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RECYCLING—METALS

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Recycling—Metals

By John F. Papp

Survey data and tables were prepared by Maria Arguelles, E. Lee Bray, James F. Carlin, Jr., Daniel L. Edelstein, Michael D. Fenton, George M. Bedinger, David E. Guberman, Deborah A. Kramer, Peter H. Kuck, and Amy C. Tolcin.

In 2011, the United States recycled 68.8 million metric tons (Mt) of selected metals, an amount equivalent to 62% of the apparent supply of those metals (table 1). More than 92% of recycled metal was steel, and 90% of apparent supply was steel. The United States exported 30.1 Mt of scrap metal and imported 6.0 Mt of these same metals (table 2).

Metals are important, reusable resources. Although the ultimate supply of metal is fixed by nature, human ingenuity determines the quantity of supply available for use by developing economical processes to recover metal from the Earth (the primary source of metal) and recycle metal from the use/process stream (the secondary source of metal). The reusable nature of metals contributes to the sustainability of their use. Recycling, a significant factor in the supply of many of the metals used by our society, provides environmental benefits such as energy savings and reduced volumes of waste.

The term "primary" indicates material from ore deposits, and the term "secondary" indicates material from recycling, including used products and residuals from manufacturing. Recycling practices and the description of those practices vary substantially among the metal industries. Generally, scrap is categorized as "new" or "old." "New" indicates preconsumer sources, and "old," postconsumer sources. The many stages of industrial processing that precede formation of an end product are the sources of new scrap. For example, when metal is converted into shapes—bars, plates, rods, or sheets—new scrap is generated in the form of cuttings, trimmings, and off-specification forms. When these shapes are converted to parts, additional new scrap may be generated in the form of cuttings, stampings, turnings, and off-specification parts. Similarly, when parts are assembled into products, new scrap may be generated.

Once a product completes its useful life, it becomes old scrap. Used appliances, automobiles, and beverage cans are examples of old consumer scrap; used jet engine blades and vanes, junked machinery and ships, and metal recovered from commercial buildings or industrial plants are examples of old industrial scrap. A wide variety of descriptive terms, including external scrap, home scrap, internal scrap, mill scrap, prompt scrap, and purchased scrap, have evolved to describe scrap generated by diverse industry practices. The material flow of recycled metal commodities in the United States has been documented in a series of reports published by the U.S. Geological Survey (Sibley, 2006–11).

The U.S. electronics recycling industry treated about 3.5 Mt of electronics in 2010, about 70% of which was recycled in the United States into commodity-grade scrap. Industry was the leading source of this material; however, households were the leading consumer of such equipment, indicating a significant opportunity to increase the recycling rates of used electronics (Daoud, 2011, p. 1, 11–12).

Metal recycling provides a source of raw materials that is independent of local geology, effectively reduces energy consumption and pollution, and supplements raw materials from mineral mining. Because metal use is generally increasing and lasts for a long period of time, even reuse of all metal may not satisfy demand (Espinoza, 2012). Metal recycling comprises collection, preprocessing, and end processing. Metal recycling is limited by social behavior, product design, recycling technologies, and the thermodynamics of separation. Metal recycling could be improved by increased collection rates of discarded products, improved design for recycling, and deployment of modern recycling technology (Reck, 2012).

The compound annual growth rate of world crude stainless steel production was 5.88% from 1950 to 2011, during which time, production increased from about 1 million tons per year (Mt/yr) to more than 32 Mt/yr. Measured during the 1980 to 2010 time period, the stainless steel growth rate exceeded that of aluminum, carbon steel, copper, lead, and zinc (Lawrence, 2012). World stainless steel production reached a historical high in 2012, mainly driven by China and India. Stainless steel scrap is generated during the production process and as a post-consumer product. Stainless steel scrap is by weight about 75% iron, 17% chromium, and 8% nickel; however, in 2011, stainless steel scrap was by value about 72% nickel, 15% chromium, and 13% iron. About 90% of stainless steel used in manufacturing is recycled after an average life of about 22 years. Stainless steel production has been increasing, resulting in a growing reserve of material in use expected to become scrap supply (Gledhill, 2012).

