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2014 Minerals Yearbook

LITHIUM [ADVANCE RELEASE]

U.S. Department of the Interior
U.S. Geological Survey

October 2016

Lithium

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In the United States, one lithium brine operation with an associated lithium carbonate plant operated in Silver Peak, NV. Domestic and imported lithium carbonate, lithium chloride, and lithium hydroxide were consumed directly in industrial applications and used as raw materials for downstream lithium compounds. In 2014, lithium consumption in the United States was estimated to be 2,000 metric tons (t) of contained lithium, 11% greater than that in 2013. Increased U.S. consumption in 2014 was primarily the result of increased demand for lithium-based air treatment, battery, ceramic and glass, grease, metallurgical, pharmaceutical, and polymer products in the United States. In 2014, the gross weight of lithium compounds imported into the United States decreased by about 4% from those in 2013. Argentina and Chile were the principal sources of imported lithium carbonate, lithium chloride, and lithium hydroxide.

World lithium production in 2014 (excluding U.S. production) was estimated to be 31,500 t of lithium contained in minerals and compounds, an increase of 4% from the revised figure of 30,400 t in 2013 (also excluding U.S. production). World lithium production increased by an average of 6% per year from 2004 through 2014 (fig. 1). World lithium consumption was estimated to be approximately 31,000 t of lithium contained in minerals and compounds, an increase of 3% from that of 2013. More than 50% was consumed by countries within Asia. World lithium consumption increased by an average of 8% per year from 2004 through 2014 (fig. 1). Lithium carbonate and lithium hydroxide import prices, on average, increased by 3% and 9%, respectively, from those of 2013.

Lithium historically has been mined from two distinct sources—continental brines and hard rock minerals. In Chile, the world's leading producer of lithium carbonate, lithium was recovered from two brine operations on the Salar de Atacama in the Andes Mountains. Concentrated brines were transported to Antofagasta, on the coast of Chile, and processed at two lithium carbonate plants, one lithium chloride plant, and one lithium hydroxide plant. Lithium carbonate and lithium chloride also were produced from brines from the Salar del Hombre Muerto in the Andes Mountains in Argentina. A large percentage of the lithium carbonate produced in South America was exported to the United States. Australia was, by far, the leading producer of lithium mineral concentrates. Brazil, China, Portugal, and Zimbabwe also produced significant quantities of lithium concentrates, most of which were used directly in the production of ceramics and glass. China was the only country that produced large quantities of lithium carbonate and lithium hydroxide from mineral concentrates, mostly from spodumene imported from Australia. In China, lithium carbonate was also produced from brines from the Zabayu Salt Lake in western Xizang Autonomous Region (Tibet) and from the Dongtai and Xitai Salt Lakes in Qinghai Province.

Worldwide lithium resource exploration (led predominantly by startup companies in Australia and Canada) has increased significantly in recent years. A major focus of exploration in the United States was the continental brine and clay resources of Nevada, the oil field brines of Arkansas, and the geothermal brines of California. Brine resources of Argentina, pegmatite resources of Australia, pegmatite and oil brine resources of Canada, clay resources of Mexico, and continental brines in Bolivia and Chile were also explored for lithium recovery.

Lithium is sold as brines, compounds, metal, or mineral concentrates depending on the end use. Lithium's low atomic mass, low coefficient of thermal expansion, high electrochemical reactivity, and other unique properties resulted in many commercial lithium products. Lithium's properties make it one of the most attractive battery materials of all the elements. Worldwide, rechargeable lithium batteries powered most cellular telephones and laptop computers, as well as many heavy-duty power tools. Automakers were developing and improving lithium batteries for electric vehicles (EVs), hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs).

Production

The U.S. Geological Survey (USGS) collected domestic production data for lithium from a voluntary canvass of the only U.S. lithium carbonate producer, Rockwood Lithium Inc., which was in the process of being acquired by Albemarle Corp. of Baton Rouge, LA, in late 2014. Production and stock data collected from Rockwood Lithium were withheld from publication to avoid disclosing company proprietary data. The company's Silver Peak facility had a lithium carbonate production capacity of 6,000 metric tons per year (t/yr) (Rockwood Holdings, Inc., 2014a, p. 16).

In May, Rockwood Lithium's parent company, Rockwood Holdings, Inc. (Princeton, NJ), acquired a 49% interest in Australia's Talison Lithium Pty Ltd. from Chengdu Tianqi (Group) Co., Ltd. (China). Chengdu Tianqi, the world's leading producer of lithium compounds from concentrates, purchased Talison, a spodumene producer with a 110,000-t/yr lithium carbonate equivalent (LCE) production capacity, in 2013. The acquisition of Talison provided Rockwood Holdings with access to another significant lithium reserve, raw material diversity in the form of brines and mineral concentrates, and the flexibility to quickly ramp up production when necessary. By acquiring Talison's lithium production facilities in Australia, Rockwood Holdings became the world's leading producer of lithium in 2014, producing an estimated 56,000 t of LCE (Rockwood Holdings, Inc., 2014b, p. 8; Merriman, 2015, p. 9).

In July 2014, specialty-chemicals producer Albemarle entered into an agreement to acquire Rockwood Holdings.

The Rockwood Holdings acquisition was also expected to expedite Albemarle's long-standing plan to extract lithium from the bromine brine tailings at its Magnolia plant in Arkansas and produce as much as 20,000 t/yr of lithium carbonate (Kaskey, 2014).

Rockwood Holdings operated a 5,000-t/yr battery-grade lithium hydroxide production facility in Kings Mountain, NC, that used Rockwood Lithium's lithium carbonate as feedstock. The company's other downstream lithium operations in the United States include a butyllithium plant in New Johnsonville, TN, and facilities for producing lithium compounds in Kings Mountain. Rockwood Holdings' other global lithium operations, also included in Albemarle's acquisition, were a brine extraction operation in Chile's Salar de Atacama; lithium carbonate and lithium chloride plants in La Negra, Chile; a butyllithium, lithium chloride, and specialty chemical/metal plant in Langelsheim, Germany; and a butyllithium plant in Taichung, Taiwan (Rockwood Holdings, Inc., 2014a, p. 16, 44; Albemarle Corp., 2015b, p. 22–25).

FMC Lithium, a division of FMC Corp. (Philadelphia, PA), produced a full range of downstream inorganic lithium compounds, lithium metal, and organic lithium compounds at its main facility in Bessemer City, NC. The company sourced its lithium carbonate and lithium chloride from its brine operation in Argentina. FMC's other global lithium operations include a butyllithium facility in Zhangjiagang, China; a butyllithium/organometallic compound facility in Bromborough, United Kingdom; and an organolithium compound facility in Patancheru, India (Schneberger, 2015, p. 61).

In 2012, Western Lithium USA Corp. (Vancouver, British Columbia, Canada) completed a NI 43–101-compliant prefeasibility study of lithium-rich hectorite clay deposits at its King's Valley, NV, project. The study reported that lithium carbonate could be produced at a rate of 26,000 t/yr within 4 years after the initial plant startup. In 2014, Western Lithium began construction of a lithium demonstration plant to collect design data for a definitive feasibility study and to demonstrate the viability of extracting high-purity lithium from a hectorite deposit on a commercial scale (Western Lithium USA Corp., 2014).

Legislation and Government Programs

***National Defense Stockpile.*—**In October, the U.S. Department of Defense, Defense Logistics Agency Strategic Materials began to acquire selected lithium materials for the National Defense Stockpile. The Annual Materials Plan for fiscal year 2015, which represented the maximum quantities of lithium material that could be acquired from October 1, 2014, through September 30, 2015, was 150 kilograms (kg) for lithium-cobalt oxide and 540 kg for lithium-nickel-cobalt-aluminum oxide (U.S. Department of Defense, 2014).

