

Modelling Fuel Consumption in Kerbside Source Segregated Food Waste Collection: Separate Collection and Co-collection

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Outline

- Introduction
- Motivation
- Methodology
- Findings
- Conclusion
- Future work

Introduction

- In Europe, 25%-35% of food waste in household waste
- Adverse effect on the environment
- Direct and indirect measures to tackle the problem
 - EU landfill Directive (1999/31/EC)
 - Waste (Scotland) Regulations
- AD industry demands for contaminant-free food waste

Introduction



- Minimise the energy use in waste collection to maximise the net energy gain from the process
- Energy recovered can be used in collection vehicle

Introduction

- In the UK, 64% of population are offered food waste collection; 41% collect food waste only (Heaven et al., 2012)
- Collection methods: Kerbside and bring site
- Collection frequency is varied, weekly or fortnightly
- Collection vehicle: Single or multi-compartment



Motivation

- Lack of studies on energy consumption with respect to source segregated food waste
- Choice of collection system and separation category has significant implications
- Limited access to information to support the choice of collection vehicle

Aim and objective

- Compare the differences in fuel consumption for single collection and co-collection
- Select the optimal collection system
- Select the best refuse collection vehicle

Methodology

- Developed a deterministic model to allow analysis of fuel consumption (Everett & Shahi, 1997; Sonesson, 2000)

File Analyse

Waste Area RCVs Output

General Information

Area Name: Default

Number of Households: 20000

Number of Collectors: 3

Total Household Waste Gen: 2.38 kg/HH/day

Set Out Rate: 100

Speed

Speed In Collection: 10 kph

Speed In Transportation: 50 kph

Time

Working Hours: 6 hours

Break: 30 mins

Traffic Congestion: 0 mins

Pickup Crews: 5 mins

Fuel Filling: 10 mins

Depot To First Dwelling: 15 mins

Last Dwelling To Depot: 15 mins

At Unloading Site: 30 mins

Dwelling To Bulking When Full: 15 mins

Bulking Point To Depot: 0 mins

Unloading Tip: 15 mins

Pickup Time Biowaste: 21.6 secs

Pickup Time Mixed Recyclable: 33 secs

Pickup Time Residual: 33 secs

Sort Time Mixed Recyclable: 60 secs

Distance

From Depot To Dwelling: 12.5 km

From Dwelling To Depot: 12.5 km

Between Dwellings: 0.015 km

To Tip: 12.5 km

Bulking To Depot: 0 km

Vehicles

RCV	Frequency
1 Twin2	Weekly

Collection

Collection	Frequency	RCV
1 Recyclable	Weekly	1
2 Residual	Fortnightly	1

Waste Type

Composition	Proportion	Capture Rate	To	Density	Compartment	Bin
1 Paper and Card	24.85	50	Recyclable	405	1	1
2 Food	24.10	50	BioWaste	473	2	3
3 Garden and other organic waste	13.45	0	NotCollected	338	0	0
4 Plastics	10.92	50	Recyclable	405	1	1
5 Glass	6.23	50	Recyclable	405	1	1
6 Metals	3.30	50	Recyclable	405	1	1
7 Wood	0.84	0	Residual	69	2	2
8 Textiles	2.93	0	Residual	69	2	2
9 WEEE	1.03	0	Residual	69	2	2
10 Other	12.35	0	Residual	69	2	2

Input of the collection model

File Analyse

Waste Area RCVs Output

Area Name: Default

Vehicles

RCV:	Twin2	Amount Of Waste Collected:	420.998	tonnes
Limiting Collection:	Residual	Distance Per Collection:	6,300.000	kilometres
Limited By:	Volume	Number Of Routes Per Collection:	60	
Time Per Household:	20.96	secs	Total Time Spent In Collection:	311.424
Frequency:	Weekly		Total Time:	356.424
Max Households Before Tip:	90		Fuel Per Tonne Collected:	3.732
Max Weight Before Tip:	1.894	tonnes		
Number Of Rounds Per Day:	4			
Max Households Per Day:	343			
Average Households Per Day:	334			
Number Of Vehicles:	12			
Laden Percent:	18.94			
Fuel Consumption In Collection:	224.45	litres		
Fuel Consumption Depot To Collection Area:	161.64	litres		
Fuel Consumption Collection Area To Bulking:	175.05	litres		
Fuel Consumption To Tip:	525.14	litres		
Fuel Consumption From Tip:	484.92	litres		
Fuel Consumption Bulking To Depot:	0.00	litres		
Fuel Consumption Total:	1,571.19	litres		
Energy Consumption Total:	63,004.88	MJ		

