USGS
science for a changing world

2019 Minerals Yearbook

LITHIUM [ADVANCE RELEASE]

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

August 2024

Lithium

By Brian W. Jaskula

Domestic survey data and tables were prepared by Annie Hwang, statistical assistant.

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 2019, lithium consumption in the United States was estimated to be equivalent to 2,000 metric tons (t) of elemental lithium (table 1) [11,000 t of lithium carbonate equivalent (LCE)], primarily in lithium-based batteries, ceramics and glass, grease, pharmaceuticals, and polymer products. In 2019, the gross weight of lithium compounds imported into the United States decreased by 23%, and the gross weight of exports increased slightly from those in 2018. The average unit value of lithium carbonate imports (including pharmaceutical grade) increased by 10% from that in 2018, and the average unit value of lithium hydroxide imports decreased by 14%. Argentina and Chile were the principal sources of imported lithium carbonate, and Chile, China, and Russia were the principal sources of imported lithium hydroxide (table 3).

High lithium prices, beginning in 2015, prompted an aggressive increase in lithium production in Australia, which in turn led to world lithium production substantially exceeding world lithium consumption beginning in 2017. Owing to excess producer inventory, the price of lithium decreased considerably beginning in 2018. The difference between lithium production and consumption was further exacerbated in 2019 owing to weaker-than-expected sales of electric vehicles (EVs), particularly in China. Spot prices for battery-grade lithium carbonate in China decreased by 37% during the year, from an average of $11,440 per metric ton in January to an average of $7,190 per metric ton in December (Asian Metal Corp., 2019, p. 1; 2020, p. 1).

World lithium production in 2019 (excluding United States production) was estimated to be 86,100 t of lithium contained in minerals and compounds (458,000 t of LCE), about 6% lower than the revised lithium production of 91,800 t (489,000 t of LCE) in 2018, owing primarily to decreased production of mineral-sourced lithium from Australia (table 1). World lithium production decreased further because mineral-sourced lithium facilities in Canada and Namibia ceased operation in 2019. World lithium production (excluding U.S. production) increased at a compound annual growth rate (CAGR) of 16% per year from 2009 through 2019 (fig. 1). Roskill Information Services Ltd. estimated 2019 world lithium consumption to be approximately 56,000 t of lithium (298,000 t of LCE) contained in minerals and compounds, a 12% increase from that in 2018. Approximately 86% of world lithium consumption was in Asia (Roskill Information Services Ltd., 2020a, p. 68). World lithium consumption increased at a CAGR of 12% per year from 2009 through 2019 (fig. 1).

Legislation and Government Programs

National Defense Stockpile.—In 2014, the Defense Logistics Agency Strategic Materials (DLA Strategic Materials), an agency of the U.S. Department of Defense, began to acquire selected lithium-battery materials for the National Defense Stockpile (NDS). The DLA Strategic Materials Annual Materials Plan (AMP) (potential acquisitions) for fiscal year 2019 (October 1, 2018, through September 30, 2019), which represented the maximum quantities of materials that could be acquired during the year, was 19,000 kilograms (kg) of lithium-ion (Li-ion) precursors, which include lithium-cobalt oxide and lithium-nickel-cobalt-aluminum oxide. The AMP (potential acquisitions) for fiscal year 2020 (October 1, 2019, through September 30, 2020) did not include any lithium materials (Defense Logistics Agency Strategic Materials, 2018, 2019). At yearend 2019, the NDS held 750 kg of lithium-cobalt oxide and 1,900 kg of lithium-nickel-cobalt-aluminum oxide.

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, Albemarle Corp. of Charlotte, NC. Production and stock data collected from Albemarle were withheld from publication to avoid disclosing company proprietary data. The company's 6,000-metric-ton-per-year (t/yr) Silver Peak, NV, facility was expected to produce lithium carbonate for an additional 20 years at 2019 production levels (Albemarle Corp., 2020c, p. 4).

Albemarle operated a 5,000-t/yr battery-grade lithium hydroxide production facility in Kings Mountain, NC, that used Silver Peak's lithium carbonate as feedstock. Albemarle's other downstream lithium operations in the United States included a plant for producing specialty lithium products in New Johnsonville, TN, and facilities for producing other lithium compounds in Kings Mountain. Albemarle's global lithium operations included a brine extraction operation in Chile's Salar de Atacama; lithium carbonate and lithium chloride plants in La Negra, Chile; lithium carbonate and lithium hydroxide plants in Meishan and Xinyu, China; a butyllithium, lithium chloride, and specialty chemical and metal plant in Langelsheim, Germany; and a butyllithium plant in Taichung, Taiwan (Albemarle Corp., 2020c, p. 23–25).

Albemarle owned a 49% interest in Australia's Talison Lithium Pty Ltd, a spodumene producer with a 170,000-t/yr LCE production capacity, which increased by 62% in 2019 from 105,000 t/yr in 2018. Sichuan Tianqi Lithium Industries, Inc., a subsidiary of Chengdu Tianqi (Group) Co., Ltd. (China), owned the remaining interest in Talison (Albemarle Corp., 2020c, p. 4). Albemarle was the world's leading producer of lithium in 2019,

producing 17,400 t of elemental lithium (92,300 t of LCE) from its operations in Australia, Chile, and the United States (Roskill Information Services Ltd., 2020a, p. 267).

Livent Corp. (Philadelphia, PA), an independent lithium business that was spun off from FMC Corp. in 2018, produced a full range of downstream organic and inorganic lithium compounds and lithium metal at its facility in Bessemer City, NC. The company sourced its lithium carbonate and lithium chloride from its brine operation in Argentina. Livent's other global lithium operations included a lithium hydroxide and butyllithium facility in Zhangjiagang, China; a butyllithium-organometallic compound facility in Bromborough, United Kingdom; and a butyllithium-organometallic compound facility in Patancheru, India (Livent Corp, 2020a, p. 7, 30).

