



2015 Minerals Yearbook

CADMIUM [ADVANCE RELEASE]

CADMIUM

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Refined cadmium was produced domestically by two companies. One company recovered cadmium as a byproduct of zinc recovery through leaching of roasted sulfide concentrates at a smelter in Tennessee, and the other company recovered secondary cadmium metal from recycled nickel-cadmium (NiCd) batteries at a facility in Ohio. Annual domestic production data for 2011–15 were withheld to avoid disclosing company proprietary data.

The United States was a net exporter of unwrought cadmium metal and powders in 2015, with net exports totaling 113 metric tons (t) in 2015. Imports for consumption of unwrought cadmium increased by 79% to 237 t in 2015 from those of 2014, and exports increased by 77% to 350 t (table 1). Almost all cadmium metal was exported to China (table 2), whereas Canada (43%) supplied the majority of imports (table 3). The annual average Platts Metals Week New York dealer price of cadmium metal in 2015 decreased by 24% from that of 2014 to \$1.47 per kilogram (\$0.67 per pound) (table 1).

In 2015, estimated global primary production of cadmium, excluding U.S. production, was 23,200 t (table 5). A smaller amount of secondary cadmium metal was recovered from recycling NiCd batteries. Although detailed data on the global consumption of primary cadmium in 2015 were not available, NiCd battery production was thought to have continued to account for the majority of global cadmium consumption. Other end uses for cadmium included alloys, anticorrosive coatings, pigments, polyvinyl chloride (PVC) stabilizers, and semiconductors for solar cells. Cadmium metal is sold in several shapes and forms depending on end use: slabs or sticks are commonly consumed for alloys; balls and spheres for plating; and flakes, powder, or sticks for chemicals and pigments.

Production

Mine Production.—Domestic data on the recoverable cadmium content of zinc concentrates, the principal source of primary cadmium, were not available. Zinc concentrates typically contain from 0.2% to 0.3% cadmium. In 2015, zinc-concentrate-producing States were Alaska, Idaho, Missouri, Tennessee, and Washington. Zinc concentrates from Alaska, Idaho, Missouri, and Washington were exported for processing. Zinc concentrates from Tennessee were smelted and refined domestically in Tennessee and processed for byproduct cadmium recovery.

Metal Production.—Domestic metal production data were collected by the U.S. Geological Survey (USGS) from a voluntary survey of cadmium metal and compounds production. In 2015, cadmium metal was produced at one primary and one secondary smelter. Annual domestic production data for 2011–15 were withheld to avoid disclosing company proprietary data.

Primary.—Nyrstar NV's (Belgium) electrolytic zinc refinery in Clarksville, TN, produced zinc metal and several byproducts, including cadmium metal. Nyrstar's East and Middle Tennessee zinc mines supplied most of the zinc concentrate feed treated at Clarksville. In December, Nyrstar placed the Middle Tennessee zinc mines on care-and-maintenance status owing to a sharp decrease in zinc prices in the fourth quarter. As a result, zinc metal production at Clarksville was expected to decrease by 7% in 2016 (Nyrstar NV, 2016, p. 37).

Secondary.—Retriev Technologies Inc.'s (Anaheim, CA) battery recycling operations in Lancaster, OH, recovered cadmium metal in the form of ingot from consumer and industrial NiCd batteries.

Consumption

Data on the domestic consumption of cadmium were not available. Most of the cadmium consumed globally was thought to be used in NiCd batteries. Other uses included alloys, coatings, pigments, solar cells, and stabilizers.

Nickel-Cadmium Batteries.—The NiCd battery industry was almost exclusively located in Asia, and the leading manufacturers included BYD Co., Ltd. (China) and Panasonic Corp. (Japan). Small portable batteries were used to power consumer electronics (commonly, power tools), and large industrial NiCd batteries were used predominantly for aeronautical and railway applications. In railway and transit systems, NiCd batteries were used to start locomotive engines and to power passenger cars and trackside signaling. In airplanes, NiCd batteries provided startup power for jet engines and emergency backup power for aircraft electrical systems (Morrow, 2011, p. 10–11).

