Final Report

Supplementary Report - Economic Modelling of Options for Waste Infrastructure in the ACT

27 AUGUST 2010

Prepared for

DECCEW

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Abbreviations

Abbreviation	Description
ACT	Australian Capital Territory
AD	Anaerobic Digestion
BCA	Benefit Cost Analysis
C&D	Construction and Demolition Waste
C&I	Commercial and Industrial Waste
CCA	Copper Chrome Arsenate
CHP	Cogeneration of Heat and Power
CWS	Commercial Waste Scheme
CO_2-e	Carbon Dioxide Equivalent
DECCEW	ACT Government Department of the Environment, Climate Change, Energy and Water
EOI	Expression of Interest
EW	EcoWaste Pty Ltd
GHG	Greenhouse Gas
HCF	High Calorific Fraction of waste stream
HHW	Household Hazardous Waste
HNRV	Highest Net Resource Value
LCA	Life Cycle Assessment
LDPE	Low Density Polyethylene
LMWQCC	Lower Molonglo Water Quality Control Centre
MRF	Materials Recovery Facility
MSW	Municipal Solid Waste
NPV	Net Present Value
PEF	Process Engineered Fuel (same as RDF)
P&G	Parks and Gardens
PP	Polypropylene
PET	Polyethylene terephthalate
PSD	Pollution Solutions & Designs Pty Ltd
RDF	Refuse Derived Fuel (same as PEF)
TCF	Thermal Conversion Facility
TCT	Thermal Conversion Technologies
TPD	Tonnes per day
TPA	Tonnes per annum
URS	URS Australia Pty Ltd

Introduction

1.1 Purpose of the supplementary report

This report summarises the assumptions and results from the additional modelling work that was undertaken for the ACT Department of the Environment, Climate Change, Energy and Water (DECCEW), following from the first phase of the study as reported in the *Pre-Feasibility Assessment of a Thermal Conversion Facility for the Australian Capital Territory*, (URS) dated 27 August 2010. This supplementary report should be read in conjunction with the main report.

The options modelled in this supplementary report have been developed in conjunction with DECCEW and TAMS NoWaste, with whom URS has worked closely.

1.2 Scope of work

The primary objective of the supplementary analysis was to conduct a high level economic Benefit Cost Analysis (BCA) from a "whole of society" perspective, relying on an analysis of the estimated waste streams and their treatment by various facilities. The following categories of costs and benefits were considered for each option:

- infrastructure costs (Capex and Opex) for the different waste facilities;
- material recovery and transformation, including electricity production; and
- externalities such as Greenhouse Gas production.

It must be noted that the objective of the BCA was to compare each option to the "Base Case". Therefore, some components common to all options have been excluded from the analysis as they would not impact the difference between the various options. It is essential to bear this in mind when considering the results of the analysis, as results for individual options only present a partial view of the benefits/costs or technical particulars of the options.

In addition to the BCA modelling, the model produced the following information to support the Territory's decision-making processes:

- percentages of waste going to landfill and biosolids incinerated at the Lower Molonglo Water Quality Control Centre (LMWQCC), the resources being recovered (recycling and composting), and the waste sent to thermal conversion, for the various options;
- the GHG emissions from the various waste treatment or disposal facilities, including landfill gases, and emissions related to the running of the various facilities including the thermal facilities. An estimated high level GHG balance has therefore been calculated for each option based on assumptions made (and subject to the caveat mentioned above about this being a differential analysis). Whenever possible (mainly for third bin), transport impacts have been included.

The scope of work did not include consideration of risks or issues beyond the high-level costs and benefits described above. Such considerations should form part of a more detailed feasibility study.

1.3 Options for analysis

The options analysed in this supplementary report, as described below, have been defined by DECCEW in line with the decisions that the Department needs to make, to which the present analysis is only one contributor.

- Base Case: This is the business as usual or current situation in the ACT. Modelling the current situation will establish the benchmark for any subsequent options. The model of the current

1 Introduction

situation will quantify the cost of managing those materials currently presenting for landfill disposal and those materials which are currently diverted but whose current market value is limited (e.g. C&D timber or Grade B materials (Refer to Appendix B for definitions of different grades)), created by current sorting facilities, for which no current market exists.

- Commercial Waste Scheme (CWS) Option: Current ACT Government operations (Base Case) + MRF catering for dry (bulky) C&I waste, operational in 2012.
- Option 1: Commercial Waste Scheme plus a dirty Material Recovery Facility (MRF) that caters for residual domestic waste and all remaining C&I waste, operational in 2014. An organics waste facility also operational in 2014, is built to process the organic stream from this MRF. Biosolids are excluded and continue to be incinerated at LMWQCC. .. Options for organic waste processing modelled are:

  A. in-vessel composting;
  B. anaerobic digestion;
  C. gasification;
  D. incineration;
  E. pyrolysis.

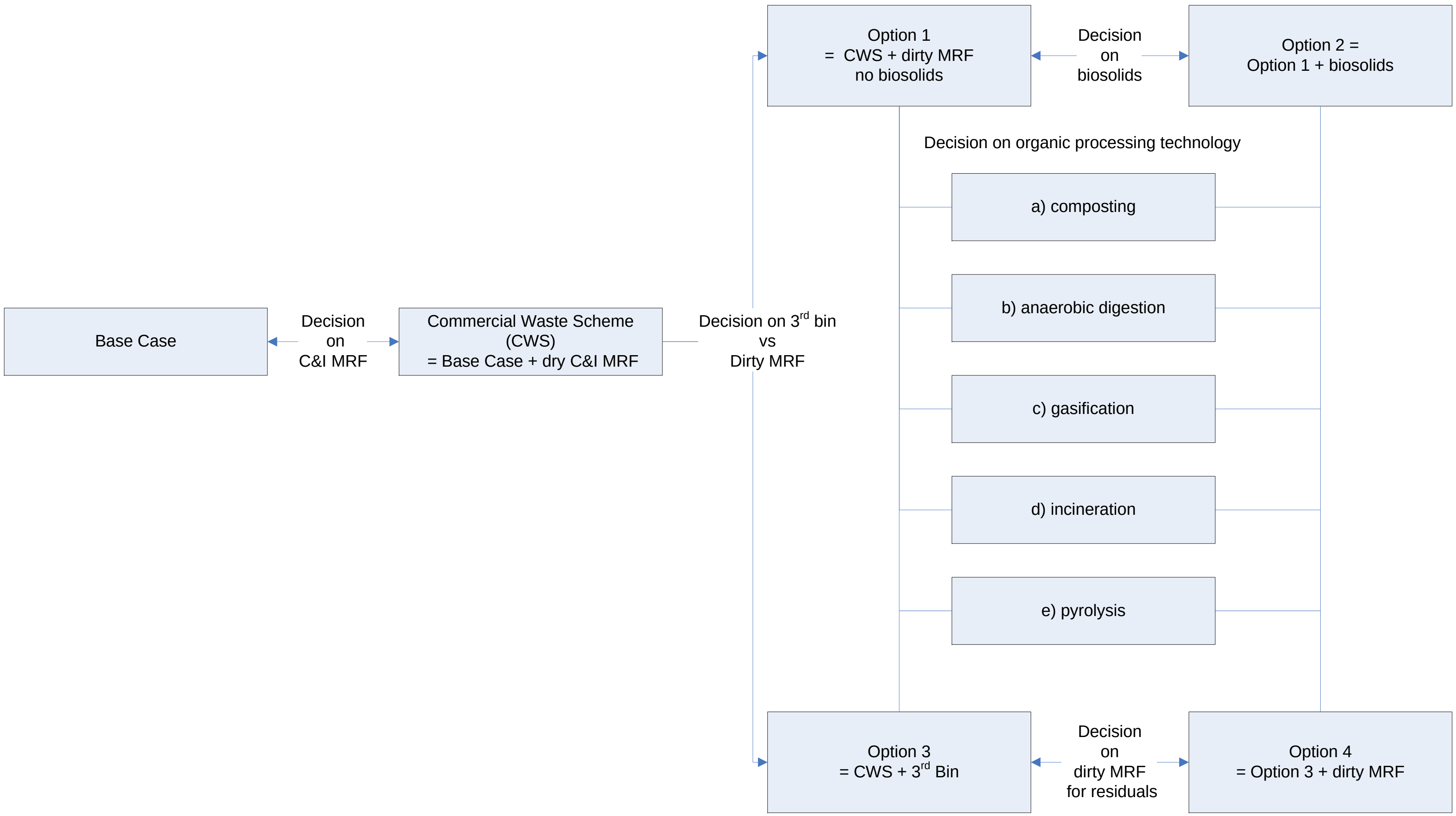
- Option 2: Commercial Waste Scheme plus a dirty Material Recovery Facility plus biosolids processing. Assess all organic waste processing options with the inclusion of biosolids (i.e. shut the LMWQCC incinerator).
- Option 3: Commercial Waste Scheme plus an organic household waste collection service. This option introduces a domestic organic (third bin) collection service in 2014 and the construction of a sorting and processing facility that accepts the third bin material and sorted organic C&I waste. Options for organic waste processing to be modelled in this option are:

  — in-vessel composting (without biosolids)
  — anaerobic digestion (with and without biosolids)
  — pyrolysis[1] (with and without biosolids)

- Option 4: Option 3 (incorporating preferred organic waste processing option) plus construct a dirty MRF for household residual waste & any remaining C&I waste, built in 2016.

[1] which was selected as the superior TCT from the assessment of options 1&2

Figure 1-1 Options considered in the BCA



The characteristics and purpose of the various facilities, as well as the waste streams have been described in the main TCF report.

