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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 2020, lithium consumption in the United States was estimated to be equivalent to 2,000 metric tons (t) of elemental lithium content (table 1) [11,000 t of lithium carbonate equivalent (LCE)], primarily in lithium-based batteries, ceramics and glass, grease, pharmaceuticals, and polymer products. In 2020, the gross weight of lithium compounds imported into the United States decreased by 6%, and the gross weight of exports decreased by 31% from those in 2019. The average annual unit value of lithium carbonate imports (including pharmaceutical grade) decreased by 20% from that in 2019, and the average annual unit value of lithium hydroxide imports decreased by 35%. Argentina and Chile were the principal sources of imported lithium carbonate, and Chile and Russia were the principal sources of imported lithium hydroxide (tables 2, 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 excessive producer inventory, the price of lithium decreased considerably between 2018 and the first three quarters of 2020. The decline in lithium production and price was further exacerbated in 2020 owing to the economic impact of the global coronavirus disease 2019 (COVID-19) pandemic. The fourth quarter of 2020 saw the consumption and price of lithium increase considerably owing to strong growth from the lithium-ion battery market. Spot prices for battery-grade lithium carbonate in China increased by 14% during the year, from an average of $7,150 per metric ton in January 2020 to an average of $8,150 per metric ton in December 2020 (Asian Metal Corp., 2019, p. 1; 2021, p. 11).

World lithium production in 2020 (excluding United States production) was estimated to be 82,500 t of lithium content in minerals and compounds (439,000 t of LCE), slightly lower than the lithium production of 84,000 t (447,000 t of LCE) (revised) in 2019 owing primarily to decreased production of mineral-sourced lithium from Australia (table 4). World lithium production increased at a compound annual growth rate (CAGR) of 12% per year from 2010 through 2020 (fig. 1). Roskill Information Services Ltd. estimated world lithium consumption in 2020 to be approximately 70,000 t of lithium (373,000 t of LCE) contained in minerals and compounds, a 25% increase from that in 2019. Approximately 86% of world lithium consumption was in Asia (Roskill Information Services Ltd., 2020, p. 68; 2021a, p. 7). World lithium consumption increased at a CAGR of 12% per year from 2010 through 2020 (fig. 1).

Legislation and Government Programs

National Defense Stockpile.—The Defense Logistics Agency Strategic Materials (DLA Strategic Materials), an agency of the U.S. Department of Defense, began acquiring selected lithium battery materials for the National Defense Stockpile (NDS) in 2014. In 2020, DLA Strategic Materials was not seeking to acquire lithium materials (Defense Logistics Agency Strategic Materials, 2019, 2020). At yearend 2020, the NDS held 750 kilograms (kg) of lithium-cobalt oxide and 2,700 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., headquartered in Charlotte, NC. Production and stock data collected from Albemarle were withheld from publication to avoid disclosing company proprietary data. Albemarle announced that the production capacity of its 5,000-metric-ton-per-year (t/yr) lithium carbonate plant in Silver Peak, NV, would expand to 10,000 t/yr by 2025 (Albemarle Corp., 2020a, p. 12; 2021b, p. 30).

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 butyllithium and specialty lithium products in New Johnsonville, TN, and facilities for producing lithium salts and battery-grade lithium metal products 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., 2021b, p. 23).

Albemarle owned a 49% interest in Australia's Talison Lithium Pty Ltd, a spodumene producer with a 178,000-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's other lithium operations in Australia included a spodumene mine in Wodgina and a plant for producing lithium carbonate and lithium hydroxide in Kemerton that was under construction. Albemarle was the world's leading producer of lithium in 2020, with 24,800 t of elemental lithium (132,000 t of LCE) produced from its operations in Australia, Chile, and the United States (Albemarle Corp., 2021b, p. 23–30).

Livent Corp. (Philadelphia, PA), an independent lithium business that was spun off from FMC Corp. in 2019, produced

a range of downstream products including inorganic lithium compounds, lithium metal, and organic lithium compounds at its facility in Bessemer City, NC. The company sourced its lithium carbonate and lithium chloride from its Salar del Hombre Muerto brine operation in Argentina via its local operating subsidiary, Minera del Altiplano. 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., 2021, p. 9, 38).

