THE LITHIUM VOICE
INTERNATIONAL LITHIUM ASSOCIATION (ILiA)
The journal of the International Lithium Association (ILiA)
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LITHIUM FOR FLIGHT

How lithium alloys are making aircraft lighter

CONTENTS

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Chair's WELCOME

Welcome to the 11th edition of *The Lithium Voice* in which we explore how lithium alloys are used to make aircraft lighter and therefore help to reduce carbon emissions from air travel.

Continuing from the last two editions, we explore the historical development of lithium applications. Earlier editions covered initial discoveries, properties, and early uses, laying the foundation for advances still vital today, such as lithium greases that keep machinery, vehicles, and aircraft running efficiently. The accidental creation of thermal shock–resistant glass ceramics, like Corning Ware, transformed cookware, enabling food to go from freezer to heat without having to change the utensils or cracking the glass ware. This innovation later extended into induction cooktops, making cooking cleaner and more efficient.

Modern air travel is far more efficient than decades ago, thanks in part to reduced aircraft weight through lithium–aluminum alloys. These alloys, also used in spacecraft, are poised to play a critical role in both aviation and space exploration.

Lithium even contributed to a milestone in science — the first time humans changed one type of atom into another — and provided the first quantitative test of Einstein's equation $E=mc^2$. This edition looks at an era whose discoveries still benefit mankind.

We are honoured to feature Honorary Fellow Dr Brendan Moran, sharing his passion for hydrogeology, salars, and to consider the question: is brine water?

In building a sustainable supply chain, it is important for lithium refineries to continue to find ways to reduce their carbon footprint. See how one of our important associate members, MLC, a leading lime producer in the US & UK is helping the lithium refiners on this journey.

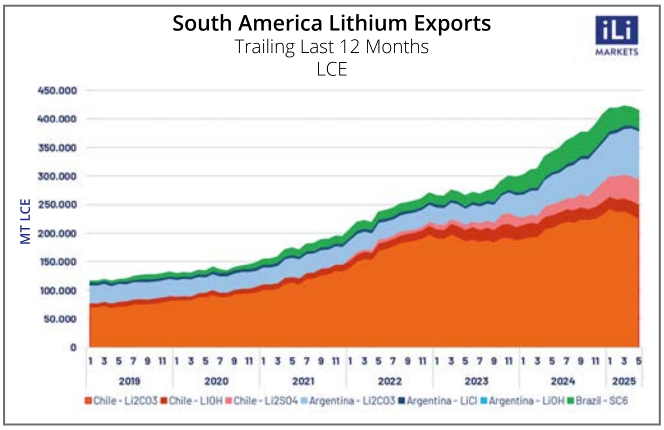
We continue to learn about the remarkable properties of lithium, building on past breakthroughs while pursuing innovations for the future! I hope that you will find this edition very informative.

Anand Sheth
Founding Chairman

Opinion

View from SOUTH AMERICA

From Daniel Jiménez of iLiMarkets



The South American lithium space entered the second quarter of 2025 with developments building in Chile and Argentina, where governments pushed forward with state backed partnerships and new permits. Brazil continues to expand its resource base steadily, while Bolivia struggles with judicial setbacks and limited progress.

In **Chile**, two landmark joint ventures have increased the state's leading role into the future. Codelco and Rio Tinto agreed to jointly develop the Salar de Maricunga, with Codelco holding 50.01% and Rio Tinto 49.99%. The deal involves up to USD900 million in staged funding, with production targeted for 2030 using conventional evaporation pond technology. Maricunga is viewed as Chile's most advanced new salar, complementing Codelco's copper dominance with a long term lithium assets.

At the same time, ENAMI and Rio Tinto finalized a binding partnership for the Altoandinos project. Rio Tinto will invest an initial USD425 million in the project with production planned for 2032, employing Direct Lithium Extraction (DLE). Together, the two deals make Rio Tinto the most prominent foreign partner in Chile's lithium sector, while ensuring that state companies hold majority or equal stakes.

Further consolidating this model, the Codelco–SQM joint venture in the Salar de Atacama advanced with a major regulatory approval. Chile's Nuclear Energy Commission (CChEN) authorized Minera Tarar, their joint venture, to extract up to 2.5 million MT of lithium metal equivalent starting in 2031. The approval allows for production of up to 330 kMT of lithium carbonate annually for 30 years, with early extraction permitted from January 2029.

In **Argentina**, momentum and incentive remained strong. In July, Galan Lithium has been granted RIGI status for its Hombre Muerto West project in Catamarca, with an investment plan of USD217 million. The approval made HMW the second lithium project and sixth overall to secure such RIGI status. Earlier this year, the government had already approved Rio Tinto's Rincon project in Salta. RIGI is an incentive regime for large-scale investments that secures a reduced corporate income tax (from 35% to 25%), fiscal stability around income tax, royalties, and export duties for 30 years, foreign exchange preferential access to currency markets for imports and dividend repatriation, customs & tariff exemptions and accelerated depreciation. On the other side, POSCO delayed Phase 2 at Hombre Muerto until early 2026 due to low prices, while Argosy Minerals secured a sales contract with a Hong Kong based buyer for lithium carbonate from its Rincon operations.

In **Brazil**, Minas Gerais remained the epicenter of development. Lithium Ionic Corp. updated resources at Baixa Grande, Atlas Lithium advanced with its modular Dense Media Separation plant designed to produce up to 150 kMT of spodumene concentrate annually, and PLS completed the acquisition of Latin Resources' Colina project, its first upstream investment outside Australia. Separately, Companhia Brasileira de Litio (CBL) announced a slight postponement to its expansion, though its medium term growth trajectory remains intact.

Finally, **Bolivia**, by contrast, saw limited progress. A court in Potosí revoked permits for two major projects with Russia's Uranium One and China's CBC/CATL consortium, suspending more than USD2 billion in planned investment due to inadequate consultation and environmental concerns. Despite vast reserves, Bolivia has not been able to produce lithium chemicals, leaving its lithium ambitions in uncertainty.

In the end, South America's lithium sector continues to develop its role as an important hub of the lithium production. The past quarter brought partnerships, regulatory approvals, and investment commitments that show the region's strategic importance. While policies and partnerships are making progress in key markets, ongoing price pressures and governance challenges are a reminder that growth in the sector is rarely easy or straightforward.

View from South America represents the opinions of iLiMarkets and does not reflect the opinions of ILiA.

iLi MARKETS

LITHIUM-ALUMINIUM ALLOYS TAKE OFF!

The next time you take a flight, you will probably fly in an aircraft constructed from aluminium-lithium alloys, at least in part. This little-known application of lithium makes huge contributions to aircraft, spacecraft and even racing cars.

Introduction

Pure lithium is the lightest metal in existence, with a density of 0.534 g/cm³, but it is also reactive and quickly oxidises in air or water, which makes it unsuitable to use on its own. However, when lithium is alloyed with either aluminium or magnesium[1], the result is a light metal which is also stable, offering a very useful combination for aerospace applications where strength-to-weight ratios are critical.

The most common alloys which use lithium are the "2000" family of aluminium-lithium (Al-Li) alloys containing between 1 and 2% lithium (by mass). These alloys have unique properties and are used in applications where their relatively higher cost is more than compensated for by the reduction in weight, such as aircraft, spacecraft and even racing cars.

The development of Al-Li alloys

Today Al-Li alloys can be found in many passenger and military aircraft, but their adoption did not happen overnight and included several false starts.

The first lithium-containing aluminium alloy to be developed, called *Scleron*, was created in 1927 in Germany, and contained 0.1% Li, but found few uses. The next development saw Alcoa patent an aluminium-lithium-copper alloy in 1945, but again it didn't really take off. The first generation of aircraft Al-Li alloys arrived in 1958 with Alcoa's AA 2020 alloy, used for the wing skins and tails of the US Navy's Northrop RA-5C Vigilante aircraft. Over 170 such aircraft were built until problems with fatigue, fracture and weldability of AA 2020 became evident and Alcoa stopped production in 1969. Meanwhile, across the Atlantic Ocean, Soviet variations of Al-Li alloys had evolved and were being widely used in military aircraft. The Yakovlev Yak-38/141 vertical take-off aircraft is an example.