Individual annual reviews for each of the metals listed in the tables are in the respective chapters in this volume of the U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals.

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TABLE 1
SALIENT U.S. RECYCLING STATISTICS FOR SELECTED METALS[1]

Year	Quantity of metal (metric tons)					Value of metal (thousands)			
	Recycled from new scrap[2]	Recycled from old scrap[3]	Recycled[4]	Apparent supply[5]	Percentage recycled[6]	Recycled from new scrap[2]	Recycled from old scrap[3]	Recycled[4]	Apparent supply[7]
Aluminum:[8]									
2007	2,450,000	1,660,000	4,120,000	7,620,000 r	54 r	$6,610,000	$4,480,000	$11,100,000	$20,600,000 r
2008	2,130,000	1,500,000	3,630,000	6,070,000	60	5,660,000	3,970,000	9,640,000	16,100,000
2009	1,570,000	1,260,000	2,820,000	4,890,000	58	2,740,000	2,200,000	4,940,000	8,550,000
2010	1,540,000 r	1,250,000	2,790,000 r	5,000,000	56	3,550,000 r	2,880,000	6,430,000 r	11,500,000
2011	1,650,000	1,450,000	3,110,000	5,200,000	60	4,230,000	2,720,000	7,950,000	13,300,000
Chromium:[9]									
2007	NA	NA	162,000	493,000	33	NA	NA	297,000	1,860,000
2008	NA	NA	146,000	432,000	34	NA	NA	491,000	2,600,000
2009	NA	NA	141,000	160,000	88	NA	NA	218,000	234,000
2010	NA	NA	144,000	384,000 r	37 r	NA	NA	329,000 r	800,000 r
2011	NA	NA	147,000	451,000	33	NA	NA	270,000	828,000
Copper:[10]									
2007	772,000 r	162,000 r	933,000 r	3,050,000 r	30.6 r	5,580,000 r	1,170,000 r	6,750,000 r	22,000,000
2008	700,000 r	159,000 r	859,000 r	2,700,000 r	31.8 r	4,930,000 r	1,120,000 r	6,050,000 r	18,900,000
2009	639,000	138,000	777,000	2,220,000	35.0	3,400,000 r	734,000	4,130,000 r	11,800,000
2010	642,000 r	143,000 r	785,000 r	2,400,000 r	32.7 r	4,930,000	1,100,000 r	6,030,000 r	18,400,000 r
2011	649,000	153,000	802,000	2,380,000	33.7	5,810,000	1,370,000	7,180,000	21,300,000
Iron and steel:[11]									
2007	NA	NA	64,000,000	119,000,000	54	NA	NA	16,200,000	29,200,000
2008	NA	NA	67,600,000 r	109,000,000	62	NA	NA	23,600,000 r	37,600,000
2009	NA	NA	53,500,000 r	69,300,000	77	NA	NA	11,100,000 r	12,600,000
2010	NA	NA	59,700,000 r	90,200,000	66 r	NA	NA	19,800,000 r	27,100,000
2011	NA	NA	63,100,000	99,800,000	63	NA	NA	25,500,000	37,000,000
Lead:[12]									
2007	24,100	1,160,000	1,180,000	1,540,000	76.7	65,700	3,150,000	3,220,000	4,200,000
2008	20,100	1,120,000	1,140,000	1,540,000	74.5	53,300	2,980,000	3,040,000	4,080,000
2009	21,600	1,090,000	1,110,000	1,380,000	80.5	41,400	2,090,000	2,130,000	2,640,000
2010	24,100	1,120,000 r	1,140,000	1,380,000 r	81.0 r	57,900 r	2,680,000 r	2,740,000 r	3,310,000 r
2011	21,600	1,110,000	1,130,000	1,520,000	73.0	58,000	2,980,000	3,040,000	4,080,000
Magnesium:[13]									
2007	59,900	23,500	83,300	160,000	52	227,000	89,000	316,000	608,000
2008	61,100	22,600	83,700	170,000	49	451,000	167,000	618,000	1,250,000
2009	47,100	20,500	67,600	118,000	59 r	269,000	117,000	386,000	672,000
2010	51,500	20,500	72,000	137,000	55 r	291,000 r	116,000	407,000 r	741,000 r
2011	50,900	24,100	74,900	140,000	53	269,000	127,000	396,000	743,000
Nickel:[14]									
2007	NA	NA	94,000 r	206,000 r	47	NA	NA	3,500,000 r	7,660,000 r
2008	NA	NA	86,700 r	202,000 r	43	NA	NA	1,830,000 r	4,260,000 r
2009	NA	NA	79,900	174,000 r	46	NA	NA	1,170,000	2,550,000 r
2010	NA	NA	82,000 r	195,000 r	42 r	NA	NA	1,790,000 r	4,250,000 r
2011	NA	NA	89,300	214,000	42	NA	NA	2,040,000	4,890,000
Tin:[15]									
2007	2,860	12,200	15,100	44,500	31	56,700	242,000	298,000	882,000
2008	2,100	11,700	13,800	24,700	56	52,300	291,000	344,000	615,000
2009	2,310	11,100	13,400	82,300	16	42,600	205,000	247,000	1,520,000
2010	2,680	11,100 r	13,800 r	42,800 r	32	73,200	303,000 r	377,000 r	1,170,000 r
2011	2,530	11,000	13,500	41,700	32	87,800	382,000	470,000	1,450,000
Titanium:[16]									
2007	NA	NA	23,800	W	41	NA	NA	167,000	NA
2008	NA	NA	23,200	W	W	NA	NA	148,000	NA
2009	24,700 e	1,000 e	25,700 e	W	W	NA	NA	101,000	NA
2010	28,200	1,000 e	29,200	W	46	NA	NA	212,000	NA
2011	30,900	1,000 e	31,900	W	39	NA	NA	223,000	NA

