Carbon Modelling Report for Herefordshire Council

17-Nov-21

Acknowledgements:

Frith Resource Management would like to thank the essential contributions from waste management officers Kenton Vigus and Nicola Percival at Herefordshire Council throughout these modelling phases.

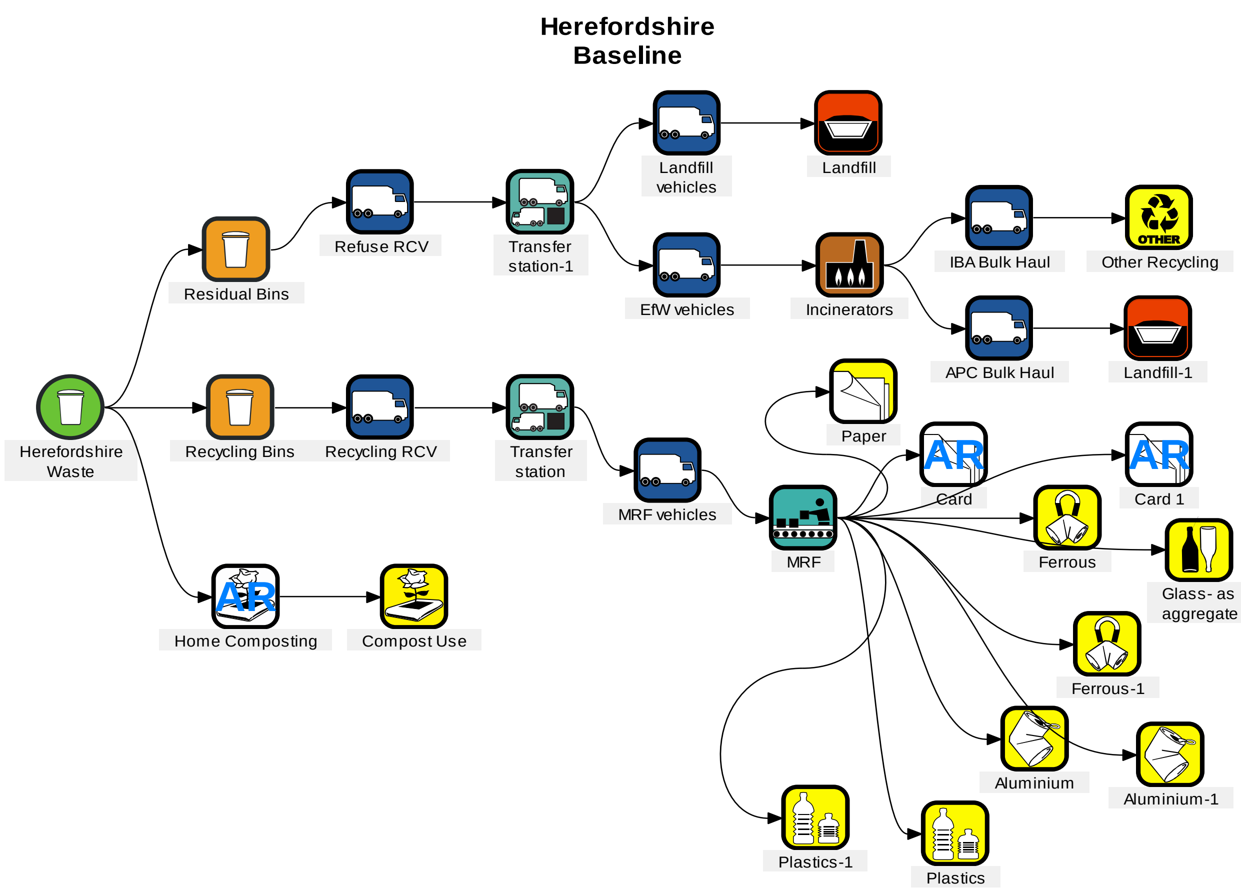
Disclaimer:

Frith Resource Management Ltd (FRM) is an independent waste and resource management consultancy providing advice in accordance with the project brief. FRM has taken all reasonable care and diligence in the preparation of this report to ensure that all facts and analysis presented are as accurate as possible within the scope of the project. However no guarantee is provided in respect of the information presented, and FRM is not responsible for decisions or actions taken on the basis of the content of this report.

Executive Summary

Frith Resource Management (FRM) Limited were engaged by Herefordshire Council to undertake a short project to review the carbon impacts of a range of collection options modelled previously by FRM in the project 'Waste and recycling collection service options modelling'[1]. FRM applied the Waste & Resources Assessment Tool for the Environment (WRATE), version 4.0.1.0. This is a Life Cycle Assessment model developed by the Environment Agency specifically for the purpose of modelling municipal waste management systems.

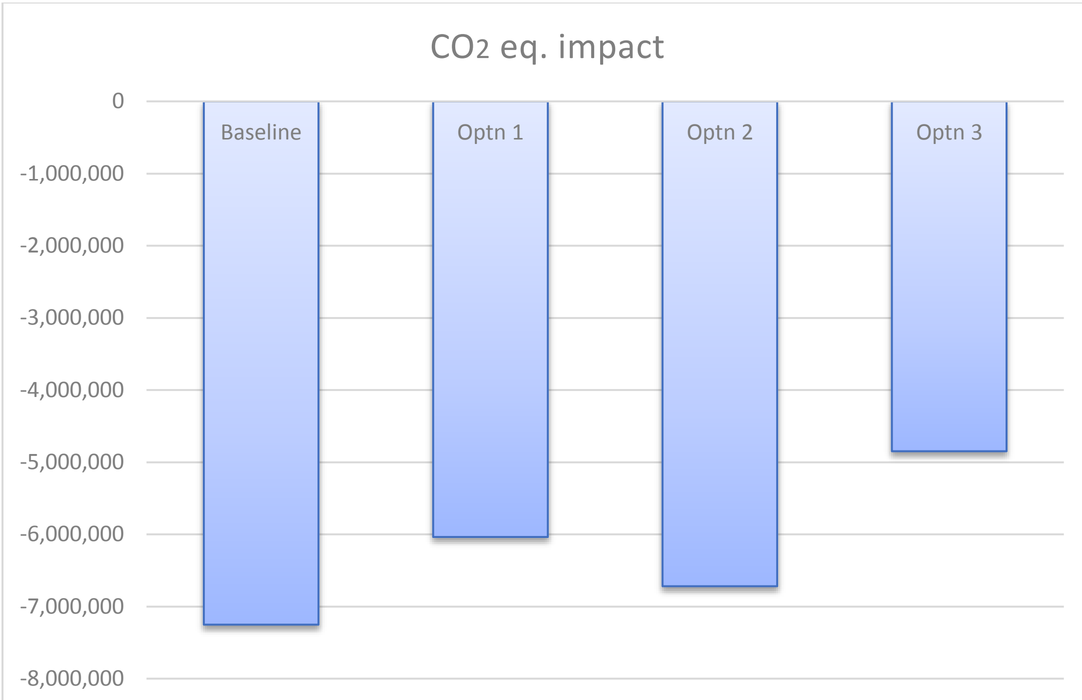
A schematic of the current collection system, as modelled is shown below.



