BATTERY COUNCIL INTERNATIONAL

SINCE 1924

U.S. RECYCLING RATE STUDY

Maximizing Lead Battery Recycling for Critical-Mineral Recovery & Supply Chain Security

Study Years 2020-2024

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EXECUTIVE SUMMARY

A strong future for America depends on a strong battery industry. Batteries are vital to energy, national security, manufacturing, and critical infrastructure including data centers.

North American battery manufacturing is only as strong as the supply of critical minerals and raw materials feeding it, and demand is outpacing supply. The lead battery industry provides a rare supply chain success story for battery minerals due to its highly successful closed-loop system built by the U.S. and trusted partners in Canada and Mexico.

More than 20 years of studies show a consistent recycling rate for lead batteries in the U.S. of approximately 99% in most years, with the current study finding a 98% rate. The 10-year average remains above 99%. This is a figure that the energy storage industry is tremendously proud of, and it is the result of more than 100 years of continuous improvement across logistics, safety, and recycling practices.

Protecting this 98% recycling rate is critical. Supporting a circular economy for batteries in North America isn't just about sustainability or stewardship. It's an economic imperative.

This study demonstrates how the domestic lead battery industry operates as a closed loop to 1) prevent disruptions in the flow of essential materials, and 2) decrease geopolitical dependence on foreign suppliers. Without recycling, manufacturers would lose access to critical input materials and be susceptible to supply chain irregularities and cost volatility.

During the study period (2020–2024), U.S. lead battery recycling companies recycled over 11 billion pounds of critical-mineral lead to achieve a 98% lead recycling rate. Annually, these companies recycle over 174 million lead batteries, delivering over 2.2 billion pounds of lead to the domestic battery manufacturing supply chain.

The lead battery industry's existing infrastructure and vast, established networks are fundamental to the circular economy of this industry. In North America there are over 300,000 spent-battery collection sites, 15+ recycling facilities (10 in the U.S.), 60 manufacturing facilities (54 in the U.S.), and 62 material and component suppliers (57 in the U.S.). Because the industry operates as a closed-loop system, any disruption in recycling breaks the flow of materials to manufacturers and risks disruptions to U.S. battery production. A resulting decline in manufacturing capacity would put broader energy and economic infrastructure at risk, and have significant follow-on impacts to North America and the rest of the world.

The battery industry is a significant contributor to the U.S. economy. Annually, domestically produced batteries support economic activity valued at approximately $10 trillion, representing 21% of the U.S. economy. This figure reflects the combined impact of all battery technologies, including lead batteries. In addition, more than 54 million jobs depend on the battery industry in some way, highlighting its importance to the nation's economic strength, industrial competitiveness and energy security. The U.S. lead battery segment alone produces more than 163 GWh of batteries each year.

It is vital that North America protect the proven circular economy of lead batteries to provide certainty and resilience for businesses that rely on energy storage. As battery manufacturers scale production and meet growing demand, it is strategically important to keep battery materials onshore and support the energy needs of an increasingly electrified economy.

ABOUT THE BCI U.S. RECYCLING RATE STUDY

This study was commissioned by Battery Council International (BCI), the leading trade association representing the global battery manufacturing and recycling industry. Vault Consulting prepared the study results. Updated periodically, the current study is based on aggregating BCI member-supplied data for years 2020–2024. The study has been regularly conducted by BCI since 1990, and was last released in 2023 for years 2017–2021.

BCI's National Recycling Rate Study aims to answer a fundamental question: of all the lead in batteries that reached the end of its service life, what share was successfully collected and recycled?

For 2020 through 2024, the answer is 97.7%. A more comprehensive explanation of the methodology behind this recycling rate appears later in this report.

What does a 98% recycling rate mean?

For the purpose of this report, “recycling rate” refers to the portion of the total amount of lead in batteries reaching end of life that is available for collection that is successfully collected and recycled for the recovery of lead. That includes batteries used in automobiles, forklifts, grid backups, and more. This study’s EPA-accepted methodology uses lead weight as a representative proxy for battery unit volumes because lead makes up the majority of a typical battery’s weight as well as its material costs.

Lead batteries are kept out of the nation’s landfills

Because the recycling rate is statistically derived, some variability is anticipated – and should not be interpreted as suggesting improper landfill disposal. Independent waste characterization studies consistently confirm what the lead battery recycling network is designed to deliver: spent lead batteries almost never reach landfills.

State and municipal governments periodically sort and weigh representative samples of disposed waste to determine what residents and businesses are throwing away, and study after study finds that lead-acid batteries register at or near zero in the disposed stream. Maryland’s 2024 statewide characterization study, conducted to support the state’s recycling needs assessment, measured lead-acid batteries at less than 0.1% of all disposed municipal solid waste, and at 0.0% of the residential waste stream. **[1] [2]**

The near-total absence of lead-acid batteries from the disposed waste stream reflects the maturity and reach of the recycling network described elsewhere in this report. In addition to critical minerals, lead battery recyclers also recover plastic, electrolytes, and other materials. In fact, nearly every piece of modern batteries designed by BCI members can be recycled and given new life.

[1] For example, see Maryland Department of the Environment, Statewide Recycling Needs Assessment — Waste Characterization Study (2024), Appendix A, Statewide Aggregate Disposed MSW Composition (lead-acid batteries reported at less than 0.1% of disposed MSW; 0.0% in the residential stream).

[2] New York City Department of Sanitation, 2023 NYC Waste Characterization Study (2023), Harmful Household Products in residential curbside refuse. The study’s “wet-cell batteries” category is defined to include lead-acid automotive batteries and was measured at 0.02 pounds per household per year in 2023.

RECYCLING IS ESSENTIAL TO MEETING FUTURE BATTERY DEMAND

The nation depends on a diverse portfolio of battery technologies, and lead batteries are the foundation of America's economy and infrastructure. The U.S. lead battery industry produces more than 125 million batteries annually and has the capacity to deliver over 163 GWh of batteries. Within North America, over 150 million lead batteries are produced annually, with manufacturing capacity over 211 GWh.

From data centers and AI processing to energy storage, backup power, aerospace and defense, and industrial logistics, lead batteries provide the reliable power that sustains critical industries and strengthens U.S. economic competitiveness.

Lead Batteries Protect Public Safety and Health

In hospitals around the world, lead batteries save lives by providing emergency power for lifesaving equipment during temporary power outages. In times of crisis, lead batteries deliver essential energy and critical backup power for 911 call centers, emergency response teams, and healthcare infrastructure. This includes emergency lighting, as well as power for helicopters and other lifesaving vehicles. The U.S. military also relies on lead batteries for mission-critical applications, including communications and vehicles.

Lead Batteries Power America's Digital Infrastructure

Artificial intelligence (AI) is driving explosive growth in domestic data centers. This growth is reshaping electricity demand patterns across the United States and accelerating demand for energy storage solutions. These facilities require enormous amounts of always-on power to support AI workloads.

U.S. data centers are projected to consume more than 420 TWh of electricity by 2030, according to data from Lawrence Berkeley National Laboratory. Achieving AI's full potential will require massive investments in power generation, transmission and distribution, along with new approaches to delivering reliable electricity.

Lead batteries play a critical role in the data center ecosystem, providing the reliability, cost effectiveness, and high-temperature performance needed to maintain continuous AI operations. Even a momentary power disruption can halt AI processes, interrupt cloud services, and compromise critical digital operations. The effects can reverberate across sectors ranging from healthcare and financial services to national defense.

Lead batteries are also the dominant technology used to provide uninterruptible power supply (UPS) systems for telecommunications infrastructure, including emergency call centers and cellular towers. The telecommunications industry relies on lead batteries for the backup power needed to support 24/7 mobile connectivity.

