# Appendix D

# Comparison of GHG emission factor data from the literature

An overview of material recycling GHG emission factors reported in the literature is presented in Table D1.

**Table D1**

Overview of material recycling GHG emissions literature data.

| Waste material group | Waste material type | Reference | Geographic coverage | Reference year | Substituted production | GHG emissions (net) kg CO2-eq. |
| --- | --- | --- | --- | --- | --- | --- |
| Glass | Green glass | Pratt (2014) | Scotland | 2012 | 56% primary glass; 44% primary aggregates | -201 |
| WRAP (2012) | England | 2011 | Unknown | -392 |
| Larsen *et al.* (2009) | Northern Europe | 2009 | Primary glass | -506 to -445 |
| Fisher (2006) | UK | 2006 | Primary glass | -762 |
| Smith *et al.* (2001) | Europe | 2001 | Primary glass | -253 |
| US EPA (2015) | USA | 2015 | Primary glass | -309 |
| Brown glass | Pratt (2014) | Scotland | 2012 | 56% primary glass; 44% primary aggregates | -201 |
| WRAP (2012) | England | 2011 | Unknown | -392 |
| Larsen *et al.* (2009) | Northern Europe | 2009 | Primary glass | -506 to -445 |
| Fisher (2006) | UK | 2006 | Primary glass | -762 |
| Smith *et al.* (2001) | Europe | 2001 | Primary glass | -253 |
| US EPA (2015) | USA | 2015 | Primary glass | -309 |
| Clear glass | Pratt (2014) | Scotland | 2012 | 56% primary glass; 44% primary aggregates | -201 |
| WRAP (2012) | England | 2011 | Unknown | -392 |
| Larsen *et al.* (2009) | Northern Europe | 2009 | Primary glass | -506 to -445 |
| Fisher (2006) | UK | 2006 | Primary glass | -762 |
| Smith *et al.* (2001) | Europe | 2001 | Primary glass | -253 |
| US EPA (2015) | USA | 2015 | Primary glass | -309 |
| Mixed glass | Pratt (2014) | Scotland | 2012 | 56% primary glass; 44% primary aggregates | -201 |
| WRAP (2012) | England | 2011 | Unknown | -233 |
| Larsen *et al.* (2009) | Northern Europe | 2009 | Primary glass | -506 to -445 |
| Fisher (2006) | UK | 2006 | Primary glass | -762 |
| Smith *et al.* (2001) | Europe | 2001 | Primary glass | -253 |
| US EPA (2015) | USA | 2015 | Primary glass | -309 |
| Paper & card | Paper | Pratt (2014) | Scotland | 2012 | Unknown – assumed primary paper and card | -888 |
| WRAP (2012) | England | 2011 | Unknown | -811 |
| Merrild *et al.* (2009) | Northern Europe | 2009 | Virgin paper | -1269 to 390 |
| Fisher *et al.* (2006) | UK | 2006 | Virgin paper | -620 to -280 |
| Fisher (2006) | UK | 2006 | Virgin thermo-mechanical pulp | -496 |
| Smith *et al.* (2001) | Europe | 2001 | Virgin newsprint | -600 |
| US EPA (2015) | USA | 2015 | Virgin newspaper | -3031 |
| US EPA (2015) | USA | 2015 | Virgin office paper | -3153 |
| US EPA (2015) | USA | 2015 | 48% virgin fibre corrugated containers; 8% primary magazines, 24% primary newspaper; 20% primary office paper | -3891 |
| Card | Pratt (2014) | Scotland | 2012 | Unknown – assumed primary paper and card | -888 |
| Fisher *et al.* (2006) | UK | 2006 | Virgin paper | -620 to -280 |
| WRAP (2012) | England | 2011 | Unknown | -894 |
| Fisher (2006) | UK | 2006 | Virgin thermo-mechanical pulp | -496 |
| US EPA (2015) | USA | 2015 | Virgin corrugated containers | -3439 |
| Books | Pratt (2014) | Scotland | 2012 | Unknown – assumed primary paper and card | -888 |