Pigments.—Inorganic cadmium pigments are based on cadmium sulfide, which is golden yellow in color. The replacement of zinc or mercury for cadmium and the substitution of selenium for sulfur form the spectrum of cadmium pigments that range from bright yellow to maroon. Because cadmium pigments are able to withstand elevated temperatures without degrading, they were predominantly used to color engineering plastics that were processed at high temperatures.

Coatings and Plating.—Cadmium anticorrosive coatings were used by the aerospace industry and military for some critical applications where coating substitution might compromise operational safety. The metal was commonly used to plate fasteners in aircraft landing gear and parachutes owing to a combination of properties not available from other coatings.

Solar.—Cadmium was consumed for the production of cadmium telluride (CdTe), a semiconducting compound used in thin-film photovoltaics. First Solar, Inc. (Tempe, AZ) was a leading producer of CdTe-based solar modules with

manufacturing locations in Perrysburg, OH, and Kulim, Malaysia (First Solar, Inc., 2016, p. 18). In June, the company announced that it had increased the energy conversion efficiency of its CdTe modules to 18.6%, equating to a higher energy density than the leading multicrystalline silicon modules (First Solar, Inc., 2015). 5N Plus Inc. (Canada) was the sole supplier of CdTe to First Solar (5N Plus Inc., 2014). PPM Pure Metals GmbH (Germany) also produced high-purity CdTe for photovoltaic applications at its manufacturing facility in Langelsheim, Germany (PPM Pure Metals GmbH, undated).

Prices

In 2015, the average Platts Metals Week New York dealer price for 99.95%-minimum-purity cadmium was quoted at \$0.67 per pound, 24% less than the average price in 2014. This price reflected the average price of cadmium traded on a spot basis; however, most cadmium produced was sold through long-term contracts. After decreasing in the first quarter from \$0.79 per pound in January to \$0.65 per pound in March, the average monthly New York dealer price remained unchanged from April through December. Aside from a notable increase in 2010, U.S. cadmium prices have generally trended downwards since 2007. According to Metal Bulletin published prices, the global free market price for 99.95%-minimum-purity cadmium in 2015 averaged \$0.50 per pound, declining from an average of \$0.80 per pound in January to a low of \$0.36 per pound in September. The price rose somewhat during the fourth quarter, increasing to an average of \$0.43 per pound in December. Global prices were thought to have decreased during the first 9 months of the year owing in part to decreased demand in India, the second-leading global consumer of cadmium (Heywood, 2015a, b).

World Industry Structure

Primary Production.—Global cadmium production, excluding U.S. production, totaled 23,200 t in 2015 (table 5), a slight increase from the amount produced in 2014. Most (62%) of the world's refined cadmium was produced in Asia and the Pacific (Australia, China, India, Japan, and the Republic of Korea), followed by Europe and Central Eurasia (Bulgaria, Germany, Kazakhstan, the Netherlands, Norway, Poland, Russia, and Uzbekistan) with 23%; North America (Canada and Mexico), 11%; and South America (Argentina, Brazil, and Peru), 4%. Major global producers of primary cadmium are listed in table 4.

Secondary Production.—Most secondary metal was recovered at NiCd battery recycling facilities in Asia, Europe, and the United States. In Asia, NiCd battery recyclers included Kansai Catalyst Co., Ltd. and KOBAR Ltd. in the Republic of Korea, and Nippon Recycle Center Corp. in Japan. In Europe, NiCd battery recycling took place at Accurec GmbH's facility in Germany, Saft AB's plant in Sweden, and Societe Nouvelle D'Affinage des Metaux's two recycling facilities in France.

