	0.07
Sc 4- MBT-RDF to 3rd party	34.13	0.52
Sc 5- MBT-AD + Aerobic	34.24	0.50
Sc 6- MBT-AD + Aerobic with RDF onsite	36.44	0.00
Sc 7 – EfW	33.50	0.66
Sc 8 - EfW-CHP	33.50	0.66
Sc 9- ATT Gasification	33.50	0.66

Scenario 1 (Base Case) performs best due to the lack of residual waste processing facilities. MBT technology and recycling facilities such as a MRF or Aerobic treatment have the highest potential for noise problems due to the mechanical separation and processing involved. The noise level of landfilling has been taken into account in this assessment whereas the combustion of RDF at 3rd parties has not been included. Scenario 2 shows a higher potential for noise level due to additional rejects or compost like output (CLO) needing to be landfilled.

A1.3 Minimise extent of odour problems

Odour is produced by all waste management activities, and Table A.2 shows that all nine scenarios have similar odour and dust issues.

Table A.2: Odour potential for each scenario

Scenario	Odour potential	Normalised score
Sc 1- Base Case	48.15	0.91
Sc 2- MBT-Aerobic	49.96	0.36
Sc 3- MBT-RDF on site	50.58	0.17
Sc 4- MBT-RDF to 3rd party	49.58	0.47
Sc 5- MBT-AD + Aerobic	49.78	0.41
Sc 6- MBT-AD + Aerobic with RDF onsite	51.13	0.00
Sc 7 – EfW	47.86	1.00
Sc 8 - EfW-CHP	47.86	1.00
Sc 9- ATT Gasification	47.84	1.00

The MBT with RDF onsite technologies have the highest potential to create odour due to having a MBT plant and a combustion plant on the same site. Consequently these scenarios receive the lowest scores for odour. Odour is also generated during landfilling activities and at the EfW and ATT facilities, but these are less than those created by the MBT processes. Scenario 1 is likely to create higher levels of odour than the thermal treatment options (EfW & ATT) due to the large quantities of unprocessed residual waste landfilled.

A1.4 Minimise extent of dust problems

Dust is produced by all waste management activities, and Table A.3 shows that all nine scenarios have similar dust potential.

Table A.3: Dust potential for each scenario

Scenario	Dust potential	Normalised score
Sc 1- Base Case	27.10	0.95
Sc 2- MBT-Aerobic	28.04	0.53
Sc 3- MBT-RDF on site	28.71	0.22
Sc 4- MBT-RDF to 3rd party	27.71	0.68
Sc 5- MBT-AD + Aerobic	27.88	0.60
Sc 6- MBT-AD + Aerobic with RDF onsite	29.20	0.00
Sc 7 – EfW	27.01	0.99
Sc 8 - EfW-CHP	27.01	0.99
Sc 9- ATT Gasification	26.99	1.00

The MBT with RDF onsite technologies have, again, the highest potential to create dust due to both the mechanical sorting process and the RDF burning process. Consequently these scenarios receive the lowest scores for dust potential. Dust is also generated during landfilling activities and at the EfW facility, but this is less than that created by the MBT processes. Scenario 1 is likely to create higher levels of dust than the thermal treatment options (EfW & ATT) due to the large quantities of unprocessed residual waste landfilled.

A1.5 Minimise extent of litter and vermin generation

The potential for all scenarios to generate litter and attract vermin is shown in Table A.4

Table A.4: Litter and vermin generation for each scenario

Scenario	Litter and vermin potential	Normalised score
Sc 1- Base Case	45.30	0.96
Sc 2- MBT-Aerobic	46.74	0.43
Sc 3- MBT-RDF on site	47.41	0.18
Sc 4- MBT-RDF to 3rd party	46.41	0.55
Sc 5- MBT-AD + Aerobic	46.58	0.49
Sc 6- MBT-AD + Aerobic with RDF onsite	47.90	0.00
Sc 7 – EfW	45.21	1.00
Sc 8 - EfW-CHP	45.21	1.00
Sc 9- ATT Gasification	45.19	1.00

MBT scenarios with RDF onsite have the most potential to generate litter and attract vermin due to the nature of its operation even though the mechanical process is enclosed and controlled.

When comparing the overall scenario, the rest of the MBT technologies show a higher potential for litter and vermin generation compared to the remaining scenarios although

Scenario 5 (MBT with RDF to 3rd party) scores slightly better than others because the RDF is taken to a 3rd party facility and less waste is landfilled. Overall, thermal treatment scenarios (EfW & ATT) show lower potential and therefore score highest because they landfill low quantities of waste and the technologies cause less litter and vermin problems than the MBT technologies.

A1.6 Minimising local transport impacts

The impacts on transport caused by waste management activities arise mainly from two sources - congestion and emissions. The congestion, disruption and noise caused by waste vehicles on residential streets are important factors and may cause traffic hold-ups, and thereby cause additional pollution. The impact of transport may be reduced by dealing with waste locally wherever practicable and by the efficient organisation of collection rounds and any onward journey to treatment facilities, re-processors and markets. In addition, depending on the location, scope may exist to utilise integrated transport.

Dealing with waste locally will decrease the distance travelled. Consequently the assessment was based on the distance of travelling required within the Lincolnshire boundary for collection of material and removal of products from the treatment processes. These are shown in Table A.5.

Table A.5: Distance travelled

Scenario	Number of transport movements	Normalised score
Sc 1- Base Case	2,949,281	1.00
Sc 2- MBT-Aerobic	3,600,175	0.00
Sc 3- MBT-RDF on site	3,459,179	0.22
Sc 4- MBT-RDF to 3rd party	3,600,175	0.00
Sc 5- MBT-AD + Aerobic	3,550,103	0.08
Sc 6- MBT-AD + Aerobic with RDF onsite	3,517,161	0.13
Sc 7 – EfW	3,449,953	0.23
Sc 8 - EfW-CHP	3,449,953	0.23
Sc 9- ATT Gasification	3,449,953	0.23

Scenarios 2 and 4 have the highest transport impact. In scenario 2 there is still a high percentage of rejects going from the facility to landfill and scenario 4 has increased transport due to the RDF going to a 3rd party facility. Thermal treatment scenarios have a lower transport impact than MBT.

The Base Case (Scenario 1) has the lowest movements as the residual waste is going straight to the landfill sites.

A1.7 Minimising the health impact of waste treatment facilities.

Where impacts on human health and the environment are concerned there is no definitive solution to managing waste; all treatment technologies generate various types and levels of emissions to air, land and water.

Many studies have been conducted into the health impacts of waste management facilities. For example:

- Landfill sites have been investigated as the possible cause of birth defects, cancers and respiratory illnesses including asthma;
- Incinerators have been investigated as to possible increases in cancer, birth defects and respiratory illnesses including asthma. Other studies have particularly concentrated on emissions of dioxins; and
- Composting and Materials Recycling Facilities (MRFs) have been investigated for possible exposures to micro-organisms and odours, and lung diseases like bronchitis.

In 2004, Defra published a review[1] of the assessment of available research, which attempted to quantify, where possible, the potential health effects of waste management. Although the limited data in some areas, particularly for composting facilities, means that caution is needed in using the findings from this study, the report identifies that:

- There is some evidence that the number of deaths brought forward per tonne of waste managed is higher for incineration facilities, but the margin of uncertainty means that it is not possible to determine if one option for managing waste is better than another in terms of deaths brought forward due to emissions to air;
- There is an indication that incineration may have a greater effect on hospital admissions due to respiratory conditions than landfills; and
- The available data does not indicate that any option for managing waste is better or worse than other options in terms of cancer cases caused by emissions to air.

However, it should be noted that emission levels from incinerators have significantly reduced in the last 10 years, and thus the potential health impacts from newer facilities, due to air emissions, may well be lower than those used in the 2004 study.

Some of the emissions that can have an impact on human health are:

- Benzene – this can cause cancer, but waste management accounts for less than 0.1% of UK emissions; the main source is transport which accounts for about 50% of UK emissions[1].
- Dioxins and furans – these are regarded as a probable cause of cancer. EfW facilities are estimated to account for less than 1% of total UK dioxin emissions; the main sources are fireworks (about 14% of total UK emissions, accidental vehicle fires (about 16% of total UK emissions), the iron and steel industry, and bonfires and barbeques[1].

Landfill is estimated to account for almost all of the cadmium emissions from waste management activities. The iron and steel industry is the main source of emissions of cadmium, and is also the main source for emissions of mercury, arsenic and lead.

The Defra report estimated that total emissions to air from managing waste are likely to result in one death brought forward and five hospital admissions every year. For comparison, traffic accidents result in over 3,000 deaths and over 300,000 hospital admissions every year, and total hospital admissions due to all sources of air pollution are

[1] Review of Environmental and Health Effects of Waste Management. Defra, May 2004

estimated to be about 14,000 per year. The number of cancers caused per year from waste management activities was estimated to be less than 0.001% of those caused by passive smoking.

The Environment Agency's WRATE software was used to determine the human health impacts of each scenario. This uses an assessment based on the fact that some substances can accumulate in living organisms (e.g. through the lungs, skin from food etc), increasing the risk that toxic concentrations will be reached; some of the best known of these substances are mercury, Dichlorodiphenyltrichloroethane (DDT) and dioxins. The WRATE index is expressed as kg of 1,4-dichlorobenzene through equivalence factors for the relative toxicity of the emitted compounds, and the findings from the WRATE assessment of each scenario are shown in

Figure A.1and Table A.6. A negative index score assumes that the scenario has a positive lifecycle impact, whereas a positive score indicates a detrimental impact.

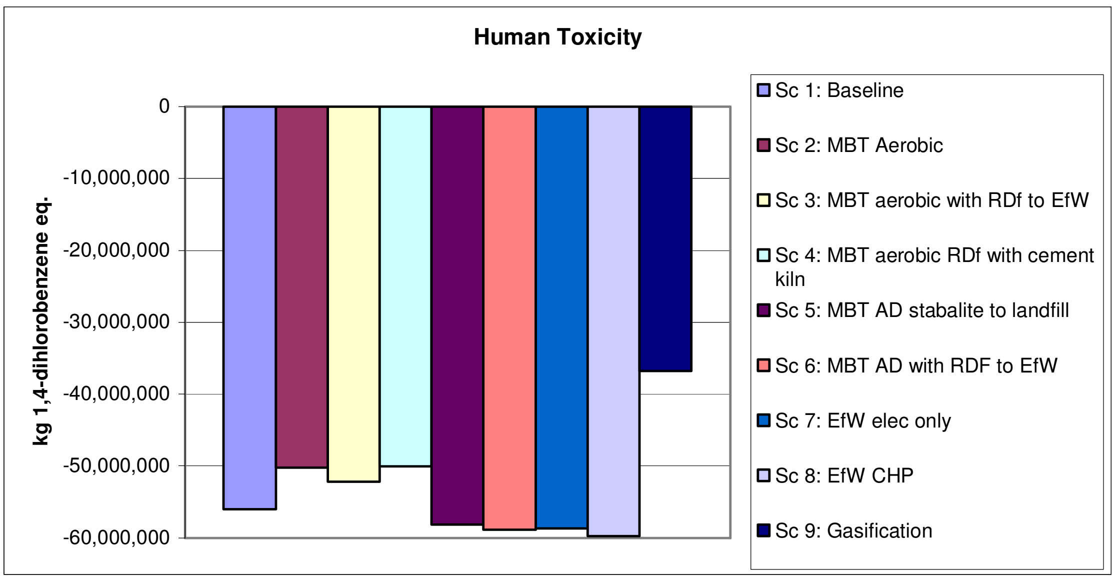

Figure A.1: Human toxicity potential

All the scenarios show a benefit in the effect on human toxicity as the large amounts of energy generated can be offset against the use of direct fossil fuels and the associated toxic emissions from power plants.

