

Lithium largesse?

Bolivia's Evo Morales watches over the world's largest lithium deposits. Is that bad, or will it even matter?



Lithium lowdown

Will Bolivia's Evo Morales' terms for mining block the road to battery innovation?

Just about a year ago, while on the campaign trail in Michigan, then-Senator Barack Obama laid out a bold vision for America's transportation future: one million, 150-mile per gallon plugin hybrid electric vehicles on the road by 2015.

The brash goal of one million PHEVs initially triggered some snickers – not necessarily out of disrespect for the concept, but more because of cynicism over whether Detroit's Big-Three automakers could ever transform their engineering, manufacturing and marketing departments. It would be easier to turn around one million supertankers, they said.

But a lot has happened in 12 months. Chrysler has nearly disappeared, and what's left is essentially Fiat. GM was chopped in half and put on a short leash by Washington. Ford is actually acting like it's ready to try something new.

Peter Wray

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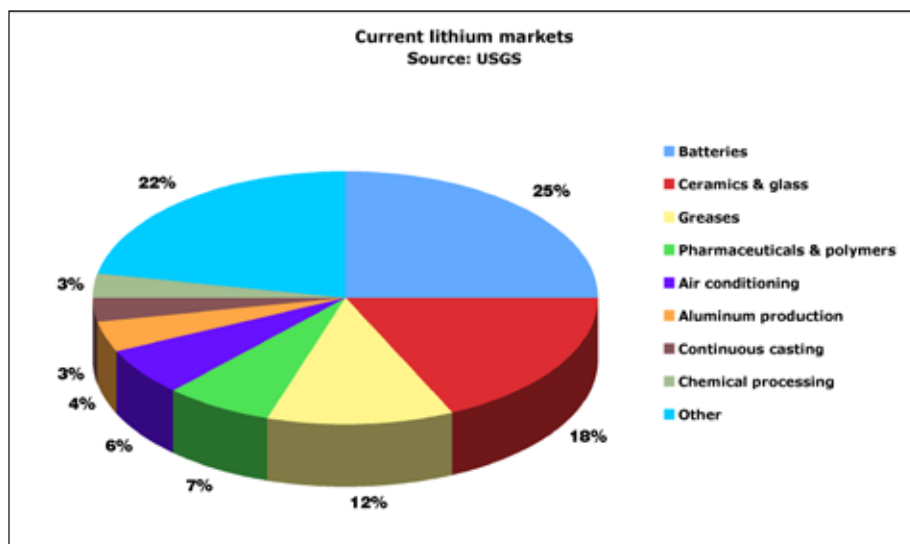
Obama's vision, too, has been boosted by local government officials and community leaders who are desperate to see some signs of new job developments in their areas. They like the idea of "green jobs," and they are guessing that one million PHEVs are going to require lots of new and different parts, materials, subassemblies and high-energy-density batteries.

Did someone mention batteries?! It didn't take long before economic development officials, entrepreneurs, laboratories, auto industry suppliers and electronics makers smelled a big opportunity in the wind and started to school themselves about lithium-ion battery technologies.

For scientists, the idea of the nation embracing this new technology has been exciting. "Tremendous changes will be brought by lithium batteries," says Jeff Chamberlain, chief of a lithium-ion technology transfer project at Argonne National Laboratory between ANL and BASF. "Energy storage is a key component of energy independence, and the weight and energy density of lithium technology changes everything. It's like we are at the start of the microchip industry."

Regardless of the science, there is one simple equation that the economic development crowd is interested in: One million PHEVs equal a sudden demand for millions and millions of those high-tech storage devices. Let the celebrations begin!

In March, now-President Obama pumped even more enthusiasm into the celebration with one of his first announcements about the American Recovery and Reinvestment Act. His speech, given at Southern California Edison's Electric Vehicle Center, renewed his one-million vehicle pledge, and, moreover, announced that the Department of Energy would give \$1.5 billion in grants to U.S.-based manufacturers to produce advanced batteries and their components. For those who were already cheering for establishing an advanced battery beachhead, Obama's announcements were like a giant cash-spewing confetti cannon.



But William Tahil thinks the celebration is premature.

