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BUSINESS

The Battery Is Ready to Power the World

After a decade of rapidly falling costs, the rechargeable lithium-ion battery is poised to disrupt industries

By Russell Gold and Ben Foldy
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Rechargeable lithium-ion batteries were first commercially used in hand-held camcorders in 1991. Laptops soon followed. A decade later, batteries enabled the rise of tech titans such as Apple Inc. by powering smartphones and wearable devices, then made their way into electric vehicles. The basic technology throughout remained pretty much the same: Lithium ions move through a liquid from the cathode to the anode, and back again.

This, however, was just the beginning. After a decade of rapidly falling costs, the battery has reached a tipping point. No longer just for consumer products, it is poised to transform the way the world uses power.

In the energy sector, affordable batteries are making it possible for companies to store electricity and harvest renewable power. In the auto industry, they are set to challenge the gas-powered engine's centurylong domination. Costs have come down so far and so fast that most car makers expect that electric vehicles, which are currently more expensive than their gas-powered counterparts, will cost the same amount to build within the next five years.

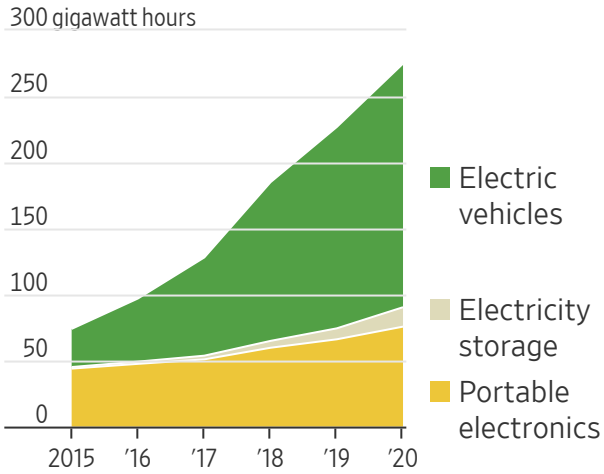
The gains are likely to continue. Electric vehicles are currently the main source of demand for battery cells. As demand grows and costs fall further, batteries will become even more disruptive across industries. Batteries recently scored a win at General Motors Co., which

said it hoped to phase out gasoline- and diesel-powered vehicles from its showrooms world-wide by 2035.

Battery Boom

Demand for lithium-ion batteries is on the rise.

Global production of lithium-ion cells, by usage



Source: Benchmark Mineral Intelligence

The battery boom could erode demand for crude oil and byproducts such as gasoline—as well as for natural gas, which is primarily used in power plants. While mining materials and manufacturing batteries produce some greenhouse gas emissions, analysts believe shifting to batteries in the auto and energy sectors would reduce emissions overall, boosting efforts to tackle climate change.

U.S. power plants alone produce about a quarter of the country's emissions, while light-duty vehicles such as cars and vans contribute another 17%.

The rise of rechargeable batteries is now a matter of national security and industrial policy. Control of the minerals and manufacturing processes needed to make lithium-ion batteries is the 21st-century version of oil security.

The flow of batteries is currently dominated by Asian countries and companies. Nearly 65% of lithium-ion batteries come from China. By comparison, no single country produces more than 20% of global crude oil output.

Employees assemble lithium-ion batteries at a factory in Huaibei, China, last year.

