Comparison of Greenhouse Gas Emissions from Centralised and Household Treatments of Food Waste

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Food Cycle GHG Emissions

Complete food life cycle responsible for
22% of UK's total GHG emissions from:

- fossil energy sources used in farming
- manufacture of fertilisers & pesticides
- food processing, storage, packaging, transport, retailing & preparation
- management of waste (6.7 Mt/y household food)

Reference Centralised Treatment Waste Management System

- Kerbside collection of household segregated uncontaminated food waste in purpose supplied Food Waste Collection Receptacles (FWCRs)

- Transportation of waste via transfer station to In-Vessel Composting (IVC) plant & treatment

- Bulk transportation of compost to suitable application sites & subsequent land spreading

Reference Household Treatment Waste Management System

- Household segregation of uncontaminated food waste

- Waste deposited into reference Food Waste Digester (FWD) located in household's garden

Function of Reference FWD

- Accelerate natural decomposition process by:
  - raising temperatures
  - maintaining aerobic conditions
  - encouraging growth of micro-organisms
- Contain & enclose food waste to prevent dispersion, soil contamination & eliminate odours
- Create barriers to human, farm animal, wild animal, pet & bird activity
- Meet all relevant legislation

Modelling Methodology (1)

- Common Life Cycle Assessment (LCA) approach adhering to principles of relevant ISO standards

- GHGs converted to Carbon Dioxide Equivalents (CO_2E) using standard Global Warming Potential (GWP) factors

- Emission factors (kg CO_2E/unit variable) acquired for each specified component of life cycle irrespective of geographic location

Modelling Methodology (2)

- Model includes emissions associated with:

  - embodied energy of capital plant & equipment expanded to include end-of-life treatment
  - energy consumed in day-to-day plant & transport operations
  - anthropogenic and biogenic processes

System Boundaries (1)

- **Includes** embodied & operational energy emissions of dedicated capital plant & equipment:
  - vehicles for collection & transportation of food waste from households to transfer station
  - vehicles for bulk transport of waste from transfer station to treatment plant
  - vehicles for bulk transport of compost from treatment plant to application site
  - IVC treatment plant
  - FWCRs & FWDs

System Boundaries (2)

- **Excludes** embodied energy emissions & **includes** operational energy emissions of non-dedicated plant & equipment:

    - e.g. freight ships & delivery vehicles for FWCRs/FWDs

System Boundaries (3)

- **Excludes** embodied & operational energy emissions associated with:
  - Secondary non-dedicated plant & equipment (e.g. transport & energy infrastructure)
  - management offices & infrastructure
  - minor components & consumables (e.g. operatives uniforms, cleaning products)
  - work related transport & staff food consumption
  - health & safety (e.g. emergency service support for accidents/fires & emissions associated with fires)

Study Calculations

- Case inputs:
  - 250,000 households, 20% food waste in 1 tonne MSW/household/year
- Sensitivity analysis:
  - input variables
  - individual uncertainties
  - system boundaries
  - key assumptions

Household Dispersion

Average distance between households

- This study:
  - urban < 0.02 km
  - semi-rural 0.02 - 0.10 km
  - rural > 0.10 km

- ERM Ltd:
  - UK average 0.03 - 0.04 km

- SLR Consulting Ltd:
  - Cheshire (semi-rural) 0.017 km

Collection Strategy

- Single pass segregated co-collection:
  - all MSW

- Semi-dedicated segregated co-collection:
  - e.g. excludes dry recyclables

- Dedicated segregated collection:
  - only food waste

Waste Collection Vehicles

- ## Typical urban cycle times:
  - 76% collection, 20% transfer, 4% unloading

- ## Fuel efficiency:
  - function of vehicle type, vehicle efficiency, speed, terrain, quality of road infrastructure, driver ability, household dispersion & collection strategy
  - 0.6 - 1.2 l/km over complete cycle
  - complete cycle 2 - 4 times less than freight vehicles
  - 40% fuel consumed generating hydraulic power
  - collection mode 3 - 7 times less than freight vehicles