Skeptics and optimists

Tahil, who runs an "independent strategy research and technology consultancy" firm, Meridian International Research, thinks there is a fatal flaw in these plans. Tahil is stirring up some controversy by asserting in a widely discussed report, "The Trouble with Lithium," that there isn't enough lithium to go around.

It should be noted from the outset that Tahil has his detractors. People in the battery industry – who should be aware of lithium supplies – think Tahil is all wet, and many in science and government echo this attitude.

They'll be more on Tahil later in this story, but the fundamental question he raises can't be ignored.

Is there enough lithium? The answer is, well . . . complicated.

Sure, there are plenty of opinions around. But ultimately everyone's answer depends on how much confidence one puts in demand predictions, how much belief they put in market-based economic forces, how much confidence they have in the ability of future researchers to solve today's technology roadblocks and how much faith they have in international diplomacy and business common sense.

If Tahil is the supreme doubter when it comes to lithium supplies, R. Keith Evans is the supreme believer. His

website url says it all: www.lithium-abundance.blogspot.com. According to his website, Evans is a geologist who lives in San Diego, Calif., who has a history of working on several international lithium-mining projects. Evans has drafted another widely circulated report titled, "Lithium Abundance – World Lithium Reserve." In this paper, he compares known worldwide reserves with demand predictions, and, he concludes, "Concerns regarding lithium availability for hybrid or electric vehicle batteries or other foreseeable applications are unfounded."

A logical place to start sorting through all of this would be to look at demand predictions. Logical, yes. Easy to determine, no. To grasp the difficulty of this prediction, try to imagine that you are living in 1915 and your job is to accurately predict the demand for lead for use in lead-acid batteries.

Lithium technology, too, is in flux. While batteries based on lithium carbonate are relatively common, other systems, such as lithium iron phosphate and lithium nickel manganese cobalt are being rapidly introduced, in part to lessen the need for lithium.

Another difficulty in estimating lithium needs is that growth opportunities aren't limited to cars or even transportation. Everyone is already familiar with lithium batteries for portable computers, cell phones and small appliances. On top of that, Smart-Grid planners are also expecting that there will have

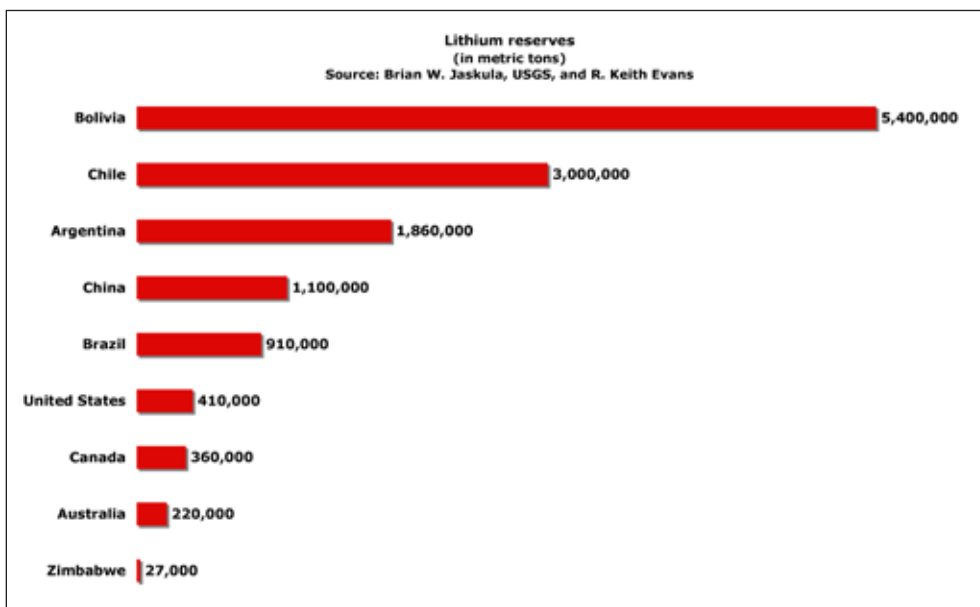
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to be enormous investments in utility-scale lithium-based energy storage devices that will be required to balance energy supply–demand fluctuations as more alternative energy sources are added to the national grid.

And, we have to add to all this the fact that lithium is also extensively used in the manufacture of glass, grits, greases, aluminum and other processes.