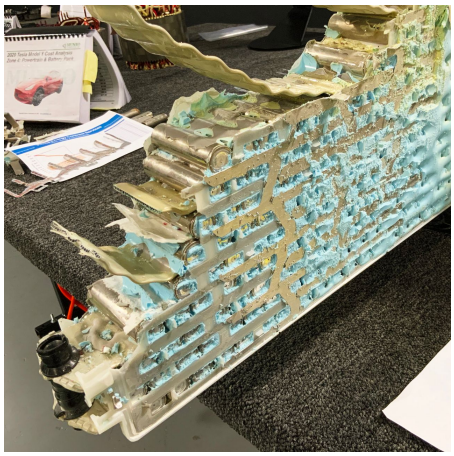
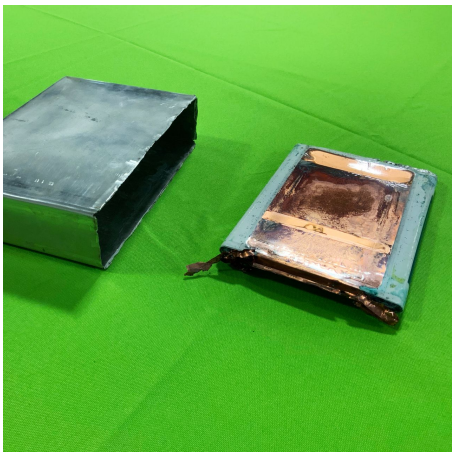
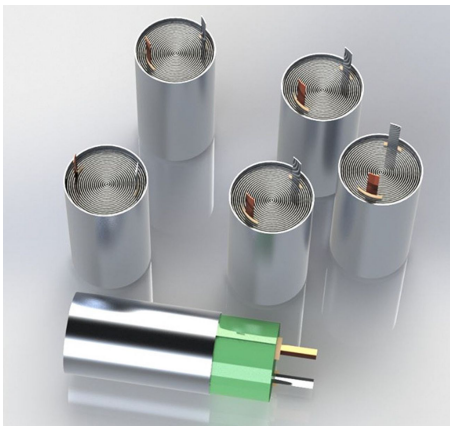
PHOTO: WAN SHANCHAO/VCG/GETTY IMAGES

Companies are working on new configurations—such as solid-state batteries, which don't transfer ions through liquid—that could significantly enhance the power and further lower battery prices. The value of such a breakthrough could be measured in the billions of dollars, if not trillions.

"There's still a huge amount of innovation to come," says Christina Lampe-Onnerud, chief executive at Connecticut-based battery startup Cadenza Innovation Inc. Her company envisions that buildings could someday have their own batteries, giving them reserves of electricity they could use during peak hours to reduce costs.

The first commercially available electric vehicle that ran off lithium-ion batteries came in 2008, with the Tesla Roadster. One of Tesla Inc.'s early advantages came from figuring out that it could use readily-available laptop battery cells to power its cars. It initially purchased off-the-shelf battery cells manufactured in Asia intended for laptops, which at the time used between six and 12 cells. The two-seater Roadster needed nearly 7,000.

Now, more than two-thirds of the world's lithium-ion batteries are used in vehicles, a figure expected to reach three-quarters before 2030, according to Benchmark Mineral Intelligence, a London-based firm that tracks battery prices and industry developments.

A Tesla Model Y battery module, showing individual cells with blue insulation. A battery cell from a BMW i3. Cadenza Innovation's 'jelly rolls.' PHOTOS: LEAN DESIGN(2); CADENZA INNOVATION

The same batteries are being deployed on the power grid in growing numbers. Construction began in January on a battery in Florida that will use 2.5 million lithium-ion cells—similar in chemistry to Tesla cells, only larger. Florida Power & Light, part of NextEra Energy Inc., said the battery will be capable of powering Disney World for seven hours.

Used automotive batteries, slightly degraded from years of filling up and discharging, are finding new life as storage projects. Amsterdam's Johan Cruijff Arena has a three-megawatt "super battery" made from 148 Nissan Leaf battery packs, many of them recycled, storing electricity generated by rooftop solar panels and helping balance the stadium's energy usage.

To meet expected demand, global output of lithium, a silvery metal also used to make nuclear bombs and treat bipolar disorder, has nearly tripled in the past decade, according to Benchmark. Lithium is mostly mined in Australia and Chile, where it is found in underground brine deposits, although efforts to increase U.S. output from mines in Nevada and North Carolina are gaining attention from investors.

An aerial view of the brine pools and processing areas of a lithium mine in northern Chile.
PHOTO: IVAN ALVARADO/REUTERS

In recent years, prices have fallen more quickly than expected due to demand from auto makers. Electric vehicle battery packs and motors currently cost about $4,000 more to manufacture than a comparable fossil fuel-burning midsize sedan engine. By 2022, the difference will be $1,900—and will disappear by mid-decade, according to investment bank UBS Group AG .

Ken Morris, the head of electric vehicles at GM, said in September he expects cost parity in five years. Auto makers such as Volkswagen AG, Tesla Inc. and GM are pushing battery prices down further as they race to lock up the giant capacity needed to power millions of EVs. The rise of electric transportation is also drawing in some of the biggest tech companies, including Apple and Amazon.com Inc.