In 2020, Livent produced 15,589 t of lithium carbonate in Argentina, which was converted to 14,686 t of lithium hydroxide in China and the United States. The company also produced 4,836 t of lithium chloride in Argentina, which was converted to 2,180 t of butyllithium in China, India, the United Kingdom, and the United States, and 160 t of high-purity lithium metal in the United States. Livent's lithium carbonate, lithium chloride, and lithium hydroxide production capacities were 18,000 t/yr, 9,000 t/yr, and 25,000 t/yr, respectively. Owing to declining lithium prices in 2019 and the first half of 2020, 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., 2021, p. 9).

In 2019, US Magnesium LLC (Salt Lake City, UT) began construction of a 10,000-t/yr lithium carbonate plant in Delle, UT. Lithium chloride would be extracted from a stockpile of cell salt residue accumulated over the course of 50 years from the production of magnesium. US Magnesium would use technology developed in-house to convert the lithium chloride to lithium carbonate. The cell salt residue was estimated to contain 7% lithium. In 2020, Sumitomo Corp. (Tokyo, Japan) entered into an agreement with US Magnesium to sell the lithium carbonate in China, Japan, and the Republic of Korea (Gillie, 2019; Sumitomo Corp., 2020).

Substantial efforts have been taken recently by four automobile and battery manufacturers in the United States to construct new large-scale lithium-ion (Li-ion) battery factories (gigafactories) or to expand existing facilities. Li-ion battery gigafactories are factories with more than 1 gigawatthour per year (GWh/yr) of 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 battery cells within Tesla's Gigafactory. With an operational capacity of 37 GWh/yr in 2020, the Gigafactory was among the largest Li-ion battery plants in the world (Randall, 2017; Benchmark Mineral Intelligence, 2020, p. 70).

Production capacity of LG Chem Ltd.'s (Seoul, Republic of Korea) Li-ion battery cell plant in Holland, MI, was 5 GWh/yr to accommodate production of General Motors Co. (GM) (Detroit, MI) electric vehicles. In 2020, GM and LG Chem formed a new joint-venture company, Ultium Cells LLC, and began construction on a 35-GWh/yr Li-ion battery cell production facility in Lordstown, OH. Battery production was expected to begin in 2022 (General Motors Co., 2020; Colthorpe, 2021).

In 2019, South Korean energy company SK Innovation Co., Ltd. (Seoul, Republic of Korea) began constructing the first of two Li-ion battery plants in Commerce, GA, which was to supply automakers Ford and Volkswagen. Construction continued in 2020. Li-ion cell capacity of the first battery plant was 9.8 GWh/yr, with production expected to begin in 2022. Li-ion cell capacity of the second battery plant was 11.7 GWh/yr, with production expected to begin in 2023 (Kane, 2020; Mulholland, 2021).

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 was collaborating with DOE's Argonne National Laboratory, the National Renewable Energy Laboratory, the 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. ReCell researchers investigated various processes for cathode relithiation, a critical step to restore lithium stoichiometry of the cathode materials. In 2020, the researchers studied electron backscatter diffraction of various chemically delithiated cathodes versus pristine cathodes and added different relithiation processes to EverBatt, Argonne's closed-loop battery life-cycle model, to evaluate the processes at lab and production scale. Researchers also advanced their efforts in the recovery of clean black mass, which is 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, p. 6; 2020a, p. 6; 2020b, p. 6).

Consumption

In 2020, the global markets for lithium products were estimated to be batteries, 72%; ceramics and glass, 15%; lubricating greases, 4%; continuous casting mold flux powders, 2%; polymer production, 2%; air treatment, 1%; and other uses, 4% (Roskill Information Services Ltd., 2021a, p. 7). 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., 2021a).

Battery-grade lithium carbonate accounted for 40% of the 373,000 t of LCE consumed globally in 2020, battery-grade lithium hydroxide accounted for 30%, and technical-grade mineral concentrates accounted for 10%. Technical grades of lithium carbonate and lithium hydroxide accounted for 8% and 6%, respectively. Other lithium compounds, including lithium bromide, butyllithium, and battery-grade lithium metal,

accounted for the remaining 6% (Roskill Information Services Ltd., 2021a, p. 8).