Concerns about unsatisfactory fracture properties were also the reason that the early Al-Li alloys never saw widespread adoption in passenger aircraft and it took considerable research and development efforts to overcome these problems. The second generation of Al-Li alloys contained higher levels of lithium (~2% Li), but they continued to have undesirable characteristics, and as such were never widely used.

The turning point came in the late 1980s with the development of a range of significantly improved third-generation of Al-Li alloys. These new Al-Li alloys, containing from 0.75 to 1.8% Li, were low density but had higher specific stiffnesses, making them both lighter and stronger than earlier iterations.

With this successful development, Al-Li alloys began to be used extensively. The use of Al-Li alloys in passenger aircraft gives

continued on page 6

[1] Mg-Li alloys will be discussed in a future edition of *The Lithium Voice*

Northrop RA- 5C Vigilante aircraft. *(Image: US Navy)*

Yakovlev Yak-141. *(Image: Ken Videan)*

continued from page 5

considerable weight savings, resulting in fuel savings and therefore, cost savings. As a result, today they can be found in most of the world's passenger aircraft.

Table 1. **Chemical compositions of key Al–Li alloys (weight %) (after Rioja and Liu, 2012)**[i]

Alloy	Li	Cu	Mg	Ag	Zr	Sc	Mn	Zn	Al	Place and data
First generation									Balance	
2020	1.2	4.5					0.5			Alcoa, 1958
1420	2.1		5.2		0.11					Soviet, 1965
1421	2.1		5.2		0.11	0.17				Soviet, 1965
Second generation										
2090	2.1	2.7			0.11	0.17				Alcoa, 1984
2091	2.0	2.0	1.3		0.11				Balance	Pechiney, 1985
8090	2.4	1.2	0.8		0.11					EAA, 1984
1430	1.7	1.6	2.7		0.11					Soviet, 1980s
1440	2.4	1.5	0.8		0.11					Soviet, 1980s
1450	2.1	2.9			0.11					Soviet, 1980s
1460	2.25	2.9			0.11	0.09				Soviet, 1980s
Third generation										
2195	1.0	4.0	0.4	0.4	0.11				Balance	LM/Reynolds, 1992
2196	1.75	2.9	0.5	0.4	0.11		0.35 max	0.35 max		LM/Reynolds, 2000
2297	1.4	2.8	0.25 max		0.11		0.3	0.5 max		LM/Reynolds, 1997
2397	1.4	2.8	0.25 max		0.11		0.3	0.1		Alcoa, 1993
2198	1.0	3.2	0.5	0.4	0.11		0.5 max	0.35 max		Reynolds/McCook, 2005
2099	1.8	2.7	0.3		0.09		0.3	0.7		Alcoa, 2003
2199	1.6	2.6	0.2		0.09		0.3	0.6		Alcoa, 2005
2050	1.0	3.6	0.4	0.4	0.11		0.35	0.25 max		Pechiney, 2004
2060	0.75	3.95	0.85	0.25	0.11		0.3	0.4		Alcoa, 2011
2055	1.15	3.7	0.4	0.4	0.11		0.3	0.5		Alcoa, 2012

Metallurgy

The properties of an alloy depends on its composition and microstructure (grain size, shape, crystallization phases). Their precise properties can be changed by controlling the manufacturing process, including the solidification rates, ageing by heat treatment, and rolling. Each process changes the alloy's crystalline microstructure and influences the mechanical properties of the final product.

Typically, an addition of 1% lithium by mass in the aluminium alloy matrix can reduce the alloy's density by ~3% and increase the modulus of elasticity (i.e. stiffness) by ~6%, compared with conventional aluminium alloys.

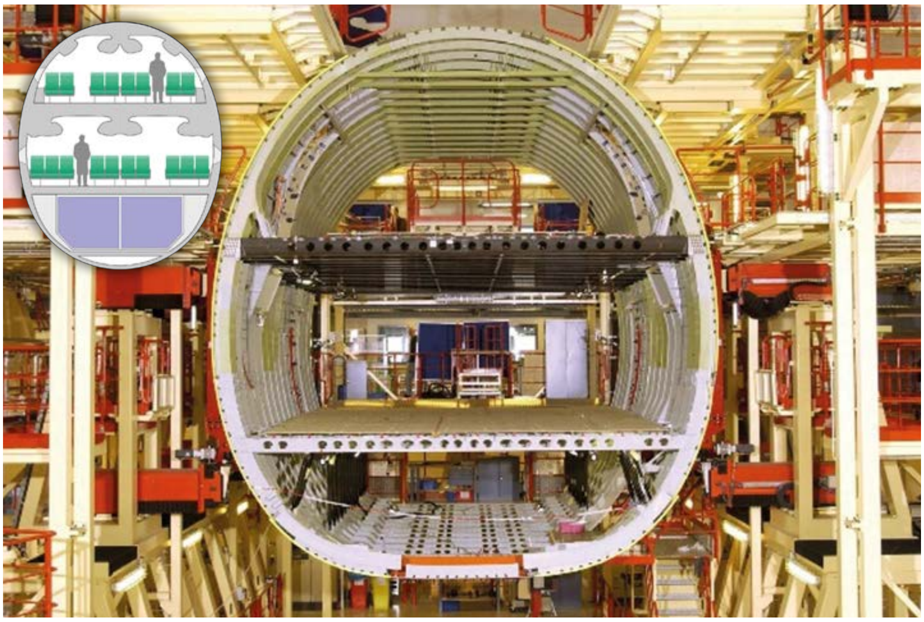
Critically, it is essential to control the chemical composition, since even relatively small amounts (< 10 ppm) of impurities such as sodium (Na) or potassium (K) in the alloys can reduce the toughness and ductility. Consequently, only very pure aluminium and lithium metal (containing 50 ppm to 300 ppm Na) can be used for their production.

Al-Li for spacecraft

Al-Li alloys are well-established and widely-used in spacecraft. Their selection was based on their ability to withstand the loads and stresses during launch, relatively high structural efficiency, and excellent fabricability. The main applications for Al-Li alloys in spacecraft are for cryogenic (liquid) propellant tanks, such as the NASA Space Shuttle Super Lightweight External Tank (SLW ET), which was first launched in June 1998. This tank used Al-Li alloy 2195 and was over 10% lighter than the tank it replaced, which had been constructed from a non-lithium alloy of aluminium.

Today the SpaceX Falcon 9 and Falcon Heavy launcher continue this tradition. Both use the Al-Li alloy AA 2198 to fabricate the walls of the tanks of its two-stage liquid propellant rocket. The Falcon's tanks are 3.66 m in diameter and are manufactured using a technique called friction stir welding - the highest strength and most reliable welding technique available for aluminium alloys.

Alloy 2198 was chosen because of its advantages in specific stiffness and compressive strength, compared to older, conventional aluminium alloys, plus additional advantages in toughness and fatigue and corrosion resistance. The Chinese Long March 12 launch vehicle and Russia's Soyuz also use Al-Li alloys extensively.



An Airbus A380 being constructed, showing Al-Li beams (lower deck) and CFRP beams (upper deck). *(Image: Airbus)*

Al-Li for aircraft

"The future of aviation is being built with aluminum-lithium", said Klaus Kleinfeld, Alcoa's Chairman and CEO in 2014, when Alcoa Inc. (now Arconic Inc.) opened what was then the world's largest Al-Li plant in Indiana, USA. Today, capacity at the plant is 20,000 tonnes (44m lb) of Al-Li alloys annually, and the customer list includes aircraft, space applications, and high-performance automotive, including Formula One cars.

These extraordinary metals would have probably been used even more if their development had not coincided with the increased use of carbon fibre reinforced plastics (CFRPs, or composites) for aircraft bodies. For example, the Boeing 747, which first flew in 1969 was over 75% aluminium alloys by weight, whereas the Boeing 787 which took its first flight in 2009 is just 20% aluminium alloys and around 50% composites.

Examples of Al-Li alloys in aircraft include the lower-deck floor beams of the Airbus 380, structural components and fuselage for the EH101 Merlin helicopter, and structural components for the US Lockheed Martin F16 fighter (alloys 2297 and 2397).

