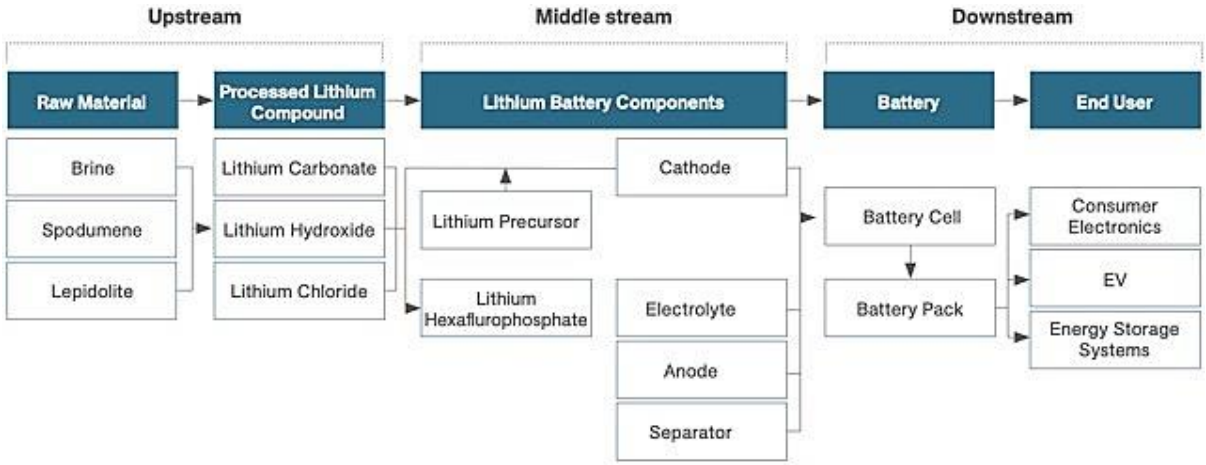
The rapidly evolving lithium scene is a different place than 12 months ago and barely recognisable from the fledgling sector it was a decade ago, with a flurry of lithium stocks joining the ASX in recent years.

As the sector continues to grow and change, lithium investors can be certain about one thing – it is here to stay.

Less than 10 years ago, not many people would have predicted the boom that was about to occur with experts suggesting the lithium-battery value chain will be worth trillions in the not-too-distant future.



The lithium-ion battery industry chain.

By 2025, the lithium-ion battery value chain is expected to reach $2 trillion and this number is only predicted to continue rising as the sector expands on the back of the electric vehicle and renewable energy revolutions.

Triggering a price reduction in 2018 was the wave of new hard rock mines arising out of Western Australia, including Altura Mining (ASX: AJM) and Pilbara Minerals' (ASX: PLS) new mines and Galaxy Resources' (ASX: GXY) expanded operations.

Despite the current slump, analysts continue to advocate for the metal's longer-term outlook.

According to the Australian Government Office of Chief Economist's report *Resources and Energy Quarterly* (December edition), the new mines and expanded operations have now tipped the lithium market into oversupply, with spodumene production soaring 70% to 366,000t in 2017 and this is expected to climb to more than 411,000t by 2020.

Meanwhile, refined lithium is also increasing, with output from China alone expected to have risen 23% between 2017 and 2018.

The report predicts the largest refined lithium growth will come from Tianqi's Chinese facilities which are scheduled to undergo extensive bottlenecking this year.

Although the market will likely remain in oversupply in the near-term, the report forecasts demand will outpace supply after 2020 primarily due to the accelerated uptake in electric vehicles across the globe.

It's expected the lithium market will come under "significant pressure" from 2022.

With lithium fundamentals expected to tighten for the majority of the next decade, it helps to understand more about the commodity and its uses.

About lithium

Lithium is a "comparatively rare element" and, in nature, it is usually found in ionic compounds such as granite pegmatites (hard rock deposits) or in brines.

Also, as the world's lightest and least densest metal, lithium is so soft it can be cut with a knife.

In its pure form, lithium is silvery-white, but because it is highly reactive, it is not found in nature in its metal form.

Trace amounts of lithium are found in the human body and lithium salts have been used to stabilise mood in bi-polar sufferers.

The main global uses of lithium.

