Economic Contribution of the Missouri Lead Battery Industry in 2021

The Doe Run Company

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EBP

Contents

Executive Summary

Missouri is home to a considerable amount of lead battery manufacturing, recycling, and mining activity. This activity generates economic impacts that spread throughout the statewide economy, supporting growth in industry and a wide range of jobs in the following ways:

- When battery manufacturing, recycling, and mining companies employ workers and generate business income. These represent **direct impacts.**
- When battery manufacturing, recycling, and mining companies purchase goods and services from other companies. These represent **supplier impacts.**
- When workers at battery manufacturing, recycling, and mining companies, as well as workers at supplier companies, spend their after-tax income on consumer goods. These represent **worker spending impacts.**
- Lead battery companies, recyclers, and mining companies innovate through ongoing **research and development (R&D).** These R&D activities contribute to the industry's future growth and productivity.

In addition to direct activity in the manufacturing, recycling, and mining sectors, the Missouri lead battery industry is supported by numerous suppliers, retailers, and marketing companies. In 2021, Missouri's lead battery industry directly employed 4,110 workers and spent $293.7 million annually on payroll. Doe Run accounts for 1,080 of these jobs and $103.8 million in payroll. In addition to the workers Missouri's lead battery industry directly employs, it supports 2,170 supplier jobs and 2,270 jobs from worker spending in different industries.

Together, these statewide impacts total 8,550 jobs (including research and development jobs). Beyond its job impact, the Missouri lead battery industry annually supports:

- **$553.7 million in labor income,**
- **$981.9 million in gross state product (GSP),**
- **$2.3 billion in output or overall economic impact,**
- **an average of $71,500 in payroll per worker,**
- **$114.3, and $69.7 million in federal, state and local tax revenue respectively (combined $184.0 million), and**
- **$3.6 million in R&D spending.**[1]

These impacts are spread across a variety of industries in Missouri, with the services, trade, and transportation sectors benefiting the most. Of these economic impacts generated in the lead

[1] All reported R&D spending in Missouri in 2021 was from Doe Run.

battery sector across the state, the Doe Run Company is estimated to be responsible for generating:

- **2,620 jobs,**
- **$198.2 million in labor income,**
- **$341.0 million in GSP,**
- **$715 million in output or overall economic impact,**
- **an average $96,300 in payroll per worker,**
- **$40.1, and $32.1 million in federal, state and local tax revenue respectively (combined $72.2 million), and**
- **$3.6 million in R&D spending.**

Study Purpose

The following study measures the statewide economic contribution of the Missouri lead battery industry in calendar year 2021. The analysis was conducted using the IMPLAN economic impact model. A survey was used to collect data including annual employment, sales, and payroll information from Battery Council International (BCI) member companies with manufacturing, recycling, or mining operations in Missouri.[2] Survey results were then added across companies to yield state-level activity that was entered into a Missouri IMPLAN model. Impact results are presented in terms of jobs, labor income, gross state product, output, and tax revenue.

About The Doe Run Company

Based in St. Louis, The Doe Run Company is a privately held natural resources company and a global provider of lead, copper, and zinc concentrates. Dedicated to environmentally responsible mineral and metal production, Doe Run operates one of the world's largest, single-site lead recycling centers, located in Boss, Missouri, and mines from one of the world's largest lead mining districts, also in Missouri. The Doe Run Company and its subsidiaries deliver products and services necessary to provide power, protection, and convenience. Doe Run has operations in Missouri, Washington, and Arizona.

About EBP US

EBP US is an American company that provides superior, cutting-edge economic expertise, tools, and analysis to help our clients make better decisions on policies, programs, and investments in the transportation, energy, environment, and economic development sectors. We shape the future through innovative and best-of-class solutions to public and private sector challenges to create a more sustainable world. EBP US belongs to the EBP Global family of firms, with full-service offices in the United States, Switzerland, Germany, China, Brazil, and Chile.

[2] Eighteen BCI member companies responded to the survey, including five with direct operations in Missouri. In a previous version of this study, Seventeen BCI member companies reported on direct employment and payroll, including five companies with direct operations in Missouri. All individual company data was kept confidential and company identities were not revealed as part of this study.

Lead Battery Industry Overview

Lead batteries are among the world's safest and most reliable sources of energy. Whether starting a car, storing power from a solar panel, or providing emergency backup power, lead batteries provide energy for the daily activities of billions of people around the globe.

Lead batteries are also among the most environmentally sustainable consumer products, with a recycling rate exceeding 99%. By comparison, the recycling rate for aluminum cans is 50%.[3] The typical new lead battery is comprised of more than 80% recycled material.[4] The lead battery industry uses a circular economy model, which means nearly all the materials used to produce batteries are either reused by the industry or recycled into other products (Figure 1).[5] Lead used in batteries can be infinitely recycled with no loss of performance — a quality that is unique among consumer products. This, coupled with high recycling rates, reduces the need to mine for virgin materials.

