The Big Read **Commodities**

How the US plans to break China's stranglehold on lithium

New technology that extracts the metal from underground brines has been compared to the shale revolution

Jamie Smyth in El Dorado, Arkansas

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Just over a century ago, an oil discovery near El Dorado in south-west Arkansas sparked a drilling frenzy that played a part in establishing the country as a global energy superpower.

At its peak the town, which styles itself "Arkansas' Original Boomtown", hosted more than 50 oil companies and the Smackover was the world's largest operational oilfield.

Production has fallen sharply over recent decades and prospectors are now drilling the Smackover for something new: lithium, a metallic element that is a key ingredient in the rechargeable batteries that power electric vehicles, smartphones and defence equipment.

Underground brine reservoirs flowing across Arkansas and neighbouring states contain high concentrations of the silvery-white metal; a US Geological Survey study published in October estimated the total resource in south-west Arkansas alone at up to 19mn tonnes. Even though not all of this may be recoverable, it could easily yield enough to satisfy total current US lithium demand.

ExxonMobil, Occidental Petroleum and Equinor are among a dozen companies seeking to drill for lithium brines in the region. They are piloting direct lithium extraction, an emerging technology that advocates say could support a multibillion-dollar industry in the US — and loosen China's current stranglehold over lithium-ion battery supply chains.

"DLE could do for the US lithium industry and economy what fracking did for the US oil industry almost 20 years ago," says Andy Robinson, a geoscientist and co-founder of Standard Lithium, which is seeking to develop a $1.5bn project near El Dorado in partnership with Norwegian energy group, Equinor.

How the US could break China's hold on lithium supply

As demand for lithium for use in battery technology rises, large saline (brine) aquifers could be a rich source of the element

Aquifers are geological formations containing significant amounts of water. The **Smackover Formation** in the southern US is a large limestone aquifer of heavily saline water (10 times saltier than seawater), known as brine, with high quantities of lithium dissolved in it

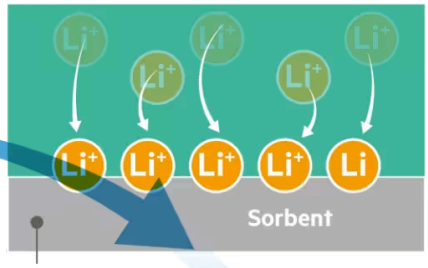
The direct lithium extraction (DLE) process

Brine is pumped from the aquifer

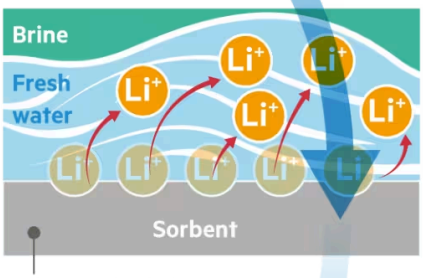
Initial pre-treatment removes hydrogen sulphide and solids

Lithium and chloride ions (particles with a positive or negative charge) are then extracted from the brine

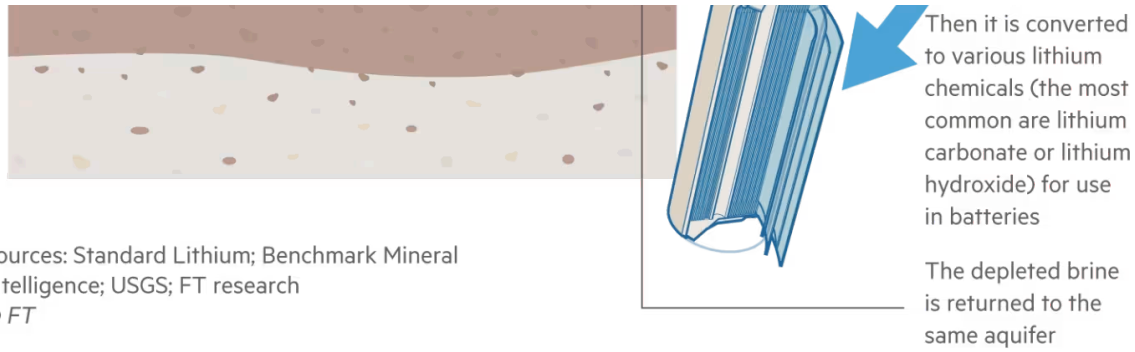
Of the various processes, a common one is adsorption