In 2020, electric vehicles (EVs), hybrid-electric vehicles (HEVs), and plug-in hybrid-electric vehicles (PHEVs) accounted for approximately 52% of global Li-ion batteries produced as measured in GWh. Portable applications (cameras and camcorders, cellular telephones and smartphones, and laptop and tablet computers) accounted for 16% of Li-ion batteries produced; power and motive devices (cordless power and garden tools, electric bicycles, motorcycles, and scooters) accounted for 24%; and grid storage accounted for the remaining 8% (Roskill Information Services Ltd., 2021b, p. 13).

In 2020, battery manufacturers were ramping up construction or planning to construct 755 GWh of global production capacity for large EV-sized Li-ion battery cells. Approximately 75% of capacity was in China, 8% in the United States, and 7% in Europe. Asia (excluding China) and other regions accounted for the remaining 10% (Moores, 2021).

Prices

Average customs unit values for U.S. imports of lithium carbonate and lithium hydroxide were used as indicators of the trends in lithium pricing; producer prices were not available for lithium carbonate or lithium hydroxide. In 2020, the average customs unit value for imported lithium carbonate was $6.40 per kilogram, a decrease of 20% from that in 2019 (table 3). The average customs unit value for imported lithium hydroxide was $9.20 per kilogram, 35% lower than that in 2019. The average unit value of exported lithium carbonate in 2020 was $9.50 per kilogram, 30% lower than that in 2019 (table 2). The average unit value of exported lithium hydroxide was $11.40 per kilogram, no change from that in 2019. In 2020, the average unit value of exported lithium carbonate was 48% higher than that of imported lithium carbonate, and the average unit value of exported lithium hydroxide was 24% higher than that of imported material. This suggests that domestic lithium carbonate and lithium hydroxide exports were of a higher quality than imports. Import values mostly reflected companies importing their own materials at cost for further processing.

At yearend 2020, Fastmarkets IM (2020) reported that the U.S. import price for lithium carbonate [99% minimum, technical and industrial grades, contract price delivered duty paid (ddp) Europe and the United States] was $7,800 per metric ton. The price for lithium hydroxide (56.5% minimum, battery grade, contract price ddp Europe and the United States) was $11,000 per metric ton. The cost, insurance, and freight (c.i.f.) price for 6% minimum lithium oxide spodumene delivered to China was $395 per metric ton.

The spot price for battery-grade lithium carbonate in China averaged $8,150 per metric ton in December 2020, a 14% increase from the average price of $7,150 per metric ton in January. The spot price for battery-grade lithium hydroxide in China averaged $7,400 per metric ton in December, an 8% decrease from the average price of $8,000 per metric ton in January (Asian Metal Corp., 2021, p. 11–13).

Foreign Trade

In 2020, total exports of lithium compounds, by lithium content, from the United States decreased by 30% compared with those in 2019. The leading destinations of all United States exports of lithium compounds were Japan (63%), Germany (12%), and India and the Republic of Korea (4% each) (table 2). Lithium hydroxide accounted for 80% of the total lithium exports in 2020, and lithium carbonate accounted for the remaining 20%. Exports of lithium carbonate increased by 33% in 2020 compared with those in 2019, and exports of lithium hydroxide decreased by 37%.

Imports of lithium compounds, by lithium content, into the United States decreased by 6% in 2020 compared with those in 2019. About 57% came from Argentina, 35% from Chile, and 5% from Russia (table 3). The USGS estimated that the United States was the third largest importer of lithium concentrates from Australia in 2020, after China and Belgium.

