

Life Cycle Assessment Data for Multi-Function Devices & Printers

Energy consumption data for product manufacturing							
MFD-Color, Printer-B&W and MFD-B&W:							
Parameter	Value		Reference*		Notes		
Energy for production of MFD-Color	34.55 kWh/kg		Fraunhofer, 2007. SimaPro, 2013.		MJ/kg MFD-Color from SimaPro model, converted to kWh/kg using 3.6 MJ/kWh		
Energy for manufacturing Printer-B&W	52.43 kWh/kg		Fraunhofer, 2007. SimaPro, 2013.		MJ/kg Printer-B&W from SimaPro model, converted to kWh/kg using 3.6 MJ/kWh		
Energy for production of MFD-B&W	43.12 kWh/kg		Fraunhofer, 2007. SimaPro, 2013.		MJ/kg MFD-B&W from SimaPro model, converted to kWh/kg using 3.6 MJ/kWh		
Average (weighted) production energy	48.21 kWh/kg		Calculated		kWh per kg of product weighted by FEC 2012 product distribution (used in longevity calc for energy).		
LIFE CYCLE IMPACT DATA							
LCI production data							
For product materials:							
Process	Emissions to air (kg)	Emissions to water (kg)	Total energy demand (MJ/kg)	Material inputs (kg)	GWP, 100 yr (kg CO ₂ -equiv./kg or MJ)	Reference*	Nation
ABS co-polymer (ABS)	3.54	0.08	100.78	2.56	4.12	Average of two plastic data sources. Ecoinvent, 2012; US LCI Database, 2012.	Europe, US
Polycarbonate granulate (PC)	6.19	1.09	105.58	3.25	7.77	Ecoinvent, 2012. Plastics, Europe data.	Europe
Polystyrene high impact gran. (HIPS)	2.83	0.03	90.15	2.01	3.36	Average of two plastic data sources. Ecoinvent, 2012; US LCI Database, 2012.	Europe, US
Plastics (average) per kg material production	4.19	0.40	98.84	2.61	5.08		
Copper mix	1.78	8.35	32.19	2.27	1.71	Ecoinvent, 2012. Copper at regional storage.	European mix, from global sources
Copper (average) per kg material production	1.78	8.35	32.19	2.27	1.71		
Silver	98.1	144	1,459	93	95	Ecoinvent, 2012. Silver at regional storage.	European mix, from global sources
Gold	12,490	37,311	214,334	7,448	12,621	Ecoinvent, 2012. Gold at regional storage.	European mix, from global sources
Palladium	14,588	4,898	183,737	5,859	9,297	Ecoinvent, 2012. Palladium at regional storage.	European mix, from global sources
Precious Metals (weighted average) per kg material production	2,601.73	5,945.73	41,528.19	1,453.90	2,385.87		