Methodology, assumptions and unit costs and benefits

2.1 Methodology

The preliminary economic model used here was built using a benefit-cost analysis framework to evaluate the economic efficiency of the proposed options. BCA, through discounting procedures, converts future flows of benefits and costs to a comparable basis at a common point in time. The BCA is used to assess the marginal change in benefits and costs associated with the various options relative to a Base Case. As mentioned in Section 1, it is therefore a partial differential model which should only be used for comparative purposes. Decision-making processes need to be cognisant of this limitation.

The model can be considered as an economic model in that it incorporates CO_2-e emission costs, which are not currently priced on a market. It also considers the benefits of producing electricity and by-products such as biochar (using their sale prices as proxy). However, the model does not consider more general benefits to society, such as the innovative character and demonstration effect of a TCT facility. In this respect, the model is very close to a financial model.

The model does not include any funding costs and does not assess the financial viability of each facility, which, we understand, would be contracted out to private operators.

The BCA model does not include any gate fee, as it was considered as an internal transfer to the economic model: the gate fee should, in theory, cover the lifecycle costs of each facility (plus a margin for risk and commercial return). Such gate fee should however be taken into consideration for any affordability and market analysis (which is not part of the scope of this study).

2.2 Waste quantity assumptions

The waste streams assumed for the supplementary report are described in further detail in the main report.

It should be noted that the volume of C&D masonry waste and the C&I waste going directly to recycling have been mentioned for completeness but do not drive any cost and benefit in the model, as it has been assumed that the size of the various facilities would not be influenced by these waste volumes and as these volumes are identical across all options.

Appendix A presents an overview of the assumed waste quantities.

2.3 Economic modelling parameters

Discount rate and analysis period

The analysis has been carried out over a horizon of 26 years, covering the period from 2010 to 2035 inclusive, as this can be considered as the useful life of the investment. 2010 is the first year of the period and has not been discounted, the discounting starting in 2011, i.e. all costs and benefits can be considered as discounted back to 2010.

In line with previous reports and with the recommendations of Infrastructure Australia for investment assessments, the key discount rate used was 7% (real), and 4% and 10% discount rates were used in the sensitivity analysis. As a real discount rate has been used, current prices, costs and benefits have been used throughout the model.

2.4 Unit costs and benefits

2.4.1 Capital expenditure, renewals and salvage values

Apart from landfill costs, initial capital expenditures and renewals of pieces of equipment have been included in the model as cashflows at the time of the expenditure.

Capital expenditure (Capex) costs have been estimated on a per unit cost basis (i.e. per tonne of waste processed) depending on the size of the facility or module (see below Table 2-5 and Table 2-7).

Unless indicated otherwise, capital and operating cost estimates are based on information supplied to URS by international suppliers and operators on similar projects. It is noted that locally based suppliers have indicated the capital cost of suitable TCT facilities for the ACT could be less than the information used in our analysis, depending on the extent of works and material / labour prices. The actual cost of a TCT suitable for the ACT would need to be confirmed through a call for tender process.

The timing of the capital expenditure was determined in line with each option's requirements, i.e. based on the quantities of waste assumed to be processed by each facility. The initial investment was determined by reference to the initial volume of waste to be treated by the facility and considering a standard size for the facility (thus leaving some scope for growth in volumes) and is considered to occur one year ahead of the time when the capacity is required. Once a facility reaches its maximum capacity, it has been assumed that an additional module would be added, typically a 50,000 wet tonne/year capacity module. Again, the investment is assumed to occur one year ahead of the time when the additional capacity is required.

It should be noted that there may be opportunities to optimise the investment by fine-tuning the timing of the investment, but no optimisation process has been attempted in this study.

It has been considered that a major refurbishment (renewals) would be necessary after a period of time for most facilities. The expenditure was generally estimated at 25% of the initial expenditure (assumptions are presented in the tables below).

At the end of the analysis period, no salvage value has been considered, although some components would have some residual useful life. This may need to be explored in subsequent more detailed analyses.

Landfill costs

A landfill cost of $50/tonne of waste was used from the Wright Corporate Strategy report (Wright, 2008). It must be noted that this approach is a simplification as the actual cost of landfills consists of development costs, operating costs and post closure expenses. To be consistent with the BCA approach to other pieces of waste infrastructure each of these costs would be estimated and discounted individually. However this data was not available, particularly for the new landfill that would be required in the ACT somewhere between 2014 and 2020, for this study. The Wright 2008 estimate of landfill cost also appears to be low compared to data available to URS for other urban landfills in Australia, and while it has been tested for sensitivity ($100/tonne), further analysis may be warranted.

In addition to these technical costs, it has been assumed that landfills create externalities above and beyond CO_2-e emissions, which should be valued in an economic model. In the present case, such externalities have been estimated at $2/tonne of waste received by the landfill, based on a report prepared by BDA Group for the Department of Environment, Water Heritage and Arts, which examined the full cost of landfill disposal in Australia (BDA, 2009). The externalities considered in this $2/tonne are amenity, other air emissions and leachate impacts for an urban well controlled landfill. As discussed earlier, the greenhouse emissions are taken into consideration separately within the BCA model.

Existing facilities – MRF and biosolids management

Capital costs relating to the existing MRF and C&D MRF are considered as sunk costs and are not included in the model. Moreover, these costs would be equivalent for all options.

With regard to biosolids incineration (relevant for the options where biosolids remain managed in such a way, specifically Base Case, CWS, options 1, 3B(i) and 3C(i)), most costs have been considered as sunk, except for a $6M investment required in 2011 if the biosolids incineration facility is to be retained beyond 2013.

Composting and urban trees wood-chipping

Existing composting and transformation of urban tree waste into woodchips for mulching have both been valued using an estimated net value representing the net whole-of-life cost (Capex and Opex). The estimated net value used for mulch ($15/tonne) and compost ($15/tonne) includes the estimated retail sale price[2] net of the process and transport prices.

C&I MRF facility

Table 2-1 C&I MRF Capex

	Initial investment	Additional module
Capacity (dry t/year)	150,000	50,000
Capital Cost($)	15,000,000	4,500,000
Replacement cost	25% of capital cost	25% of capital cost
Replacement timing	10 years	10 years

Dirty MRF facility

Table 2-2 Dirty MRF Capex

	Initial investment	Additional module
Capacity (wet t/year)	100,000	50,000
Capital Cost($)	10,000,000	5,000,000
Replacement cost	25% of capital cost	25% of capital cost
Replacement timing	10 years	10 years

[2] Ref Email sent to URS on 1st March 2010 by Senior Policy Officer, DECCEW

2 Methodology, assumptions and unit costs and benefits

In-Vessel composting facility (options 1A, 2A and 3A)

Table 2-3 In-Vessel composting facility Capex

Plant capacity (wet t/year)	Initial investment ($)	Additional module ($)
50,000	15,000,000	12,500,000
100,000	25,000,000	
150,000	37,500,000	
Replacement cost	25% of capital cost	25% of capital cost
Replacement timing	10 years	10 years

Anaerobic Digestion facility (options 1B, 2B and 3B)

Table 2-4 Anaerobic Digestion facility Capex

Plant capacity (wet t/year)	Initial investment ($)	Additional module ($)
50,000	24,444,444	23,333,000
100,000	46,666,667	
150,000	70,000,000	
Replacement cost	25% of capital cost	25% of capital cost
Replacement timing	10 years	10 years

Gasification plant (options 1C and 2C)

Table 2-5 Capex Gasification plant

Plant capacity (wet t/year)	Initial investment ($)	Additional module ($)
50,000	38,888,889	32,500,000
100,000	66,666,667	
150,000	97,500,000	
200,000	126,666,667	
250,000	152,777,778	
Replacement cost	25% of capital cost	25% of capital cost
Replacement timing	10 years	10 years

2 Methodology, assumptions and unit costs and benefits

Incineration plant (options 1D and 2D)

Table 2-6 Capex Incineration plant

Plant capacity (wet t/year)	Initial investment ($)	Additional module ($)
50,000	52,777,778	50,000,000
100,000	100,000,000	
150,000	150,000,000	
200,000	200,000,000	
250,000	236,111,111	
Replacement cost	25% of capital cost	25% of capital cost
Replacement timing	10 years	10 years

Pyrolysis plant (options 1E, 2E, 3C and 4)

Table 2-7 Capex Pyrolysis plant

Plant capacity (wet t/year)	Initial investment ($)	Additional module ($)
50,000	51,666,667	43,050,000
100,000	88,888,889	
150,000	129,166,667	
200,000	166,666,667	
250,000	194,444,444	
Replacement cost	25% of capital cost	25% of capital cost
Replacement timing	10 years	10 years

Third bin collection (options 3 and 4)

Table 2-8 Capex third bin collection

Capacity (wet t/year)	Initial investment ($)
50,000	N/A
100,000	7,000,000[3]
Replacement cost	25% of capital cost
Replacement timing	5 years

[3] Ref: Based on information supplied by ACT TAMS sent to URS via email dated 8 February 2010 by Senior Policy Officer, DECCEW.

2.4.2 Operation and maintenance costs

Apart from landfill costs for which Capex and Opex have been merged into annualised costs (as mentioned above), operation and maintenance costs have been estimated per tonne of waste processed, depending on the size of the facility considered (see tables below). As with any analysis using standardised costs, it may be that in some cases (modular plant), further economies of scale should be considered when carrying out the more detailed assessment.

Unit costs have been multiplied by the relevant yearly volume of waste to obtain yearly cost estimates.

