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LITHIUM [ADVANCE RELEASE]

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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 2018, lithium consumption in the United States was estimated to be equivalent to 3,000 metric tons (t) of elemental lithium (table 1) [16,000 t of lithium carbonate equivalent (LCE)]. In 2018, the lithium content of lithium compounds imported into the United States increased by 3% and the lithium content of exports decreased by 15% from those in 2017 (table 1). The average unit value of lithium carbonate imports (including pharmaceutical grade) increased by 50% from that in 2017, and the average unit value of lithium hydroxide imports increased by 12% (table 2). 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).

World lithium production in 2018 (excluding United States production) was 95,000 t of lithium contained in minerals and compounds (510,000 t of LCE), 25% higher than the revised lithium production of 76,200 t in 2017 owing to increased production of brine- and mineral-sourced lithium from all countries, including the addition of new lithium production from Canada and Namibia. Australia increased lithium production markedly in 2018 (tables 1, 4). World lithium production increased at a compound annual growth rate (CAGR) of 14% from 2008 through 2018 (fig. 1). Roskill Information Services Ltd. (2019c, p. 58) estimated world lithium consumption to be approximately 49,000 t of lithium (260,000 t of LCE) contained in minerals and compounds, an increase of 24% from that in 2017. Approximately 70% of world lithium consumption was in Asia by China (42%), the Republic of Korea (16%), and Japan (12%). World lithium consumption increased at a CAGR of 9% from 2008 through 2018 (fig. 1).

High lithium prices beginning in 2015 and an aggressive effort in Australia to increase lithium production capacity, led to world lithium production substantially exceeding consumption in 2018. Owing to excessive producer inventory, spot battery-grade lithium carbonate prices in China decreased by 53% for the year, decreasing from an average of $21,006 per metric ton in the first quarter to an average of $9,882 per metric ton in the fourth quarter, although the average unit value of imported lithium carbonate in the United States was 50% higher than that in 2017 (Roskill Information Services Ltd., 2019a, p. 2–3).

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 (Potential Acquisitions) for fiscal year 2019 (October 1, 2018, through September 30, 2019), which defined the maximum quantities of materials that could be acquired during the year, included 19,000 kilograms (kg) of lithium-ion precursors (Defense Logistics Agency Strategic Materials, 2018). At yearend 2018, the NDS held 750 kg of lithium-cobalt oxide and 1,620 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 facility in Nevada was expected to supply lithium carbonate for an additional 20 years at 2018 production levels (Albemarle Corp., 2019c, 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 were a brine extraction operation at Chile's Salar de Atacama salt flat; 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., 2019c, p. 23–24, 29).

Albemarle owned a 49% interest in Australia's Talison Lithium Pty Ltd., a spodumene producer with a 105,000-t/yr LCE production capacity. Sichuan Tianqi Lithium Industries, Inc., a subsidiary of Chengdu Tianqi (Group) Co., Ltd. (China), owned the remaining interest in Talison (Albemarle Corp., 2019c, p. 4). Albemarle was the world's leading producer of lithium in 2018, with an estimated 16,700 t of elemental lithium (89,000 t of LCE) produced from its operations in Australia and Chile in addition to an undisclosed quantity produced in the United States.

Livent Corp. (Philadelphia, PA), an independent lithium business spinoff of FMC Corp., produced a full range of downstream organic and inorganic lithium compounds and lithium metal at its facilities in Bessemer City, NC. The company sourced lithium carbonate and lithium chloride from its Salar de Hombre Muerto 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., 2019 p. 7, 30).

In 2018, Livent produced 17,238 t of lithium carbonate (3,241 t of elemental lithium) in Argentina, most of which was converted to 15,936 t of lithium hydroxide in China and the United States. Livent also produced 5,005 t of lithium chloride in Argentina, which was used as feedstock to produce 2,389 t of butyllithium in China, India, the United Kingdom, and the United States, and 140 t of high-purity lithium metal in the United States. Livent increased its lithium hydroxide production capacity to 18,500 t/yr in 2017 and anticipated expanding its lithium hydroxide production capacity to 55,000 t/yr by yearend 2025 at multiple locations worldwide. The company also planned to increase lithium carbonate capacity in Argentina to 60,000 t/yr during the same period. Livent's butyllithium production capacity was 3,265 t/yr, and its high-purity lithium metal production capacity was 250 t/yr (Livent Corp., 2019, p. 6–8).