Thus, anyone attempting to estimate long-run lithium demand is relying on calculations that have a lot of moving parts. Even estimates for five- and 10-year horizons are filled with lots of statistical uncertainties.

“We are in our infancy,” says Bob Kanode, CEO of Valence Technologies, one of the relatively larger players among United States energy-storage businesses. “Lots of people are throwing around estimates that the auto battery business could



be worth as much as \$33 billion. But we don't know. The truth is that until we show consumers how great [electric vehicles] are – and I think EVs provide an amazingly great driving experience – we have no idea how fast or how large the demand will be.”

(A note to readers – A123, an ACerS corporate member and another well-known player in the lithium battery market, was also contacted for this story, but declined to comment because of “quiet period” regulations related to a recent IPO filing.)

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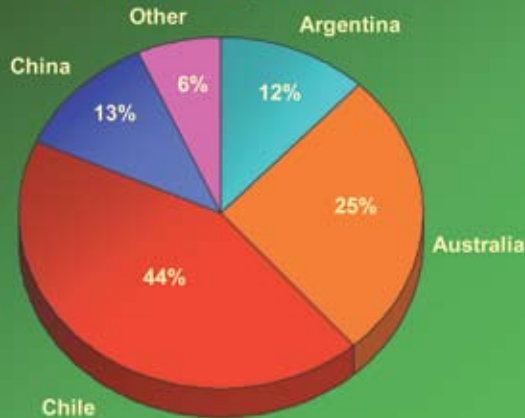
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Estimated World Mine Production of Lithium, 2008



USGS

(27,400 metric tons, Li content; excludes U.S. production)

Some experts attempt to solve the demand quantification dilemma by essentially ignoring it. Why worry about demand, they seem to say, when the supply potential looks rosy?

Reserves? Not in the U.S.

So, is there an abundance of lithium, as Evans believes? His point of view is largely supported by the U.S. Geological Service, a group that is in the business of keeping a watchful eye on the world's supply of strategic minerals and metals.

The USGS 2009 Mineral Commodities Summary on lithium offers some startling numbers. It reports that while 27,400 metric tons of lithium were mined in 2008, 13 million metric tons remain in global reserves.

That should be more than enough for millions and millions of Chevy Volts, right?

Oh, if things were only that easy.

The U.S. has a major strategic problem. Very little lithium mining occurs in the U.S., and the nation has only a very small portion – less than 3 percent – of the total world's reserves.

Who does have lithium? Chile is the largest producer in the world and supplies the U.S. with 61 percent of its needs. According to the USGS, Chile also has 3,000,000 metric tons waiting to be tapped. China also is ramping up its lithium mining and sits on a 1,100,000

metric ton reserve.

But, what catches the eye of everyone who reads the USGS reports is the data on Bolivia. The USGS says that the South American nation has a whopping 5,400,000 metric tons of unmined lithium, yet Bolivian mining operations are nearly nonexistent.

Minerals, metals and Morales

With nearly half of the world's lithium, Bolivia could be the answer to any short- and long-term worries about whether lithium supplies can keep pace – and keep inexpensive – as demand surges.

As one of the poorest nations in South America, the link to lithium has given new hopes to Bolivia and its people. The writer of a Feb. 19, 2009, *New York Times* story spoke with Francisco Quisbert, the leader of a group of salt gatherers and farmers who work near the salt desert that lies over much of the lithium deposits. Quisbert told the reporter, "We know that Bolivia can become the Saudi Arabia of lithium."

All Bolivians don't necessarily share Quisbert's views, but there is a ring of truth to his comment. A comparison with Saudi Arabia conjures up images of cartels and market manipulations, and instills some trepidation among battery makers.

"There's lots of noise about reserves

in countries that may not be friendly," says Valence's Kanode. "But Australia has reserves, China has reserves and South Africa may have reserves well beyond anything that's been reported."

That's not to say that Bolivia is "unfriendly." Business people such as Kanode and others in the U.S., are trying to maintain a wait-and-see attitude.

From a practical standpoint, Bolivia has some hurdles, including little mining experience, an undeveloped transportation system and no seaports, not to mention lithium deposits located in high altitudes and remote locations.