In addition to the human body, the mineral has multiple and varied applications, with the element sought for use in the nuclear sector as well as in heat-resistant glass and ceramics, greases and polymers, air treatments, industrial powders, steel and aluminium.

However, what the mineral has become renowned for in recent years is its critical inclusion in the lithium-ion battery, which now accounts for almost half of global consumption.

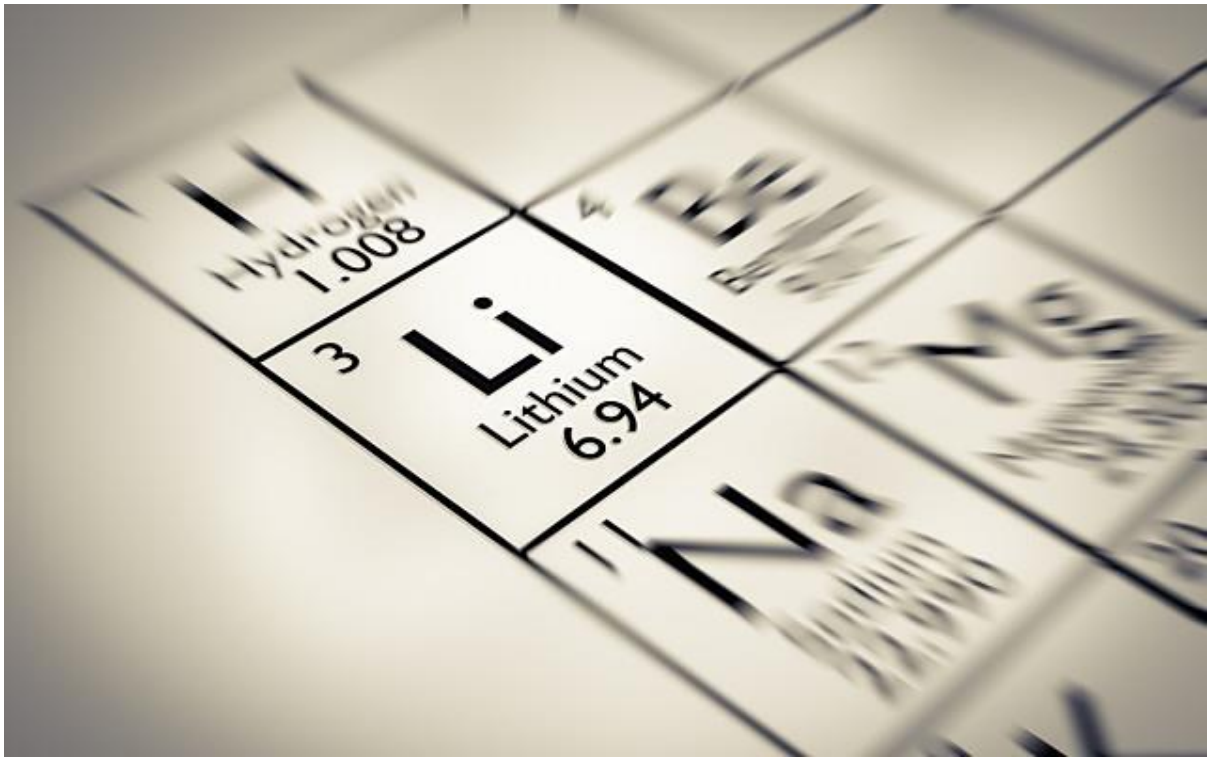
History of lithium

Modern cosmological theory believes lithium was one of the three elements synthesised in the Big Bang.

Fast forward to the 1800s and the lithium mineral petalite is believed to have been discovered by Brazilian chemist Jose Bonifacio de Andrada e Silva in a Swedish mine.

While examining the petalite ore in 1817, Johan Arfwedson and Jons Jakob Berzelius identified a new material by isolating it as a salt and named it lithium.

Arfwedson then noticed the element was also present in spodumene and lepidolite.



Lithium is the 3rd element on the periodic table, it bears the symbol Li, has an atomic number 3 and atomic weight of 6.94.

It was first extracted from its salt when William Thomas Brande used electrolysis on lithium oxide in 1821. Lithium was then generated in larger quantities by 1855.

The metal's first primary use was in greases for aircraft engines, due to its heat resistant properties. Lithium-based soaps were found to have a higher melting point than other alkali soaps.