Table 2-9 Opex existing MRF facilities

Type of facility	Cost per tonne of capacity
Existing clean MRF	$28
C&D MRF	$20

Table 2-10 Opex existing biosolid incineration facility

Type of facility	Cost per tonne of capacity
Biosolid incineration	$195 Ref PSD (2008)

Table 2-11 Opex MRF facilities

Type of facility	Cost per tonne of capacity
C&I MRF	$35
Dirty MRF	$35

Table 2-12 Opex In-Vessel composting facility

Gasification	Cost per tonne of capacity	
Plant capacity	USD	AUD
50,000	60	67
100,000	60	67

Table 2-13 Opex Anaerobic Digestion facility

Gasification	Cost per tonne of capacity	
Plant capacity	USD	AUD
50,000	70	78
100,000	65	72

Table 2-14 Opex Gasification plant

Gasification	Cost per tonne of capacity	
Plant capacity	USD	AUD
50,000	120	133
100,000	80	89
150,000	73	81
200,000	65	72
250,000	60	67

Table 2-15 Opex Incineration plant

Incineration	Cost per tonne of capacity	
Plant capacity	USD	AUD
50,000	80	89
100,000	70	78
150,000	68	75
200,000	65	72
250,000	60	67

Table 2-16 Opex Pyrolysis plant

Pyrolysis	Cost per tonne of capacity	
Plant capacity	USD	AUD
50,000	85	94
100,000	70	78
150,000	65	72
200,000	60	67
250,000	55	61

Table 2-17 Opex Third bin

Type of facility	Cost per tonne of capacity
Third bin collection system	$171.43[4]

2.4.3 CO_2-e emissions

Emissions from landfill

CO_2-e emissions have been calculated for the Base Case and each option based on standard emissions from the various processes and facilities. Note that only additional emissions from waste sent to landfill from 2010 onwards have been considered, which means that 2010 emissions are null and build up from this date; this is because emissions from waste sent to landfill prior to 2010 are the same for all options.

[4] Based on information supplied by ACT TAMS sent to URS via email dated 8 February 2010 by Senior Policy Officer, DECCEW.

Landfill gas emissions were calculated in a separate model (IPCC, 2006 Tier 1 Spreadsheet model) and results have been used in the BCA.

Emissions from the operation of the various facilities

Table 2-18 details how the biosolids incineration emission factor has been calculated for the relevant options (note that this does not include the mass burn incineration process (organics processing option D), which is a different process).

Table 2-18 CO_2-e emissions from biosolids incineration

Assumption	Value	Reference
Emission Factor	1.8	Table 1 NGA (2009)
Energy Content (GJ/t)	6.3	
Total Emissions (tCO_2-e) / tonne biosolid	0.01134	

The operation of the various facilities, including TCT, uses energy (electricity). The quantity of electricity required to run these facilities has been estimated and corresponding emissions have been included in the BCA model (see Table 2-19).

Table 2-19 CO_2-e emissions from electricity generation

Emissions from Gasification, Incineration or Pyrolysis	Value	Reference
Emission Factor	1.8	Table 1 NGA (2009)
Energy Content (GJ/t)	12.2	Table 1 NGA (2009)
Total Emissions (t CO2-e) / tonne waste processed	0.02196	

It should be noted that, as the TCT facility is avoiding the production of methane from the decomposition of waste and producing electricity, it may be that CO_2-e emitted in the process will not attract any cost under a CPRS. At this stage, it has been considered that CO_2-e emissions are an externality which can legitimately be included as such in the BCA.

CO_2-e emission price

Although currently no price is attached to CO_2-e emissions, which remain essentially an externality (in economic terms), the Commonwealth Treasury has modelled CO_2-e prices under various Carbon Pollution Reduction Scheme (CPRS) options. These prices have been used in the model and are shown below (Table 2-20); CO_2-e prices between these dates have been linearly extrapolated. Wholesale electricity production prices have been used as the best point of reference (rather than retail prices).

Table 2-20 CO_2-e prices

Carbon prices ($/tCO2-e)	2010	2020	2050
Scenario CPRS 5	20	35	115
Scenario CPRS 15	28	50	158

Source: Commonwealth Treasury CPRS modelling, 2008

It must be noted that CO_2-e emission prices have been used to value emissions in all options (but is only material in the Base Case) from 2010, as a proxy representing the benefit to the whole of community (economic benefit). This is legitimate as in the context of an economic model, but other assumptions should be defined, should it be attempted to consider the financial perspective.

2.4.4 Sale of Renewable Energy Certificates (RECs)

As the facilities producing electricity (Anaerobic Digester, TCF) from waste are eligible to the Renewable Energy Target (up to 2030), a source of revenues for the project would be the sale of Renewable Energy Certificates (REC). RECs are based on the quantity of electricity produced from eligible waste (one REC per MWh of electricity). In each option, the quantity of eligible electricity produced has been calculated and considered as attracting RECs sales benefit in the same year. It has been considered as the percentage of eligible waste content to total waste delivered to the TCF would be quite high at 98%. Should this percentage prove to be lower, it would have a direct impact on the number of RECs created and hence on revenues.

Future RECs prices are largely uncertain and difficult to predict, due to the complex interaction between renewable energy technology and financing costs, prices of electricity and CO_2-e emission costs. Further research into this issue may be warranted, but the following possible options have been considered for modelling purposes (see Table 2-21). In particular, the consistency between these REC price estimates and the CO_2-e and electricity prices (see previous and following paragraphs) would need to be ascertained.

Table 2-21 RECs prices

RECs prices($/MWh)	2010	2020	2030
Rounded down current REC prices (main options)	30	30	30
Scenarios for sensitivity analysis			
Decreasing prices, as per : McLennan Magasanik Associates, January 2009	65	41	18
Low estimate scenario (URS' own)	25	15	5

2.4.5 Electricity sales prices

In addition to generating RECs, one of the benefits of the anaerobic digestion and TCT options will be the generation of electricity from gas recovered during the waste treatment process. The price of electricity sales has been considered as a good proxy for the value of this electricity production. The wholesale electricity prices are relevant to value these benefits, as the TCT effectively becomes a player on the wholesale market.

Should CO_2-e emissions costs be internalised, electricity prices would be directly impacted. The Commonwealth Treasury has also modelled likely wholesale electricity prices (see below), which have been used to value the electricity produced under the various options, to maintain consistency with CO_2-e emissions costs.

Table 2-22 Wholesale electricity prices

Wholesale electricity prices($/MWh)	2010	2020	2050
Scenario CPRS 5	60	80	112
Scenario CPRS 15	60	80	136

Source: Commonwealth Treasury CPRS modelling, 2008

2.4.6 Benefits from the sale of bi-products

Royalties from electricity production from landfill gas

A portion of the methane from the landfill is captured (60% is assumed to be captured) and sold by the landfill gas contractor, that pays a royalty back to the ACT Government, equivalent to 2% of the sales of electricity. This benefit has been included in the model as a proxy for the benefit from electricity production, in the absence of information on the infrastructure cost for producing electricity. It was assumed that 7.31 MWh of electricity could be produced per tonne of gas captured and that the electricity has been assumed to be sold at the same price as the prices mentioned in Table 2-22.

Sale of lime substitute produced from biosolids incineration

In the base case, it has been considered that a lime substitute would be produced from biosolids incineration from 2010 onwards. The sale of lime has been estimated at $16.12 per dry tonne of biosolid as interpreted from PSD (2008). This applies to the base case only and only when biosolids are considered.

Sale of biochar

In Option 3, the pyrolysis process would produce biochar of low and high quality, which could be sold. As the market for biochar is only emerging, there is significant uncertainty around biochar prices, but according to some sources it could reach as much as $1,000 per tonne. Table 2-23 indicates biochar prices that have been used in the economic model, based on information provided to URS from Ecowaste Pty Ltd (Mark Glover) in an email dated 29 September 2009. To be conservative, the low estimates have been used for the key results and the high estimates in the sensitivity analysis.

Table 2-23 Biochar prices

Biochar sales prices - $ per t	Low	High	Percentage of each quality as a percentage of initial waste tonnage
Low quality	100	200	5%
High quality	300	500	30%

It has been assumed that the pyrolysis process would not produce any residual waste which would need to go to landfill.

2.4.7 Benefits from the sale of recyclable materials

The various MRF facilities allow for the sorting and recovery of recyclable materials, which have been valued at their potential selling price. It was not within the scope of this study to ascertain the availability of markets for recovered materials or the likely level of price that can be obtained for such recycled materials. Market prices indicated in Table 2-24 from a previous survey carried out for ACT TAMS (Wright, 2008) have therefore been used (with the exception of plasterboard). Given the high variability associated with prices for these materials, sensitivity analysis has been carried out on these prices to assess the impact of the uncertainty.

Table 2-24 Assumed prices for recycled materials

Category of material	$ per t	Reference
Existing C&D MRF		
Timber Recycling	21	Wright(2008)
Plasterboard Recycling	5	URS Estimate
Paper Recycling	105	Wright(2008) (Mixed Paper)
Plastic Recycling	250	Wright(2008) (Other Plastic)
Metal Recycling	88	Wright(2008) (Steel)
Inert Recycling	14	Wright(2008) (Concrete)
C&I dry MRF		
Timber Recycling	21	Wright(2008)
Paper Recycling	105	Wright(2008) (Mixed Paper)
Plastic Recycling	600	Wright(2008) (PET)
Metal Recycling	1900	Wright(2008) (Non-ferrous)
Inert Recycling	84	Wright(2008) (Glass)
Proposed MSW Dirty MRF		
HCF from Dirty MRF to Markets $10 per tonne	10	Wright(2008) (Mixed Paper)
Dry Recycling from Dirty MRF to Markets $100/tonne	100	Wright(2008) (PET)
Metals from Dirty MRF to Markets $1500/tonne	1500	Wright(2008) (non-ferrous)
Inerts from Dirty MRF to Markets $10 per tonne	10	Wright(2008) Glass
Food Organics	0	
Existing MSW Kerbside Dry Recyclables		
Paper Recycling	105	Wright(2008) (Mixed Paper)
Plastic Recycling	600	Wright(2008) (PET)
Metal Recycling	1900	Wright(2008) (non-ferrous)
Inert Recycling	84	Wright(2008) Glass
Combined output from MRF average price estimate	150.5	Combined output from MRF average price estimate.[5]

[5] Breakdown of different material provided by Senior Policy Officer DECCEW via email to URS on 21 April 2010 based on information supplied by existing clean MRF operator

2.4.8 Gate fees and Commercial Charges

As the objective of the BCA was to compare the economic benefits and costs of the various waste management options rather than to judge the financial viability of each piece of waste infrastructure, no gate fees were included in the analysis. In the context of the economic analysis these are simply transfers between commercial entities.