Recycling

In 2014, lithium battery recycling projects were under development in Belgium, Germany, Japan, and the United States. As part of the American Recovery and Reinvestment Act of 2009 (ARRA, Public Law III–5), the U.S. Department of Energy awarded $9.5 million to California-based battery recycler Retriev Technologies Inc. (formerly Toxco, Inc.) to construct the first U.S. recycling facility for lithium-ion vehicle batteries. The company has been recycling lithium batteries at its facility in Trail, British Columbia, Canada, since 1993, and recycled nickel-metal hydride and lead-acid batteries from HEVs at its plant in Lancaster, OH. At yearend, construction of the new Lancaster facility, designed to process up to 4,000 t/yr of lithium-ion battery packs, was reported to be near completion (U.S. Department of Energy, 2013, p. 59–60; Retriev Technologies Inc., 2015).

Consumption

In 2014, the main global markets for lithium products were estimated to be batteries, 35%; ceramics and glass, 32%; lubricating greases, 9%; air treatment, 5%; continuous casting mold flux powders, 5%; polymer production, 4%; primary aluminum production, 1%; and other uses, 9% (David Merriman, Senior Analyst, Roskill Information Services Ltd., written commun., October 13, 2015). Other uses may have included agrochemicals, alloys, cement and concrete additives, dyes and pigments, industrial bleaching and sanitation products, organic synthesis, pharmaceuticals, pool chemicals, and welding (Rockwood Lithium GmbH, 2014). Data to make reliable estimates of U.S. consumption were not available.

Consumer and industrial electronics accounted for approximately 78% of global lithium-ion battery market revenues; transportation applications such as EVs, HEVs, and PHEVs accounted for approximately 20%; and grid applications accounted for approximately 2%. Global lithium-ion battery consumption increased by an average of 27% per year from 2011 through 2014, reaching an estimated 55 gigawatthours (GWh) in 2014 from 27 GWh in 2011 (1 GWh is the equivalent of consuming 1 billion watts for 1 hour). About 85% of the world's active lithium-ion battery cell production capacity was in China, Japan, and the Republic of Korea. Additional lithium-ion battery cell production capacity under construction in China was expected to more than double the country's production capacity. The United States and the European Union also had active lithium-ion battery cell production capacity, accounting for about 7% and 3%, respectively, of world capacity (Chung and others, 2015, p. 10, 12).

In 2014, electric car manufacturer Tesla Motors, Inc. (Palo Alto, CA) began construction of a lithium-ion battery "gigafactory" outside of Sparks, NV. The factory's planned annual battery cell production capacity of 35 GWh was expected to require 15,000 to 25,000 t/yr of lithium hydroxide to produce 500,000 lithium-ion vehicle batteries per year by 2020. Tesla planned to use the gigafactory's economies of scale and vertical integration capabilities (producing finished battery packs directly from raw materials under one roof) to reduce battery production costs by at least 30% in order to advance mass-market electric vehicle sales. Panasonic Corp. (Japan) joined Tesla in 2014 as a principal partner responsible for production of the lithium-ion battery cells and was to occupy approximately one-half of the gigafactory's manufacturing space (Tesla Motors, Inc., 2014, 2015).

Alcoa Inc. developed a third-generation aluminum-lithium alloy in 2011 that contributes to lighter, less costly, and more corrosion resistant airplanes compared with those using composite alternatives. The alloy enables better fuel efficiency, which is the largest single expense for many airlines. In 2014, Alcoa opened a new $90 million, 20,000-t/yr aluminum-lithium facility adjacent to its Lafayette, IN, plant. It was the largest aluminum-lithium aerospace plant in the world. Alcoa also expanded the capacity of its two other aluminum-lithium facilities: the Alcoa Technical Center in Alcoa Center, PA, and the Kitts Green plant in the United Kingdom (Alcoa Inc., 2014a; 2014b, p. 15).

Lithium-ion batteries have rapidly replaced nickel-cadmium batteries in heavy-duty power tools. According to Robert Bosch GmbH, a leading manufacturer of power tools, more than 80% of cordless power tools produced for the European market in 2014 were powered by lithium-ion batteries, an increase from 52% in 2009 (Robert Bosch GmbH, 2015, p. 34). It was likely that the United States market experienced a similar trend.

Consulting firm Lux Research, Inc. (Boston, MA) reported that, in terms of all the battery grid storage installations proposed worldwide in 2014, lithium-ion battery grid storage systems were, by far, the dominant technology, accounting for 90% of the proposals. Lux indicated that, although molten salt batteries account for the majority of existing grid storage installations, lithium-ion grid storage is now considered the technology of choice for future installations (Lux Research, Inc., 2015).

Prices

Customs values for U.S. imports of lithium carbonate and lithium hydroxide were used as an indication of the trends in lithium pricing; producer pricing was not available for lithium carbonate or lithium hydroxide. In 2014, the average customs unit value for imported lithium carbonate was $4.51 per kilogram, 3% higher than that of 2013. The average customs unit value for imported lithium hydroxide was $6.34 per kilogram, 9% higher than that of 2013. The average unit value of exported non-pharmaceutical-grade lithium carbonate in 2014 was $6.23 per kilogram, 7% higher than that of 2013. The average unit value of exported lithium hydroxide was $7.39 per kilogram, slightly lower than that of 2013. The average unit values of exported lithium carbonate and lithium hydroxide in 2014 were 38% and 17% higher, respectively, than the average unit values of imported carbonate and hydroxide. This suggests that the materials exported from the United States were higher quality than those that were imported. Import values mostly reflect companies importing their own materials at cost for further processing.

At yearend 2014, Industrial Minerals magazine reported that the U.S. import price for lithium carbonate (large contracts, delivered to the continental United States) was $6,000 to $6,800 per metric ton. The U.S. import price for lithium hydroxide (56.5% to 57.5% lithium hydroxide; large contracts, packed in drums or bags) delivered to Europe or the United States was $7,500 to $8,500 per metric ton. The U.S. import price for glass-grade spodumene (5% lithium oxide; cost, insurance, and freight) was $363 to $408 per metric ton. The U.S. import price for >7.5% lithium oxide spodumene (cost, insurance, and freight) was $635 to $703 per metric ton (Syrett, 2014).

In May, FMC increased its lithium hydroxide price by 10%. In December, FMC increased pricing for all grades of lithium carbonate and lithium salts including lithium hydroxide and specialty salts by 10% (FMC Corp., 2014). Sociedad Química y Minera de Chile S.A. (SQM) reported a 4% average price decrease for its lithium carbonate (Sociedad Química y Minera de Chile S.A., 2015, p. 54). China's Tianqi Lithium Co., Ltd. reported a 13% price increase for its lithium carbonate at yearend. Tianqi also reported that Talison Lithium in Australia saw a 3% to 5% price increase for its lithium concentrate (Minor Metals Monthly, 2014, 2015).

Foreign Trade

In 2014, total exports of lithium compounds, by gross weight, from the United States increased by 17% compared with those of 2013. About 60% of all U.S. exports of lithium compounds went to Japan, 13% went to Germany, and 5% went to Belgium (table 2). Lithium hydroxide accounted for 89% of the total lithium exports in 2014, whereas lithium carbonate accounted for the remaining 11% of total exports. Exports of lithium hydroxide increased by 28% in 2014 compared with those of 2013, whereas exports of lithium carbonate decreased by 30% in 2014.

Imports of lithium compounds, by gross weight, into the United States decreased by 4% in 2014 compared with those of 2013. About 66% came from Chile and 29% from Argentina (table 3). Lithium concentrates from Australia and Zimbabwe may have entered the United States, but these materials have no unique import code, and disaggregated import data were not available.