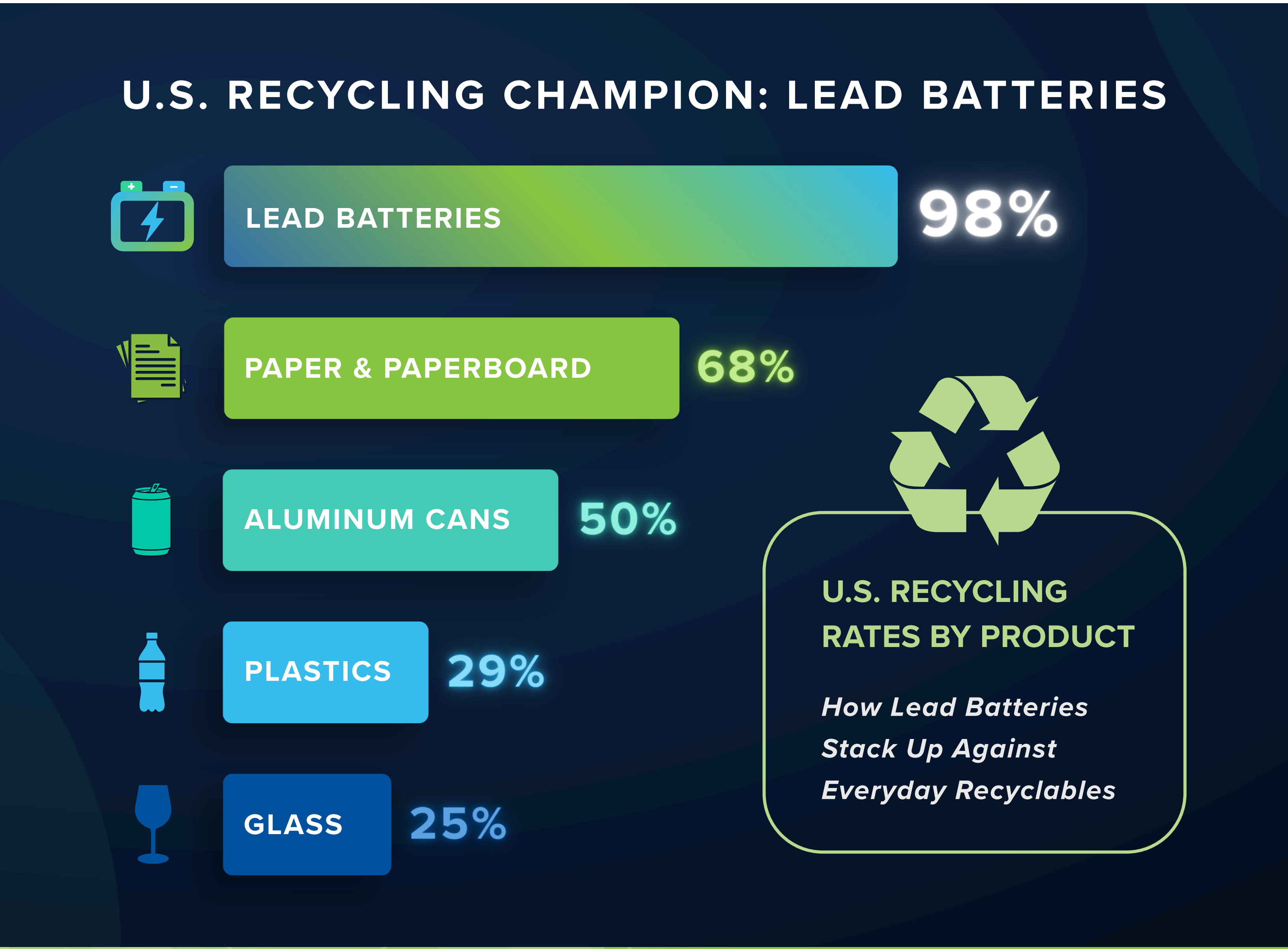
As electricity demand grows far beyond what the grid was originally designed to deliver, advanced lead battery systems have become critical infrastructure. They help smooth power fluctuations, protect uptime, and maintain resilient, reliable, and cost-effective operations.

Lead Batteries Power Transportation and Logistics

Lead batteries reliably power the transportation and logistics networks that move people between home, work, school, and recreational activities. Lead batteries help support roughly 6,800 U.S. public transportation systems that provide roughly 34 million passenger trips each weekday.

Nearly every mass-produced car and truck in the United States, including electric vehicles, contains and relies on a lead battery. More than 290 million vehicles on U.S. roads depend on lead batteries for critical functions. Americans purchase approximately 16 million new vehicles each year, and the average vehicle will use three to four lead batteries over its lifetime, including the original battery and subsequent replacements. Beyond passenger vehicles, lead batteries power boats, RVs, mobility scooters, ATVs and a wide range of specialized transportation equipment.

Lead batteries also help keep goods moving. Warehouse operations rely on zero-emission electric forklifts powered by lead batteries to maintain efficient order fulfillment. In addition, lead batteries support the commercial vehicles that crisscross the nation, transporting products to consumers and materials to manufacturers.



BUILDING A SAFE AND SUCCESSFUL CIRCULAR ECONOMY

Each year, the U.S. battery recycling system recycles more than 174 million lead batteries. Although a portion of end-of-life (EOL) lead batteries are exported for recycling outside the United States, the domestic system recovers and recycles nearly all batteries that remain within the U.S. recycling stream. Consequently, lead batteries have the highest collection and recycling rate of any battery type and remain the most recycled consumer product in the nation.

During the study period (2020–2024), domestic lead battery recyclers recovered over 11 billion pounds of critical-mineral lead. This recycled material enables the U.S. industry to supply approximately 70% of U.S. lead demand annually. Factoring in lead battery recyclers in Mexico and Canada, collectively the three countries fulfill more than 83% of North America lead demand annually.

Additionally, primary lead smelters as well as secondary lead recyclers have both declined in recent years, with a total of nine facility closures between 1990 and 2021. This dynamic makes the production of existing lead recyclers all the more important given the scarcity of onshore suppliers. The region's world-class lead battery recycling system ensures spent batteries are directed to safe, responsible domestic recycling facilities, where high-value minerals and other materials are recovered and returned to productive use. Thanks to a history of continuous improvement and industry-led best practices, recyclers across North America meet internal targets for worker safety and environmental protection that are even more restrictive than regulatory standards.

The North American battery industry serves as a strategic industrial asset that strengthens U.S. economic competitiveness, supports energy reliability, enhances supply chain resilience, and helps ensure the continuity of critical infrastructure. However, it is also a shining example of how to recycle batteries safely and responsibly. Through efforts including the Lead Battery 360° Certification program (LB360), the industry continues to support responsible production and material sourcing practices in the lead battery supply chain worldwide.

Battery Council International and its member companies have a longstanding commitment to responsible recycling. A resolution passed by the BCI Board of Directors in 1999 raised recycling standards globally. The resolution calls for international "efforts to bring all regulatory schemes [for battery recycling] to the levels existing in the United States, Western Europe and many other areas."

Further, the resolution declares that the association "opposes the export of used batteries to recycling facilities outside the United States-Mexico-Canada Agreement (USMCA) countries that are known or suspected to use environmentally unsound practices." More recently, the Lead Battery 360° framework launched in 2022 represents the industry's commitment to responsible recycling through a certification initiative. Designed to promote responsible production and material sourcing within the lead battery supply chain, Lead Battery 360° continues its work around the world and currently has 10 total participating facilities.

RECYCLING RECOVERS CRITICAL MINERALS

Lead battery recycling provides multi-material recovery in one system. Each of the critical minerals within a lead battery – lead, tin and antimony – is infinitely recyclable. Recycling gives the U.S. supply chain a built-in critical minerals recovery system that, in turn, gives the nation a strong supply chain advantage.