However, should a commercial operator consider investing and operating such facilities, a gate fee would apply to waste accepted by the facility, in order to make it a financially viable proposition.

Results

Considering that this study only presents a preliminary costing of the waste infrastructure options, the results presented below should be considered with caution. In particular, it is important to consider not only the main results, which only reflect one possible market configuration but the whole range of possible results, as explored in the sensitivity analysis.

3.1 Main results

The main results presented in Table 3-1 correspond to the following assumptions: CPRS 5 prices for CO_2-e and wholesale electricity and current REC prices (conservative estimates: $30/MWh) all through the period. Benefits and costs until 2035 have been discounted, then netted off. All options have been compared to the Base Case. As mentioned above, no gate fees have been considered.

It must be noted that the uncertainty around the assumptions made means that results should be seen as an indicative rather than precise estimates. A difference of a few million dollars can be considered as non-significant.

The results show that, while most options would be more favourable than the Base Case, options 1D and 2D are significantly negative, while options 3 and 4 can be considered as almost on par with the Base Case (i.e. plus or minus $20M cannot be considered as materially different). CWS, 1A, 1B, 1E, 2B and 2E can be considered as significantly positive and within the same range.

Table 3-1 Main comparative results (in $M), assuming CPRS5 for CO_2-e and electricity prices and current REC prices, 7% discount rate

Option	Benefits	Costs	NPV (NPC)
BASE CASE (BC)	-	-	-
CWS = BC + dry C&I MRF	153	25	128
1A = CWS + dirty MRF + composting (of MSW organics)	194	84	110
1B = CWS + dirty MRF + AD	221	107	114
1C = CWS + dirty MRF + gasification	295	265	30
1D = CWS + dirty MRF + incineration	273	348	-74
1E= CWS + dirty MRF + pyrolysis	332	237	95
2A= 1A + biosolids (processed with MSW organics)	195	127	68
2B = 1B + biosolids	239	138	100
2C = 1C + biosolids	316	284	32
2D = 1D + biosolids	291	370	-79
2E = 1E + biosolids	377	263	113
3A = CWS + 3rd bin + compost (of MSW organic material collect via the 3rd bin)	154	175	-22
3B(i) = CWS + 3rd bin + AD	182	174	8
3B(ii) = CWS + 3rd bin + AD + biosolids	202	197	5
3C(i) = CWS + 3rd bin + pyrolysis	293	304	-12
3C(ii) = CWS + 3rd bin + pyrolysis + biosolids	344	347	-3
4 = 3C(ii) + a dirty MRF for the MSW residuals	386	377	8

3.2 Sensitivity analysis

The sensitivity analysis has been carried out by varying one parameter at a time and observing how the results change in different circumstances (in particular different market conditions). In particular, the following parameters have been tested:

- Discount rate: 4%,7%, 10%;
- Electricity prices and carbon prices (correlated): CPRS 5, CPRS 15, zero carbon price;
- REC prices: current prices, Dept of Climate Change modelling (McLennan Magasanik Associates, 2009, consistent with CPRS 5), low estimates (URS estimated);
- Landfill costs: $50/tonne, $100/tonne.

3.2.1 Discount rate sensitivity

When considering a lower discount rate, the most favourable options become more clearly so and some options previously unfavourable become favourable. Only options 1D, 2D and 3A remain unfavourable compared to the Base Case.

Conversely, when the discount rate is increased, most options appear less favourable. The gap between options is reduced. When considering a 10% discount rate, options CWS, 1A, 1B, 1E, 2A, 2B and 2E still remain favourable, while all the others are either neutral or negative.

Table 3-2 Sensitivity to discount rate (NPV comparison to Base Case, in $M)

Option	4%	7%	10%
BASE CASE (BC)	-	-	-
CWS = BC + dry C&I MRF	187	128	92
1A = CWS + dirty MRF + composting (of MSW organics)	172	110	73
1B = CWS + dirty MRF + AD	184	114	71
1C = CWS + dirty MRF + gasification	85	30	-1
1D = CWS + dirty MRF + incineration	-51	-74	-85
1E= CWS + dirty MRF + pyrolysis	181	95	44
2A= 1A + biosolids (processed with MSW organics)	112	68	42
2B = 1B + biosolids	167	100	60
2C = 1C + biosolids	92	32	-2
2D = 1D + biosolids	-48	-79	-94
2E = 1E + biosolids	217	113	52
3A = CWS + 3rd bin + compost (of MSW organic material collect via the 3rd bin)	-21	-22	-21
3B(i) = CWS + 3rd bin + AD	29	8	-4
3B(ii) = CWS + 3rd bin + AD + biosolids	27	5	-8
3C(i) = CWS + 3rd bin + pyrolysis	29	-12	-33
3C(ii) = CWS + 3rd bin + pyrolysis + biosolids	48	-3	-31
4 = 3C(ii) + a dirty MRF for the MSW residuals	72	8	-27

3.2.2 Electricity and carbon prices sensitivity

While electricity prices can be influenced by many different drivers, the only impact considered here is the impact a CPRS (or other forms of carbon prices) may have on electricity prices. For the purpose of the sensitivity analysis, it has therefore been considered that carbon prices and electricity prices were correlated and influenced by the same CO_2-e price options (as defined above in 2.4.3 and 2.4.5).

The approximate average annual and total scope 1 and 2 CO_2-e emissions considered when calculating the cost of CO_2-e emissions for each option, are summarised in Table 3-3.

Table 3-3 Estimated carbon emissions (tCO_2-e) to nearest 1,000

Option	Average Annual (tCO_2-e)	Total Emissions over 26 year (tCO_2-e)	Total Emission reduction compared to Base Case (tC02-e)
BASE CASE (BC)	123,000	3,199,000	-
CWS = BC + dry C&I MRF	113,000	2,950,000	249,000
1A = CWS + dirty MRF + composting (of MSW organics)	97,000	2,522,000	677,000
1B = CWS + dirty MRF + AD	117,000	3,046,000	153,000
1C = CWS + dirty MRF + gasification	104,000	2,693,000	506,000
1D = CWS + dirty MRF + incineration	81,000	2,107,000	1,092,000
1E= CWS + dirty MRF + pyrolysis	79,000	2,058,000	1,141,000
2A= 1A + biosolids (processed with MSW organics)	104,000	2,697,000	502,000
2B = 1B + biosolids	87,000	2,256,000	943,000
2C = 1C + biosolids	85,000	2,218,000	981,000
2D = 1D + biosolids	81,000	2,095,000	1,104,000
2E = 1E + biosolids	80,000	2,067,000	1,132,000
3A = CWS + 3rd bin + compost (of MSW organic material collect via the 3rd bin)	105,000	2,723,000	476,000
3B(i) = CWS + 3rd bin + AD	91,000	2,365,000	834,000
3B(ii) = CWS + 3rd bin + AD + biosolids	91,000	2,358,000	841,000
3C(i) = CWS + 3rd bin + pyrolysis	87,000	2,269,000	930,000
3C(ii) = CWS + 3rd bin + pyrolysis + biosolids	99,000	2,565,000	634,000
4 = 3C(ii) + a dirty MRF for the MSW residuals	84,000	2,196,000	1,003,000

Based on these assumptions, the sensitivity analysis, as summarised in Table 3-4 shows that a higher price of carbon and electricity makes all options look slightly more favourable against the Base Case, without significantly changing the results. Conversely a lower price on carbon (zero, as in the “low price” scenario), affects options differently, widening the gap between options. In particular, options 1C and 2C become unfavourable and options 3 and 4 more significantly unfavourable, while options 1D and 2D remain the worst options.

Table 3-4 Sensitivity to electricity and carbon prices (NPV comparison to Base Case, in $M)

Option	Zero price on GHG emissions	Scenario CPRS 5	Scenario CPRS 15
BASE CASE (BC)	-	-	-
CWS = BC + dry C&I MRF	124	128	130
1A = CWS + dirty MRF + composting (of MSW organics)	100	110	115
1B = CWS + dirty MRF + AD	89	114	121
1C = CWS + dirty MRF + gasification	-31	30	41
1D = CWS + dirty MRF + incineration	-128	-74	-64
1E= CWS + dirty MRF + pyrolysis	43	95	105
2A= 1A + biosolids (processed with MSW organics)	61	68	71
2B = 1B + biosolids	70	100	108
2C = 1C + biosolids	-36	32	43
2D = 1D + biosolids	-140	-79	-68
2E = 1E + biosolids	52	113	124
3A = CWS + 3rd bin + compost (of MSW organic material collect via the 3rd bin)	-29	-22	-19
3B(i) = CWS + 3rd bin + AD	-15	8	14
3B(ii) = CWS + 3rd bin + AD + biosolids	-24	5	12
3C(i) = CWS + 3rd bin + pyrolysis	-60	-12	-3
3C(ii) = CWS + 3rd bin + pyrolysis + biosolids	-58	-3	5
4 = 3C(ii) + a dirty MRF for the MSW residuals	-57	8	19

3.2.3 REC prices sensitivity

It is difficult to assess long term REC prices (even assuming that the Renewable Energy scheme will last for the whole period of analysis). However, the sensitivity shows that REC prices make relatively little difference to the outcome of the BCA and to the ranking of options.