See footnotes at end of table.

TABLE 1—Continued
SALIENT U.S. RECYCLING STATISTICS FOR SELECTED METALS[1]

Year	Quantity of metal (metric tons)					Value of metal (thousands)			
	Recycled from new scrap[2]	Recycled from old scrap[3]	Recycled[4]	Apparent supply[5]	Percentage recycled[6]	Recycled from new scrap[2]	Recycled from old scrap[3]	Recycled[4]	Apparent supply[7]
Zinc:[17]									
2007	207,000	26,700	234,000	1,100,000 r	21 r	705,000	90,900	796,000	3,740,000 r
2008	247,000	92,900	339,000	1,180,000 r	29 r	483,000	182,000	665,000	2,310,000 r
2009	194,000	78,900	273,000	1,060,000 r	26 r	334,000	135,000	469,000	1,810,000 r
2010	208,000	123,000	332,000 r	1,120,000 r	30 r	468,000	277,000 r	746,000 r	2,520,000 r
2011	213,000	123,000	336,000	1,160,000	29	500,000	288,000	788,000	2,710,000

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Scrap that results from the manufacturing process, including metal and alloy production. New scrap of aluminum, copper, lead, tin, and zinc excludes home scrap, which is scrap generated and recycled in the metal producing plant.

[3]Scrap that results from consumer products.

[4]Metal recovered from new plus old scrap.

[5]Apparent supply is production plus net imports plus stock changes. Production is primary production plus recycled metal. Net imports are imports minus exports. Apparent supply is calculated on a contained-weight basis.

[6]Also referred to as recycling rate.

[7]Same as apparent supply defined in footnote 5 above but calculated based on a monetary value.

[8]Quantity of metal is the calculated metallic recovery from purchased new and old aluminum-base scrap, estimated for full industry coverage. Monetary value is estimated based on average U.S. market price for primary aluminum metal ingot. Series revised by removing imported scrap to avoid double counting.