They were also noted to be less corrosive than calcium soaps.

Lithium demand picked up during the Cold War where it was used in manufacturing nuclear fusion weapons.

The metal was then used to lower the melting pressure of glass and enhance the liquefying behaviour of aluminium oxide during the Hall-Heroult process.

Until the mid-1990s, these applications swallowed up most lithium demand.

However, this changed with the advent of lithium-ion batteries, with the battery accounting for the majority of lithium consumption by 2007.

Lithium-ion batteries

Driving lithium-ion battery growth are energy storage and electric vehicle markets, which are on the rise as the global population moves away from fossil-fuel power.

Benchmark Mineral Intelligence managing director Simon Moores told the US senate the world was currently "in the midst of a global battery arms race".

"The advent of electric vehicles and energy storage has sparked a wave of battery mega-factories that are being built around the world," he said.

"Since my last testimony only 14 months ago, we have gone from only 17 lithium-ion battery mega-factories to 70."

Li-ion batteries are being increasingly used to meet energy storage needs.

He said in gigawatt hour terms, battery mega-factories have surged from 289GWh to 1,549GWh – the equivalent of 22 million pure electric vehicles worth of battery capacity in the pipeline.

"The scale and speed of this growth is unprecedented, and it will have a profound impact on the raw materials that fuel these battery plants."

Mr Moores added he expects the investment scope will also drive the cost of lithium-ion battery production below $100 per kilowatt hour this year.

"For example, in the next decade, the demand for lithium is set to go up nine times – this is lithium used in the battery industry."

"Cobalt is set to go up six times, nickel is set to go up five times, and graphite anodes is set to go up nine times."

Slightly less bullish on how much lithium consumption will increase is Australia's Chief Economist, which forecasts lithium demand will grow "six fold" over the next decade.

China leads the charge

As with most other supply chains, China is leading the charge in the lithium-ion battery space, with Mr Moores pointing out China was on track to control 65% of the world's battery capacity by 2028.

"It already has 51% of lithium chemical capacity, 80% of cobalt chemical capacity, 100% of graphite anode capacity and a third of nickel chemical capacity," Mr Moores added.

Powering China's growing lithium-ion battery capacity is the country's electric vehicle uptake – with the nation accounting for nearly half of global electric car sales in 2017.

China accounted for nearly half of all global electric vehicle sales in 2017.

The China Association of Automobile Manufacturers (CAAM) reported sales of new energy vehicles in China hit 607,000 units in the first eight months of 2018 – up almost 90% on 2017 levels.

This was despite a fall in overall automobile sales.

Why lithium-ion batteries?

What makes the lithium-ion battery appealing to electric vehicle and consumer electronics manufacturers is the combination of the battery's lighter-weight and high electrochemical properties.

Although the lithium-ion battery dominates the renewable energy market, substitutes and alternatives do exist.

Calcium, magnesium, mercury and zinc can be used as anode material in batteries.

Meanwhile, the redox flow battery market is also on the rise, with more common choices being the vanadium and the zinc batteries.

However, these batteries tend to be used in much larger applications, leaving the lithium-ion battery as the preferred chargeable source in the rapidly growing electric vehicle sector, for now.

Elon Musk powers lithium's future

At the forefront of the electric vehicle scene is notorious entrepreneur and Tesla co-founder and chief executive officer Elon Musk.

South African-born Mr Musk is renowned for a variety of business ventures including co-founding and selling PayPal.

He went on to establish Tesla in 2003 where the company's first Roadster sports car was unveiled to the market in 2008, followed by the Model S sedan in 2012.

Elon Musk with the Tesla Powerpack energy storage unit.

By 2017, Tesla had begun delivering the Model 3 mass-market electric car comprising over 215 miles of range.