In adsorption, the lithium and chloride ions in the high salinity brine adsorb (adhere to) small beads of an aluminium-based sorbent material



Once attached, the loaded sorbent is washed with fresh water, releasing the lithium in a process called elution



Sources: Standard Lithium; Benchmark Mineral Intelligence; USGS; FT research
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Proponents say DLE offers a faster and less environmentally damaging alternative to existing extraction methods. For oil companies, which have extensive skills in drilling, pumping and processing fluids, it represents a useful way to diversify their businesses.

"We can build an industry that provides good, well-paying jobs for decades and in the process secures America's supply of a key battery metal," adds Robinson.

The nascent industry has attracted powerful backers including President Donald Trump, who is prioritising critical minerals production at home and abroad. Last month, his administration selected Standard's demonstration lithium plant as one of 10 critical minerals projects to benefit from a new fast-tracked permitting process. The venture had already secured a $225mn grant from the previous administration.

But experts warn that US lithium pioneers must prove the new technology can be commercially successful at scale and compete with both existing extraction technologies and rival DLE projects in lower-cost countries.

The lithium market is also highly politicised. US producers say that China, by far the biggest player in both lithium processing and battery production, has deliberately flooded the lithium market and crashed prices, aiming to frustrate new entrants and preserve its dominance. Lithium carbonate prices have slumped by 80 per cent to about $9,000 per tonne from their peak in November 2022.

Beijing has also moved to restrict the export of some technologies and materials required to process lithium and other critical minerals that are vital to the defence, automotive and semiconductor industries.

Will Smith, plant manager, and Andy Robinson, Standard Lithium co-founder, describe the process of making lithium at their southern Arkansas demonstration plant © Katie Adkins/FT

"It's no coincidence that China started aggressively manipulating the lithium market at a time when several formidable US projects were completing feasibility and engineering studies and working towards securing financing," says David Park, chief executive of Standard.

"DLE technology could potentially reshape global lithium markets over the next decade and help US-based companies gain a foothold in the industry," says Federico Gay, an analyst at Benchmark Mineral Intelligence, a research group.

"But first they must prove they can overcome technical, financial and strategic challenges."

For most of the 20th century lithium production was a small-scale industry, reflecting the mineral's limited range of applications.

The element was mostly used as an ingredient in grease, nuclear warheads and later as a mood stabilising medication. It was once present in the popular soft drink 7-Up, until US authorities banned the use of lithium salts in drinks in 1948.

But the commercialisation of lithium-ion batteries in the early 1990s by Japanese technology group Sony, and more recently their use in EVs and other high-tech products, has sparked a boom in demand that is transforming the industry.