Figure 1. Circular Economy of Lead Batteries

Source: Battery Council International, 2019.

[3] *Advancing Sustainable Materials Management: 2018 Fact Sheet*, Environmental Protection Agency, December 2020.

[4] "Environmental Impact and Life Cycle Assessment of Lead Battery and Architectural Sheet Production," The International Journal of Life Cycle Assessment, 2016.

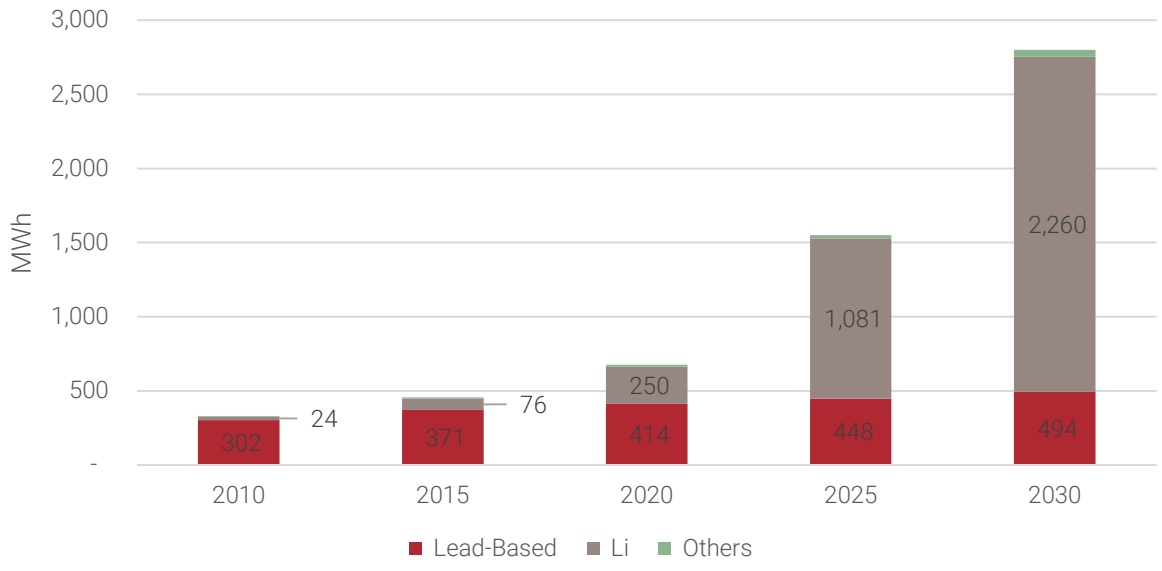
[5] "The Circular Economy of Lead Batteries," April 18, 2019, Essential Energy Everyday, https://essentialenergyeveryday.com/wp-content/uploads/2019/04/Circular-Economy-Brief.pdf.

New Battery Demand and Recycling

Rechargeable batteries are needed now more than ever to meet the energy demands of the growing U.S. and world populations, and the growing need for batteries in new concepts of electric mobility and stationary energy storage (Figure 2). Unfortunately, many rechargeable batteries are not recycled profitably (and therefore hardly recycled at all) because the price of recycled materials is higher than the price of virgin materials. Lead batteries are the exception to this. Lead battery manufacturing is the most environmentally sustainable of all battery technologies, with lead batteries being the most recycled consumer product in the U.S. (Figure 3).

Rechargeable battery market projections show lead battery demand increasing over time, driven by shifts in population growth, a demand for more renewable alternatives to fossil fuels, and an increasing awareness of global warming and its effects.[6] From these trends, we are seeing a growth in alternative battery technologies, as well as a constant rate of sustained demand for lead batteries as the U.S. explores new concepts of mobility and energy (e.g., electric mobility, renewable energy storage).

Figure 2. Rechargeable Battery Market Worldwide (2010 – 2030)