Date 31/07/2019
Software Version 4.0.1.0
Database Version 4.0.1.0

The results of the impact on carbon emissions of the service are highlighted in the figure below . The results show negative figures because recycling and energy recovery has offset more damaging, carbon intensive processes, such as primary resource extraction and burning of fossil fuels. This therefore represents a carbon 'saving' as a result of the resource management activity in Herefordshire.

[1] For Herefordshire Council, Frith Resource Management, July 2019



The results of this study are displayed in kg of Carbon Dioxide equivalents, and show that the baseline (current service) has the lowest carbon impact, and is the most beneficial in carbon terms. The reasons for this are primarily as follows:-

- **It has the lowest transport impact** – all other options (options 1-3) have substantially more vehicle movements as the result of the introduction of a separate fortnightly free garden waste collection and a weekly food waste collection. There may however be some impacts unaccounted for in the model, for example if many households currently make individual car journeys to the HWRC to deposit garden waste, however it is unclear as to the magnitude of this, and is outside the scope of the model.
- **The carbon benefit of composting the garden waste is already captured** – the fact that there are relatively low amounts of garden waste within the residual stream at present suggests that, of the available garden waste to be drawn into a free collection, this is probably already being composted either at home or at the HWRC in most cases, and therefore there is limited additional carbon benefit gained in options 1, 2 and 3.
- **The residual waste is predominantly managed via the Energy from Waste plant** – this means that the carbon impact of, for example food waste, is much lower than would be the case from landfill, and so there is less of a relative carbon benefit from digesting it in an anaerobic digestion facility.

Setting aside the Baseline service, which is unlikely to be deliverable under future resource management policies, the best of the alternative three options analysed is Option 2, which performs well compared to options 1 and 3, due to lower transport emissions and higher recycling, both as a result of the 3 weekly residual waste / recyclables collection.

Contents

1 Introduction

Frith Resource Management (FRM) Limited were engaged by Herefordshire Council to undertake a short project to review the carbon impacts of a range of collection options modelled previously by FRM in the project 'Waste and recycling collection service options modelling'[2].

These collection options were as follows, the elements in **bold** are variations from the current service.:-

Scenario	Collection Stream	Frequency	Capacity (l)
Baseline	Residual waste	Fortnightly	180l wheeled bin
	Dry recycling (Commingled)	Fortnightly	240l wheeled bin
As current	Food waste	*No separate food collection*	
	Garden waste	*No formal garden collection service*[3]	
Option 1	Residual waste	Fortnightly	180l wheeled bin
Current AWC	Dry recycling (Commingled)	Fortnightly	240l wheeled bin
+ food	**Food waste**	**Weekly**	**Kitchen caddy and 23l bin**
+ garden	**Garden waste (free)**	**Fortnightly**	**240l wheeled bin**
Option 2	Residual waste	**Three weekly (week 1)**	180l wheeled bin
Alternate Three Weekly (ATWC)	Dry recycling (**Twin stream, paper and card out**)	**Three weekly (week 2) Cans, plastic, glass**	**180l wheeled bin**
		Three weekly (week 3) Paper and card	240l wheeled bin
+ food	**Food waste**	**Weekly**	**Kitchen caddy and 23l bin**
+ garden	**Garden waste (free)**	**Fortnightly**	**240l wheeled bin**
Option 3	Residual waste	Fortnightly	180l wheeled bin
	Dry recycling	**Weekly**	**3x 50l boxes**
Kerbside sort	**Food waste**	**Weekly**	**Kitchen caddy and 23l bin**
+ food + garden	**Garden waste (free)**	**Fortnightly**	**240l wheeled bin**

[2] For Herefordshire Council, Frith Resource Management, July 2019

[3] Householders can purchase sacks and present garden waste to be collected with residual waste, however this is not considered a formal service as the garden waste does not go for recycling.

2 Methodology

FRM applied the Waste & Resources Assessment Tool for the Environment (WRATE), version 4.0.1.0. This is a Life Cycle Assessment model developed by the Environment Agency specifically for the purpose of modelling municipal waste management systems.

Paul Frith is trained at Advanced level in the use of this tool and undertook the modelling.

Key assumptions applied in the modelling and agreed prior to the modelling phase included the following.

2.1 Project Scope

The Model was to comprise the collection, recycling, treatment and disposal phases of the municipal waste management collection system, focussed on the areas and options addressed in the initial 'Waste and recycling collection service options modelling' report.

2.2 Project Year & Waste Composition

The project was modelled using the latest waste arisings and composition data (2019) and by applying the 2019 UK Energy Mix in WRATE. The waste composition was applied as shown in Table 1 below. .

Table 1: Waste composition applied in WRATE

Waste Fraction	%	Quantity [tonnes]
Paper and card		
Newspapers	7.6	5021.09
Magazines	7.5	4955.03
Card packaging	2.9	1915.94
Other card	1.6	1057.07
Unspecified plastic film	3.1	2048.08
Drinks bottles	1.8	1189.21
Other packaging	3.4	2246.28
Unspecified textiles	1.7	1123.14
Unspecified combustibles	9.2	6078.16
Unspecified non-combustibles	6	3964.02
Green bottles	2	1321.34
Clear bottles	2	1321.34
Brown bottles	2	1321.34
Jars	0.8	528.536
Garden waste	25	16516.8
Food waste	20.7	13675.9
Steel food and drink cans	1.7	1123.14

Waste Fraction	%	Quantity [tonnes]
Aluminium drinks cans	0.4	264.268
Foil	0.6	396.402

This composition is a combination of the waste composition analysis data provided by Herefordshire Council (2019) and the addition of the anticipated amount of garden waste brought into the collection system via the free collections included in Options 1 – 3. Total waste arisings were modelled as 66,067tonnes per annum, again including the additional garden waste.