In 2019, Livent produced 16,785 t of lithium carbonate in Argentina, which, with additional lithium carbonate purchased from a third party, was converted to 21,348 t of lithium hydroxide in China and the United States. The company also produced 4,284 t of lithium chloride in Argentina, which was converted to 2,437 t of butyllithium in China, India, the United Kingdom, and the United States, and 167 t of high-purity lithium metal in the United States. Livent increased its lithium hydroxide production capacity to 25,000 t/yr in 2019. Owing to global lithium overproduction and low lithium prices, Livent slowed down or paused lithium carbonate and lithium hydroxide expansion projects. Livent's butyllithium production capacity was 3,265 t/yr, and its high-purity lithium metal production capacity was 250 t/yr (Livent Corp., 2020a, p. 6, 7; 2020b, p. 11).

Substantial efforts have been taken recently by three automobile battery manufacturers in the United States to construct new large-scale Li-ion battery factories (megafactories) or to expand existing facilities. Li-ion battery megafactories are defined by Benchmark Mineral Intelligence (2019) as factories with more than 1 gigawatthour per year (GWh/yr) in capacity. A gigawatthour (GWh) is a unit of energy equivalent to the consumption of 1 billion watts for 1 hour. In 2017, Tesla Inc. (Freemont, CA) began commercial production of Li-ion battery cells at its "Gigafactory" in Nevada. Panasonic Corp. (Osaka, Japan) established a partnership with Tesla to independently manufacture the battery cells within Tesla's Gigafactory. With an operational capacity of 37 GWh/yr in 2019, the Gigafactory was the largest Li-ion battery plant in the world (Randall, 2017; Benchmark Mineral Intelligence, 2020, p. 70).

In 2018, LG Chem Ltd. (Seoul, Republic of Korea) increased the production capacity of its Li-ion battery cell plant in Michigan to 3 GWh/yr to accommodate the expansion of General Motors Co. (GM) (Detroit, MI) EVs. In 2019, GM and LG Chem announced the formation of a new joint-venture company that was expected to build a 30-GWh/yr Li-ion battery cell production facility in Ohio. Construction was expected to begin in 2020 (General Motors Co., 2019; Roskill Information Services Ltd., 2020b, p. 388).

In 2018, Automotive Energy Supply Corp. (AESC), a joint venture between Nissan Motor Company Ltd. (Yokohama, Japan) and NEC Tokin (Shiroishi, Japan), manufactured 1 GWh/yr of Li-ion battery cells at its production facility in Tennessee. In 2019, Envision Group (Shanghai, China) acquired AESC (Roskill Information Services Ltd., 2020b, p. 394–395).

Recycling

To initiate development of new Li-ion battery recycling techniques and new battery designs, the U.S. Department of Energy's (DOE's) Vehicle Technologies Office began a collaboration with DOE's Argonne National Laboratory, the National Renewable Energy Laboratory, Oak Ridge National Laboratory, and several universities to establish DOE's first advanced battery recycling research and development facility called the ReCell Center. The goal of the Center was to develop technologies to cost effectively reclaim and recycle critical materials from all lithium-based battery technologies and help the United States establish a globally competitive recycling industry. Construction of the ReCell Center at the Argonne National Laboratory in Lemont, IL, commenced in 2018. In 2019, the ReCell researchers investigated various processes for cathode relithiation, a critical step to restore lithium stoichiometry of cathode materials and advance efforts in the recovery of clean black mass (the anode and cathode material that remains after the battery cell is shredded) (Gillard and others, 2019, p. 4, 18; U.S. Department of Energy, 2019; 2020, p. 3).

Consumption

In 2019, the global markets for lithium products were estimated to be batteries, 61%; ceramics and glass, 22%; lubricating greases, 6%; polymer production, 5%; continuous casting mold flux powders, 3%; air treatment, 2%; and other uses, 1% (Roskill Information Services Ltd., 2020a, p. 69). Other uses may have included agrochemicals, airbag ignition, aluminum alloys, carbon dioxide absorption media, cement and concrete additives, dyes and pigments, industrial catalysts, organic synthesis agents, pharmaceuticals, and scintillation counters (Albemarle Corp., 2020a).

Battery-grade lithium carbonate accounted for 41% of the 298,000 t of LCE consumed globally in 2019, battery-grade lithium hydroxide accounted for 18%, and technical-grade mineral concentrates accounted for 16%. Technical grades of lithium carbonate and lithium hydroxide accounted for 11% and 7%, respectively. Lithium bromide, butyllithium, and battery-grade metal accounted for 2%, 2%, and 1%, respectively, and other lithium compounds accounted for the remaining 2% (Roskill Information Services Ltd., 2020a, p. 71).

In 2019, EVs, hybrid-electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs) accounted for approximately 58% of the global Li-ion battery market as measured in GWh. Portable applications (cameras and camcorders, cellular telephones and smartphones, and laptop and tablet computers) accounted for 24% of the Li-ion battery market; power and motive devices (cordless power and garden tools, electric bicycles, motorcycles, and scooters) accounted for 12%; and grid storage accounted for the remaining 6%. Global Li-ion battery consumption increased at a CAGR of 22% per year from 2000 through 2019, reaching an estimated 165 GWh in 2019 (Roskill Information Services Ltd., 2020a, p. 68, 70).

In 2019, battery manufacturers were ramping up construction or planning to construct 455 GWh/yr of global production capacity for large EV-sized Li-ion battery cells. Approximately 73% of this capacity was in China, the United States had 10%,

and Europe had 6%. Asia (excluding China) and other regions accounted for the remaining 11%. Of the 115 battery-production facilities in the pipeline to be built worldwide, 88 were in China (Benchmark Mineral Intelligence, 2019; Moores, 2020).