Consumption.—Based on production and trade data, China was the leading consumer of cadmium, followed by, in descending order of quantity, India, Japan, and Belgium. Most of the NiCd battery manufacturing industry was located

in China and, to a lesser degree, in Japan. In 2015, China imported 9,910 t of unwrought cadmium, slightly less than the amount imported in 2014 and equivalent to about 63% of global production outside of China. China's leading import sources included the Republic of Korea (46%), Kazakhstan (14%), Canada (8%), and Uzbekistan (6%) (Global Trade Information Services Inc., 2016). In India, cadmium was thought to be consumed mostly for the production of silver-cadmium alloy for jewelry. In Japan, cadmium consumption decreased by 7% in 2015 from that of 2014 to 1,380 t. Almost all of the cadmium consumed in Japan was for the production of NiCd batteries (Roskill's Letter from Japan, 2016). In Belgium, Aurea SA (France, formerly Floridienne Chimie S.A.), an intermediate processor of cadmium, accounted for almost all of the country's cadmium consumption for the production of cadmium compounds.

World Review

Australia.—Nyrstar continued to advance projects that would allow for the increased treatment of cadmium at its Hobart zinc smelter in Tasmania and its Port Pirie lead smelter in South Australia. Following the completion of mining at MMG Ltd.'s Century zinc-lead mine in Australia in August, Nyrstar was reconfiguring its Hobart smelter to allow it to treat increased volumes of cadmium and zinc smelting residues generated from newly sourced, more complex feedstock. The project was expected to be commissioned in the second half of 2015. The Century Mine operated for 16 years and, at full production, was one of the leading global zinc-producing mines. In 2015, the mine produced 393,000 t of zinc in concentrate, a 16% decrease from that of 2014. Nyrstar was also increasing its cadmium cake production capacity at Port Pirie. The expansion project was expected to be completed in the third quarter of 2016 (MMG Ltd., 2016, p. 26; Nyrstar NV, 2015).

Belgium.—Flaurea Chemicals [owned by Aurea SA (France), formerly Floridienne Chimie] consumed cadmium to produce cadmium compounds, including cadmium chloride, nitrate, and oxide, and cadmium powder at its manufacturing facility in Ath. Cadmium compounds and powder were used mainly in coatings, industrial paint pigments, NiCd batteries, PVC stabilizers, surface treatments, and thin-film solar panels (Flaurea Chemicals, undated).

Canada.—Teck Resources Ltd.'s metallurgical complex in Trail, British Columbia, had the capacity to produce up to 1,400 metric tons per year (t/yr) of refined cadmium. Cadmium metal products included balls, billets, and sticks for NiCd battery manufacturing and continuously cast cadmium sheet for radiation shielding. Teck also produced cadmium chemicals. HudBay Minerals Inc.'s copper smelting and zinc refining operations in Flin Flon, Manitoba, produced cadmium metal. Most of the cadmium metal produced in Canada was thought to be exported.

India.—Hindustan Zinc Ltd. (HZL) produced cadmium metal at its Chanderiya lead-zinc smelter complex and Debari zinc smelter. The two plants had a combined cadmium production capacity of 695 t/yr. HZL produced 99.95%-cadmium at Debari and 99.99%-cadmium at Chanderiya. Binani Zinc Ltd. ceased operations at its zinc plant in Binanipuram in April 2014 owing

to low liquidity. Cadmium production capacity at the plant was 80 t/yr. In 2015, Binani (renamed Edayar Zinc Ltd. in September) was seeking financial help from the Government of India in order to resume production (Binani Industries Ltd., 2015, p. 9; Indian Bureau of Mines, 2015).

Korea, Republic of.—Korea Zinc Ltd.'s Onsan zinc-lead refinery had the capacity to produce 3,000 t/yr of refined cadmium, and Young Poong Corp.'s Sukpo zinc refinery had the capacity to produce 1,400 t/yr of cadmium. Most of the cadmium produced in the Republic of Korea was exported to China.

Mexico.—The Instituto Nacional de Estadística y Geografía (2016) reported that Mexico produced about 1,300 t of cadmium in 2015, 8% less than that in 2014. According to data reported by the two known producers, total cadmium production in 2015 was about 1,230 t. Industrias Peñoles S.A.B. de C.V.'s Met-Mex metallurgical complex in Torreon produced 633 t of cadmium in 2015, 9% less than that in 2014, and Grupo Mexico S.A.B. de C.V.'s zinc smelter in San Luis Potosi produced about 600 t of cadmium in 2015, unchanged from that in 2014 (Industrias Peñoles S.A.B. de C.V., 2016; Southern Copper Corp., 2016, p. 49).