World Review

World lithium production in 2014 (excluding U.S. production) was estimated to be 31,500 t of lithium contained in minerals and compounds, an increase of 4% from the revised figure of 30,400 t in 2013 (table 1). The three leading producing countries, Argentina, Australia, and Chile, increased lithium production by 32%, slightly, and 3%, respectively, from that of 2013. Gross weight production figures for lithium carbonate, lithium chloride, lithium hydroxide, and lithium mineral concentrates are listed in table 4. Argentina, Chile, China, and the United States were the leading producers of brine-based lithium carbonate. Significant quantities of lithium compounds and concentrates also were produced in Australia, Brazil, China, Portugal, and Zimbabwe. Several brine operations were under development in Argentina, Bolivia, and Chile; spodumene mining operations were under development in Australia, Canada, China, and Finland; a jadarite mining operation was under development in Serbia; and a lithium-bearing clay mining operation was under development in Mexico. Pegmatites containing lithium minerals also have been identified in Afghanistan, Austria, Congo (Kinshasa), France, India, Ireland, Mozambique, Spain, and Sweden, but have not been developed. Lithium also has been identified in subsurface brines in Afghanistan and Israel. Companies in China, France, Germany, Japan, the Republic of Korea, Russia, Taiwan, the United Kingdom, and the United States produced downstream lithium compounds from imported lithium carbonate.

In 2014, worldwide lithium production capacity was estimated by the USGS to be 250,000 t/yr of LCE (47,000 t/yr lithium content), and worldwide capacity utilization was 67%. In comparison, FMC reported worldwide lithium production capacity to be 240,000 t/yr of LCE (45,100 t/yr lithium content) and worldwide capacity utilization to be 61% (Brondeau, 2015, p. 22).

Market analyst IHS, Inc. reported that lithium compounds accounted for an estimated 90% of global lithium consumption, and the direct market for mineral concentrates accounted for the remaining 10%. Battery-grade and technical-grade lithium carbonate accounted for approximately 70% of lithium consumption; battery-grade and technical-grade lithium hydroxide accounted for approximately 15% of lithium consumption; and lithium chloride accounted for the remaining 5% of lithium compound consumption (Schlag, 2014, p. 10).

In 2014, global lithium consumption for batteries, ceramics and glass, grease, pharmaceuticals, and other industrial applications increased; lithium consumption for primary aluminum production decreased. The USGS estimated that about 31,000 t of lithium contained in minerals and compounds was consumed worldwide in 2014, a 3% increase from that of 2013. Worldwide lithium consumption figures, however, varied considerably for the year depending on the source of information. Roskill estimated that 31,400 t of lithium contained in compounds and mineral concentrates was consumed worldwide (David Merriman, Senior Analyst, Roskill Information Services Ltd., oral commun., June 17, 2015). FMC, Albemarle, and Orocobre Ltd. estimated that 28,000 t, 30,100 t, and 32,000 t of lithium, respectively, was consumed worldwide (Albemarle Corp., 2015d, p. 27; Brondeau, 2015, p. 22; Calaway, 2015, p. 7). SQM reported that 26,700 t of lithium contained in compounds was consumed worldwide (Sociedad Química y Minera de Chile S.A., 2015, p. 23). Assuming the lithium consumption ratio provided by IHS (90% compound to 10% concentrate), and SQM's reported figure for compounds, the USGS estimated that approximately 29,700 t of lithium contained in compounds and mineral concentrates was consumed worldwide in 2014. According to USGS estimates, total global lithium consumption increased by an average of 8% per year from 2004 through 2014. According to SQM, lithium consumption for rechargeable batteries increased at an average rate of 25% per year from 2003 through 2013 (Sociedad Química y Minera de Chile S.A., 2014, p. 52).

FMC and SQM reported that countries within the Asia-Pacific region consumed 57% or more of their lithium output. Europe and North America consumed, on average, 22% and 20%, respectively, of their lithium, and Central and South America consumed the remaining 1% (Schneberger, 2015, p. 29; Sociedad Química y Minera de Chile S.A., 2015, p. 24).

Argentina.—Production of lithium carbonate in 2014 was reported to be 11,698 t, an increase of 26% from that of 2013 following a rampup of expanded capacity. Production of lithium chloride was reported to be 7,370 t, an increase of 43% from that of 2013. FMC has operated its facility at the Salar de Hombre Muerto since 1998. The facility was initially designed to produce about 12,000 t/yr of lithium carbonate and about 5,500 t/yr of lithium chloride. In 2012, FMC's lithium carbonate production capacity increased to 23,000 t/yr (Merriman, 2015, p. 13–14).

Enirgi Group Corp. of Canada developed proprietary technology to produce lithium directly from non-concentrated brine at the Salar del Rincón in Salta Province. The technology was expected to reduce processing time from the conventional 18 months to less than 24 hours, as well as increase the lithium recovery rate. The company planned to begin construction of a 50,000-t/yr LCE plant at the Salar del Rincón in 2015, and begin production in 2017 (Enirgi Group Corp., 2014).

In 2014, Australia's Orocobre Ltd. completed construction and began to ramp up production of its joint-venture Olaroz Lithium Project [Orocobre (66.5%),Toyota Tsusho Corp. (25%), and government of Jujuy Province (8.5%)] at the Salar de Olaroz in northwestern Argentina. Production capacity was reported to be 17,500 t/yr of battery-grade lithium carbonate. Owing to the low magnesium-to-lithium ratio in its brine and lower required lithium content for processing to lithium carbonate (0.7% lithium instead of the conventional 6% lithium), Orocobre reported that the length of its brine evaporation process was expected to be approximately 8 months compared with 18 months for Chile's lithium operations. Production was intended to supply low-cost lithium to automotive and battery industry markets (James Calaway, Chairman, Orocobre Ltd., oral commun., June 17, 2015).

In January, exploration company Lithium Americas Corp. (Canada) announced an agreement to install POSCO's (Republic of Korea) 200-t/yr LCE lithium extraction pilot plant at its Cauchari-Olaroz Lithium Project on the Puna plateau in northwestern Argentina. POSCO's new lithium extraction technology was expected to reduce the total brine-to-lithium-carbonate-production process to 8 hours. The lithium recovery rate from POSCO's technology was expected to be greater than 80%, compared with the typical 50% of traditional evaporation technology. Lithium Americas planned to build its project in two stages with each stage consisting of a 20,000-t/yr LCE facility. Construction of the first stage was underway, and in December, POSCO's pilot plant began production. Construction of the second stage was not expected to begin until 2018 (Lithium Americas Corp., 2014, p. 4; 2015).

Australia.—In 2014, Talison Lithium Pty Ltd. produced an estimated 40% of the global lithium supply from its deposit in Western Australia, which reportedly was the largest spodumene deposit in the world. Talison produced two types of lithium concentrate. Its chemical-grade lithium concentrate (6% lithium oxide content) is primarily used for conversion into lithium chemicals for applications including lithium batteries. Its technical-grade lithium concentrate (5% to 7.5% lithium oxide content) is a low-iron concentrate that is used directly in the manufacture of ceramics, glass, and heat-proof cookware. Talison's lithium concentrate production capacity was 740,000 t/yr, equivalent to approximately 110,000 t/yr of lithium carbonate (Talison Lithium Pty Ltd., 2012, p. 11–12, 29).