Prices

Because producer prices were not available for lithium carbonate or lithium hydroxide, average customs unit values for U.S. imports of lithium carbonate and lithium hydroxide were used as indicators of the trends in lithium pricing. In 2019, the average customs unit value for imported lithium carbonate (including pharmaceutical-grade lithium carbonate) was $8.03 per kilogram, an increase of 10% from that in 2018 (table 3). The average customs unit value for imported lithium hydroxide was $14.60 per kilogram, 14% lower than that in 2018. The average unit value of exported lithium carbonate (including pharmaceutical-grade lithium carbonate) in 2019 was $13.60 per kilogram, 3% lower than that in 2018 (table 2). The average unit value of exported lithium hydroxide was $11.40 per kilogram, a slight decrease from that in 2018. In 2019, the average unit value of exported lithium carbonate was 69% higher than that of imported lithium carbonate, and the average unit value of exported lithium hydroxide was 22% lower than that of imported material. This suggests that domestic lithium carbonate exports were of a higher quality than imports. Import values mostly reflected companies importing their own materials at cost for further processing.

At yearend 2019, Fastmarkets IM (2020) reported that the U.S. import price range for lithium carbonate (large contracts, delivered to the continental United States) was $9,000 to $13,000 per metric ton. The price range for 56.5% to 57.5% lithium hydroxide, large contracts, packed in drums or bags, delivered to Europe or the United States was $10,500 to $14,000 per metric ton. The cost, insurance, and freight (c.i.f.) price range for 5% to 6% lithium oxide spodumene delivered to China was $480 to $550 per metric ton. The c.i.f. price range for 7% to 7.5% lithium oxide spodumene delivered to China was $850 to $1,000 per metric ton.

Spot prices for battery-grade lithium carbonate in China fell considerably throughout the year, averaging $7,190 per metric ton in December, a 37% decrease from $11,440 per metric ton in January. Spot prices for battery-grade lithium hydroxide in China also decreased considerably, averaging $7,840 per metric ton in December, a 49% decrease from $15,430 per metric ton in January (Asian Metal Corp., 2019, 2020).

Foreign Trade

In 2019, total exports of lithium compounds, by lithium content, from the United States increased slightly compared with those in 2018 (table 2). About 60% of all United States exports of lithium compounds went to Japan, 16% went to Germany, and 7% went to the Republic of Korea. Lithium hydroxide accounted for 90% of the total lithium exports in 2019, and lithium carbonate accounted for the remaining 10%. Exports of lithium carbonate decreased by 38% in 2019 compared with those in 2018, and exports of lithium hydroxide increased by 9%.

Imports of lithium compounds, by lithium content, into the United States decreased by 23% in 2019 compared with those in 2018 (table 3). About 59% came from Argentina, 29% from Chile, and 8% from China. Lithium concentrates from Australia and Zimbabwe may have been imported by the United States, but these materials have no unique import code, and so disaggregated import data were not available.

World Industry Structure

Lithium historically has been mined from two distinct sources—continental brines and hard-rock minerals. In Chile, 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. In the Andes Mountains in Argentina, lithium carbonate and lithium chloride also were produced from brines from the Salar del Hombre Muerto, and lithium carbonate was produced from brines from the Salar de Olaroz. A substantial 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 produced large quantities of lithium carbonate and lithium hydroxide from mineral concentrates, mostly from spodumene imported from Australia. In China, lithium carbonate also was produced from brines from the Zabayu Salt Lake in western Tibet and from the Dongtai and Xitai Salt Lakes in Qinghai Province.

Worldwide exploration for lithium resources had increased significantly in recent years. Exploration in the United States focused on the continental brine and clay resources of Nevada, the spodumene resources of North Carolina, the oil field brines of Arkansas, and the geothermal brines of California. In recent years, there was considerable lithium exploration in Argentina, Australia, Canada, Chile, China, and many other countries in Africa and Europe.

Lithium was sold as brines, compounds, metal, and 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 most heavy-duty power tools. Automakers were developing and improving lithium batteries for EVs, HEVs, and PHEVs. Rechargeable lithium batteries also were being used in electrical grid storage applications.

World Review

World lithium production in 2019 (excluding U.S. production) was estimated to be 86,100 t of lithium (458,000 t of LCE) contained in minerals and compounds, 6% lower than the revised quantity of 91,800 t (488,000 t of LCE) in 2018

(table 1), owing primarily to decreased production of mineral-sourced lithium from Australia. World lithium production also decreased because mineral-sourced lithium facilities in Canada and Namibia ceased operations in 2019 owing to low lithium prices. Global lithium production capacity was estimated to be 127,000 t/yr of lithium (676,000 t/yr of LCE), a 15% increase from that in 2018. The leading producing country was Australia, where production in terms of lithium content was approximately 2.3 times that of Chile, the second-ranked producing country. Based on data from Roskill Information Services Ltd. (2020a, p. 230), China was the third-ranked lithium-producing country. Production figures for lithium carbonate, lithium chloride, lithium hydroxide, and lithium mineral concentrates in table 4 are reported in gross weight. Argentina, Chile, China, and the United States were the leading producers of brine-based lithium carbonate. Australia, Brazil, China, Portugal, and Zimbabwe were the leading producers of lithium minerals. Additional brine deposits were being explored or were under development in Argentina, Bolivia, Chile, China, and the United States; new pegmatite mines were under consideration or development in Australia, Austria, Brazil, Canada, China, Congo (Kinshasa), Czechia, Finland, Germany, Ireland, Mali, Portugal, Russia, South Africa, Spain, Sweden, the United Kingdom, and Zimbabwe; a jadarite mine was under development in Serbia; and lithium-bearing clay mines were under development in Mexico and the United States. Reduced lithium prices in 2019, however, curtailed exploration and development efforts worldwide. Pegmatites containing lithium minerals also have been identified in Afghanistan, France, India, and Mozambique, 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, lithium chloride, and lithium hydroxide.

In 2019, global lithium consumption for air treatment, ceramics, glass, metallurgical powders, polymers, rechargeable batteries, and other industrial applications increased; lithium consumption for grease remained the same; and lithium consumption for glass ceramics and primary batteries decreased from that in 2018. In total, an estimated 56,000 t of lithium (298,000 t of LCE) contained in minerals and compounds was consumed worldwide in 2019, a 12% increase from the estimated consumption of 50,000 t (266,000 t of LCE) for 2018. China was the leading consumer of lithium minerals and compounds, accounting for 54% of worldwide consumption; the Republic of Korea consumed 20%; Japan, 12%; Europe, 8%; the United States, 5%; India and Southeast Asia, 1% (Roskill Information Services Ltd., 2020a, p. 4, 68).