In Russia, Al-Li is still frequently used in military aircraft, while in China the new COMAC C919 passenger aircraft widely uses Al-Li alloys in the fuselage structure, including alloys 2198-T8, Al–Li–Sc-T8, 2196-T8511, and 2099-T83.

Al-Li for high performance cars and sporting equipment

No introduction to Al-Li alloys would be complete without mentioning high-performance cars and lightweight sporting equipment, two further applications where a high strength at low weight justifies a premium price.

In the automotive industry Al-Li alloys can be used for body panels, chassis parts, and suspension components. For example, the Italian engineering group Brembo has supplied Al-Li brake calipers to cars racing in Formula 1 and the World Endurance Championship (WEC).

A wide range of sporting equipment is manufactured with Al-Li alloys, including bicycles, golf clubs, tennis rackets, and baseball bats, where its unique properties enhance performance, speed, and manoeuvrability.

Looking ahead

In applications such as flight and space travel, where weight equals fuel cost, there will always be a strong drive to reduce mass without sacrificing performance, and Al-Li alloys offer a solution. The unique strength-to-weight properties of Al-Li alloys have seen them become widely used in the last thirty years and this looks set to increase in the future.

Editorial credit: Aerospace Trek / Shutterstock.com

Opinion

View from NORTH AMERICA

From Adriana Carvalho, Senior Managing Editor, Metals
S&P Global Commodity Insights

U.S. fast-tracks lithium mining approvals

The U.S. government is looking to accelerate the approval process for mining initiatives focused on lithium resources, under a program to speed up permitting. The Fixing America's Surface Transportation Act (FAST-41) aims to enhance domestic supply and lessen dependency on imports.

The latest addition to the FAST-41 list is the Angel Island Project, backed by Century Lithium. Situated in Clayton Valley, Esmeralda County, NV, this development-stage lithium production venture could produce an average of 34,000 metric tons per year of battery-grade lithium carbonate over a 40-year operational lifespan, pending permitting by the Department of the Interior's Bureau of Land Management. Albemarle Corp. also is set to finalize its permitting and environmental review for the Silver Peak lithium mine by February 27, 2026, pending operational plans and an environmental impact statement. Meanwhile, Jindalee Lithium Ltd. and HiTech Minerals Inc. anticipate completing permits for exploration drilling at the McDermitt lithium mine in Oregon by January 2, 2026. Standard Lithium Ltd. and Equinor ASA project to finish permitting for their Smackover lithium brine operation in Arkansas by June 1, 2026.

According to US Census Bureau statistics, in the first quarter of 2025, US imports of processed lithium materials – such as lithium carbonate and hydroxide – increased by 16.7% compared to the previous year, totaling 5,340 metric tons, and surged 87.3% from Q4 2024.

Analysts at S&P Global attribute this increase to automakers ramping up lithium acquisitions in anticipation of potential tariffs, trade disputes and rising production expenses.

Almost all US processed lithium materials imports in Q1 were sourced from Chile and Argentina, with Chile contributing 3,285 metric tons (61.5% of total imports) and Argentina supplying 2,011 metric tons (37.7%). Canada, a Free Trade Agreement partner, exported 7,651 metric tons of refined lithium compounds, accounting for 46.7% of U.S. imports, while China made up 29.5% (4,833 metric tons), according to customs data.

Downstream developments

State governments will have increasing power to shape electric vehicle (EV) adoption rates across the U.S. as the federal EV tax credit expires for vehicles purchased or leased after September 30, 2025.

Several states have already initiated self-funded subsidy programs and charging infrastructure projects. S&P Global predicts that by 2050, California (90%), Washington D.C. (88%), and New York (88%) will lead in EV sales penetration, whereas states like Alaska (37%), Alabama (39%), and Nebraska (57%) will lag.

California is expected to remain at the forefront of policy innovation and investment in EVs. However, analysts caution that without sufficient investment in charging infrastructure and regulatory incentives, consumer uptake of EVs could decline.

The US battery storage sector could also face challenges in light of supply chain shifts. Developers of large battery storage facilities are expected to sustain growth into the next decade, aided by the continuation of clean energy tax credits in President Trump's budget bill, which largely avoided drastic cuts to such incentives. However, the legislation's restrictions on tax credit eligibility for facilities associated with foreign entities of concern (FEOC) have prompted developers to procure inventory and adjust sourcing in anticipation of restrictions set to take effect in 2026.

Tesla Inc. has entered into a three-year agreement worth approximately USD4.3 billion with LG Energy Solution Ltd. for lithium-iron phosphate (LFP) cells for its battery systems, with deliveries commencing in 2027. LG Energy plans to boost its U.S. energy storage manufacturing capacity to more than 30 GWh by the end of 2026, up from an earlier target of 17 GWh, by repurposing some EV battery production lines for energy storage systems. The company began producing LFP-type lithium-ion battery cells for storage applications at its Michigan facility in May.

Analysts say other lithium-ion battery manufacturers might adopt a similar approach by repurposing some EV production lines to produce cells for stationary energy storage.

Preliminary analysis from S&P Global Commodity Insights indicates that U.S.-manufactured batteries eligible for a 30%-40% investment tax credit could be more competitively priced than Chinese imports subject to a 30% tariff under Trump's proposed tariff plan.

View from North America represents the opinions of S&P Global Commodity Insights and does not reflect the opinions of ILiA.

Platts
S&P Global
Commodity Insights

LITHIUM COMES OF AGE
(PART 1) 1920 – 1958

This is the third article in our series which explores the historical development of lithium applications. In this chapter we look at the period from the first industrial production of lithium in 1920s through to the late 1950s when the first mass-produced lithium-based consumer products appeared on the market.

What is the connection between the drink 7Up and lithium? You'll find the answer at the end of this article!

In the last edition of *The Lithium Voice* (#10), we looked at the history of lithium between 1817 and 1917. During this period lithium was discovered in rocks and waters all over the world, scientists examined it's fundamental properties and the first applications were developed.

We rejoin the story in 1920, just as the first industrial production of lithium is about to start - and it is all due to the German railways.

Before the development of heavy-duty grease lubricants, the bearings in the wheels of railway trains used low-friction tin- or lead-based alloys. One such metal was developed by Metallgesellschaft in Germany and was known as Bahnmetall (the German for "railway metal"). It was produced at Langelsheim and in 1920 it was discovered that adding 0.04% lithium made it work even better, especially for the bearings on heavier and faster trains.

1920s: Industrial production starts

The new and improved Bahnmetall was a big success. However, there was not enough lithium to meet demand. In 1920 there was no industrial production of lithium since up until then it had only been used in niche applications.

Image: Albemarle GmbH

A piece of historic Bahnmetall with HHH (Hans Heinrich Hütte) engraved.

To address this shortage in 1923 Metallgesellschaft started to produce lithium on an industrial scale for the first time ever (see *The Lithium Voice* #4).

Initially, the lithium was extracted from zinnwaldite, a form of lithium-rich mica, found in old tin mine tailings at Zinnwald on the German-Czech border. The new plant provided enough lithium for Bahnmetall production to increase rapidly.

It was so successful that Bahnmetall was used in German railway bearings until the 1950s. Today lithium chemicals are still handled at the Langelsheim plant, now as part of Albemarle Corporation.

In America the success of Bahnmetall had been noticed with interest and just four years after industrial production started in Germany, the Maywood Chemical Company of New Jersey began its own lithium production, using minerals from the Etta mine in South Dakota. Maywood was followed by Foote Mineral Company in the late 1930s and both companies developed thriving operations, sourcing spodumene and other minerals from across North America.

1932: A signal year for nuclear physics

The next important date in the lithium story is arguably 1932, a year which revolutionised our understanding of atoms. Over the course of the year, four significant events changed the face of nuclear physics for ever: the discoveries of neutrons, positrons and deuterium,

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and the first human-made nuclear reactions, involving the disintegration of lithium nuclei by particle accelerators.

John Cockcroft and Ernest Walton were physicists at the University of Cambridge's Cavendish Laboratory in the UK. There they built a machine using a series of capacitors and diodes that rectified electrical current from AC to DC to produce very high voltages and accelerate protons (dubbed "swift protons" by Cockcroft).