Responsibility for determining whether or not Bolivia is considered a "friendly" nation currently rests with Evo Morales, elected president of Bolivia in 2006.

Morales has been a sometimes-critic of the U.S., and tensions rose not long ago when he nationalized Bolivia's oil and natural-gas industries, demanding that international contracts be renegotiated. But, from many Bolivians' viewpoint, Morales' nationalization moves were more about correcting internal inequities than sending a hostile message to other countries.

A report from the Center for Economic and Policy Research, a Washington think tank, notes that nearly 38 percent of the people in Bolivia live in extreme poverty, much of which is linked to extreme imbalances in distribution and ownership of Bolivia's natural resources. According to the CEPR, 0.66 percent of the total number of landowners own 66 percent of the land in Bolivia. At the other extreme, 86 percent of these landowners own 2.4 percent of the land.

"The concentration of land in Bolivia among a very small group of landowners appears to be almost the worst in the entire world, with the exception of Chile," says the CEPR.

Because oil and natural-gas contracts were property based, almost none of the benefits of these natural resources ever trickle down to Bolivians. The worst fear for many Bolivians is that the same thing will happen with lithium.

The first fully indigenous head of

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state of Bolivia, Morales rose to power as a leader of several “social movements” including ones involving peasants, coca growers and gas protestors. A conservative opposition based in a crescent of provinces where a great deal of the natural resources are located – including much of the lithium – opposes his political coalition. To stay in power, he must walk a tightrope, balancing development of resources, such as lithium, with internal and external policies that provide some guarantee that the resources will lead to national economic development.

Indeed, peasant leader Quisbert told the *Times*, “We are poor, but we are not stupid peasants. The lithium may be Bolivia’s, but it is also our property.”

Members of Morales administration are quick to note that economic polarization and unfair exploitation of Bolivia’s natural resources is not new, and they say the president is being cautious about how Bolivia’s lithium reserves will be used.

“Even before gas and oil, Bolivians



had a long, dark history with silver and tin,” says Osvaldo Cuevas, the country’s consul in Washington, D.C. “Silver and tin were taken from Bolivia and we

really received nothing for it. We are not going to give away our raw materials again.”

Lithium has presented Morales with

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Estimated World Lithium Carbonate Consumption, 2008-2018



USGS

Source: SQM

an unexpected opportunity to do something about Bolivia's economic development. Likewise, lithium's strategic role in the world's economy has raised Morales' profile everywhere.

Cuevas said that Bolivia is eager to see its lithium put to use. "Yes, lithium is a huge deal for Bolivia. Everything is open now. All discussions are open. We are meeting with representatives from many nations, including the United States," he says.

Cuevas also brushed off talk about whether Bolivia should be considered friendly or unfriendly to U.S. concerns. "Of course there are going to be differences between governments, but that doesn't mean we are unfriendly. Providing lithium or any other resource isn't about being friendly or unfriendly. Ultimately, it is just a business negotiation, a transaction between the buyer and seller. We want to see the lithium extracted, we want to give the riches to all of the population and develop our

own industries."

It's important to note Cuevas' comment about wanting to develop Bolivia's own industries. What does that mean, exactly?

According to Cuevas, it means that Bolivia is interested in learning how to develop an indigenous mining industry, and it wants to play a role in manufacture of the batteries, themselves.

But Bolivia has sent mixed signals about how it intends to develop these capabilities. On one hand, it seems to be willing to take the go-it-alone road. For example, Comibol, the national agency that oversees Bolivia's mining, is independently investing \$6 million in a mining operation at the Salar de Uyuni, a vast salt desert that is the location of one of the largest lithium reserves.

But joint ventures are also held out as a goal. Saul Villegas, a Comibol manager who oversees lithium projects, told the *Times*, "Maybe there could be the possibility of foreigners accepted as minority

partners, or better yet, as our clients."

As consul Cuevas noted, negotiations with potential partners are already occurring. The *Guardian* newspaper reported that France's Bolloré Group, South Korea's LG Group and Japan's Sumitomo and Mitsubishi were in serious talks with Bolivian officials.

What type of limits Morales is putting on these negotiations is unclear, but according to the *Latin American Herald Tribune*, "Morales has said on several occasions that he will not grant a lithium monopoly to any firm, and that he will demand that the state have a majority participation in the income from the business."

