Delivering sustainable solutions in a more competitive world

Carbon Balances and Energy Impacts of the Management of UK Wastes

Defra R&D Project WRT 237

Annex C

December 2006
Annex C

Carbon and Greenhouse Gas Balances
Carbon and greenhouse gas balances for each waste material and scenario are shown in the following diagrams. Each details:

- the carbon that remains within the material fraction following treatment or disposal (both carbon in inert fractions that have been deposited in land, as well as organic carbon that has not degraded but is sequestered in landfill or other soil carbon sink);
- carbon that is contained in products, such as recyclate or composts; and
- carbon that is released to atmosphere, as carbon dioxide (fossil/biogenically derived) or methane.

A greenhouse gas balance is shown in red, detailing:

- ‘ancillary’ greenhouse gas emissions predominantly associated with fuel, energy and transport;
- greenhouse gas releases directly associated with the degradation of waste materials (eg on biological processing or landfill of biogenic wastes, or combustion of fossil-derived materials); and
- avoided greenhouse gases through resource and energy recovery.

The information contained in these diagrams is summarised in Table C1.1.
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<th>Material/Scenario</th>
<th>Carbon in Waste</th>
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<th>Carbon Released as CO₂ (Fossil)</th>
<th>Carbon Released as CH₄</th>
<th>Carbon in Products</th>
<th>Carbon Remaining in Landfill/ Soil</th>
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<th>GHG Released from Fraction</th>
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<td>37.3</td>
<td>20.1</td>
<td>4.5</td>
<td>89.5</td>
<td>-47.0</td>
<td>-22.9</td>
<td>47.0</td>
<td>71.2</td>
</tr>
</tbody>
</table>
C1.1  PAPER AND CARD

Figure C1.1  Baseline Scenario

Carbon Balance (mt Carbon)  
100 year time frame

C as CO₂ (biogenic)  C as CO₂ (fossil)  C as CH₄

57.7  0.0  4.8

GHG from fraction (mt CO₂-eq)  
140.0

Avoided GHG (mt CO₂-eq)  
Max  127.3  Min  68.4

Ancillary GHG (mt CO₂-eq)  
4.6

118.0  C in waste  47.2  C in products

8.5  C remaining in fraction

Net GHG Emissions  
Min impact  17.2 mt CO₂ eq  
Max impact  76.1 mt CO₂ eq

Figure C1.2  High Resource Recovery Scenario

Carbon Balance (mt Carbon)  
100 year time frame

C as CO₂ (biogenic)  C as CO₂ (fossil)  C as CH₄

42.1  0.0  3.6

GHG from fraction (mt CO₂-eq)  
110.08

Avoided GHG (mt CO₂-eq)  
Max  150.8  Min  77.5

Ancillary GHG (mt CO₂-eq)  
5.0

118.0  C in waste  64.5  C in products

7.8  C remaining in fraction

Net GHG Emissions  
Min impact  35.7 mt CO₂ eq  
Max impact  37.6 mt CO₂ eq
Figure C1.3  High Energy Recovery Scenario

<table>
<thead>
<tr>
<th>C as CO2 (biogenic)</th>
<th>C as CO2 (fossil)</th>
<th>C as CH4</th>
</tr>
</thead>
<tbody>
<tr>
<td>85.3</td>
<td>0.0</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Carbon Balance (mt Carbon)  
100 year time frame

- GHG from fraction (mt CO2-eq) 83.6
- Ancillary GHG (mt CO2-eq) 6.1
- C in waste 118.0
- C in products 24.1
- C remaining in fraction 5.9

Net GHG Emissions  
Min impact -98.1 mt CO2 eq  
Max impact 8.3 mt CO2 eq

Figure C1.4  Combined Scenario

<table>
<thead>
<tr>
<th>C as CO2 (biogenic)</th>
<th>C as CO2 (fossil)</th>
<th>C as CH4</th>
</tr>
</thead>
<tbody>
<tr>
<td>42.7</td>
<td>0.0</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Carbon Balance (mt Carbon)  
100 year time frame