Outlook

Concern over cadmium's toxicity has spurred legislation, especially in the European Union, to restrict the use of cadmium in most of its applications. In May, the European Parliament voted against extending an exemption to the Restriction of Hazardous Substances directive that would have allowed the use of cadmium-containing quantum dots in displays and lighting until June 30, 2018. Several companies, including The Dow Chemical Co. (Midland, MI) and Quantum Materials Corp. (Tempe, AZ), produce cadmium-free quantum dots for displays (Willing, 2015).

NiCd batteries had been favored for use in less expensive consumer appliances and electronics owing to their cost advantage over other battery chemistries. During the past few years, lithium-ion batteries have significantly replaced NiCd batteries in some low-cost electronics and substitution is expected to continue as the manufacturing cost of lithium-ion batteries decreases and their electrical storage capacity increases.

NiCd batteries, however, are expected to continue to be used in certain industrial applications because of their superior reliability and stability compared with the other rechargeable battery technologies. NiCd batteries power some battery-powered electric vehicles and are also used in a limited number of hybrid electric vehicles. NiCd batteries also are used as buffers in transportable, renewable hybrid-power systems developed to generate electricity in remote locations and in underdeveloped regions. Industrial-sized NiCd batteries potentially could be used to store energy produced by certain on-grid solar or wind systems. Excess energy generated during periods of low electricity demand could be stored in batteries, from which it would later be dispatched during periods of high electricity demand. NiCd may be a favored battery chemistry for this use owing to its stability in offshore and harsh weather environments.

Cadmium-containing residues will continue to be produced as a byproduct from zinc smelting, regardless of cadmium demand. Although there is growth potential in certain end uses, if applications for and consumption of cadmium continue to decline, excess byproduct residues may need to be permanently stockpiled and managed.

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TABLE 1
 SALIENT CADMIUM STATISTICS¹

		2011	2012	2013	2014	2015
United States:						
Production of metal ²	metric tons	W	W	W	W	W
Shipments of metal by producers	do.	W	W	W	W	W
Exports, unwrought metal and powders	do.	63	253	131	198	350
Imports for consumption, unwrought metal and powders	do.	201	170	284	133	237
Apparent consumption of metal	do.	W	W	W	W	W
Price, average, New York dealer ³	dollars per pound	1.25	0.92	0.87	0.88	0.67
Do. ³	dollars per kilogram	2.76	2.03	1.92	1.94	1.47
World, refinery production ^{c,4}	metric tons	21,100 ^r	22,300 ^r	22,700 ^r	22,700 ^r	23,200

^cEstimated. ¹Revised. Do., do. Ditto. W Withheld to avoid disclosing company proprietary data.

¹Data are rounded to no more than three significant digits, except prices.

²Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.

³Price for 1- to 5-short-ton lots of metal having a minimum purity of 99.95% (Platts Metals Week).

⁴Excludes U.S. production.