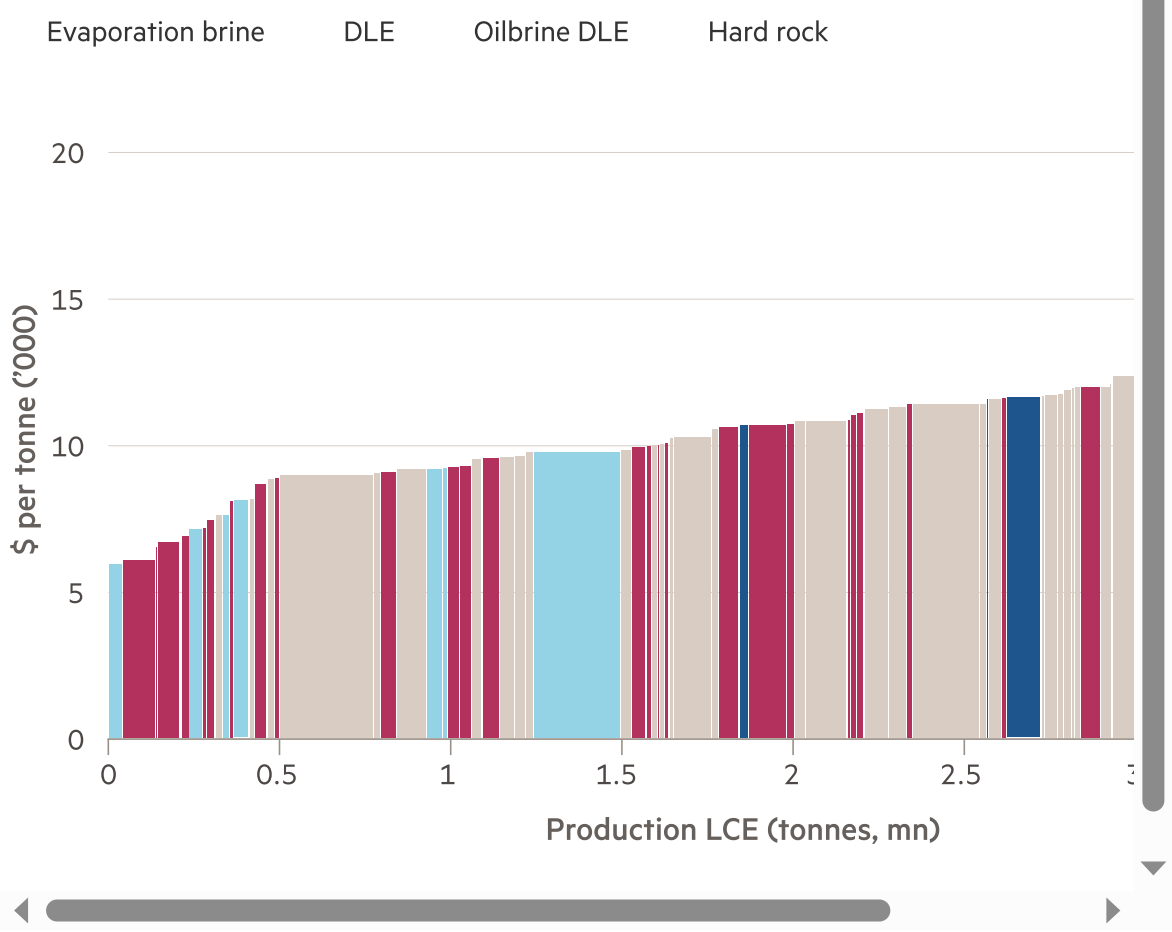
Between 2020 and 2024 global demand for lithium tripled to around 1.2mn tonnes, according to energy research group Wood Mackenzie, which is forecasting lithium consumption will reach 5.8mn tonnes by 2050. To meet demand, producers have over the past decade expanded hard rock mining in Australia and China and lithium brine extraction in Latin America, giving these three regions control of more than 80 per cent of the extraction industry.

Hard rock mining of lithium is much like any other metal production process; ores such as spodumene are excavated from open pit mines, crushed and chemically processed to separate the lithium.

Brine extraction involves pumping lithium-rich brines into large ponds, typically in regions with a hot, dry climate. The water gradually evaporates, leaving behind concentrated lithium salts that can be processed.

DLE projects compete with evaporation and hard rock mining on costs

Lithium carbonate C3 cost curve



Until recently, US-based lithium miners have struggled. They face higher costs, tougher mining regulations and less favourable geological and climatic conditions than in the "lithium triangle" in Chile, Argentina and Bolivia.

The development of direct lithium extraction, which usually involves using solvents or ceramic materials to separate lithium from the brines, has changed all that. DLE takes a matter of hours to separate lithium from brines, while evaporation ponds can take as long as 18 months.

Recovery rates are around 70 to 90 per cent, according to Wood Mackenzie, compared to 40 to 60 per cent for evaporation ponds, and DLE also uses less land and less water.

Combined with the discovery of high concentrations of lithium in oilfield brines within the so-called Smackover Formation, which extends across Arkansas, Louisiana, Texas, Alabama, Mississippi and Florida, DLE has opened up an opportunity. Existing oil and chemical infrastructure in the formation also makes these resources more accessible than greenfield sites.