In late 2025, the U.S. Geological Survey (USGS) designated lead a critical mineral. It joined other minerals deemed by USGS as essential to economic and national security, while facing supply chain vulnerabilities. Critical minerals typically have:

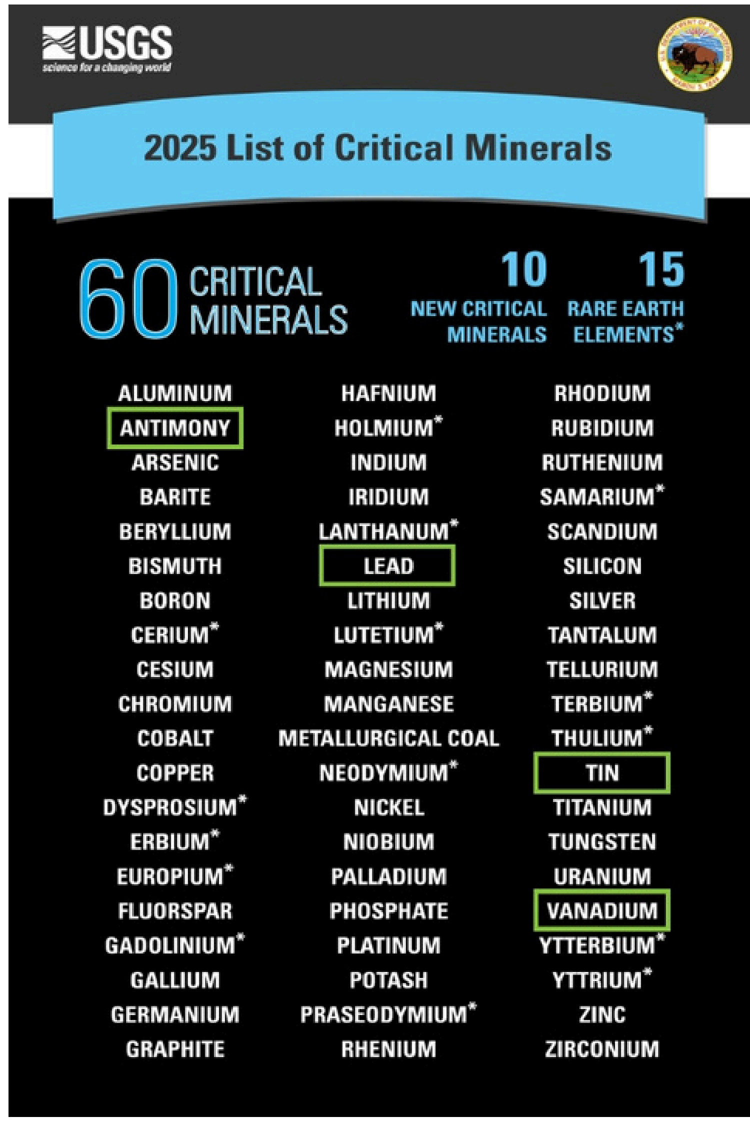
- Production concentrated in a small number of countries;
- Limited or nonexistent domestic sources;
- Applications across multiple industries;
- Vulnerability to disruption.

In many cases, lead battery products are designed for recycling and efficiency from the outset, anticipating use beyond an individual battery's end of life and acknowledging the need to keep materials within the circular economy of the industry to fuel the value chain.

The North American battery industry is incredibly proud of this study's 98% recycling rate. However, it remains focused on improving recovery rates for the 2% of batteries that are currently unaccounted for.

One noteworthy factor driving that 2% gap in the latest recycling rate is potentially illicit and/or un-reported exports of spent (scrap) lead batteries.

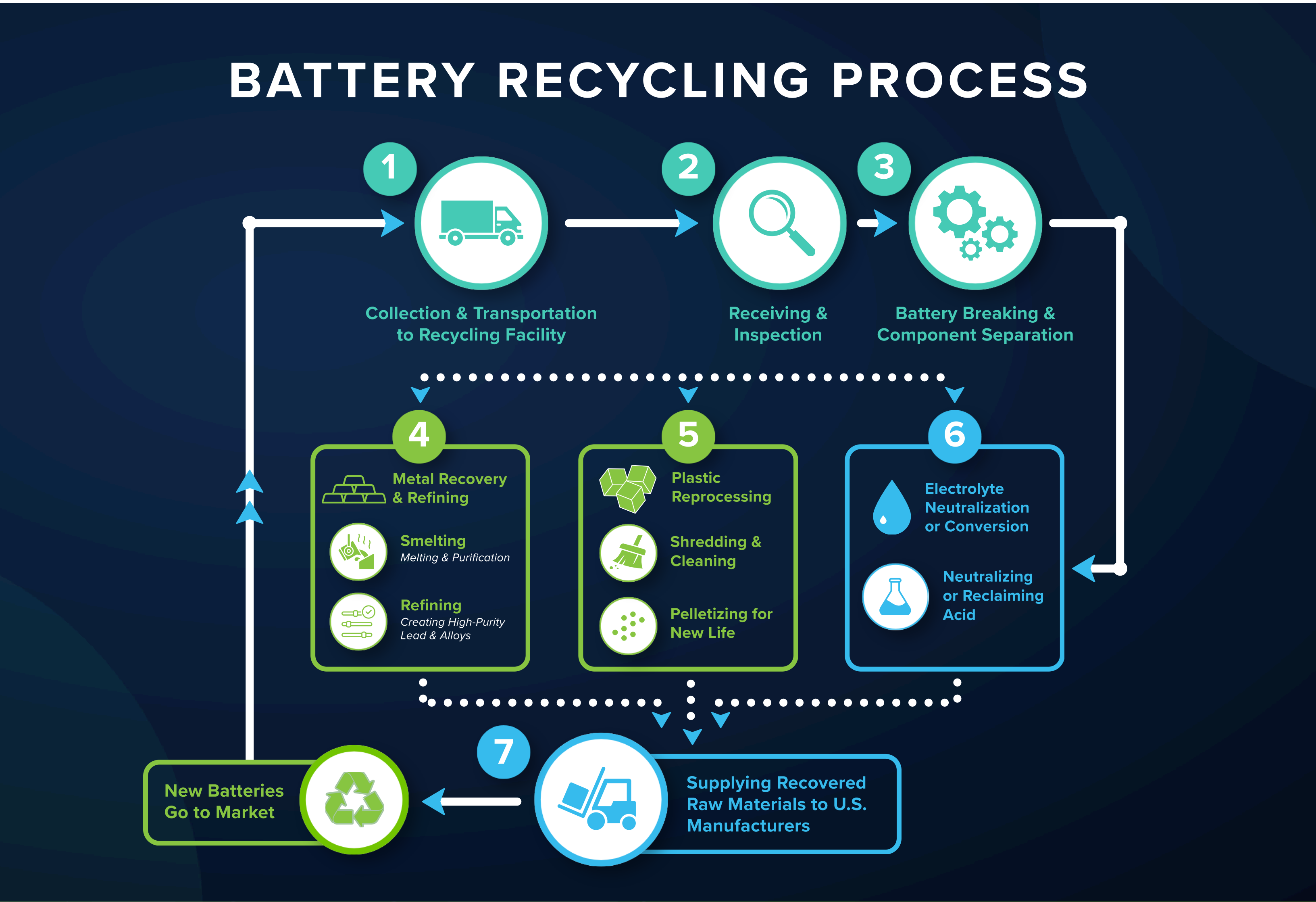
Trusted foreign partners are critical to the industry, but BCI stands in firm opposition to the illicit trade in scrap and the diversion of used batteries from high-performing regions to poor-performing facilities. By bypassing North America's world-class recycling infrastructure, illicit exports remove valuable critical minerals and materials from the responsible supply chain and complicate efforts to accurately report recycling activity.



