BATTERY COUNCIL INTERNATIONAL

ESSENTIAL ENERGY EVERYDAY

INFORMATION BRIEF

# Renewable Energy Storage:

## Meeting U.S. Environmental and Economic Goals with Sustainable Lead Batteries

Experts project that renewable energy will be the fastest-growing source of energy through 2050.[1] However, delivering the full benefits of renewable energy generation requires support from equally sustainable energy storage solutions. This brief explains why highly sustainable, U.S.-made lead batteries – one of multiple battery chemistries that will be needed – deserve continued investment to unlock their full potential and help our country meet its low carbon energy goals with green energy and energy independence.

## Introduction

Over the past decade, renewable energy capacity in the U.S. nearly quadrupled.[2] There is interest for both Behind the Meter (BTM) where consumers or commercial operations generate and store their own energy, and grid level storage, where the utility company is using energy storage. To keep pace, our country needs multiple battery chemistries to provide the energy storage that enables renewable energy, such as solar, wind and hydropower, to work at commercial and residential scale, both on and off the grid. Batteries are needed to regulate renewable energy by banking energy during low demand, then regulating and releasing stored energy when needed.

**With a focus on batteries, this information brief will explain:**

- The growth and challenges outlook for renewable energy in the new energy economy.
- How to compare top energy storage options, including lead and lithium-ion.
- How advanced lead batteries already support renewable energy.
- The importance of continued funding for lead battery research to unlock the chemistry's full potential.

**+ FACT**

Wind, solar and **battery storage** represented 81% of new U.S. power additions across all energy types in 2021 as reported by American Clean Power.

## A Call to Action

The intention of this report is to ensure policymakers make renewable energy storage policy decisions based on the full range of battery chemistries, including lead. We urge policymakers to:

- Stop regulations that would eliminate battery chemistries from the market, especially established options such as lead batteries.
- Support government research investment for the mix of battery chemistries available today.
- Include the domestic availability and sustainability of top battery options when considering appropriations.
- Recognize the urgency to act now. We must:
  - Slow climate change by reducing GHG emissions.
  - Increase U.S. energy independence by removing our vulnerability to globally priced fossil fuels, critical mineral availability and other trade disruption issues.

### The Biden-Harris Administration's Position on Clean Energy

The Inflation Reduction Act signed into law in August 2022 has been billed as the most significant climate legislation in U.S. history. The legislation includes $370 billion to combat climate change and boost U.S. energy production through financial incentives for companies to produce more renewable energy and households to change their energy use and consumption.

The bill aims to reduce greenhouse gas emissions by about 1 gigaton by 2030, or a billion metric tons – 10 times more climate impact than any other single piece of legislation ever enacted.

Section 13502 would establish a new Advanced Manufacturing Production Tax Credit which would be given to domestically produced "eligible components," including solar and wind energy components, inverters, and battery components.

## The Renewable Energy Outlook: Growth

The energy landscape is quickly changing. Several factors have propelled the growth trajectory of renewable clean energy as an alternative to fossil fuels and nuclear energy:

- State and federal governments have set aggressive milestones to phase out nonrenewable energy sources (oil, coal and natural gas).
- Unstable geopolitical climates are creating wide fluctuations in prices for oil and natural gas.
- Public policies are providing significant incentives to invest in renewable energy.
- Technological advancements continue to lower costs, making renewables more price competitive.
- Social pressure from consumers and investors is increasing for environmentally friendly energy solutions to mitigate climate change.

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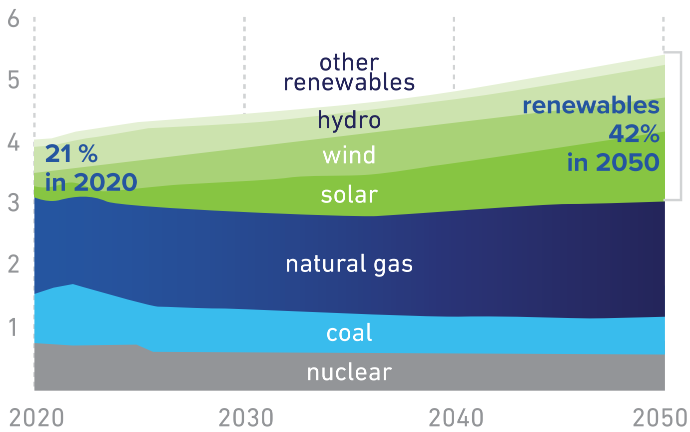
**U.S. Electricity Generation, Projection 2020–2050**
(trillion kilwatthours)




**Source:** U.S. Energy Information Administration, Annual Energy Outlook 2021 (AEO2021)

## Global Growth by the Numbers

Investment in global battery energy storage is expected to more than double to reach almost $20 billion in 2022.[3]

- **85%** The predicted amount of renewables by 2050.[4]
- **7.7 TWh** Battery storage in 2050, avg. 257 GWh installed per year to 2050.[4]
- **Between $92T** and **$173T** The investment in energy supply and infrastructure by 2050.[4]
- **20.1%** Amount of electricity generation in the U.S. from renewable energy sources in 2021.[5]

## Renewable Energy and Battery Outlook: Challenges

**Soaring Demand.** The need for energy, electricity and energy storage options is outpacing supply. Demand is only increasing for a greener, cleaner electrification world: renewable energy; electrified vehicle platforms; security, telecom, data centers, and more. All require safe, cost-effective energy storage.