The brines flowing in aquifers two kilometres below Standard's project area in Lafayette county, Arkansas, contain more than 400 milligrams of lithium per litre, a level which should reduce the cost of the DLE extraction process by enough to make it profitable.

DLE technology could potentially reshape global lithium markets over the next decade and help US-based companies gain a foothold in the industry

Federico Gay, analyst at Benchmark Mineral Intelligence

"We always knew the resource was world class in Arkansas but we needed to figure out the technology to extract it. We have achieved that," says Robinson, during a tour of Standard's pilot plant a 90-minute drive from Standard's project area in Lafayette.

Over the past five years Robinson and his team have processed about 120mn litres of oilfield brines at the plant, located at a chemical factory run by Lanxess, a German company.

Huge pipes pump salty water to the surface, which Lanxess processes to make bromine, a chemical used in the pharmaceutical and fire safety industries. A portion of this brine is then piped to Standard's processing plant, which has deployed DLE filtering technologies licensed from US industrial giant Koch Industries, a minority shareholder in the Toronto-listed company.

But DLE technology can be challenging. One of the first pure DLE plants in Latin America, developed by French mining company Eramet, has faced delays since starting up late last year.

"Even after years of testing and trialling they are facing some issues now that they are on the ramping up stage," says Gay from Benchmark, adding that the hybrid model — where operators combine DLE technology and evaporation ponds — is likely to dominate until fully DLE-based operations come online later this decade.

A worker at the Standard Lithium plant in southern Arkansas pulls water samples, which are then tested in the plant's laboratory before the lithium is extracted © Katie Adkins/FT

Gay adds that oilfield brines require extensive pre-treatment to remove contaminants that interfere with the crystallisation of lithium. "This adds time and cost, and because each brine has a unique impurity profile, it complicates efforts to scale up and standardise the process."

Benchmark estimates the "all-in" costs of oil brine DLE, including mining, processing, transporting and royalties, are currently around $10,000 per tonne. It puts Standard's total costs at about $10,735 per tonne, significantly higher than the most competitive evaporation ponds and hybrid producers, where costs can be as low as $6,000 a tonne.

Companies like Standard can also no longer depend on the tax incentives introduced by former president Joe Biden to build domestic critical minerals supply chains, as Congressional Republicans have proposed cutting such support.

But US producers say advances in DLE technology and the high lithium concentrations in the Smackover are reducing costs. "Most of the new planned capacity will probably have to wait until [lithium] prices get back into the $18,000-$20,000 a tonne range. But we don't plan on waiting for that," says Standard's Park.

"We are one of only a few planned [DLE] projects on the planet that can produce battery-quality carbonate at under $6,000 a tonne cash operating costs [a different measure to the one used by Benchmark, as Standard's doesn't include capital charges] and because of that we're getting the attention from the right partners, customers, and lenders," he adds.

US-based producers are not the only ones racing to commercialise DLE. There are at least 36 DLE projects at varying stages of development around the world, according to Columbia University's Center on Global Energy Policy.

Of those, 13 are in China, while Latin American producers are shifting towards DLE in response to concerns that evaporation ponds deplete valuable water resources. In January, Saudi Aramco announced it was forming a joint venture with mining company Ma'aden to develop DLE projects in the Middle East, with a target date to begin commercial production by 2027.

In 2023 the government in Chile, the world's second-largest producer of lithium, announced a pivot towards DLE technology for environmental reasons. In December Rio Tinto said it would invest $2.5bn to expand its Rincon lithium facility in Argentina using DLE technology. The mining company paid $6.7bn last year for Arcadium Lithium, which was already using DLE at its Hombre Muerto project in Argentina.

View of the SQM lithium plant in Chile's Atacama Desert. In 2023 the country, which is the world's second-largest producer, announced a pivot towards DLE technology for environmental reasons © Lucas Aguayo/picture-alliance/dpa/AP

"Evaporation ponds are not suitable for large-scale expansion of lithium extraction in the Andes, so the use of DLE and reinjection helps to minimise the environmental footprint," says Elias Scafidas, Rio Tinto's managing director of battery materials.