Treatment Plant Compost

- Compost benefits:
  - improving soil structure & fertility
  - mitigating land degradation
  - rehabilitating degraded land

- Potential avoidance of inorganic fertilisers & soil improvers or peat:
  - wide range of offsets 14 - 61 kg CO_2E/t_w

- Concerns over food waste feedstock

Capital GHG Emissions

Manufacturing/Construction & End-of-Life Recycling/Disposal of Capital Plant & Associated Transportation	Centralised (kg CO_2E/t_w)	Household (kg CO_2E/t_w)
Waste treatment plant	3.77	
Waste collection vehicles	0.82	
Bulk waste transport vehicles	0.19	
Bulk compost transport vehicles	0.18	
FWCR or FWD units	6.41	4.68
Bulk transportation of FWCR or FWD units and/or feedstock materials	0.04	0.34
Household delivery & end-of-life collection of FWCR or FWD units	0.07	0.04
Total anthropogenic emissions	**11.48**	**5.06**

Operations GHG Emissions

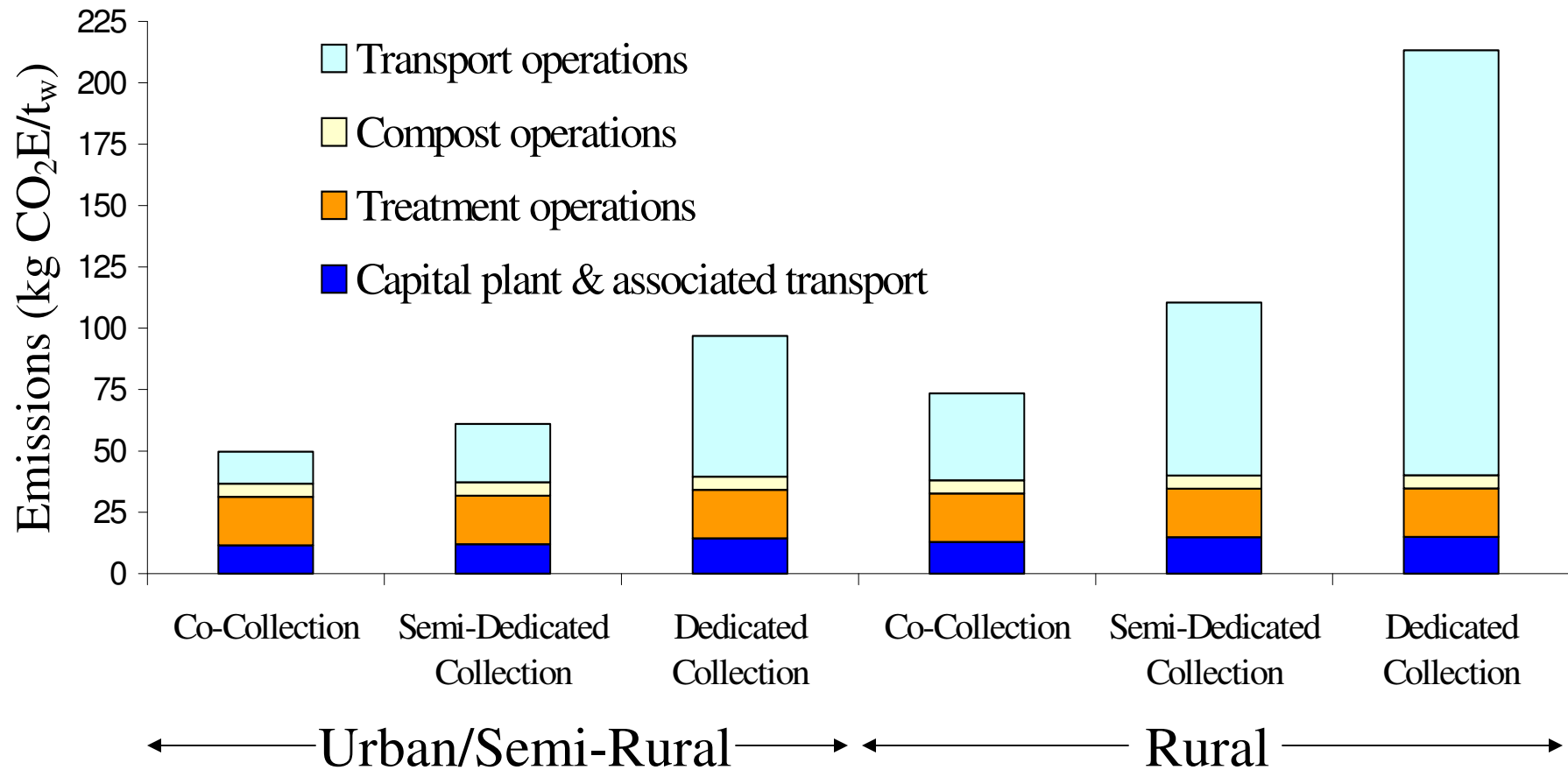| Day-to-Day Operations	Centralised (kg CO_2E/t_w)	Household (kg CO_2E/t_w)
Segregated household collection & transportation to transfer station	11.58	
Handling and bulking of waste at transfer station	0.22	
Bulk transportation of waste from transfer station to treatment plant	1.42	
Treatment of waste in IVC plant	19.56	
Bulk transportation of compost from treatment plant to application sites	2.96	
Application of compost to land using agricultural tractors & spreaders	2.47	
Total anthropogenic emissions	**38.21**	**0**