Output of the collection model

Methodology

- Composition of kerbside household waste
 - On average, 869.4 kg of kerbside waste generated from each household per year

Waste type	Composition (%)
Paper and card	24.85
Food	24.1
Garden & other organic waste	13.45
Plastics	10.92
Glass	6.23
Metals	3.3
Wood	0.84
Textiles	2.93
WEEE	1.03
Others	12.35

(Adapted from DEFRA, 2006)

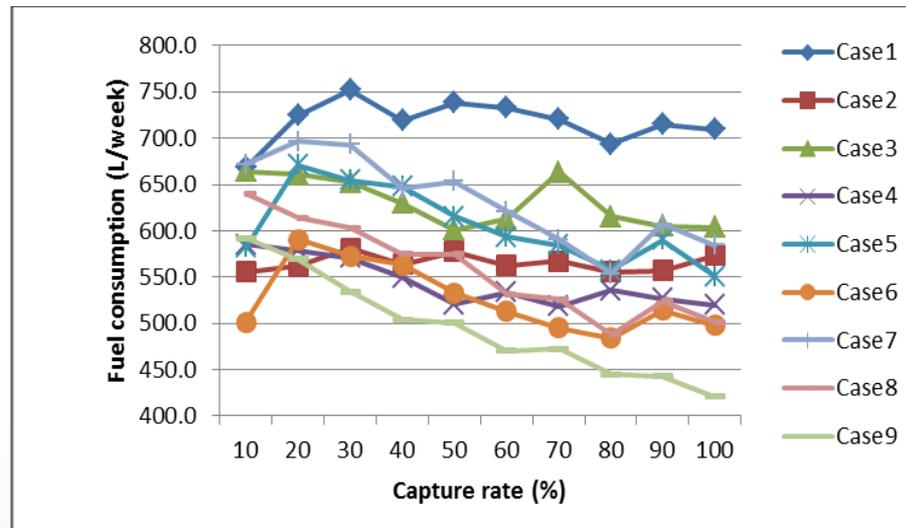
Methodology

- A hypothetical city of 20,000 households
- 6 different sizes of single compartment vehicles and 6 compartmentalised vehicles with different size and split ratio
- Weekly food waste collection run along with weekly or fortnightly basis for recyclable and residual waste collection