According to Roskill Information Services Ltd. (2020a, p. 68) and USGS estimates, total global lithium consumption increased at a CAGR of 12% from 2009 through 2019 (fig. 1). According to Roskill Information Services Ltd. (2020a, p. 68), lithium consumption for rechargeable batteries increased at a CAGR of 22% from 2000 through 2019.

Argentina.—Production of lithium carbonate in 2019 was reported to be 29,994 t, a slight increase from that in 2018, and production of lithium chloride was 4,284 t, a decrease of 14% (table 4) (Ministerio de Energia y Mineria, 2019). Livent produced 16,800 t of lithium carbonate and 4,280 t of lithium chloride at its 26,000-t/yr LCE facility, which had been operating since 1998, on the Salar de Hombre Muerto in Catamarca Province (Livent Corp., 2020a, p. 7). Orocobre Ltd. produced 13,200 t of lithium carbonate at its joint-venture Olaroz Lithium Project [Orocobre (66.5%), Toyota Tsusho Corp. (25%), and the government of Jujuy Province (8.5%)] at the Salar de Olaroz in northwestern Argentina. Production capacity was 17,500 t/yr of battery-grade lithium carbonate (Orocobre Ltd., 2018, p. 3–6; 2019a, p. 2; 2019b, p. 2; 2019c, p. 2; 2020, p. 2).

Lithium Americas Corp. and Ganfeng Lithium Co. Ltd., co-owners of the Argentine joint-venture company, Minera Exar S.A., continued development of the Cauchari-Olaroz Lithium Project on the Puna plateau in northwestern Argentina. In 2019, Ganfeng Lithium Co. increased its interest in Minera Exar to 50%, with Lithium Americas holding the other 50% interest. Minera Exar updated the definitive feasibility study and mineral reserves estimation of the project, increasing the planned production capacity to 40,000 t/yr of LCE over the course of 40 years. Proven and probable mineral reserves were reported to be 684,000 t of contained lithium [3.64 million metric tons (Mt) of LCE]. By yearend 2019, earthworks for the evaporation ponds were 98% complete, about 38% of the pond liner was installed, 18 production wells were complete, and an additional 12 were still in progress (Lithium Americas Corp., 2019, p. 2, 7, 8; 2020, p. 11).

Australia.—In 2019, the government of Western Australia reported total spodumene concentrate production of 1.62 Mt, a decrease of 18% from its revised production figure of 1.97 Mt in 2018 (Government of Western Australia, Department of Mines, Industry Regulation and Safety, 2020). Production was estimated to be equivalent to approximately 45,000 t of contained lithium (240,000 t of LCE). Talison Lithium Pty Ltd (a subsidiary of Sichuan Tianqi Lithium and Albemarle) produced approximately 105,000 t of LCE from its Greenbushes spodumene deposit in Western Australia (Roskill Information Services Ltd., 2020a, p. 211). Talison's lithium concentrate production capacity increased to 32,000 t/yr of contained lithium (170,000 t/yr of LCE) in 2019 (Albemarle Corp., 2020c, p. 4).

In 2019, Albemarle acquired a 60% interest in the Wodgina spodumene mine in Pilbara, Western Australia, from Mineral Resources Ltd. and formed a joint venture named MARBL Lithium Joint Venture. MARBL idled spodumene production until market conditions improved. A 50,000-t/yr lithium hydroxide plant was scheduled to be commissioned in 2021. The Wodgina mine's spodumene resource was reported to be 259 Mt, grading 1.17% lithium oxide, with a lithium recovery rate of 65% (Mineral Resources Ltd., 2019, p. 14; Albemarle Corp., 2020c, p. 4).

The Mt Marion lithium project, a joint venture between Mineral Resources and Ganfeng Lithium Co., Ltd., was Western Australia's second-ranked spodumene producer after Talison. In 2019, the Mt Marion operation produced 386,000 t of spodumene concentrate, equivalent to 11,000 t of contained lithium (57,000 t of LCE) (Mineral Resources Ltd., 2019, p. 15; 2020, p. 25).

Galaxy Resources Ltd. produced 192,000 t of spodumene concentrate at its 210,000-t/yr Mt Cattlin operation near Ravensthorpe, Western Australia. With lithium oxide content reported to be 5.93%, the spodumene concentrate was equivalent to 5,270 t of contained lithium (28,100 t of LCE). Mt Cattlin's spodumene ore reserves were reported to be 8.2 Mt, grading 1.29% lithium oxide (Galaxy Resources Ltd., 2020, p. 19).

Altura Mining Ltd. produced 165,000 t of spodumene concentrate, equivalent to 4,590 t of contained lithium (24,400 t of LCE) at its Altura lithium mine located at Pilgangoora in Western Australia. The Altura lithium mine has a spodumene ore reserve of 37.6 Mt, grading 1.08% lithium oxide (Altura Mining Ltd., 2019, p. 10; 2020, p. 2).

Pilbara Minerals Ltd. produced 152,000 t of spodumene concentrate, equivalent to 4,230 t of contained lithium (22,500 t of LCE) at its Pilgangoora Lithium-Tantalum Project in Western Australia's Pilbara region. Pilbara's spodumene resource was reported to be 223 Mt, grading 1.27% lithium oxide (Henderson, 2020, p. 6; Pilbara Minerals Ltd., 2020, p. 5).

Canada.—In February 2019, North American Lithium Inc. ceased production of spodumene concentrate at its open pit mine in La Corne, Quebec, owing to low spodumene prices. In 2018, the company exported 140,000 t of spodumene concentrate, equivalent to about 3,900 t of contained lithium (20,800 t of LCE) (Facada, 2019).