SUPPLY CHAIN SECURITY FOR DOMESTIC MANUFACTURING

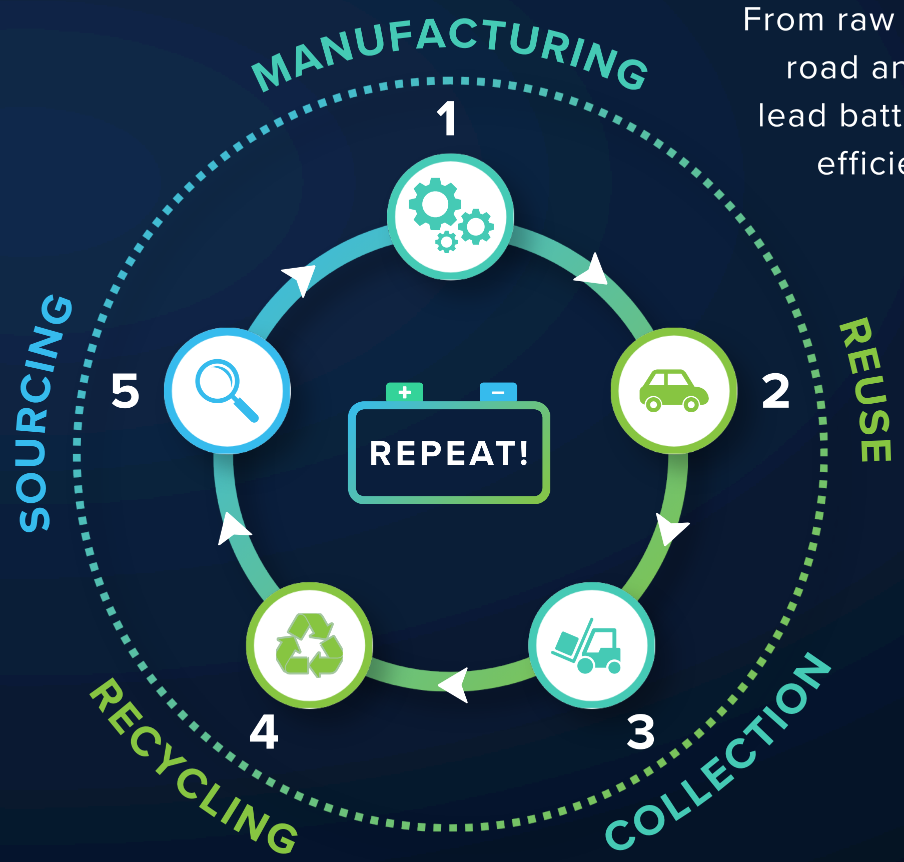
Without lead battery recycling, the U.S. would depend entirely on foreign imports for critical minerals that are essential to battery manufacturing. The lead battery recycling industry's successful closed loop exemplifies an integrated U.S. – and North American – system that fosters a successful circular economy. The foundation of this successful battery recycling industry is a consistent, safe and reliable flow of recyclable materials. Lead battery recyclers designed and built the blueprint for an economically viable closed loop for lead batteries. The industry's established domestic collection network and infrastructure have become a model for other battery chemistries – and industries – in how to responsibly source, use, reuse and manage input and output materials. Foremost, the process recovers critical minerals within a lead battery, ensuring a stable input flow for domestic battery manufacturers to make new batteries.

For decades, North America's battery companies have worked to keep critical minerals onshore to meet growing energy storage needs. This is particularly true for lead, where the U.S. produces no "primary" lead from ore-processing operations. Protecting lead battery recycling infrastructure and the impressive 98% recycling rate reported by this study will allow the U.S. to strengthen its supply chain and, in turn, operate at full manufacturing capacity for new batteries that depend on critical minerals.



LEAD BATTERIES: A CIRCULAR ECONOMY

From raw materials to the road and back again — lead batteries feature an efficient, closed-loop system.



HOW A “CLOSED-LOOP” RECYCLING SYSTEM WORKS

The U.S. lead battery industry has established a mature and highly efficient circular economy built on the collection, recycling and reuse of battery materials.

The process begins with collection. Through a nationwide network of retailers, service centers and distribution facilities, spent lead batteries are collected, sorted and transported to specialized recycling facilities. There, critical minerals and other materials are recovered and processed for reuse. The final step is refining these recovered materials to meet the precise specifications required to manufacture new batteries, thus completing and restarting the circular cycle.

U.S. recycling facilities operate under stringent environmental, health and safety standards designed to protect workers, communities and the surrounding environment. Comprehensive Environmental, Health and Safety (EHS) programs, personal protective equipment, workplace controls and protocols ensure recycling operations are conducted safely and responsibly.

RESPONSIBLE RECYCLING PROTECTS WORKERS & COMMUNITIES

North American battery recyclers are committed to a safe, responsible recycling system built on worker safety, environmental stewardship, and community protection. On average, U.S. battery recyclers invest about 15,000 hours annually in Environmental, Health and Safety (EHS) training to support these core values.

Since 1997, BCI's manufacturing and recycling members have participated in a voluntary program that exceeds U.S. federal requirements for blood lead levels in the workplace. This industry-led initiative has helped drive innovation in air filtration, water treatment, and other exposure controls that often exceed baseline requirements.

Members also regularly collaborate through BCI's EHS Committee work, in-person safety forums, and other efforts that promote continuous improvement, best practices, and regulatory compliance. That includes the biennial BCI Environmental Health & Safety Conference, the largest meeting of lead battery EHS professionals in the nation.

ehs ENVIRONMENTAL HEALTH & SAFETY CONFERENCE

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RECYCLING LEAD REDUCES ENERGY COSTS AND EMISSIONS

Recycling lead is one of the clearest examples of how the circular economy delivers measurable environmental benefits. However, keeping spent batteries out of landfills is not only a waste management victory but also a win for emissions and energy efficiency.

Benchmark data from Bureau of International Recycling shows that producing 100,000 metric tonnes of lead from recycled material requires just 13 terajoules (TJ) of energy, compared with 1,000 TJ for primary lead produced from mined ore—a savings of 987 TJ, or nearly 99%.

The carbon benefits of lead recycling are striking. For the exact same amount of metal, secondary lead smelters generate just 2 kilotonnes of CO_2 compared with 163 kilotonnes for primary production – another 99% reduction.

These dramatically lower emissions translate into lower energy consumption, lower operating costs, and a substantially smaller carbon footprint. That makes recycling lead an important part of domestic supply chain security, greenhouse gas reduction, and industrial competitiveness.

Energy Requirement and Savings (TJ per 100,000 tonnes)

Material	Primary	Secondary	Saving/100,000 Tonnes (% energy savings)
Iron	1,400	1,170	230 (16%)
Lead	1,000	13	987 (99%)
Nickel	2,064	186	1,878 (91%)
Tin	1,820	20	1,800 (99%)
Zinc	2,400	1,800	600 (25%)

Carbon Footprint and Savings (ktCO_2 per 100,000 tonnes)

Material	Primary	Secondary	Saving/100,000 Tonnes (% CO_2 savings)
Iron	167	70	97 (58%)
Lead	163	2	161 (99%)
Nickel	212	22	190 (90%)
Tin	218	3	215 (99%)
Zinc	236	56	180 (76%)

BATTERY INDUSTRY BACKGROUND

Economic Impact

Batteries are a cornerstone of the modern American economy. Annually, the domestic battery industry directly supports $10 trillion worth of domestic industrial economic output (21% of the U.S. economy). In addition, roughly 54 million jobs are related to, or reliant upon, battery innovation, technology, sustainability, and manufacturing. Downstream economic impacts include other industries, such as transportation, telecommunications and alternative energy.

The U.S. government also depends on batteries. There is roughly $7.5 billion in annual demand for domestically produced batteries used in government and defense applications.