Recycling

To initiate development of new lithium-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 October 2018, and was expected to be completed by September 2021 (Gillard and others, 2019, p. 4, 18; U.S. Department of Energy, 2019).

Consumption

In 2018, the global markets for lithium products were as follows (percentages were estimated): batteries, 57%; ceramics and glass, 22%; lubricating greases, 6%; polymer production, 4%; continuous casting mold flux powders, 3%; air treatment, 2%; and other uses, 6% (Roskill Information Services Ltd., 2019c, p. 59). Other uses included agrochemicals, airbag ignition, aluminum alloys, carbon dioxide absorption, cement and concrete additives, dyes and pigments, industrial catalysts, organic synthesis, pharmaceuticals, and scintillation (Albemarle Corp., 2019a).

In 2018, electric vehicles (EVs), hybrid-electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs) accounted for approximately 72% of the global lithium-ion battery market as measured in gigawatthours. A gigawatthour (GWh) is a unit of energy equivalent to the consumption of 1 billion watts for 1 hour. Portable applications (cameras and camcorders, cellular telephones, and laptop and tablet computers) accounted for 25% of the lithium-ion battery market; power and motive devices (cordless power and garden tools and electric bicycles, motorcycles, and scooters) accounted for 2%; and grid storage accounted for the remaining 1%. Global lithium-ion battery use increased by an average of 23% per year from 2000 through 2018, reaching an estimated 158 GWh in 2018 (Roskill Information Services Ltd., 2019c, p. 59, 61, 241).

In 2018, global lithium-ion battery cell production capacity, including existing operational capacity and that under construction, was estimated to be 290 GWh. About 83% of operational production capacity was in Asia owing to longstanding public and private investments in lithium-ion battery technology by consumer electronics companies and governments. Approximately 67% of planned capacity was in China; Japan and the Republic of Korea combined had about 16%; the United States and Europe accounted for 10% and 7%, respectively. Lithium-ion battery cell production capacity continued to increase in the United States and Europe as Asian-based battery manufacturers opened production facilities to supply the United States and European automotive markets (Colbourn, 2019, p. 6). Panasonic Corp. planned to increase its lithium-ion battery cell production capacity at Tesla Inc.'s Gigafactory 1 in Nevada from 35 GWh to 54 GWh (Lambert, 2019).

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 2018, the average customs unit value for imported lithium carbonate was $7.30 per kilogram, an increase of 50% from that in 2017 (table 3). The average customs unit value for imported lithium hydroxide was $17.00 per kilogram, 12% higher than that in 2017. The average unit value of exported lithium carbonate in 2018 was $14.00 per kilogram, 31% higher than that in 2017 (table 2). The average unit value of exported lithium hydroxide was $11.60 per kilogram, 8% higher than that in 2017. In 2018, the average unit value of exported lithium carbonate was almost double that of imported lithium carbonate, and the average unit value of exported lithium hydroxide was 32% lower than that of imported material. This suggests that domestic lithium carbonate exports, which include high-purity pharmaceutical-grade lithium carbonate, were of a higher quality than imports. Import values mostly reflect companies importing their own materials at cost for further processing.

At yearend 2018, Fastmarkets Industrial Minerals (2019) reported that the U.S. import price range for lithium carbonate (large contracts, delivered to the continental United States) was $12,500 to $16,000 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 $15,000 to $17,000 per metric ton. The cost, insurance, and freight (c.i.f.) price range for spodumene with a minimum of 5% to 6% lithium oxide delivered to China was $600 to $750 per metric ton. The c.i.f. price range for spodumene with a minimum of 7% to 7.5% lithium oxide spodumene delivered to China was $850 to $950 per metric ton.