TABLE 2
U.S. EXPORTS OF CADMIUM PRODUCTS, BY COUNTRY AND TYPE¹

	2014		2015	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Unwrought metal and powders:				
Argentina	2,000	\$7,910	--	--
Canada	554	14,100	236	\$4,700
China	195,000	465,000	349,000	760,000
Germany	364	17,100	--	--
India	--	--	30	2,500
Korea, Republic of	150	5,210	4	12,200
Latvia	--	--	1	3,540
Total	198,000	509,000	350,000	783,000
Waste and scrap, Canada	--	--	147	3,010
Cadmium sulfide:				
Korea, Republic of	495	99,000	15	3,030
Malaysia	2,250	563,000	3,410	763,000
Venezuela	251	50,200	316	63,300
Total	3,000	712,000	3,740	829,000
Cadmium pigments:				
Australia	11,300	32,700	8,980	30,800
Barbados	--	--	4,200	5,990
Belgium	--	--	4,600	84,100
Brazil	55,500	288,000	15,300	217,000
Canada	372,000	1,790,000	--	--
Colombia	4,540	43,100	268	6,320
Germany	--	--	3,160	17,000
Indonesia	612	45,000	222	16,000
Italy	1,220	186,000	4,390	49,700
Jamaica	1,630	53,600	272	9,000
Japan	3,000	166,000	1,500	73,700
Korea, Republic of	--	--	11,900	52,000
Mexico	2,370,000	8,190,000	3,210,000	10,200,000
Netherlands	14,600	64,000	--	--
Peru	1,230	29,700	--	--
Philippines	8,120	103,000	--	--
Saint Kitts and Nevis	19,800	8,500	--	--
Switzerland	1,000	4,200,000	30,900	9,600,000
Taiwan	675	7,600	2,290	17,200
Trinidad and Tobago	17,500	52,100	--	--
United Kingdom	--	--	5,810	26,600
Venezuela	6,220	101,000	--	--
Vietnam	6,500	141,000	--	--
Other	4,390 ^r	117,000 ^f	6,760	51,700
Total	2,900,000	15,600,000	3,310,000	20,500,000

^rRevised. -- Zero.

^fData are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau, U.S. International Trade Commission.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF CADMIUM PRODUCTS, BY COUNTRY AND TYPE¹

	2014		2015	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Unwrought metal and powders:				
Australia	--	--	37,500	\$100,000
Belgium	4,350	\$130,000	4,000	111,000
Canada	103,000	206,000	101,000	163,000
China	452	7,210	62,300	338,000
Mexico	19,300	46,100	--	--
Peru	6,000	10,200	32,000	57,200
Total	133,000	399,000	237,000	769,000
Waste and scrap:				
Australia	--	--	41,000	92,300
United Kingdom	--	--	29,500	459,000
Total	--	--	70,500	551,000
Cadmium oxide:				
Belgium	52,100	595,000	50,000	624,000
United Kingdom	1,540	14,700	--	--
Total	53,600	610,000	50,000	624,000
Cadmium sulfide:				
Canada	--	--	14	7,250
Russia	9,000	1,680,000	1,860	336,000
Total	9,000	1,680,000	1,870	343,000
Cadmium pigments:				
Belgium	1,300	19,300	1,000	14,900
Brazil	11,300	390,000	9,040	300,000
Canada	62,300	338,000	30,100	400,000
China	55,400	4,230,000	152,000	6,550,000
France	--	--	60	2,550
Georgia	180	10,900	--	--
Germany	137,000	925,000	1,090	34,100
Japan	3,570	292,000	3,330	314,000
Mexico	1,710	86,600	1,680	87,000
Spain	--	--	2,940	18,300
United Kingdom	78,100	1,480,000	80,100	1,540,000
Total	351,000	7,770,000	281,000	9,260,000

-- Zero.

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

Source: U.S. Census Bureau, U.S. International Trade Commission.