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 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, the geothermal brines of California, and the lithium-rich boron and magnesium waste residues in California and Utah. In recent years, considerable lithium exploration also has taken place in Argentina, Australia, Canada, Chile, China, and 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, laptop computers, and 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 2020 (excluding U.S. production) was estimated to be 82,500 t of lithium contained in minerals and compounds (439,000 t of LCE), slightly lower than lithium production of 84,000 t (447,000 t of LCE) (revised) in 2019 (table 4) owing primarily to decreased production of mineral-sourced lithium from Australia. Global lithium production capacity was estimated to be 160,000 t/yr of lithium (852,000 t/yr of LCE), a 26% increase from that in 2019. The leading producing country was Australia, where production in terms of lithium content was 85% more than that of Chile, the second-ranked producing country. Based on data from Roskill Information Services Ltd. (2021a, p. 9), 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, lithium content, and LCE. 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, Namibia, Peru, Portugal, Russia, South Africa, Spain, Sweden, the United Kingdom, the United States, and Zimbabwe; a jadarite mine was under development in Serbia; lithium-bearing clay mines were under development in Mexico and the United States; and lithium chemical plants were under development in California and Utah using stockpiles of lithium-rich waste residue from boron and magnesium production. Reduced lithium prices in 2019 and the first three quarters of 2020, 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 2020, global lithium consumption for rechargeable batteries increased; lithium consumption for polymers and other industrial applications remained the same; and lithium consumption for air treatment, ceramics, glass, glass-ceramics, grease, metallurgical powders, and primary batteries decreased from that in 2019. In total, an estimated 70,000 t of lithium (373,000 t of LCE) contained in minerals and compounds was consumed worldwide in 2020, a 25% increase from the estimated consumption of 56,000 t (298,000 t of LCE) in 2019 (Roskill Information Services Ltd., 2021a, p. 7). 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%; and India and Southeast Asia, 1% each (Roskill Information Services Ltd., 2020, p. 4, 68).

According to USGS estimates, total global lithium consumption increased at a CAGR of 12% from 2010 through 2020 (fig. 1). According to Roskill Information Services Ltd. (2020, p. 68; 2021a, p. 7), lithium consumption for rechargeable batteries increased at a CAGR of 23% from 2000 through 2020.

Argentina.—Production of lithium carbonate in 2020 was reported to be 26,900 t, a decrease of 10% from that in 2019, and production of lithium chloride was 4,836 t, an increase of 13% (table 4). Livent produced 15,589 t of lithium carbonate and 4,836 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 planned to increase lithium carbonate production capacity to approximately 60,000 t/yr in multiple phases. Orocobre Ltd. produced 11,322 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 planned to increase lithium carbonate production capacity to 42,500 t/yr by 2024 (Ministerio de Energia y Mineria, 2020; Orocobre Ltd., 2020, p. 5; 2021, p. 6–9; Livent Corp., 2021, p. 8).

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 2020, Ganfeng Lithium Co., Ltd. increased its interest in Minera Exar to 51%, with Lithium Americas holding the other 49% interest. Minera Exar planned to increase its production capacity to 40,000 t/yr of LCE over the course of 40 years (Lithium Americas Corp., 2020a, p. 11; 2020b).

Multiple lithium projects by other companies were in various stages of development in Argentina. Approximately 12 junior operations have completed feasibility studies, and several have developed pilot plants.

Australia.—In 2020, the government of Western Australia reported total spodumene concentrate production of 1,427,380 t, a decrease of 10% from its revised production figure of 1,587,980 t in 2019 (Government of Western Australia, Department of Mines, Industry Regulation and Safety, 2021). Production was equivalent to 39,738 t of lithium content (211,525 t of LCE). Talison Lithium Pty Ltd (a subsidiary of Sichuan Tianqi Lithium and Albemarle) produced approximately 16,500 t of lithium content (88,000 t of LCE) from its Greenbushes spodumene deposit in Western Australia (Albemarle Corp., 2021b, p. 26). Talison's lithium concentrate production capacity was reported to be 33,500 t/yr of lithium content (178,000 t/yr of LCE) in 2020 (Roskill Information Services Ltd., 2020, p. 9).

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. In 2020, MARBL kept the mine idle until spodumene market conditions improved. 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., 2019, p. 14; Albemarle Corp., 2020b, p. 4).

In 2020, Albemarle continued construction of a mineral conversion plant in Kemerton, Western Australia, that would convert spodumene from Albemarle's Talison and Wodgina sites to lithium hydroxide. The Kemerton plant was expected to have an initial lithium hydroxide production capacity of 50,000 t/yr of LCE, with an ability to expand to 100,000 t/yr of LCE over time (Albemarle Corp., 2021b, p. 31).

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 2020, the Mt Marion operation produced approximately 11,100 t of lithium content (59,300 t of LCE) (Roskill Information Services Ltd., 2021a, p. 9).