Spot prices for battery-grade lithium carbonate in China fell precipitously throughout the year, averaging $9,882 per metric ton (less a 16% to 17% value added tax) in the fourth quarter of 2018, a 53% decrease from $21,006 per metric ton in the first quarter of 2018. Spot prices for battery-grade lithium hydroxide in China also decreased, averaging $14,572 per metric ton in the fourth quarter of 2018, a 28% decrease from $20,267 per metric ton in the first quarter of 2018 (Roskill Information Services Ltd., 2019a, p. 2–3).

Foreign Trade

In 2018, total exports of lithium compounds, by lithium content, from the United States decreased by 15% compared with those in 2017 (table 2). About 58% of all United States exports of lithium compounds went to Japan, 19% went to Germany, and 6% went to Canada. Lithium hydroxide accounted for 83% of the total lithium exports in 2018, and lithium carbonate accounted for the remaining 17%. Exports of lithium carbonate increased by 4% in 2018 compared with those in 2017, and exports of lithium hydroxide decreased by 18%.

Imports of lithium compounds, by lithium content, into the United States increased by 3% in 2018 compared with those in 2017 (table 3). About 46% came from Argentina, 43% from Chile, and 6% from China. Lithium concentrates from Australia and Zimbabwe may have entered the United States, but these materials had no unique import code, and 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 salt flat 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 lithium resource exploration has increased significantly in recent years. Exploration in the United States has 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. Considerable lithium exploration also has taken place in Argentina, Australia, and Canada.

Lithium is sold as brines, compounds, metal, mineral concentrates, and most recently, direct-shipping ore 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 2018 (excluding U.S. production) was 95,000 t of lithium (510,000 t of LCE) contained in minerals and compounds, 25% higher than that in 2017 (table 1). Global lithium production capacity was estimated to be 110,000 t/yr of lithium (590,000 t/yr of LCE), a 21% increase from that in 2017. The leading producing country, by far, was Australia, where lithium production was more than double that of Chile, the second-ranked producing country. Direct-shipping ore (DSO), unprocessed spodumene ore, was mined in Australia and shipped to China for processing. Based on data from Roskill Information Services Ltd. (2019c, p. 26), China was the third-ranked lithium-producing country. Global 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. Australia, Brazil, China, Portugal, and Zimbabwe were the leading producers of lithium minerals. Canada and Namibia resumed production of lithium minerals in 2018. Lithium mineral production in Canada was last reported in 2009, and Namibia had last produced lithium minerals in 1998. Additional brine operations were under exploration or development in Argentina, Bolivia, Chile, China, and the United States; new pegmatite mines were under exploration 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 a lithium-bearing clay mine was under development in Mexico. 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.

In 2018, global lithium consumption for air treatment, ceramics and glass, grease, metallurgical powders, polymers, rechargeable batteries, and other industrial applications increased; lithium consumption for primary batteries remained the same as that in 2017. An estimated 49,000 t of lithium (260,000 t of LCE) contained in minerals and compounds was consumed worldwide in 2018, a 23% increase from the

consumption estimate of 40,000 t (210,000 t of LCE) for 2017. China was the leading consumer of lithium minerals and compounds, accounting for 42% of worldwide consumption; the Republic of Korea consumed 16%; Europe, 12%; Japan, 12%; North America, 8%; Middle East, 4%; Southeast Asia, 3%; Russia, 2%; and Latin America, 1% (Roskill Information Services Ltd., 2019c, p. 58, 64).

According to USGS estimates, total global lithium consumption increased at a CAGR of 9% from 2008 through 2018 (fig. 1). According to Roskill Information Services Ltd. (2019c, p. 59), lithium consumption for rechargeable batteries increased at a CAGR of 23% from 2000 through 2018.

Argentina.—Production of lithium carbonate in 2018 was reported to be 29,707 t, an increase of 12% from that in 2017, and production of lithium chloride was 5,005 t, an increase of 11% (table 4) (Ministerio de Energia y Mineria, 2018). Livent produced 17,238 t of lithium carbonate and 5,005 t of lithium chloride at its 26,000-t/yr LCE facility, which had been operating since 1998, on the Salar de Hombre Muerto salt pan in Catamarca Province (Livent Corp., 2019, p. 8). Orocobre Ltd. produced 12,147 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; 2019, p. 5–7).