Chile.—In 2019, the Government of Chile reported production of 101,000 t of lithium carbonate, an increase of 16% from that in 2018; 1,890 t of lithium chloride, a decrease of 51%; and 9,930 t of lithium hydroxide, an increase of 54%. Sociedad Química y Minera de Chile S.A. (SQM) produced 62,300 t of lithium carbonate and 9,930 t of lithium hydroxide. The company accounted for 15% of global lithium chemical sales and sold 45,100 t of LCE in 2019, the same as that in 2018. SQM's value of sales decreased by 31% to $506 million owing to lower lithium prices. In 2019, 75% of the company's lithium products, by sales value, went to Asia and other locations, 15% went to Europe; 9% to North America; and 1% to Central America and South America. SQM's lithium was recovered from its brine operation at the Salar de Atacama and processed into lithium carbonate and lithium hydroxide in Antofagasta. Owing to increasing demand for lithium carbonate and lithium hydroxide from EV battery manufacturers, SQM increased its lithium carbonate and lithium hydroxide production capacities to 70,000 t/yr and 13,500 t/yr, respectively, in 2018. SQM began the process of increasing its lithium carbonate and lithium hydroxide production capacities to 120,000 t/yr and 21,500 t/yr, respectively. The expansion projects were expected to be completed in 2021 (Servicio Nacional de Geología y Minería, 2020, p. 120–121; Sociedad Química y Minera de Chile S.A., 2020, p. 21–23, 33, 53).

Albemarle produced an estimated 38,500 t of lithium carbonate and 1,890 t of lithium chloride. It commissioned its new 20,000-t/yr lithium carbonate plant in La Negra in 2017, increasing its total lithium carbonate and lithium chloride production capacity in Chile to 44,000 t/yr of LCE, and used lithium carbonate and lithium chloride from its operations in Chile as feedstock for some of its downstream chemical production in Germany, Taiwan, and the United States. Albemarle planned to increase its lithium carbonate and lithium chloride capacity in Chile to 80,000 t/yr of LCE (Albemarle Corp., 2020b; 2020c, p. 23–24).

China.—China produced large quantities of lithium carbonate and lithium hydroxide from domestic and imported mineral concentrates. In 2019, China produced 57,500 t of LCE from domestic sources, a 52% increase from the revised 2018 production of 37,800 t owing mostly to an increase in mineral-sourced mining capacity. China ranked third in lithium production, after Australia and Chile. Six Chinese lithium brine operations and six lithium mineral mines were in operation in 2019; brine-sourced lithium and mineral-sourced lithium each accounted for 50% of China's lithium mine production. Production capacity of the brine-based operations was 65,000 t/yr of LCE, and mineral-based production capacity was 75,700 t/yr. China's lepidolite, mica, petalite, and spodumene was produced mostly within Jiangxi and Sichuan Provinces but also took place in Hunan Province and Xinjiang Uyghur Autonomous Region. China's brine was extracted in the Qinghai and Tibet Provinces (Roskill Information Services Ltd., 2020a, p. 225–231).

In 2019, total lithium consumption in China was 163,000 t of LCE (Roskill Information Services Ltd., 2020a, p. 72). The rapid expansion of China's spodumene-based lithium carbonate and lithium hydroxide production facilities in recent years significantly affected the global lithium supply chain and enabled mineral-sourced lithium, the majority of which was mined by Talison in Australia, to account for the majority of production in 2019.

Outlook

Lithium supply security has become a top priority for technology companies worldwide. Strategic alliances and joint ventures have been and continue to be established with commercial lithium companies and lithium exploration companies to ensure reliable, diversified supplies of lithium for battery and vehicle manufacturers. With lithium carbonate and (or) lithium hydroxide being some of the lowest cost components of Li-ion batteries, price is of less concern than supply security.

In anticipation of robust EV battery demand, vigorous efforts are underway by battery companies worldwide to construct new large-scale Li-ion battery factories (megafactories) or to expand existing facilities. In 2019, megafactories with a combined battery capacity of 455 GWh/yr either were ramping up or being planned for construction throughout Asia, Europe, and North America. By 2029, battery capacity is expected to increase to 2,450 GWh/yr, with China accounting for 70% of the world's Li-ion battery production capacity; Europe, 16%; North America, 9%; and Asia (excluding China) and other regions, 5% (Moores, 2020).

References Cited

Albemarle Corp., 2020a, Applications: Charlotte, NC, Albemarle Corp. (Accessed November 7, 2020, at https://www.albemarle.com/businesses/lithium/markets--applications.)

Albemarle Corp., 2020b, Chile: Charlotte, NC, Albemarle Corp. (Accessed November 7, 2020, at https://www.albemarle.com/locations/south-america/chile.)

Albemarle Corp., 2020c, Form 10–K—2019: U.S. Securities and Exchange Commission, 115 p. (Accessed August 8, 2020, at http://investors.albemarle.com/static-files/37d4e140-ebe0-4e7b-8d9f-7b995197ae08.)

Altura Mining Ltd., 2019, Annual report 2019: Perth, Western Australia, Australia, Altura Mining Ltd., November 6, 94 p. (Accessed May 10, 2020, at https://alturamining.com/wp-content/uploads/2019/10/1993105.pdf.)

Altura Mining Ltd., 2020, ASX announcement, quarterly activities report—December 2019: Perth, Western Australia, Australia, Altura Mining Ltd. press release, January 31, 5 p. (Accessed May 10, 2020, at https://alturamining.com/wp-content/uploads/2020/01/2024716.pdf.)

Asian Metal Corp., 2019, Monthly lithium market report January 2019: Beijing, China, Asian Metal Corp., February 15, 10 p. (Accessed July 15, 2019, via http://www.asianmetal.com.)

Asian Metal Corp., 2020, Monthly lithium market report December 2019: Beijing, China, Asian Metal Corp., January 14, 10 p. (Accessed March 25, 2020, via http://www.asianmetal.com.)

Benchmark Mineral Intelligence, 2019, EV battery arms race enters new gear with 115 megafactories, Europe sees most rapid growth: London, United Kingdom, Benchmark Mineral Intelligence, December 31. (Accessed July 8, 2020, at https://www.benchmarkminerals.com/ev-battery-arms-race-enters-new-gear-with-115-megafactories-europe-sees-most-rapid-growth/.)