In 2013, Chengdu Tianqi (China), the world's leading producer of lithium compounds from concentrates, purchased

Talison Lithium. Chengdu sought to secure chemical-grade spodumene to produce lithium chemicals for its growing battery and electronics markets. In 2014, Rockwood Holdings, Inc. acquired a 49% interest in Talison from Chengdu Tianqi (Rockwood Holdings, Inc., 2014b, p. 8). Talison previously reported that 100% of its chemical-grade lithium concentrate was sold to China, and its technical-grade lithium concentrate was distributed throughout the world with approximately 40% (by weight) going to China, 37% to Europe, 13% to North America, and 7% to Japan (Talison Lithium Pty Ltd., 2012, p. 11–12). In 2012, Talison was the source of about 80% of the lithium consumed in China (Wheatley, 2012, p. 21).

In 2014, Neometals Ltd. (formerly Reed Resources Ltd.) completed continuous bench-scale test work for its proprietary process to produce battery-grade lithium hydroxide from spodumene sourced from its Mount Marion lithium project in Western Australia (jointly owned with Mineral Resources Ltd.). A 2012 prefeasibility study indicated that the Mount Marion lithium project could support a production capacity of 10,000 t/yr of lithium hydroxide and 8,800 t/yr of lithium carbonate (Reed Resources Ltd., 2014).

Bolivia.—Bolivia's undeveloped Salar de Uyuni is the largest salt flat in the world, with an area of about 11,000 square kilometers and containing vast lithium resources. In 2013, Bolivia began operation of a 40-ton-per-month lithium carbonate pilot plant at the Salar de Uyuni. In 2014, Bolivia opened a lithium-ion battery pilot plant in La Palca in the Potosi region of Bolivia. The plant was built by LinYi Dake Trade Co. (China), whose employees were to train 21 technicians in Bolivia in the technology and operation of the plant. Production capacity was expected to be 1,000 batteries per day (GlobalPost, 2014).

Canada.—Nemaska Lithium Inc. continued development of its Whabouchi Mine and lithium hydroxide-lithium carbonate plant in Quebec. Production capacity was anticipated to be 28,000 t/yr of lithium hydroxide and 3,000 t/yr of lithium carbonate using a proprietary membrane electrolysis process that produces high-purity lithium hydroxide directly from spodumene concentrate. The new technology was expected to reduce processing costs by using electricity to replace caustic soda and by eliminating the production, handling, and disposal of sodium sulfate. Nemaska expected to begin full operation of phase I, a 500-t/yr lithium hydroxide demonstration plant, by yearend 2015 (Industrial Minerals, 2015b).

Chile.—In 2014, SQM, which reportedly accounted for 27% of global lithium chemicals sales, sold 39,500 t of LCE, 9% more than in 2013 principally owing to an increase in secondary (rechargeable) battery consumption and lack of new lithium supply. The value of sales increased by 5% to $207 million. In 2014, the company's lithium products were distributed throughout the world, with 66%, by sales, going to Asia; 22% to Europe; 11% to North America; and 1% to Central and South America. SQM's lithium carbonate production capacity was 48,000 t/yr in 2014, and its lithium hydroxide production capacity was 6,000 t/yr. Engineering work was undertaken to expand lithium carbonate capacity by 42% to 68,000 t/yr (Hughes, 2014; Sociedad Química y Minera de Chile S.A., 2015, p. 23–24).

Lithium carbonate production capacity for Rockwood Holdings' operation in Chile was 27,000 t/yr, and lithium chloride capacity was 4,500 t/yr. In 2014, the company produced an estimated 19,500 t of lithium carbonate in Chile, an increase of 3% from that of 2013 (Merriman, 2015, p. 9), and a reported 2,985 t of lithium chloride, a decrease of 27% from 2013 (Comisión Chilena del Cobre, 2015). Albemarle, which was in the process of acquiring Rockwood Holdings in late 2014, reported strong sales growth for Rockwood Holdings' battery-grade lithium owing to rising demand in consumer devices and electric vehicles, but a decrease in butyllithium sales (Albemarle Corp, 2015c, p. 9). During 2014, Rockwood Holdings continued construction of a 20,000-t/yr lithium carbonate plant in La Negra, which would increase its total Chilean lithium carbonate production capacity to 47,000 t/yr. The new plant was scheduled to begin producing commercial quantities of lithium carbonate by the third quarter of 2015. Rockwood Holdings used lithium carbonate and lithium chloride from its operations in Chile as feedstock for some of its downstream chemical production in Germany, India, Taiwan, and the United States. All of the Rockwood Holdings operations in Chile were included in the Albemarle acquisition (Albemarle Corp, 2015a).

China.—China was the only country that continued to produce large quantities of lithium carbonate and lithium hydroxide from domestic and imported mineral concentrates. Lithium mineral deposits were estimated to contain 22% of China's lithium reserves, and lithium brines were estimated to contain the remaining 78% (Roskill Information Services Ltd., 2013, p. 147).

In 2014, China produced an estimated 10,100 t of LCE from domestic sources (6,030 t from brines and 4,050 t from spodumene and lepidolite), a 10% decrease from 11,230 t in 2013. Spodumene-based production capacity of China's mineral producers was 19,850 t/yr of LCE; lepidolite-based production capacity was 3,250 t/yr of LCE; and brine-based production capacity was 15,200 t/yr of LCE. China's spodumene and lepidolite production was mostly within Sichuan Province but also took place in Hunan and Jiangxi Provinces and in Xinjiang Uyghur Autonomous Region (David Merriman, Senior Analyst, Roskill Information Services Ltd., written commun., July 30, 2015). In 2014, apparent consumption of lithium carbonate in China was reported to be 53,000 t, a 5% increase from that of 2013 (Research in China, 2015). Global Lithium LLC reported total lithium consumption in China was 62,000 t of LCE (Lowry, 2015).

By yearend 2013, China's total brine and mineral conversion capacity was estimated to be 100,000 t/yr of lithium compounds, increasing at a rate of 37% per year from about 8,000 t/yr in 2005. China produced 38,000 t of lithium carbonate from domestic and imported mineral feedstock in 2013, the majority of which was from Australia. China also produced 19,000 t of lithium hydroxide from domestic and imported mineral feedstock (Tse, 2015). The rapid expansion of China's spodumene-based lithium carbonate production facilities in recent years has significantly affected the global lithium supply chain and has enabled spodumene-sourced lithium to account for one-half of the world's lithium supply since 2012.

Qinghai Lanke Lithium Industry Co., Ltd. operated a 5,000-t/yr lithium carbonate-lithium chloride project in the Chaerhan Salt Lake Zone in Qinghai Province and a 200-t/yr lithium carbonate pilot project (with Qinghai Salt Lake Industry Group Co., Ltd.) in the East Taijiner Salt Lake Zone. Qinghai Lanke planned to expand production capacity of these operations to 17,000 t/yr and 10,000 t/yr of LCE, respectively. CITIC Guoan Lithium Science & Technology Co., Ltd. operated a 5,000-t/yr lithium carbonate plant at West Taijiner Salt Lake in Qinghai Province with plans to expand capacity to 20,000 t/yr. Tibet Mineral Development Co., Ltd. operated a 5,000-t/yr lithium carbonate-lithium hydroxide project at the Zabayu Salt Lake in western Tibet with plans to expand to 18,000 t/yr (David Merriman, Senior Analyst, Roskill Information Services Ltd., written commun., July 30, 2015).

In 2014, China's Sichuan Tianqi Lithium Industries, Inc. [a subsidiary of Chengdu Tianqi (Group) Co., Ltd.] agreed to purchase the Jiangsu lithium carbonate plant from Australia's Galaxy Resources for $230 million. The Jiangsu plant was designed to produce 17,000 t/yr of battery-grade lithium carbonate (Diniz, 2014).