| WRAP (2012) | England | 2011 | Unknown | -811 |
| US EPA (2015) | USA | 2015 | Virgin fibre textbooks | -3428 |
| Mixed paper & card | Pratt (2014) | Scotland | 2012 | Unknown – assumed primary paper and card | -888 |
| WRAP (2012) | England | 2011 | Unknown | -873 |
| Fisher *et al.* (2006) | UK | 2006 | Virgin paper | -620 to -280 |
| Fisher (2006) | UK | 2006 | Virgin thermo-mechanical pulp | -496 |
| Yellow pages | Pratt (2014) | Scotland | 2012 | Unknown – assumed primary paper and card | -888 |
| US EPA (2015) | USA | 2015 | Virgin fibre phone books | -2910 |
| Metal | Steel cans | Pratt (2014) | Scotland | 2012 | Unknown – assumed primary ferrous metals | -1806 |
|  | WRAP (2012) | England | 2011 | Unknown | -1799 |
|  | Damgaard *et al.* (2009) | Northern Europe | 2009 | Primary steel | -2360 to -560 |
|  | Fisher *et al.* (2006) | UK | 2006 | Pig iron (max) Primary steel (min) | -830 to -580 |
|  | Fisher (2006) | UK | 2006 | Pig iron | -496 |
|  | Smith *et al.* (2001) | Europe | 2001 | Primary tin plate | -1487 |
|  | US EPA (2015) | USA | 2015 | Primary steel | -1995 |
| Aluminium cans | Pratt (2014) | Scotland | 2012 | Unknown – assumed primary non-ferrous metals | -9985 |
|  | WRAP (2012) | England | 2011 | Unknown | -9267 |
|  | Damgaard *et al.* (2009) | Northern Europe | 2009 | Primary aluminium | -19340 to -5040 |
|  | Fisher *et al.* (2006) | UK | 2006 | Primary aluminium | -13100 to -12300 |
|  | Fisher (2006) | UK | 2006 | Primary aluminium | -11634 |
|  | Smith *et al.* (2001) | Europe | 2001 | Primary aluminium | -9074 |
|  | US EPA (2015) | USA | 2015 | Primary aluminium | -10042 |
| Mixed cans | Pratt (2014) | Scotland | 2012 | Unknown – assumed primary ferrous and non-ferrous metals | -2573 |
|  | WRAP (2012) | England | 2011 | Unknown | -3965 |
|  | US EPA (2015) | USA | 2015 | Primary steel and aluminium (unknown proportion) | -4828 |
| Other scrap metal | Pratt (2014) | Scotland | 2012 | Unknown – assumed primary ferrous and non-ferrous metals | -2573 |
|  | WRAP (2012) | England | 2011 | Unknown | -2239 |
|  | US EPA (2015) | USA | 2015 | Primary steel and aluminium (unknown proportion) | -4828 |
| Aluminium foil | WRAP (2012) | England | 2011 | Unknown | -9267 |
| Plastic | Mixed plastics | Pratt (2014) | Scotland | 2012 | Unknown | -566 |
| WRAP (2012) | England | 2011 | Unknown | -1215 |
| Astrup *et al.* (2009) | Northern Europe | 2009 | Virgin plastic | -1574 to -838 |
| Astrup *et al.* (2009) | Northern Europe | 2009 | Virgin wood lumber | -108 to -58 |
| Fisher *et al.* (2006) | UK | 2006 | Primary PET (max)  Primary plastic (LDPE) lumber (min) | -1820 to 1470 |
| Fisher (2006) | UK | 2006 | Primary PET | -2324 |
| US EPA (2015) | USA | 2015 | Primary HDPE (35%) and PET (65%) | -1135 |
| Mixed plastic bottles | Pratt (2014) | Scotland | 2012 | Unknown | -566 |
| WRAP (2012) | England | 2011 | Unknown | -1156 |
| Fisher *et al.* (2006) | UK | 2006 | Primary PET (max)  Primary Plastic (LDPE) lumber (min) | -1820 to 1470 |
| Fisher (2006) | UK | 2006 | Primary PET | -2324 |
| US EPA (2015) | USA | 2015 | Primary HDPE (35%) and PET (65%) | -1135 |
| PET | Pratt (2014) | Scotland | 2012 | Unknown | -566 |
| WRAP (2012) | England | 2011 | Unknown | -1705 |