Using their "Cockcroft-Walton machine" on April 14th 1932 the pair achieved an output voltage of 600 kV and accelerated protons to incredible speeds across a sheet of mica coated with lithium as a target.

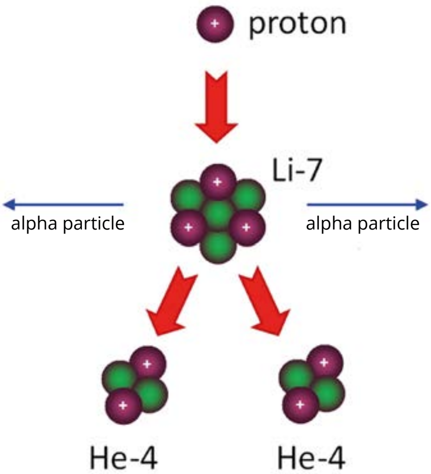
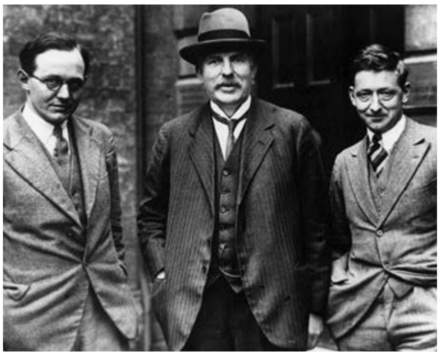


Diagram showing the transmutation of lithium into two helium atoms

The power of the reaction caused the nucleus of the lithium atom to split into two helium atoms and created two alpha particles that shot off in opposite directions (with the reaction p + 7Li → 4He + 4He). For the first time in history humans had succeeded in changing one type of atom into another type of atom.

Later that year, in September, at the University of California, Berkeley, USA, Ernest Lawrence and Stanley Livingston repeated the fission experiment on lithium atoms and then proceeded to split apart boron



From left to right: Ernest Walton, Ernest Rutherford and John Cockroft outside the Cavendish Laboratory.

(Image: UK Atomic Energy Authority, courtesy of AIP Emilio Segrè Visual Archives)

and fluorine too. Because both the kinetic energies of the emitted alpha particles were measurable and the nuclear masses were known, these experiments provided the first quantitative test of Einstein's mass–energy equivalence, described by the famous equation $E=mc^2$ where energy (E) is equal to mass (m) multiplied by the speed of light (c) squared.

1940s: Two new applications are developed and demand surges

US efforts during World War Two led to two significant developments involving lithium: improved lubricants and the Manhattan Project.

Grease lubricants

Lithium-based greases are excellent lubricants in high-temperature machinery, including heavy industrial machines and aircraft engines.
The beginning of this technology dates to 1942 when the American chemical engineer Clarence Earle filed a patent for his invention called "Lubricant Containing Lithium Salts," a grease based on simple lithium soaps (metallic salts of fatty acids). Just four years later in 1946, Harold M. Fraser was granted a US patent for using lithium 12-hydroxystearate as the thickener and a year after that, in 1947, Lester W. McClennan was granted a further patent for a lithium complex grease that could operate at even higher temperatures.

Lithium greases remain useful general-purpose lubricants to this day and continue to be used in many machinery applications including automotive, heavy machines, ships and aircraft. They are also widely available to the public for domestic use. They have high resistance to water and can be used not only as a corrosion inhibitor in petroleum, but also as a stabilizer both in the plastics and cosmetic industries.

Atomic power (top secret)

When Cockcroft and Walton first split lithium atoms in 1932 they could not have imagined where their work would lead. By the 1940s lithium was again involved with splitting atoms, this time as part of the US-led Manhattan Project, the top-secret, program focused on

Lithium grease in a bearing. *(Image: Shutterstock)*

Kings Mountain lithium mine, NC, USA, currently being dewatered. (Image: ILiA)

creating the first nuclear weapons.

In its Geological Survey Bulletin 1027-G entitled Lithium Resources of North America, published in 1955, the US Department of the Interior is remarkably coy about lithium and some of its uses post-1923. Having noted that “increased demand during World War Two was caused largely by the use of lithium hydride as a hydrogen carrier to inflate certain types of naval and air force rescue equipment,” it goes on to say that “the transient uses during World War Two were succeeded by more permanent uses that created a strong market leading to the great expansion of the industry in the years following 1948.”

What is not mentioned is that in the 1940s and 50s one of the most significant uses of lithium (not least in the US) was related to manufacturing nuclear weapons, although this is not surprising as this fact was a highly-classified state secret.

The race to build nuclear weapons during the Cold War involved the US, the Soviet Union, France, the UK and China, and was one of the reasons why new lithium mines were developed in the US at that time. Beginning in 1942, the Solvay Process Company established a lithium-producing plant at the pegmatite ore body near Kings Mountain, North Carolina, that held considerable reserves of spodumene, the richest lithium-containing mineral. Kings Mountain was taken over in 1951 by the Foote Mineral Company and expanded to become the largest lithium mine in the world by 1954. In 1955 a second spodumene mine was developed by the Lithium Corporation of American, near Bessemer City, North Carolina, about 6 miles northeast of the Kings Mountain deposit.

Today Albemarle is in the process of reopening the Kings Mountain mine.

1950s: Lithium appears in the kitchen

In 1953, Stanley Donald Stookey, a research chemist working for the North American glass company Corning Inc., made a remarkable, accidental discovery.

A classic CorningWare Pyroceram ‘Blue Cornflower’ casserole set.
(Image: Corning)

By mistake he heated a batch of lithium-containing photosensitive glass to over 482°C (900°F) and it had turned milky-white colour. As he took it out of the furnace it slipped and dropped on to the hard floor. But nothing happened; the glass did not shatter.

Stookey realised that adding lithium to glass reduces thermal expansion and with the right amount of lithium added glass could be used in extreme temperature variations without cracking.

Corning trademarked it as Pyroceram in 1957 and began marketing it for military applications such as the nose-cones of guided missiles. However, the launch in 1958 of the CorningWare kitchenware range pushed all other applications into the shade. Suddenly it became possible to take a dish of food straight from the freezer to the oven.

It was one of Corning’s most successful product lines of all time, selling several hundred million pieces over the next 50 years. Today lithium-bearing glass ceramics can be found in many applications, from heat-shock-resistant cookware and flat-top ovens to the largest telescopes in the world; all applications where a minimal thermal expansion is essential.

Did somebody say “battery”?

In the next chapter we will examine the developments which ultimately led to the launch of the world’s first commercial rechargeable lithium-ion batteries in 1991.

Quiz answer: 7Up was originally called Bib-Label Lithiated Lemon-Lime Soda and it contained lithium citrate from its launch in 1929 until 1948. The name combined the atomic weight of lithium (6.94) and the alleged mood-enhancing feeling it gave the drinker.

Opinion

View from AUSTRALIA

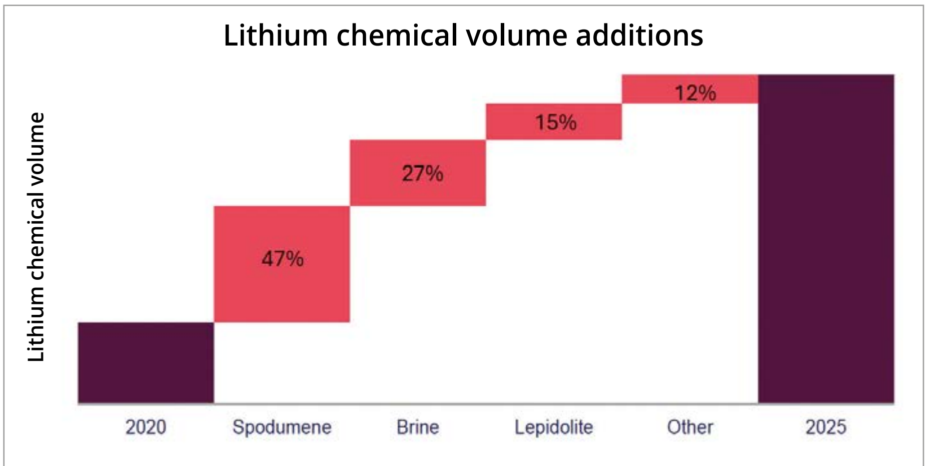
From Allan Pedersen, Research Director for Wood Mackenzie

The supply growth story

The lithium industry has undergone a profound transformation over the past decade. Demand and supply dynamics have shifted dramatically, creating periods of deficit followed by oversupply. The market responds to price signals with significant volatility.