Japan.—Consumption of lithium compounds in Japan in 2014 increased to an estimated 17,800 t of LCE, 24% greater than the 14,410 t of LCE consumed in 2013, owing to greater demand for lithium-ion battery cathode materials by Tesla Motors. Lithium hydroxide consumption increased owing to Tesla Motors use of lithium hydroxide rather than lithium carbonate for its lithium-ion cathode. Although Japan's consumption of lithium carbonate for lithium-ion battery cathodes in 2014 was estimated to be 7,500 t, an increase of 7% from that of 2013, lithium carbonate consumption was 9% less than that in 2011 owing to continued transfer of lithium-ion battery manufacturing plants to lower cost plants in China. Japan's consumption of lithium hydroxide was estimated to have increased sharply in 2014 to 5,720 t of LCE, 86% higher than the 3,080 t of LCE consumed in 2013. Japan's lithium metal consumption decreased to 50 t in 2014, 18% lower than that of 2013 and 61% lower than that of 2012, owing to primary battery manufacturing plants relocating from Japan to Indonesia (Roskill's Letter from Japan, 2014, 2015).

Mexico.—In 2014, Canada's Bacanora Minerals Ltd. provided a preliminary economic assessment update of its Sonora Lithium Project in Sonora. The project consisted of 10 mining concessions about 125 miles south of Arizona. Mineralization on the concessions consisted of lithium-bearing clays localized in lake basins. The preliminary economic assessment update focused on 7 of the 10 concessions, which were reported as the La Ventana concession and the El Sauz–Fleur concessions. The La Ventana concession had an indicated lithium resource of 75 million metric tons (Mt) averaging 3,174 parts per million (ppm) lithium, capable of producing 1.3 Mt of LCE at a rate of 35,000 t/yr. The El Sauz–Fleur concessions had an indicated lithium resource of 121 Mt averaging 3,120 ppm lithium, capable of producing 2 Mt of LCE (Verley, 2014, p. 1–5).

Zimbabwe.—In an effort to increase the economic value of Zimbabwe's lithium, the Government of Zimbabwe began planning for the construction of a lithium compound processing plant. The Government anticipated selling the value-added lithium compounds to China for the production of lithium-ion batteries. Additionally, petalite mining company Bikita Minerals Ltd. began the first ever lithium resource study of Zimbabwe to determine if spodumene can be found in economic concentrations (Herald, The, 2014; Njanjamangezi, 2014).

Outlook

In 2014, FMC and lithium market analysts Credit Suisse Group, IHS Supply, and Roskill projected world lithium consumption levels in 2020. Their conclusions varied from 260,000 to 355,000 t/yr of LCE, with an average world lithium consumption in 2020 of approximately 280,000 t/yr of LCE. Average annual growth in world lithium consumption from 2014 through 2020 is expected to be between 9.6% and 12% (Credit Suisse Group, 2014: Schlag, 2014, p. 16; Brondeau, 2015, p. 22; Merriman, 2015, p. 21). New lithium producers are expected to supply approximately 25% of the lithium required by 2020 (Merchant Research & Consulting Ltd., 2014).

For lithium use in batteries, rechargeable lithium-ion batteries continue to have the greatest potential for growth. Based on a USGS estimate for 2014 and a projection for demand in 2020, worldwide lithium consumption for lithium-ion batteries in vehicle transportation applications is expected to increase by 20% per year through 2020 (Chung and others, 2015, p. 12). The lithium-ion battery energy storage market is forecast to constitute 60% of all LCE consumption by 2020 (Industrial Minerals, 2015a). Other lithium end uses are projected to increase also, but at lower rates than batteries. Owing to the potentially large demand for lithium hydroxide needed by Tesla at its gigafactory in Nevada, FMC and Albemarle reported the possibility of constructing new lithium hydroxide plants in the future (Benchmark Mineral Intelligence, 2015).

Lithium supply security has become a top priority for Asian technology companies. Strategic alliances and joint ventures have been, and continue to be, established with lithium exploration companies worldwide to ensure reliable, diversified supplies of lithium for Asia's battery and vehicle manufacturers. With lithium carbonate being one of the lowest cost components of a lithium-ion battery, the issue to be addressed is not cost difference or production efficiency, but supply security.

Most global automobile manufacturers have announced plans to use lithium-ion batteries in current and future generations of EVs, HEVs, and PHEVs. In 2015, new vehicle models with lithium-ion batteries are to be introduced into the United States by companies such as Bavarian Motor Works AG (BMW); BYD Co., Ltd.; Daimler AG (Mercedes-Benz); Ford Motor Co.; General Motors Co.; Mitsubishi Motors; Tesla Motors, Inc.; and Volkswagen Group. Major automobile manufacturers formed partnerships with established battery manufacturers to build battery plants for HEVs and EVs and to begin mass production of automotive lithium-ion batteries.

The successful use of lithium-ion batteries in EVs, HEVs, and PHEVs could greatly increase consumption of lithium. If the rate of consumption increases faster than supply, prices could increase, and other lithium resources that had been considered uneconomic might become economic for producing lithium carbonate. New lithium mineral operations under development throughout the world, which were specifically designed to produce battery-grade lithium carbonate and lithium hydroxide, demonstrate the potential economic viability of these operations.

Various countries worldwide are establishing national alternative energy policies that have the potential to substantially increase lithium demand. It was anticipated that countries in Asia, North America, and Western Europe would be at the forefront of adopting utility-scale energy storage systems that would become integral components of electricity grids for long-duration storage as well as short-duration ancillary services. China, in particular, is expected to become the largest utility-scale energy storage market in the world, with $586 billion in Government funds to be invested by 2020. These energy storage systems could be the beneficiaries of the widespread research and development of lithium-ion batteries for the transportation sector. Of several energy storage technologies competing within the short-duration ancillary services market, advanced lithium-ion batteries are expected to hold the greatest potential, capturing approximately 70% of the global ancillary services market by 2019. Worldwide revenue from sales of lithium-ion batteries for use in utility-scale energy storage systems is expected to increase to nearly $6 billion in 2020 from $72 million in 2012 (Pike Research, 2010; Oyama, 2011).

References Cited

Albemarle Corp., 2015a, Albemarle begins commissioning of new lithium carbonate production plant in Chile: Baton Rouge, LA, Albemarle Corp. press release, July 8. (Accessed September 8, 2015, at http://investors.albemarle.com/phoenix.zhtml?c=117031&p=irol-newsArticle&ID=2066247.)

Albemarle Corp., 2015b, Annual report—2014: Baton Rouge, LA, Albemarle Corp., March, 126 p. plus exhibits. (Accessed June 15, 2015, via http://investors.albemarle.com/phoenix.zhtml?c=117031&p=irol-reportsannual.)

Albemarle Corp., 2015c, Fourth quarter earnings: Baton Rouge, LA, Albemarle Corp., presentation, 10 p. (Accessed February 10, 2015, via http://investors.albemarle.com/phoenix.zhtml?c=117031&p=QuarterlyEarnings2014.)

Albemarle Corp., 2015d, Goldman Sachs Basic Materials Conference presentation: Baton Rouge, LA, Albemarle Corp., presentation, 33 p. (Accessed June 15, 2015, via http://investors.albemarle.com/phoenix.zhtml?c=117031&p=irol-EventDetails&EventId=5192146.)

Alcoa Inc., 2014a, Alcoa opens world's largest aluminum-lithium aerospace plant in Indiana: Pittsburgh, PA, Alcoa Inc. press release, October 2. (Accessed January 16, 2015, at http://www.alcoa.com/global/en/news/news_detail.asp?pageID=20141002000232en&newsYear=2014.)

Alcoa Inc., 2014b, Annual report—2013: Pittsburgh, PA, Alcoa Inc., April, 208 p. (Accessed April 13, 2014, at http://www.alcoa.com/global/en/investment/pdfs/2013_Annual_Report.pdf.)