One of the key differences affecting the human toxicity impact is the amount of biodegradable waste landfilled. Biodegradable waste landfilled will have a detrimental impact on human toxicity and therefore the scenarios where more biodegradable waste is sent to landfill have a lower environmental benefit i.e. scenarios 1, 2, & 5.

Scenarios 5, 6, 7,and 8 have the greatest benefit to human toxicity due to the amount of waste that is combusted resulting in an energy output from the facilities. The CHP EfW has the highest energy output, and subsequently the greatest benefit.

Table A.6: Potential health impacts from waste facilities (kg 1,4 dichlorobenzene eq.)

Scenario	Human toxicity (WRATE)	Normalised score
Sc 1- Base Case	-56,022,438	0.84
Sc 2- MBT-Aerobic	-50,258,709	0.59
Sc 3- MBT-RDF on site	-52,214,751	0.67
Sc 4- MBT-RDF to 3rd party	-50,096,094	0.58
Sc 5- MBT-AD + Aerobic	-58,114,399	0.93
Sc 6- MBT-AD + Aerobic with RDF onsite	-58,857,108	0.96
Sc 7 – EfW	-58,640,517	0.95
Sc 8 - EfW-CHP	-59,733,594	1.00
Sc 9- ATT Gasification	-36,791,988	0.00

A2. Minimise impact on air, water and land

The assessment criteria cover the following:

- Minimising harmful emissions from waste facilities to water
- Minimising the impact of waste treatment on soil quality
- Minimising the impact of waste treatment and transport on air quality.

A2.1 Minimising harmful emissions from waste facilities to water

The release of compounds containing the nutritive elements nitrogen, phosphorus or organic matter, can potentially lead to eutrophication of surface watercourses. The accumulation of nutritive elements in the water leads to the growth of particular types of algae, resulting in a subsequent depletion of oxygen in the water, and a change in species living in the body of water (e.g. the disappearance of fish such as trout). Leachate from landfills and treatment facilities are the main source of such compounds in waste management.

The Environment Agency's WRATE software was used to determine the impact of the waste facilities on water quality through an assessment of their eutrophication potential. The WRATE index is expressed in terms of phosphate content (kg PO_4 equivalent), and the findings from the WRATE assessment of each scenario are shown in

Figure **A.2** and Table A. 7. A negative index score assumes that the scenario has a positive lifecycle impact, whereas a positive score indicates a detrimental impact.

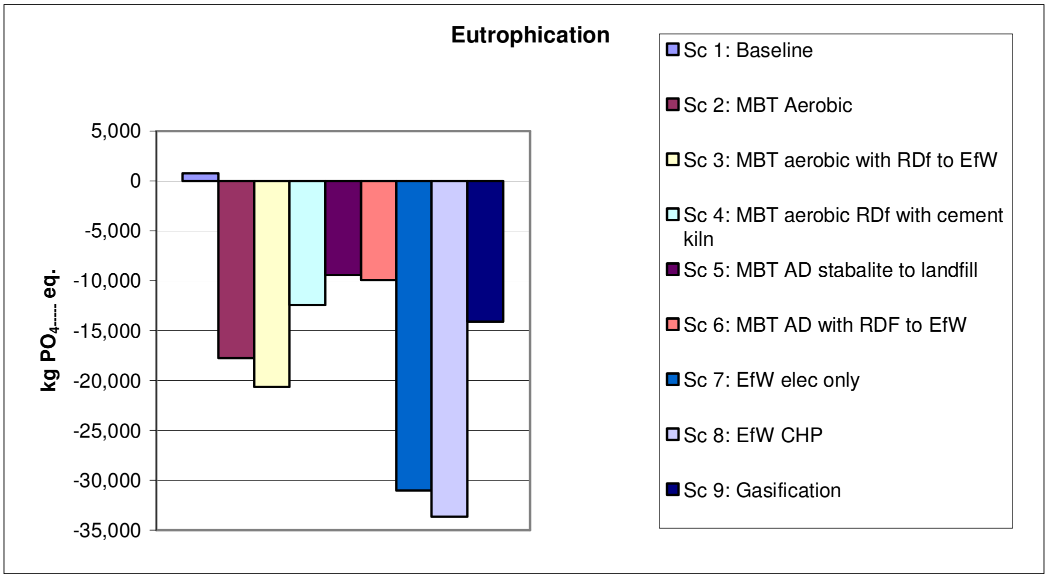

Figure A.2 Eutrophication Impacts

With the exception of Scenario 1, all the scenarios show an overall benefit to eutrophication. This is due to the combustion of the organics in these scenarios and the avoidance of these going to landfill.

Scenario 1 results in an overall contribution to eutrophication (i.e. detriment to the environment). One of the key factors in this is the quantity of waste sent to landfill and the treated residues (eg CLO) used on land or sent to landfill, which can cause eutrophication through leaching. .

Table A. 7: Potential harmful emissions from waste facilities to water (kg PO_4 equivalent)

Scenario	Eutrophication potential	Normalised score
Sc 1- Base Case	742	0.00
Sc 2- MBT-Aerobic	-17,750	0.54
Sc 3- MBT-RDF on site	-20,657	0.62
Sc 4- MBT-RDF to 3rd party	-12,449	0.38
Sc 5- MBT-AD + Aerobic	-9,454	0.30
Sc 6- MBT-AD + Aerobic with RDF onsite	-9,921	0.31
Sc 7 – EfW	-30,983	0.92
Sc 8 - EfW-CHP	-33,613	1.00
Sc 9- ATT Gasification	-14,081	0.43

A2.2 Minimising the impact of waste treatment on soil quality

This is assessed by one criterion the amount of hazardous waste produced. Hazardous waste may be collected at two points within the municipal waste stream:

- Hazardous waste items arising in household waste; and
- Hazardous items arising in collected trade waste.

Education campaigns aim to encourage separation of hazardous items and thus reduce the hazardous materials that are landfilled. As the hazardous materials arise prior to the treatment process, the tonnage of these hazardous waste streams are assumed to be the same in all scenarios, and thus they are not further considered in this assessment. An important consideration for this SEA is that some waste treatment processes can also concentrate and potentially generate hazardous waste. It is unlikely that any hazardous waste stream would be produced by MBT, composting, aerobic or anaerobic digestion processes other than what already exists in the waste stream. However, waste combustion using an EfW or ATT facility will produce fly-ash, and this is classified as a hazardous waste. Consequently, the amount of fly-ash produced reflects the difference between the residual treatment technologies and quantity of waste processed as shown in Table A.8.

Table A.8: Potential for hazardous waste generation

Scenario	Amount of hazardous waste arising (tonnes)	Normalised score
Sc 1- Base Case	0	1.00
Sc 2- MBT-Aerobic	0	1.00
Sc 3- MBT-RDF on site	2,820	0.29
Sc 4- MBT-RDF to 3rd party	0	1.00
Sc 5- MBT-AD + Aerobic	0	1.00
Sc 6- MBT-AD + Aerobic with RDF onsite	659	0.83
Sc 7 – EfW	3,953	0.00
Sc 8 - EfW-CHP	3,953	0.00
Sc 9- ATT Gasification	3,953	0.00

Scenarios 7, 8 and 9 all generate the same level of hazardous waste from utilising either an EfW or ATT technology.

A2.3 Minimising the impact of waste treatment and transport on air quality.

Emission of acid gases into the air can have a number of environmental impacts at a local to regional level, including effects on human health, sensitive ecosystems, soiling and deterioration of building facades, forest decline and acidification of lakes. Air acidification potential is largely dependant on the emissions of SO_x and HCl. The main source of SO_x is from combustion of sulphur rich fossil fuels and one source of HCl is from the combustion of wastes. Waste treatment technologies that generate energy (such as EfW or plants which produce a fuel product such as MBT) enable a reduction in energy generated from fossil fuel sources to be achieved and this reduces emissions of SO_x. HCl emissions have a relatively minor impact in this balance. Energy saving through recycling also has a beneficial effect in reducing SO_x emissions.

Nitrogen dioxide also contributes to acid rain and excessive levels can cause damage to some environments. Management of MSW contributes about 1% of total emissions; the main source is from EfW combustion, which is tightly controlled (other emissions from landfill and composting are much smaller)[2]. The main UK-sources of nitrogen emissions are road traffic (37%), and electricity generation (27%)[3].

The Environment Agency's WRATE software was used to determine the impact of each scenario (in terms of both waste treatment processes and transport distances) on acid gas emissions as these reflect their impact on air quality. The WRATE index is expressed in terms of sulphur dioxide (SO_2) emissions, as this is the main acidic gas. The findings from the WRATE assessment of each scenario are shown in Figure A.3 and Table A.9. A negative index score assumes that the scenario has a positive lifecycle impact, whereas a positive score indicates a detrimental impact.

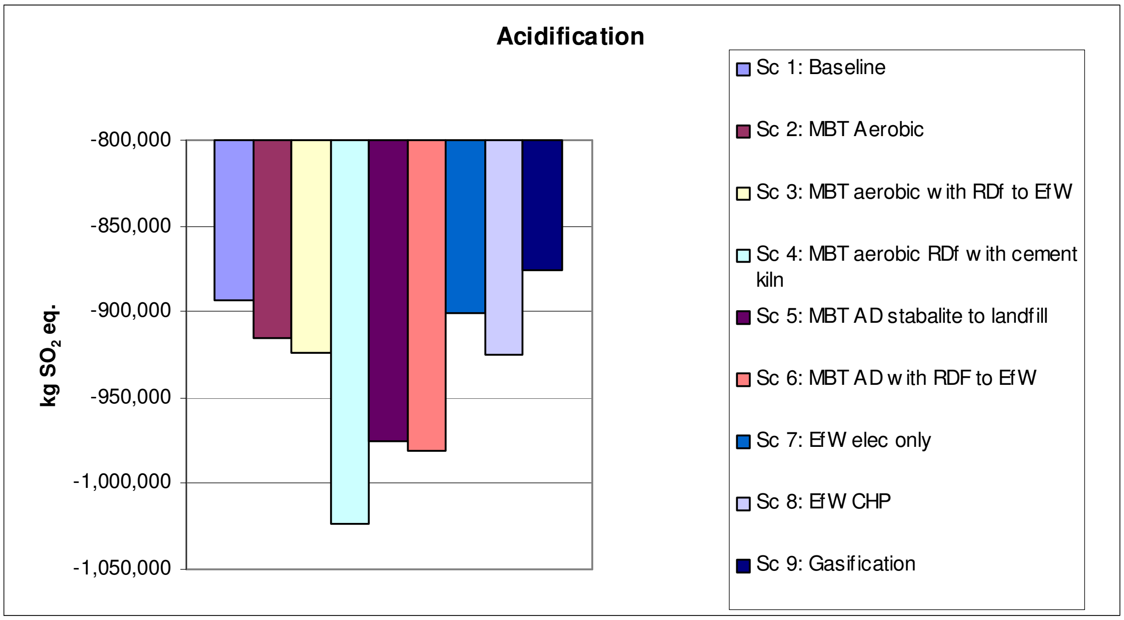

Figure A.3: Acidification Potential (kg SO_2 eq.)