During the late 2010s and early 2020s, supply growth remained subdued whilst demand surged. This imbalance created a supply deficit that drove prices to record highs in 2022. The industry responded swiftly with significant capacity and supply additions across multiple production routes.

Between 2020 and 2025, lithium chemicals supply expanded at a compound annual growth rate of 32%. Spodumene concentrate-based production dominated this growth, accounting for 47% of additional volume. Lepidolite contributed 15% of new supply, whilst brine operations provided 27%.



Source: Wood Mackenzie

Chinese assets drove three-quarters of global lithium chemicals supply growth during this five-year period. By contrast, capacity expansions from Chilean brine operators contributed just 13% of total growth. This geographic concentration highlights China's dominant role in meeting surging lithium chemical demand.

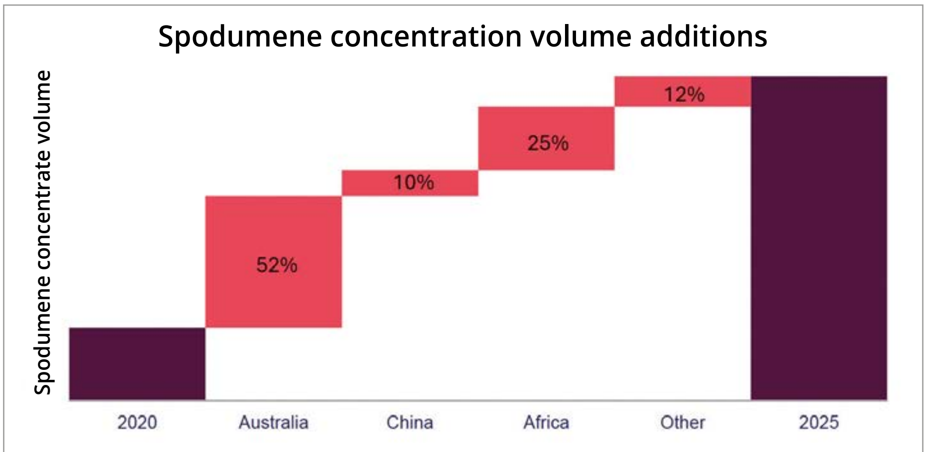
Raw material supply surges to meet chemical demand

The growth in lithium chemicals production drove a strong expansion in raw material supply.

Lepidolite volume grew the fastest, with a 50% CAGR from 2020 to 2025. The growth is entirely attributable to China. Despite relatively high costs, it has become an expanding domestic resource.

Spodumene concentrate supply grew the second fastest, with a 35% CAGR from 2020 to 2025. Australia supplied over half of this volume growth, with Africa contributing approximately half of Australia's volume again. Production from Chinese-based assets accounted for 10% of the growth.

Brine assets delivered additional volume with a 25% CAGR. Chile accounted for 45% of the new brine supply, followed closely by Chinese assets at 37%. This data highlights incredible growth across the lithium industry and a changing resource landscape.



Source: Wood Mackenzie

Spodumene concentrate cements market dominance

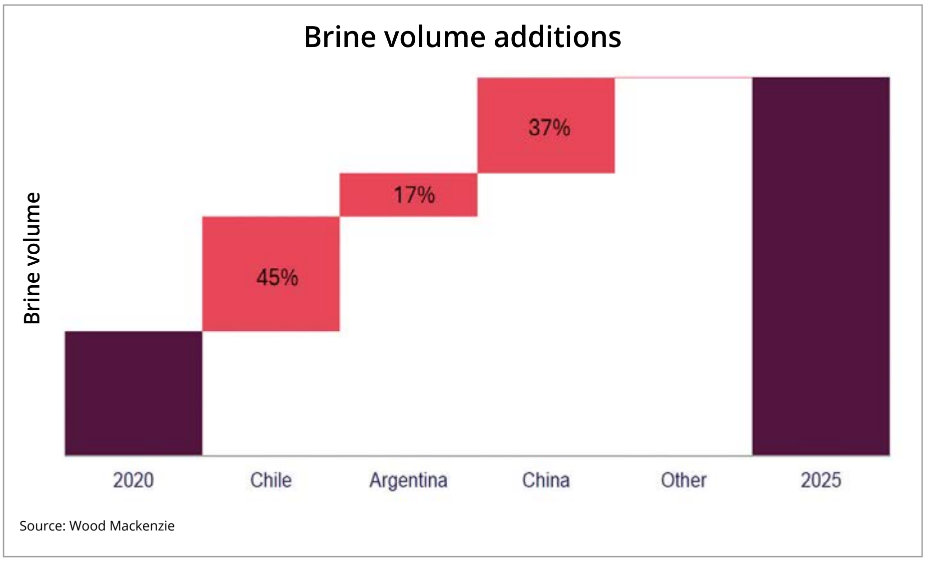
Lithium chemical production from spodumene concentrate increased its market share to 45% in 2025. This growth rate exceeded the lithium chemical industry overall, with 35% versus 32%. This cemented the dominance of spodumene concentrate. Lepidolite showed the largest growth rate, but from a low base, accounting for 13% of raw material input into lithium chemicals in 2025.

The explosive growth in lepidolite and strong growth in spodumene concentrate reduced brine-based lithium chemicals' share from 40% to 30% over the five-year period. Wood Mackenzie expects this feedstock diversification to continue reshaping supply chains and cost structures across the industry.

The market balance remains precarious

The market balance across the lithium chemical industry remains precarious. We have seen extraordinary growth in supply, which was largely spurred by the very high margins achieved in 2022. These growth rates coincided with slowing demand growth rates.

The result is a current market in oversupply with depressed prices. These price levels will put raw material producers under continued price pressure until the market moves towards equilibrium.



View from Australia represents the opinions of Wood Mackenzie and does not reflect the opinions of ILiA. ILiA member benefits include exclusive quarterly webinars with Allan regarding the lithium market. Contact ILiA for details.

Wood Mackenzie

THE CURRENT

Catch up with ILiA's work at a glance

ILiA membership update

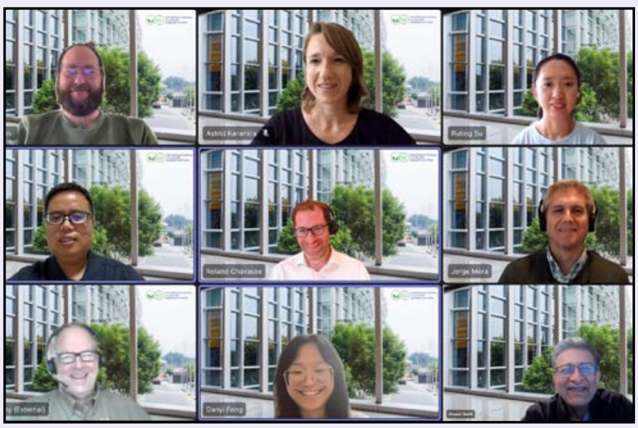
Since the last edition of *The Lithium Voice* nine companies have joined ILiA's global community:

- ElectraLith Pty Ltd, Australia
- Glencore International AG, Switzerland
- Licube Inc., USA
- Neptune Energy Holding Germany GmbH, Germany
- PowerCo SE, Germany
- Princeton Critical Minerals, Inc., USA
- Rock Tech Lithium Inc., Germany
- Shanghai Zhongteng Equipment Technology Co., Ltd, China
- Veolia Water Technologies, France

Executive Committee update

In July we welcomed three new representatives to the Executive Committee, George Thomas from Rio Tinto, Sharon Iu from Chengxin Lithium, and Pablo Ortega Van Giel from AMG Lithium.

We are greatly looking forward to working with them as the Association grows and develops.



Secretariat update

Recently ILiA welcomed two new members of staff to the team.

Austin Devaney is our new North American Representative Director. Austin will strengthen the Association's presence across the US and Canada and actively support our members that our based there.