[9]Chromium quantity of metal recycled was estimated as chromium content of stainless steel scrap receipts (reported by the iron and steel and pig iron industries). For the calculation of apparent supply, trade includes reported or estimated chromium content of chromite ore, ferrochromium, chromium metal and scrap, a variety of chromium-containing chemicals, and stainless steel mill products and scrap. Stocks include estimated chromium content of reported and estimated producer, consumer and Government stocks. Recycled monetary value estimated as recycled quantity times the average import value of high-carbon ferrochromium. Apparent supply monetary value estimated like apparent supply quantity with monetary value substituted for chromium content.

[10]Includes copper recovered from unalloyed and alloyed copper-base scrap, as refined copper or in alloy forms, as well as copper recovered from aluminum-, nickel-, and zinc-base scrap. Monetary value based on annual average refined copper prices.

[11]Recycled scrap reported from consuming manufacturers. Apparent supply measured as shipments of iron and steel products plus castings corrected for imported semifinished products. Recycled unit value is the U.S. annual average composite price for No. 1 heavy-melting steel calculated from prices published in American Metal Market. Unit value for the year used to calculate values of recycled scrap and apparent supply of scrap.

[12]Monetary value of scrap and apparent supply estimated based upon average quoted price of common lead.

[13]Includes magnesium content of aluminum-base scrap. Monetary value based on the annual average Platts Metals Week U.S. spot Western magnesium price.

[14]Nickel statistics were derived from the following:

Production, consumption, receipts

- Reported nickel content of products made from reclaimed stainless steel dust, spent nickel-cadmium batteries, plating solutions, and other products.
- Estimated nickel content of reported net receipts of alloy and stainless steel scrap.
- Reported nickel content of recovered copper-base scrap.
- Reported nickel content of obsolete and prompt purchased nickel-base scrap.
- Estimated nickel content of various types of reported obsolete and prompt aluminum scrap.

Trade data

- Reported nickel content of International Nickel Study Group (INSG) class I primary products, including briquets, cathode, flake, pellets, and powder.
- Reported or estimated nickel content of INSG class II primary products, including ferronickel, metallurgical-grade nickel oxide, and a variety of nickel-containing chemicals.
- Estimated nickel content of secondary products, including nickel waste and scrap and stainless steel scrap.

Stock data

- Reported or estimated nickel content of all scrap stocks, except copper.
- Reported nickel content of primary products held by world producers in U.S. warehouses.
- Reported nickel content of primary products held by U.S. consumers.
- Reported nickel content of U.S. Government stocks.

Monetary value based on annual average cash price for cathode, as reported by the London Metal Exchange.

[15]Monetary value based on Platts Metals Week composite price for tin. Apparent supply excludes withheld stock changes.

[16]Percentage recycled based on titanium scrap consumed divided by primary sponge and scrap consumption.

[17]Monetary value based on annual average Platts Metals Week metal price for North American special high-grade zinc.

TABLE 2
SALIENT U.S. RECYCLING TRADE STATISTICS FOR SELECTED METALS[1]

