

# Grid Storage: A New Paradigm for Solid-State Batteries



by **Denis Phares**  
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First it was power tools and laptops, then smartphones, and now electric vehicles. Lithium-ion batteries have revolutionized how we live our lives.

They've given us freedom and flexibility and have completely changed the way we look at power.

Of course, the rise in gas prices and the shift to look toward a greener future have played an integral part, but what has really been at the epicenter of the switch from gas guzzlers to electric vehicles is

the advancements in Li-ion battery technology. At the end of last year, there were approximately 16.5 million electric cars on the road.

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That's triple the amount as of 2018, and nearly 10% of the total cars that were sold worldwide in 2021. There's been a significant shift in this world of transportation, thanks to this battery technology.

While the portability and flexibility of powerful lithium-ion batteries, whether it be in an EV or a cell phone, has facilitated the technology on which we have relied over the last decade, it's also no secret that Li-ion batteries have earned their fair share of a bad reputation.

LG, one of the world's largest lithium-ion battery manufacturers, recalled its home storage solution. In China, a lithium iron phosphate storage system caught fire in Beijing and killed two fire fighters. GM recalled 142,000 of its Chevy Bolts because of risk of fire. The flammability of these types of batteries is a huge pain point, one that needs to be addressed and solved, especially for specific applications, like residential energy storage, for example.

So that leads us to the question: Can they be made better? Can Li-ion batteries be made lighter? Safer? Non-flammable? More powerful? And longer lasting? The answer is: probably. But not all at once. The metrics to optimize really depend on the desired application. From electric vehicles to deep cycle grid storage, there is no one Li-ion battery solution.

### Li-ion Battery Basics

To start with the fundamentals, there are a number of elements inside a Li-ion battery cell that are ripe for innovation. Each of those elements represents an active area of research, both at research labs globally and among large and small battery companies looking for an

advantage—looking for a way to take the capabilities of Li-ion batteries to the next level and to undiscovered markets.

But no matter the elements it's comprised of, every Li-ion battery works in the same fundamental way. Here's how.

A lithium-ion battery is an electrochemical cell that consists of a cathode as the positive side, an anode as the negative side, a separator, and an electrolyte in the middle.

The cathode typically consists of a lithium-containing compound, either in the form of a lithium metal oxide or a lithium metal phosphate.

and Aluminum (NCA) or Nickel, Cobalt and Manganese (NCM).

Now, on the negative side of the battery, you have the anode, typically comprised of graphite. As the battery charges, lithium ions insert themselves into the graphite particles in a process known as intercalation.

When it comes to looking to develop a lighter-weight battery, graphite is the next target for replacement as it tends to be a fairly heavy material and replaceable.

Gaining great traction commercially as an alternative to its heavier counterpart is silicon.

While silicon has its benefits, the true gamechanger is a pure lithium metal anode.

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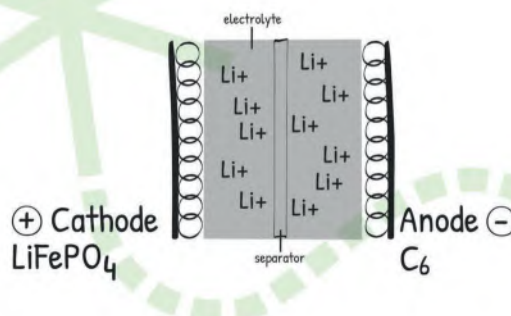
Phosphates tend to be heavier, but safer and longer lasting, while oxides tend to be lighter but more volatile. Most of the successfully deployed technological improvements have focused on the lighter oxide chemistries, including those that contain Nickel, Cobalt

Using pure lithium metal as the anode requires no intercalation at all. Instead, lithium ions become lithium metal in a process that may not even require a host material, and this means that the battery can be made to be much lighter.

Moreover, without needing to rely on the intercalation process when using lithium metal or a host material to hold lithium ions on the anode, a battery with a lithium metal anode can also be charged much faster. This seems like the ultimate solution. Lighter-weight and faster charging—the perfect Li-ion battery.