Benchmark Mineral Intelligence, 2020, Do we need a Terrafactory?: Benchmark Mineral Intelligence, no. 22, Q2, 70 p.

Defense Logistics Agency Strategic Materials, 2018, Annual Materials Plan for FY 2019 (potential acquisitions): Fort Belvoir, VA, Defense Logistics Agency Strategic Materials, October 3, 1 p. (Accessed October 15, 2018, at https://www.dla.mil/Portals/104/Documents/Strategic%20Materials/Announcements/3152%20FY19%20AMP_ACQ.pdf?ver=2018-10-03-091748-770.)

Defense Logistics Agency Strategic Materials, 2019, Annual Materials Plan for FY 2020 (potential acquisitions): Fort Belvoir, VA, Defense Logistics Agency Strategic Materials, October 4, 1 p. (Accessed October 20, 2019, at https://www.dla.mil/Portals/104/Documents/Strategic%20Materials/Announcements/3167%20FY20%20AMP_ACQ.pdf?ver=2019-10-04-090806-880.)

Facada, Martim, 2019, Lower prices push North American Lithium to pause spodumene production: Fastmarkets, February 21. (Accessed August 21, 2019, at https://www.fastmarkets.com/article/3859688/lower-prices-push-north-american-lithium-to-pause-spodumene-production.)

Fastmarkets IM, 2020, Fastmarkets IM December 2019 price movements: Fastmarkets IM, January 10. (Accessed May 10, 2020, via https://indmin.com.)

Galaxy Resources Ltd., 2020, Annual report—Year ended 31 December 2019: Applecross, Western Australia, Australia, Galaxy Resources Ltd., 108 p. (Accessed July 29, 2020, at https://gxy.com/wp-content/uploads/2020/05/44h2780x1sr108.pdf.)

General Motors Co., 2019, General Motors and LG Chem team up to advance toward an all-electric future, add jobs in Ohio: General Motors Co. press release, December 5. (Accessed March 17, 2021, via https://media.gm.com/media/us/en/gm/news.detail.html/content/Pages/news/us/en/2019/dec/1205-lgchem.html#:~:text=DETROIT%20%E2%80%94%20General%20Motors%20(NYSE%3A,equally%20owned%20joint%20venture%20company.)

Gillard, Sam, Gaines, Linda, and Spangenberger, Jeff, 2019, Li-ion recycling center overview: Washington, DC, U.S. Department of Energy presentation, June 11, 26 p. (Accessed November 7, 2019, at https://www.energy.gov/sites/prod/files/2019/06/f64/bat377_spangenberger_2019_o_5.14_2.58pm_jl_chg6.4ls.pdf.)

Government of Western Australia, Department of Mines, Industry Regulation and Safety, 2020, 2019 major commodities resources file: Perth, Western Australia, Australia, Government of Western Australia, Department of Mines, Industry Regulation and Safety. (Accessed May 21, 2020, at http://www.dmp.wa.gov.au/Documents/Investors/2019-Major-commodities.xlsx.)

Henderson, Dale, 2020, Evolving landscape of strategic partnerships in the lithium supply chain: Roskill Lithium Mine to Market Conference, Perth, Western Australia, Australia, February 12–13, 2020, presentation, 17 p. (Accessed September 20, 2020, at http://www.pilbaraminerals.com.au/site/PDF/a0e05a83-c3a8-492a-9518-f83c6fa282b3/CorporatePresentationRoskillConference.)

Lithium Americas Corp., 2019, NI 43–101 technical report—Updated feasibility study and mineral reserve estimation to support 40,000 tpa lithium carbonate production at the Cauchari–Olaroz Salars, Juijuy Province, Argentina: Vancouver, British Columbia, Canada, Lithium Americas Corp., November 11, 371 p. (Accessed January 15, 2020, at https://www.lithiumamericas.com/_resources/pdf/investors/technical-reports/cauchari-olaroz/LAC43101Nov112019FINAL.pdf.)

Lithium Americas Corp., 2020, Annual information form for the year ended December 31, 2019: Vancouver, British Columbia, Canada, Lithium Americas Corp., 82 p. (Accessed June 5, 2020, at https://www.lithiumamericas.com/_resources/pdf/investors/AIF/2019.pdf.)

Livent Corp., 2020a, Form 10–K—2019: U.S. Securities and Exchange Commission, 97 p. (Accessed July 7, 2020, at https://s22.q4cdn.com/453302215/files/doc_financials/2019/annual/10-K.pdf.)

Livent Corp., 2020b, Fourth quarter 2019 earnings call script: Philadelphia, PA, Livent Corp., February 20, 23 p. (Accessed July 7, 2020, at https://s22.q4cdn.com/453302215/files/doc_financials/2019/q4/LTHM-4Q-2019-Earnings-Call-Script-vFinal_for-delivery.pdf.)

Mineral Resources Ltd., 2019, Annual report 2019: Applecross, Western Australia, Australia, Mineral Resources Ltd., 117 p. (Accessed May 4, 2020, at https://s3.ap-southeast-2.amazonaws.com/assets.mineralresources.com.au/app/uploads/2019/10/09081031/2019AnnualReport02156834.pdf.)

Mineral Resources Ltd., 2020, 2020 annual report: Applecross, Western Australia, Australia, Mineral Resources Ltd., 140 p. (Accessed December 2, 2020, at https://s3-ap-southeast-2.amazonaws.com/assets.mineralresources.com.au/app/uploads/2020/10/19170651/2020-Annual-Report-reading-view.pdf.)

Ministerio de Energia y Mineria, 2019, Centro de Informacion Minera de Argentina [Mining Information Center of Argentina]: Buenos Aires, Argentina, Ministerio de Energia y Mineria. (Accessed June 9, 2020, via http://informacionminera.produccion.gob.ar/dataset/620/produccion.) [In Spanish.]

Moores, Simon, 2020, Written testimony of Simon Moores, managing director, Benchmark Mineral Intelligence: U.S. Senate Hearing, Washington, DC, June 24, 2020, written testimony. (Accessed September 15, 2020, at https://www.energy.senate.gov/services/files/6A3B3A00-8A72-4DC3-8342-F6A7B9B33FEF.)