| Fisher *et al.* (2006) | UK | 2006 | Primary PET | -1820 |
| Fisher (2006) | UK | 2006 | Primary PET | -2324 |
| Smith *et al.* (2001) | Europe | 2001 | Primary PET granules | -1761 |
| US EPA (2015) | USA | 2015 | Primary PET | -1246 |
| HDPE | Pratt (2014) | Scotland | 2012 | Unknown | -566 |
| WRAP (2012) | England | 2011 | Unknown | -1161 |
| Fisher (2006) | UK | 2006 | Primary PET | -2324 |
| Smith *et al.* (2001) | Europe | 2001 | Primary HDPE granules | -253 |
| US EPA (2015) | USA | 2015 | Primary HDPE | -970 |
| PVC | Pratt (2014) | Scotland | 2012 | Unknown | -566 |
| WRAP (2012) | England | 2011 | Unknown | -888 |
| Fisher (2006) | UK | 2006 | Primary PET | -2324 |
| LDPE | Pratt (2014) | Scotland | 2012 | Unknown | -566 |
| WRAP (2012) | England | 2011 | Unknown | -948 |
| Fisher *et al.* (2006) | UK | 2006 | Primary LDPE (max)  Virgin timber (min) | -1470 to 850 |
| Fisher (2006) | UK | 2006 | Primary polyethylene | -1586 |
| PP | Pratt (2014) | Scotland | 2012 | Unknown | -566 |
| WRAP (2012) | England | 2011 | Unknown | -948 |
| Fisher (2006) | UK | 2006 | Primary PET | -2324 |
| PS | WRAP (2012) | England | 2011 | Unknown | -1240 |
| Other plastics | WRAP (2012) | England | 2011 | Unknown | -688 |
| Wood | Wood | Pratt (2014) | Scotland | 2012 | N, P, and K fertilisers (unknown proportions) | -265 |
| WRAP (2012) | England | 2011 | Unknown | -1276 |
| Merrild and Christensen (2009) | Northern Europe | 2009 | Virgin wood chips | -665 to -125 |
| Fisher *et al.* (2006) | UK | 2006 | Virgin timber | -90 to 1.2 |
| US EPA (2015) | USA | 2015 | Virgin timber | -2712 |
| Chipboard & MDF | Pratt (2014) | Scotland | 2012 | N, P, and K fertilisers (unknown proportions) | -265 |
| WRAP (2012) | England | 2011 | Unknown | -1276 |
| Merrild and Christensen (2009) | Northern Europe | 2009 | Virgin wood chips | -665 to -125 |
| Fisher *et al.* (2006) | UK | 2006 | Virgin timber | -90 to 1.2 |
| US EPA (2015) | USA | 2015 | Virgin MDF | -2723 |
| Composite wood materials | Pratt (2014) | Scotland | 2012 | N, P, and K fertilisers (unknown proportions) | -265 |
| WRAP (2012) | England | 2011 | Unknown | -1276 |
| Merrild and Christensen (2009) | Northern Europe | 2009 | Virgin wood chips | -665 to -125 |
| Fisher *et al.* (2006) | UK | 2006 | Virgin timber | -90 to 1.2 |
| WEEE | WEEE – LDAs | Pratt (2014) | Scotland | 2012 | Primary ferrous and non-ferrous metals (unknown proportions) | -181 |
| WRAP (2012) | England | 2011 | Unknown | -1266 |
| WEEE – SDAs | WRAP (2012) | England | 2011 | Unknown | -1482 |
| WEEE – CRTs | US EPA (2015) | USA | 2015 | Primary asphalt (38%), steel sheet (27%, lead bullion (10%), CRT glass (2%), copper wire (5%), and aluminium sheet (18%) | -2767 |
| WEEE – fridges & freezers | Pratt (2014) | Scotland | 2012 | Primary ferrous and non-ferrous metals (unknown proportions) | -181 |
| WRAP (2012) | England | 2011 | Unknown | -656 |
| Smith *et al.* (2001) | Europe | 2001 | Primary tin plate; primary aluminium, primary copper; marginal heat and electricity (plastics incineration) (unknown proportions) | -1042 |
| Batteries | Automotive batteries | Pratt (2014) | Scotland | 2012 | Unknown | -487 |
| WRAP (2012) | England | 2011 | Unknown | -563 |