Benchmark Minerals, 2015, Fears of lithium supply shortage become reality: Benchmark Mineral Intelligence, no. 2, June, p. 18–19. (Accessed July 14, 2015, at http://benchmarkminerals.com/benchmark-q2-2015.pdf.)

Brondeau, Pierre, 2015, First quarter results and opening remarks, *in* FMC corporate investor day presentation: Philadelphia, PA, FMC Corp., presentation. (Accessed June 25, 2015, via http://phx.corporate-ir.net/phoenix.zhtml?c=117919&p=irol-irhome.)

Calaway, James, 2015, Orocobre Limited—The newest lithium carbonate global supplier and long-term boron producer: Lithium Supply & Markets 2015, 7th, Shanghai, China, June 16–18, presentation, 18 p.

Chung, Donald, Elgqvist, Emma, and Santhanagopalan, Shriram, 2015, Automotive lithium-ion battery (LIB) supply chain and U.S. competitiveness considerations: U.S. Department of Energy, 40 p. (Accessed July 18, 2015, at http://www.nrel.gov/docs/fy15osti/63354.pdf.)

Comisión Chilena del Cobre, 2015, Anuario de estadísticas del—Cobre y otros minerals 1995–2014: Santiago, Chile, Comisión Chilena del Cobre, September, 166 p. (Accessed September 12, 2015, at http://www.cochilco.cl/descargas/estadisticas/anuarios/Anuario2015web.pdf.)

Credit Suisse Group, 2014, Lithium—A powerful story for investors: Zurich, Switzerland, Credit Suisse Group, May 27, 21 p. (Accessed October 24, 2014, at https://doc.research-and-analytics.csfb.com/docView?language=ENG&format=PDF&source_id=csplusresearchcp&document_id=1033413451&serialid=hB5rl6634lHQhI9aJANYDt%2BWIuwzOdNHujpWwDcKlOQ%3D.)

Diniz, Vivien, 2014, Galaxy Resources selling Jiangsu lithium carbonate plant for $230 million: Vancouver, British Columbia, Canada, Lithium Investing News, May 5. (Accessed May 15, 2014, at http://investingnews.com/daily/resource-investing/energy-investing/lithium-investing/galaxy-resources-selling-jiangsu-lithium-carbonate-plant-for-230-million/.)

Enirgi Group Corp., 2014, Enirgi Group validates revolutionary new proprietary lithium extraction technology: Toronto, Ontario, Canada, Enirgi Group Corp. press release, October 29, 2 p. (Accessed November 4, 2014, at http://www.enirgi.com/wp-content/uploads/2015/04/News-Release-10-29-2014-Enirgi-Group-Validates-Proprietary-Lithium-Extraction-Technology.pdf.)

FMC Corp., 2014, FMC Corporation announces lithium carbonate and lithium salts price increase: Philadelphia, PA, FMC Corp. press release, November 4. (Accessed November 20, 2014, at http://www.prnewswire.com/news-releases/fmc-corporation-announces-lithium-carbonate-and-lithium-salts-price-increase-281500611.html.)

GlobalPost, 2014, Bolivia inaugurates pilot plant for making lithium batteries: GlobalPost [Boston, MA], February 17. (Accessed February 18, 2014, at http://www.globalpost.com/dispatch/news/agencia-efe/140217/bolivia-inaugurates-pilot-plant-making-lithium-batteries.)

Herald, The, 2014, Govt to set up lithium plant: The Herald [Harare, Zimbabwe], March 20. (Accessed October 10, 2014, at http://www.herald.co.zw/govt-to-set-up-lithium-plant/.)

Hughes, Emma, 2014, Charging ahead—What 2014 holds for lithium: Industrial Minerals, no. 560, May, p. 49.

Industrial Minerals, 2015a, FMC look to high-growth lithium markets: Industrial Minerals, no. 570, March, p. 10.

Industrial Minerals, 2015b, Nemaska charges towards lithium hydroxide production: Industrial Minerals, no. 571, April, p. 70.

Kaskey, Jack, 2014, Lithium boom drives Albemarle $6.2 billion Rockwood deal: Bloomberg Business, July 15. (Accessed July 16, 2014, at http://www.bloomberg.com/news/articles/2014-07-15/lithium-boom-drives-albemarle-6-2-billion-rockwood-deal.)

Lithium Americas Corp., 2014, Developing one of the world's largest and lowest cost lithium operations: Toronto, Ontario, Canada, Lithium Americas Corp., presentation, July, 27 p. (Accessed August 19, 2014, via http://www.lithiumamericas.com.)

Lithium Americas Corp., 2015, Lithium Americas announces first production of lithium ready for export from Cauchari Salar in Jujuy Province, Argentina: Toronto, Ontario, Canada, Lithium Americas Corp. press release, January 20, 2p. (Accessed January 29, 2015, at http://www.marketwired.com/press-release/lithium-americas-announces-first-production-lithium-ready-export-from-cauchari-salar-tsx-lac-1984414.htm.)

Lowry, Joe, 2015, The end of the lithium "Big 3" final chapter: LinkedIn, June 1. (Accessed February 24, 2016, at https://www.linkedin.com/pulse/end-lithium-big-3-final-chapter-joe-lowry?trk=mp-reader-card.)

Lux Research, Inc., 2015, Li-ion dominates the booming grid storage market with 90% of 2014 proposals: Boston, MA, Lux Research, Inc. press release, March 4. (Accessed March 9, 2015, at http://www.luxresearchinc.com/news-and-events/press-releases/read/li-ion-dominates-booming-grid-storage-market-90-2014-proposals.)

Merchant Research & Consulting Ltd., 2014, Global lithium consumption to grow 9.5% yoy through 2020, according to in-demand report by Merchant Research & Consulting: Birmingham, United Kingdom, Market Publishers Ltd. press release, April 18. (Accessed April 25, 2014, at http://www.prweb.com/release/2014/04/prweb11776318.htm.)

Merriman, David, 2015, Roskill—Examining the pipeline of production and the impact on supply and demand balances: Lithium Supply & Markets 2015, 7th, Shanghai, China, June 16–18, presentation, 25 p.

Minor Metals Monthly, 2014, Tianqi Lithium—Talison lithium concentrate price rises: Minor Metals Monthly [published by Beijing Antaike Information Development Co., Ltd., or Antaike], no. 170, June, p. 16.

Minor Metals Monthly, 2015, Tianqi Lithium Co. Ltd. raises lithium carbonate price: Minor Metals Monthly [published by Beijing Antaike Information Development Co., Ltd., or Antaike], no. 177, January, p. 44.