Danyi Feng is our new China Public Policy & Sustainability Manager. Danyi will strengthen the Association's presence in China, in particular regarding ESG and sustainability issues.

ILiA's team is based in Australia, China, Peru, Portugal, South Africa, the UK, and the USA.

In conversation with Dr BRENDAN MORAN

Assistant research professor of hydrogeology at University of Massachusetts Amherst and Honorary Fellow of ILiA.

How did you first get interested in science?

I've always just been fascinated with the natural world. As a child I would be out in the woods and streams all day, breaking rocks open and just wondering about how nature brought it all together. I was a really curious child and I can remember being out in the forests of New England with my dad and asking him "Why? Why? Why?" about everything that we saw.

And how did you end up working in hydrogeology?

At college I studied geology. Trying to understand the Earth system as a whole fitted pretty seamlessly into my interests. After graduating from Saint Lawrence University I was a consultant for a while, but I missed the challenge of working on really complex problems, so in about 2015 when a friend of mine told me about Dr David Boutt at University of Massachusetts Amherst I was immediately interested. Growing up in New England you're always around water, and I've always been fascinated by how it moves over and through the landscape, so combining geology and hydrology made a lot of sense.

Was salar hydrogeology a well-established science then?

No, not really. Mineral extraction from salars was several decades old, of course, but salars had not really been studied in much depth before, partly because they are incredibly complex systems. Salar hydrogeology research really started in earnest a couple of years previously when David began working with one of the true pioneers of the field, Dr LeeAnn Munk at the University of Alaska Anchorage.

The opportunity to study these incredibly complex systems was too good to pass up, so I applied to join the programme in 2016. In those days we were mostly looking at the Salar de Atacama in Chile and Clayton Valley in Nevada, USA, but since then the research team and our work has ballooned as more and more lithium projects have been developed.

What makes a good hydrogeologist?

Creativity and team-work are key because the problems that we're trying to answer aren't often well defined. In the team with David and LeeAnn we each have slightly different strengths, which is really good. You can't work in a silo as hydrogeologists, and you need to be flexible and take on things from different perspectives and angles. So many skill sets are needed that you need to have a team with an integrated approach where knowledge can cross over. If you can integrate different fields in a clever and creative way, then that's a great start.

What's the biggest challenge in hydrogeology at the moment?

You can't see groundwater. It's not like surface water flows, it's runs deep underground and to understand it requires input from a lot of different fields of geology, hydrology and even climatology. To see the full picture you need to bring in geophysics, stratigraphy and hydrogeochemistry and triangulate the results. Modelling is really important too. In my work within the group I often incorporate things like hydroclimate modelling, hydrology, geophysics, stratigraphy and isotope geochemistry.

Can you explain your recent work on relic water?

Our work has shown that in the salar system a lot of the water is

really old, or relic water. This was initially a surprising discovery. Generally speaking, there is quite a bit of recent rain water near the surface and then really old water underground, and you need to understand their relationship when estimating the water budget for these basins.

We can show this by looking at the levels of tritium [a naturally occurring radioactive isotope of hydrogen]. Tritium has a half-life of slightly over 12 years, so measuring the level of tritium in a water sample can tell you if it was recently rain or not, up to about 100 years old. It's very reliable, partly because levels of atmospheric tritium peaked during atmospheric nuclear bomb testing in the second half of the 20th century, meaning that if a sample has no tritium it is certainly quite old [>100 years].

How do you estimate the age of very old water?

This is something we are working on. There are noble gas tracers, such as at Krypton-81 which has very long half-life and exists at really low levels in the atmosphere, but it's a really difficult method since you literally have to count atoms. It is possible to measure the age of water up to about a million years old this way, but it's difficult and expensive at the moment.

This will get more important as we start to extract brines from deeper under the salars. Traditionally solar brine mining has been focused on the upper 30 metres, just beneath the surface. Lately, there's there has been a lot more deep drilling in salars, especially in Argentina. Deeper subsurface brine hydrogeology can be quite different and presents some unique challenges.

Is there much read-across from salars to other lithium-containing brines?

From both a hydrogeological a geochemical perspective there are some similar process occurring in geothermal brines like in the Salton Sea and also brines taken from the deep oil and gas reservoirs like in like the Smackover in southern USA. Colleagues like Kristina Butler at UT Dallas and LeeAnn Munk look at this area more than I do, however. This is a field that's developing fast and the challenge of freshwater is common to all types of brine extraction. You still need to understand the watershed and aquifers that you're extracting water from to use it responsibly.

Science and industry: partners or rivals?

Partners. We are aiming to get to a place where we're reducing the impacts of mineral extraction and communicating the context for water to all sides, well. I often hear the question 'is brine water?', but this probably is not as important as questions of where that water is coming from, it's hydrological context and how we're reducing impacts of extraction and balancing the many different demands on water resources.

What are you working on at the moment, if you can say?

We have several ongoing projects in Argentina and a few Chilean and US and Canadian projects too, at various stages of development. We're always exploring new opportunities to help push the science forward. Our goal is to deeply understand the water budgets and the holistic systems at these salars. There's some fundamental arid climatology angles too, along the lines of the papers that we published a couple of months ago. We try to align those questions with the governments, civil society and industry groups we work with. The complexity of the direct lithium extraction (DLE) is undoubtedly going to bring complex new questions.

Do you own an electric vehicle?

Not yet, but my wife and I talk about it all the time. The next car we get is definitely going to be electric. I'm really impressed by how far the technology has come and they're the way of the future. I think there's no question about that!

[i] Kirshen, A. B., Moran, B. J., Munk, L. A., Russo, A. A., McKnight, S. V., Jenckes, J., Corkran, D. B., Bresee, M., & Boutt, D. F. (2025). Freshwater inflows to closed basins of the Andean plateau in Chile, Argentina, and Bolivia. Communications Earth & Environment, 6(1), 177. https://doi.org/10.1038/s43247-025-02130-6

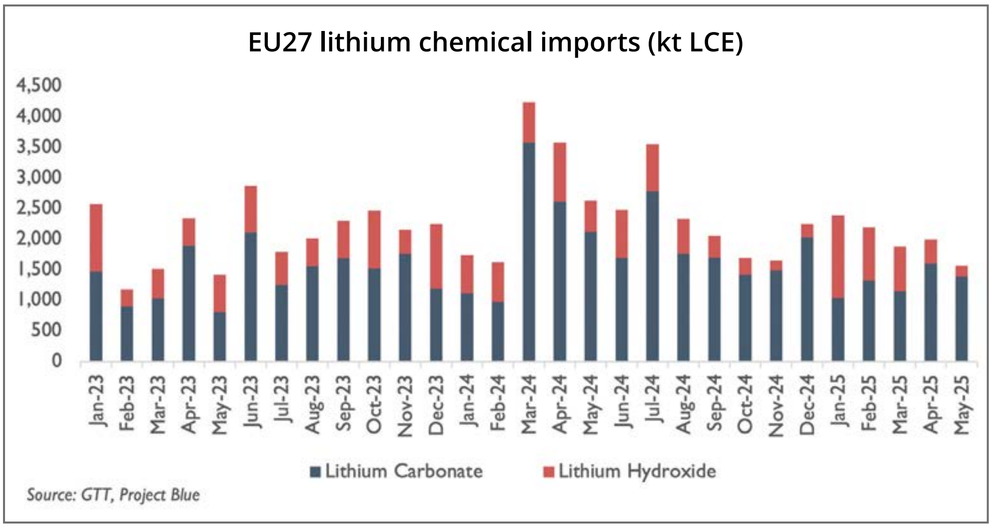
Munk, L..A., Boutt, D., Butler, K., Russo, A., Jenckes, J., Moran, B., & Kirshen, A. (2025). Lithium Brines: Origin, Characteristics, and Global Distribution. Economic Geology, 120(3), 575–597. https://doi.org/10.5382/econgeo.5134

Opinion

View from EUROPE

From Jordan Roberts of Project Blue

Against a backdrop of subdued lithium prices and bearish sentiment on the near-term market outlook, encouraging announcements from key players in Europe has shown projects have continued to progress in the region despite the currently challenging environment.