**Raw Material Shortages.** A mix of battery chemistries, each with pros and cons in specific applications, is needed to meet demand. The supply of critical materials for batteries and resiliency of their supply chains greatly affect availability and cost. Except for lead batteries, the United States is dependent on foreign sources for several critical materials needed for battery manufacturing.

**Lithium Sourcing.** Lithium-ion batteries are currently the dominant storage technology for large-scale plants to help electricity grids ensure a reliable supply of renewable energy. In 2020, worldwide demand for lithium was about 350,000 tons, but industry estimates project demand will be up to six times greater by 2030.[6]

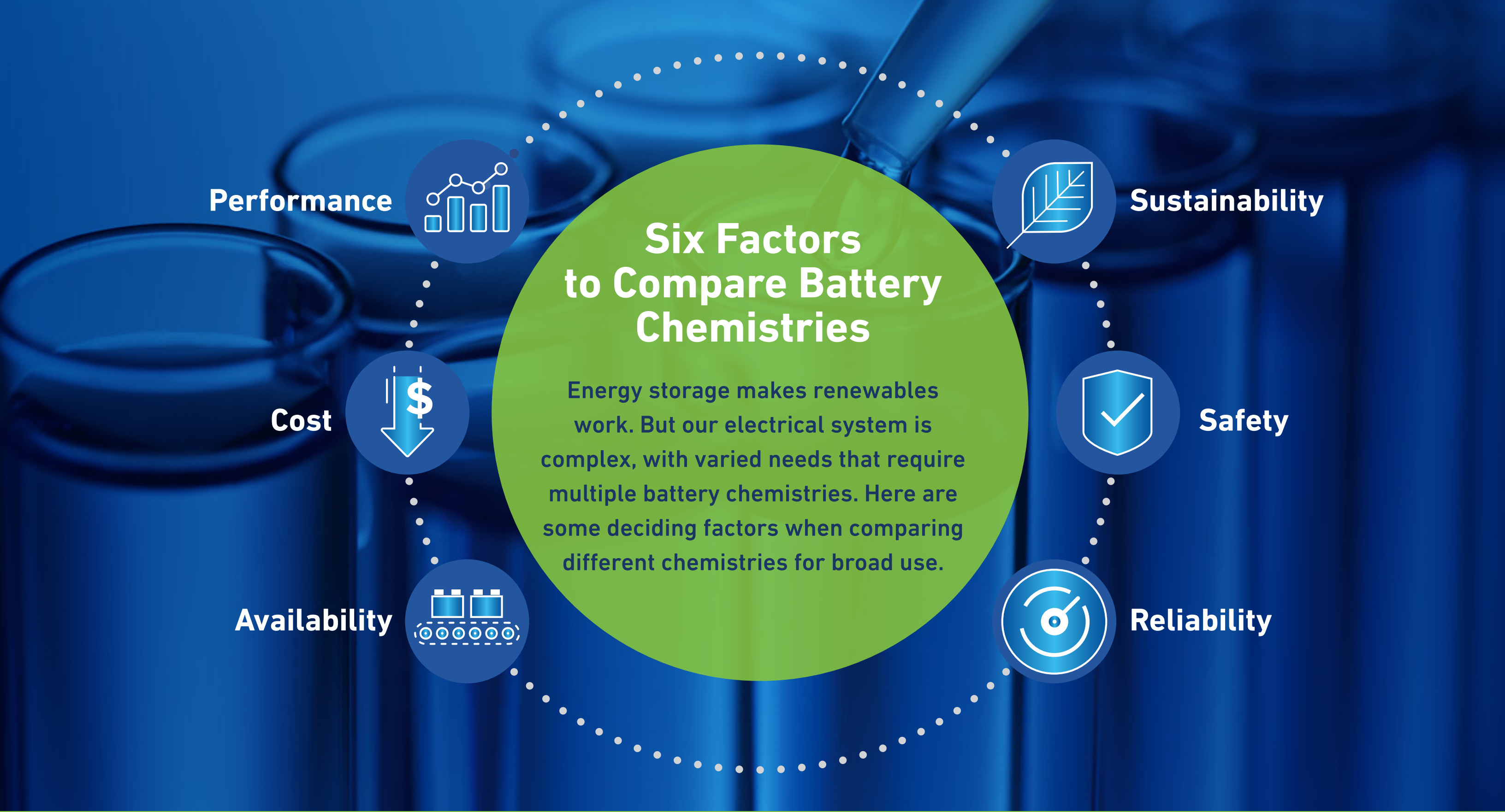
Some critical metals used in lithium-ion batteries, namely lithium, cobalt and graphite are scarce, are not currently mined in large quantities, or are mined in only a few countries whose trade policies could limit availability and impact prices as demand increases.[7]