	Exports			Imports for consumption		
	Quantity			Quantity		
Year	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)
Aluminum:						
2007	1,550,000	NA	$3,050,000	471,000	NA	$803,000
2008	1,980,000	NA	3,420,000	494,000	NA	853,000
2009	1,660,000	NA	2,120,000 r	433,000	NA	503,000
2010	1,910,000	NA	3,190,000	504,000	NA	763,000
2011	2,140,000	NA	4,050,000	579,000	NA	1,020,000
Chromium:[2]						
2007	882,000	150,000	1,620,000	118,000	20,400	200,000
2008	1,000,000	170,000	1,190,000	140,000	24,300	220,000
2009	1,130,000	192,000	778,000	124,000	21,200	138,000
2010	937,000	159,000	937,000	196,000	33,700	307,000
2011	656,000	111,000	959,000	170,000	29,400	297,000
Copper:[3]						
2007	907,000	704,000	2,840,000	133,000	112,000	657,000 r
2008	908,000	688,000	2,960,000	106,000	85,700	480,000
2009	843,000	633,000	2,010,000	71,800	56,300	234,000
2010	1,030,000	788,000	3,550,000	95,800	75,000	399,000
2011	1,240,000	981,000	4,980,000	110,000	87,600	547,000
Iron and steel:						
2007	16,500,000 r	16,500,000 r	6,890,000 r	3,700,000 r	3,700,000 r	1,040,000 r
2008	21,500,000	21,500,000	10,400,000	3,600,000	3,600,000	1,450,000
2009	22,400,000	22,400,000	7,120,000	2,990,000	2,990,000	814,000
2010	20,500,000	20,500,000	8,380,000	3,780,000	3,780,000	1,420,000
2011	24,300,000	24,300,000	11,400,000	4,010,000	4,010,000	1,650,000
Lead:[4]						
2007	129,000	129,000	55,400	1,590	1,400	2,740
2008	175,000	175,000	92,800	1,470	1,290	2,040
2009	140,000	140,000	72,000	1,600	1,310	2,620
2010	43,500	43,500	33,800	5,020	3,730	8,880
2011	31,100	31,100	36,800	3,030	2,400	5,380
Magnesium:						
2007	1,800	1,800	4,000	21,200	21,200	34,500 r
2008	2,600	2,600	5,420	24,100	24,100	58,800
2009	2,280	2,280	5,200	20,900	20,900	40,300
2010	481	481	802	22,100	22,100	56,500
2011	1,680	1,680	3,960	22,000	22,000	48,700
Nickel:[5]						
2007	2,800,000	110,000	3,110,000	826,000	19,000	488,000
2008	2,720,000	101,000	2,670,000	788,000	22,600	613,000
2009	2,420,000	95,100	1,710,000	699,000	20,000	442,000
2010	1,870,000	84,000	1,870,000	954,000	26,700	711,000
2011	1,630,000	68,600	1,670,000	983,000	24,500	794,000
Tin:						
2007	9,930	9,930	26,900	10,200	10,200	7,430
2008	10,300	10,300	26,600	23,300	23,300	17,700
2009	9,430	9,430	25,600	80,600	80,600	16,200
2010	10,700	10,700	26,500	57,300	57,300	18,300
2011	14,800	14,800	31,300	57,700	57,700	23,400
Titanium:[6]						
2007	9,510	NA	67,300	12,200	NA	133,000
2008	8,180	NA	52,000	10,400	NA	68,900
2009	4,200	NA	14,000	4,770	NA	17,600
2010	3,480	NA	19,200	10,700	NA	75,500
2011	5,150	NA	33,300	13,900	NA	116,000

See footnotes at end of table.

TABLE 2—Continued
SALIENT U.S. RECYCLING TRADE STATISTICS FOR SELECTED METALS[1]

	Exports			Imports for consumption		
	Quantity			Quantity		
Year	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)
Zinc:						
2007	102,000	NA	103,000	21,800	NA	32,500
2008	91,000	NA	99,100	17,000	NA	20,300
2009	47,100	NA	54,300	9,100	NA	8,800
2010	77,900	NA	85,200	15,600	NA	19,400
2011	85,600	NA	93,900	18,500	NA	23,400

[r]Revised. NA Not available.

[1]Contained weight based upon 100% of gross, unless otherwise specified.

[2]Includes stainless steel scrap and chromium metal waste and scrap. Contained weight for import and export quantities of Harmonized Tariff Schedule of the United States (HTS) code 7204.21.0000 is 17% of gross weight; 8112.22.0000 is 100% of gross weight.

[3]For HTS codes 7404.00.0045, 7404.00.0062, and 7404.00.0080 contained weight for import quantity is 65% of gross weight. For HTS codes 7404.00.3045, 7404.00.3055, 7404.00.3065, 7404.00.3090, 7404.00.6045, 7404.00.6055, 7404.00.6065, and 7404.00.6090 contained weight for import quantity is 72%.

[4]Lead content of waste and scrap obtained from lead-acid batteries (HTS 7802.00.0030) included in exports but excluded from imports.

[5]Contained weight for import and export quantities is 0.4% of gross weight for HTS code 7204.29.0000, 50% for HTS code 7503.00.0000, and 7.5% for HTS code 7204.21.0000.

[6]Includes titanium waste and scrap HTS code 8108.30.0000.