3 Results

Table 3-5 Sensitivity to REC prices (NPV comparison to Base Case, in $M)

Option	Low estimates	Current price scenario	High estimates (*)
BASE CASE (BC)	-	-	-
CWS = BC + dry C&I MRF	128	128	128
1A = CWS + dirty MRF + composting (of MSW organics)	110	110	110
1B = CWS + dirty MRF + AD	110	114	115
1C = CWS + dirty MRF + gasification	11	30	36
1D = CWS + dirty MRF + incineration	-90	-74	-70
1E= CWS + dirty MRF + pyrolysis	79	95	99
2A= 1A + biosolids (processed with MSW organics)	68	68	68
2B = 1B + biosolids	94	100	102
2C = 1C + biosolids	9	32	39
2D = 1D + biosolids	-98	-79	-74
2E = 1E + biosolids	94	113	119
3A = CWS + 3rd bin + compost (of MSW organic material collect via the 3rd bin)	-22	-22	-22
3B(i) = CWS + 3rd bin + AD	4	8	9
3B(ii) = CWS + 3rd bin + AD + biosolids	-2	5	7
3C(i) = CWS + 3rd bin + pyrolysis	-27	-12	-7
3C(ii) = CWS + 3rd bin + pyrolysis + biosolids	-23	-3	3
4 = 3C(ii) + a dirty MRF for the MSW residuals	-14	8	14

(*) as per McLennan Magasanik Associates (2009)

3.2.4 Biochar prices sensitivity

As biochar is only produced in options involving a pyrolysis TCT facility, it was expected that only options 1E, 2E, 3C(i), 3C(ii) and 4 would be impacted. As highlighted in Table 3-6, high biochar prices (i.e. $200/tonne for low quality and $500/tonne for high quality biochar), have a significant impact on these options and make options 1E and 2E look very attractive, while options 3C and 4 become favourable compared to the Base Case.

3 Results

Table 3-6 Sensitivity to biochar prices (NPV comparison to Base Case, in $M)

Option	Base Case	High hypothesis
BASE CASE (BC)	-	-
CWS = BC + dry C&I MRF	128	128
1A = CWS + dirty MRF + composting (of MSW organics)	110	110
1B = CWS + dirty MRF + AD	114	114
1C = CWS + dirty MRF + gasification	30	30
1D = CWS + dirty MRF + incineration	-74	-74
1E= CWS + dirty MRF + pyrolysis	**95**	**152**
2A= 1A + biosolids (processed with MSW organics)	68	68
2B = 1B + biosolids	100	100
2C = 1C + biosolids	32	32
2D = 1D + biosolids	-79	-79
2E = 1E + biosolids	**113**	**189**
3A = CWS + 3rd bin + compost (of MSW organic material collect via the 3rd bin)	-22	-22
3B(i) = CWS + 3rd bin + AD	8	8
3B(ii) = CWS + 3rd bin + AD + biosolids	5	5
3C(i) = CWS + 3rd bin + pyrolysis	**-12**	**46**
3C(ii) = CWS + 3rd bin + pyrolysis + biosolids	**-3**	**73**
4 = 3C(ii) + a dirty MRF for the MSW residuals	**8**	**94**

3.2.5 Landfill costs sensitivity

It has been assumed that landfill lifecycle costs could be captured in a single cost of $50 per tonne. However, there is significant uncertainty surrounding this estimate. The sensitivity analysis carried out here looks at the impact of a doubling of the actual landfill management cost to $100 per tonne. As shown in Table 3-7, the impact on most options is significant and all options become favourable, all of them very materially so, except options 1D and 2D.

Table 3-7 Sensitivity to landfill costs (NPV comparison to Base Case, in $M)

Option	Base Case = $50	High hypothesis = $100
BASE CASE (BC)	-	-
CWS = BC + dry C&I MRF	128	166
1A = CWS + dirty MRF + composting (of MSW organics)	110	195
1B = CWS + dirty MRF + AD	114	196
1C = CWS + dirty MRF + gasification	30	130
1D = CWS + dirty MRF + incineration	-74	30
1E= CWS + dirty MRF + pyrolysis	95	206
2A= 1A + biosolids (processed with MSW organics)	68	139

Option	Base Case = $50	High hypothesis = $100
2B = 1B + biosolids	100	177
2C = 1C + biosolids	32	128
2D = 1D + biosolids	-79	22
2E = 1E + biosolids	113	224
3A = CWS + 3rd bin + compost (of MSW organic material collect via the 3rd bin)	-22	44
3B(i) = CWS + 3rd bin + AD	8	75
3B(ii) = CWS + 3rd bin + AD + biosolids	5	74
3C(i) = CWS + 3rd bin + pyrolysis	-12	82
3C(ii) = CWS + 3rd bin + pyrolysis + biosolids	-3	90
4 = 3C(ii) + a dirty MRF for the MSW residuals	8	124

3.2.6 Sensitivity to the price of recyclable materials

As mentioned in 2.4.7, the price of recycle materials has been taken from a previous study (Wright 2008) and applied to broad categories of recovered materials no specific work has been done to test the market and confirm these estimates in the present study. These prices drive a large portion of the benefits in all options. To test the sensitivity of the results to these assumed prices on the ranking of options, a +50% / -50% variation has been applied to the model (not applied to composting or to urban trees turned into woodchips). As shown in Table 3-8, the impact of lower prices for recyclable materials (across the board: all existing and new facilities), is significant for all a options and only option CWS still remains materially favourable compared to the Base Case while options 1A, 1B, 2B and 2E are still positive or neutral (2E being the most favourable of this group). Higher recyclable materials prices make all options favourable compared to the Base Case, although 1D and 2D only slightly so.

Table 3-8 Sensitivity to price of recyclable materials (NPV comparison to Base Case, in $M)

Option	Low = -50%	Base Case	High = +50%
BASE CASE (BC)	-	-	-
CWS = BC + dry C&I MRF	47	128	220
1A = CWS + dirty MRF + composting (of MSW organics)	11	110	220
1B = CWS + dirty MRF + AD	14	114	224
1C = CWS + dirty MRF + gasification	-59	30	125
1D = CWS + dirty MRF + incineration	-163	-74	21
1E= CWS + dirty MRF + pyrolysis	5	95	190
2A= 1A + biosolids (processed with MSW organics)	-32	68	178
2B = 1B + biosolids	1	100	211
2C = 1C + biosolids	-57	32	127
2D = 1D + biosolids	-168	-79	16
2E = 1E + biosolids	23	113	209

Option	Low = -50%	Base Case	High = +50%
3A = CWS + 3rd bin + compost (of MSW organic material collect via the 3rd bin)	-103	-22	70
3B(i) = CWS + 3rd bin + AD	-73	8	100
3B(ii) = CWS + 3rd bin + AD + biosolids	-76	5	97
3C(i) = CWS + 3rd bin + pyrolysis	-83	-12	66
3C(ii) = CWS + 3rd bin + pyrolysis + biosolids	-75	-3	74
4 = 3C(ii) + a dirty MRF for the MSW residuals	-74	8	96

3.2.7 Sensitivity to infrastructure capital cost – new MRF facilities, anaerobic digestion and in-vessel composting

Reduced capital cost for MRF facilities, anaerobic digester and in-vessel composting make options that include these facilities look better: options 1B and 2B take the lead and only options 1D and 2D remain clearly unfavourable if these costs drop by 50%. Conversely, with higher capital costs, options that include these facilities look less favourable, although without changing the results.

Table 3-9 Sensitivity to capital costs for new MRF, AD and in-vessel composting (NPV comparison to Base Case, in $M)

Option	Cap cost -50%	Base Case	Cap cost +50%
BASE CASE (BC)	-	-	-
CWS = BC + dry C&I MRF	136	128	120
1A = CWS + dirty MRF + composting (of MSW organics)	138	110	83
1B = CWS + dirty MRF + AD	152	114	76
1C = CWS + dirty MRF + gasification	46	30	15
1D = CWS + dirty MRF + incineration	-59	-74	-90
1E= CWS + dirty MRF + pyrolysis	110	95	79
2A= 1A + biosolids (processed with MSW organics)	114	68	4
2B = 1B + biosolids	170	100	-3
2C = 1C + biosolids	47	32	17
2D = 1D + biosolids	-64	-79	-94
2E = 1E + biosolids	129	113	98
3A = CWS + 3rd bin + compost (of MSW organic material collect via the 3rd bin)	3	-22	-46
3B(i) = CWS + 3rd bin + AD	40	8	-24
3B(ii) = CWS + 3rd bin + AD + biosolids	68	5	-93
3C(i) = CWS + 3rd bin + pyrolysis	-2	-12	-21
3C(ii) = CWS + 3rd bin + pyrolysis + biosolids	6	-3	-12
4 = 3C(ii) + a dirty MRF for the MSW residuals	22	8	-6

3.2.8 Sensitivity to infrastructure capital cost – new TCT facilities

As expected, a drop in capital cost for TCF by 50% make options 1E and 2E look particularly favourable and option 1D becomes favourable, while an increase in capital cost makes options 1A and 1B all the more attractive (as they do not include TCF) and only options 1E and 2E remain slightly positive compared to the Base Case.