Galaxy Resources Ltd. produced approximately 2,990 t of lithium content (15,900 t of LCE) at its Mt Cattlin operation near Ravensthorpe, Western Australia. Mt Cattlin's spodumene ore reserves were reported to be 8.2 Mt, grading at 1.29% lithium oxide (Galaxy Resources Ltd., 2020, p. 19; Roskill Information Services Ltd., 2021a, p. 9).

Pilbara Minerals Ltd. produced approximately 4,840 t of lithium content (26,900 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; Roskill Information Services Ltd., 2021a, p. 9).

In the first three quarters of 2020, Altura Mining Ltd. produced approximately 3,670 t of lithium content (19,500 t of LCE) at its Altura Lithium Mine located at Pilgangoora in Western Australia. Owing to low spodumene prices, Altura ceased production in October and entered receivership. The Altura Lithium Mine had a spodumene ore reserve of 37.6 Mt, grading 1.08% lithium oxide (Altura Mining Ltd., 2019, p. 10; Burton, 2020; Roskill Information Services Ltd., 2021a, p. 9).

Chile.—In 2020, the Government of Chile reported production of 114,000 t of lithium carbonate, an increase of 13% from that in 2019 (revised); 9,000 t of lithium hydroxide, a decrease of 9%; and no production of lithium chloride. Sociedad Química y Minera de Chile S.A. (SQM) produced 72,200 t of lithium carbonate and 9,000 t of lithium hydroxide. The company reported that it accounted for 19% of global lithium chemical sales volumes and sold 64,600 t of LCE in 2020, a 43% increase from that in 2019. SQM's value of sales decreased by 24% to $383 million owing to lower lithium prices. In 2020, 80% of the company's lithium products, by sales value, went to Asia and other locations, 13% went to Europe, and 7% to North 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. As of 2020, SQM's lithium carbonate and lithium hydroxide production capacities were 70,000 t/yr and 13,500 t/yr, respectively. These capacities have been in place since 2018. Owing to increased demand for lithium carbonate and lithium hydroxide from EV battery manufacturers, SQM began expanding its lithium carbonate and lithium hydroxide production capacities in 2020 to 180,000 t/yr and 30,000 t/yr, respectively. The expansion projects were expected to be completed in 2023 (Servicio Nacional de Geología y Minería, 2021, p. 112–113; Sociedad Química y Minera de Chile S.A., 2021, p. 22–23, 29, 52).

In 2020, Albemarle produced 42,000 t of lithium carbonate in Chile. Albemarle planned to increase its lithium carbonate and lithium chloride capacity in Chile to 80,000 t/yr from 44,000 t/yr of LCE. The company 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 Corp., 2019, p. 29; 2021b, p. 28).

China.—China produced large quantities of lithium carbonate and lithium hydroxide from domestic and imported mineral concentrates. In 2020, China produced 70,600 t of LCE from domestic sources, a 23% increase from 2019 production of 57,500 t owing to increases in brine-sourced output and 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; 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 production was mostly within Jiangxi and Sichuan Provinces but also took place in Hunan Province and Xinjiang Uyghur Autonomous Region. China's brine was extracted in Qinghai and Tibet Provinces (Roskill Information Services Ltd., 2020, p. 225–231; 2021a, p. 9).

Total lithium consumption in China was reported to be 163,000 t of LCE in 2019 (Roskill Information Services Ltd., 2020, p. 72). For 2020, China was estimated by the USGS to have consumed 200,000 t of LCE, given that worldwide lithium consumption increased by 25% to 373,000 t of LCE, with China accounting for an estimated 54% of worldwide consumption. 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 2020.

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 worldwide 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 lithium-ion batteries, for some companies, 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 (gigafactories) or to expand existing facilities. In 2020, Benchmark Mineral Intelligence reported that gigafactories with a combined battery capacity of 755 GWh/yr either were ramping up or being planned for construction throughout Asia, Europe, and North America. By 2030, battery capacity was expected to increase to 3,400 GWh/yr, with China accounting for 67% of the world's Li-ion battery production capacity, Europe and North America accounting for 18% and 11% of capacity, respectively, and Asia (excluding China) and other regions accounting for 4% (Moores, 2021).

