

BATTERY SPOTLIGHT

By the numbers, 2023

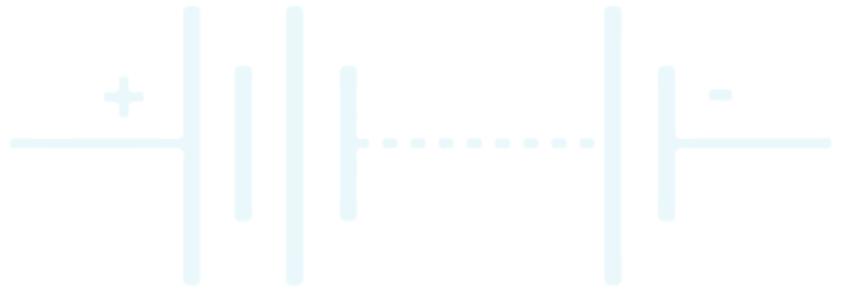
A landscape view of the battery sector in the US

A report underwritten by *Sigler*



Batteries

A Primer



Use it or lose it!

Electricity's expiration date is immediate, and the "use by" date of electrons is "now." Battery storage, often called the holy-grail for renewable energy, balances the intermittent production of power over time.

Battery science 101

Batteries turn electricity into stored energy. Electrons funneled into a battery force a chemical change through an electrolyte, which enables the formation of chemical compounds that can store extra electrons. To use that stored energy, a different chemical reaction occurs that releases the electrons so that they flow from the battery as electricity. When a battery is disconnected from its circuit, it will simply hold those electrons in a kind of chemical stasis, ready to deliver them when needed. What makes lithium-ion (or nickel-metal hydride) batteries especially useful is that they can be recharged.

Influencer input

AES editors used "wisdom of the crowd" to collect data for *Battery Spotlight*. Specifically, we sought input from influencers who are directly or indirectly involved in RD&D or commercialization of next generation battery storage, with an emphasis on lithium-ion, the prevailing technology in this sector.

RD&D

Tomorrow's storage today

7 Elite US epicenters in battery/storage RD&D

- 1st place **New York**
Columbia University, Electrochemical Energy Center
NY-Best (Upstate NY): SUNY Binghamton, SUNY-Stony Brook
- 2nd (tie) Stanford/Berkeley (LBL)
MIT/Harvard
- 3rd (tie) JCESR/Argonne National Lab*
UT Austin/Texas ECE
Georgia Tech
NC Research Triangle

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Leading US national labs

<u>Tier 1</u>	<u>Tier 2</u>
Argonne*	Idaho
Berkeley	Pacific NW
Brookhaven	NETL
NREL	Sandia
Oak Ridge	SLAC

5 Academic programs pushing the storage edge

- Caltech, LiSA
- University of North Carolina, CHASE Hub
- University of Maryland, MEI², including the CREB
- Case Western Reserve, BEES
- UCLA, SCALAR

- 1 And the most overlooked . . .
Naval Research Laboratory, Advanced Electrochemical Materials Division

*Remembering George Crabtree; a great battery scholar and an even greater friend.

Federal funds

The state of storage

10 US federal offices funding battery RD&D

Advanced Materials and Manufacturing Technologies Office (AMMTO)
Advanced Research Projects Agency-Energy (ARPA-E)
American Battery Materials Initiative (focus on state/federal cooperation)
National Energy Technology Laboratory (NETL) – for production of REMs
Office of Clean Energy Demonstrations (OCED)
Office of Energy Efficiency and Renewable Energy (EERE)
Office of Fossil Energy and Carbon Management (FECM) – production of REMs
Department of Energy, Office of Science
Office of State and Community Energy Programs (SCEP) – schools and vehicles
Title 17 under the Loan Programs Office (authorized by the IRA)

18 The first programs to receive Bipartisan Infrastructure federal funding for battery RD&D

6K Inc (Pennsylvania) – processing
Albemarle US (North Carolina) – cathodes
American Battery Technology Co. (Nevada) – cathodes
Anovion LLC (Alabama) – anodes
Applied Materials Inc. (North Carolina) – processing
Ascend Elements (Kentucky) – cathodes
Cibra Solutions (Ohio) – recycling
Group14 Technologies, Inc. (Washington) – anodes
ICL-IP America, Inc. (Illinois) – cathodes
Lilac Solutions (Nevada) – cathodes
Microvast Inc. (Tennessee) – separators
NOVONIX Anode Materials LLC (Tennessee) – anodes
Orbia Fluorinated Solutions, Koura (Louisiana) – precursors
Piedmont Lithium Inc (Tennessee) – cathodes
Sila Nanotechnologies (Washington) – anodes
Solvay Specialty Polymers USA (Georgia) – precursors
Syrah Technologies (Mississippi) – anodes
Talon Nickel (North Dakota) – cathodes

Note: Funds from the previous Democrat-led Congress are going almost entirely to Republican states.