- Today, three countries – Australia, Chile, and China – mine roughly **86% of the world's lithium,**[8] and U.S. domestic mining of lithium is limited to less than 2% of annual global production.[6]
- **60% of the world's cobalt** is mined in the Democratic of Congo, and 80% of that supply is processed in China.[9]

According to an analysis by BloombergNEF, in early 2019 there were 316 gigawatt-hours (GWh) of global lithium cell manufacturing capacity. China is home to 73% of this capacity, followed by the U.S., far behind in second place with 12% of global capacity.[10]

**+ FACT**

Lead batteries and lithium-ion batteries will remain the most important rechargeable energy storage options, as reported through 2030.[11]




## Performance*

Significant innovation in lead battery R&D has dramatically improved their technical performance.

+ **Up to 20 years** A lead battery's demonstrated lifespan.[12]
+ **100%** By 2030, the cycle life of current lead battery energy storage systems is expected to double.[13]
+ **120°F to -40°F** When used properly, lead batteries can capably withstand extreme temperatures.

## Cost**

Compared to other battery technologies, lead batteries are a more affordable storage option in terms of upfront and overall lifetime costs.

+ Once installed, lead batteries can be **one-third the cost** of comparable energy storage systems.[14]
+ A comparable analysis of lithium-ion and lead battery systems, including decommissioning, showed lead batteries had an **end-of-life net credit** of approximately $33 per kWh versus lithium's $91 cost per kWh.[15]

## Availability

An established infrastructure exists to handle the growing demand for the manufacture, distribution, collection and recycling of lead batteries.

+ The World Bank forecasts a **1,200% increase** in lead demand for batteries in energy storage.[16]
+ U.S. lead battery manufacturers currently source **more than 83%** of the needed lead from North American recycling facilities.[17]
+ The lead in lead batteries can be **recycled infinitely**, with no loss of performance.

* Duration of operation can impact battery performance.

**Lifetime battery cost will vary depending on battery application.

## Six Factors to Compare Battery Chemistries

### Sustainability

Lead batteries are one of the most environmentally sustainable battery technologies, due to their model circular economy. They add to the sustainability of renewable energy in several ways.

+ On average, a typical new lead battery is comprised of **80%** recycled material.[18]
+ Made of three distinct components. **All are recyclable.**
+ **Over 99%** of spent lead batteries in the U.S. are recycled.[19] Estimates show fewer than 15% of lithium ion batteries in similar uses are recycled.[20]
+ An **existing network** of nation-wide collection sites and recycling facilities.

### Safety

The safer makeup of lead batteries compared to other chemistries makes them a preferred choice for system installations near schools, hospitals, apartment buildings and in residential areas.

+ They have a **very low risk of fire or explosion** resulting from overcharge, heat exposure, mechanical damage and short-circuiting.
+ Lead batteries have an **aqueous electrolyte** and active material compared to other battery chemistries.

### Reliability

Lead batteries are a proven, 160-year-old technology that has advanced significantly over the last 20 years.

+ They are the **most widely used electricity storage system on earth**, comprising 50% of the worldwide rechargeable battery market share.[21]
+ They **already reliably support** numerous renewable installations and critical infrastructure including wireless and wired communications, E911, utility substations, nuclear safety systems, data centers, traffic control systems and other applications.

## The Recycling Leader: Lead Batteries

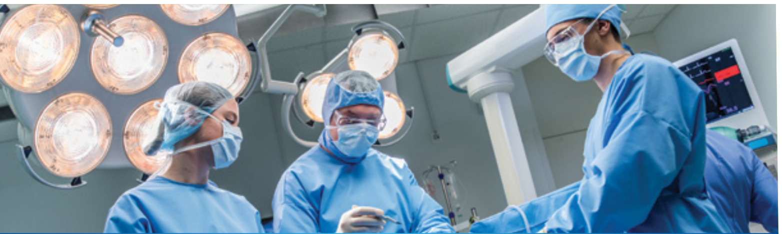
99% Pb <15% Li

Lead batteries have the **highest collection and recycling rate** of any battery chemistry.

**80%** The percentage of recycled material in a new lead battery.

The lead in lead batteries is **infinitely recyclable**.

