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# The Best Lithium Brine Development Project in the World

INDUSTRIAL MINERALS
RESEARCH

# GLOBAL LITHIUM MARKET: FIVE YEAR STRATEGIC OUTLOOK

## SPECIAL FOCUS ON THE SUPPLY SIDE

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### Next wave of producers

- Pilbara Minerals Australia: Western Australia**
  - Pilbara Minerals is piloting a lithium-brine project starting processing one in 2018
  - In the first phase, Pilbara's lithium-brine production of 300,000 tpy of 6% spodumene concentrate by June 2018. Targeted production in the second phase is 600,000 tpy of 6% lithium carbonate equivalent by June 2018. As well, Pilbara Minerals will ship almost 1 million tonnes of iron ore shipping one (LCO) over the year of April 2018
- Mineral Resources Australia: Western Australia**
  - Mineral Resources announced its first LDCO with 6% lithium content (LDCO) from its Wodgina operations in Western Australia in March last year
  - Mineral Resources aims to boost exports of LDCO one to a 120 million tonnes over forecast 2018 year from Wodgina
  - As well, it is looking to build its own spodumene plant with capacity of 750,000 tpy to be built in three tranches of 250,000 tpy in Wodgina. It expects the first tranche to come into operation in the third quarter of 2018
- Tanaka Resources Australia: Western Australia**
  - Tanaka Resources and Allkem Mineral Assets Ltd. have the ownership of their remote 140-Mt mine on a 50-50 basis
  - Best 140-Mt started first-phase lithium concentrate production in March 2018 and is targeting production at full capacity of 150,000 tpy
  - It made its first shipment of 3,500 tonnes of lithium concentrate on May 2. The company intends to ship on a monthly basis
- AMC Lithium Brazil: South-Eastern Brazil**
  - AMC Lithium invested around \$20 million in 2016 to develop a lithium concentrate plant at its Moa mine, located 200 km Northwest of Rio de Janeiro in Brazil
  - Company already built a 100,000 tpy wet plant production of 90,000 tpy and an option to expand to 180,000 tpy by the end of 2018
  - In its third phase, AMC would expand into downstream conversion of lithium concentrate into lithium hydroxide monohydrate and/or lithium carbonate
- Alura Mining Australia: Western Australia**
  - The first phase of mining and processing at Alura Mining's Pilgangoora lithium mine in the north of 1.54 million tpy of one to produce around 250,000 tpy of lithium carbonate
  - In its phase, it will determine optimal mine output with the aim of converting lithium concentrate to 450,000 tpy of lithium carbonate
- Yacimiento de Lito Boliviana (YLB) Bolivia: Sal de Uyuni**
  - Corporación Minera de Bolivia (Comibol) started the development of lithium resources at the Sal de Uyuni in 2008. The Bolivian government last year set up YLB to take over Comibol's operations
  - YLB has produced 300 tpy of lithium carbonate pilot plant in Lito in the Sal de Uyuni
  - YLB aims to increase production of lithium carbonate once construction of the lithium carbonate plant is complete, targeting output of 50,000-60,000 tpy by 2020
- Lithium Americas Corp. Argentina: Cauchari-Olaroz**
  - Lithium Americas' Sal de Cauchari-Olaroz operation in July in the northwest part of Argentina is targeting production by 2020. Its production target is 50,000 tpy of LDCO
  - Lithium Americas operations in the north-western of Nevada in the US as of the exploration stage. It should be a pre-feasibility study at the end of the second quarter
- Kidman Resources Ltd and SCM operations at Mt Holland Australia: Western Australia**
  - The East Gary Lithium Deposit in Western Australia is a 50-50 joint venture between Kidman Resources and SCM
  - Targeted output is 250,000-300,000 tpy of 6% LDCO concentrate production of lithium carbonate/lithium hydroxide is 44,000 tpy/ 800 tpy respectively
- Nemaska Lithium Canada: Quebec**
  - Nemaska Lithium is exploring and developing hard-rock lithium resources in the north of Quebec in the Canadian Shield
  - The company is currently developing its lithium carbonate plant in Nemaska, Quebec, with a capacity of 100,000 tpy of lithium carbonate
  - The company is also exploring and developing hard-rock lithium resources in the north of Quebec in the Canadian Shield
  - The company is also exploring and developing hard-rock lithium resources in the north of Quebec in the Canadian Shield