The scenarios all show a benefit on acidification releases.

The gasifier in scenario 9 has lower NOx emissions than an incinerator and NOx is a contributor to atmospheric acidification. However the lower energy production from the gasifier results in a similar effect on acidification as the other scenarios.

The RDF combustion in scenarios 4 and 6 has the greatest benefit as although some acid gases are emitted, not as much waste is combusted as in some other scenarios and therefore the acid emissions are lower. It also has the benefit gained by the energy production, which can be offset against the use of fossil fuels.

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2 Review of Environmental and Health Effects of Waste Management. Defra, May 2004
3 UK Emissions of Air Pollutants 1970 to 2004, UK Emissions Inventory Team, 2006.

Table A.9: Potential harmful gas emissions from waste facilities and transport (kg SO_2 equivalent)

Scenario	Air quality impact	Normalised score
Sc 1- Base Case	-893,140	0.12
Sc 2- MBT-Aerobic	-914,651	0.26
Sc 3- MBT-RDF on site	-923,899	0.33
Sc 4- MBT-RDF to 3rd party	-1,024,053	1.00
Sc 5- MBT-AD + Aerobic	-975,382	0.67
Sc 6- MBT-AD + Aerobic with RDF onsite	-981,110	0.71
Sc 7 – EfW	-900,547	0.17
Sc 8 - EfW-CHP	-925,255	0.34
Sc 9- ATT Gasification	-875,336	0.00

A3. Minimising global warming potential

This is assessed through two criteria:

- Reduction in greenhouse gases.
- Energy production by waste treatment.

A3.1 Reduction in Greenhouse gases

There is now an international consensus that emissions of greenhouse gases are responsible for ‘global warming’ or 'global climate change’. Global climate change could lead to substantial changes in global temperatures, weather patterns and sea levels, with subsequent effects in a diverse number of areas, e.g. agriculture, water resources, human health, natural ecosystems.

The main sources of greenhouse gases from a waste management perspective are methane (CH_4) emissions from landfill sites and carbon dioxide (CO_2) from the combustion of fossil fuels. Fossil fuels including; vehicle fuels (e.g. diesel in the operation of refuse vehicles), power station fuel sources to produce electricity used at waste treatment facilities and the combustion of fossil fuel originated material, such as plastics, in EfW plants. CO_2 emissions from the combustion or degradation of ‘organic’ material such as putrescibles and paper are not considered to contribute to climate change, as they are carbon neutral – they release carbon that was originally recently sequestered from the air.

Waste management scenarios that produce energy (e.g. EfW plant and/or beneficial use of landfill gas) will assist in reducing greenhouse gas emissions by decreasing the amount of fossil fuels required to produce the equivalent quantity of electricity – the assumption is made that the displaced power generation capacity is from coal fired plants. Recycling has a similar effect in that it often saves energy in the production of raw materials.

The findings from the WRATE assessment of each scenario are shown in Figure A.4 and Table A10. A negative index score assumes that the scenario has a positive lifecycle impact, whereas a positive score indicates a detrimental impact.

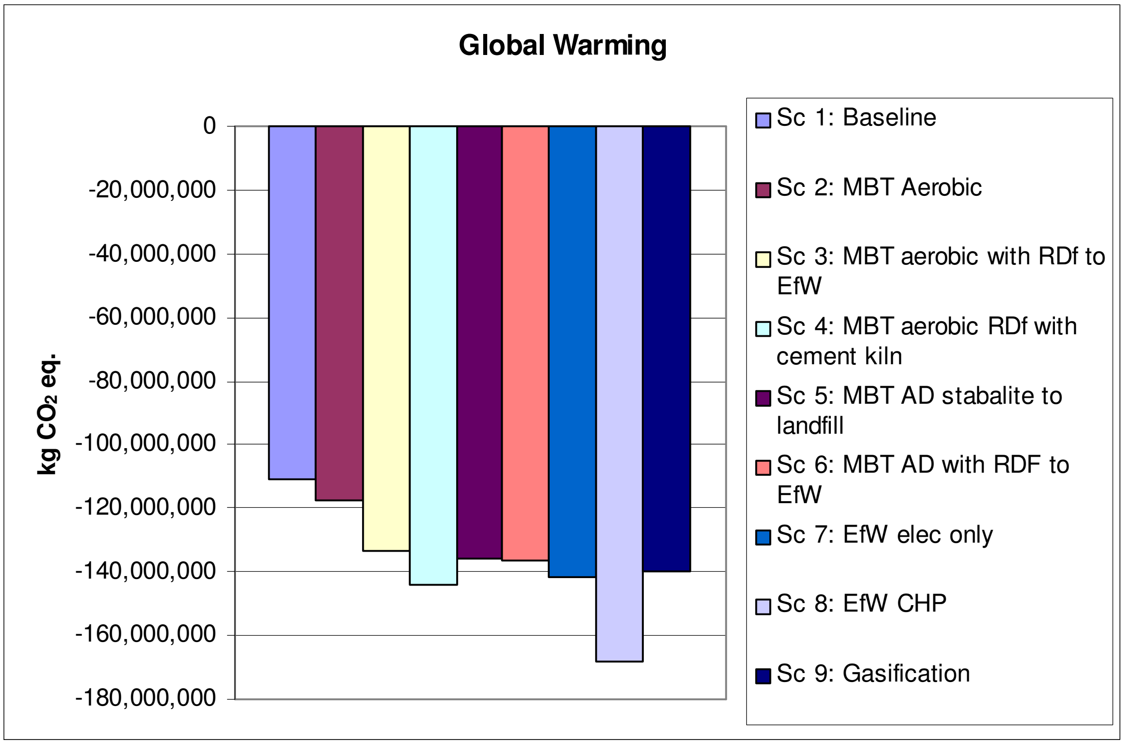


Figure A. 4: Global warming potential (kg CO_2 eq.)

All the scenarios show a low impact on global warming as they include high levels of recycling and also produce energy, which can be offset against the direct use of fossil fuels.

The results show a similar pattern as for the resource depletion analysis as they are predominantly based on the energy output of the processes. The EfW CHP scenario (Scenario 8) has the greatest benefit as it has the highest energy output. Although MBT with third party RDF has a high-energy output the greenhouse gas emissions from this are also high and therefore it does not perform as well as the EfW CHP.

The landfill baseline scenario performs worst as landfilling of waste releases large amounts of CO_2 and other greenhouse gases. The scenarios where more waste is diverted from landfill have a lower impact on global warming.

The gasifier in scenario 9 performs well because although less energy is produced in this scenario, the NOx emissions from the gasifier are much lower than for the EfW and NOx emissions and emissions of N_2O, whilst small, have a large impact (approximately 310 times CO_2 equivalents).

Table A10: Potential greenhouse gas emissions from waste facilities and transport (kg CO_2 equivalent)

Scenario	Impact on climate change	Normalised score
Sc 1- Base Case	-110,840,326	0.00
Sc 2- MBT-Aerobic	-117,495,536	0.12
Sc 3- MBT-RDF on site	-133,494,348	0.39
Sc 4- MBT-RDF to 3rd party	-144,017,183	0.58
Sc 5- MBT-AD + Aerobic	-135,539,794	0.43
Sc 6- MBT-AD + Aerobic with RDF onsite	-136,423,744	0.44
Sc 7 – EfW	-141,522,073	0.53
Sc 8 - EfW-CHP	-168,446,793	1.00
Sc 9- ATT Gasification	-139,809,958	0.50

A3.2 Energy produced

Some technologies have the advantage of reducing greenhouse gases as a result of the production of energy at the treatment plant. The typical process energy production for each treatment technology is indicated in Table A 11.

Table A 11: Typical energy production from waste treatment facilities

Technology	Energy output (kWh) [4]
AD	75
Small EfW (RDF scenarios)	992
EfW	567
EfW with CHP	2280
EfW/ATT	493

Table A 12 shows the estimated yearly process energy production for each scenario. These have been determined using the typical process energy production per tonne of material processed for each type of facility and the tonnage throughputs determined during the modelling of the scenarios.

Table A 12: Renewable energy produced

Scenario	Energy output (kWh)	Normalised score
Sc 1- Base Case	0	0.00
Sc 2- MBT-Aerobic	0	0.00
Sc 3- MBT-RDF on site	65,359	0.22
Sc 4- MBT-RDF to 3rd party	0	0.00
Sc 5- MBT-AD + Aerobic	9,883	0.03
Sc 6- MBT-AD + Aerobic with RDF onsite	60,863	0.20
Sc 7 – EfW	74,715	0.25
Sc 8 - EfW-CHP	300,440	1.00
Sc 9- ATT Gasification	64,964	0.22

[4] Data supplied by the waste management industry

The EfW with CHP has the highest amount of energy produced because of the extra amount of energy from the heat provided. The MBT with RDF scenarios do not produce as much energy as the thermal treatments due to smaller quantities of RDF combusted.

A4. Minimising the use of resources

This is assessed through three criteria:

- Prudent use of land
- Prudent use of water
- Prudent use of other resources.

A4.1 Prudent use of land

Land is a valuable resource and should be treated accordingly. The area of land required by the waste management system is estimated from the number of facilities that will be required and the amount of residual waste sent to landfill, and is shown in Table A.13. This assessment is based on the typical land requirements for generic types and sizes of facility; this data has been derived from access to tendered information (for various waste management systems) as part of our activity in the environmental consultancy sector and information openly available, such as the Juniper technology reports and the Environment Agency's Waste Technology Data Centre.

Table A.13: Estimated landtake (hectares) for each scenario

Scenario	Landtake (ha)	Normalised score
Sc 1- Base Case	16.07	1.00
Sc 2- MBT-Aerobic	19.98	0.00
Sc 3- MBT-RDF on site	19.12	0.22
Sc 4- MBT-RDF to 3rd party	19.12	0.22
Sc 5- MBT-AD + Aerobic	19.32	0.17
Sc 6- MBT-AD + Aerobic with RDF onsite	19.24	0.19
Sc 7 – EfW	18.43	0.40
Sc 8 - EfW-CHP	18.43	0.40
Sc 9- ATT Gasification	18.43	0.40

The landtake requirement for the Base Case scenario is the smallest as no land is required for a residual waste treatment plant (though it could be argued that the greater use of the existing landfill will advance the time when a replacement needs to be brought on-line). Processing facilities with mechanical separation and bio-waste processing generally require more land than thermal treatment facilities (EfW, ATT), as demonstrated by Scenarios 2, 3, 4, 5 & 6. All the thermal treatment scenarios require similar levels of landtake due to the capacities being identical, no composting requirements, and the residues sent to landfill being similar in quantity.