But even that was thrown into question a few weeks ago. On July 12, the head of Comibol, Freddy Beltran, announced that Bolivia would do the mining without partners. Beltran told the *La Razon* newspaper that, "In reality, what the state wants is to have the industrial plant for lithium carbonate with its own resources. It doesn't really matter that we may have to seek financial support with a bank or some other entity."

But Beltran kept alive the idea of some Journal Venture to create some value-added industrialization with the lithium. "We need the technology to manufacture batteries and we are light years behind in that. That's why we need a partner," he told *La Razon*.

Watching, but not waiting

So, Morales is holding the keys to a high-tech goldmine, and his next steps are anybody's guess. Not surprisingly, people in the U.S. battery industry continue to study developments in Bolivia closely. The stakes are too high and the competitive pressures are too intense not to.

But no one is waiting around for Morales' final decisions.

Bob Kanode, for example, says he has little reason to be interested in sharing his prized, and closely guarded, battery technology with another country, such as Bolivia. Although Valence has facilities in China, Kanode has concerns about international manufacturing.

Kanode stated, "In this competitive

How much lithium is required for an electric vehicle?

Power requirements	16 kilowatt hours (specified for Chevy Volt)
Lithium estimate per kWh	0.431 kg (U.S. Department of Transportation estimate)
Total lithium for one Chevy Volt	6.896 kg
Total Li ₂ CO ₃ for one Chevy Volt	36.5 kg
Total Li ₂ CO ₃ one million PHEVs	36,500 metric tons

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and cutting-edge environment, companies like Valence have to keep their hands firmly on critical technology. It's a problem to find qualified chemists and material scientists in a place like China. More importantly, we run the risk of losing intellectual property in other countries."


Indeed, Kanode also spoke of bringing some of his company's Chinese operations back to the U.S., although he acknowledged that this move would also be linked to winning one of the major grants that will soon be awarded as part of the DOE's battery stimulus programs.

Kanode emphasizes that he isn't losing any sleep worrying about where the U.S. is going to get its lithium supplies. "I am not concerned because of a couple of trends. The demand is still small and it is being done by small mining companies that are not well established or well organized. Right now, there is just not enough money involved to bring the major players in. When the major mining companies enter the picture, they

How much lithium will be needed?

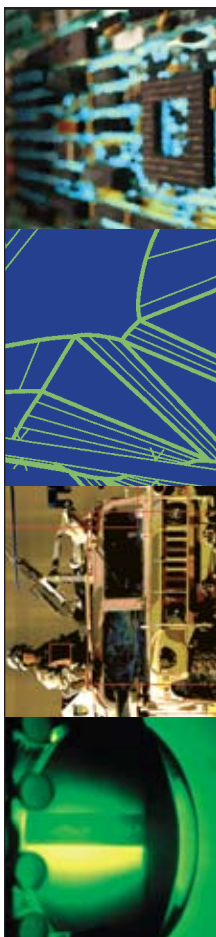
Application	Lithium carbonate content
Cell Phone	3 grams ~ 0.1 oz
Laptop Computer	30 grams ~ 1.0 oz
Commercial Power Tool	30-40 grams ~ 1.0-1.4 oz
Hybrid Electric Vehicle / Electric Vehicle	1 - 10 kg ~ 2-25 lbs
Tesla Motors' Li-ion cell	Approx. 23 kg ~ 50 lbs

Source: Rockwood/Chemetall



will bring new efficiencies," says Kanode. Kanode predicts that the U.S.'s scant reserves can and will be a substantial source when the time is right. "I think

the market will balance supply and demand, and create strong competitive drivers that will mediate the situation," he says. "I think the official numbers



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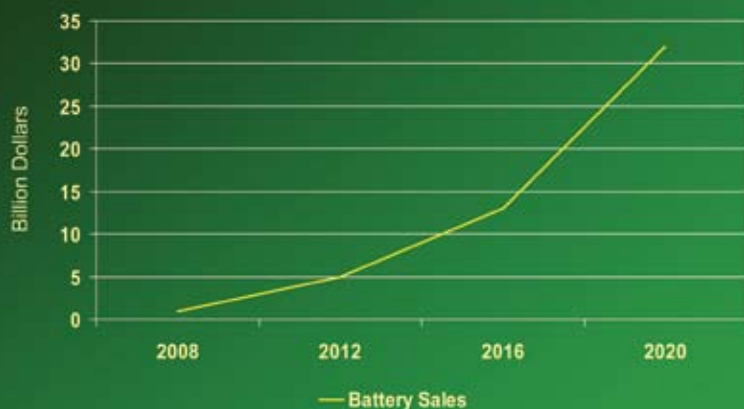
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Advanced Automobile Battery Market Growth Projection