Table 3-10 Sensitivity to capital costs for new TCT facilities (NPV comparison to CWS, in $M)

Option	Cap cost -50%	Base Case	Cap cost +50%
BASE CASE (BC)	-	-	-
CWS = BC + dry C&I MRF	128	128	128
1A = CWS + dirty MRF + composting (of MSW organics)	110	110	110
1B = CWS + dirty MRF + AD	114	114	114
1C = CWS + dirty MRF + gasification	**103**	**30**	**-42**
1D = CWS + dirty MRF + incineration	**40**	**-74**	**-188**
1E= CWS + dirty MRF + pyrolysis	**175**	**95**	**14**
2A= 1A + biosolids (processed with MSW organics)	68	68	68
2B = 1B + biosolids	100	100	100
2C = 1C + biosolids	**118**	**32**	**-54**
2D = 1D + biosolids	**54**	**-79**	**-212**
2E = 1E + biosolids	**213**	**113**	**13**
3A = CWS + 3rd bin + compost (of MSW organic material collect via the 3rd bin)	-22	-22	-22
3B(i) = CWS + 3rd bin + AD	8	8	8
3B(ii) = CWS + 3rd bin + AD + biosolids	5	5	5
3C(i) = CWS + 3rd bin + pyrolysis	**103**	**-12**	**-203**
3C(ii) = CWS + 3rd bin + pyrolysis + biosolids	**148**	**-3**	**-254**
4 = 3C(ii) + a dirty MRF for the MSW residuals	123	8	-107

Conclusion from Economic Modelling

On balance, options 1A (CWS + dirty MRF + composting (of MSW organics)) and 1B (CWS + dirty MRF + Anaerobic Digestion) appear as the most stable when tested for sensitivity, which can be interpreted as being the options that present the lowest economic risk.

However, options using pyrolysis (particularly 1E (CWS + dirty MRF + pyrolysis) and 2E (1E + biosolids) but also 3C (CWS + 3rd bin + pyrolysis) and 4 (3C(ii) + a dirty MRF for the MSW residuals)) present more upsides in the sensitivity analysis, specifically if biochar prices are higher than those assumed in the main results or landfill costs escalate. Higher landfill costs also make practically all options look significantly more favourable.

While the high level analysis is based on numerous assumptions and should be taken with customary caution, it presents a clear picture of the net benefits or costs of implementing new technologies. In particular, pyrolysis appears as the best of the TCT options, especially when dealing with biosolids, while in-vessel composting and anaerobic digestion appear as good solutions for processing organic waste if biosolids are excluded.

It should be noted that market conditions, and particularly the price of recyclable materials, but also the price of electricity (driven by carbon prices), have a significant influence on the results. REC prices have a lesser influence.

This analysis only provides one type of input to the decision-making with regard to the waste treatment facilities in the ACT and should therefore be combined with technical analysis and complemented by a more detailed economic and financial analysis once a short-list of feasible options has been defined.

In particular, the present model does not assess the financial viability of the various facilities considered, which will need to be assessed separately by asking potential technology providers about the gate fees and market conditions required to ensure commercial viability.

5

Non-economic factors

To further support the ACT government's decision making process the following non-economic factors were investigated by URS:

- GHG emission difference of each option compared to use of electricity purchased from the grid (generated via burning fossil fuels); and
- Net benefit, expressed as GHG emission saved, associated with recovery and reuse of recyclable material from the waste streams.

5.1 Emissions associated with electricity purchased from the grid

Table 5.1 provides the annual average electricity generated for each of the options considered, compared to the indirect (Scope 2) emissions resulting from the consumption of equivalent amount electricity generated by fossil fuels. An emission factor of 0.89 kgCO2-e/kWh (DCC, 2009) was used to estimate the indirect (Scope 2) emissions associated with consumption of purchased electricity from the grid in NSW/ACT.

Table 5-1 Emissions associated with equivalent amount of electricity purchased from the grid

Option	Average Annual Electricity Generation (MWh)	Equivalent Indirect (Scope 2) Emissions from purchased electricity (tCO2-e)
BASE CASE (BC)	41,556	36,985
CWS = BC + dry C&I MRF	33,532	29,843
1A = CWS + dirty MRF + composting (of MSW organics)	16,159	14,382
1B = CWS + dirty MRF + AD	40,559	36,098
1C = CWS + dirty MRF + gasification	123,693	110,087
1D = CWS + dirty MRF + incineration	104,514	93,017
1E= CWS + dirty MRF + pyrolysis	97,588	86,853
2A= 1A + biosolids (processed with MSW organics)	14,111	12,559
2B = 1B + biosolids	55,199	49,127
2C = 1C + biosolids	147,079	130,900
2D = 1D + biosolids	122,415	108,949
2E = 1E + biosolids	120,690	107,414
3A = CWS + 3rd bin + compost (of MSW organic material collect via the 3rd bin)	22,758	20,255
3B(i) = CWS + 3rd bin + AD	46,895	41,737
3B(ii) = CWS + 3rd bin + AD + biosolids	61,265	54,526
3C(i) = CWS + 3rd bin + pyrolysis	105,710	94,082
3C(ii) = CWS + 3rd bin + pyrolysis + biosolids	140,238	124,812
4 = 3C(ii) + a dirty MRF for the MSW residuals	141,275	125,735

URS

The use of energy generated from a renewable source (in this case TCT) compared to purchasing electricity from the grid, would result in a reduction in greenhouse emissions associated with use of electricity in the ACT. The economic benefit associated with this reduction has been taken into consideration in the CBA, by incorporating the revenue obtained from selling RECs into the analysis as discussed in Section 2.4.4.

5.2 Net Benefit of Recycling

As a separate exercise to the economic modelling, estimates of the net benefit of recycling associated with each option, as expressed by GHG (tCO2-e) emissions saved compared with the use of virgin materials and landfill of material, was calculated to further support DECCEW's decision making process. The net benefit, expressed as tCO2-e saved per tonne of material recycled, was obtained from the report *Environmental Benefits of Recycling*, NSW DECCW (2010). A summary of the LCA modelling results is presented in Appendix C. These benefits have not been included in the BCA, considering that the recycling processes (and related costs and benefits) were not within the scope of this study and the use of the emission data in this way is not consistent with generally accepted BCA standards.

References

BDA Group (2009), *The full cost of landfill disposal in Australia*, prepared for the Department of the Environment, Water, Heritage and Arts.

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Appendix A Waste quantities

Appendix A

In t/year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
BASED ON 2014 HIGH POPULATION GROWTH												
Domestic Kerbside Mixed Waste	67,820	69,741	71,661	73,582	75,502	77,423	79,450	81,477	83,504	85,531	87,558	89,674
Domestic Drop-off Waste	13,310	13,687	14,064	14,441	14,818	15,195	15,593	15,991	16,388	16,786	17,184	17,599
C&D (Mixed C&D waste to MRFs)	123,413	126,908	130,403	133,898	137,393	140,888	144,577	148,265	151,954	155,642	159,331	163,182
C&D (Wood Waste Only)	2,037	2,095	2,152	2,210	2,267	2,325	2,386	2,447	2,508	2,569	2,630	2,694
Mixed C&D to Landfill	27,522	28,301	29,081	29,860	30,640	31,419	32,242	33,064	33,887	34,709	35,532	36,391
Commercial and Industrial	105,317	108,300	111,282	114,265	117,247	120,230	123,378	126,525	129,673	132,820	135,968	139,254
Urban trees waste	15,000	15,425	15,850	16,274	16,699	17,124	17,572	18,021	18,469	18,918	19,366	19,834
Biosolids (wet tonnes)	38,209	39,291	40,373	41,455	42,537	43,619	44,761	45,903	47,045	48,187	49,329	50,521
Dry Recycling	61,137	62,868	64,600	66,331	68,063	69,794	71,621	73,448	75,276	77,103	78,930	80,838
Composters (unlikely to Rise Significar	198,138	199,723	201,308	202,894	204,479	206,064	207,712	209,361	211,009	212,658	214,306	216,020
C&D Recycled Masonry	156,943	161,388	165,832	170,277	174,722	179,166	183,857	188,548	193,238	197,929	202,620	207,516
C&I direct to recycled	99,363	102,177	104,991	107,805	110,619	113,433	116,402	119,372	122,342	125,311	128,281	131,381
Grand Total	908,209	929,903	951,597	973,292	994,986	1,016,680	1,039,551	1,062,422	1,085,293	1,108,164	1,131,035	1,154,904
Variance		2.4%	2.3%	2.3%	2.2%	2.2%	2.2%	2.2%	2.2%	2.1%	2.1%	2.1%

In t/year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
BASED ON 2014 HIGH POPULATION GROWTH															
Domestic Kerbside Mixed Waste	91,790	93,906	96,022	98,138	100,244	102,351	104,457	106,563	108,670	110,776	112,883	114,966	117,049	118,778	120,861
Domestic Drop-off Waste	18,014	18,430	18,845	19,260	19,673	20,087	20,500	20,914	21,327	21,736	22,145	22,553	22,962	23,311	23,720
C&D (Mixed C&D waste to MRFs)	167,032	170,883	174,733	178,584	182,417	186,250	190,082	193,915	197,748	201,539	205,329	209,120	212,911	216,142	219,933
C&D (Wood Waste Only)	2,757	2,821	2,884	2,948	3,011	3,074	3,138	3,201	3,264	3,327	3,389	3,452	3,514	3,568	3,631
Mixed C&D to Landfill	37,250	38,108	38,967	39,826	40,681	41,535	42,390	43,245	44,099	44,945	45,790	46,635	47,481	48,201	49,046
Commercial and Industrial	142,540	145,826	149,112	152,398	155,669	158,940	162,210	165,481	168,752	171,987	175,222	178,457	181,691	184,449	187,684
Urban trees waste	20,302	20,770	21,238	21,706	22,172	22,638	23,103	23,569	24,035	24,496	24,956	25,417	25,878	26,271	26,732
Biosolids (wet tonnes)	51,713	52,905	54,097	55,289	56,476	57,662	58,849	60,036	61,223	62,396	63,570	64,743	65,917	66,917	68,091
Dry Recycling	82,745	84,653	86,560	88,468	90,367	92,266	94,164	96,063	97,962	99,840	101,718	103,596	105,473	107,074	108,952
Composters (unlikely to Rise Significar	217,735	219,449	221,164	222,878	223,324	223,770	224,215	224,661	225,107	226,377	227,646	228,916	230,185	227,358	228,628
C&D Recycled Masonry	212,413	217,310	222,207	227,103	231,977	236,852	241,726	246,600	251,474	256,294	261,115	265,935	270,756	274,865	279,686
C&I direct to recycled	134,482	137,582	140,682	143,783	146,869	149,955	153,041	156,127	159,213	162,265	165,317	168,369	171,421	174,022	177,074
Grand Total	1,178,773	1,202,643	1,226,512	1,250,381	1,272,880	1,295,378	1,317,876	1,340,375	1,362,873	1,385,976	1,409,079	1,432,159	1,455,238	1,470,956	1,494,036
Variance	2.1%	2.0%	2.0%	1.9%	1.8%	1.8%	1.7%	1.7%	1.7%	1.7%	1.7%	1.6%	1.6%	1.1%	1.6%