A4.2 Prudent use of water

The main use of water by waste treatment plants will be the requirement for process water. Water will also be used for staff hygiene activities, and for washing/cleaning activities at the plant, but this is likely to be similar for all of the treatment processes being considered, and thus the evaluation is based on process water consumption. The typical process water consumption for each treatment technology is indicated in Table A.14.

Table A.14: Typical water consumption for waste treatment

Technology	Water consumption (litres/tonne processed) [5]	Comments
Mechanical sorting	10	Dust control
IVC	5	Dust control and processing
AD	20	Dust control and processing
EfW/ATT	450	Flue gas cleaning and make-up water for steam raising plant

Table A.15 shows the estimated yearly process water consumption for each scenario. These have been determined using the typical process water consumption per tonne of material processed for each type of facility and the tonnage throughputs determined during the modelling of the scenarios.

Table A.15: Estimated total yearly water consumption (m3) for each scenario

Scenario	Water consumption (m^3)	Normalised score
Sc 1- Base Case	0	1.00
Sc 2- MBT-Aerobic	1,318	0.98
Sc 3- MBT-RDF on site	30,966	0.48
Sc 4- MBT-RDF to 3rd party	1,318	0.98
Sc 5- MBT-AD + Aerobic	2,635	0.96
Sc 6- MBT-AD + Aerobic with RDF onsite	25,761	0.57
Sc 7 – EfW	59,297	0.00
Sc 8 - EfW-CHP	59,297	0.00
Sc 9- ATT Gasification	59,297	0.00

The EfW and ATT scenarios potentially result in a much greater use of water compared with other scenarios because of the requirements of the flue gas cleaning equipment. However, it should be noted that this assumes the use of a wet gas cleaning process (other technologies for gas cleaning use far less water, but for comparison purposes we have assumed the worst case). The landfill scenario uses the smallest amount of water because it has no processing facilities, whilst the MBT scenarios require water for dust control and processing. The MBT with RDF uses more water than other MBT technologies due to its incineration process for burning the RDF.

[5] Data supplied by the waste management industry

A4.3 Prudent use of other resources

The world contains limited resources of both minerals and fossil fuels (i.e. coal, oil and gas), and the depletion of such resources is important when assessing the sustainability of any particular scenario. Some waste management scenarios recover energy (electricity) that would otherwise be generated from fossil fuel power stations, so the consumption of fossil fuels is avoided. The recycling of plastics reduces the amount of oil that is required during the manufacture of new plastic products using virgin materials. Recycling and composting of materials contributes more to conserving renewable resources when compared to energy production.

Resource efficiency and resource depletion are explicitly linked, and care is needed to ensure no double counting of issues. Resource depletion relates to the amount and type of resources displaced, but this depends also on the type and amount of materials being re-used or recycled. Therefore the prudent use of land and water are measured directly as these are not covered by the re-use and recycling/composting target.

Resource efficiency relates partly to the amount of resources displaced, but also to the energy generated and nutrients (nitrogen, phosphorus and potassium) provided through compost generation. However, these issues have already been covered by other criteria.

The Environment Agency's WRATE software was used to determine the impact of each scenario on use of other resources. The WRATE index is expressed in terms of kg of antimony, which all resources are made equivalent to through the use of factors relating to the global availability of the resource compared to consumption. The findings of the WRATE assessment of each scenario are shown in

Figure A.5 and Table A.16. A negative index score assumes that the scenario has a positive lifecycle impact, whereas a positive score indicates a detrimental impact.

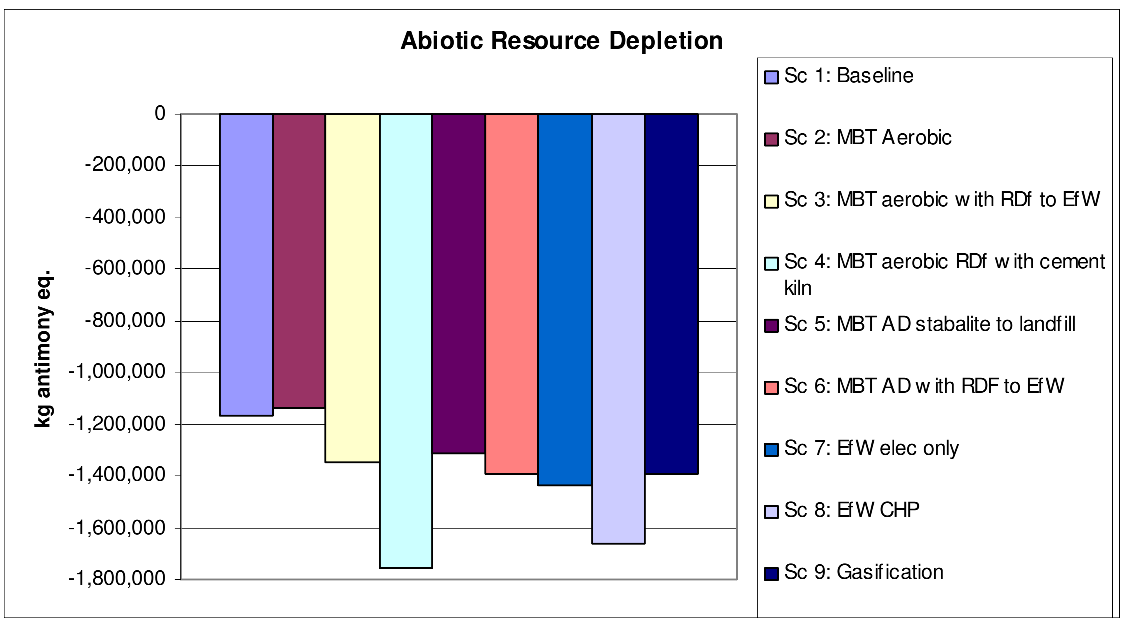


Figure A.5: Abiotic resource depletion (kg antimony equiv)

All the scenarios show a low impact on natural resources due to the recycling levels and the energy generated, which can be offset against the use of direct fossil fuels.

All the scenarios, with the exception of the MBT with third party RDF and EfW CHP, have a similar benefit over resource depletion, with the landfill baseline scenario and Aerobic MBT having the lowest benefit as very little energy is produced.

The main difference between scenarios 3 and 6 is the treatment of the green waste. In scenario 3 treatment is aerobic and in scenario 6 it is anaerobic. The anaerobic process has a more beneficial impact on resource depletion, as it generates electricity, via the biogas production.

The scenarios with some form of combustion generally perform slightly better than those without due to the higher energy recovery from these processes and therefore their greater potential to offset against direct use of fossil fuels.

MBT with third party RDF and EfW CHP produce significantly more energy than the other treatment scenarios and therefore this can be offset against the direct use of fossil fuels and helps to retain natural resources.

Table A.16: Resources depletion (kg antimony equivalent)

Scenario	Resource depletion	Normalised score
Sc 1- Base Case	-1,168,209	0.05
Sc 2- MBT-Aerobic	-1,138,310	0.00
Sc 3- MBT-RDF on site	-1,351,393	0.35
Sc 4- MBT-RDF to 3rd party	-1,755,681	1.00
Sc 5- MBT-AD + Aerobic	-1,313,326	0.28
Sc 6- MBT-AD + Aerobic with RDF onsite	-1,389,632	0.41
Sc 7 – EfW	-1,433,872	0.48
Sc 8 - EfW-CHP	-1,662,609	0.85
Sc 9- ATT Gasification	-1,393,848	0.41

A5. Economic Objectives

The two main economic objectives measured are:

- The overall cost of waste management activities
- Maximising employment opportunities

A5.1 Cost of waste management activities

The methodology for determining the overall cost for each scenario for the years 2010 to 2035 (based on an expected lifetime of a waste treatment plant of 25 years) were described in Section 3.2 of the report, and Table A 17 shows the estimated costs for each scenario over this period.

Table A 17: Total cost (£ million) for each scenario for the period 2010 to 2035

Scenario	Total cost (£ million)	Normalised score
Sc 1- Base Case	1,258	0.74
Sc 2- MBT-Aerobic	1,339	0.53
Sc 3- MBT-RDF on site	1,550	0.00
Sc 4- MBT-RDF to 3rd party	1,477	0.18
Sc 5- MBT-AD + Aerobic	1,312	0.60
Sc 6- MBT-AD + Aerobic with RDF onsite	1,848	0.17
Sc 7 – EfW	1,180	0.93
Sc 8 - EfW-CHP	1,180	0.93
Sc 9- ATT Gasification	1,154	1.00

The collection costs are the same for all Scenarios. However, the major influence on the total costs is the type of residual waste treatment and the impact on diverting material from landfill.

The ATT scenario is the least expensive option. This is owing to the low operating cost of the ATT facility because of the additional benefits of ROCs income from the energy produced, and due to gasifiers being more economic at small scale that EfW. ATT also has a higher level of diversion of biodegradable waste (compared to the MBT scenarios), which results in lower landfill costs and higher income from the sale of LATS allowances until 2019/20.

The EfW scenarios are the second least expensive options due to a lower gate fee compared to the MBT technologies and high levels of diversion of biodegradable waste, which results in lower landfill costs and higher income from the sale of LATS allowances.

Scenario 3 (MBT with RDF onsite) has the highest cost due to a relatively high MBT gate fee, a high on site combustion cost, and a significant amount of material that requires landfilling after processing that incurs both landfill disposal and tax costs. In addition, scenario 4 (MBT with RDF sent to 3rd party) has a high cost due to a relatively high gate fee which results from the high proportion of RDF material that is sent to a third party for combustion.

The Base Case scenario is the 3rd least expensive option, cheaper than all the MBT scenarios due to the low landfill gate fees compared to the high MBT gate fees, and the need for all MBT scenarios to purchase landfill allowances after 2024.

A5.2 Maximising employment opportunities

The overall number of jobs created will depend on factors such as the amount of material collected for recycling and the processes used to treat the residual waste. Table A.18 shows the estimated number of jobs (total of jobs for waste collection, transfer and treatment) for each scenario. The number of estimated jobs for transfer and treatment was determined using data obtained from the waste management industry. The employment opportunities created at reprocessors and at the markets for the treatment products have not been considered in this criterion.

Table A.18: Estimated number of jobs in waste collection and treatment

Scenario	Number of jobs (estimated)	Normalised score
Sc 1- Base Case	96	0.00
Sc 2- MBT-Aerobic	134	0.90
Sc 3- MBT-RDF on site	134	0.90
Sc 4- MBT-RDF to 3rd party	115	0.45
Sc 5- MBT-AD + Aerobic	121	0.60
Sc 6- MBT-AD + Aerobic with RDF onsite	135	0.93
Sc 7 – EfW	138	1.00
Sc 8 - EfW-CHP	138	1.00
Sc 9- ATT Gasification	138	1.00

Thermal treatment scenarios have the highest staff requirements. The MBT with RDF scenarios all have high staff levels due to the additional residual treatment technology employed. The MBT scenarios have, in general, staffing levels that are slightly lower than the thermal technologies. The estimated number of jobs in scenario 4 does not include employment at the third party facility for RDF combustion as RDF is used as a fuel replacement and does not require a purpose built facility.

The landfill scenario results in the smallest number of jobs, as there is no requirement for an additional facility.