2.3 Project Assumptions

It is assumed for distances to the following facilities, a 'standard' 20km has been utilised:-

- Materials Recycling Facility (MRF)
- Landfill (of residual waste when the EfW plant is offline)

It is assumed that the Energy from Waste (EfW) plant operates 90% of the time, the remaining 10% of the time residual waste, in all scenarios, is sent to Landfill.

All transport of recyclables and waste after a transfer station or treatment facility takes place using bulk haul 'intermodal' vehicles in WRATE.

All collection activity utilises the vehicle types and mileages from the KAT (Kerbside Analysis Tool) modelling exercise undertaken in the preceding project[4]. The exception are the food waste vehicles for which there is not an equivalent vehicle to a specialist food waste collection vehicle, as a consequence a 7.5t caged recycling vehicle was used as an alternate. The mileages are included in Appendix A.

All landfill employed are standard 'clay liner, clay cap' type within WRATE.

The Air Pollution Control (APC) residues are sent to Avonmouth for treatment, however there is no processes equivalent to this in WRATE, and therefore these are sent to landfill in this model.

Contamination within recyclables is assumed to be left in the residual stream to account for the impacts of disposal of this material. The consequences of transporting it are captured in the vehicle mileage modelled in KAT.

2.4 Baseline Assumptions

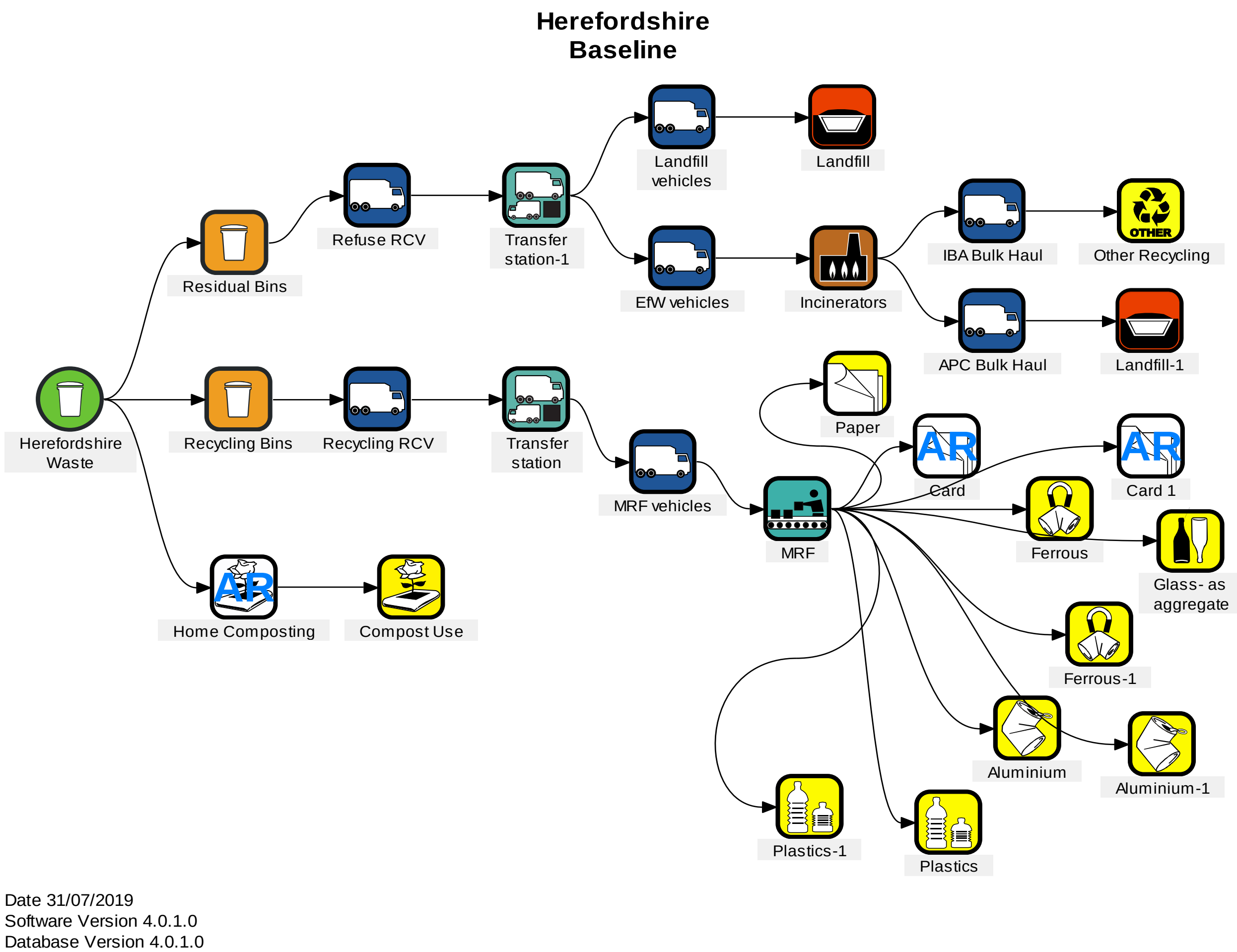
It is assumed that for all garden waste currently not collected in the baseline collection system, that this material is home composted. This is a significant assumption, as in practice some may be sent to a Household Waste Recycling Centre, other material home composted and some may be left as grass cuttings or burnt etc.

[4] For Herefordshire Council, Frith Resource Management, July 2019

For glass sent to the MRF, it is assumed that all glass from the facility is sent as aggregate (none is suitable for remelt applications).

The schematic for the Baseline model is shown as Figure 1.