3 The states most actively funding battery RD&D

CEC (California)
NYSERDA (New York)
MassCEC (Massachusetts)

Commercial Markets

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Influential early-stage investors in storage

Amazon Climate Fund
Anzu Partners
Battery Ventures
Breakthrough Energy Ventures
BMW-I Ventures
Capricorn
Charles River Ventures
Chevron Ventures
Energize Ventures
Energy Foundry
Energy Impact Partners
Fifth Wall
General Catalyst
Generate
SJF
Shell Tech Ventures
Threshold
Volta Energy Technologies

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Interesting storage start-ups

NanoGraf
KoBold Metals
Ambri
EnZinc
Quantumscape
Natron Energy
Cuberg
Redwood Materials
Amprius
XL Batteries
Elestor
Sila Nanotechnologies
Blue Current

And the most interesting . . . Form Energy

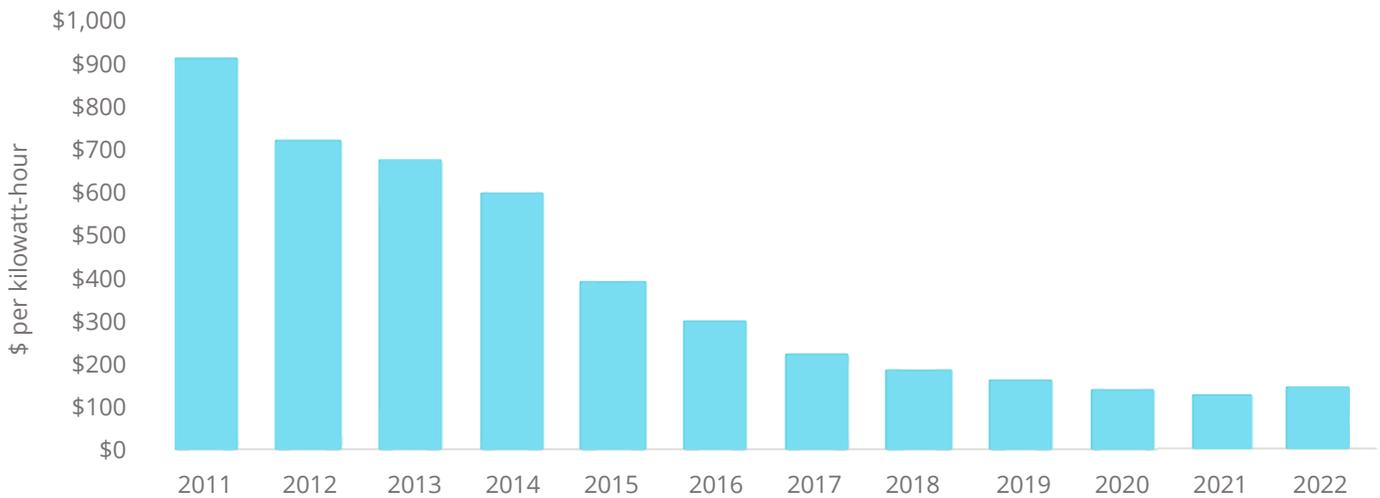
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The hottest commercial battery market:
Solar + Storage (hybrid) PPAs

Note: in 2020 there were 0 hybrid PPAs; in 2022, Amazon, Microsoft, and Google signed for more than 31GW of hybrid PPAs alone.