A6. Social objectives

There is one main social objective, which is maximising public involvement in achieving waste minimisation and recycling targets.

The role of the public in the success of any waste management system should not be underestimated and recycling schemes in particular will only be successful if the public is well informed and motivated to participate. There are also wider waste minimisation and social responsibility benefits by engaging the public in greater awareness of their role in waste generation and management. Thus the extent that the waste management system (as opposed to the effects of any additional promotional activities) helps to engage the public and allows them to get involved is considered a benefit. The potential for public involvement is calculated as the sum of households on dry recyclable and organic kerbside collection across the county.

The scenarios assessed within this report all have identical numbers of households on the kerbside collections. Therefore all the scenarios are given a normalised score of 0.

Table A.19: Public involvement

Scenario	Household involvement	Normalised score
Sc 1- Base Case	338,345	0
Sc 2- MBT-Aerobic	338,345	0
Sc 3- MBT-RDF on site	338,345	0
Sc 4- MBT-RDF to 3rd party	338,345	0
Sc 5- MBT-AD + Aerobic	338,345	0
Sc 6- MBT-AD + Aerobic with RDF onsite	338,345	0
Sc 7 – EfW	338,345	0
Sc 8 - EfW-CHP	338,345	0
Sc 9- ATT Gasification	338,345	0

A7. Deliverability of Scenarios

This is assessed through four criteria:

- Maturity of technology
- Flexibility of the waste management system to changes in future policy or waste arisings
- Public acceptance and achievement of planning permission
- The level of public participation required and effectiveness in the schemes

However, the only criterion to be formerly measured is the level of public involvement required within the scenarios. If a scenario is dependant on the public to maintain their involvement then the scenario could suffer detrimental implications if the levels of involvement drop. Within the scenarios modelled it is only the source-segregated collection of recyclates that is potentially impacted upon by public involvement. The residual treatment processes are independent of public involvement, and consequently, will not be influenced.

To assess the criterion, the participation rates and scheme efficiency required to achieve the kerbside collection levels for the dry and organic material have been summed. Table A 20 shows the combined efficiencies for each scenario

Table A 20: Public involvement required

Scenario	Public involvement required	Normalised score
Sc 1- Base Case	100%	1.00
Sc 2- MBT-Aerobic	100%	1.00
Sc 3- MBT-RDF on site	100%	1.00
Sc 4- MBT-RDF to 3rd party	100%	1.00
Sc 5- MBT-AD + Aerobic	100%	1.00
Sc 6- MBT-AD + Aerobic with RDF onsite	100%	1.00
Sc 7 – EfW	100%	1.00
Sc 8 - EfW-CHP	100%	1.00
Sc 9- ATT Gasification	100%	1.00

The scenarios assessed within this report all have identical collection scheme, therefore they all require the same participation and scheme efficiency rates. All scenarios are given a normalised score of 1.

A8. Waste policy

This is assessed by four criteria:

- Level of waste minimisation achieved
- Percentage of MSW recycled/composted
- Percentage of MSW recovered (including energy recovery)
- Percentage of biodegradable material diverted from landfill.

A8.1 Waste minimisation

Lincolnshire's waste strategy sets a target for waste minimisation, which has been included within all the scenarios assessed. Table A.21 shows the predicted waste arising in 2015.

Table A.21: Total waste arisings in 2015 (tonnes)

Scenario	Waste minimisation	Normalised score
Sc 1- Base Case	191,720	1.00
Sc 2- MBT-Aerobic	191,720	1.00
Sc 3- MBT-RDF on site	191,720	1.00
Sc 4- MBT-RDF to 3rd party	191,720	1.00
Sc 5- MBT-AD + Aerobic	191,720	1.00
Sc 6- MBT-AD + Aerobic with RDF onsite	191,720	1.00
Sc 7 – EfW	191,720	1.00
Sc 8 - EfW-CHP	191,720	1.00
Sc 9- ATT Gasification	191,720	1.00

The results indicate that all scenarios achieve a normalised score of 1 as they have the same waste minimisation targets.

A8.2 Recycling, recovery and diversion of biodegradable material from landfill

The methodology for modelling these factors was described in Section 4.2 of the report and Table A22 shows the recycling and composting levels, the recovery rates and the BMW diversion from landfill achieved in each scenario.

Table A22: Recycling, recovery and BMW diversion rates (Wt %) in 2015/16

Scenario	Recycling and composting (BVPI)	Recovery (MSW)	BMW diverted from landfill (MSW)
Sc 1- Base Case	50%	50%	56%
Sc 2- MBT-Aerobic	50%	54%	72%
Sc 3- MBT-RDF on site	50%	71%	80%
Sc 4- MBT-RDF to 3rd party	50%	71%	80%
Sc 5- MBT-AD + Aerobic	52%	61%	78%
Sc 6- MBT-AD + Aerobic with RDF onsite	52%	65%	78%
Sc 7 – EfW	50%	79%	87%
Sc 8 - EfW-CHP	50%	79%	87%
Sc 9- ATT Gasification	51%	79%	87%

The MBT scenarios with AD achieve the highest recycling rate due to the potential for recycling additional materials, particularly plastic from the residual waste stream. The two MBT technology types also recycle additional material from the residual stream compared to the thermal treatment technologies.

The thermal treatment scenarios (EfW & ATT) achieve the highest MSW recovery rate (because the rejects and compost from the MBT process are landfilled). The Base Case has a very low recovery level due to the high quantities of waste landfilled without treatment.

The BMW diversion ranking is similar to the recovery ranking, with the thermal treatment scenarios (EfW & ATT) scoring highest, followed by the MBT with RDF scenarios (scenarios 3 and 4). Once again the Base Case (Scenario 1) performs poorly with a very low BMW diversion rate achieved.

Table A.23 shows the normalised scores for the recycling, recovery and BMW diversion for each scenario.

Table A.23: Normalise scores for recycling, recovery and BMW diversion rates

Scenario	Recycling and composting (BVPI)	Recovery (MSW)	BMW diverted from landfill (MSW)
Sc 1- Base Case	0.00	0.00	0.00
Sc 2- MBT-Aerobic	0.14	0.53	0.53
Sc 3- MBT-RDF on site	0.14	0.77	0.77
Sc 4- MBT-RDF to 3rd party	0.14	0.77	0.77
Sc 5- MBT-AD + Aerobic	1.00	0.71	0.71
Sc 6- MBT-AD + Aerobic with RDF onsite	1.00	0.71	0.71
Sc 7 – EfW	0.00	1.00	1.00
Sc 8 - EfW-CHP	0.00	1.00	1.00
Sc 9- ATT Gasification	0.60	1.00	1.00

Appendix B - Unmeasured criteria

There are six criteria that have not been scored in the quantitative assessment:

- Minimising the visual and landscape impact of waste management facilities.
- Encouraging inward investment and providing community regeneration.
- Access to recycling facilities
- Assessing the deliverability and maturity of the residual treatment technology, i.e. how reliable and dependable will it be in the future, how effective is it and what is the risk of technology failure?
- Assessing the flexibility of the waste management system to changes in future policy, waste arisings etc.
- Assessing public acceptance and likelihood of achieving planning permission.

This appendix discusses the factors that are used to assess these criteria when the analysis of significant effects was conducted.

B1. Visual impact on landscape and townscape

Minimising the visual impact of waste management facilities has not been quantified because it is entirely subjective.

The issues to consider in the assessment of visual impact are:

- Number and type of facilities;
- Building profile (e.g. is it comparable to agricultural or other industrial warehouse-type buildings?);
- Similarity to surrounding environment;
- Presence and/or height of any chimney; and
- Change of landform.

An EfW or ATT facility will generally be the most intrusive because of the need for a chimney. Landfill is generally remote and of limited height, but it has an impact on the geographical area and landform. MBT, AD and composting facilities generally have a lower height profile, although they will require larger areas of land than an EfW facility.

B2. Encouraging inward investment and providing community regeneration

The implementation of the Waste Strategy will involve partnerships between a range of stakeholders, such as the local authority, waste management companies, recycling companies and the voluntary sector (community recycling groups, community enterprises and charities). The main role for these partnerships will be to support activities aimed at achieving waste minimisation & re-use targets but also recycling and composting targets.

As the targets are the same for all the scenarios except scenario 1, it is highly likely that the level and extent of partnership arrangements will be the same for these scenarios. The Base Case does not aim for a new facility and therefore there is arguably less potential for co-operation and partnership. Some scenarios have more problems in achieving recycling targets as the residual treatment method does not actively contribute to the recycling performance, consequently more effort will be required from the partnership to achieve these targets. However, it is difficult to measure the effort required in relation to an achieved performance level, and this in turn depends on the initiatives set-up by the partnership.

B3. Access to recycling facilities

This criterion has already been measured under the opportunities for public involvement criteria. Therefore this criterion has not been assessed again to avoid duplication.

B4. Deliverability of the residual treatment option

The assessment of the deliverability of the residual treatment options covers three criteria that have not been quantified:

- The maturity of the technology
- The flexibility of the technology
- Public acceptance of the technology

B4.1 Maturity of the waste treatment technology

The maturity of a technology depends on the status of development, its commercial use in the UK and overseas but even more on its acceptability and bankability in financial terms. Hence, no score can be given, but the deliverability of the option assessed relates to its maturity.

No nationally agreed ‘definition’ exists which identifies the point at which a technology reaches a level of commercialisation sufficient to be classified as ‘proven’. The approach to acceptable risk for purposes of bankability is most often dependent on tried and tested technology, and the track record of implementation using that technology. Consequently, the assessment is based on the current status of each technology.

The following differentiation has been assumed within the scope of this SEA:

- Landfilling and EfW are well-established technologies for treating MSW and have been operating in many locations in the UK on a commercial scale for many years. Thus it seems reasonable to assume that these can be classified as “well proven” technologies for treating MSW in the UK.
- Various types of MBT processes are now established in Europe, and plants are currently operational or under construction in the UK and Europe. However, the number of plants which are currently operating in the UK is small, with the length of time that these plants have been operating being much shorter than for EfW plants. There is also concern about the availability of suitable markets and the size of the potential markets for the MBT products. Consequently, a MBT plant is classified as ‘developed but less proven commercially compared to EfW or landfill’.
- Advanced thermal treatment (ATT) processes, such as gasification, have also been used to treat some types of waste for many years, but few plants have

been commercially proven for treating MSW. However, there is a small ATT plant (currently 8,000 tonnes per annum) operating in the UK and a small number of gasifiers operating in Europe. There also appears to be a limited number of technology providers, consequently the status of technology is seen as being between 'near market' and 'proven';

It is important to emphasise that these classifications are indicative and cannot be taken as absolute as they represent current status. Ultimately it is for the UK marketplace and not this SEA to test whether the technologies are deemed to be suitably proven for purposes of bankability.

B4.2 Flexibility of the residual treatment system

The residual waste treatment technologies that are installed will have typical operational lives of 25 years. However, there is a need to consider whether the waste management system could respond to future changes in waste policy (for example, a higher Government target for recycling than that set by the Strategy) and factors such as changes in waste arisings (for example, higher arisings resulting from waste minimisation and re-use targets not being achieved).