Figure 1: Baseline (current) Herefordshire model



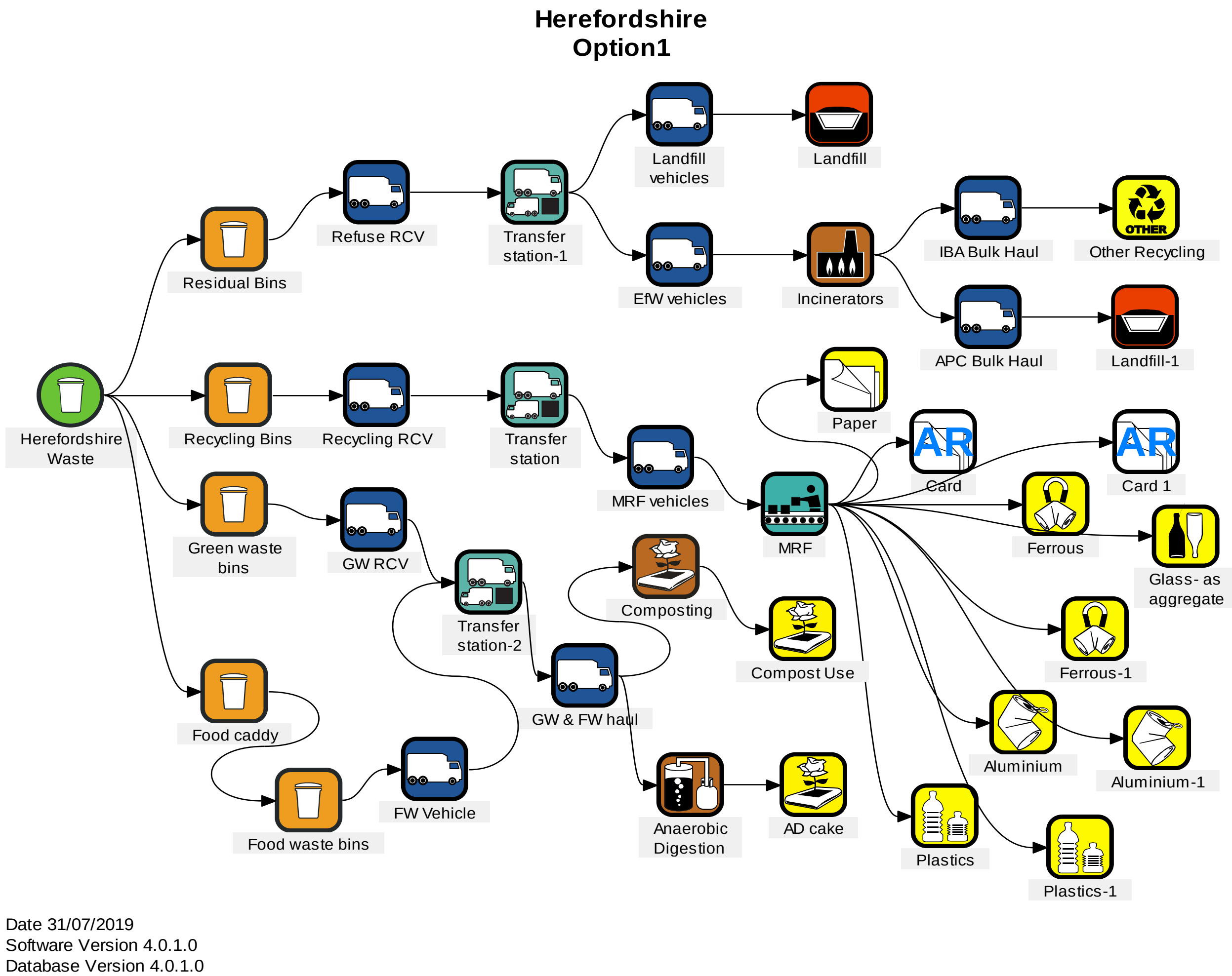
2.5 Option 1 Assumptions

It is assumed that the garden waste estimated under the previous Collection Options Appraisal project is captured via the free garden collection scheme. This waste is sent 5km to an Open Windrow Composting facility and the resulting compost applied to land.

The food waste yield is derived from the Waste & Resources Action Programme (WRAP) 'ready reckoner' and is based on a statistical link between socio-demographics and food waste arisings. We have assumed the low yield within the range for this option. All food waste is sent 5km to a wet anaerobic digestion process (the Biogen process in WRATE) and the resultant digestate is applied to land.

The schematic for Option 1 is shown in Figure 2 below.

Figure 2: Option 1 Herefordshire Model



2.6 Option 2 Assumptions

It is assumed that the garden waste estimated under the previous Collection Options Appraisal project is captured via the free garden collection scheme. This waste is sent 5km to an Open Windrow Composting facility and the resulting compost applied to land.