Njanjamangezi, Emmerson, 2014, Bikita Minerals commissions lithium study: The [Harare] Zimbabwe Mail, April 8. (Accessed January 9, 2015, at http://www.zimville.com/blogs/p/28598/bikita-minerals-commissions-lithium-study.)
Oyama, Satoru, 2011, Smart grids spur massive demand for lithium ion batteries: El Segundo, CA, iSuppli Corp. press release, September 23. (Accessed January18, 2012, at http://www.isuppli.com/Semiconductor-Value-Chain/News/Pages/Smart-Grids-Spur-Massive-Demand-for-Lithium-Ion-Batteries.aspx.)
Pike Research, 2010, Lithium ion batteries to lead the market for short-duration energy storage ancillary services: Boulder, CO, Navigant Consulting, Inc. press release, September 13. (Accessed September 15, 2010, at http://www.navigantresearch.com/newsroom/lithium-ion-batteries-to-lead-the-market-for-short-duration-energy-storage-ancillary-services.)
Reed Resources Ltd., 2014, Successful completion of semi-pilot plant for battery grade lithium hydroxide: West Perth, Western Australia, Australia, Reed Resources Ltd. press release, June 30. (Accessed July 18, 2014, at http://www.reedresources.net/announce-blog.php?id=847&projpg=mtmar.)
Research in China, 2015, Global and China lithium carbonate industry report, 2014: Beijing, China, PRNewswire press release, January 8. (Accessed May 27, 2015, at http://www.prnewswire.com/news-releases/global-and-china-lithium-carbonate-industry-report-2014-300018056.html.)
Retriev Technologies Inc., 2015, Retriev Technologies Inc. appoints new president: Lancaster, OH, Retriev Technologies Inc. press release, January 8. (Accessed May 11, 2015, at http://www.prnewswire.com/news-releases/retriev-technologies-inc-appoints-new-president-300018278.html.)
Robert Bosch GmbH, 2015, Annual report—2014: Stuttgart, Germany, Robert Bosch GmbH, May, 144 p. (Accessed July 20, 2015, at http://annual-report.bosch.com/fileadmin/pdf/en/Bosch_Annual_Report_2014.pdf.)
Rockwood Holdings, Inc., 2014a, Form 10–K—For the fiscal year ended December 31, 2013: Princeton, NJ, Rockwood Holdings, Inc., April, 166 p. (Accessed May 1, 2014, at http://www.sec.gov/Archives/edgar/data/1315695/000110465913013682/a13-1429_110k.htm.)
Rockwood Holdings, Inc., 2014b, Form 10–Q—For the quarterly period ended June 30, 2014: U.S. Securities and Exchange Commission, 53 p. plus exhibits. (Accessed January 16, 2015, at http://www.sec.gov/Archives/edgar/data/1315695/000110465914058646/a14-14080_110q.htm.)
Rockwood Lithium GmbH, 2014, Application areas: Frankfurt, Germany, Rockwood Lithium GmbH. (Accessed August 11, 2014, at http://www.rockwoodlithium.com/applications/.)
Roskill Information Services Ltd., 2013, Lithium—Market outlook to 2017 (12th ed.): London, United Kingdom, Roskill Information Services Ltd., April, 426 p.
Roskill's Letter from Japan, 2014, Lithium—Sharp rise in Japanese demand forecast for 2014: London, United Kingdom, Roskill's Letter from Japan, no. 453, May, p. 1–4.
Roskill's Letter from Japan, 2015, Trade—8% rise in the value of Japanese rare metal imports in 2014: London, United Kingdom, Roskill's Letter from Japan, no. 463, March, p. 22.
Schlag, Stefan, 2014, Charging up?—Outlook for the global lithium market: Industrial Minerals International Congress and Exhibition 2014, Vancouver, British Columbia, Canada, April 1–3, presentation, 23 p.
Schneberger, Tom, 2015, FMC Lithium, *in* FMC corporate investor day presentation: Philadelphia, PA, FMC Corp., presentation. (Accessed June 25, 2015, via http://phx.corporate-ir.net/phoenix.zhtml?c=117919&p=irol-irhome.)
Sociedad Química y Minera de Chile S.A., 2014, Annual report—2013: Santiago, Chile, Sociedad Química y Minera de Chile S.A., April, 290 p. (Accessed May 8, 2014, at http://ir.sqm.com/files/doc_financials/annual_report/memoria%20SQM%20INGLES%202013_Total.pdf.)
Sociedad Química y Minera de Chile S.A., 2015, Annual report—2014: Santiago, Chile, Sociedad Química y Minera de Chile S.A., April, 324 p. (Accessed June 29, 2015, at http://s1.q4cdn.com/793210788/files/doc_financials/annual_report/Memoria-Annual-2014-Final_eng.pdf.)
Syrett, Laura, 2014, IM December price movements: Industrial Minerals, December 1. (Accessed February 16, 2015, via http://www.indmin.com/.)
Talison Lithium Pty Ltd., 2012, Annual information form for the year ended June 30, 2012: Perth, Western Australia, Australia, Talison Lithium Pty Ltd., 77 p. (Accessed October 20, 2012, via http://www.talisonlithium.com.)
Tesla Motors, Inc., 2014, Panasonic and Tesla sign agreement for the gigafactory: Palo Alto, CA, Tesla Motors, Inc. press release, July 31. (Accessed November 20, 2014, at http://ir.teslamotors.com/releasedetail.cfm?ReleaseID=863207.)
Tesla Motors, Inc., 2015, Tesla gigafactory: Palo Alto, CA, Tesla Motors, Inc. (Accessed August 26, 2015, at http://www.teslamotors.com/gigafactory.)
Tse, Pui-Kwan, 2015, The mineral industry of China [advance release], *in* Area reports—International—Asia and the Pacific: U.S. Geological Survey Minerals Yearbook 2013, v. III, p. 9.1–9.28. (Accessed August 12, 2015, at http://minerals.usgs.gov/minerals/pubs/country/2013/myb3-2013-ch.pdf.)
U.S. Department of Defense, 2014, Annual materials plan for FY 2015 for possible acquisition of new NDS stocks: Fort Belvoir, VA, U.S. Department of Defense, October 2. (Accessed November 18, 2014, at http://www.dla.mil/Portals/104/Documents/StrategicMaterials/3088%20FY15%20AMP_ACQ.pdf.)
U.S. Department of Energy, 2013, FY 2012 progress report for energy storage R&D: U.S. Department of Energy. (Accessed April 17, 2013, at http://energy.gov/eere/vehicles/fy-2012-progress-report-energy-storage-rd.)
Verley, Carl, 2014, Updated and reclassified lithium resources, Sonora Lithium Project: Calgary, Alberta, Canada, Bacanora Minerals Ltd., 66 p. (Accessed December 15, 2014, at http://www.bacanoraminerals.com/reports/pdf/2014sonora_resourceupdate.pdf.)
Western Lithium USA Corp., 2014, Western Lithium advances Nevada lithium supply with demonstration plant startup: Vancouver, British Columbia, Canada, Western Lithium USA Corp. press release, September 8. (Accessed September 14, 2014, at http://www.westernlithium.com/wp-content/uploads/2014/09/wlcsept82014.pdf.)
Wheatley, Frank, 2012, Global trends & the lithium market: Lithium Supply & Markets 2012, 4th, Buenos Aires, Argentina, January 23–25, presentation, 21 p.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Historical Statistics for Mineral and Material Commodities in the United States. Data Series 140.
Lithium. Ch. in Mineral Commodity Summaries, annual.
Lithium. Ch. in United States Mineral Resources Professional Paper 820, 1973.
Lithium. International Strategic Minerals Inventory Summary Report, Circular 930–I, 1990.
Lithium (Li). Ch. in Metal Prices in the United States Through 2010, Scientific Investigations Report 2012–5188, 2013.
Lithium Resources and Requirements by the Year 2000. Professional Paper 1005, 1976.

Other

Lithium. Ch. in Minerals Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
Lithium. U.S. Bureau of Mines Information Circular 9102, 1986.

TABLE 1
SALIENT LITHIUM STATISTICS[1]

(Metric tons of contained lithium)

	2010	2011	2012	2013	2014
United States:					
Production	W	W	W	870 [2]	W
Exports[3]	1,410	1,310	1,300	1,230	1,420
Imports[3]	1,960	2,850	2,760	2,210	2,120
Consumption[e]	1,100	2,000 [4]	2,000 [4]	1,800	2,000 [4]
Rest of world, production[5]	26,300 [r]	30,900 [r]	32,200 [r]	30,400 [r]	31,500 [e]

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Data are rounded to no more than three significant digits.
[2]Source: Rockwood Holdings, Inc., 2014a, Form 10–K—For the fiscal year ended December 31, 2013: Princeton, NJ, Rockwood Holdings, Inc., April, p. 16.
[3]Compounds. Source: U.S. Census Bureau.
[4]Rounded to one significant figure to avoid disclosing company proprietary data.
[5]Mineral concentrate, lithium carbonate, lithium chloride, and lithium hydroxide.