Lithium-ion and Beyond

151 Average price for a Li-ion battery pack in 2022 (\$/kWh)

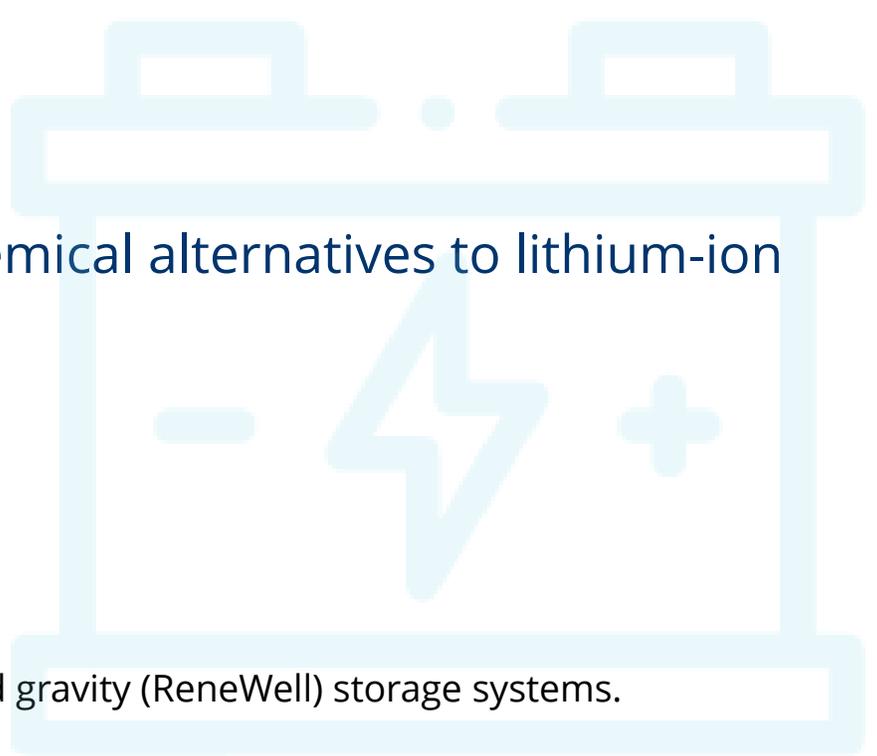


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A few electrochemical alternatives to lithium-ion

- Redox flow
- Iron-air
- Sodium-ion
- Solid-state
- Lithium-sulphur
- Calcium-ion

And don't forget . . . thermal (like Malta) and gravity (ReneWell) storage systems.



Networking Events

5 Organizations to know

California Energy Storage Association
Energy Storage Technology Advancement Partnership
NAATBatt International
StorageX
Volta Foundation

4 Must-attend events

Berkeley Lab National Energy Storage Summit
Energy Storage Summit in Austin, Texas
International Battery Seminar in Orlando, Florida
Solid-State Battery Summit in Chicago, Illinois

3 US federal agencies offering accessible (aka "easiest to get") federal funding

Tribal Loan Guarantee Program (TELGP)
Department of Agriculture's Rural Energy for America (REAP)
Department of Energy, Loan Program Office (*debt*)

2 Key resources

Benchmark Minerals Intelligence
Batteries News

Digging Deeper

1...

... overlooked problem

The environmental risk of disposal and recycling.

... big concern

The 17 rare earth elements, metals and minerals supply chain.

... significant development

US battery storage markets are outpacing records set by utility-scale solar between 2010 and 2015.

... thing to watch in 2023

The US Department of Energy will be looking for technically and economically viable projects on current and former mine lands (~\$500M funding).

The largest utility-scale storage project in the US

Bath County Pumped Storage hydropower station in Virginia

The topic that US agencies want to know more about

Pumped hydropower, via the US Water Power Technologies Office (WPTO)

US public funding

Summary storage snapshot

The 2022 Inflation Reduction Act (IRA) gets a lot of attention because it unlocks valuable tax credit incentives for standalone energy storage projects. But the Bipartisan Infrastructure Law is more significant for battery/storage RD&D. The Bipartisan Infrastructure Law provides US\$2.8 billion to support and develop the domestic manufacturing of batteries for electric vehicles (EVs) and utility-scale (grid) storage, as well as US\$7 billion to support the battery supply chain – adding US capacity for processing, manufacturing, and recycling of critical minerals, including lithium, nickel and graphite.

Current federal funding is especially generous for:

- Earlier stages in the critical mineral supply chain, such as US production of mature technologies, like lithium iron phosphate (LFP) cathodes and graphite anodes (which are currently almost exclusively sourced from Chinese imports);
- R&D funding for more innovative technologies at earlier stages of commercialization, like silicon anodes and advanced battery production techniques.



The Last Word

by Sigler

We are pleased and proud to underwrite this *Battery Spotlight* by the American Energy Society. It is critical to have a clear view of the storage capabilities that are catalyzing transitions to clean energy around the world. This is an essential resource to understand where we are today and where we're headed tomorrow and into the future.

Why is Sigler, a market-leading HVAC distributor, sponsoring this report? Much attention about batteries focuses on raw materials, such as elements and metals, or their applications, such as EVs or consumer devices. But battery systems all require cooling. When batteries charge and discharge, they release enormous amounts of heat that must be cooled to operate at maximum efficiency.

We at Sigler offer innovative cooling solutions for all kinds of battery systems and electrical enclosures used in a wide range of renewable energy storage systems. We have been providing air conditioning products and services for over 60 years, and we're poised and ready to continue to lead the market in the next phase of the global energy transition.