| Post-consumer, non-automotive batteries | Pratt (2014) | Scotland | 2012 | Unknown | -487 |
| WRAP (2012) | England | 2011 | Unknown | -563 |
| Tyres | Car tyres | WRAP (2012) | England | 2011 | Unknown | -1910 |
| US EPA (2015) | USA | 2015 | Sand (42%) and synthetic rubber (58%) | -430 |
| Van tyres | WRAP (2012) | England | 2011 | Unknown | -1910 |
| US EPA (2015) | USA | 2015 | Sand (42%) and synthetic rubber (58%) | -430 |
| Large vehicle tyres | WRAP (2012) | England | 2011 | Unknown | -1910 |
| US EPA (2015) | USA | 2015 | Sand (42%) and synthetic rubber (58%) | -430 |
| Mixed tyres | WRAP (2012) | England | 2011 | Unknown | -1910 |
| US EPA (2015) | USA | 2015 | Sand (42%) and synthetic rubber (58%) | -430 |
| Furniture | Furniture | WRAP (2012) | England | 2011 | Unknown | -921 |
| Rubble | Rubble | Pratt (2014) | Scotland | 2012 | Unknown | 2 |
| WRAP (2012) | England | 2011 | Unknown | -9 |
| Fisher *et al.* (2006) | UK | 2006 | Gravel (max)  No substitution (min) | -2.3 to 2.1 |
| Fisher (2006) | UK | 2006 | Gravel | -2.7 |
| Soil | Soil | Pratt (2014) | Scotland | 2012 | Unknown | 1 |
| Fisher *et al.* (2006) | UK | 2006 | Gravel (max)  No substitution (min) | -2.3 to 2.1 |
| Plasterboard | Plasterboard | WRAP (2012) | England | 2011 | Unknown | -139 |
| US EPA (2015) | USA | 2015 | Virgin gypsum drywall | 33 |
| Oil | Vegetable oil | Pratt (2014) | Scotland | 2012 | Unknown | -725 |
| Mineral oil | Pratt (2014) | Scotland | 2012 | Unknown | -725 |
| WRAP (2012) | England | 2011 | Unknown | -725 |
| Composite | Composite food & beverage cartons | WRAP (2012) | England | 2011 | Unknown | -1730 |
| Mattresses | Mattresses |  |  |  |  |  |
| Paint | Paint | WRAP (2012) | England | 2011 | Unknown | -2840 |
| Textiles | Textiles & footwear | Pratt (2014) | Scotland | 2012 | 46% primary textiles; 32% virgin paper; 22% primary shoes | -5891 |
| WRAP (2012) | England | 2011 | Unknown | -2028 |
| Fisher *et al.* (2006) | UK | 2006 | 50% cotton cloth; 50% primary PET (max)  Kraft paper (min) | -1750 to -930 |
| Fisher (2006) | UK | 2006 | 50% cotton cloth; 50% primary PET | -7869 |
| Smith *et al.* (2001) | Europe | 2001 | Woollen rags | -3169 |
| Textiles only | Pratt (2014) | Scotland | 2012 | 46% primary textiles; 32% virgin paper; 22% primary shoes | -5891 |
| WRAP (2012) | England | 2011 | Unknown | -5987 |
| Fisher *et al.* (2006) | UK | 2006 | 50% cotton cloth; 50% primary PET (max)  Kraft paper (min) | -1750 to -930 |
| Fisher (2006) | UK | 2006 | 50% cotton cloth; 50% primary PET | -7869 |
| Smith *et al.* (2001) | Europe | 2001 | Woollen rags | -3169 |
| Footwear only | Pratt (2014) | Scotland | 2012 | 46% primary textiles; 32% virgin paper; 22% primary shoes | -5891 |
| WRAP (2012) | England | 2011 | Unknown | -4385 |
| Carpets | US EPA (2015) | USA | 2015 | Primary Nylon 6, Nylon 6-6, PET, and PP plastic resins | -2601 |

GHG, greenhouse gas; PET, polyethylene terephthalate; LDPE, low-density polyethylene; HDPE, high-density polyethylene; PVC, polyvinyl chloride; PP, polypropylene; PS, polystyrene; MDF, medium-density fibreboard; WEEE, waste electrical and electronic equipment; LDA, large domestic appliance; SDA, small domestic appliance; CRT, cathode ray tube

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