### Exploration & Development

- South America**
  - Argento Minerals Ltd. Argentina: Salta**
    - Argento Minerals is developing its Rionir lithium project in Salta in the Northern part of Argentina, aiming at scale up the pilot plant to produce up to 500 tpy, with commissioning in April 2018
    - In the second phase, it will expand capacity to 1,000-1,500 tpy of LCE in building a larger pilot plant
  - Bearing Lithium Chile: Atacama**
    - The company exploring and developing Maricunga in Northern Chile and waiting for a definitive feasibility study in 2018
  - Codrica Chile: Chile: Atacama**
    - The Chilean state-owned copper producer is looking for partners to operate the Salares de Maricunga and Pedernales
  - Dain Resources Corp. Argentina: Uruguay: US: Nevada**
    - Dain Resources is looking to develop assets in Tost-Ma and Alti Lake in Nevada and the Salinas Grandes project in northern Argentina
  - Erasmio Argentina: Salta**
    - Erasmio is targeting output of 20,000 tpy of lithium carbonate at its Condor-Rosario project in the north-west part of Argentina. Erasmio aims to become profitable before the end of the decade
  - Energy Group Corp. Argentina: Salta**
    - Energy Group plans to construct a lithium processing facility at the Sal de Uyuni in Salta Province in the Northern part of Argentina, aiming at producing 50,000 tpy of battery grade lithium carbonate before the end of the decade
  - International Lithium Corp. Ireland: Wicklow Argentina: Salta, Canada: Ontario**
    - International Lithium is developing in partnership with Ganfeng the Avonlea project in Wicklow in Ireland and the Maricunga project in northern Argentina. The company is also developing the Maria Lake and Renge projects in Ontario in Canada
  - Lithium Power International Ltd. Chile: Maricunga Australia: Western Australia**
    - Looking to develop its joint venture in Maricunga in Chile. The company has another interest in the Greenbushes area and Pilgangoora project in Western Australia
  - NIRA Miner Argentina: Salta and Catamarca**
    - Looking to develop two projects in Catamarca in the north of Argentina at the Salares del Hombre Muerto and Escondido
  - North America**
    - Alta Resources Ltd. Mexico: Sonora**
      - Conducting exploration work on the El Estero project in Sonora, Mexico
    - Bonanza Minerals Ltd. Mexico: Sonora**
      - Working to produce lithium from lithium-bearing brines and geothermal waters at the El Estero project in northern Mexico. The company expects to start the construction of a 30,000 tpy lithium carbonate operation at Sonora in the first half of this year, targeting first production in the first quarter of 2020
    - Critical Elements Corporation: Canada: Quebec**
      - Aiming to start production at its Royal Lithium-Tantalum project to produce 250,000 tpy on average of technical and chemical grade spodumene concentrates
    - Iconic Minerals Ltd. US: Nevada**
      - Exploring the Boron, Clive lithium project in Nye County, Nevada
    - Lithium X Energy Corp. Argentina: Salta; Nevada: US**
      - Developing the Clayton Valley North and Clayton Valley South lithium projects in Nevada and the Sal de Uyuni lithium project in the Diablos Salt in Salta, Argentina
    - Malco Enterprises Inc. US: Nevada**
      - Exploring at its Nevada lithium project and McEwen claims project, both based in Oriskany Valley
    - MSX Minerals Inc. Canada: Alberta**
      - Holds several lithium properties in Alberta, Canada
    - Nevada Sunrise Gold Corp. US: Nevada**
      - Has several lithium properties in and around the Clayton Valley area in Esmeralda County, Nevada
  - North America**
    - North America: Canada: Quebec**
      - Canadian Industrial Minerals company located in Ashby, near Val d'Or, Quebec. Expects to produce approximately 23,000 tonnes of battery grade lithium carbonate
    - Pure Energy Minerals Ltd. US: Nevada; Argentina: Salta**
      - Looking to develop its pilot plant in Nevada and Tost Ma and Alti Lake in Nevada and the Sal de Uyuni lithium project in northern Argentina
    - Rayon Mining Chile: Chile: Atacama**
      - Targeting completion of a definitive feasibility study early in 2018
    - Sino Lithium US: Arizona; Canada: Quebec**
      - Owens the Fortuna lithium project in Quebec and the Wilcox lithium project in Arizona
    - Ultra Lithium Inc. US: Nevada**
      - Conducting exploration work at its South Big Smoky Valley lithium brine project in Esmeralda County, Nevada, US, and has other assets in Canada and Argentina
    - Zeuth Minerals Ltd. US: Nevada; Arizona; Mexico: Central Mexico**
      - Carrying out exploration work at multiple North American sites including the Zeuthone lithium brine project in Mexico and the San Domingo lithium project, the Burn Creek lithium project and the Spencer & Wilson Salt Flat lithium brine project in the US
  - Europe**
    - Lithium Australia Australia: Western Australia**
      - Lithium Australia is involved in different projects in Western Australia among the Pilbara, Cogalga, Ravensthorpe, Seabrook and Wodgina
      - Lithium Australia is also involved in other projects Europe and North America
    - Nemaska Lithium Australia: Western Australia**
      - Looking to develop its project in Pilgangoora-Wodgina in Western Australia
    - Core Exploration Ltd. Australia: Northern Territory**
      - Looking to develop the Mount Fennell lithium mine and the Arnhem and Barrow Creek pegmatite fields near Mt Peake
    - Nemaska Minerals Corp. Australia: Western Australia**
      - Looking to develop its lithium resources in Western Australia
    - Lithium Resources Ltd. Australia: Western Australia**
      - Developing its Kathleen Valley and Bussellina lithium projects in Western Australia
    - Novo Lithium Australia: Wodgina**
      - Looking to develop its Wodgina lithium project in Australia
    - Norika Minerals Corp. Finland: Southern Finland**
      - Developing the Tampere project in southern Finland
    - Kallio Resources Ltd. Finland: Central Ostrobothnia**
      - Developing its Svalbard lithium project in the country's Ostrobothnia region
    - Novo Lithium Portugal: Northern Portugal**
      - Looking to develop its Sapaia lithium project in the North of Portugal and the Spanghede lithium project in Sweden
    - Savannah Resources Plc. Portugal: Northern Portugal**
      - Looking to develop its lithium project Mina do Barroso in the northern part of Portugal and the Spanghede lithium project in Sweden
    - Zeuth Minerals Ltd. US: Nevada**
      - Looking to develop its lithium project in Nevada
  - South America**
    - Neo Lithium Argentina: Catamarca**
      - Neo Lithium is currently developing its namapelite lithium project, Tost Ma (Tost Ma) in the north-western part of Argentina in the lithium brine lake of Tost Ma (Tost Ma) in the Argentine region of Catamarca
      - The company is currently building its lithium carbonate pilot plant in Tost Ma, with a capacity of 100,000 tpy of lithium carbonate
      - Neo Lithium aims to reach a production of lithium carbonate per year of 100,000 tonnes, starting operation in 2018 and 2020, anticipating to ramp up production between 2021 and 2023