An uncertain geopolitical landscape has continued to weigh on lithium demand in the EU. Total imports of lithium chemicals decreased 27% in the period from January-May 2025 to 10kt LCE. The decrease was solely attributable to lithium carbonate, with lithium hydroxide imports increasing due to significant volumes from Australia starting in February, which offset decreases from established sources; Chile, China and the US. Imports of hydroxide from Australia contributed 28% of the total in the period. Although demand for lithium chemicals is subdued at present, the long-term outlook remains robust.

The development of domestic lithium production capacity is imperative to avoid strategic dependencies and reduce reliance on imports. There have been a few casualties along the way, and the pace of development has slowed, but it has progressed nonetheless. Two key announcements from the period stand out.

In June, Rock Tech Lithium announced the signing of a strategic Memorandum of Understanding (MoU) with Ronbay Technology, a Chinese-registered cathode active material (CAM) manufacturer. Under the agreement, Rock Tech Lithium will supply battery-grade lithium hydroxide to Ronbay's European cathode plant in Konin, Poland. Ronbay will offer direct support, including technical resources and potential investment, to ensure the project continues to move forward.

In July, Livista announced a cooperation agreement with Chinese company Tianqi Lithium, one of the largest and most established lithium producers globally. The cooperation will see Tianqi supply Livista with spodumene concentrate, R&D collaboration and provide technical support. There are also options to participate in future investment opportunities in Europe. One could view the continued interest in investment in Europe from established Chinese companies as a vote of confidence in the European value chain.

In addition to the above and on the theme of progressing domestic projects, Vulcan Energy Resources received USD122 million in grants issued by the federal government and states of Rhineland-Palatinate and Hesse. Rio Tinto announced that the Jadar Project in Serbia, has been designated a strategic project by the European Union under the Critical Raw Materials Act (CRMA).

Although not the intention from the start, lithium refining projects seem to be moving toward closer ties with Chinese entities. The relationships being established to further project development will likely turn out to be imperative in progressing these facilities toward first production. Perhaps disappointingly, what is missing from each announcement is the guarantee of capital investment. Capital continues to be difficult to secure and is preventing several projects from moving through Final Investment Decision (FID) and into construction. If the current bearish outlook on the market continues to persist, access to capital could continue to be challenging and likely to result in further delays to project timelines despite the strategic relationships being established.

View from Europe represents the opinions of Project Blue and does not reflect the opinions of ILiA.

PROJECT BLUE

View from CHINA

From Maria Ma of SMM Information & Technology Co., Ltd

Chinese lithium: pricing and policy impact the market

In Q2 2025, under the dual pressures of cost collapse and policy games, the Chinese lithium carbonate market saw prices first decline then rebound unexpectedly by the end of the quarter. Loose supply, adjustments in tariffs, and ore license reviews all became key variables disrupting the one-sided downward trend seen in the previous quarter.

Review of lithium carbonate supply-demand and price historical trends

In Q2, the price trend for China's lithium carbonate formed a shallow "V" shape. In April, with a clear surplus in the supply-demand pattern and an increase in long-term contract ratios, cathode companies showed little willingness to place orders for more spot material. The Sino-US tariff tension, coupled with a bearish macro sentiment, dragged down lithium carbonate prices significantly. In May, lagging declines in lithium ore prices led to smelters incurring losses, which prompted several firms to cut or halt production.

However, a temporary easing of US tariffs spurred an export rush for electricity storage solutions (ESS), while sales growth in new energy vehicles (NEV, which includes electric vehicles) brought additional demand, reversing the supply-demand pattern into a tight balance. Nevertheless, high port inventories of lithium ore accelerated price drops. The collapse in cost support further pulled down lithium carbonate prices.

In June, driven by hedging profits and increased production from leading chemical plants, output rose; although demand from the NEV market weakened, ESS demand continued to grow due to the export rush and rising demand in Europe, edging up lithium carbonate demand. By late June, as multiple policies were implemented, short-term demand exceeded expectations, and disturbances in lithium ore and lithium chemicals supply pushed both futures and spot prices upwards.

Policy-driven: intensive domestic and overseas policies with far-reaching impacts

In the US, the Sino-US tariff conflict in April raised the export tariff on ESS to 155.9%. In mid-May both sides agreed to suspend the tariff hike for 90 days, clearly defining a short-term export rush for ESS. Meanwhile, the US One Big Beautiful Bill Act (OBBBA) was then signed, terminating federal tax credits for NEVs starting September 30th and ending the investment tax credit (ITC) for ESS in 2036, which will impact the US EV industry and reshape the cost structure and supply chain of the ESS sector.

In China, the Ministry of Ecology and Environment issued new regulations in June, allowing the free import of qualified semi-recycled battery black mass materials from August 1st, alleviating the tightness in recycling material supply and strengthening expectations for increased lithium carbonate production from recycled sources. In mid-July, the Ministry of Commerce added five lithium extraction technologies to the restricted export list, temporarily suppressing overseas lithium capacity expansion, reinforcing China's pricing power, and accelerating the restructuring of the global industry chain in the medium and long term.

Supply variables persist: frequent maintenance and mining license disputes

In mid-to-late June, Sinomine Resource Group announced a six-month technological transformation and maintenance project for its lithium chemical plant in Jiangxi. In July, the Natural Resources Bureau of Yichun City, Jiangxi, required eight lithium-related mining enterprises to complete their ore reserve verification reports by the end of September, with the documents mentioning unauthorized approval issues. Meanwhile, Jiangxi Special Electric Motor and Zangge Mining announced production suspensions, exacerbating fears of reduced lithium ore and lithium chemical supplies, driving prices to rebound from late June and continue rising in July.

Conclusion

In Q2, the Chinese lithium industry experienced turbulence amid policy and geopolitical dynamics, with prices rapidly falling before rising at the end of the quarter. Fluctuations in US tariffs reshaped demand structures, compliance risks in resources disrupted supply expectations, and restrictions on technology exports intensified global competition restructuring. In such circumstances market participants would benefit from enhancing supply chain flexibility and closely monitoring policy developments in major markets.

View from China represents the opinions of SMM and does not reflect the opinions of ILiA.
ILiA member benefits include exclusive quarterly webinars with SMM regarding the Chinese lithium market. Contact ILiA for details.

SMM Shanghai Metals Market

Feature

SPOTLIGHT ON SUSTAINABILITY

Lithium, lime and carbon neutrality

When determining the Product Carbon Footprint (PCF) for refined lithium products, choosing reagents that are produced with a lower carbon footprint in turn enables lithium producers to reduce their own PCF and meet their respective environmental targets.

Lime plays an essential role in lithium processing, albeit one which is seldom in the spotlight. Derived from limestone, quicklime and hydrated lime are used to refine lithium extracted from both hard rock and brine sources. Lime is a white, alkaline powder that precipitates impurities, adjusts acidity levels, leaches spodumene ores, treats flue-gas emissions, and is critical in the process of converting lithium carbonate to lithium hydroxide. Lime can further be used for wastewater treatment and soil stabilization. It is hard to overstate the importance of lime to the lithium industry.

To better understand the role of lime in lithium processing – and its impact on sustainability – we talked with Mikaela Hall, Director of Market Growth at MLC, a US-based international lime manufacturer and a member of ILiA.

Image: MLC

"Lime is essential to many industrial processes and plays a crucial role in lithium," Hall explains. "At MLC, we prioritize responsible lime production to ensure reliable access to this finite mineral while actively reducing the environmental impact of our operations and supply chain." A challenge is that lime production is energy intensive as it emits carbon through calcination and fossil fuel combustion. Achieving carbon neutrality in lime production requires advancing technology, rethinking energy inputs, and building the right infrastructure.

"As we work towards a decarbonised economy," Hall adds, "MLC is investing in those sustainable technologies that are available today, while also developing partnerships to accelerate the breakthrough solutions of tomorrow. Sharing insights across the value chain through groups such as ILiA plays an important role".