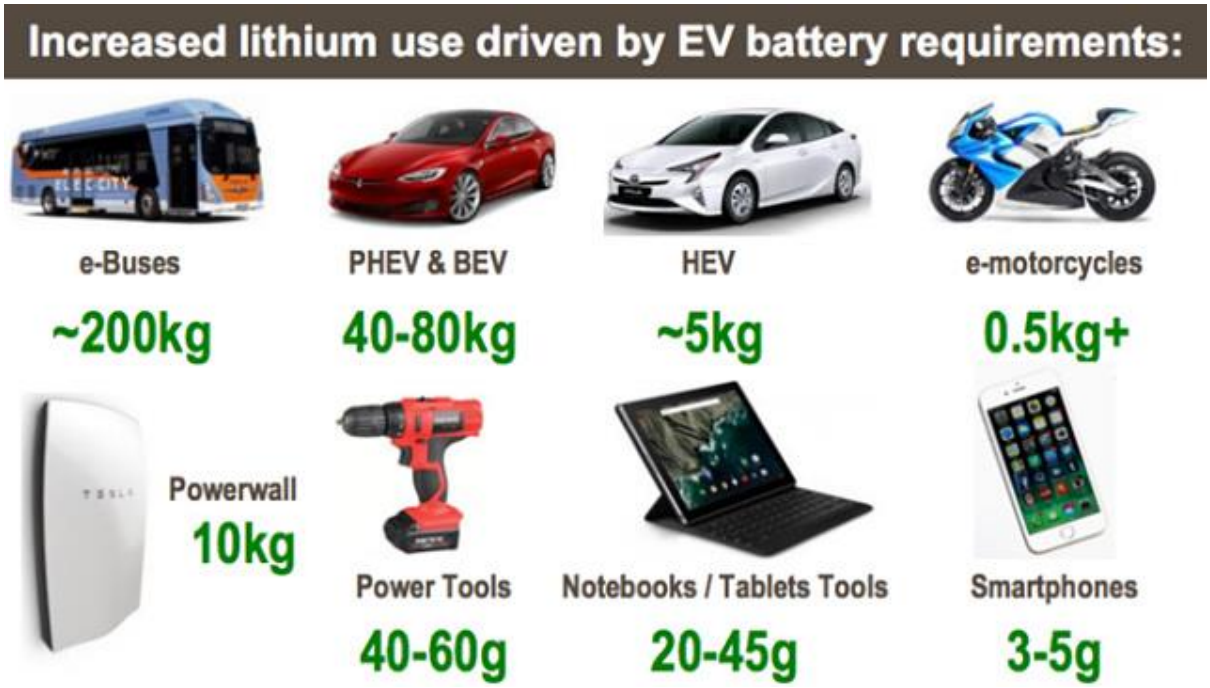
Other auto manufacturers began to follow Tesla's example with most majors having either built or announced plans to manufacture electric vehicles.

BMW and Porsche have also unveiled charging station infrastructure that can power a vehicle to travel 100km in less than three minutes.

Electric vehicles

In a speech at the AMPLA Annual Conference in October last year, Office of the Chief Economist general manager of the economic advice service Melissa Bray said demand for lithium-ion batteries "is expected to be particularly strong" as a result of their use in electric vehicles.

"The outlook for lithium seems particularly bright," Ms Bray added.



Lithium-ion batteries used in modern electric powered products.

By 2025, analyst JP Morgan predicts electric vehicles and hybrid electric vehicles will make up a third of all global vehicles sales – up from a meagre 1% in 2015.