\*Please note that this list is not exhaustive

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# World Lithium 2018

## INDUSTRIAL MINERALS

### TOP LITHIUM PRODUCERS 2017 (TONNES)

Australia (18,700)	Zimbabwe (1,000)
Chile (14,100)	Portugal (400)
Argentina (5,500)	Brazil (200)
China (3,000)	

Unit: tonnes of lithium metal contained  
Source: USGS, MBR

### KEY

Producers
Consumers
Producers and consumers

### Ganfeng Lithium Co.

China: Jiangxi, Australia: WA, Argentina: Salta

- Ganfeng Lithium among the largest producers of lithium compounds in China, aims to raise its lithium carbonate capacity to 40,000 tpy this year from 20,000 tpy. It will also increase its lithium hydroxide capacity to 30,000 tpy by 2018 from 5,000 tpy in 2017. The company is targeting LCE capacity of 58,000 tpy up from 60,000 tpy currently
- Ganfeng Lithium owns a stake in the Mount Marion spodumene project in Western Australia
- The company also has a stake at the Maricunga brine project in Salta in Northern Argentina

### Tianqi Lithium

China: Sichuan, Jiangsu, Australia: Western Australia

- Tianqi Lithium is one of the largest lithium producers in China. It is looking to expand its total lithium hydroxide capacity to 24,000 tpy by 2018 from 5,000 tpy in 2017. The company is targeting LCE capacity of 58,000 tpy in 2019
- Tianqi sources part of its raw material from Greenbushes, Western Australia, through its 51% ownership of Tailian Lithium
- Tianqi has also brine operations at its Zhushan in Tibet
- Tianqi Shenghe, a wholly owned subsidiary, has a mining mine at Qaidam Spodumene in Yaling County in the West Block of the Jialu Spodumene Mine in Asia