Lithium Americas Corp., co-owner of the Argentinian joint-venture company, Minera Exar S.A., continued development of the Cauchari-Olaroz Lithium Project on the Puna plateau in northwestern Argentina. In 2018, Chile's Sociedad Química y Minera de Chile S.A. (SQM) sold its 50% interest in Minera Exar S.A. to China's Ganfeng Lithium Co. Ltd. Lithium Americas increased its interest in Minera Exar S.A. to 62.5%, with Ganfeng holding the remaining 37.5% interest. In 2017, Minera Exar S.A. updated Lithium Americas' 2012 definitive feasibility study of the project including a production capacity of 50,000 t/yr of LCE built in two stages of 25,000 t/yr each. By yearend 2018, two evaporation ponds were completed and four more were under construction (Lithium Americas Corp., 2017; 2019, p. 9, 11).

Australia.—In 2018, the government of Western Australia reported total spodumene concentrate production of 2,112,667 t, an increase of 24% from 1,706,618 t in 2017, and nearly five times the 440,525 t produced in 2016 (table 4; Government of Western Australia, Department of Mines, Industry Regulation and Safety, 2019). Production in 2018 was estimated to be equivalent to approximately 58,800 t of contained lithium (313,000 t of LCE). Talison Lithium Pty Ltd. (a subsidiary of Sichuan Tianqi Lithium and Albemarle) produced an estimated 100,000 t of LCE from its Greenbushes spodumene deposit in Western Australia. Talison's lithium concentrate production capacity was approximately 105,000 t/yr of LCE, or 19,700 t/yr of contained lithium. Sichuan Tianqi and Albemarle announced plans to increase production capacity of the Greenbushes Mine to 190,000 t/yr of LCE. Commissioning of the expansion was expected in 2019 (Albemarle Corp., 2019c, p. 4).

The Mount Marion lithium project, a joint venture between Mineral Resources Ltd. and Ganfeng Lithium Co., Ltd., was Western Australia's second-ranked spodumene producer after Talison. In 2018, the Mount Marion operation produced 418,711 t of spodumene concentrate, equivalent to 11,700 t of contained lithium (62,300 t of LCE). Mineral Resources and Ganfeng planned to build a 20,000- to 25,000-t/yr battery-grade lithium hydroxide plant using Mount Marion's spodumene concentrate as input (Facada, 2019).

Mineral Resources terminated commercial production of lithium DSO from its Wodgina spodumene mine in Pilbara, Western Australia, in the fourth quarter of 2018. The mine had produced 2.4 million metric tons (Mt) of unprocessed spodumene ore for the year, most of which was shipped directly to China for processing. The ore contained 8,500 t of lithium content (45,000 t of LCE). Wodgina's spodumene resource was reported to be 259 Mt, grading 1.17% lithium oxide, with a lithium recovery rate of 65% (Mineral Resources Ltd., 2018a, p. 3; 2018b, p. 10; 2019, p. 3).

Galaxy Resources Ltd. produced 156,689 t of spodumene concentrate at its 210,000-t/yr Mt Cattlin operation near Ravensthorpe, Western Australia. With lithium oxide content reported to be 5.76%, the spodumene concentrate was equivalent to 4,190 t of contained lithium (22,300 t of LCE). Mt Cattlin's spodumene ore reserves were reported to be 10,700,000 t, grading 1.15% lithium oxide (Galaxy Resources Ltd., 2019, p. 11).

In 2018, Pilbara Minerals Ltd. commenced commercial production of spodumene concentrate and DSO at its lithium-tantalum Pilgangoora Project in Western Australia's Pilbara region. Pilbara Minerals produced 58,874 t of spodumene concentrate, equivalent to 1,640 t of contained lithium (8,700 t of LCE). Pilbara Minerals also produced 351,740 t of unprocessed spodumene ore grading at 1.5% lithium oxide. The ore contained 2,450 t of elemental lithium (13,000 t of LCE). Pilbara Minerals' spodumene resource was reported to be 226 Mt, grading 1.27% lithium oxide (Read, 2016; Pilbara Minerals Ltd., 2018, p. 19; 2019, p. 4).