- GHG from fraction (mt CO2-eq) 103.7
- Ancillary GHG (mt CO2-eq) 5.2
- C in waste 118.0
- C in products 84.6
- C remaining in fraction 7.3

Net GHG Emissions  
Min impact -155.0 mt CO2 eq  
Max impact -78.5 mt CO2 eq
C1.2 KITCHEN/FOOD WASTE

Figure C1.5 Baseline Scenario

Figure C1.6 High Resource Recovery Scenario
Figure C1.7  High Energy Recovery Scenario

![High Energy Recovery Scenario Diagram](image)

Figure C1.8  Combined Scenario

![Combined Scenario Diagram](image)
C1.3  GREEN WASTE

Figure C1.9  Baseline Scenario

![Baseline Scenario Diagram]

Figure C1.10  High Resource Recovery Scenario

![High Resource Recovery Scenario Diagram]
Figure C1.11  High Energy Recovery Scenario

Carbon Balance (mt Carbon)
100 year time frame

C as CO₂ (biogenic)  C as CO₂ (fossil)  C as CH₄

33.1  0.0  0.5

GHG from fraction (mt CO₂-eq) 17.42
Avoided GHG (mt CO₂-eq)
Max 47.6  Min 24.0

Ancillary GHG (mt CO₂-eq) 6.1

49.2 C in waste

12.7 C in products

C remaining in fraction 2.9

Figure C1.12  Baseline Scenario

Carbon Balance (mt Carbon)
100 year time frame

C as CO₂ (biogenic)  C as CO₂ (fossil)  C as CH₄

21.5  0.0  0.0

GHG from fraction (mt CO₂-eq) 0.0
Avoided GHG (mt CO₂-eq)
Max 4.7  Min -1.4

Ancillary GHG (mt CO₂-eq) 0.8

22.0 C in waste

0.0 C in products

0.5 C remaining in fraction

Net GHG Emissions
Min impact -3.9 mt CO₂ eq
Max impact 0.7 mt CO₂ eq

C1.4  AGRICULTURAL CROP WASTE
Figure C1.13  High Resource Recovery Scenario

Figure C1.14  High Energy Recovery Scenario
**Figure C1.15** Baseline Scenario

![Diagram of Baseline Scenario]

- **Carbon Balance (mt Carbon)**
  - 100 year time frame
  - C as CO₂ (biogenic): 379.1
  - C as CO₂ (fossil): 0.0
  - C as CH₄: 0.0

- **Ancillary GHG**
  - (mt CO₂-eq): 8.3

- **Net GHG Emissions**
  - Min impact: 8.8 mt CO₂-eq
  - Max impact: 5.2 mt CO₂-eq

- **C in waste**: 388.6

- **C in products**: 0.2

- **C remaining in fraction**: 9.4

**Figure C1.16** High Resource Recovery Scenario

![Diagram of High Resource Recovery Scenario]

- **Carbon Balance (mt Carbon)**
  - 100 year time frame
  - C as CO₂ (biogenic): 333.2
  - C as CO₂ (fossil): 0.0
  - C as CH₄: 0.0

- **Ancillary GHG**
  - (mt CO₂-eq): 16.3

- **Net GHG Emissions**
  - Min impact: 3.5 mt CO₂-eq
  - Max impact: 15.7 mt CO₂-eq

- **C in waste**: 388.6

- **C in products**: 48.4

- **C remaining in fraction**: 7.0
**Figure C1.17  High Energy Recovery Scenario**

![Diagram showing carbon balance in a high energy recovery scenario](image)

- Carbon Balance (mt Carbon) 100 year time frame
- C as CO2 (biogenic): 333.0
- C as CO2 (fossil): 0.0
- C as CH4: 0.0
- GHG from fraction (mt CO2-eq): 2.2
- Ancillary GHG (mt CO2-eq): 22.7
- Avoided GHG (mt CO2-eq): Max -191.3, Min -84.6
- C in waste: 388.6
- C in products: 48.6
- Net GHG Emissions:
  - Min impact: -106.3 mt CO2 eq
  - Max impact: -59.6 mt CO2 eq
- C remaining in fraction: 7.0