Appendix B TCT Feedstock Quality Grades

Appendix B

Adopted Grade	Criteria
A	“Dry”, clean wood, timber, paper/cardboard and garden/parks wastes Max. average moisture up to 65% Minimal engineered timber products Treated (especially CCA) timber products removed Minimal < 1% w/w plastic content – No PVC
B	“Dry” wood, timber, paper/cardboard and garden/parks wastes Max. Average moisture up to 65% Treated (especially CCA) timber products removed Non PVC plastic contamination approximately 10% w/w
C	“Wet”, clean organic food wastes, vegetative materials or sludges Average moisture content > 65% Minimal < 1% w/w plastic content –No PVC Minimal heavy metal content (see Appendix A) Minimal inerts < 5% w/w (see Appendix A)
D	“Wet” organic residuals, food and vegetative materials and sludges Average moisture content > 65% Non PVC plastic content approximately 10% w/w Minimal heavy metal content (see Appendix A) Minimal inerts < 5% w/w (see Appendix A)

Appendix C Net Benefit of Recycling

URS

SUMMARY SHEET:

NET CARBON EMISSION BENEFITS FROM RECYCLING

Scenario	Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
BASE CASE (BC)																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	79,651	81,736	83,822	85,907	87,992	90,078	92,255	94,432	96,609	98,786	100,963	103,129	105,296	107,463	109,630	111,797	113,940	116,083	118,226	120,369	122,196	124,339
From HRRE C&I dry MRF	t Co2e/year	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
From HRRE MSW Dirty MRF	t Co2e/year	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***127,476***	***130,803***	***134,131***	***137,642***	***141,154***	***144,665***	***148,177***	***151,689***	***155,355***	***159,021***	***162,687***	***166,353***	***170,019***	***173,668***	***177,317***	***180,966***	***184,615***	***188,264***	***191,873***	***195,481***	***199,090***	***202,699***	***205,775***	***209,384***
CWS = BC + dry C&I MRF																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	79,651	81,736	83,822	85,907	87,992	90,078	92,255	94,432	96,609	98,786	100,963	103,129	105,296	107,463	109,630	111,797	113,940	116,083	118,226	120,369	122,196	124,339
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	57,685	59,195	60,705	62,216	63,726	65,236	66,812	68,389	69,966	71,542	73,119	74,688	76,257	77,827	79,396	80,965	82,517	84,069	85,621	87,173	88,497	90,049
From HRRE MSW Dirty MRF	t Co2e/year	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***191,816***	***196,837***	***201,859***	***206,881***	***211,903***	***216,925***	***222,167***	***227,410***	***232,652***	***237,895***	***243,137***	***248,356***	***253,574***	***258,792***	***264,011***	***269,229***	***274,390***	***279,551***	***284,712***	***289,873***	***294,272***	***299,433***
1A = CWS + dirty MRF + composting (of MSW organics)																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	79,651	81,736	83,822	85,907	87,992	90,078	92,255	94,432	96,609	98,786	100,963	103,129	105,296	107,463	109,630	111,797	113,940	116,083	118,226	120,369	122,196	124,339
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	57,685	59,195	60,705	62,216	63,726	65,236	66,812	68,389	69,966	71,542	73,119	74,688	76,257	77,827	79,396	80,965	82,517	84,069	85,621	87,173	88,497	90,049
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	35,188	36,109	37,030	37,952	38,873	39,794	40,756	41,718	42,679	43,641	44,603	45,560	46,517	47,475	48,432	49,389	50,347	51,304	52,251	53,197	53,983	54,930
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***227,003***	***232,946***	***238,890***	***244,833***	***250,776***	***256,719***	***262,923***	***269,127***	***275,332***	***281,536***	***287,740***	***293,916***	***300,091***	***306,267***	***312,443***	***318,618***	***324,736***	***330,855***	***336,962***	***343,070***	***348,255***	***354,363***
1B = CWS + dirty MRF + AD																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	79,651	81,736	83,822	85,907	87,992	90,078	92,255	94,432	96,609	98,786	100,963	103,129	105,296	107,463	109,630	111,797	113,940	116,083	118,226	120,369	122,196	124,339
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	57,685	59,195	60,705	62,216	63,726	65,236	66,812	68,389	69,966	71,542	73,119	74,688	76,257	77,827	79,396	80,965	82,517	84,069	85,621	87,173	88,497	90,049
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	35,188	36,109	37,030	37,952	38,873	39,794	40,756	41,718	42,679	43,641	44,603	45,560	46,517	47,475	48,432	49,389	50,347	51,304	52,251	53,197	53,983	54,930
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***227,003***	***232,946***	***238,890***	***244,833***	***250,776***	***256,719***	***262,923***	***269,127***	***275,332***	***281,536***	***287,740***	***293,916***	***300,091***	***306,267***	***312,443***	***318,618***	***324,736***	***330,855***	***336,962***	***343,070***	***348,255***	***354,363***
1C = CWS + dirty MRF + gasification																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	76,905	78,919	80,932	82,946	84,959	86,973	89,074	91,176	93,278	95,380	97,482	99,574	101,666	103,759	105,851	107,943	110,012	112,081	114,150	116,220	117,983	120,053
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	51,167	52,507	53,846	55,186	56,526	57,865	59,264	60,662	62,060	63,459	64,857	66,249	67,641	69,033	70,425	71,817	73,194	74,571	75,947	77,324	78,498	79,874
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	35,188	36,109	37,030	37,952	38,873	39,794	40,756	41,718	42,679	43,641	44,603	45,560	46,517	47,475	48,432	49,389	50,347	51,304	52,251	53,197	53,983	54,930
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***217,740***	***223,440***	***229,141***	***234,842***	***240,542***	***246,243***	***252,194***	***258,145***	***264,096***	***270,047***	***275,998***	***281,922***	***287,845***	***293,769***	***299,693***	***305,616***	***311,485***	***317,354***	***323,213***	***329,071***	***334,044***	***339,902***
1D = CWS + dirty MRF + incineration																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	76,905	78,919	80,932	82,946	84,959	86,973	89,074	91,176	93,278	95,380	97,482	99,574	101,666	103,759	105,851	107,943	110,012	112,081	114,150	116,220	117,983	120,053
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	51,167	52,507	53,846	55,186	56,526	57,865	59,264	60,662	62,060	63,459	64,857	66,249	67,641	69,033	70,425	71,817	73,194	74,571	75,947	77,324	78,498	79,874
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	35,188	36,109	37,030	37,952	38,873	39,794	40,756	41,718	42,679	43,641	44,603	45,560	46,517	47,475	48,432	49,389	50,347	51,304	52,251	53,197	53,983	54,930
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***217,740***	***223,440***	***229,141***	***234,842***	***240,542***	***246,243***	***252,194***	***258,145***	***264,096***	***270,047***	***275,998***	***281,922***	***287,845***	***293,769***	***299,693***	***305,616***	***311,485***	***317,354***	***323,213***	***329,071***	***334,044***	***339,902***
1E= CWS + dirty MRF + pyrolysis																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	76,905	78,919	80,932	82,946	84,959	86,973	89,074	91,176	93,278	95,380	97,482	99,574	101,666	103,759	105,851	107,943	110,012	112,081	114,150	116,220	117,983	120,053
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	51,167	52,507	53,846	55,186	56,526	57,865	59,264	60,662	62,060	63,459	64,857	66,249	67,641	69,033	70,425	71,817	73,194	74,571	75,947	77,324	78,498	79,874
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	35,188	36,109	37,030	37,952	38,873	39,794	40,756	41,718	42,679	43,641	44,603	45,560	46,517	47,475	48,432	49,389	50,347	51,304	52,251	53,197	53,983	54,930
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***217,740***	***223,440***	***229,141***	***234,842***	***240,542***	***246,243***	***252,194***	***258,145***	***264,096***	***270,047***	***275,998***	***281,922***	***287,845***	***293,769***	***299,693***	***305,616***	***311,485***	***317,354***	***323,213***	***329,071***	***334,044***	***339,902***
2A= 1A + biosolids (processed with MSW organics)																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	79,651	81,736	83,822	85,907	87,992	90,078	92,255	94,432	96,609	98,786	100,963	103,129	105,296	107,463	109,630	111,797	113,940	116,083	118,226	120,369	122,196	124,339
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	57,685	59,195	60,705	62,216	63,726	65,236	66,812	68,389	69,966	71,542	73,119	74,688	76,257	77,827	79,396	80,965	82,517	84,069	85,621	87,173	88,497	90,049
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	35,188	36,109	37,030	37,952	38,873	39,794	40,756	41,718	42,679	43,641	44,603	45,560	46,517	47,475	48,432	49,389	50,347	51,304	52,251	53,197	53,983	54,930
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***227,003***	***232,946***	***238,890***	***244,833***	***250,776***	***256,719***	***262,923***	***269,127***	***275,332***	***281,536***	***287,740***	***293,916***	***300,091***	***306,267***	***312,443***	***318,618***	***324,736***	***330,855***	***336,962***	***343,070***	***348,255***	***354,363***
2B = 1B + biosolids																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	79,651	81,736	83,822	85,907	87,992	90,078	92,255	94,432	96,609	98,786	100,963	103,129	105,296	107,463	109,630	111,797	113,940	116,083	118,226	120,369	122,196	124,339
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	57,685	59,195	60,705	62,216	63,726	65,236	66,812	68,389	69,966	71,542	73,119	74,688	76,257	77,827	79,396	80,965	82,517	84,069	85,621	87,173	88,497	90,049
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	35,188	36,109	37,030	37,952	38,873	39,794	40,756	41,718	42,679	43,641	44,603	45,560	46,517	47,475	48,432	49,389	50,347	51,304	52,251	53,197	53,983	54,930
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***227,003***	***232,946***	***238,890***	***244,833***	***250,776***	***256,719***	***262,923***	***269,127***	***275,332***	***281,536***	***287,740***	***293,916***	***300,091***	***306,267***	***312,443***	***318,618***	***324,736***	***330,855***	***336,962***	***343,070***	***348,255***	***354,363***
2C = 1C + biosolids																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	76,905	78,919	80,932	82,946	84,959	86,973	89,074	91,176	93,278	95,380	97,482	99,574	101,666	103,759	105,851	107,943	110,012	112,081	114,150	116,220	117,983	120,053
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	51,167	52,507	53,846	55,186	56,526	57,865	59,264	60,662	62,060	63,459	64,857	66,249	67,641	69,033	70,425	71,817	73,194	74,571	75,947	77,324	78,498	79,874
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	35,188	36,109	37,030	37,952	38,873	39,794	40,756	41,718	42,679	43,641	44,603	45,560	46,517	47,475	48,432	49,389	50,347	51,304	52,251	53,197	53,983	54,930
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***217,740***	***223,440***	***229,141***	***234,842***	***240,542***	***246,243***	***252,194***	***258,145***	***264,096***	***270,047***	***275,998***	***281,922***	***287,845***	***293,769***	***299,693***	***305,616***	***311,485***	***317,354***	***323,213***	***329,071***	***334,044***	***339,902***
2D = 1D + biosolids																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	76,905	78,919	80,932	82,946	84,959	86,973	89,074	91,176	93,278	95,380	97,482	99,574	101,666	103,759	105,851	107,943	110,012	112,081	114,150	116,220	117,983	120,053
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	51,167	52,507	53,846	55,186	56,526	57,865	59,264	60,662	62,060	63,459	64,857	66,249	67,641	69,033	70,425	71,817	73,194	74,571	75,947	77,324	78,498	79,874
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	35,188	36,109	37,030	37,952	38,873	39,794	40,756	41,718	42,679	43,641	44,603	45,560	46,517	47,475	48,432	49,389	50,347	51,304	52,251	53,197	53,983	54,930
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***217,740***	***223,440***	***229,141***	***234,842***	***240,542***	***246,243***	***252,194***	***258,145***	***264,096***	***270,047***	***275,998***	***281,922***	***287,845***	***293,769***	***299,693***	***305,616***	***311,485***	***317,354***	***323,213***	***329,071***	***334,044***	***339,902***