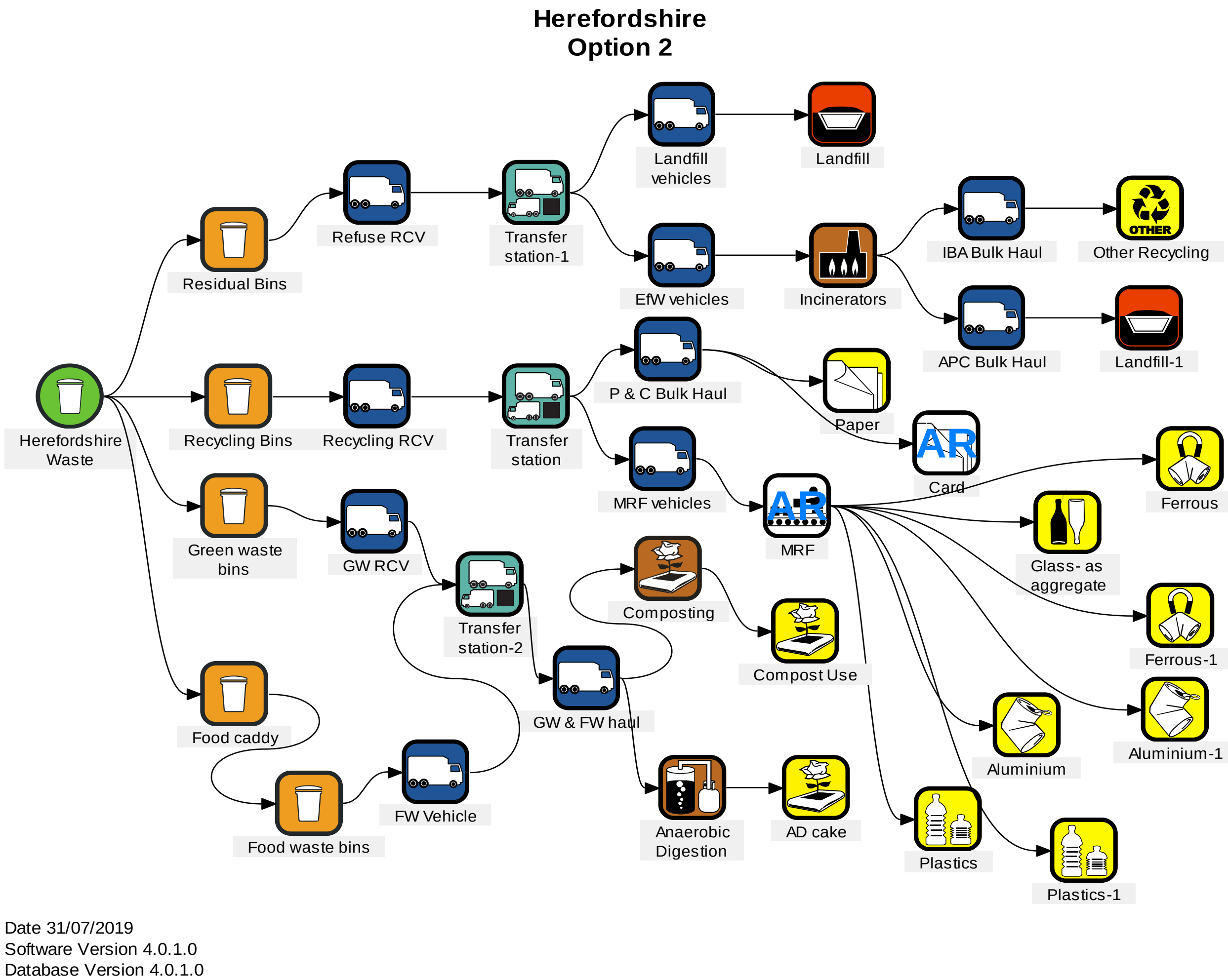
The food waste yield is derived from the WRAP 'ready reckoner' for food waste collection, and based on a statistical link between socio-demographics and food waste arisings. We have assumed the medium yield within the range for this option. All food waste is sent 5km to a wet anaerobic digestion process (the Biogen process in WRATE) and the resultant digestate is applied to land.

An uplift[5] has been applied to the dry recycling as a result of the three weekly residual waste collection. The dry recyclables are collected via a two stream collection (paper and card separate), and it is assumed that all recyclables have a 20km transfer distance.

[5] +5% materials capture +2% participation

The schematic for Option 2 is shown in Figure 3 below.

Figure 3: Option 2 Herefordshire Model



2.7 Option 3 Assumptions

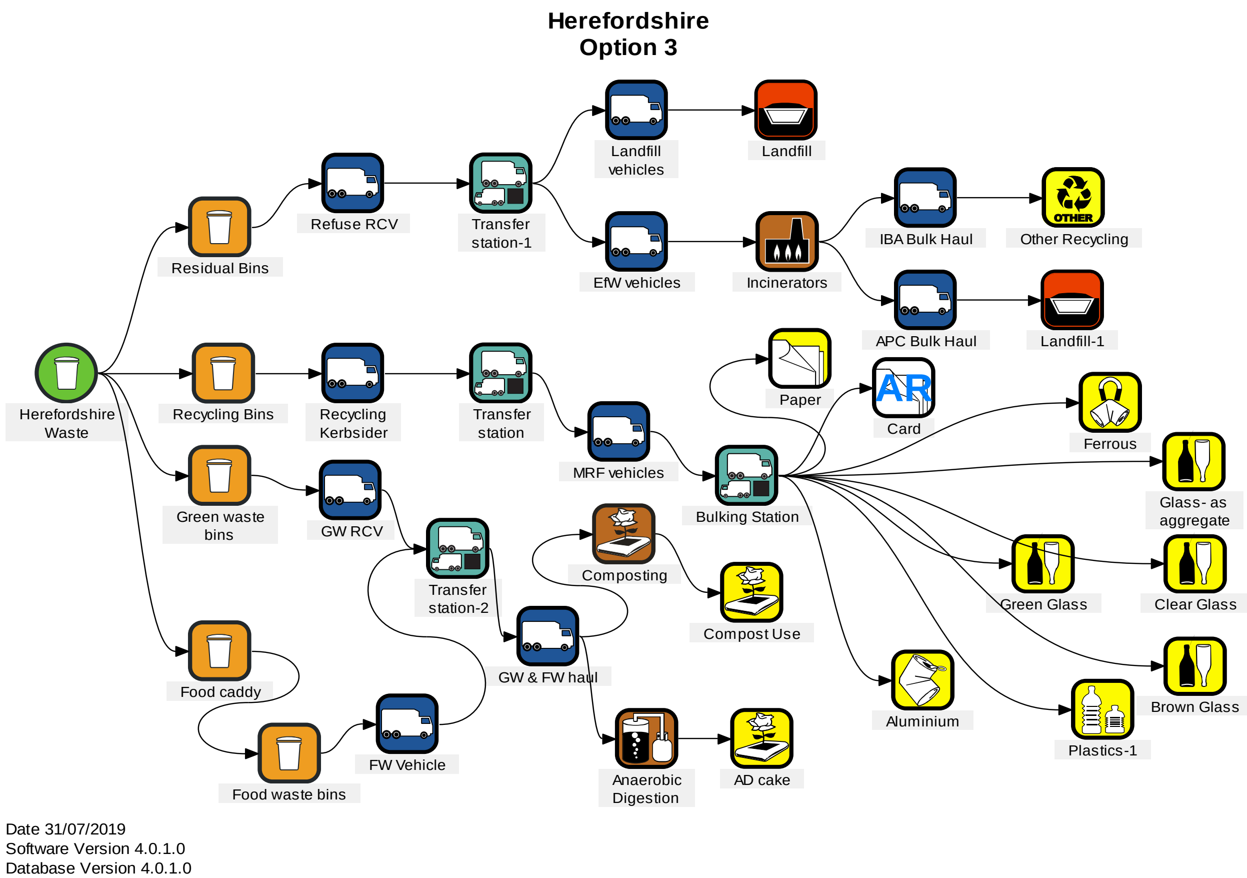
It is assumed that the garden waste estimated under the previous Collection Options Appraisal project is captured via the free garden collection scheme. This waste is sent 5km to an Open Windrow Composting facility and the resulting compost applied to land.