Orocobre Ltd., 2018, Quarterly report of operations for the period ended 31 December 2017: Brisbane, Queensland, Australia, Orocobre Ltd., January 16, 26 p. (Accessed April 19, 2018, at https://www.orocobre.com/wp/?mdocs-file=3609.)

Orocobre Ltd., 2019a, Quarterly report of operations for the period ended 30 June 2019: Brisbane, Queensland, Australia, Orocobre Ltd., July 24, 13 p. (Accessed May 7, 2020, at https://www.orocobre.com/wp/?mdocs-file=5881.)

Orocobre Ltd., 2019b, Quarterly report of operations for the period ended 30 September 2019: Brisbane, Queensland, Australia, Orocobre Ltd., October 22, 14 p. (Accessed May 7, 2020, at https://www.orocobre.com/wp/?mdocs-file=6480.)

Orocobre Ltd., 2019c, Quarterly report of operations for the period ended 31 March 2019: Brisbane, Queensland, Australia, Orocobre Ltd., April 17, 15 p. (Accessed May 7, 2020, at https://www.orocobre.com/wp/?mdocs-file=5598.)

Orocobre Ltd., 2020, Quarterly report of operations for the period ended 31 December 2019: Brisbane, Queensland, Australia, Orocobre Ltd., January 30, 11 p. (Accessed May 7, 2020, at https://www.orocobre.com/wp/?mdocs-file=6935.)

Pilbara Minerals Ltd., 2020, Interim financial report—December 31, 2019: West Perth, Western Australia, Australia, Pilbara Minerals Ltd. 29 p. (Accessed May 26, 2020, at http://www.pilbaraminerals.com.au/site/PDF/432a68e2-a48d-484c-91c1-9d9eaaed815c/HalfYearlyReportandAccounts.)

Randall, Tom, 2017, Tesla flips the switch on the Gigafactory: New York, NY, Bloomberg L.P., January 4. (Accessed March 16, 2021, at https://www.bloomberg.com/news/articles/2017-01-04/tesla-flips-the-switch-on-the-gigafactory.)

Roskill Information Services Ltd., 2020a, Lithium—Outlook to 2030 (17th ed.): London, United Kingdom, Roskill Information Services Ltd., August, 619 p.
Roskill Information Services Ltd., 2020b, Li-ion batteries—Outlook to 2029 (4th ed.): London, United Kingdom, Roskill Information Services Ltd., April, 479 p.
Servicio Nacional de Geología y Minería, 2020, Anuario de la mineria de Chile, 2019 [Chilean mining yearbook, 2019]: Santiago, Chile, Servicio Nacional de Geología y Minería, 283 p. (Accessed October 20, 2020, at https://www.sernageomin.cl/wp-content/uploads/Anuarios/anuario_2019_act231120.pdf.) [In Spanish.]
Sociedad Química y Minera de Chile S.A., 2020, Annual report 2019: Santiago, Chile, Sociedad Química y Minera de Chile S.A., April, 396 p. (Accessed July 9, 2020, at https://s25.q4cdn.com/757756353/files/doc_financials/2019/ar/Memoria-Anual-2019_eng_final.pdf.)
U.S. Department of Energy, 2019, Energy Department announces opening of battery recycling center at Argonne National Lab: U.S. Department of Energy press release, February 15. (Accessed March 1, 2019, via https://www.energy.gov/articles/energy-department-announces-opening-battery-recycling-center-argonne-national-lab.)
U.S. Department of Energy, 2020, ReCell Advanced Battery Recycling Center—First quarter progress report 2020: U.S. Department of Energy, January 1, 83 p. (Accessed June 9, 2020, at https://anl.app.box.com/s/gv95sl2ijacot47e6odn6vztgtiu15dh.)

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 Critical Mineral Resources of the United States—Economic and Environmental Geology and Prospects for Future Supply, Professional Paper 1802, 2017.
Lithium. Ch. in Mineral Commodity Summaries, annual.
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, lithium content)

	2015	2016	2017	2018	2019
United States:					
Production	W	W	W	W	W
Exports[2]	1,790	1,520	1,960	1,660	1,680
Imports[2]	2,750	3,140	3,330	3,420	2,620
Consumption[e, 3]	2,000	3,000	3,000	3,000	2,000
Rest of world, production[4]	32,200 [r]	41,600 [r]	76,400 [r]	91,800 [r]	86,100 [e]

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through November 16, 2020. Data are rounded to no more than three significant digits.
[2]Compounds. Source: U.S. Census Bureau.
[3]Rounded to one significant digit to avoid disclosing company proprietary data.
[4]Lithium content of mineral concentrate, lithium carbonate, and lithium chloride.

TABLE 2
U.S. EXPORTS OF LITHIUM CHEMICALS, BY COMPOUND AND COUNTRY OR LOCALITY[1]

Compound and country or locality	2018 Gross weight (metric tons)	2018 Value[2] (thousands)	2019 Gross weight (metric tons)	2019 Value[2] (thousands)
Lithium carbonate:				
Belgium	25	$240	22	$84
Canada	103	468	40	177
Finland	5	94	--	--
Germany	1,060	12,100	703	7,940
India	10	190	--	--
Japan	92	1,470	--	--
Korea, Republic of	20	73	1	3
Mexico	3	12	2	7
Taiwan	--	--	38	136
United Kingdom	3	10	2	10
Other	4 r	29 r	12	59
Total	1,320	14,700	819	8,410
Total Li content	249	XX	154	XX
Lithium carbonate, U.S.P.:[3]				
Colombia	6	88	2	282
India	119	4,770	90	3,390
Israel	7	274	3	287
Korea, Republic of	5	488	--	--
Other	4 r	159 r	1	24
Total	141	5,780	95	3,980
Total Li content	27	XX	18	XX
Lithium hydroxide:				
Argentina	112	2,040	165	2,960
Australia	60	1,010	60	1,020
Belgium	408	6,490	330	3,290
Canada	444	2,600	311	1,760
Chile	29	275	35	321
China	197	3,800	111	2,010
Colombia	12	181	--	--
Egypt	160	2,370	74	1,210
France	(4)	69	40	338
Germany	756	9,790	834	14,700
Guyana	22	44	--	--
India	20	250	11	55
Indonesia	--	--	13	229
Italy	5	33	--	--
Japan	5,780	62,900	6,130	62,200
Korea, Republic of	71	1,100	754	9,340
Mexico	25	528	7	92
Peru	8	208	--	--
Russia	66	398	--	--
Singapore	63	1,150	81	1,310
Thailand	132	1,220	188	1,390
United Arab Emirates	20	380	--	--
United Kingdom	1	92	15	1,650
Other	7 r	732 r	3	298
Total	8,400	97,600	9,160	104,000
Total Li content	1,390	XX	1,510	XX