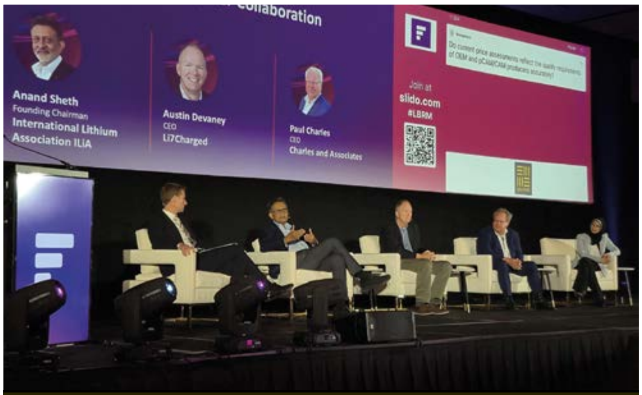
In their operations, MLC has upgraded kiln efficiency, expanded natural gas capability, and reduced waste.

In the UK, its anaerobic digesters generate green energy equivalent to 99% of the site's electricity use. They are also evaluating carbon capture and alternative fuels, supported by government grants in the USA and UK.

"As we invest in sustainable development, transparent reporting keeps us accountable to our commitment of reducing and repairing environmental impact, and deliver meaningful, lasting results." concludes Hall. Given the role of lime as a key reagent for clean lithium production, lime producers can positively impact sustainability in the lithium supply chain while reducing the environmental impact of lithium mining and refining.

Image: MLC

ILiA Connections

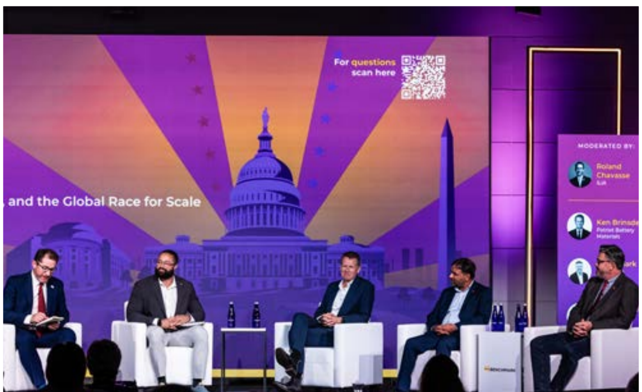


ILiA's Anand Sheth joined a panel at the Fastmarkets conference in Las Vegas, USA, to discuss lithium qualification. He joined Paul Lusty (Fastmarkets), Maha Hammoud (GM), Austin Devaney (Li7 Charged & ILiA), and Paul Charles (Charles & Associates). (Image: Fastmarkets)


At the China International Battery Industry Cooperation Summit (CIBICS) ILiA won an award for "Best Partnership 2025", presented by Mr. Liu Yanlong, former Secretary-General of the China Industrial Association of Power Sources (CIAPS). Later CIAPS joined ILiA as an Affiliate Partner.

ILiA's trade stand at CIBF in Shenzhen, China, promoted lithium, our work and our members. We were visited by hundreds of delegates, including battery thought leader Paul Charles. Tianqi Lithium and Sichuan Union Shine New Energy Sci-Tech Co. Ltd shared the stand and provided valuable support.


In May Talison Lithium's Guy Meade and Kate McGuire welcomed ILiA Founding Chairman Anand Sheth and Roland Chavasse to visit the largest hard-rock lithium mine in the world, the Greenbushes mine in Western Australia. (Image: Talison Lithium)



ILiA's Roland Chavasse chaired a panel at the Benchmark Mineral Intelligence GIGA USA 2025 conference and was joined by Ken Brinsden (Patriot Battery Materials), Leigh Clarke (E3), Ashish Patki (Rio Tinto Lithium) and Rock Hoffman (Bank of America Securities).

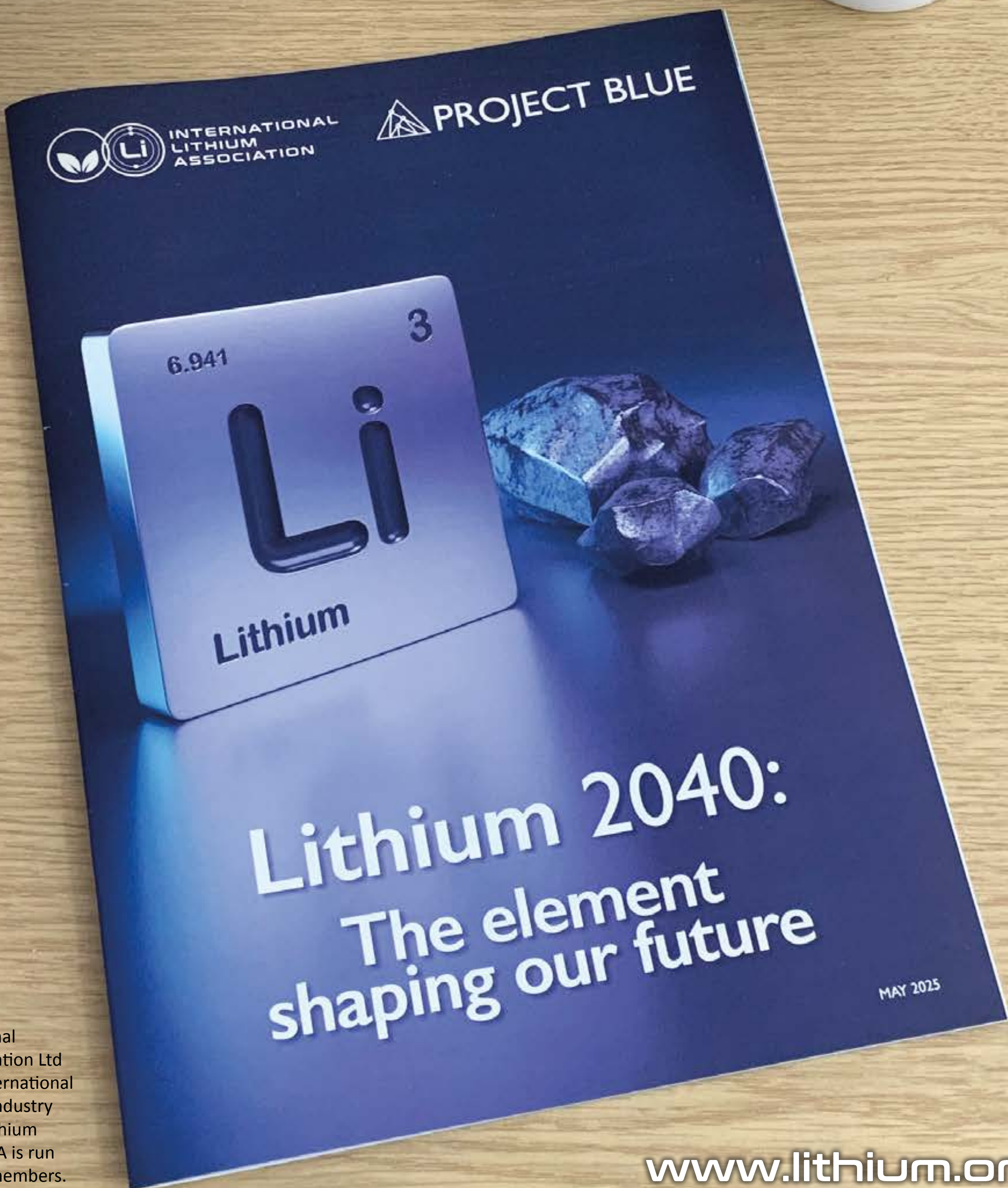

In June ILiA hosted a networking dinner for members and guests in Washington DC, USA. It was held to coincide with the Benchmark Mineral Intelligence GIGA USA 2025 conference.

ILiA's New Report: Lithium 2040

By 2040, lithium demand is forecast to more than triple from today's levels, making it one of the fastest-growing commodities of this generation. Lithium 2040 is a new report commissioned by ILiA from Project Blue, a leading provider of market intelligence on energy transition supply chains and the critical materials that underpin them.

Anand Sheth, ILiA's Founding Chairman said "Lithium is the essential enabler of technologies driving a greener and more sustainable society – today and for generations to come. This report was commissioned to highlight lithium's strategic importance and the strong, long-term demand underpinning its global value."

Free to download at https://lithium.org/lithium-2040/



The International Lithium Association Ltd (ILiA) is the international not-for-profit industry body for the lithium value chain. ILiA is run by and for its members.

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