Currently, U.S. lead battery manufacturers contribute roughly $3 billion in tax revenue annually. Domestic lead battery manufacturers are a significant driver of jobs and economic growth. These companies and their supply chains provide more than 106,000 U.S. jobs.

Key Applications of Batteries

Lead batteries have provided the foundation of rechargeable energy storage in the United States for more than 125 years. Their proven performance, reliability, safety, and recyclability continue to make them indispensable across the economy. Batteries power these essential applications:

Automotive

Automotive batteries are the most familiar energy storage product for most Americans. That includes traditional 12-volt lead batteries used for starting engines as well as lithium power supplies for EV drive trains. More modern vehicle electronics may also require a 48-volt system to support high-tech conveniences.

Telecom, AI, Data Centers & Critical Systems

The rapid growth of AI and digital infrastructure is increasing demand for reliable backup power. Battery systems provide uninterrupted power for AI data centers, telecommunications networks, emergency communications and other mission-critical systems, supporting 24/7 availability and the resilient operation of essential services.

Aerospace and Defense

Batteries are a critical component in all aviation missions, from military tactical operations – including warfare and supply deliveries to military bases – to providing reliable power for aircraft, from starting and in-flight operations to landing safely.

Power Grid & Energy Storage

Batteries provide a measure of reliability to intermittent power by allowing storage of excess energy. This includes batteries for residential use, microgrid storage systems for industrial use, and long-duration grid storage.

Industrial Logistics

Batteries power forklifts and lift trucks, providing cost-effective operation, as well as a lower carbon footprint than combustion engine alternatives. Currently, more than two-thirds of all forklifts use some kind of battery power.

Mobility and Power Sports

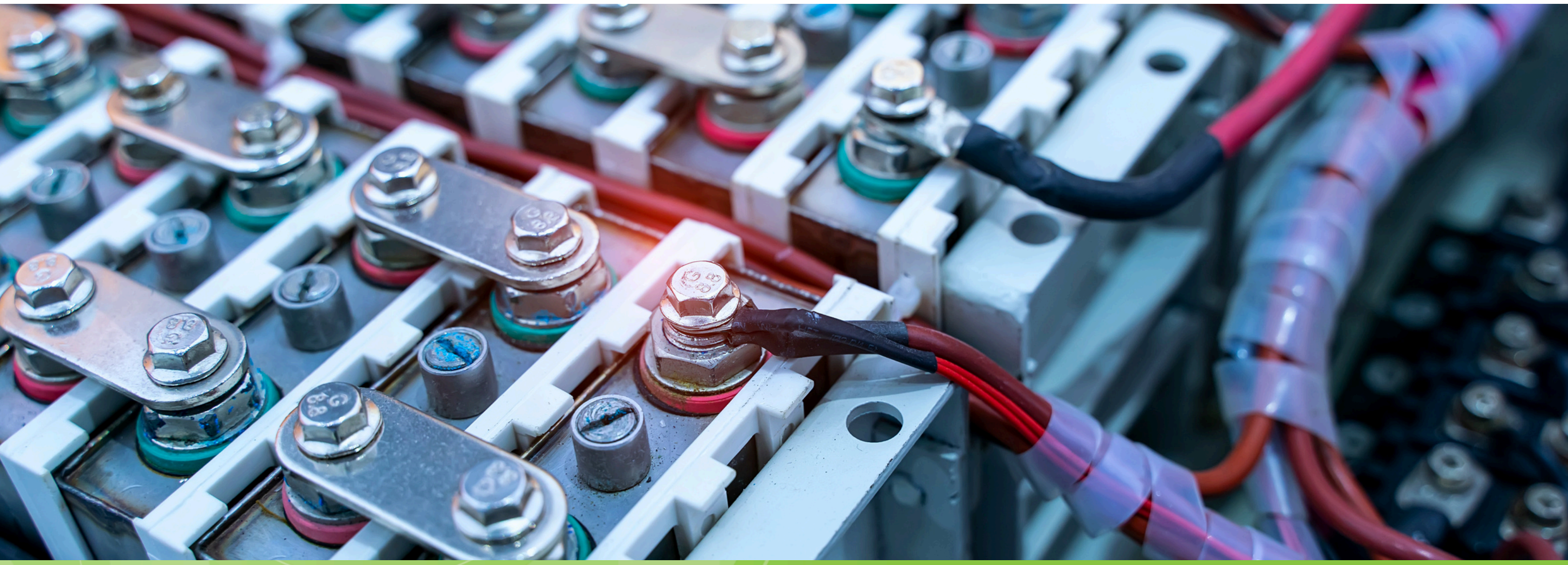
Batteries provide critical personal freedom for millions of individuals with physical mobility limitations who rely on wheelchairs or motorized scooters. Batteries also power off-road ATVs, watercraft and other vehicles.

All Batteries are Needed – from Lead to Lithium to Beyond

Meeting the fast-growing need for battery power in North America will require that all battery technologies be available. BCI advocates for a multi-chemistry battery ecosystem, built on the proven success of the domestic lead battery industry.

To remain global leaders, the U.S. must support the continued commercialization of next-generation lead, sodium, flow, and other battery technologies. These new technologies will provide growth and smartly diversify supply chains.

A true multi-chemistry approach means using the right product to deliver results. This ensures the nation's future energy storage needs are met reliably, safely, and with North American production sources.



ABOUT BATTERY COUNCIL INTERNATIONAL

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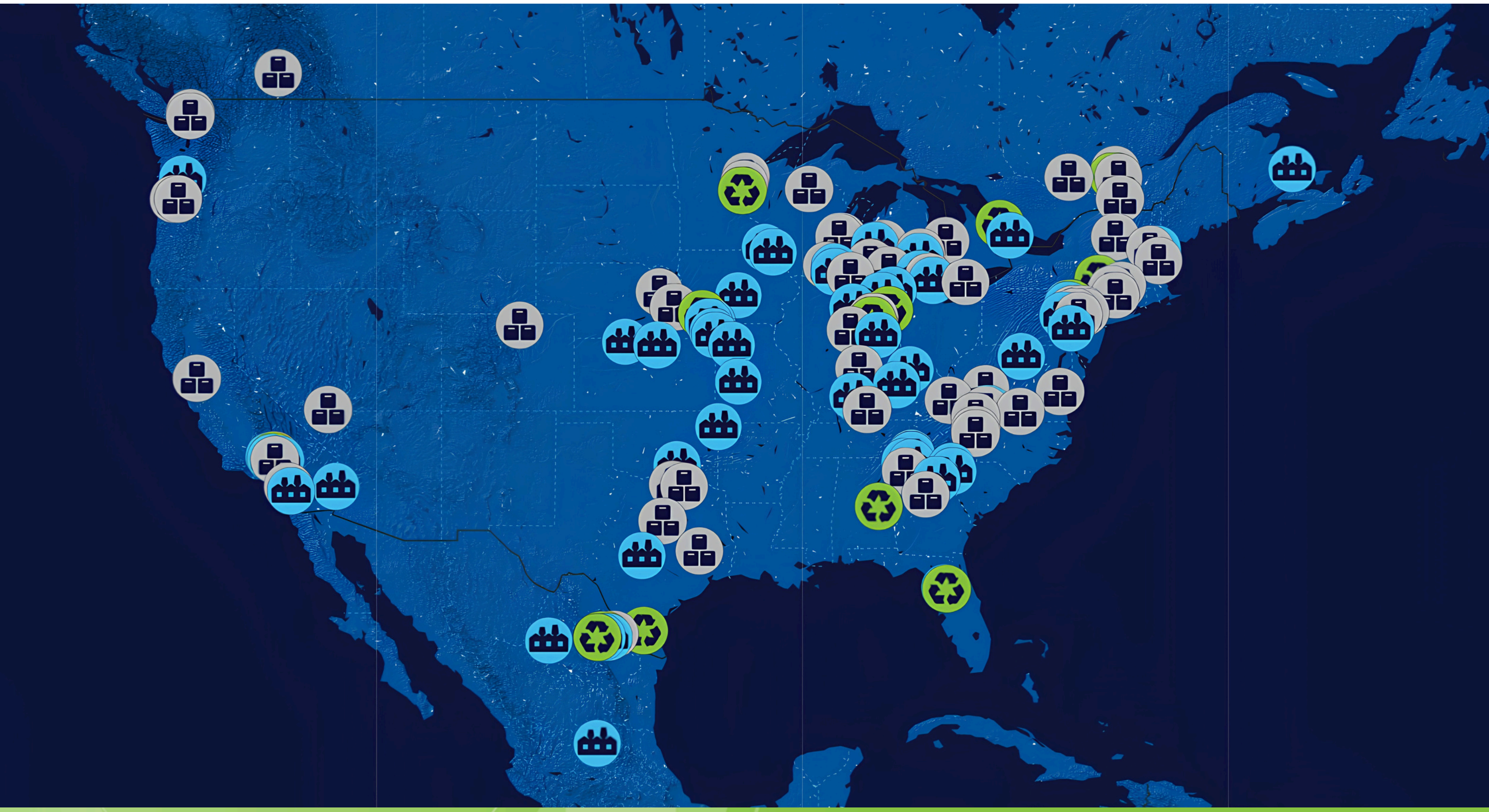
Battery Council International (BCI) is the leading trade association representing the global battery industry and the premier authority on energy storage solutions. Founded in 1924, BCI advocates and educates on behalf of battery manufacturers and recyclers, marketers and retailers, suppliers of raw materials and equipment, and battery distributors.

