

# BATTERY SPOTLIGHT

By the numbers, 2023

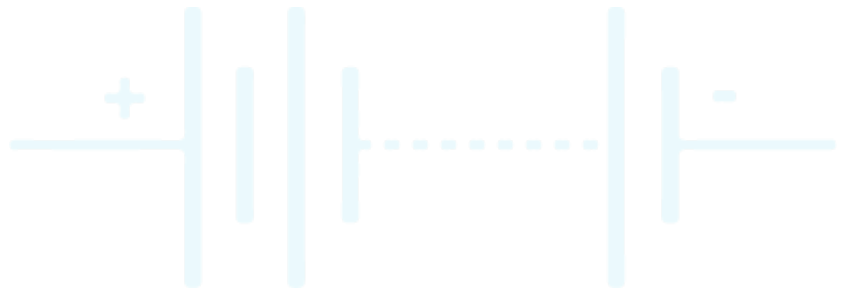
A landscape view of the battery sector in the US

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 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

- 1<sup>st</sup> place **New York**  
Columbia University, Electrochemical Energy Center  
NY-Best (Upstate NY): SUNY Binghamton, SUNY-Stony Brook
- 2<sup>nd</sup> (tie) Stanford/Berkeley (LBL)  
MIT/Harvard
- 3<sup>rd</sup> (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, MEI<sup>2</sup>, 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

# 18

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*

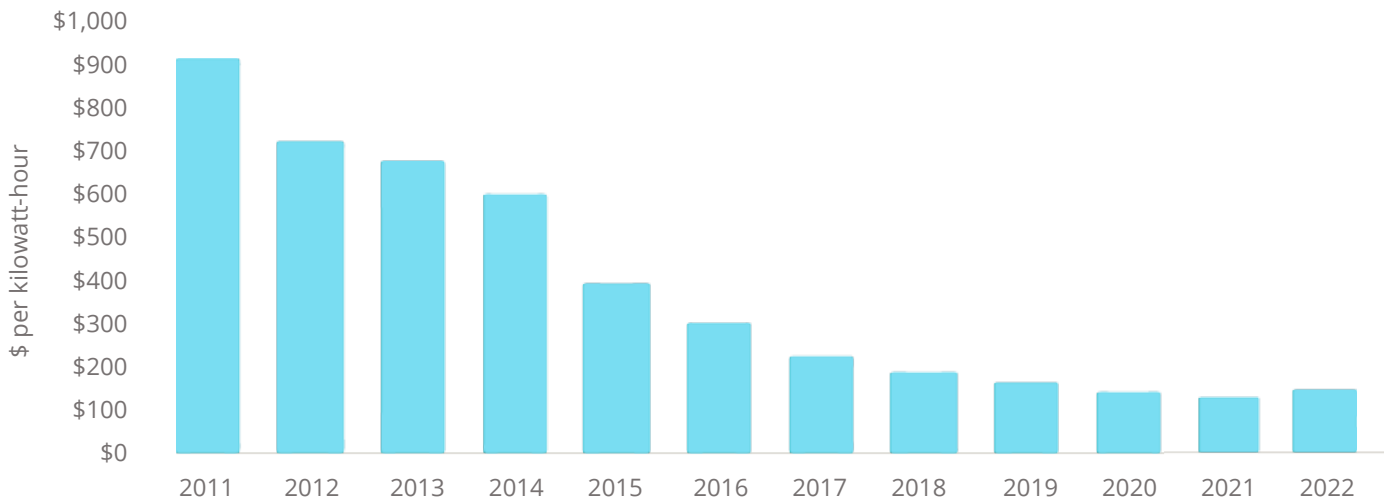
# 1

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)



**6**

## 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.