Alliance Mineral Assets Ltd. began commercial production of spodumene concentrate at its Bald Hill lithium and tantalum mine in the Eastern Goldfields region of Western Australia. Alliance produced 68,546 t of spodumene concentrate, equivalent to 1,910 t of contained lithium (10,160 t of LCE). The Bald Hill Mine had a spodumene ore reserve of 11.3 Mt, grading 1.0% lithium oxide (Alliance Mineral Assets Ltd., 2019a, p. 7; 2019b).

Altura Mining Ltd. began commercial production of spodumene concentrate at its Altura Lithium Mine located at Pilgangoora in Western Australia. Altura produced 31,379 t of spodumene concentrate, equivalent to 874 t of contained lithium (4,700 t of LCE). The Altura Lithium Mine had a spodumene ore reserve of 41.1 Mt, grading 1.05% lithium oxide (Altura Mining Ltd., 2019a, p. 3; 2019b, p. 22).

Canada.—North American Lithium Inc. commenced commercial production of spodumene concentrate at its open pit mine located at La Corne, Quebec. The company produced spodumene concentrate equivalent to 12,900 t of LCE, or about 2,400 t of contained lithium (Roskill Information Services Ltd., 2019b, p. 12).

Chile.—In 2018, the Government of Chile reported production of 87,029 t of lithium carbonate, an increase of 18% from that in 2017; 3,826 t of lithium chloride, an increase of 51%; and 6,468 t of lithium hydroxide, an increase of 23% (table 4; Servicio Nacional de Geología y Minería, 2019, p. 108–109). SQM produced 50,400 t of lithium carbonate and 6,468 t of lithium hydroxide. The company accounted for 17% of global lithium chemical sales and sold 45,100 t of LCE in 2018, a decrease of 9% from that in 2017. SQM's value of sales increased by 14% to $735 million, most likely owing to favorable pricing of SQM's long-term contracts. In 2018, the company's lithium products were distributed throughout the world, with 76%, by value of sales, going to Asia; 14% 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 salt flat and processed into lithium carbonate and lithium hydroxide in Antofagasta. Owing to rapidly increasing demand for lithium carbonate and lithium hydroxide from electric vehicle 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 planned further increases of its lithium carbonate capacity to 180,000 t/yr (Sociedad Química y Minera de Chile S.A., 2019, p. 22–24, 34, 54).

Albemarle produced an estimated 36,600 t of lithium carbonate and 3,826 t of lithium chloride. It commissioned its new 20,000-t/yr lithium carbonate plant in La Negra in 2018, increasing its total lithium carbonate and lithium chloride production capacity in Chile to 44,000 t/yr of LCE. Albemarle 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., 2019b; 2019c, p. 23–24, 29).

China.—China produced large quantities of lithium carbonate and lithium hydroxide from domestic and imported mineral concentrates. In 2018, China produced 37,800 t of LCE from domestic sources, a slight increase from the revised 2017 production of 37,300 t (table 4). China ranked third in world lithium production, after Australia and Chile. Six lithium brine operations and five lithium mineral mines in China were in operation in 2018. Brine-sourced lithium accounted for 66% of China's lithium mine production; mineral-sourced lithium accounted for 34%. Production capacity of the brine-based operations was 65,000 t/yr of LCE and mineral-based production capacity was 40,500 t/yr. China's spodumene and lepidolite production was mostly within Sichuan Province but also took place in Hunan Province, Jiangxi Province, and Xinjiang Uyghur Autonomous Region. China's brine was extracted in Qinghai and Tibet Provinces (Roskill Information Services Ltd., 2019c, p. 170–176).