### Neometals Ltd

Australia: Western Australia

- The Mount Marion lithium project is a joint venture between Mineral Resources Ltd (42.1%), Neometals Ltd (13.8%) and Jiangsu Ganfeng Lithium Co Ltd (44.1%)
- Mount Marion made its first shipment of 15,000 tonnes of spodumene in February 2017 and shipped 104,505 tonnes in the first quarter of 2018 after shipping 221,388 tonnes in the second half of last year
- Mount Marion is aiming for full capacity of 400,000 tpy
- Neometals is looking to build a plant in Kooragang with namapelite capacity of 20,000-25,000 tpy of battery-grade lithium hydroxide compounds

### Albemarle Corp

US: North Carolina, Tennessee, Nevada; Chile: Atacama; China: Jiangxi; Australia: Western Australia

- Albemarle is the world's largest lithium producer with three US production sites: Kings Mountain in North Carolina (lithium chemicals), New Johnsonville in Tennessee (normal and secondary butyl lithium, lithium-based organometallic compounds) and Silver Peak in Nevada (lithium carbonate, lithium hydroxide - tonnes)
- It also produces from the Sal de Uyuni in Argentina, where it has a 50-50 joint venture with the Chilean Economic Development Agency (CORFO) to triple brine extraction and may increase its production of lithium carbonate equivalent (LCE) to as much as 145,000 tonnes per year until 2023 from 44,000 tonnes in 2017
- Albemarle is also a producer of spodumene at its operations in Greenbushes in Western Australia through its 49% share in Tailian Lithium Pty Ltd. Tailian Lithium owns the remaining 51%. Greenbushes will raise its spodumene capacity to 1.34 million tpy by 2020 from 740,000 tpy currently
- In 2017 the company acquired Jiangxi Ganfeng New Materials, with capacity of 15,000 tpy of lithium hydroxide. It is looking to ramp this up to 40,000 tpy in 2018

### Galaxy Resources

Australia: Western Australia

- Galaxy produces spodumene in its Mt Cattin mine in Ravensthorpe, Western Australia
- In 2017 the company produced 155,700 tpy of spodumene. It produced 60,000 tpy in the first four months of 2018
- Galaxy recently reached binding long-term off-take agreements with multiple Asian customers
- The company also owns a stake in the Jialu Spodumene project in Northern Argentina and the James Bay lithium pegmatite project in Quebec in Canada

### Orocobre Ltd

Argentina: Salta del Hombre Muerto

- The newest South American lithium brine producer, Orocobre operates its Olcaro brine project in a joint venture between Orocobre (66.5%), Toyota Tsusho Corp (25%) and Jiangsu Ganfeng Lithium Co (8.5%)
- After ramping up production to 11,392 tonnes of lithium carbonate in 2017, the company now aims to produce 14,000 tonnes of lithium carbonate in 2018
- Orocobre plans to increase lithium carbonate and lithium hydroxide capacity to 35,000 tpy and 10,000 tpy respectively by 2019
- Orocobre and Toyota Tsusho hope to finalize the development of a 10,000-tpy lithium hydroxide plant in Fukushima in Japan, scheduled to come online in 2019

### Bikita Minerals

Zimbabwe

- Bikita is ramping up production this year to at least 80,000 tonnes of pebble from 40,000 tonnes in 2017, doubling LCE output to 8,000 tonnes from 4,000 tonnes previously

### Sociedad de Quimica y Minera SA (SQM)

Chile: Atacama; Argentina: Cauchari-Olaroz

- SQM is the world's largest producer from brines. Its brine evaporation pond operations at the Sal de Uyuni produce both lithium carbonate and lithium hydroxide at the Sal de Uyuni and the Spencer & Wilson Salt Flat lithium brine project in the US
- The deal between Corfo and SQM will enable SQM to increase its production of lithium carbonate equivalent (LCE) almost five-fold to 216,000 tpy by 2025. SQM plans to increase lithium carbonate capacity to 100,000 tpy by 2019 from 40,000 tpy in 2017
- SQM has a joint venture with Kidman Resources Ltd on a 50-50 basis at Mt Holland in the East Gary Lithium Deposit in Western Australia, targeting 250,000-300,000 tpy of 4% LDCO spodumene output by 2019. Namapelite capacity for the first phase is 44,000 tpy of lithium hydroxide or 37,800 tpy of lithium carbonate
- SQM has another 50-50 joint venture with Lithium Americas to develop and operate the Cauchari-Olaroz project in Northern Argentina, targeting production of 50,000 tpy of LCE

## SPECIAL FOCUS ON CHINA

### CHINA - LITHIUM PRODUCTION OF PROCESSED MATERIAL (LCE)

2015: Brine 12,500, Spodumene 10,500  
2016: Brine 10,500, Spodumene 10,500  
2017: Brine 10,500, Spodumene 10,500