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TABLE 1
SALIENT LITHIUM STATISTICS[1]

(Metric tons, lithium content)

	2016	2017	2018	2019	2020
United States:					
Production	W	W	W	W	W
Exports[2]	1,520	1,960	1,660	1,660 r	1,170
Imports[2]	3,140	3,330	3,420	2,620	2,460
Consumption[e, 3]	3,000	3,000	3,000	2,000	2,000
Rest of world, production[4, 5]	40,200 r	76,400	91,800	84,000 r	82,500

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through July 19, 2021. 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.
[5]May include estimated data.

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

Compound and country or locality	2019 Gross weight (metric tons)	2019 Value[2] (thousands)	2020 Gross weight (metric tons)	2020 Value[2] (thousands)
Lithium carbonate:				
Belgium	22	$84	9	$31
Canada	40	177	67	293
Chile	--	--	5	19
Colombia	4	14	48	172
Finland	--	--	5	104
Germany	703	7,940	563	6,090
India	--	--	274	1,550
Taiwan	38	136	26	95
Other	13 r	64 r	4	22
Total	819	8,410	1,000	8,380
Total lithium content	154	XX	188	XX
Lithium carbonate, U.S.P.:[3]				
India	90	3,390	81	2,070
Israel	3	287	5	235
Mexico	--	--	124	803
Other	2 r	306 r	3	82
Total	95	3,980	213	3,190
Total lithium content	18	XX	40	XX
Lithium hydroxide:				
Argentina	165	2,960	149	1,980
Australia	60	1,020	30	432
Belgium	330	3,290	99	828
Canada	311	1,760	224	1,240
Chile	35	321	6	101
China	111	2,010	3	64
Egypt	73 r	1,210	44	495
France	40	338	8	451
Germany	834	14,700	200	3,400
India	11	55	--	--
Indonesia	13	229	6	101
Japan	6,010 r	61,200 r	4,440	49,700
Korea, Republic of	754	9,340	58	922
Mexico	7	92	6	105
Netherlands	(4)	22	183	1,640
Saudi Arabia	--	--	108	845
Singapore	81	1,310	33	716
Thailand	188	1,390	69	609
United Arab Emirates	--	--	7	129
United Kingdom	15	1,650	7	795
Other	3	276 r	14	580
Total	9,040 r	103,000 r	5,690	65,100
Total lithium content	1,490 r	XX	939	XX

rRevised. XX Not applicable. -- Zero.
[1]Table includes data available through April 29, 2021. 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	2019		2020	
	Gross weight (metric tons)	Value[2] (thousands)	Gross weight (metric tons)	Value[2] (thousands)
Lithium carbonate:				
Argentina	8,190 r	$45,500 r	7,440	$39,300
Chile	3,630 r	45,800 r	4,010	33,600
China	976	11,400	174	1,850
Japan	8	136	4	77
Netherlands	1	11	13	104
Russia	(3)	4	5	42
United Kingdom	22	269	17	121
Other	4 r	38 r	--	--
Total	12,800	103,000	11,700	75,100
Total Li content	2,410	XX	2,190	XX
Lithium carbonate, U.S.P.,[4] India	(3)	8	(3)	10
Lithium carbonate, U.S.P.,[4] India, lithium content	(3)	XX	(3)	XX
Lithium hydroxide:				
Chile	419	5,680	710	6,730
China	148	1,840	29	210
Germany	60	346	100	557
Japan	2	72	11	87
Romania	11 r	780 r	6	466
Russia	597	8,710	732	6,400
United Kingdom	3	80	6	185
Other	3	22	1	40
Total	1,240 r	17,500 r	1,600	14,700
Total lithium content	206 r	XX	265	XX

rRevised. XX Not applicable. -- Zero.
[1]Table includes data available through April 29, 2021. 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 LOCALTY[1]

(Metric tons)