With a unified voice, BCI conveys an industrywide commitment to sustainability, safety and science. BCI unites its 160 members to successfully communicate and protect the most successful circular economy on the planet through education, science, and advocacy efforts. For more information, visit BatteryCouncil.org.

Map of BCI Member Facilities

Collectively, BCI members represent the majority of the incumbent battery supply chain in North America. BCI members manufacture a wide range of battery technologies including lead, lithium, flow, sodium, supercapacitors, and more. The lead battery industry's successful circular economy is the result of an integrated, ready-to-scale network of BCI member facilities throughout North America. This established foundation ensures that battery manufacturers have the reliable supply chain required to meet the growing demand for batteries.



BCI Recycling Rate Worksheet: 2020 - 2024

The following pages contain the worksheet from which the recycling rate for the years 2020 - 2024 was calculated and footnotes listing sources from which relevant data were obtained.

AVERAGE BATTERY LIFE 1/	YEAR OF MFR. 2/	BATTERY TYPE AUTOMOTIVE:	BATTERY SHIPMENTS (units) 9/	BATTERY EXPORTS (kg Pb) – 3/	BATTERY EXPORTS (units) – 3/	BATTERY IMPORTS (units) +15/	BATTERY IMPORTS (kg PB) +15/	VEHICLE/ PRODUCT IMPORTS (units) + 4/	VEHICLE/ PRODUCT EXPORTS (units) – 5/	Net Imports of Batteries (units)	AVERAGE LEAD WEIGHT (lbs) 7/	LEAD IN BATTERIES (lbs) EOL in USA = 8/	Weight from US Replacement Shipments	Weight from US Scrapped Vehicles
4	2017 - 2021	Passenger Car & Light Truck									25.04	9,819,357,656	8,407,536,463	1,411,821,193
3	2018 - 2022	Truck & Heavy-Duty Truck									46.92	2,101,446,633	2,063,606,631	37,840,001
3	2018 - 2022	Tractor	2,037,967	-	-	-	-	-	-	2,037,967	31.30	63,789,595		
3	2018 - 2022	Marine & RV	37,317,118	-	-	-	-	-	-	37,317,118	36.41	1,358,771,149		
2	2019 - 2023	General Utility	37,633,331	-	-	-	-	-	-	37,633,331	9.63	362,220,811		
3	2018 - 2022	Golf Car & Floor Scrubber	32,450,783	-	-	-	-	126,864	165,488	32,412,159	39.31	1,273,986,403		
2	2019 - 2023	Motorcycle	25,796,420	33,202,686	7,682,330	-	-	6,297,110	564,391	31,529,139	9.76	234,573,595		
2	2018 - 2022	Aircraft												
6	2015 - 2019	Military												
3	2018 - 2022	Aircraft, Military, Miscellaneous & Others	11,002,502	-	-	-	-	-	-	11,002,502	25.00	275,062,557		
		Total Automotive										**15,489,208,400**		
6	2016 - 2020	MOTIVE POWER****:										1,528,035,152		
10	2011 - 2015	STATIONARY >25Ah:										877,281,176		
5	2016 - 2020	STATIONARY SSL <25Ah:	-	411,809,279	46,496,885	156,191,892	552,154,050	-	-	156,191,892	4.40	309,406,889		
						TOTAL POUNDS OF LEAD IN BATTERIES CONSUMED DOMESTICALLY:						**18,203,931,617**		
						LEAD RECYCLED FROM BATTERIES :						**11,050,891,844**		

Total Lbs Lead in Batteries EOL in USA	BATTERY SCRAP LEAD IMPORTS	BATTERY SCRAP LEAD EXPORTS	Total Lbs. Lead in Batteries Available for Recycling
18,203,931,617	244,205,671	7,142,366,331	11,305,770,957

2020 - 2024 RECYCLING	**LEAD RECYCLED**	=	**11,050,891,844**	=	**97.7%**
RATE	**LEAD AVAILABLE**		**11,305,770,957**		

Footnotes to the Recycling Rate Worksheet

FOOTNOTE	DESCRIPTION
1/	**Average battery life.** Source: BCI Lead Content and Expected Life by Battery Type Survey, collected annually from BCI member manufacturers for automotive types. Industrial and SSLA data developed in consultation with relevant manufacturers.
2/	**Year of manufacture.** Year of manufacture is the year in which the product shipped. For each category the window shown is determined by offsetting the 2020–2024 study period by that category's average life.
3/	**Battery exports.** Source: U.S. Department of Commerce, accessed through U.S. International Trade Commission DataWeb. New battery exports are drawn from two HTS families: the 8507.10 series (lead-acid storage batteries of a kind used for starting piston engines) and the 8507.20 series (other lead-acid storage batteries, including SSLA). Where DataWeb reports a second-unit quantity in kilograms, gross weight is converted to lead content using the shipping-weight-to-lead factor in the parameter table.
4/	**Vehicle and product imports.** Source: U.S. Department of Commerce via ITC DataWeb. Four HTS families are used: 8702 (public transport passenger vehicles), 8703 (passenger motor vehicles), 8704 (motor vehicles for the transport of goods), and 8711 (motorcycles and powersport vehicles). Statistical suffixes are mapped to battery categories to assign appropriate battery size/type based on vehicle type. Golf cart imports are reduced by 50% to reflect the reported lithium share of that import stream over the study period. Battery-electric vehicle lines that do not carry a lead starter battery are excluded.
5/	**Vehicle and product exports.** Source: U.S. Department of Commerce via ITC DataWeb, using the same HTS families and category mapping as 4/. Used vehicle exports, which are deducted separately within the scrappage calculation at 17/, are taken from U.S. Department of Commerce used vehicle export data.
6/	**Batteries reaching end of life in the United States.** For passenger car and light truck and for truck and heavy-duty, this is the sum of the replacement shipment stream (16/) and the vehicle scrappage stream (17/) (See methodology description for additional details). For every other automotive category it is U.S. shipments, less battery exports, plus battery imports, plus vehicle and product imports, less vehicle and product exports.
7/	**Average lead weight.** Source: BCI Battery Weight and Group Size Survey, in which member manufacturers report shipments and average lead content by group size.
8/	**Lead in batteries reaching end of life.** Unit counts multiplied by average lead weight (7/). Motive power and stationary batteries are reported directly in pounds of lead and require no conversion.
9/	**Battery shipments.** Source: BCI Monthly Transportation Battery Shipment Report for 2020 forward, and BCI's historical shipments database, which extends to 1937, for earlier years in each lagged window. Reported shipments cover all batteries shipped in the United States, including imported batteries subsequently shipped to a domestic destination. SSLA shipments are set to zero because that segment is served almost entirely by import. Member-reported volumes are grossed to a total market basis using the total market adjustment factor in the parameter table.
10/	**Confidentiality.** Aircraft, military, and miscellaneous battery shipments are reported by too few companies to be published separately and are combined on a single line. The underlying data are included in every calculation. Individual smelter volumes (18/) are likewise confidential and are published only in aggregate.