A Brief History of Lithium-Ion

1985

Japanese chemist Akira Yoshino files patent for lithium-ion battery. PHOTO: ASAHI KASEI CORPORATION

1991

Lithium-ion batteries appear in first commercial product: a Sony camcorder. PHOTO: YOSHIKAZU TSUNO/GAMMA-RAPHO/GETTY IMAGES

1994

Dell releases the Latitude XP, the first mainstream laptop computer with a lithium-ion battery.

2007

Apple introduces the iPhone, powered by a lithium-ion battery.

2008

Tesla begins selling the Roadster, which uses 7,000 glued-together lithium-ion cells. PHOTO: JUSTIN SULLIVAN/GETTY IMAGES

2017

After summertime blackouts, Tesla builds the world's largest battery to store renewable energy in Australia.

Globally, battery-powered electric cars made up around 4% of all new cars sold last year in the world's largest markets—the U.S., Europe and China—up from around 1% in 2017, according to data from Deutsche Bank. In 2025, the bank expects that share of the market to be 22%.

In the energy sector, power grids have been built around just-in-time electricity generation for more than a century. Every second of the day, the supply of electrons needed to match demand to keep the lights from going out, because there was no way to store energy for use at another time.

To get around that problem, demand during the hottest and coldest days in recent decades has been met by on-call natural gas-burning plants known as "peakers" that were fired up for a few select hours when needed.

Large installations of lithium-ion batteries have begun replacing peakers in parts of the U.S. These batteries—which often draw energy from solar farms, though they can be set up to draw cheap power from the grid—tend to bank electricity during the day. They discharge power as needed for a couple of hours in the evening when power demand rises, along with prices, after the sun sets.

Developers and utilities are looking at another evolutionary step in the industry: building batteries to harvest and dispatch inexpensive and clean power from wind and solar farms, and not just for a couple of hours after sunset.

That threatens not only peakers, but many traditional power plants financed under the assumption that they would be able to competitively sell electricity at all hours of the day for decades.

Batteries "are right on the precipice of being highly disruptive," said Chris McKissack, chief executive of GlidePath Power Solutions LLC, an Illinois-based company that builds renewable energy generation. He estimates there are well more than 100 gigawatts of gas- and coal-fired power plants—out of a total 800 gigawatts plants that burn these fuels—that could be immediately rendered uneconomic and unnecessary. "This presents a massive opportunity for battery storage," he said.

Construction of a GlidePath project south of Houston in 2019.

PHOTO: GLIDEPATH

In Texas, which has a competitive power market, economic forces are driving a boom in batteries on the grid. At the end of 2020, installed batteries had the capacity to deliver 215 megawatts of electricity. The grid operator expected nearly 2,000 megawatts worth of batteries by the end of 2023, about 4% or 5% of average electricity demand for the state's main power grid this time of year.

California and New York have introduced mandates for utilities to install more batteries, to increase grid reliability and smooth out price volatility as well as to incorporate more renewable energy.

Last year, two California firms that procure electricity for nearly 700,000 customers expanded an existing deal to acquire the output of a large solar and battery-storage project north of Bakersfield. The companies, Silicon Valley Clean Energy and Central Coast Community Energy, said the batteries would allow them to deliver renewable energy without price spikes.

A lithium-ion battery storage project in Ottawa.

PHOTO: RECURRENT ENERGY

"I am thinking about the grid in an entirely different way," said Girish Balachandran, chief executive of Silicon Valley Clean Energy, who expects that natural gas will be a smaller part of the company's portfolio in California as more wind and solar power is stored in batteries.

He said he is envisioning new ways to deploy batteries as prices continue to fall, to ensure reliable grid operation.