EfW or ATT facilities need a specified waste throughput in order to release the amount of heat required to produce the rated amount of electricity. They also operate 24-hours per day. A higher recycling target or a higher waste minimisation target would reduce the amount of residual waste that was produced, and whilst this could make it more difficult for a thermal treatment facility to process the required tonnage of MSW, alternative waste sources (such as suitable commercial and industrial waste) could be used to meet the waste input target.

MBT facilities are more flexible than thermal treatment facilities as they can operate for one, two or even three shifts per day depending on arisings. This means that they would be more flexible in terms of responding to changes in residual waste arisings. However, this could result in the plant either failing to supply minimum tonnages of products if residual arisings reduced or having to landfill excess material if residual arisings increased and markets were not available for the additional tonnage of products which were produced.

B4.3 Public acceptance

Public acceptance and obtaining planning permission for all of the waste treatment processes will be required in order to implement the chosen scenario.

New facilities required will vary depending on the scenario modelled:

- Landfill capacity (Scenario 1)
- Mechanical biological treatment (MBT) plant (Scenarios 2, 3, 4, 5 & 6).
- Energy from waste (EfW) facility (Scenarios 7 & 8)
- Advanced thermal treatment (ATT) (Scenario 9)

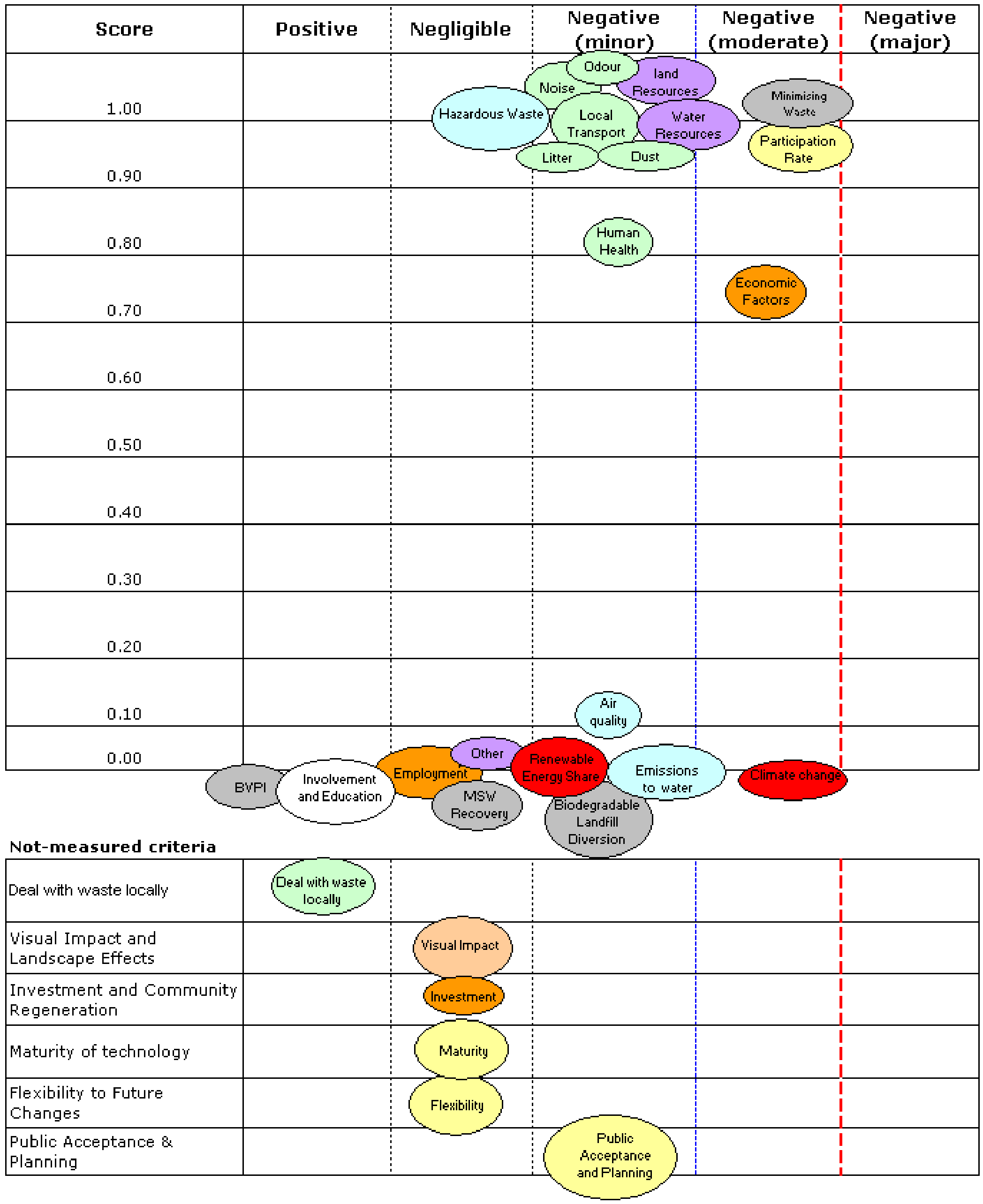
The MBT plant will also require landfill capacity to dispose of waste which is not suitable for processing and for the stabilised organic fraction.

The factors that are most likely to affect public acceptance for a new waste management scenario are the number and types of new facilities required, therefore there might be some level of opposition to any new waste management facility.