FOOTNOTE	DESCRIPTION
11/	**Battery scrap lead imports.** Source: U.S. Department of Commerce via ITC DataWeb. Two HTS families are used: 7802 (lead waste and scrap obtained from lead-acid storage batteries), reported in kilograms, and the 8548.10 series (spent primary cells, primary batteries, and electric storage batteries imported for the recovery of lead), reported in numbers of batteries. Kilogram quantities are converted to pounds; unit counts are converted to lead weight.
12/	**Battery scrap lead exports.** Source: U.S. Department of Transportation, Bureau of Transportation Statistics, reported in metric tons, as the primary series, corroborated against U.S. Department of Commerce via ITC DataWeb; Global Trade Tracker (GTT); Global Trade Atlas (GTA); and CEPII, BACI: International Trade Database (2026). Spent battery tonnage is converted to lead content and then to pounds. BCI uses multiple U.S. and international sources because U.S. export classification of spent lead batteries has been inconsistent and is recognized to under-report export volumes.
13/	**Lead available for recycling.** Total lead in batteries reaching end of life in the United States (6/), plus battery scrap lead imports (11/), less battery scrap lead exports (12/).
14/	**Recycling rate.** Total pounds of lead recycled from batteries (18/) divided by total pounds of battery lead available for recycling in the United States (13/), expressed as a percentage of the five-year period 2020–2024.
15/	**Battery imports.** Source: U.S. Department of Commerce via ITC DataWeb, 8507.20.80 series (lead-acid storage batteries other than those used for starting piston engines). This line carries SSLA imports only; automotive battery imports enter the worksheet through shipments (9/) and are not added again here. The recodified 8507.20.80 series is used and the superseded 8507.20.00 series excluded, so that the same trade is not counted twice across the recodification. The 36-volt lines are excluded because motive power lead is reported directly by member companies.
16/	**Weight from U.S. replacement sales.** Retail replacement shipments are utilized to account for end-of-life batteries being replaced with like-for-like batteries. Shipments are aggregated by group size, priced at the group size average lead weight (7/), and placed on a U.S. basis using the U.S. share of North American shipments.
17/	**Weight from U.S. scrapped vehicles.** Source: Auto Care Association, automotive scrappage rates and vehicle fleet changes.
18/	**Lead recycled from batteries.** Source: BCI Recycling Survey of U.S. secondary lead smelters. Individual company volumes are confidential; only the aggregate is published.
19/	**Rounding.** Figures are calculated at full precision and rounded for presentation; line items may not sum exactly to the totals shown.

HOW BCI MEASURES THE RECYCLING RATE

The lead battery is the most recycled consumer product in the United States, and BCI has measured how completely that recycling happens using the same underlying framework since 1990. Every edition of the National Recycling Rate Study asks one question and answers it the same way: of all the lead in batteries that reached the end of its service life in the United States over the study period, what share was successfully collected and returned to a secondary smelter for recycling? For 2020 through 2024, the answer is 97.7%. The paragraphs that follow explain how that figure is built, what each input is drawn from, and what changed in this edition.

The calculation itself is a single ratio. Lead recycled from batteries, divided by lead available for recycling, expressed as a percentage. The discipline of the study lies almost entirely in reliably constructing those two quantities from hundreds of data points.

Why Five Years

BCI reports a five-year rate rather than an annual one because the physical system does not run on a calendar. A battery bought in December is not scrapped in December, and a truckload of spent batteries collected at the end of one year may cross a smelter scale in the next. Battery sales move with weather and with the economy; scrap moves with the lead price; trade moves with freight capacity and with tariff schedules. Major economic disruptions (e.g., COVID-19) can dramatically alter sales and use patterns in specific years. Any of those can push a single year several points high or low without anything real having changed. Aggregating over five years provides a more accurate view of how the collection and recycling system is working.

The Numerator: Lead Actually Recovered

The numerator is the firmer half of the equation. Ten U.S. secondary lead recycling facilities process spent batteries. Over 2020–2024, 11.05 billion pounds of battery lead was collected and returned to those facilities for recycling.

Due to the significant volumes (more than 174 million batteries processed per year), recyclers weigh incoming loads rather than sorting them. The numerator cannot be disaggregated by battery type. A rate for automotive batteries alone, or for SSLA alone, cannot be produced from this data and BCI does not publish one.

Retiring the Fleet Aging Model

In 2026, BCI is replacing the fleet aging model previously used for passenger cars, light trucks, and heavy-duty vehicles. For most of the study's history, the volume of lead available for recycling was built by aging the in-use battery fleet. Total shipments in a year were assumed to retire a fixed number of years later, equal to the average life of that battery category — four years for total automotive, three for heavy-duty. For example, batteries retiring in 2020 through 2024 were assumed to be the batteries shipped in 2017 through 2021. The lifespan estimates were updated each cycle to account for product development and maturation, but the methodology was unchanged.

The assumption was defensible because the use pattern was stable: a mature product with a well-characterized service life, sold into a vehicle fleet whose composition changed slowly. That stability no longer holds. Three factors were most significant across the years this study covers.

- The composition of the market moved: light truck and SUV platforms continued to displace passenger cars, and the group sizes that dominate shipments shifted with them. Additionally, the growing number of stop-start vehicles and auxiliary load batteries face fundamentally different use-demands than traditional SLI applications.
- The 2020-21 COVID pandemic broke the traditional trends between when a battery shipped and when it entered end-of-life. Changes in vehicle use patterns disrupt the aging assumptions during the specific study years, and the cumulative impacts extend beyond those years.
- Continuous product improvements have changed the underlying lifespan profiles: enhanced flooded and AGM formats took meaningful share from conventional flooded designs.

The fleet aging method has therefore been deprecated for passenger car, light truck, and heavy-duty vehicle battery types – the categories with the most significant market change. These categories also have available alternative data methodologies. BCI retains the calculation internally as a historical bridge, but it is no longer the basis for a published rate.

How the Denominator is Built Now

Passenger car, light truck, and heavy-duty batteries account for roughly two-thirds of the domestic pool, and for those categories the denominator is now assembled from two observable streams rather than one inferred cohort. The first stream is replacement sales. When a driver buys a battery to replace one that has failed, that purchase is a direct record of a battery leaving service. BCI's transportation survey reports shipments separately by channel, so the replacement stream can be isolated for study purposes.

The second stream is vehicle scrappage. When a vehicle is retired, whatever battery is in it leaves the domestic fleet with it. For passenger cars and light trucks (total automotive), BCI applies annual scrappage rates to vehicles in operation, deducts used vehicles exported rather than scrapped, and converts the remainder to pounds of lead. For heavy-duty trucks, where retirement behavior differs materially from the light vehicle fleet, retirements are derived from the registration data itself: new registrations less the net change in the registered population gives implied retirements directly.