In 2018, total lithium consumption in China was 100,800 t of LCE, an increase of 20% from that in 2017. 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 resulted in mineral-sourced lithium (the majority of which was mined by Talison in Australia) accounting for the majority of production in 2018 (Roskill Information Services Ltd., 2019c, p. 64).

Outlook

Lithium supply security has become a top priority for technology companies in Asia. 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 and (or) lithium hydroxide being one of the lowest cost components of a lithium-ion battery, the issue of concern is not price, but rather, supply security.

In anticipation of robust electric vehicle battery demand, vigorous efforts were underway by battery companies worldwide to construct new large-scale lithium-ion battery factories (megafactories) or to expand existing facilities. Lithium-ion battery megafactories are defined by Benchmark Mineral Intelligence Ltd. as factories with more than 1 gigawatthour per year (GWh/yr) in capacity. In 2018, megafactories with a combined battery capacity of 290 GWh/yr either were ramping up or being planned for construction throughout Asia, Europe, and North America. By 2023, battery capacity is expected to increase to 1,132 GWh/yr, with China accounting for 71% of the world's lithium-ion battery production capacity; Europe and the United States accounting for 13% and 8% of capacity, respectively; and the rest of Asia accounting for 7% (Colbourn, 2019, p. 6).

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TABLE 1
SALIENT LITHIUM STATISTICS[1]

(Metric tons, lithium content)

	2014	2015	2016	2017	2018
United States:					
Production	W	W	W	W	W
Exports[2]	1,420	1,790	1,520	1,960	1,660
Imports[2]	2,120	2,750	3,140	3,330	3,420
Consumption[e, 3]	2,000	2,000	3,000	3,000	3,000
Rest of world, production[4]	31,300	31,700	39,300	76,200 [r]	95,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through August 4, 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]Estimated lithium content of mineral concentrate, lithium carbonate, and lithium chloride. Lithium hydroxide produced from lithium carbonate is not included in total.

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

Compound and country or locality	2017 Gross weight (metric tons)	2017 Value[2] (thousands)	2018 Gross weight (metric tons)	2018 Value[2] (thousands)
Lithium carbonate:				
Belgium	2	$5	25	$240
Canada	74	336	103	468
Finland	--	--	5	94
Germany	944	7,370	1,060	12,100
India	--	--	10	190
Japan	166	2,180	92	1,470
Korea, Republic of	39	534	20	73
Panama	5	19	--	--
Taiwan	73	947	--	--
Other	6 r	41 r	10	50
Total	1,310	11,400	1,320	14,700
Total Li content	246	XX	249	XX
Lithium carbonate, U.S.P.:[3]				
Belgium	3	80	2	72
Colombia	2	39	6	88
India	86	3,200	119	4,770
Israel	3	85	7	274
Korea, Republic of	--	--	5	488
Other	1 r	70 r	2	87
Total	94	3,480	141	5,780
Total Li content	18	XX	27	XX
Lithium hydroxide:				
Argentina	175	2,320	112	2,040
Australia	45	661	60	1,010
Belgium	378	5,290	408	6,490
Canada	700	4,120	444	2,600
Chile	24	209	29	275
China	93	1,350	197	3,800
Colombia	10	108	12	181
Egypt	44	493	160	2,370
France	4	47	(4)	69
Germany	1,340	13,700	756	9,790
Guyana	--	--	22	44
India	(4)	7	20	250
Italy	1	77	5	33
Japan	7,100	76,100	5,780	62,900
Korea, Republic of	75	858	71	1,100
Mexico	27	580	25	528
Nigeria	5	40	--	--
Peru	10	190	8	208
Russia	--	--	66	398
Saudi Arabia	10	100	--	--
Singapore	28	454	63	1,150
Taiwan	62	915	--	--
Thailand	166	2,860	132	1,220
United Arab Emirates	--	--	20	380
Other	11 r	626 r	8	824
Total	10,300	111,000	8,400	97,600
Total Li content	1,700	XX	1,390	XX