2E = 1E + biosolids																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	76,905	78,919	80,932	82,946	84,959	86,973	89,074	91,176	93,278	95,380	97,482	99,574	101,666	103,759	105,851	107,943	110,012	112,081	114,150	116,220	117,983	120,053
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	51,167	52,507	53,846	55,186	56,526	57,865	59,264	60,662	62,060	63,459	64,857	66,249	67,641	69,033	70,425	71,817	73,194	74,571	75,947	77,324	78,498	79,874
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	35,188	36,109	37,030	37,952	38,873	39,794	40,756	41,718	42,679	43,641	44,603	45,560	46,517	47,475	48,432	49,389	50,347	51,304	52,251	53,197	53,983	54,930
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***217,740***	***223,440***	***229,141***	***234,842***	***240,542***	***246,243***	***252,194***	***258,145***	***264,096***	***270,047***	***275,998***	***281,922***	***287,845***	***293,769***	***299,693***	***305,616***	***311,485***	***317,354***	***323,213***	***329,071***	***334,044***	***339,902***
3A = CWS + 3rd bin + compost (of MSW organic material collect via the 3rd bin)																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	79,651	81,736	83,822	85,907	87,992	90,078	92,255	94,432	96,609	98,786	100,963	103,129	105,296	107,463	109,630	111,797	113,940	116,083	118,226	120,369	122,196	124,339
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	57,685	59,195	60,705	62,216	63,726	65,236	66,812	68,389	69,966	71,542	73,119	74,688	76,257	77,827	79,396	80,965	82,517	84,069	85,621	87,173	88,497	90,049
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***191,816***	***196,837***	***201,859***	***206,881***	***211,903***	***216,925***	***222,167***	***227,410***	***232,652***	***237,895***	***243,137***	***248,356***	***253,574***	***258,792***	***264,011***	***269,229***	***274,390***	***279,551***	***284,712***	***289,873***	***294,272***	***299,433***
3B(i) = CWS + 3rd bin + AD																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	79,651	81,736	83,822	85,907	87,992	90,078	92,255	94,432	96,609	98,786	100,963	103,129	105,296	107,463	109,630	111,797	113,940	116,083	118,226	120,369	122,196	124,339
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	57,685	59,195	60,705	62,216	63,726	65,236	66,812	68,389	69,966	71,542	73,119	74,688	76,257	77,827	79,396	80,965	82,517	84,069	85,621	87,173	88,497	90,049
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***191,816***	***196,837***	***201,859***	***206,881***	***211,903***	***216,925***	***222,167***	***227,410***	***232,652***	***237,895***	***243,137***	***248,356***	***253,574***	***258,792***	***264,011***	***269,229***	***274,390***	***279,551***	***284,712***	***289,873***	***294,272***	***299,433***
3B(ii) = CWS + 3rd bin + AD + biosolids																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	79,651	81,736	83,822	85,907	87,992	90,078	92,255	94,432	96,609	98,786	100,963	103,129	105,296	107,463	109,630	111,797	113,940	116,083	118,226	120,369	122,196	124,339
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	57,685	59,195	60,705	62,216	63,726	65,236	66,812	68,389	69,966	71,542	73,119	74,688	76,257	77,827	79,396	80,965	82,517	84,069	85,621	87,173	88,497	90,049
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***191,816***	***196,837***	***201,859***	***206,881***	***211,903***	***216,925***	***222,167***	***227,410***	***232,652***	***237,895***	***243,137***	***248,356***	***253,574***	***258,792***	***264,011***	***269,229***	***274,390***	***279,551***	***284,712***	***289,873***	***294,272***	***299,433***
3C(i) = CWS + 3rd bin + pyrolysis																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	76,905	78,919	80,932	82,946	84,959	86,973	89,074	91,176	93,278	95,380	97,482	99,574	101,666	103,759	105,851	107,943	110,012	112,081	114,150	116,220	117,983	120,053
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	51,167	52,507	53,846	55,186	56,526	57,865	59,264	60,662	62,060	63,459	64,857	66,249	67,641	69,033	70,425	71,817	73,194	74,571	75,947	77,324	78,498	79,874
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***182,552***	***187,331***	***192,111***	***196,890***	***201,669***	***206,448***	***211,438***	***216,427***	***221,417***	***226,406***	***231,395***	***236,362***	***241,328***	***246,294***	***251,261***	***256,227***	***261,139***	***266,050***	***270,962***	***275,874***	***280,060***	***284,972***
3C(ii) = CWS + 3rd bin + pyrolysis + biosolids																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	76,905	78,919	80,932	82,946	84,959	86,973	89,074	91,176	93,278	95,380	97,482	99,574	101,666	103,759	105,851	107,943	110,012	112,081	114,150	116,220	117,983	120,053
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	51,167	52,507	53,846	55,186	56,526	57,865	59,264	60,662	62,060	63,459	64,857	66,249	67,641	69,033	70,425	71,817	73,194	74,571	75,947	77,324	78,498	79,874
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***182,552***	***187,331***	***192,111***	***196,890***	***201,669***	***206,448***	***211,438***	***216,427***	***221,417***	***226,406***	***231,395***	***236,362***	***241,328***	***246,294***	***251,261***	***256,227***	***261,139***	***266,050***	***270,962***	***275,874***	***280,060***	***284,972***
4 = 3C(ii) + a dirty MRF for the MSW residuals																											
From Existing clean MRF	t Co2e/year	71,747	73,723	75,699	77,675	76,905	78,919	80,932	82,946	84,959	86,973	89,074	91,176	93,278	95,380	97,482	99,574	101,666	103,759	105,851	107,943	110,012	112,081	114,150	116,220	117,983	120,053
From HRRE C&I dry MRF	t Co2e/year	0	0	54,823	56,254	51,167	52,507	53,846	55,186	56,526	57,865	59,264	60,662	62,060	63,459	64,857	66,249	67,641	69,033	70,425	71,817	73,194	74,571	75,947	77,324	78,498	79,874
From HRRE MSW Dirty MRF	t Co2e/year	0	0	0	0	0	0	24,377	24,983	25,590	26,196	26,829	27,462	28,095	28,728	29,361	29,992	30,622	31,252	31,882	32,512	33,143	33,773	34,396	35,019	35,537	36,160
From existing kerbside MRF	t Co2e/year	49,074	50,425	51,777	53,128	54,480	55,906	57,332	58,758	60,185	61,611	63,100	64,589	66,078	67,567	69,056	70,538	72,020	73,502	74,985	76,467	77,933	79,398	80,864	82,330	83,579	85,045
TOTAL	***t Co2e/year***	***120,821***	***124,148***	***182,299***	***187,057***	***182,552***	***187,331***	***216,487***	***221,873***	***227,259***	***232,645***	***238,267***	***243,889***	***249,512***	***255,134***	***260,757***	***266,353***	***271,950***	***277,546***	***283,143***	***288,739***	***294,281***	***299,823***	***305,358***	***310,893***	***315,597***	***321,132***

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