### China's Leading producers of lithium carbonate equivalent (LCE) in alphabetical order

- Ganfeng, capacity of 68,500 tpy, bringing another 17,500 tpy on stream by end-2018
- Jiangxi Nemati Lithium, 10,000 tpy, to increase to 20,000 tpy in Q1 and to 40,000 tpy in 2019
- Jiangsu Ronghui General Lithium, 8,000 tpy, expected to rise to 16,000 tpy this year
- Jiangxi Special Electric Motor, 10,000 tpy, up from 5,000 tpy as of March
- Qinghai Lithium, 10,000 tpy, ramping up to 20,000 tpy in Q3
- Qinghai Salt Lake Parkas Saltas Lithium, 10,000 tpy, to increase to 30,000 tpy in 2019
- Qinghai Hengxiang Lithium Technology, 20,000 tpy
- Qinghai CITIC Technology Development, 10,000 tpy on stream by end-2018
- Shandong Ruitai, 25,000 tpy, climbing to 35,000 tpy by end-2018 and 65,000 tpy in 2019
- Sichuan Yahua Lithium, 12,000 tpy, to increase to 22,000 tpy in 2018
- Sichuan Zhiyuan Lithium, 13,000 tpy, to increase to 50,000 tpy
- Tianqi, 34,800 tpy, expected 2019 capacity of 58,800 tpy
- Tibet Mineral Development, 5,000 tpy
- Tibet Urban Development and Investment, 5,000 tpy
- Zhonghe Group, 3,000 tpy

### CHINA'S CARBONATE IMPORTS 2017

Chile 61%, Argentina 28%, Other 11%

### CHINA'S LITHIUM HYDROXIDE EXPORTS 2017

Japan 62%, United States 3%, South Korea 20%, Germany 5%, Others 10%

### Lithium in China

Production of LCE (lithium carbonate equivalent) has boomed in China, largely fed by imports of lithium concentrates from hard rock in the form of spodumene from Australia.

**Lithium carbonate**

China supplements domestic production with imports of lithium carbonate from South America, which increased from 11,000 tonnes in 2015 to 22,000 tonnes in 2016 and nearly 31,000 tonnes in 2017. China upgrades some of the brine lithium carbonate compounds imported from South America to battery grade materials. The vast majority of lithium carbonate is consumed within China with a minimal export market.

**Lithium hydroxide**

Lithium hydroxide exports from China doubled from nearly 10,000 tonnes in 2016 to nearly 20,000 tonnes in 2017. This is feeding the increasing production of higher performance nickel-rich content-Ion batteries in Japan and Korea, in addition to increasing domestic Chinese consumption.

### Lithium value chain

Source: redham from Pure Energy Minerals

## Global lithium end-use markets 2017 (%)

Ceramics and glass .....27%  
Batteries .....46%  
Lubricating greases .....7%  
Continuous casting .....4%  
Air treatment .....2%  
Other uses .....9%

Source: USGS

## Lithium used in batteries

### 2014

31%

### 2025

70%

### KEY FACTS

- World Lithium consumption is expected to increase to 370,000 tonnes (LCE) by 2020, the forecast back in 2015 for 2020 was 280,000 tonnes (LCE)
- Lithium from hardrock is in the process of taking over from brines as the biggest source of lithium supply, but both sources will remain integral to the market
- Lithium market may move into a small supply surplus in 2018-2020 as supply outstrips consumption, but the need to build up working stock for capacity expansions at battery factories is expected to absorb any surplus.

## LITHIUM TYPES

**Lithium carbonate (Li2 CO3)**

This is a fine white alkaline powder used in making lithium-ion batteries, with non-battery uses in the manufacture in glass and ceramics; aluminum smelting; specialty cement; pharmaceuticals and lithium chemical feedstock. Lithium carbonate is a lithium chloride-rich liquor concentrated from brine and soda ash.

**Lithium hydroxide (LiOH)**

Colourless to white crystals that absorb water and carbon dioxide from the air. Used in lubricants and greases; copolymer production; additive for liquid dyes and wood preservatives; stabiliser in photographic developers; heat sink material; CO2 absorption; precursor for battery materialise LiPF6; and lithium chemical feedstock. Lithium hydroxide (LiOH) is lithium carbonate (Li2CO3) plus calcium oxide (CaO). Lithium carbonate and lithium hydroxide are used as chemical feedstock for numerous lithium chemicals (see flow chart below).

## Lithium value chain

Source: redham from Pure Energy Minerals

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