The food waste yield is derived from the WRAP 'ready reckoner' for food waste collection, and based on a statistical link between socio-demographics and food waste arisings. We have assumed the low yield within the range for this option. All food waste is sent 5km to a wet anaerobic digestion process (the Biogen process in WRATE) and the resultant digestate is applied to land.

Dry recycling yield is the same as option 1, however it is collected in compartmentalised vehicles and bulked at a facility 20km away from the transfer station. The glass within the collection is predominantly sent for remelt in colour specific processes, 11.75% of the glass (representing the non colour specific jars in the waste composition profile, table 1) is sent for aggregate.

The schematic for Option 3 is shown in Figure 4 below. .

Figure 4: Option 3 Herefordshire Model



3 Results

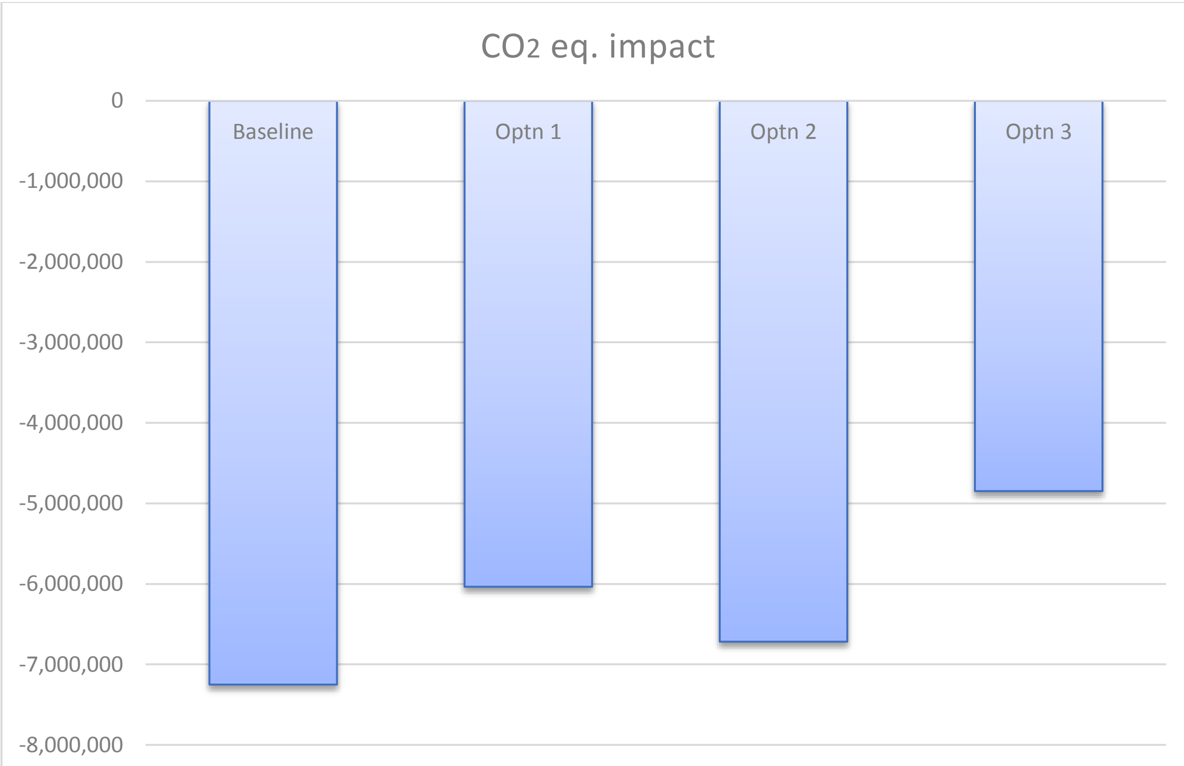
The findings of the WRATE modelling exercise are outlined in the following tables. They represent Life Cycle Assessment results, and so consider the impact of vehicles and infrastructure as a proportion of their use and their life, so for example the impact of the Energy from Waste plant (including construction burdens and operational impacts) will be assessed over a 25 year life and annualised to reflect a years' impact. As a waste management model, one of the key outcomes is the avoided impact of effective waste management, for example emissions displaced from extracting / processing of virgin materials versus secondary materials recovery for recycling. Similarly, energy recovery from waste can offset some of the emissions from fossil fuel based alternatives.

Figure 5 shows the carbon impact of the baseline and 3 alternative options as this is the focus of the project.

All emissions relating to global warming impacts (e.g. methane, carbon dioxide, nitrous oxide) are converted to kg of CO_2 equivalent, over a 100-year timeframe. This is standard practice for models considering carbon impacts of waste management processes.

It should be noted that, the lower the number, the lower the impact (or in the case of negative numbers like below (Figure 5), a -1000, is better than a -800). Negative numbers arise where recycling and energy recovery, as noted above, has offset more damaging, carbon intensive processes, such as primary resource extraction and burning of fossil fuels. This therefore represents a carbon 'saving' as a result of the resource management activity in Herefordshire.