Chromium steel (average) per kg material production	4.17	1.04	79.97	3.97	4.33	Ecoinvent, 2012. Chromium steel at regional storage.	European mix, from global sources
Aluminum (average) per kg material production	6.65	0.77	139.58	4.44	8.31	Ecoinvent, 2012. Aluminium production mix at plant.	Global
For packaging:							
Process	Emissions to air (kg)	Emissions to water (kg)	Total energy demand (MJ/kg)	Material inputs (kg)	GWP, 100 yr (kg CO2-equiv./kg or MJ)	Reference*	Nation
Low-density polyethylene (LDPE)	1.74	0.02	78.56	1.65	2.14	Average of U.S. and European plastic data. Ecoinvent, 2012; US LCI Database, 2012.	Europe, US
High-density polyethylene (HDPE)	1.55	0.02	74.82	1.59	1.91	Average of U.S. and European plastic data. Ecoinvent, 2012; US LCI Database, 2012.	Europe, US
Polyethylene terephthalate (PET)	2.23	0.07	71.01	1.78	2.51	Average of U.S. and European plastic data. Ecoinvent, 2012; US LCI Database, 2012.	Europe, US
Polystyrene, general purpose (GPPS)	2.81	0.03	89.61	1.99	3.36	Average of U.S. and European plastic data. Ecoinvent, 2012; US LCI Database, 2012.	Europe, US
Plastics (average) per kg material production	2.08	0.03	78.50	1.75	2.48	calculated.	
Cardboard (average) per kg material production	2.32	0.04	30.67	2.52	1.26	Average of U.S. and European data. Ecoinvent, 2012; US Corrugated Packaging Alliance, 2009.	Europe, US
For electricity:							
Process	Emissions to air (kg)	Emissions to water (kg)	Total energy demand (MJ/kg)	Material inputs (kg)	GWP, 100 yr (kg CO2-equiv./kg or MJ)	Reference*	Nation
Power grid mix (kg/MJ)	0.21	0.0003	3.16	0.10	0.22	U.S. LCI database, 2012. Represents average US kWh modeled in SimaPro software version 7.3.3.	US
Power grid mix (kg/kWh) (converted)	0.74	0.00118	11.38	0.37	0.78	Converted kg/MJ to kg/kWh	
<i>Note: All emissions are based on the production of 1 kg of product except power grid mix which is based on production of 1 MJ of power</i>							
LCI recycling data							
For product materials:							
Process	Emissions to air (kg)	Emissions to water (kg)	Total energy demand (MJ/kg)	Material inputs (kg)	GWP, 100 yr (kg CO2-equiv./kg or MJ)	Reference*	Nation
E-waste shredding (for metals recovery)	0.19	0.0003	0.90	not used in calculations	0.20	Geibig and Socolof, 2005. Shredding data are primary data provided by three electronic waste demanufacturing facilities.	

Copper smelting (kg or MJ/kg e-waste)	0.0003	0.002	0.01	0.0003	0.71	Geibig and Socolof, 2005. Copper smelting data are primary data collected from two electronic waste copper smelters. The energy for copper smelting derived from Geibig and Socolof, 2005, p. 2-40, using the following conversion factors: 13.4 g of SnPb solder/kg of PWB; 0.051 kg PWB/kg of e-waste; 8.4 g SnPb solder/cc of SnPb solder. Assume PWBs reaching end of life still have leaded solder.	N. America and Europe
Metals recovery (average) per kg material processed	0.19	0.002	0.91		0.91	calculated	
Silver	20.77	3.64	138.92	28.21	21.52	Ecoinvent, 2012. Silver, secondary at precious metal refinery.	Swedish process data adapted to US
Gold	1212.60	212.32	8109.10	1646.53	1256.33	Ecoinvent, 2012. Gold, secondary at precious metal refinery.	Swedish process data adapted to US
Palladium	635.15	111.21	4247.46	862.43	658.05	Ecoinvent, 2012. Palladium, secondary at precious metal refinery.	Swedish process data adapted to US
Precious Metals (weighted average) per kg material processed	227.19	39.78	1519.31	308.49	235.38	wtd avg calculated based on relative wts of silver, gold, Pd in cell phone	
Steel (average) per kg material processed	0.35	0.001	5.70	0.18	0.38	Steel billet, electric furnace. Franklin Associates private database based on the U.S. LCI database.	North America
Aluminum (average) per kg material processed	0.35	0.001	5.70	0.18	0.38	Aluminum ingot, secondary. Aluminum Association, 2010.	US
<i>Note: All emissions are based on the recycling of 1 kg of product</i>							
GHG Emissions Data							
Electricity Production							
Parameter	Value		Reference*		Notes		
GHG emissions from electricity	0.19 kgCE/kWh		CPPD, 2007.		The emission factor for electricity consumption (national average) is obtained from CPPD, and represents CPPD's best judgment for future GHG-intensity of electricity generating units across the nation. The emission factor is based on data from both e-GRID and the Integrated Planning Model (IPM), and represents CPPD's judgment of future fuel mixtures and market conditions. Last updated in July 2008). Used in GHG calculations, and to back-calculate energy for EOL reuse and recycling.		
Product Resins							
Parameter	Value		Reference*		Notes		
GHG emitted for product resins	1.39 kg CE/kg product resin		From LCI production data above, converted.		Average of ABS, PC, HIPS. Converted from CO2-equivalents in LCI production data. Used in EPEAT Material Use calculation for recycled content of resins for production of globally produced products.		
Packaging Resins							
Parameter	Value		Reference*		Notes		
GHG emissions for packaging resins							