Country or locality[2]	2016			2017			2018			2019			2020		
	Gross weight	Lithium content	LCE[3]	Gross weight	Lithium content	LCE[3]	Gross weight	Lithium content	LCE[3]	Gross weight	Lithium content	LCE[3]	Gross weight	Lithium content	LCE[3]
Argentina:															
Lithium carbonate	24,409	4,589	24,409	26,559	4,993	26,559	29,707 r	5,585	29,707	29,994	5,639	29,994	26,911	5,059	26,911
Lithium chloride	6,468	1,054	5,610	4,501	734	3,907	5,005	816	4,344	4,284	698	3,715	4,836	788	4,195
Australia, spodumene	522,181	14,538	77,386	1,706,618	47,512	252,906	1,965,910 r	54,731	291,333	1,587,980 r	44,209	235,325	1,427,380	39,738	211,525
Brazil, concentrate	8,804	245	1,304	10,547	294	1,565	41,000	1,141	6,074	38,500 r, e	1,072	5,706	51,000 e	1,420	7,559
Canada, spodumene	--	--	--	--	--	--	114,000	2,433	12,951	9,000	192	1,022	--	--	--
Chile:															
Lithium carbonate	70,831	13,316	70,831	73,563	13,830	73,563	87,029	16,361	87,029	100,787 r	18,948	100,787	114,260	21,481	114,260
Lithium chloride	1,775	289	1,538	2,535	413	2,198	3,826	624	3,322	1,886 r	307	1,634	--	--	--
Lithium hydroxide[4]	5,576	920	4,897	5,280	871	4,636	6,468	1,067	5,680	9,934 r	1,639	8,724	9,030	1,490	7,931
China, lithium carbonate equivalent[5]	25,400	4,775	25,400	37,300	7,012	37,300	37,800	7,106	37,800	57,500	10,810	57,500	70,600	13,273	70,600
Namibia, lepidolite	--	--	--	--	--	--	30,000	258	1,373	--	--	--	--	--	--
Portugal, lepidolite	25,758	386	2,055	52,741	791	4,210	76,818	1,152	6,132	59,912 r	899	4,785	23,185	348	1,852
United States, lithium carbonate	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Zimbabwe, petalite, lepidolite	50,000 e	1,000	5,323	40,000	800	4,258	80,000 e	1,600	8,517	60,400 r, e	1,208	6,430	20,859	417	2,220
Total[6]	736,000	40,200	214,000	1,950,000	76,400	406,000	2,470,000	91,800	489,000	1,950,000	84,000	447,000	1,740,000	82,500	439,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1]Table includes data available through July 19, 2021. All data are reported unless otherwise noted; totals may include estimated data. Estimated data are rounded to no more than three significant digits; may not add to totals shown.

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

[3]Lithium carbonate equivalent.

[4]Brine-sourced lithium hydroxide is produced from lithium carbonate, and therefore not included in world production total to avoid double counting.

[5]Produced from subsurface brine and domestic concentrates.

[6]Excludes U.S. production.

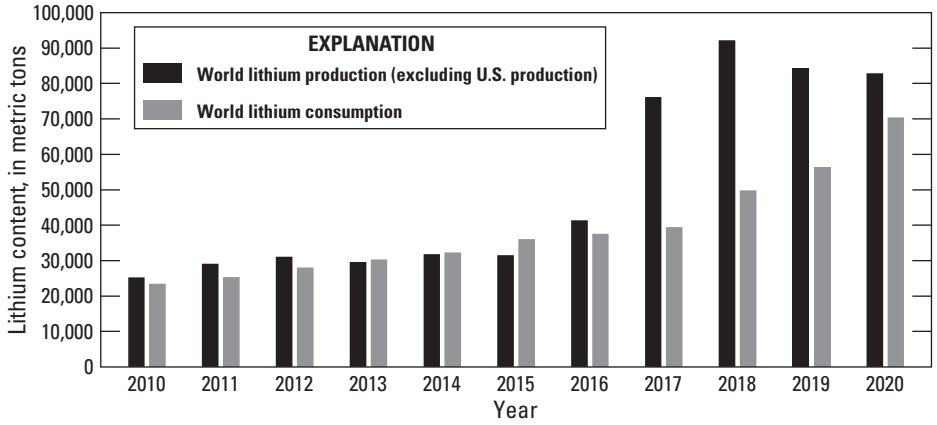

Figure 1. Estimated world lithium production (excluding U.S. production) and consumption from 2010 through 2020. The chart shows gradual increases in production from 2010 to 2016, large increases in production in 2017 and 2018, followed by decreases in production for 2019 and 2020. Consumption shows a trend of gradual increases up to 2017, with higher consumption increases from in 2018 and 2019. In 2020, consumption increased significantly. Sources: U.S. Geological Survey and Roskill Information Services Ltd.