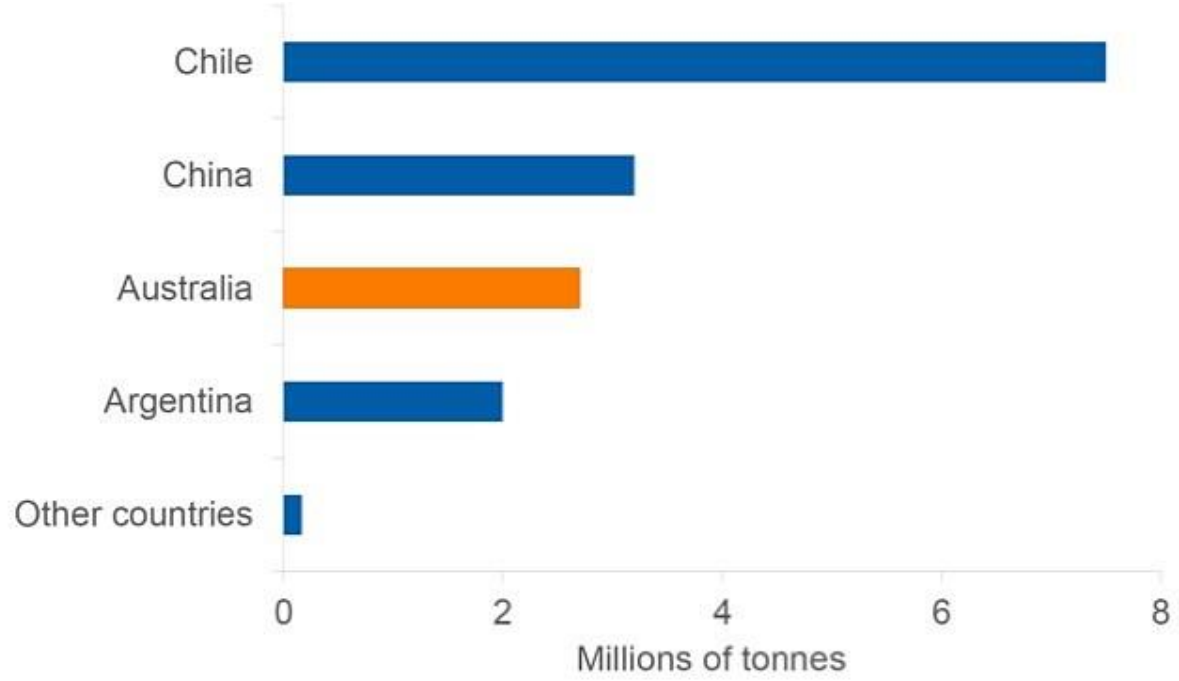
Meanwhile, Ms Bray's team forecasts global electric vehicle sales will tip 50 million by 2030, up from other estimates including Bloomberg New Energy Finance's prediction of 30 million by 2030.

Lithium reserves world-wide

As the lithium-ion battery space heats up, it is critical to know if there are enough lithium reserves to meet demand.

The US Geological Survey estimates global lithium reserves totalled 16Mt in 2018.

Australia is the world's largest lithium exporter and hosts around 17% of known global reserves.



Global lithium reserves by country.

Other top lithium producing regions include Chile and Argentina – with Chile, Bolivia and Argentina collectively known as the Lithium Triangle due to the prospective lithium brine salt flats.

Brine versus hard rock deposits

To feed the growing lithium-ion battery sector, most lithium is sourced from closed-basin brines (58%) or hard rock deposits such as pegmatites and related granites (26%).

Other rarer lithium sources include lithium clays (7%), oilfield brines (3%), geothermal brines (3%) and zeolites (3%).

In a brine operation, lithium is found dissolved in concentrations up to 2,222 parts per million. It is extracted from the saline groundwater beneath playas and salt lakes, with primary brine producing regions comprising Argentina and Chile, the US and China.

Lithium brine in Salinas Grandes, Andes, Argentina.

These operations usually require less capital outlay than hard rock mines, and work by pumping the brine to the surface using wells.

The solution is then concentrated in nearby solar ponds, and processed further to create a battery ready lithium carbonate or lithium hydroxide product.

Hard rock pegmatites are generally exploited for their spodumene content with the biggest spodumene operations existing in Australia, Zimbabwe, Brazil, China and Portugal.

The Democratic Republic of Congo is also an emerging region for hard rock spodumene deposits, with AVZ Minerals firming up the world’s largest lithium resource at its Manono project during 2018.

Diamond drill cores of spodumene-bearing pegmatite.

Pegmatite deposits can be mined via open pit or underground.

In addition to brines and spodumene deposits, petalite ore, on a lesser scale, is also exploited for lithium.

Also on the future radar are lepidolite deposits, with several companies having developed proprietary processes that can economically extract lithium from lepidolite, which has been, until now, overlooked in favour of the other lithium minerals.

Australia to dominate global hard rock supply

Known for its plentiful resources, Australia is set to dominate the lithium carbonate market with its hard rock operations estimated to account for 80% of global supply.