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### Lithium Ion Battery



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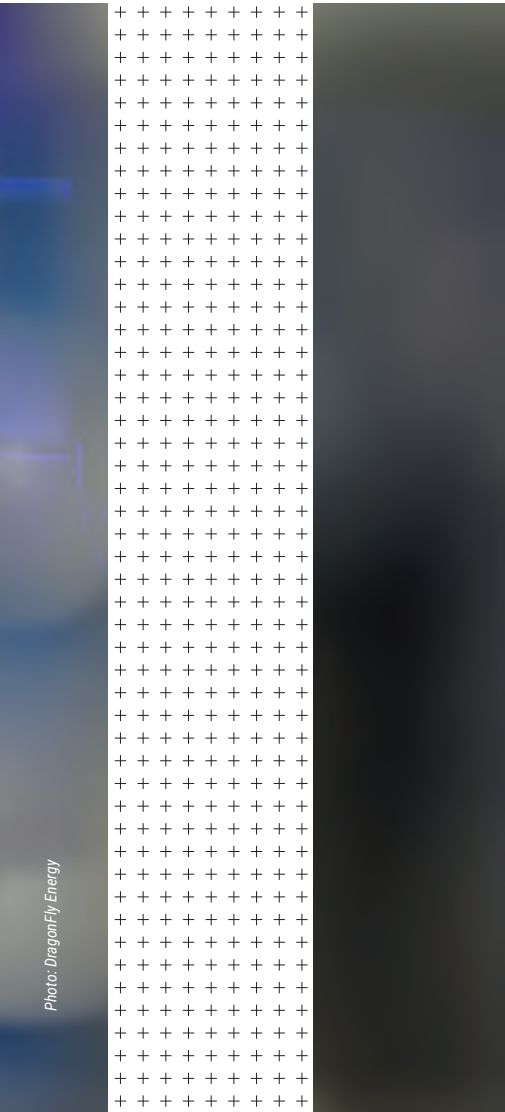
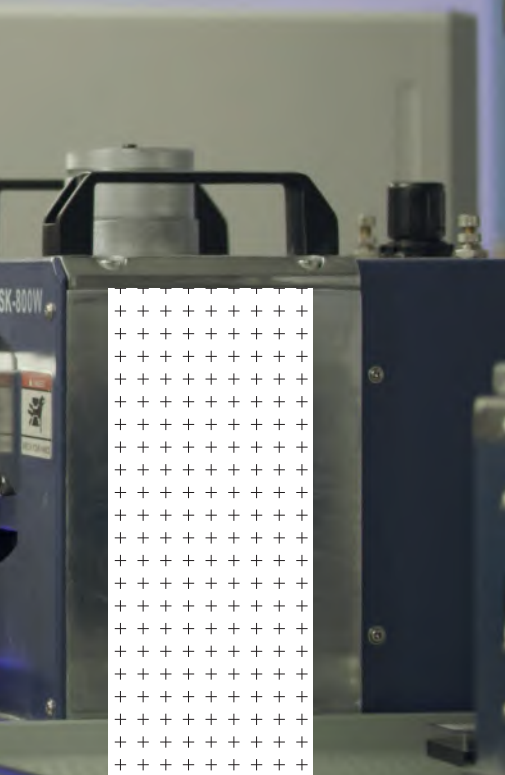
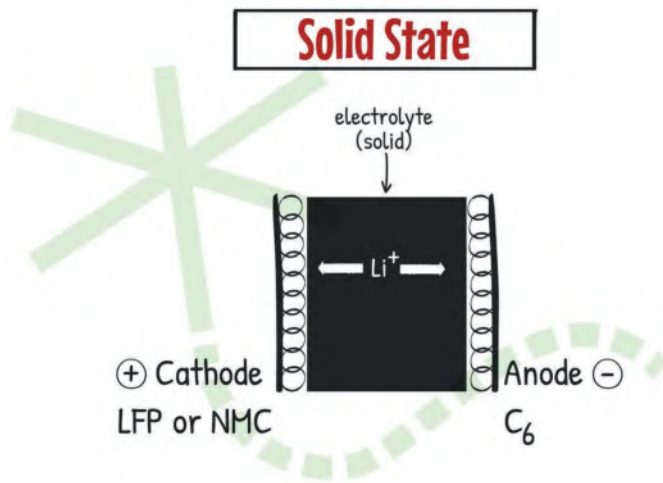


Photo: DragonFly Energy



**A solid state battery uses a lithium metal anode and a solid electrolyte.**

But there still remains a problem. With this type of anode, the lithium metal forms as whiskers, called dendrites, as it plates onto the anode. These lithium metal dendrites have a higher chance of short circuiting the battery internally, potentially causing a fire.

This risk of fire brings us to analyze another component of the battery called the electrolyte—that material located throughout the cell that serves as a conduit through which the lithium ions move between the anode and the cathode. In a conventional lithium-ion cell, this electrolyte is a liquid—a highly flammable liquid, again, posing a risk for an unsafe solution.