TABLE 2

U.S. EXPORTS OF LITHIUM CHEMICALS, BY COMPOUND AND COUNTRY[1]

Compound and country	2013 Gross weight (metric tons)	2013 Value[2] (thousands)	2014 Gross weight (metric tons)	2014 Value[2] (thousands)
Lithium carbonate:				
Australia	(3)	$8	10	$75
Bangladesh	--	--	19	45
Belgium	8	58	6	53
Bolivia	--	--	28	305
Canada	20	117	31	168
China	16	91	--	--
Germany	828	5,030	706	4,140
India	37	109	6	36
Japan	55	248	--	--
Korea, Republic of	22	111	30	157
Mexico	(3)	4	49	558
Singapore	3	23	3	23
Other	19	78 r	15	75
Total	1,010	5,870	904	5,630
Total content	190	XX	170	XX
Lithium carbonate, U.S.P.:[4]				
India	45	1,530	69	2,240
Israel	2	63	1	31
Mexico	343	379	--	--
Other	1	40	7	72
Total	391	2,020	77	2,340
Total content	73	XX	14	XX
Lithium hydroxide:				
Argentina	144	1,210	127	1,410
Australia	71	586	45	379
Belgium	626	3,980	441	2,830
Brazil	7	36	--	--
Canada	206	1,170	322	1,720
Chile	18	119	10	67
China	89	650	136	1,020
Colombia	52	390	69	493
Egypt	160	1,130	58	424
Germany	757	5,370	400	2,530
India	533	3,560	31	217
Japan	2,130	16,300	5,140	38,100
Korea, Republic of	106	876	80	660
Mexico	67	560	68	635
Peru	9	63	14	100
Russia	100	681	40	274
Saudi Arabia	113	777	85	528
Singapore	22	305	20	148
South Africa	3	403	3	312
Taiwan	317	2,380	76	604
Thailand	208	1,470	266	1,940
Trinidad and Tobago	5	50	4	50
Tunisia	18	123	--	--
United Arab Emirates	40	278	--	--
Venezuela	23	208	40	371
Vietnam	16	128	8	66
Other	9	681	34	695
Total	5,850	43,500	7,510	55,600
Total content	966	XX	1,240	XX

[r]Revised. XX Not applicable. -- Zero.

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

[2]Free alongside ship values.

[3]Less than ½ unit.

[4]Pharmaceutical-grade lithium carbonate.

Source: U.S. Census Bureau.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF LITHIUM CHEMICALS, BY COMPOUND AND COUNTRY[1]

Compound and country	2013 Gross weight (metric tons)	2013 Value[2] (thousands)	2014 Gross weight (metric tons)	2014 Value[2] (thousands)
Lithium carbonate:				
Argentina	4,670	$20,400	3,350	$15,100
Chile	5,790	24,700	5,920	26,200
China	52	150	283	861
Other	5	26	10	21
Total	10,500	45,300	9,560	42,200
Total content	1,980	XX	1,800	XX
Lithium carbonate, U.S.P.:[3]				
India	45	1,080	48	1,090
Italy	(4)	4	(4)	9
Total	45	1,080	48	1,100
Total content	8	XX	9	XX
Lithium hydroxide:				
Belgium	154	857	--	--
Chile	1,130	6,530	1,730	11,000
China	38	272	133	937
Germany	(4)	10	(4)	14
Japan	3	45	24	120
Norway	13	28	18	38
United Kingdom	(4)	2	11	62
Other	7	44	(4)	7
Total	1,340	7,790	1,920	12,200
Total content	221	XX	316	XX

XX Not applicable. -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Customs value.
[3]Pharmaceutical-grade lithium carbonate.
[4]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4
LITHIUM MINERALS AND BRINE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country[3]	2010	2011	2012	2013	2014
Argentina, subsurface brine:					
Lithium carbonate	11,196 r	10,024 r	10,535 r	9,248 r	11,698
Lithium chloride	6,832 r	4,605 r	4,297 r	5,156 r	7,370
Australia, spodumene	295,000	421,391	456,921	421,000 e	425,000 e
Brazil, concentrates	15,733	7,820	7,084	7,982 r	8,519
Chile, subsurface brine:					
Lithium carbonate	44,025	59,933	62,002	52,358	55,074
Lithium chloride	3,725	3,864	4,145	4,091	2,985
Lithium hydroxide	5,101	5,800	5,447	4,197	4,194
China, lithium carbonate equivalent[e, 4]	12,000 r	11,300 r	10,000 r	11,200 r	10,100
Portugal, lepidolite	40,109	37,534	20,698	19,940 r	17,459
United States, carbonate	W	W	W	4,600 [5]	W e
Zimbabwe, amblygonite, eucryptite, lepidolite, and petalite[e]	47,000 [6]	48,000 [6]	53,000 [6]	42,000 r	45,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Includes data available through September 7, 2016.
[2]Estimated data are rounded to no more than three significant digits.
[3]In addition to the countries listed, other nations may produce small quantities of lithium minerals, but output is not reported and no valid basis is available for estimating production levels.
[4]Produced from subsurface brine and concentrates.
[5]Source: Rockwood Holdings, Inc., 2014a, Form 10–K—For the fiscal year ended December 31, 2013: Princeton, NJ, Rockwood Holdings, Inc., April, p. 16.
[6]Reported figure.

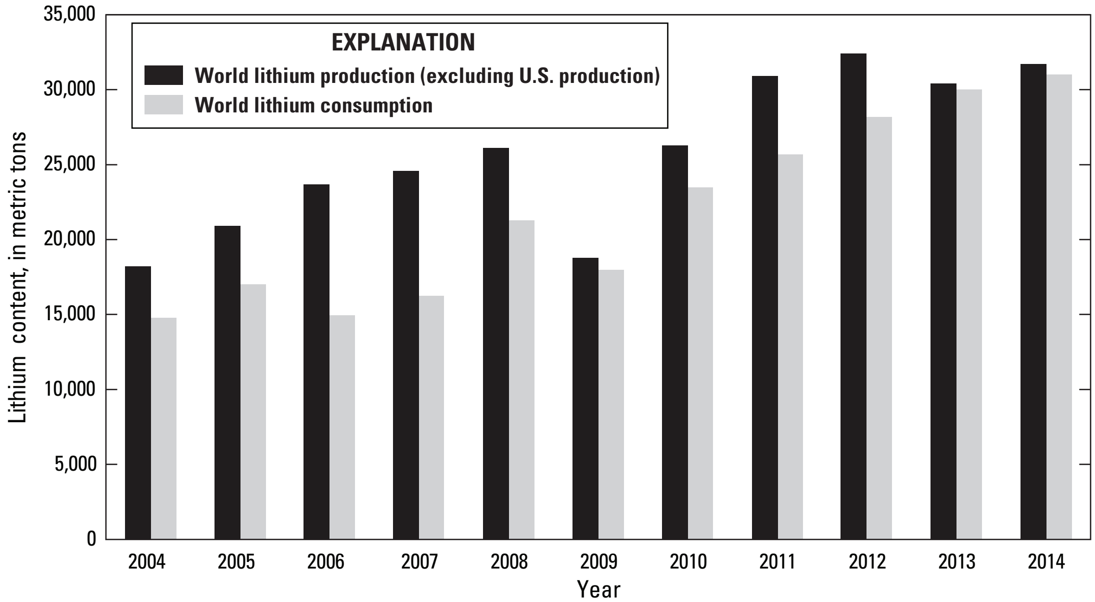

Figure 1. Estimated world lithium production (excluding U.S. production) and consumption from 2004 through 2014. Source: U.S. Geological Survey.