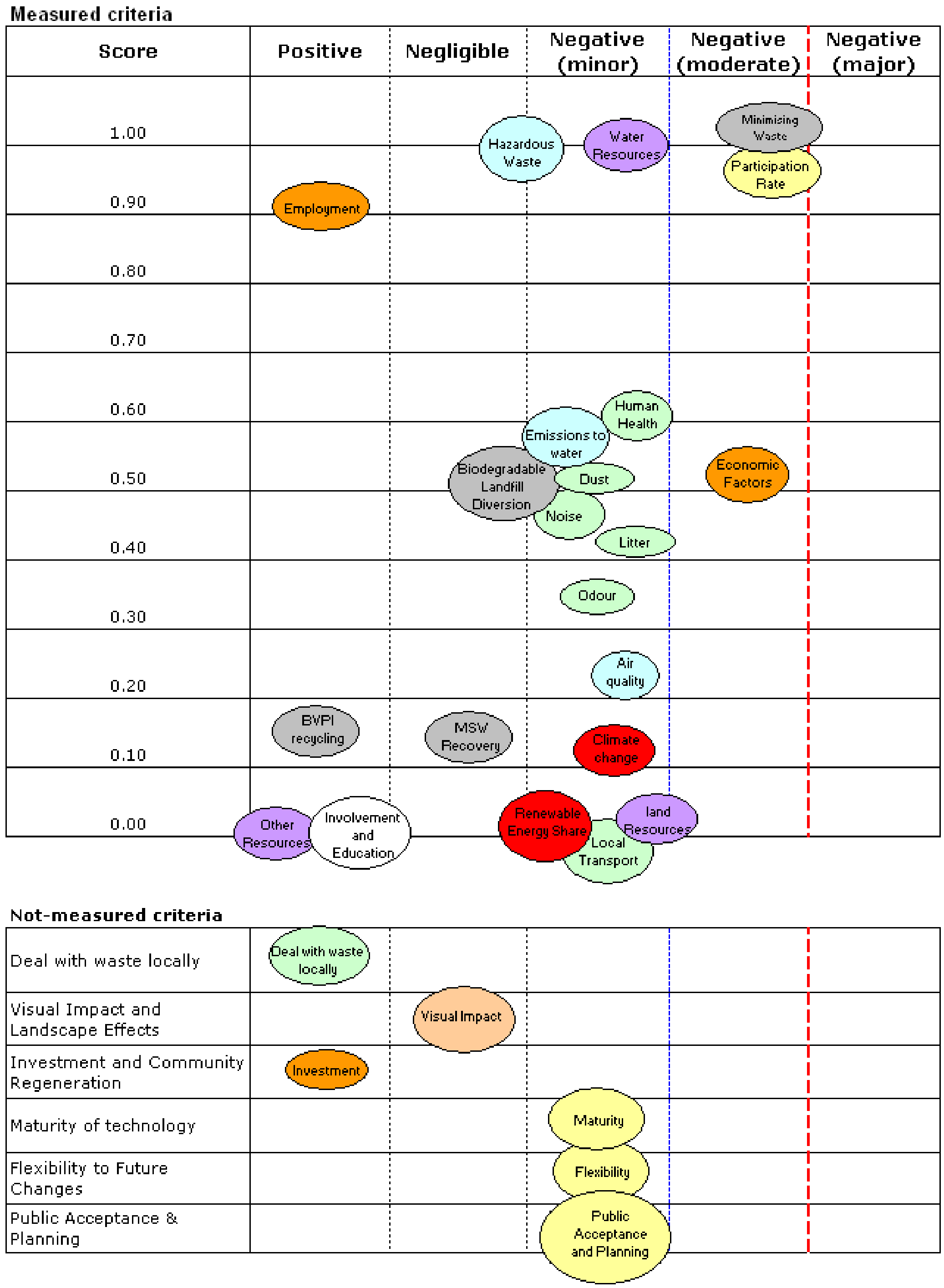
Appendix C: Scenario Specific matrix

Scenario 1 - Base Case

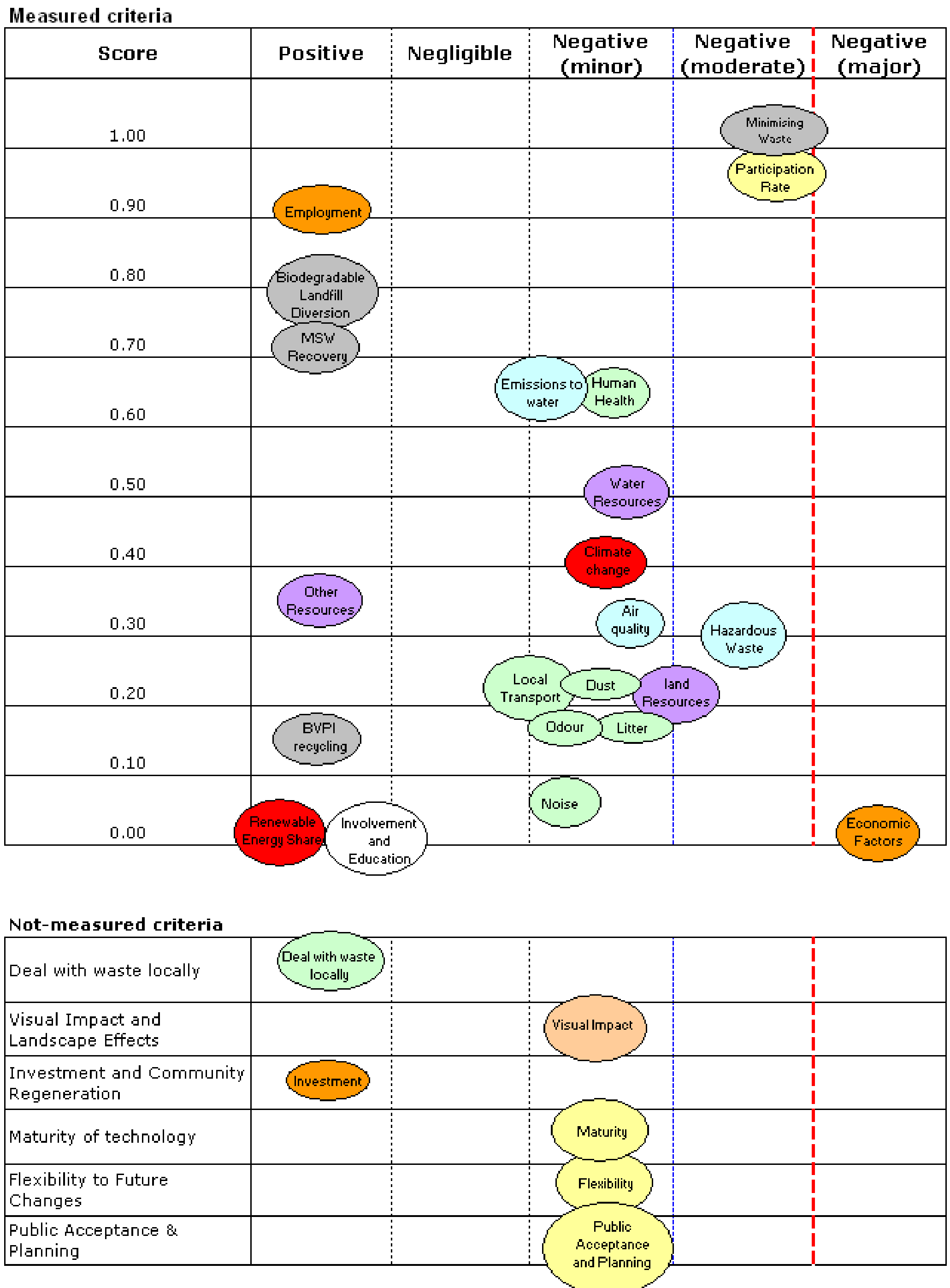
Measured criteria



Scenario 2 - MBT Aerobic

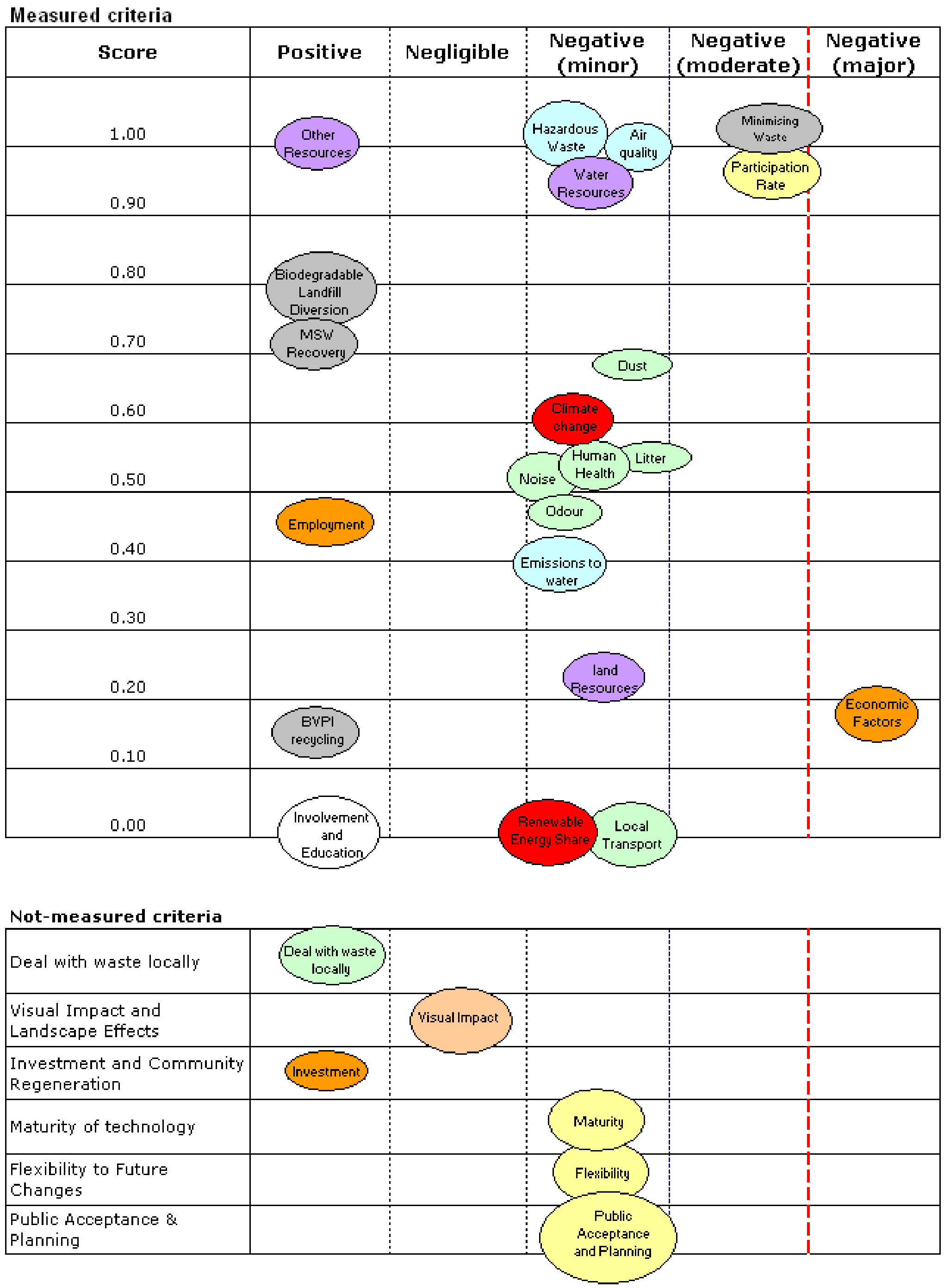


Scenario 3 - MBT RDF On site

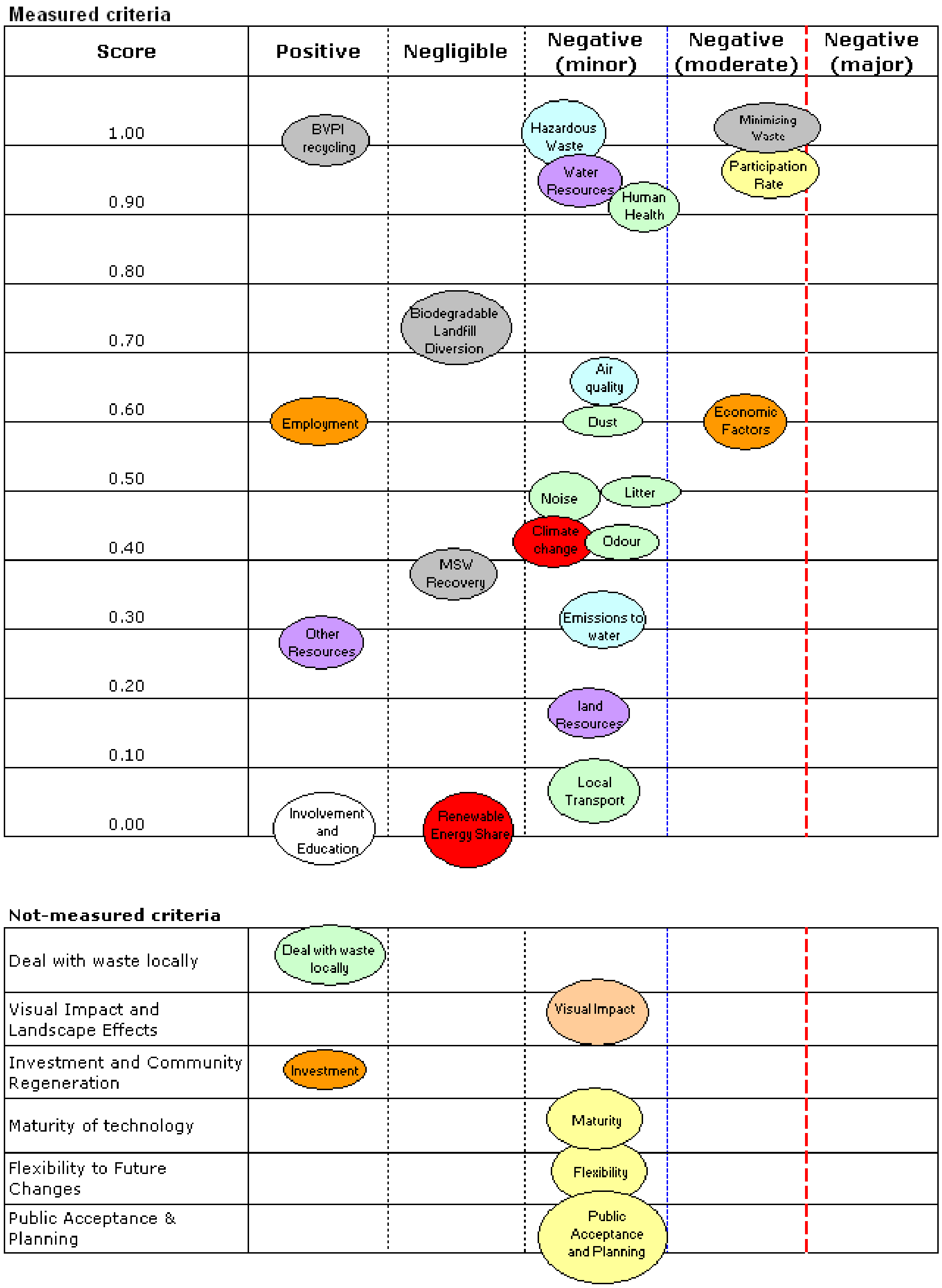


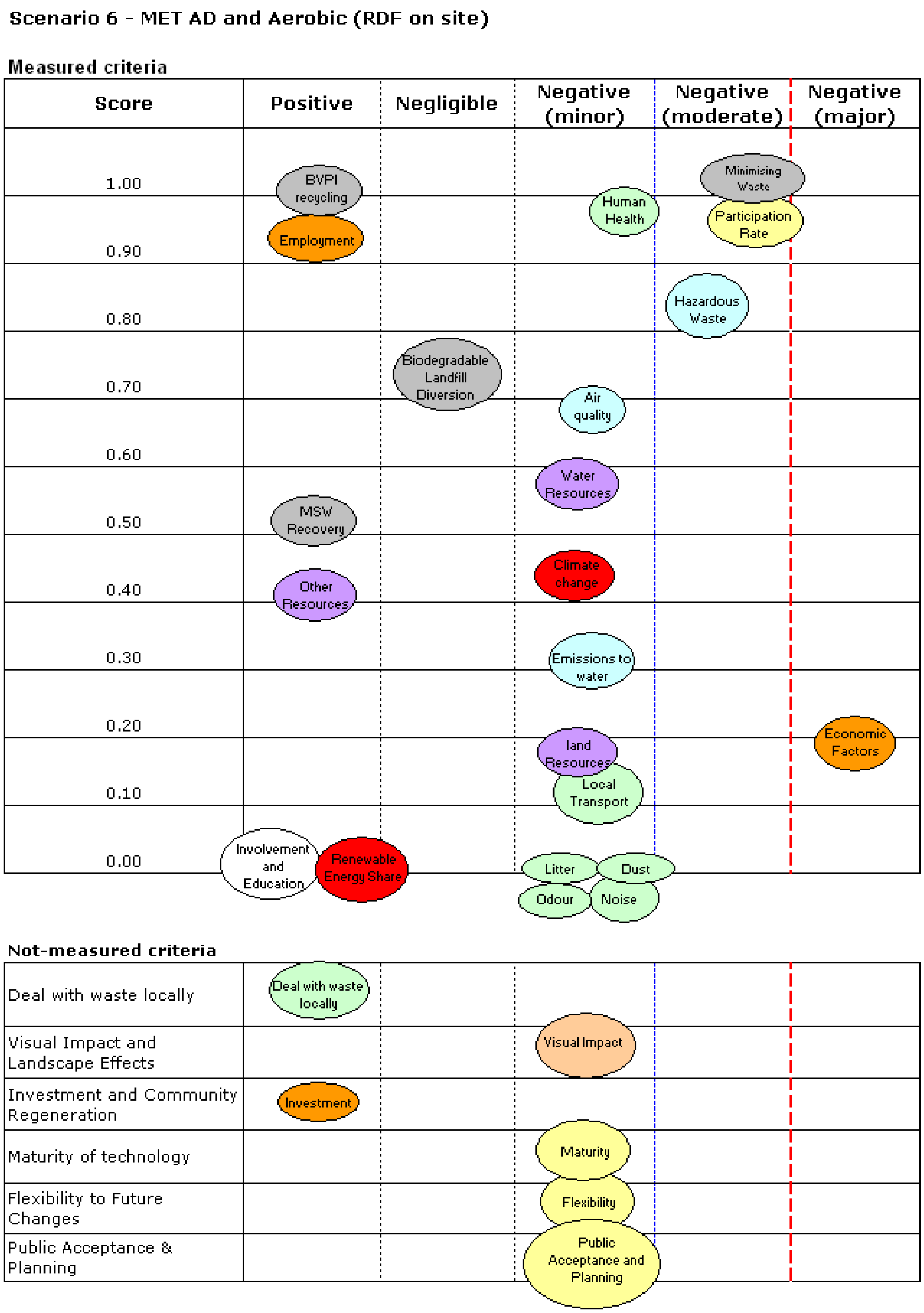
Scenario 3 - MBT RDF On site

Scenario 4 - MBT RDF to 3rd Party

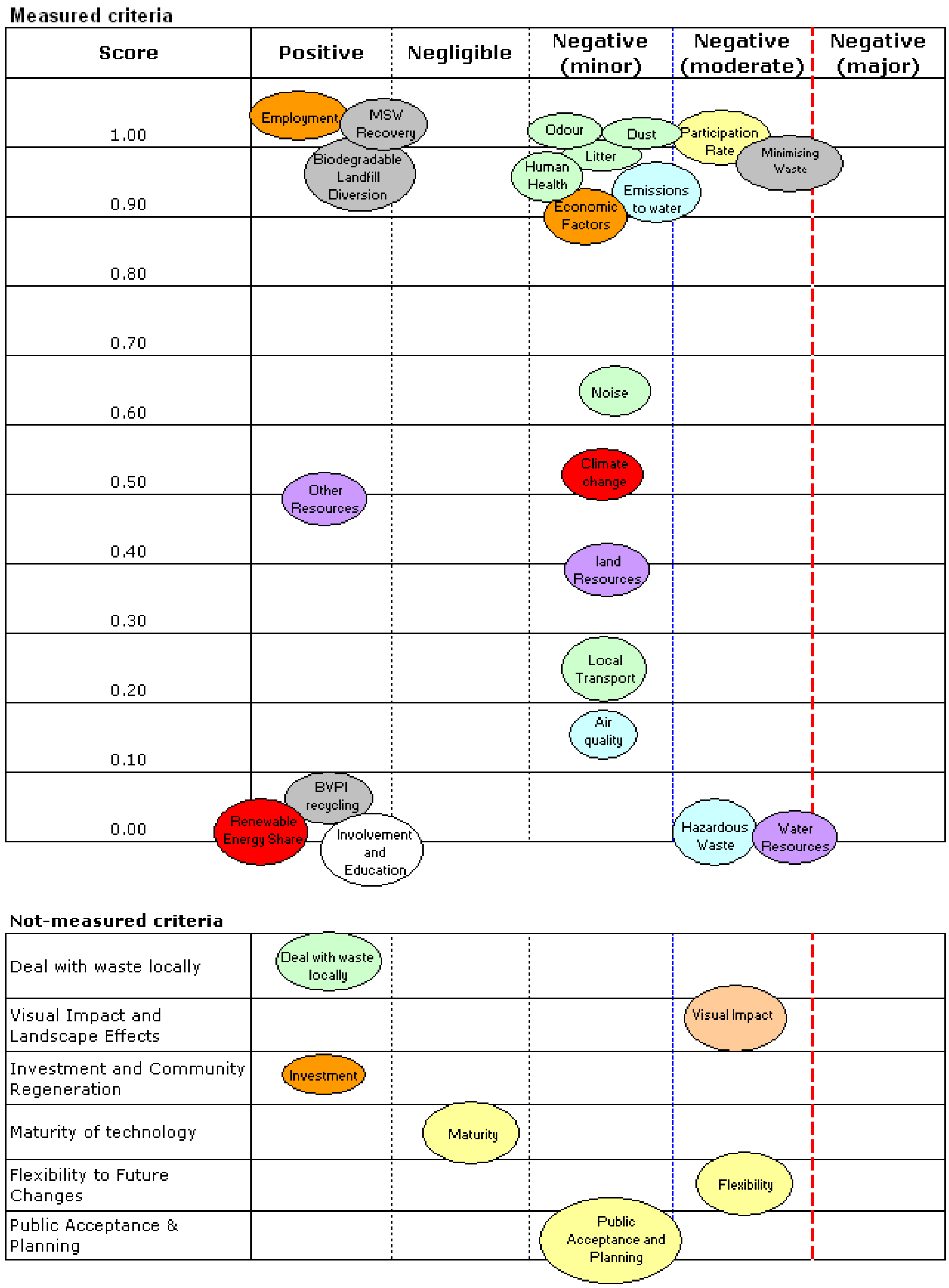


Scenario 5 – MBT AD and Aerobic

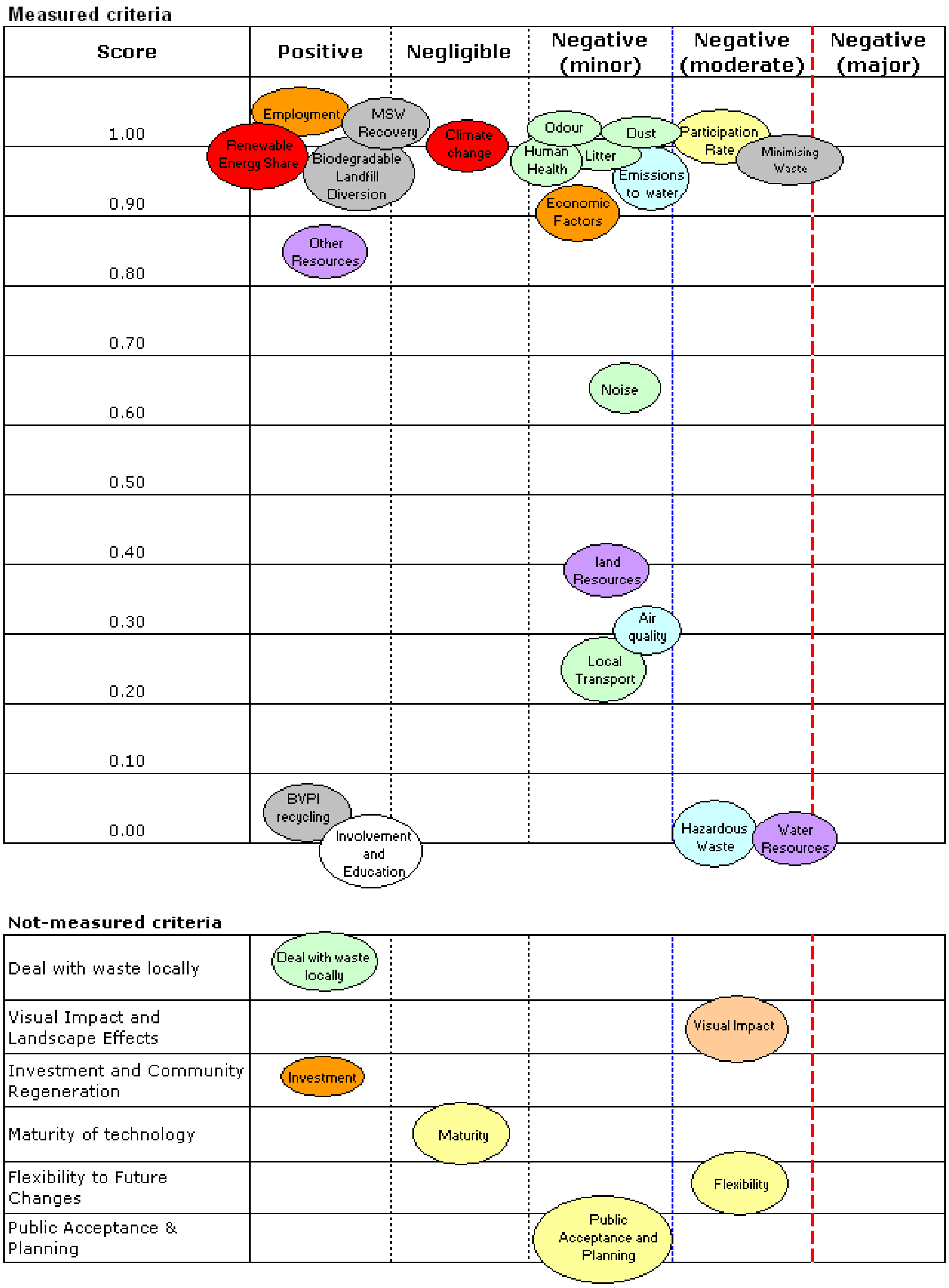



Scenario 6 - MET AD and Aerobic (RDF on site)
Measured criteria
Score
Positive
Negligible
Negative (minor)
Negative (moderate)
Negative (major)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
BVPI recycling
Employment
Human Health
Minimising Waste
Participation Rate
Hazardous Waste
Biodegradable Landfill Diversion
Air quality
Water Resources
MSW Recovery
Other Resources
Climate change
Emissions to water
Economic Factors
land Resources
Local Transport
Involvement and Education
Renewable Energy Share
Litter
Dust
Odour
Noise
Not-measured criteria
Deal with waste locally
Deal with waste locally
Visual Impact and Landscape Effects
Visual Impact
Investment and Community Regeneration
Investment
Maturity of technology
Maturity
Flexibility to Future Changes
Flexibility
Public Acceptance & Planning
Public Acceptance and Planning

Scenario 7 - EfW



Scenario 8 - EfW & CHP



Scenario 9 - ATT

Measured criteria