## How Lead Batteries Maximize Renewables



### Regulate Variability

The fluctuations in renewable electricity generation (reliant on sunlight and wind speeds) can make electric grids unstable and create low-quality power.

+ **Reserve capacity**
  Lead batteries dramatically improve power quality by storing excess energy when demand is low and releasing it when it is needed.
+ **Frequency response**
  Lead batteries smooth power variability by releasing energy to the grid when demand is high.

### Stabilize the Grid

Renewable energy can pose challenges for grid operations that are traditionally designed to send baseload power out from central power stations.

+ Lead batteries can **bolster the grid**, so that utilities can avoid replacing or making expensive upgrades to transmission lines designed to send baseload power out from central power stations.

### Bridge the Transition

Increasing numbers of people want to source their power from nature for environmental reasons.

+ **69% of U.S. adults** prioritize developing alternative energy sources, such as wind and solar, over expanding the production of oil, coal and natural gas.[22]
+ Utilities can use a mix of conventional and renewable energy, relying on **lead batteries** to store and smooth out distribution.

### Reach Remote Areas

Remote geographical areas that are off the grid need a way to reliably store renewable energy.

+ Lead batteries have unique attributes that make them well-suited to help bring electricity to the nearly **25% of the population** of all developing countries (over 1 billion people[23]) who have no electricity.[24]
+ Lead batteries are deployed in remote, small-scale hydro-electric systems to **help provide essential, clean energy** for food storage and communications.

LEARN MORE

Read our **case studies** and see how proven lead batteries are providing innovative energy storage solutions around the world.

## Lead Battery Research and Investments Underway

It's an exciting time for lead battery research. But the U.S. needs more lead-battery inclusive policies and investments to support U.S. energy infrastructure and ensure domestic energy security. These examples show research results and research underway to unlock the full potential of lead batteries for renewable energy storage.

## Research and Performance Advancements in Progress

The major driver for improvement in energy storage systems (ESS) is lowering the levelized cost of ownership (LCOS). The U.S. DOE has stated the target is an aggressive reduction in cost to $0.05/kWh for ESS. Improving total energy throughput (or cycle life) is the major driver for battery-based ESS to improve to meet such a lofty goal. Over the last three years numerous advancements in cycle life have been achieved in the lead battery industry, mainly by using advanced materials and battery management algorithms.

For commercially available gel and AGM (Absorbent Glass Mat) products, increases in energy throughput of 50-100% have been observed in battery strings (banks) by employing controlled overcharge levels from 101-103%. This is best exemplified by work performed first by NorthStar®, an EnerSys company, and then further studied by the Consortium for Battery Innovation (CBI) and Electric Applications Incorporated (EAI). Battery management is a cost-effective method to maximize energy throughput. String control, combined with advanced algorithms, has allowed lead battery strings to reach 2,500 equivalent cycles at 80% DOD (depth of discharge) without the use of other advancements.

Beyond the impact of peripheral electronics and smart management schemes, materials like additives and new alloys increase energy throughput from lead batteries used in renewable energy applications. Carbon additives increase performance, with PbC (advanced lead-carbon) batteries on the market capable of 4,000 cycles at 80% DOD from several battery manufacturers. Furthermore, innovations in alloys, such as thin-plate pure lead and doped micro-alloys, greatly reduce internal resistance. This decrease in resistance facilitates faster charging, better partial-state-of-charge (PSOC) performance, and robust long-term performance.

The use of additives, new materials, and the impact of battery management on lead battery performance are being studied and further advanced via these programs:

- Evaluation and design of expanders by University of Toledo, Argonne National Laboratory, and the American Battery Research Group.
- The Lead Battery Science Research Program (LBSRP) at Argonne National Laboratory.
- Work on battery testing and fundamentals at Pacific Northwest National Laboratory, sponsored by the DOE Office of Electricity.
- A suite of projects sponsored by CBI at UCLA, CBI member companies, and other institutions.

## Conclusion

Numerous environmental and economic factors prove the demand for renewable energy storage in the U.S. is outpacing supply. Sustainable, domestically available lead batteries are one of multiple battery chemistries that will be needed to stay ahead of that soaring demand. It is critical for policymakers to understand the stakes: Renewable energy cannot succeed without batteries. Therefore, we ask policymakers to support policies and fund investments that support renewable energy storage and, in turn, accelerate energy independence.


*Nuclear Magnetic Resonance Facility at the University of Toledo.*

*Aerial view Advanced Photon System, Argonne National Laboratory. Credit: DOE*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**BATTERY COUNCIL INTERNATIONAL** Formed in 1924, BCI joins together battery manufacturers and recyclers, marketers and retailers, suppliers of raw materials and equipment, and battery distributors from across North America and around the world. BCI members are committed to responsible manufacturing and recycling processes, and serve as a unified voice for environmental, health and safety stewardship.

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