rRevised. XX Not applicable. -- Zero.
[1]Table includes data available through June 3, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Free alongside ship values.
[3]Pharmaceutical-grade lithium carbonate.
[4]Less than ½ unit.

Source: U.S. Census Bureau.

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

Compound and country or locality	2018 Gross weight (metric tons)	2018 Value[2] (thousands)	2019 Gross weight (metric tons)	2019 Value[2] (thousands)
Lithium carbonate:				
Argentina	8,320	$51,600	8,200	$45,600
Bolivia	18	160	--	--
Chile	7,450	62,600	3,600	45,400
China	747	9,090	976	11,400
Germany	20	57	1	17
India	11	71	3	16
Japan	20	283	8	136
Korea, Republic of	548	1,730	--	--
Switzerland	42	372	--	--
United Kingdom	70	450	22	269
Other	4	34	1	20
Total	17,200	126,000	12,800	103,000
Total Li content	3,240	XX	2,410	XX
Lithium carbonate, U.S.P.:[3]				
China	(4)	14	--	--
India	--	--	(4)	8
Total	(4)	14	(4)	8
Total content	(4)	XX	(4)	XX
Lithium hydroxide:				
Chile	390	6,340	419	5,680
China	319	5,950	148	1,840
Germany	(4)	11	60	346
Hong Kong	12	192	--	--
Japan	13	211	2	72
Romania	--	--	21	1,560
Russia	321	5,270	597	8,710
United Kingdom	3	78	3	80
Other	4 r	25 r	3	22
Total	1,060	18,100	1,250	18,300
Total Li content	176 r	XX	208	XX

rRevised. XX Not applicable. -- Zero.
[1]Table includes data available through June 3, 2020. 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 OR LOCALITY[1]

(Metric tons, gross weight)

Country or locality[2]	2015	2016	2017	2018	2019
Argentina:					
Lithium carbonate	21,111	24,409	26,559	29,385 r	29,994
Lithium chloride	5,848	6,468	4,501	5,005	4,284
Australia, spodumene	439,514 r	522,181 r	1,706,618	1,965,944 r	1,616,764
Brazil, concentrate	5,781	8,804	10,547 r	41,000 r	85,000
Canada, spodumene	--	--	--	114,000	9,000
Chile:					
Lithium carbonate	50,418	70,831	73,563	87,029	99,300
Lithium chloride	2,069	1,775	2,535	3,826	3,000
Lithium hydroxide[3]	3,888	5,576	5,280	6,468	10,000
China, lithium carbonate equivalent[4]	20,470	25,400	37,300	37,800	57,500
Namibia, lepidolite	--	--	--	30,000 e	--
Portugal, lepidolite	17,120	25,758	52,741 r	76,818 r	77,000
United States, lithium carbonate	W	W	W	W	W
Zimbabwe, petalite, lepidolite	50,000 e	50,000 e	40,000	80,000 e	80,000 e

eEstimated. rRevised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1]Table includes data available through June 16, 2020. All data are reported unless otherwise noted. Estimated data are rounded to no more than three significant digits.

[2]In addition to the countries and (or) localities listed, other nations may have produced small quantities of lithium minerals, but available information was inadequate to make reliable estimates of output.

[3]Brine-sourced lithium hydroxide is produced from lithium carbonate, and therefore not included in the "Rest of world, production" total in table 1 to avoid double counting.

[4]Produced from subsurface brine and domestic concentrates.

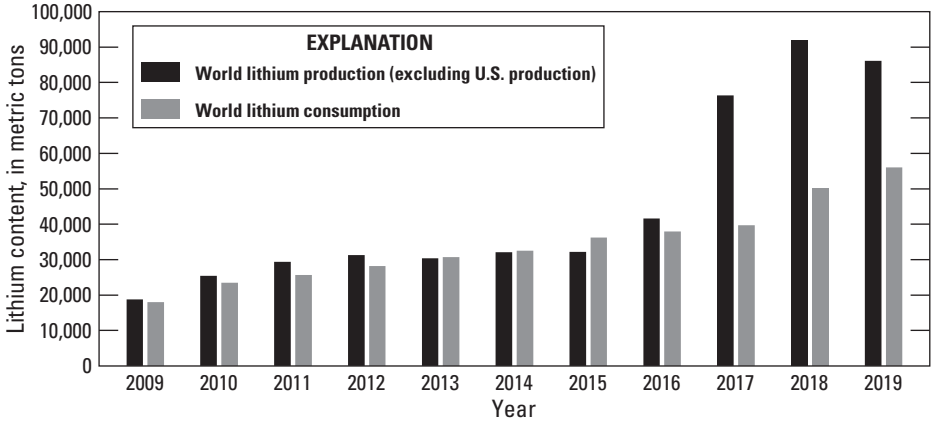

Figure 1. Estimated world lithium production (excluding U.S. production) and consumption from 2009 through 2019. The chart shows gradual increases in production from 2009 to 2016, large increases in production in 2017 and 2018, and a decrease in production in 2019. Consumption shows a trend of gradual increases during the whole time period with slightly higher increases in 2018 and 2019. Sources: U.S. Geological Survey and Roskill Information Services Ltd.