Every remaining category — tractor, marine and RV, general utility, golf car and floor scrubber, motorcycle and powersport, aircraft, military, and miscellaneous — continues to use the fleet aging methodology, which remains appropriate where the product has a stable and well-understood service life.

Motive power and stationary batteries are handled separately and simply, because members report lead content directly in pounds rather than in units. Motive power draws on six years of reporting to match a six-year average life; stationary batteries above 25Ah draw on ten years to match a ten-year life, sourced from the industry-wide survey. Small sealed lead-acid batteries are estimated entirely from trade data, since that segment is served almost wholly by import.

Trade: The Largest Single Adjustment

The domestic pool is not the same as the domestic market, and the difference is mostly trade. Batteries and the vehicles containing them cross the border in both directions, and spent batteries cross in volume. Over 2020–2024, the United States imported 0.24 billion pounds of battery lead as scrap for domestic reprocessing and exported 7.14 billion pounds of spent battery lead for smelting abroad. That export figure is the largest single line in the worksheet after total automotive batteries themselves, and it must be deducted: lead recycled in Canada, Mexico, or beyond is recycled, but it is not available to the domestic system whose performance this study measures.

Scrap export volumes rest on Bureau of Transportation Statistics tonnage as the primary series, corroborated against Commerce trade data and the international trade databases identified in the footnotes. That is a deliberate departure from relying on tariff classifications alone, and the reason is a known problem: U.S. classification of spent lead battery exports has been inconsistent between the two applicable HTS codes and is recognized to under-report volume. Tonnage reported at the border is the more stable measure, and the international sources provide a check on the scale of the shortfall.

Parameters Applied in this Edition

The principal conversion factors and reference values applied throughout the worksheet are collected here. Additional conversion factors used in the calculation are held in the study database.

Parameter	Value applied, 2020–2024
Weight set applied	**2024 market-share-weighted average**
Average lead weight, passenger car & light truck	**25.04 lbs.**
Average lead weight, truck & heavy duty	**46.92 lbs.**
Average lead weight, scrapped passenger vehicle battery	**22.42 lbs.**
U.S. share of North American shipments	**84.55% (Canada 4.09%, Mexico 11.36%)**
Total market adjustment	**1.0174**
Shipping weight to lead weight, automotive	**0.5999**
Shipping weight to lead weight, SSLA	**0.70**

About This Estimate

The recycling rate is an estimate, built from industry surveys and trade statistics and reported over a five-year period for the United States. Each input carries some uncertainty. Member companies report shipments and lead content under confidentiality; trade data reflects filing practice at the border; vehicle fleet and scrappage figures are themselves modeled estimates from their publishers. BCI works with the most complete data available for each component and identifies the source of every line in the worksheet, so that a reader can follow the calculation and form an independent judgment about it.

The five-year construction is deliberate. Timing differences between when a battery is sold, when it is taken out of service, and when it crosses a smelter scale can move any single year by several points, creating statistical anomalies. Measuring across 2020–2024 allows those differences to settle and describes how the collection system performs over a full cycle. BCI reports the figure to one decimal place, which is the precision the inputs support. The study is built to produce one rate for the five-year period across all lead battery types, and its components should not be used to derive a rate for an individual year or for a single battery type.

Methods develop as the market does. Where an input or an assumption has changed from a prior edition, the change and its basis are recorded in the study's revision history, and the underlying database is retained so earlier cycles remain reproducible. BCI reviews the framework each cycle and will continue to refine it as data sources improve. Comments and data contributions from members, researchers, and agencies are welcome.

Data Sources

The denominator draws on several distinct data pipelines, each covering a different segment of the battery pool.

BCI Member Transportation Survey	The primary source for automotive battery shipment volumes. Member companies report monthly shipments by battery type, group size, channel (OE vs. replacement), and region. Data covers the United States, Canada, and Mexico. The 2020–2024 study uses transportation survey data for 2020–2023 supplemented by BCI's historical shipments database for earlier years in the lagged windows.
BCI Group Size and Weight Survey	An annual survey of member companies reporting battery shipments and average lead weights by group size. Used to convert shipment unit counts into pounds of lead. The 2024 market-share-weighted average weights are used in this study: 25.04 lbs per passenger car battery, 29.20 lbs per standard commercial battery (31T/31A sizes), and higher values for premium formats.
ACA Vehicle-in-Operation Data	Annual estimates of registered passenger cars and light trucks in the United States, used with historical scrappage rates to estimate the number of vehicles retired each year. Vehicle exports are deducted to avoid counting batteries that left the country with their vehicles rather than entering the domestic recycling stream.
U.S. International Trade Commission / Census Bureau (ITC DataWeb)	Import and export data by Harmonized Tariff Schedule (HTS) code, used to estimate the net flow of batteries across the U.S. border. Battery imports add to the domestic pool; battery exports reduce it. Where ITC reports actual kilogram weights alongside unit counts, the weight data is used directly; otherwise, per-unit weight estimates are applied. Trade data is also used for Small Sealed Lead-Acid (SSLA) batteries, which are overwhelmingly imported.
U.S. DOT / Bureau of Transportation Statistics	Data on spent lead battery exports reported in metric tons, used to estimate the volume of used batteries exported for smelting abroad. This pipeline is used in preference to ITC data for scrap exports because Census Bureau HTS classification of spent lead battery exports has historically been inconsistent between two applicable codes.
BCI Industrial Battery Survey	BCI member companies that manufacture or distribute motive power batteries (forklifts, floor scrubbers, etc.) report annual lead content directly in pounds. Six years of data (2017–2020 from member reports; 2016 from the Smithbucklin industry-wide survey) are used to match the six-year average lifespan of industrial batteries.
Smithbucklin Industry Survey	An industry-wide survey covering motive power and stationary battery lead content for years and companies not captured in the BCI member survey. Provides the 2016 motive power supplement and the full stationary battery (>25Ah) estimate, which draws on ten years of data (2011–2015) matching a ten-year average battery lifespan.
BCI Location of Manufacture Survey	An annual survey establishing what share of batteries sold in North America were manufactured in the United States, Canada, and Mexico respectively. The 2020–2024 study applies a U.S. share of 84.6%, Canada 4.1%, Mexico 11.4%, to convert North American shipment weights to a U.S.-only denominator.

Denominator Components at a Glance

The 11,306 million pounds of lead available for recycling under the Replacement Sales methodology is composed as follows:

Category	Lead Poundage
Passenger Car & Light Truck	9,819 million lbs (8,408 replacement sales + 1,412 vehicle scrappage)
Heavy-Duty Truck	2,101 million lbs (2,064 replacement sales + 38 vehicle scrappage)
Tractor	64 million lbs
Marine & RV	1,359 million lbs
General Utility	362 million lbs
Golf Car & Floor Scrubber	1,274 million lbs
Motorcycle & Powersport	235 million lbs
Aircraft, Military & Miscellaneous	275 million lbs
Motive Power (Industrial)	1,528 million lbs
Stationary >25Ah	877 million lbs
Small Sealed Lead-Acid (SSLA)	309 million lbs
Total Lead in Batteries (Domestic)	18,204 million lbs
Plus: Battery Scrap Imports	+244 million lbs (used batteries imported for domestic reprocessing)
Less: Battery Scrap Exports	−7,142 million lbs (spent batteries exported for smelting abroad)
Net Lead Available for Recycling	11,306 million lbs

The largest single adjustment is the deduction for battery scrap exports — 7,142 million pounds over five years. The United States is a significant net exporter of spent lead batteries, shipping used batteries to smelters in Canada, Mexico, and elsewhere. Because those batteries are recycled outside the United States, the lead they contain must be subtracted from the domestic available pool before the domestic recycling rate is computed.

The second-largest component is total automotive batteries. The weight of lead in that category — and the methodology used to estimate it — therefore has the greatest influence on the final recycling rate, which is the principal reason for the methodological upgrade described above.