The emergence of DLE technology has sparked a race to secure the best brine resources. Last month, Occidental Petroleum contested Exxon's ownership of some of the brine rights in south-west Arkansas. At a packed public hearing, the state's Oil and Gas Commission ruled in favour of Saltwerx, a subsidiary of Exxon, which has set an ambitious goal of producing enough lithium to supply the manufacturing needs of more than a million EVs by 2030.

"When you look at what the US is trying to do in building out a domestic supply chain for critical minerals such as lithium, and with our position in the Smackover Formation, it's a really good fit for us," says Dan Holton, Exxon's senior vice-president of low carbon solutions.

Part of the economic calculation around DLE relates to royalties. In Arkansas, Standard is proposing a 2.5 per cent rate to be paid to landowners using a calculation based on the volume of lithium carbonate in the brine, market prices and an individual's proportional interest in the unit. But according to locals, some landowners are seeking rates of up to 12.5 per cent, or pushing for companies to buy their land outright.

"I feel like the flea on the butt of an elephant," says Harvey Woods, who owns land within Exxon's lithium production area and attended the recent commission hearing. "We are stewards of the land and we aren't going to tear it up or let someone abuse it just for a dollar."

But lithium producers say it is critical royalty rates are set at levels that enable US production to be competitive with other countries, particularly China. Over the course of a decade, Beijing has orchestrated a push into lithium mining, refining and processing that has helped make its EV industry a global leader — and unnerved western governments.

Legal representatives for ExxonMobil and its subsidiary Saltwerx speak before Arkansas' Oil and Gas Commission, which ruled in favour of Saltwerx last month over contested ownership of brine rights © Katie Adkins/FT

"Today the market is dominated by China and it's going to be a significant challenge for the US industry to compete," says Holton, adding that it too will need to become vertically integrated.

"It is not enough to have production of critical minerals here in the US, you have to have the supply chain — from lithium extraction, processing, cathode active material production right up to the gigafactories producing batteries. All of those steps need to be built out in the US."

Standard and Equinor's boards plan to take a final investment decision on the Lafayette project in the autumn. "We are de-risking the market as much as we can with [sales] agreements to satisfy lenders," says Allison Kennedy Thurmond, Equinor's vice-president of North America Lithium.

Thurmond, whose husband pitched the idea of entering the lithium business to Equinor when he worked at the company in 2017, says the Norwegian energy group has the capabilities to be a leader in the energy transition. "We don't have to go off and hire thousands of people with new skills and can use the competencies we already have," she says.

Politicians and state officials in Arkansas, which has one of the lowest median household incomes in the US at around $58,000, are doing everything they can to position investors in their state to win the DLE race and create jobs.

Former school custodian Angela Meadows retrained at South Arkansas College and now works as a lab technician at Standard Lithium © Katie Adkins/FT

Local universities and colleges are reviewing their curriculums to address skills gaps. "The chemical industry needs operators who know how to read a piping and instrumentation diagram. They need people who understand how valves work," says Jennifer Schroeder, executive director for the career accelerator at South Arkansas College.

The college is upskilling mature students, such as former school custodian Angela Meadows, to boost the local talent pool. "When I started the training programme I was 48 years old and thought I was too old for change," says Meadows. "But I was determined to switch from having a job to a career." She now works in the chemistry laboratory at Standard's El Dorado plant.

Last month the Arkansas state legislature passed a law to provide tax breaks to lithium producers and battery makers, as an incentive to encourage investment.

"This will be a big driver to get companies to continue investing," says Sarah Huckabee Sanders, Arkansas governor and a White House press secretary for Trump during his first term. "Experts believe Arkansas could supply up to 15 per cent of the world's lithium, making us very competitive and giving an alternative to China.

"That is a big win, not just for our state but the entire country."

Graphic illustration by Ian Bott and data visualisation by Steven Bernard

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