**C1.6  ‘OTHER ORGANICS’**

**Figure C1.18  Baseline Scenario**

![Diagram showing carbon balance in a baseline scenario](image)

- Carbon Balance (mt Carbon) 100 year time frame
- C as CO2 (biogenic): 26.1
- C as CO2 (fossil): 0.0
- C as CH4: 0.1
- GHG from fraction (mt CO2-eq): 2.6
- Ancillary GHG (mt CO2-eq): 1.7
- Avoided GHG (mt CO2-eq): Max -7.9, Min -3.0
- C in waste: 28.6
- C in products: 1.7
- Net GHG Emissions:
  - Min impact: -3.6 mt CO2 eq
  - Max impact: 1.2 mt CO2 eq
- C remaining in fraction: 0.7
**Figure C1.19  High Resource Recovery Scenario**

Carbon Balance (mt Carbon)  
100 year time frame

- C as CO₂ (biogenic): 23.1
- C as CO₂ (fossil): 0.0
- C as CH₄: 0.1
- GHG from fraction (mt CO₂-eq): 3.0
- Avoided GHG (mt CO₂-eq): Max Min
  - 4.5 -1.9

C in waste: 28.6  
C in products: 4.8  
C remaining in fraction: 0.7

**Figure C1.20  High Energy Recovery Scenario**

Carbon Balance (mt Carbon)  
100 year time frame

- C as CO₂ (biogenic): 25.5
- C as CO₂ (fossil): 0.0
- C as CH₄: 0.1
- GHG from fraction (mt CO₂-eq): 2.8
- Avoided GHG (mt CO₂-eq): Max Min
  - 29.3 -10.7

C in waste: 28.6  
C in products: 1.5  
C remaining in fraction: 0.5

Net GHG Emissions
- Min impact: 0.5 mt CO₂-eq
- Max impact: 3.1 mt CO₂-eq

Net GHG Emissions
- Min impact: -24.5 mt CO₂-eq
- Max impact: -5.9 mt CO₂-eq
Figure C1.21  Combined Scenario

![Combined Scenario Diagram]

Figure C1.22  Baseline Scenario

![Baseline Scenario Diagram]
Figure C1.23  High Resource Recovery Scenario

Figure C1.24  High Energy Recovery Scenario
C1.8 TEXTILES

Figure C1.26 Baseline Scenario
Figure C1.27  High Resource Recovery Scenario

Figure C1.28  High Energy Recovery Scenario
Figure C1.29  Combined Scenario

Figure C1.30  Baseline Scenario
Figure C1.31 High Resource Recovery Scenario

Figure C1.32 High Energy Recovery Scenario
**Figure C1.33 Combined Scenario**

![Diagram](Image)

**C1.10 PLASTIC (FILM)**

**Figure C1.34 Baseline Scenario**

![Diagram](Image)
Figure C1.35  High Resource Recovery Scenario

Figure C1.36  High Energy Recovery Scenario
C1.11 FERROUS METALS

Figure C1.38 Baseline Scenario
**Figure C1.39  High Resource Recovery Scenario**

**Figure C1.40  Baseline Scenario**
C1.13 **SOILS**

**Figure C1.41 High Resource Recovery Scenario**

![Diagram of Carbon Balance (mt Carbon) 100 year time frame showing C as CO2 (biogenic), C as CO2 (fossil), C as CH4, GHG from fraction (mt CO2-eq), Avoided GHG (mt CO2-eq), Net GHG Emissions (Min impact, Max impact), C in waste, C in products, C remaining in fraction.]

**Figure C1.42 Baseline Scenario**

![Diagram of Carbon Balance (mt Carbon) 100 year time frame showing C as CO2 (biogenic), C as CO2 (fossil), C as CH4, GHG from fraction (mt CO2-eq), Avoided GHG (mt CO2-eq), Net GHG Emissions (Min impact, Max impact), C in waste (fossil), C in products, C remaining in fraction.]

**C1.14** *SOILS (MINING, QUARRYING, MARINE DERIVED)*

**Figure C1.44** Baseline Scenario
Figure C1.45  Baseline Scenario

Figure C1.46  High Resource Recovery Scenario