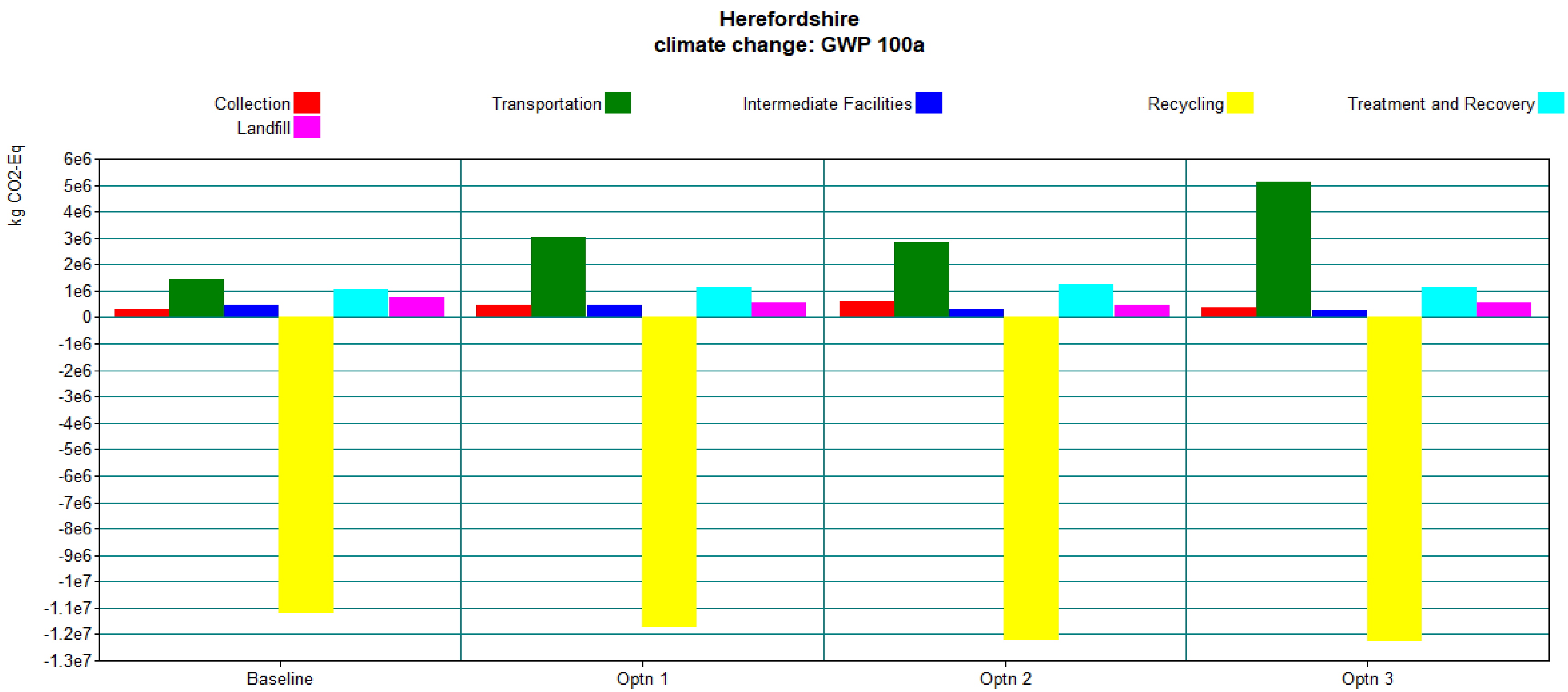
Figure 5: Global Warming Potential, expressed as kg of CO_2 equivalent



The detail behind these totals are illustrated in Figure 6. These results are classified as follows:-

- **Collection** – this accounts for the environmental burdens of the collection containers (only), so the burdens in making the containers for the various collection systems
- **Transportation** - this accounts for emissions from the vehicles in terms of construction burdens as well as fuel related emissions. This covers both collection from households and bulk haulage.
- **Intermediate Facilities** – these are the environmental burdens of transfer stations, materials recycling facilities. They include the construction and operating burdens.
- **Recycling** – this is the environmental benefit of recycling, displacing primary resource extraction / refining.
- **Treatment & Recovery** - These are the environmental burdens of composting plants, AD facilities and Energy from Waste facilities. They include the construction and operating burdens, and also any benefits associated with energy recovery.
- **Landfill** – This comprises the environmental burdens of landfill (with some benefits associated with energy recovery from landfill gas).

Figure 6: Breakdown of carbon impacts by process, for each option



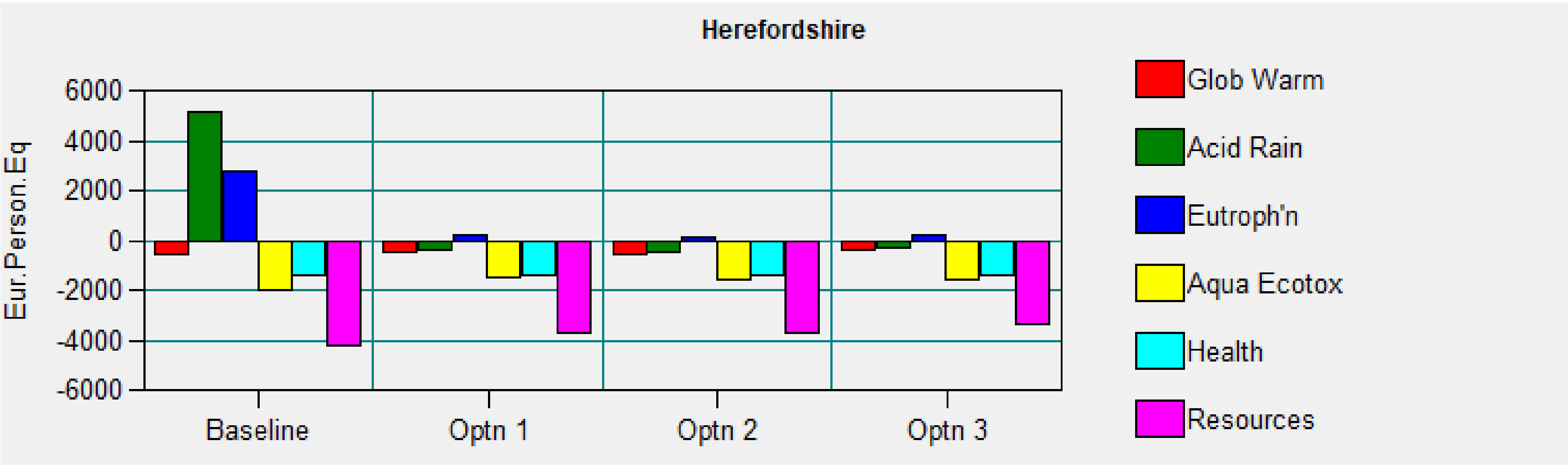
In addition to the modelling of carbon impacts, the WRATE model also derives other environmental impacts as shown in Table 2