TABLE 4
MAJOR PRIMARY CADMIUM PRODUCTION FACILITIES IN 2015

Country	Major operating company	Location of main facilities
Algeria	Société Algérienne du Zinc (METANOF)	Ghazaouet
Argentina	AR Zinc S.A. (Glencore plc)	Fray Luis Beltran
Australia	Nyrstar NV	Hobart, Tasmania
Brazil	Votorantim Metais S.A.	Juiz de Fora
Bulgaria	KCM AD	Plovdiv
Canada	HudBay Minerals Inc.	Flin Flon, Manitoba
Do.	Teck Resources Ltd.	Trail, British Columbia
China	Huludao Zinc Industry Co. Ltd.	Longgang, Huludao, Liaoning
Do.	Hunan Sanli Group Co. Ltd.	Huayuan, Xiangxi, Hunan
Do.	Yuguang Gold and Lead Co. Ltd.	Jiyuan, Henan
Do.	Yunnan Chihong Zinc and Germanium Co. Ltd.	Huize, Qujing, Yunnan
Do.	Yunnan Luoping Zinc & Electricity Co. Ltd.	Luoping, Qujing, Yunnan
Do.	Zhuzhou Smelter Group Co. Ltd.	Shifeng, Zhuzhou, Hunan
India	Binani Zinc Ltd.	Binanipuram
Do.	Hindustan Zinc Ltd.	Chanderiya
Do.	Hindustan Zinc Ltd.	Debari
Japan	Akita Zinc Co. Ltd. (Dowa Metals and Mining Co. Ltd.)	Iijima, Akita
Do.	Hachinohe Smelting Co. Ltd. (Mitsui Mining and Smelting Co. Ltd.)	Hachinohe, Aomori
Do.	Kamioka Mining & Smelting Co. Ltd. (Mitsui Mining and Smelting Co. Ltd.)	Hida, Gifu
Do.	Toho Zinc Co. Ltd.	Annaka, Gunma
Kazakhstan	Kazzinc JSC (Glencore plc)	Ust-Kamenogorsk
Korea, Republic of	Korea Zinc Ltd.	Onsan
Do.	Young Poong Corp.	Sukpo
Mexico	Grupo México S.A.B. de C.V.	San Luis Potosi, San Luis Potosi
Do.	Industrias Peñoles S.A.B. de C.V.	Torreón, Coahuila
Netherlands	Nyrstar NV	Budel
Norway	Boliden AB	Odda
Peru	Votorantim Metais S.A.	Cajamarquilla
Poland	Huta Cynku "Miasteczko Śląskie" S.A.	Miasteczko Śląskie
Russia	Chelyabinsk Zinc Plant OJSC	Chelyabinsk
Do.	Ural Mining and Metallurgy Co.	Vladikavkaz
United States	Nyrstar NV	Clarksville, Tennessee
Uzbekistan	JSC Almalyk Mining Metallurgical Complex	Almalyk
Do. Ditto.		

TABLE 5
CADMIUM: ESTIMATED WORLD REFINERY PRODUCTION, BY COUNTRY^{1,2}

(Metric tons)

Country ³	2011	2012	2013	2014	2015
Argentina	31 ⁴	37 ⁴	28 ⁴	30 ^r	30
Australia	390	380	380	350	380
Brazil	200	200	200	200	200
Bulgaria	427 ^r	363 ^r	270 ^{r,5}	270 ^{r,5}	360 ⁵
Canada ⁴	1,240	1,286	1,313	1,187 ^r	1,159 ^p
China	6,672 ^{r,4}	7,265 ^{r,4}	7,496 ^{r,4}	7,600 ^r	7,600
Germany ⁵	400 ^r	400 ^r	400 ^r	400 ^r	400
India	470 ⁴	396 ⁴	285 ⁴	107 ⁴	200
Japan ⁴	1,755	1,855	1,826	1,829	1,959
Kazakhstan	1,280 ^r	1,170 ^r	1,650 ^r	1,500 ^r	1,500
Korea, Republic of	3,005 ⁴	3,904 ⁴	3,950	4,010	4,200
Mexico ⁴	1,485	1,482	1,451	1,409	1,301
Netherlands	570	560	610	640	640
Norway	309 ⁴	310	310 ^r	310 ^r	310
Peru ⁴	572	684	695	769	757
Poland	526 ⁴	370 ⁴	460 ⁴	628 ⁴	630
Russia	1,500	1,300	1,100	1,200	1,300
United States ⁶	W	W	W	W	W
Uzbekistan	300	300	300	300	300
Total	21,100 ^r	22,300 ^r	22,700 ^r	22,700 ^r	23,200

^pPreliminary. ^rRevised. W Withheld to avoid disclosing company proprietary data, not included in total.

¹Estimated data and world totals are rounded to no more than three significant digits; may not add to totals shown.

²This table gives unwrought production from ores, concentrates, flue dusts, and other materials of both domestic and imported origin. Sources generally do not indicate if secondary metal (recovered from scrap) is included or not; where known, this has been indicated by a footnote. Includes data available through June 13, 2016.

³In addition to the countries listed, Algeria, North Korea, and Turkey produced cadmium, but available information is inadequate to make reliable estimates of output levels.

⁴Reported figure.

⁵Data based on exports.

⁶Includes secondary.