HDPE	0.44 kgCE/kg	EPA WARM, 2012. Plastic Products documentation, Exhibit 7.	Converted from MTCO2E/short ton.	
LDPE	0.54 kgCE/kg	EPA WARM, 2012. Plastic Products documentation, Exhibit 7.	Converted from MTCO2E/short ton.	
PET	0.67 kgCE/kg	EPA WARM, 2012. Plastic Products documentation, Exhibit 7.	Converted from MTCO2E/short ton.	
PS (general purpose)	0.75 kgCE/kg	EPA WARM, 2012. Plastic Products documentation, Exhibit 7.	Converted from MTCO2E/short ton.	
Average GHG emissions for packaging resins	0.6 kg CE/kg resin	Calculated.	Average for U.S. production of HDPE, LDPE, PET PS from WARM documentation. Used in calculations for reuse of packaging.	
Average GHG emissions for packaging resins	0.676 kg CE/kg resin	From LCI production data above, converted.	Average of global packaging data for HDPE, LDPE, PET, PS. Used in calculations for production of packaging used to deliver globally produced products.	
Paper Packaging				
Parameter	Value	Reference*	Notes	
GHG emissions from corrugated box production	0.26 kg CE/kg	EPA WARM, 2012. Paper Products documentation, Exhibit	Converted from MTCO2E/short ton. Used in calculations for reuse of packaging.	
Conversion factor (CO2-equiv to CE)				
Parameter	Value	Reference*	Notes	
Conversion factor CO2-equiv to CE	0.273	Periodic chart of elements.	Molecular weight of C (12 g/mol) / molecular weight of CO2 (44 g/mol).	
GHG emissions factors for end-of-life of personal computers				
Baseline EOL Dispositions	Value	Reference	Notes	
Source reduction (reuse)	-54.15 MTCE/short ton	SimaPro, 2013.	Source reduction GHG factors are based on avoided GHG emissions from SimaPro equipment production models.	
Recycling	-2.35 MTCE/short ton	SimaPro, 2013.	Recycling GHG are based on the amounts of resins and metals recycled from each type of equipment and credits for virgin materials displaced by the recycled materials.	
Source reduction converted	2.58 kgCE/kg	FEC, 2012; SimaPro, 2013.	FEC 2012 use-weighted avg of SimaPro production GWP for all 3 equip types	
Recycling converted	0.36 kgCE/kg	FEC, 2012; SimaPro, 2013.	FEC 2012 use-weighted avg of SimaPro production GWP for all 3 equip types	
Energy factors for end-of-life of personal computers				
Baseline EOL Dispositions	Value	Unit	Reference	Notes
Source reduction converted	48.21	kWh/kg	FEC, 2012; SimaPro, 2013.	FEC 2012 use-weighted avg of SimaPro production GWP for all 3 equip types
Recycling converted	10.98	kWh/kg	FEC, 2012; SimaPro, 2013.	FEC 2012 use-weighted avg of SimaPro production GWP for all 3 equip types

General Conversion Factors		
	1000	g/kg
	2.205	lb/kg
	0.272727273	CE/CO2 equivalent
Recycling Assumptions - Efficiency Rate		
Material Type	% of recycled material turned into reusable product	Reference*
Aluminum cans	93%	EPA WARM, 2016. Recycling document, Exhibit 2.1.
Steel cans	98%	EPA WARM, 2016. Recycling document, Exhibit 2.1.
Copper wire	81%	EPA WARM, 2016. Recycling document, Exhibit 2.1.
Glass	88%	EPA WARM, 2016. Recycling document, Exhibit 2.1.
Plastics	88%	EPA WARM, 2016. Recycling document, Exhibit 2.1.
Recycling Assumptions - CRT Glass		
Recycling Process	% of Mass	Reference
Glass-to-glass recycling	73.7%	EPA, 2008. Table 5.1, p. 29.
Lead Smelting	26.3%	EPA, 2008. Table 5.1, p. 29.

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