Table 2: Quantified Environmental impacts

Impact Assessments	Unit	Baseline	Optn 1	Optn 2	Optn 3
climate change: GWP 100a	kg CO2-Eq	-7,250,189	-6,035,499	-6,717,757	-4,847,456
acidification potential: average European	kg SO2-Eq	367,181	-29,428	-33,036	-23,928
eutrophication potential: generic	kg PO4-Eq	93,633	6,041	5,439	7,443
freshwater aquatic ecotoxicity: FAETP infinite	kg 1,4-DCB-Eq	-2,679,737	-1,990,338	-2,057,909	-2,030,585
human toxicity: HTP infinite	kg 1,4-DCB-Eq	-28,370,240	-27,213,358	-27,814,134	-27,295,474
resources: depletion of abiotic resources	kg antimony-Eq	-161,557	-141,471	-144,302	-130,648

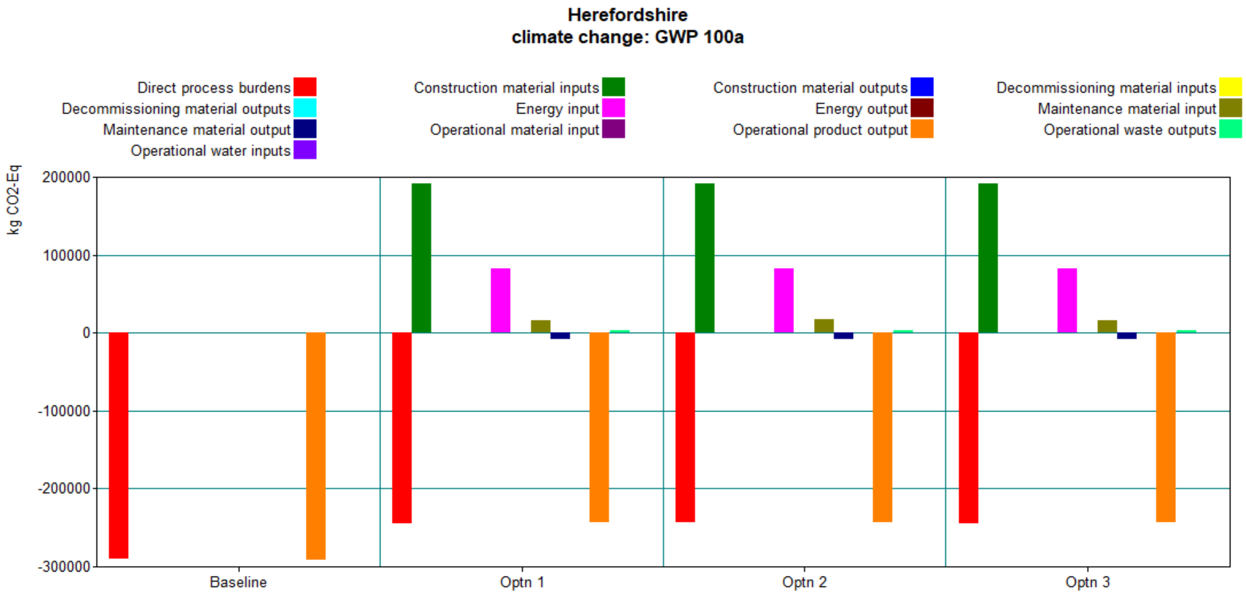
In order to compare across different environmental fields a 'normalisation' measure is applied, in this case using the measure of 'numbers of equivalent European persons' impact against each measure, the results of which are included in Figure 7.

Figure 7: Comparison of the six environmental criteria within the WRATE model



It is possible to derive more detail about the individual environmental burden emissions from the different scenarios in WRATE. An example of the green waste management is included in Figure 8 below.

Figure 8: Environmental emissions from green waste management



WRATE takes account of avoided carbon impacts, as noted previously, and whilst these may be separated out on a case by case basis, for example through de-selection of certain process stages above, some categories may have both a positive or negative impact (for example 'direct process burdens') and so care should be taken with that approach, as the net figure may be presented.

4 Conclusions

The results of this study show that the baseline (current service) has the lowest carbon impact, and is the most beneficial in carbon terms. The reasons for this are primarily as follows:-

- **It has the lowest transport impact** – all other options have substantially more vehicle movements as the result of the introduction of a fortnightly free garden waste collection and a weekly food waste collection. There may however be some impacts unaccounted for in the model, for example if many households make individual car journeys to the HWRC to deposit garden waste, however it is unclear as to the magnitude of this, and it is outside of the scope of the model.
- **The carbon benefit of composting the garden waste is already captured** – the fact that there are relatively low amounts of garden waste within the residual stream at present suggests that, of the available garden waste to be drawn into a free collection, this is probably already being composted either at home or at the HWRC in most cases, and therefore there is limited additional carbon benefit gained in options 1, 2 and 3.
- **The residual waste is predominantly managed via the Energy from Waste plant** – this means that the carbon impact of, for example food waste, is much lower than would be the case from landfill, and so there is less of a relative carbon benefit from digesting it in an anaerobic digestion facility.

Setting aside the Baseline service, which is unlikely to be deliverable under future resource management policies, the best of the alternative three options analysed is Option 2, which performs well compared to options 1 and 3, due to lower transport emissions and higher recycling, both as a result of the 3 weekly residual waste / recyclables collection.

Other points

There is some sensitivity to the following assumptions:-

- The home composting of garden waste assumed in the baseline is a significant assumption as identified above
- The 10% diversion into landfill of the residual stream (representing EfW 'downtime') will have a material effect, notably on the impact of the food waste collection system
- The 27% efficiency of the EfW plant is good practice, however lower actual performance will affect the relative impact of residual waste treatment

Whilst the focus of the project is on carbon impacts, there are some major shifts in some of the other environmental impacts, notably acidification and eutrophication, which show dramatic improvements in all the other options (1, 2 & 3) relative to the baseline. This is primarily a factor of the impact of home composting, and therefore highlights the sensitivity to this parameter in the model.

Appendix A Vehicle Mileages from KAT model

Baseline		
	Annual	*Total KM's per annum*
Residual	244467	**500860**
Dry recycling	256393	
Option 1		
Residual	233484	**1473604**
Dry recycling	256393	
Food	799619	
Garden	184109	
Option 2		
Residual	101775	**1329415**
Dry recycling (P&C)	107520	
Dry recycling (DMR)	107520	
Food	828490	
Garden	184109	
Option 3		
Residual	233484	**2399274**
Dry recycling	1182063	
Food	799619	
Garden	184109	