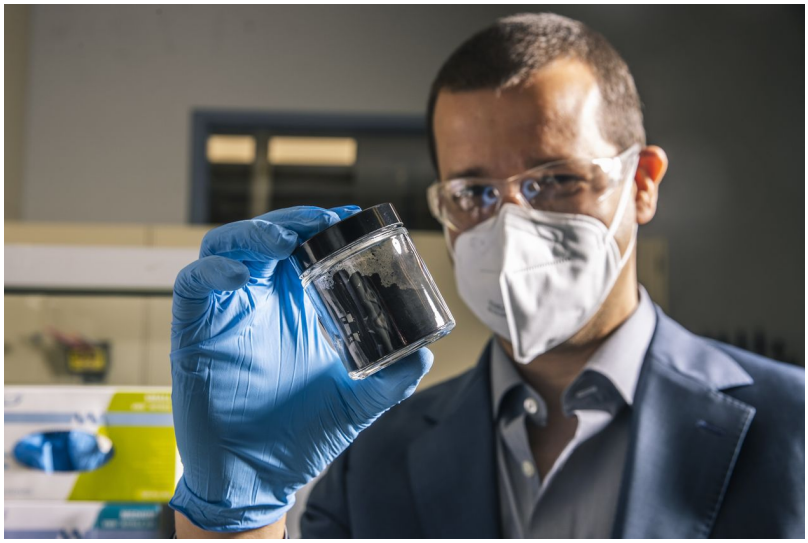
Prices have come down a long way since January 2010, when Boston Consulting Group estimated battery costs at between $1,000 and $1,200 per kilowatt-hour. It said getting to $250—a level car makers were targeting—"is unlikely to be achieved unless there is a major breakthrough in battery chemistry."

Today, battery prices are about $125 per kilowatt-hour, after big increases in manufacturing capacity lowered costs, and tweaks to chemistry and design yielded further savings.

Battery costs are widely expected to fall further, said Venkat Viswanathan, an associate professor of mechanical engineering at Carnegie Mellon University. He expects them to go as low as $80 per kilowatt-hour in two to three years before bottoming out.

Gene Berdichevsky, the former battery systems architect for the Tesla Roadster and now founder and chief executive of Sila Nanotechnologies Inc., an Alameda, Calif.-based company working to improve battery technology, said lowering the cost of storage to $50

per kilowatt-hour could be worth half a trillion dollars. “There’s going to be an immense amount of scientific ingenuity applied to it,” he said.



Gene Berdichevsky of Sila Nanotechnologies holds a jar of black powder-like material, an ingredient that’s part of Sila’s quest to improve battery technology.

PHOTO: STEPHEN LAM FOR THE WALL STREET JOURNAL

Last year, the U.S. established a consortium of agencies to promote a domestic battery industry, citing the role the industry plays in consumer electronics and national defense. It also used the Defense Production Act to speed development of mines for rare-earth elements.

During her Senate confirmation hearing to become Energy Secretary last month, Jennifer Granholm signaled her interest in domestic production, saying, “We can buy electric car batteries from Asia or we can make them in America.”

The European Union is using industrial policy to foster the development of a regional battery sector. Peter Altmaier, the German minister for economic affairs and energy, recently said the EU wants a “closed value chain for battery cells to be created in Europe” from processing raw materials through recycling used batteries.

Growing demand for batteries could tax supplies of vital minerals. And powering all those car batteries would increase demand for electricity, straining supplies.

SHARE YOUR THOUGHTS

What would it take for you to buy an electric vehicle? Join the conversation below.

Another challenge: Though battery safety has improved, lithium-ion cells have a history of catching fire, which has already resulted in recalls for companies including GM, Hyundai Motor Co. and BMW AG .

A shortage of charging stations could discourage EV customers. San Francisco estimates it could need more than 5,100 EV charging outlets by 2030, up from 834 in 2019. Filling up those batteries may also require 7% more electricity than the city currently consumes, according to an analysis co-written by two city officials.

Still, car experts believe battery-powered models—which are mechanically much simpler than those with gasoline engines, with fewer moving parts—will ultimately prevail.

The internal combustion engine, or ICE, has been engineered to near-perfection over a century, said Sandy Munro, an auto-industry consultant who takes apart about two dozen cars a year, stripping them to their parts to study the materials, technology and assembly. The innovation of the battery-powered EV, by contrast, has barely begun.

"Right now, we're basically scratching the surface," he said. "The ICE age is coming to an end."

Write to Russell Gold at russell.gold@wsj.com and Ben Foldy at Ben.Foldy@wsj.com

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