USGS

Source: Deutsche Bank Securities Inc.

underestimate the sources of lithium. We reopen old U.S. mines. We can extract lithium from oil potash, from rivers and from the ocean. Those market dynamics will continue to be played out.”

ANL’s Chamberlain and many others raise another dimension to the supply question. They note that these discussions must include some consideration of how easily lithium can be recycled. “U.S. companies are already producing lithium carbonate from recycled materials. Our thinking should be guided by the example of lead-acid batteries, where 98 percent of the lead is recycled,” he advised. While it remains to be seen if a stellar level of recycling can ever be reached, a USGS report includes data from the Rockwood/Chemetall corporation that at least a 50 percent recycling rate is expected.

Doubling Tahils

Meanwhile, skeptics like William Tahil continue to share their doubts. Tahil stirred the waters again in 2008 when he published a detailed response to the “lithium abundance” disciples. In his paper, “The Trouble with Lithium 2,” Tahil argues that there is unwarranted optimism about the quality of lithium that can be extracted. “Projections of overall lithium carbonate production

must take into account that a much higher purity of 99.95 percent is required for [lithium-ion] battery production. Therefore, battery-grade Li_2CO_3 availability will further lag behind overall industrial Li_2CO_3 . If all future Li_2CO_3 production increases are purified into battery-grade material, it will still only be sufficient in the most optimum scenario for at most four to eight million GM Volt-class vehicles worldwide per annum by 2015–2020.”

Tahil claims to have bad news for Evo Morales and his neighbors in Chile and Argentina. He asserts that as much as 50 percent of the highest-grade lithium deposits have already been extracted, that potential of some of the untapped deposits are greatly overestimated and that, in any case, mining “will destroy some of the most beautiful and unique ecosystems in the world for a material that can only supply a niche automotive market.”

Some of Tahil’s numbers and mathematics have been assailed, if not mocked, by other consultants, and his arguments are sure to be grist for many debates in the future. But, despite the flaws in his arguments, one final point he makes still seems to ring true, especially for the U.S.: “The geopolitical scenario of a world outside of China being dependent on the lithium triangle of

Bolivia, Argentina and Chile for nearly all of its future lithium carbonate supply should be sufficient in itself to give pause to the headlong adoption of lithium-ion batteries by the automotive industry.”

We know from the world’s ongoing experiences with strategic raw materials – like oil, or even the ceramics community’s recent struggles over bauxite – that geopolitics can, and often does, trump theoretical supplies.

Lithium alternatives

We also know that one generation of technologies can quickly be replaced by another. In fact, the Toyota and the Germany-based RWE have major R&D projects related to zinc–air batteries, and General Electric says is already making big commitments to sodium-battery technologies that they say are cheaper, safer and better performing than their lithium counterparts.

Along the same line, John Grose, a staffer for Lux Research, may be even more provocative than either Tahil or Evans. In a post on Lux’s blog, Grose argues that Asian countries have already established a near-insurmountable hold on PHEV battery production for the next 10–15 years.

“The U.S. government should summon the intestinal fortitude to take the long view, and pour its money into early-stage battery R&D to find the next generation of battery chemistry which will leapfrog lithium-ion and make PHEVs into a mass-market product. ... With the current drive for immediate economic stimulus that has policymakers casting about for near-term solutions, the quick fix is only likely to steer [the] country’s nascent EV battery prospect into a ditch.”

Given these experiences and warnings, and given the U.S.’s lack of domestic lithium resources, there’s a lot depending on whether industry insiders and government officials get it right. Let’s hope they have already given pause to the concerns Grose and Tahil raise and know – not just believe – with a reasonable certainty that the lithium is needed, and if it is, that it will be there when it is needed the most. ■