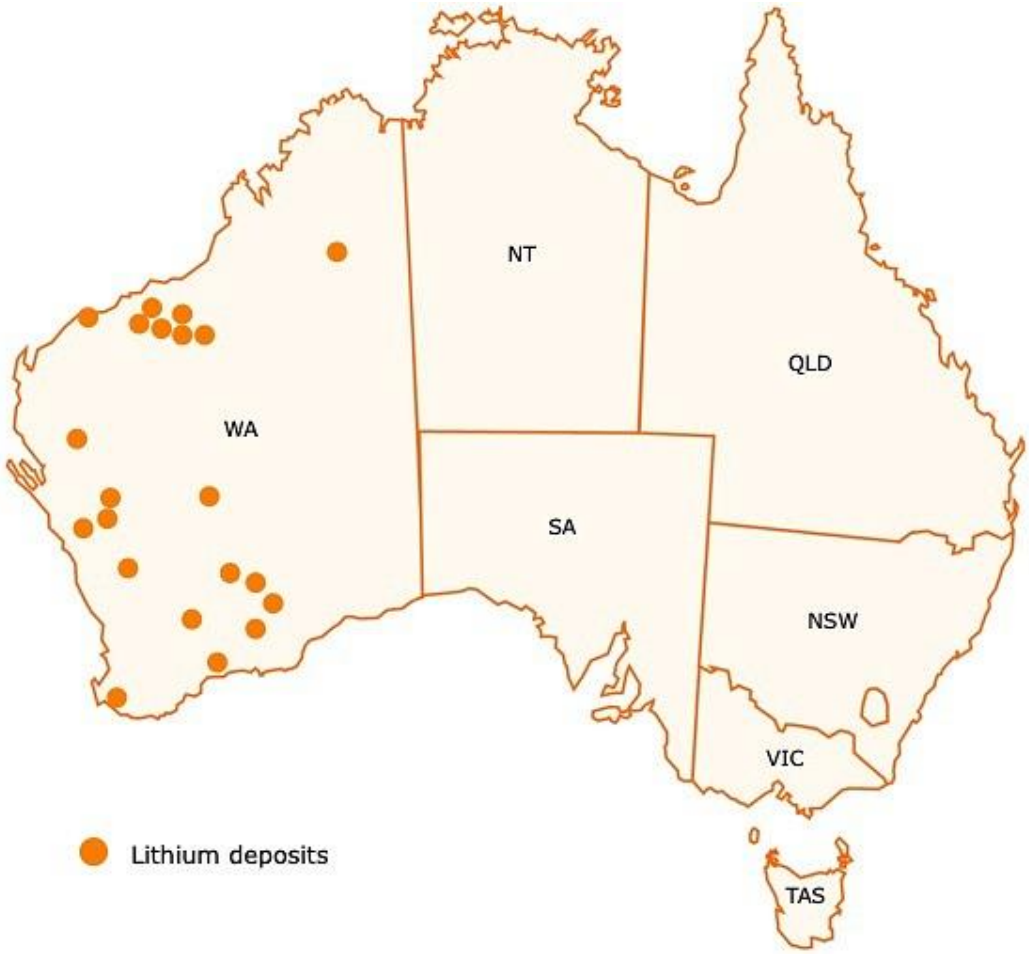
Prior to the rush to bring lithium operations off the ground world-wide, the market was spearheaded by just four large mines.

China’s Tianqi Lithium and US company Albemarle own the world’s biggest mine – Greenbushes in WA, while SQM (Sociedad Quimica y Minera) in Chile and Livent (formerly FMC Lithium) in the US made up the rest of world supply.


The Greenbushes mine in Western Australia.

Greenbushes was Australia’s first hard rock lithium mine and the joint venture has approved a $516 million expansion to the mine, which will triple production capacity with annual spodumene production to grow to 1.95 million tonnes per annum over two stages. A concentration plant is also expected to be added to the operations.

Since Greenbushes was established, Australia has seen the rise of other lithium mines including Mt Marion, Mt Cattlin, Wodgina, Bald Hill, Altura, Pilgangoora and the advancement of the Northern Territory’s first lithium operation Core Exploration’s Finniss project.



Major lithium deposits in Australia.

Due to new supply coming online, spodumene exports were estimated at $900 million in the 2017-2018 financial year and Australia's Chief Economist anticipates this will grow to $1.2 billion in 2020-2021.

As well as the advent of new mines, there is an industry push in Australia to capture more of the trillion-dollar value chain, with experts and stakeholders, alike, calling on the Australian Government to encourage further investment into downstream processing and battery manufacturing – rather than digging the valuables out of the ground and shipping them to other countries for treatment.