Methodology

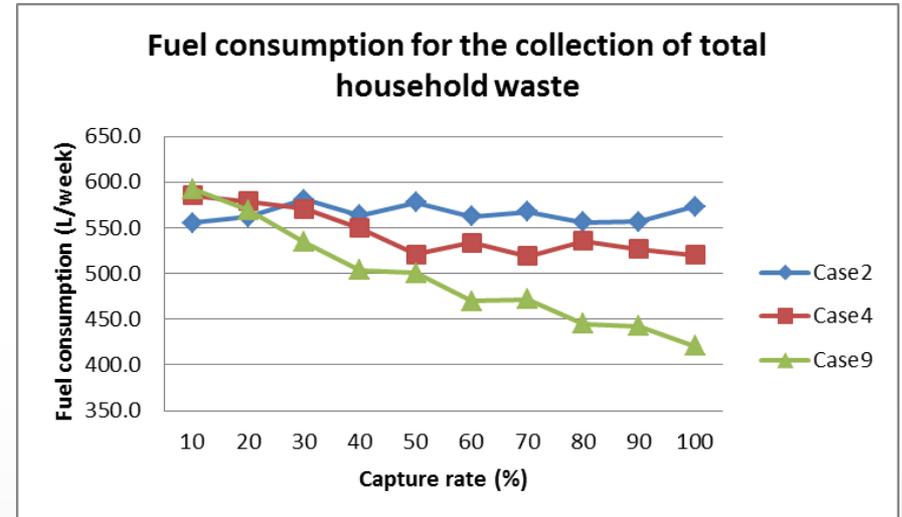
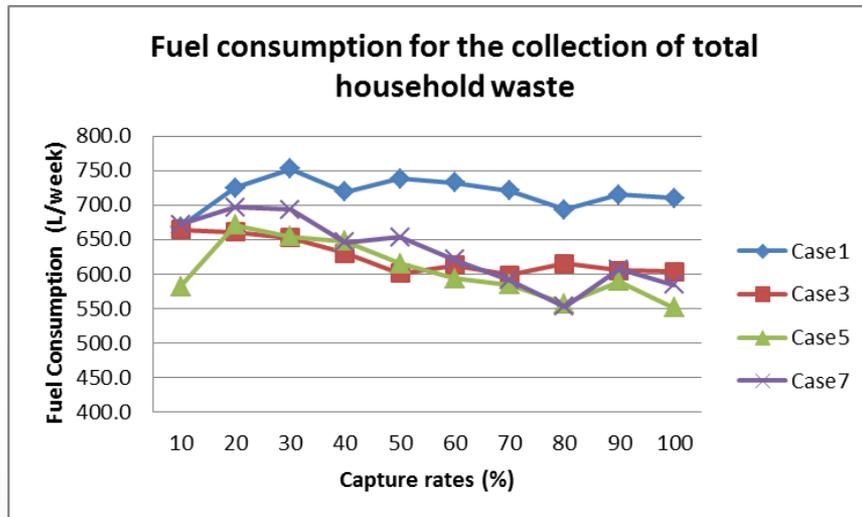
Scenario	Description
1	Weekly separate collections of recyclables, residual and food waste by single-compartment RCV
2	Alternate fortnightly collection of recyclables and residual waste and weekly collection of food waste and by single-compartment RCV
3	Weekly co-collection of recyclables and residual waste by compartmentalised RCV, weekly collection using single-compartment RCV for food waste
4	Fortnightly co-collection of recyclables and residual waste by compartmentalised RCV, weekly collection using single-compartment RCV for food waste
5	Weekly co-collection of recyclables and food waste by compartmentalised RCV, weekly collection using single-compartment RCV for residual waste
6	Weekly co-collection of recyclables and food waste by compartmentalised RCV, fortnightly collection using single-compartment RCV for residual waste
7	Weekly co-collection of residual waste and food waste by compartmentalised RCV, weekly collection using single compartment RCV for recyclables
8	Weekly co-collection of residual waste and food waste by compartmentalised RCV, fortnightly collection using single compartment RCV for recyclables
9	Weekly food waste collection with alternate weekly collection of residual waste and recyclables by compartmentalised RCV

Findings – Fuel consumption



- The best collection system:
Weekly food waste collection with AWC of recyclable and residual waste by compartmentalised vehicle
- The worst collection system:
Weekly separate collections of recyclables, residual and food waste by single-compartment RCV

Findings – Fuel consumption



- Fuel saved by weekly co-collection of household waste ranges from 7.4% to 22.4 %
- Scenarios 4 and 9 use 1.8-9.8% and 8.1-26.6% less fuel than scenario 2 at capture rates of 30% or more.

Findings – Collection vehicle

- Two-compartment RCV is not always fully utilised, limited by the volume of the compartment.
- Pod vehicle is better than the rear split collection vehicle
- 30:70 split ratio of compartment is better than 50:50 split
- Lighter material for the compartment body could improve performance

Conclusion

- Fuel consumption on single and co-collection was studied
- Recommended to adopt weekly food waste collection with AWC of the recyclables and residual waste by two compartment vehicles
- A pod vehicle with a large compartment capacity and split into 30:70 is always better than the rear split collection vehicle.

Future work

- Further studies include looking at:
 - The same scenarios but at less than 100% set-out rate;
 - The same scenarios but with different capture rates for different recyclable components
- Study the energy use in collection by multi-compartment vehicle (up to 9 compartments)

Reference

- Everett, J. W. & Shahi, S. 1997. Vehicle and labor requirements for yard waste collection. *Waste Management & Research*, 15, 627-640.
- Sonesson, U. 2000. Modelling of waste collection—a general approach to calculate fuel consumption and time. *Waste Management and Research*, 18, 115-123.
- Heaven, S., Climenhage, M., Riley, K. & Gredmaier, L. 2012. Valorisation of food waste to biogas. *Assessment of typical source segregated food waste collection schemes in operation in Europe detailing factors influencing yield, capture rates and efficiency*. Southampton: University of Southampton.