Total GHG Emissions

Component (Urban/Semi-Rural, Co-Collection)	Centralised (kg CO_2E/t_w)	Household (kg CO_2E/t_w)
Capital plant & associated transportation	11.5	5.1
Day-to-day operations	38.2	0
Total anthropogenic emissions	**49.7**	**5.1**

Annual Emissions Comparisons

Case (250,000 households, 20% food waste in 1 tonne MSW/household/year)	Centralised Treatment (t CO_2E/y)	Household Treatment (t CO_2E/y)
Urban/semi-rural, co-collection	2485	253
Urban/semi-rural, semi-dedicated collection	3051	253
Urban/semi-rural, dedicated collection	4744	253
Rural, co-collection	3675	260
Rural, semi-dedicated collection	5418	260
Rural, dedicated collection	10713	260

Centralised In-Vessel Treatment of Food Waste Greenhouse Gas Emissions

Emissions (kg CO_2E/t_w)

Legend:
- Transport operations
- Compost operations
- Treatment operations
- Capital plant & associated transport

Urban/Semi-Rural:
- Co-Collection
- Semi-Dedicated Collection
- Dedicated Collection

Rural:
- Co-Collection
- Semi-Dedicated Collection
- Dedicated Collection

Conclusions

- Centralised approach GHG emissions sensitive to:
  - household dispersion
  - waste collection strategy
  - vehicle & treatment plant efficiency
  - avoidable burden assumptions
- Household treatment GHG emissions 10 to 40 times less than centralised IVC approach

Household Treatment Economic, Health & Safety Benefits

- Economic:
  - costs 7 times less than centralised approach
  - £141 saving per tonne of waste
  - £7 M annual saving per 250,000 households
- Health & Safety:
  - lower vehicle pollution
  - helps reduce waste industry accident rate, injuries & fatalities

Final Conclusion

- Optimal household food waste management strategies should:
  - achieve health, safety, environmental & operational risk management standards
  - minimise costs
  - deliver targets
- Household treatment should be integral part of food waste management strategies

References

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3. SLR Consulting Limited (2007), Green Cone Sustainability Appraisal. *Report 402-1232-00002*, November 2007