rRevised. XX Not applicable. -- Zero.
[1]Table includes data available through August 4, 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	2017		2018	
	Gross weight (metric tons)	Value[2] (thousands)	Gross weight (metric tons)	Value[2] (thousands)
Lithium carbonate:				
Argentina	9,830	$47,600	8,320	$51,600
Bolivia	--	--	18	$160
Canada	5	12	--	--
Chile	6,140	30,400	7,450	62,600
China	23	77	747	9,090
Germany	3	18	20	57
India	9	24	11	71
Japan	76	763	20	283
Korea, Republic of	--	--	548	1,730
Switzerland	--	--	42	372
United Kingdom	38	105	70	450
Other	(3) r	3 r	4	34
Total	16,100	79,000	17,200	126,000
Total Li content	3,030	XX	3,240	XX
Lithium carbonate, U.S.P.,[4] China	--	--	(3)	14
Lithium carbonate, U.S.P.,[4] China, Li content	--	XX	(3)	XX
Lithium hydroxide:				
Belgium	37	430	--	--
Chile	662	10,800	390	6,340
China	543	9,250	319	5,950
Hong Kong	--	--	12	192
Japan	(3)	36	13	211
Korea, Republic of	17	313	4	25
Russia	561	6,980	321	5,270
Taiwan	5	29	--	--
Other	4 r	65 r	3	89
Total	1,830	27,900	1,060	18,100
Total Li content	302	XX	175	XX

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

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]	2014	2015	2016	2017	2018
Argentina:					
Lithium carbonate	11,698	21,111	24,409	26,559	29,707
Lithium chloride	7,370	5,848	6,468	4,501	5,005
Australia, spodumene	444,546	445,990 r	440,525	1,706,618	2,112,667
Brazil, concentrate	8,519	5,781	8,804 r	6,000 e	10,000 e
Canada, spodumene	--	--	--	--	114,000
Chile:					
Lithium carbonate	55,074	50,418	70,831	73,563	87,029
Lithium chloride	2,985	2,069	1,775	2,535	3,826
Lithium hydroxide[3]	4,194	3,888	5,576	5,280	6,468
China, lithium carbonate equivalent[4]	18,810	20,470	25,400	37,300 r	37,800
Namibia, lepidolite	--	--	--	--	30,000 e
Portugal, lepidolite	17,459	17,120	25,758 r	50,743	53,200
United States, lithium carbonate	W	W	W	W	W
Zimbabwe, petalite, lepidolite	50,000 e	50,000 e	50,000 e	40,000	80,000 e

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

[1]Table includes data available through September 3, 2019. 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]Lithium hydroxide is produced from lithium carbonate, and therefore not included in world production total to avoid double counting.

[4]Produced from subsurface brine and domestic concentrates.

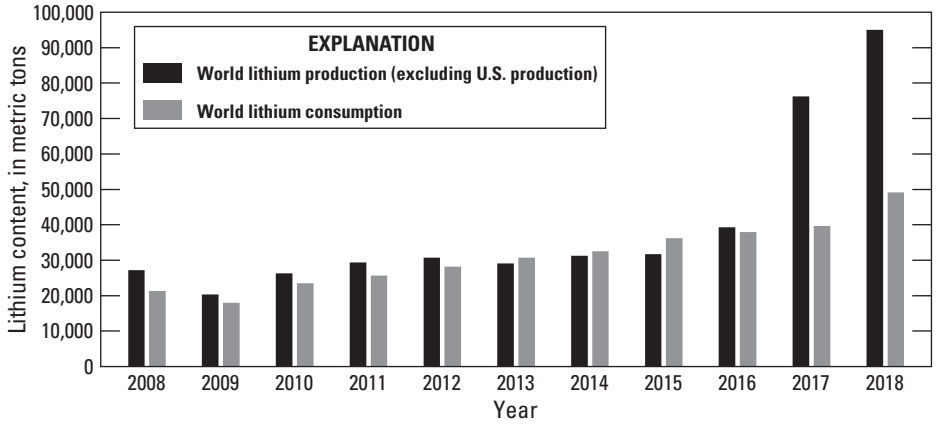

Figure 1. Estimated world lithium production (excluding U.S. production) and consumption from 2008 through 2018.