So what is that next alternative material to replace an unsafe liquid electrolyte? A solid.

### An All-Solid-State Solution

What many consider to be the next major innovation in lithium-ion battery technology is the move from a liquid to a solid—to replace that liquid electrolyte with a solid material that can also serve as an efficient conduit for lithium ions.

When a solid electrolyte is placed between the anode and the cathode, that solid becomes the separator, can block the formation of dendrites in the case that the anode is lithium metal, and allows for lithium ions to travel back and forth between the anode and the cathode, all factors making it a much safer and non-flammable alternative.

And although the electrolyte itself does not do much in terms of changing

the weight of the battery, it allows for the possibility of a battery that is not dangerous and still has that lithium metal anode—a light and fast charging battery.

When it comes to deciding on a material for that solid electrolyte, there are options, each ideal for different applications, from electric vehicles to grid storage.

### The Ideal EV Battery

For years, the two most significant “pain points” for electric vehicles have been range anxiety and charge time, and innovation in EV battery technology is generally focused around these two concerns.

The battery that can solve both of these? A solid state battery—one that uses a lithium metal anode and a solid electrolyte. But certain issues remain before the commercialization of electric vehicle batteries having a solid electrolyte can come to fruition. Why?

Well, one significant issue is how a solid electrolyte, so perfect that it can block the growth of submicrometer dendrites, has not yet been mass produced in a cost-effective way. Another issue is the interface between the solid electrolyte and the anode or the cathode, which are also solid. This interface is not a problem if the electrolyte is a liquid.

So how do we solve the issue? We could fill the cell with a liquid or gel electrolyte in addition to the solid electrolyte. But in this case, the battery is no longer an All-Solid-State-Battery (ASSB), and flammability is

reintroduced. Now you see why the race to create and then mass produce the perfect solid-state EV battery is still underway.

**The Proliferation of EVs**

It's important to be clear that a perfect solid-state lithium-ion battery has not been required for the EV revolution to occur. And that's been exactly the case for electric vehicle and lithium-ion battery manufacturers since EVs were introduced, which is great news for efficiency and clean air initiatives.

But ultimately, there is still a problem with this revolution. It's not about the batteries at this point, it's about how they're charged. The majority of the energy that is filling batteries in every

electric vehicle, solid state technology or not, is coming from burning fossil fuels—predominately how electricity is produced for the electrical grid. When EV owners park their car for the day or make the pitstop on a long road trip, they plug in that vehicle to charge—they plug it into a charging system that's tied to the grid, directly tied to burning more fossil fuels. Now isn't that counterintuitive?

To reduce our reliance on burning fossil fuels for energy, it is important to incorporate more renewable sources of electricity, like solar and wind—but these sources are intermittent.

There is a solution, and it brings us back to batteries. The grid needs more batteries to create an energy buffer to

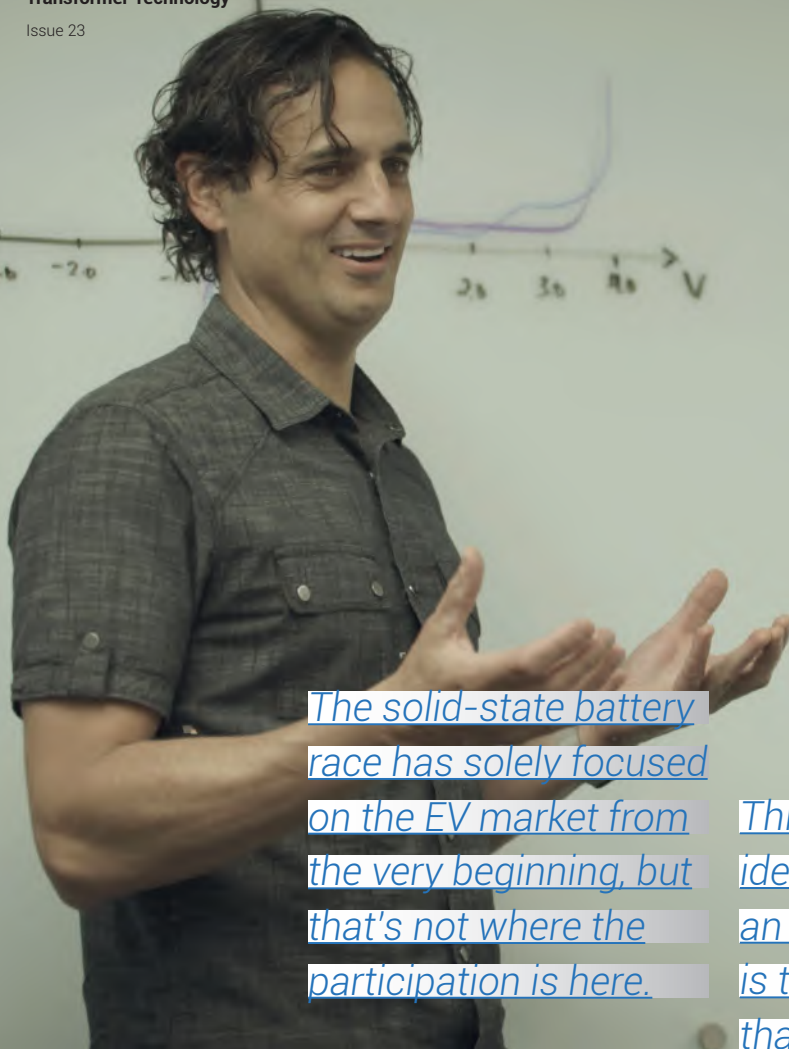
absorb the intermittent nature of solar and wind. And this grid-tied battery for storage is different than what exists in storage today, it's different than a traditional EV lithium-ion battery, and it's different than that ideal solid-state EV battery we talked about.

**A New Focus on Solid State: The Ideal Grid Storage Battery**

Suppose most of the electricity on the grid were produced from intermittent sources like solar and wind. Expect that every light you switch on inside your home and each time you charge your electric vehicle, you're utilizing renewable energy. And consider that having a large battery in every building, every home, and every workplace is critical to making this possible.



*Solid State  
Research &  
Development Lab*



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*This is clearly not an ideal Li-ion solution for an electric vehicle, but it is the solid-state battery that solves grid storage and ultimately dovetails with onset of electric vehicles to migrate our carbon footprint.*

This type of battery is much different than what's needed for electric vehicles. Range anxiety isn't an issue and there's no need for extremely fast charging. So what would this ideal grid storage battery look like?

First, it would take up little space. Granted, range anxiety is not relevant here but having half of the garage taken up by a large battery bank isn't a viable option either. So, lithium-ion technology immediately fits this bill.

Second, it has to be long-lasting and affordable enough to be widely implementable. It has to last thousands of cycles and it cannot break the bank or need to be replaced with less than a decade frequency.

Finally, this battery has to be non-flammable. Lining the wall of your garage with this type of storage or installing a huge battery bank, there is no choice other than non-flammability. And this is where a solid electrolyte comes in.

This solution is a true All-Solid-State lithium-ion battery that is made

specifically for grid storage. Not an EV battery that charges fast and is lighter than ever, but one that is purely meant to be placed in a battery bank inside a building to store renewable energy and reduce our carbon footprint by eliminating the burning of fossil fuels.

So how is this All-Solid-State Battery made and what materials are used to do it?

Since flammability and cyclability are critical for a large grid-tied battery bank in the home, the solution relies on keeping the solid electrolyte but to scrap the lithium metal anode. Keeping the graphite anode with the intercalation mechanism instead of utilizing lithium metal creates the possibility of a long-lasting, low-cost battery.

And the technique used to keep this type of battery low-cost? A patented manufacturing process. Using a

dry powder coating process, the method works with an aerosolized dry powder that's composed of

both the binder and the electrode material to dry coat the foil, leaving you with an electrode that's ready for assembly into a cell without the long process of drying. Then, a composite electrolyte is coated directly on top of the electrode.

Because a powder coating process is used, these layers are growing one particle at a time, making a very intimate, high surface area interface between the electrode and the solid electrolyte, a critical part in when it comes to the operation of the battery—getting the lithium ion out of the electrode and into the electrolyte.

This process is groundbreaking and different than anything solid-state has ever seen before, making the manufacturing high-efficient and the end product widely implementable.

### The Future of ASSBs for the Grid

The electric vehicle market, batteries, renewable energy, and grid storage are all tied together in a number of ways. Non-flammability in Li-ion batteries is important—that's where solid state comes in. The look toward a greener future is on everyone's minds but burning more fossil fuels to charge electric vehicles is taking one step forward and one step back. And utilizing renewables is powerful but there is currently have no way to store that energy safely and efficiently for long-term use.

The solid-state battery race has solely focused on the EV market from the very beginning, but that's not where the participation is here. This is clearly not an ideal Li-ion solution for an electric vehicle, but it is the solid-state battery that solves grid storage and ultimately dovetails with onset of electric vehicles to migrate our carbon footprint.



Photo: Oregon Energy