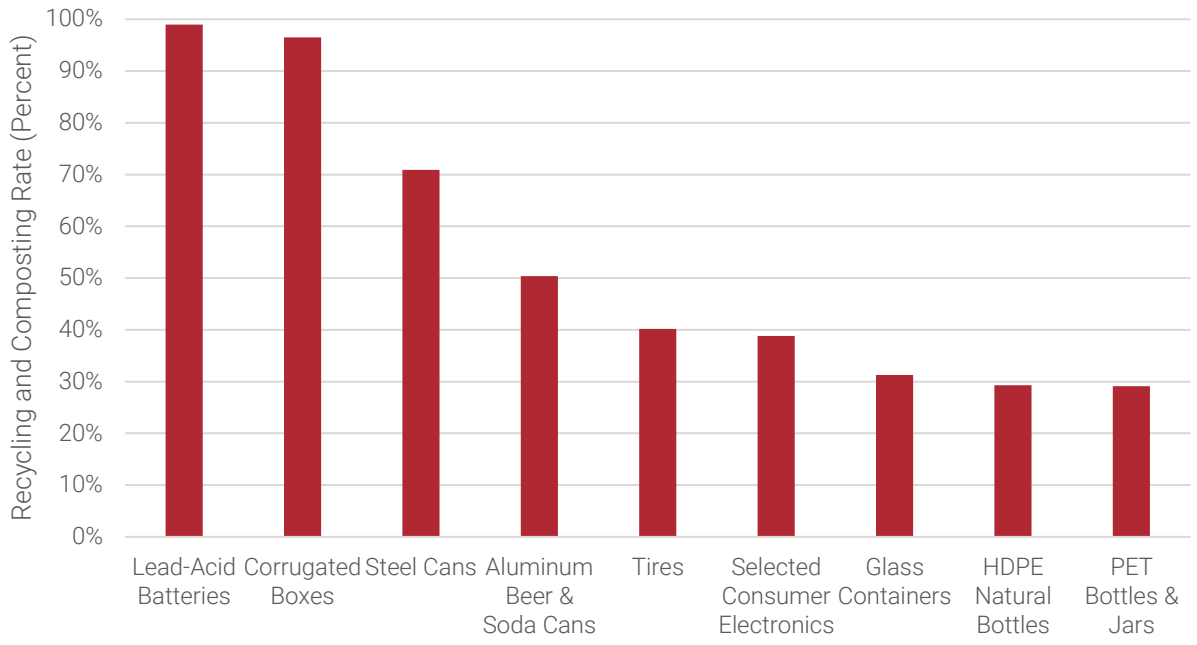
Source: Avicenne Energy Report: The rechargeable Battery Market & Main Trends, September 2022.

While all this exploratory growth in new technologies is occurring, lead batteries are particularly noteworthy for their high rates of recycling. The U.S. Environmental Protection Agency (EPA) has been tracking a range of products with respect to their rates of recycling and composting to

[6] *The Rechargeable Battery Market and Main Trends 2020-2030*, Avicenne Energy, September 2022

identify green products. As shown in Figure 3, lead batteries are at the forefront, with only corrugated boxes following closely behind (99% vs 97%).

Figure 3. Selected Products with High Recycling and Composting Rates

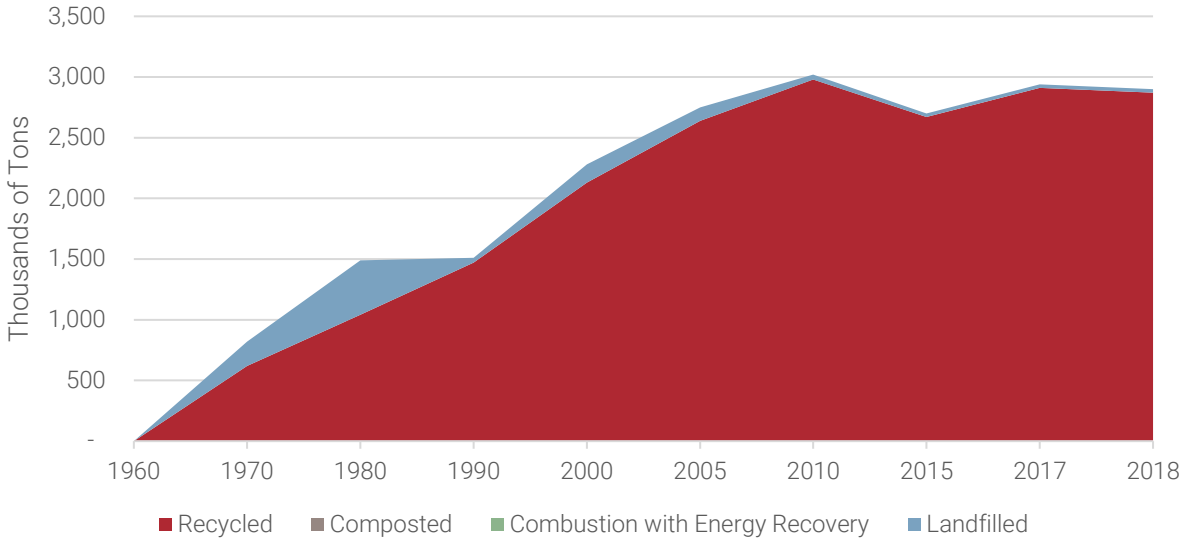


Source: *Advancing Sustainable Materials Management: 2018 Fact Sheet*, Environmental Protection Agency, December 2020.

This is not a new trend – the tracking of estimated recycling rates is maintained by the EPA and made part of a periodically updated report on materials, waste, and recycling. Figure 4 highlights the resulting estimated trend in recycling of batteries by the EPA.

It is critical to note that with the growth in demand for and consumption of lead batteries, the volume of recycled lead batteries has grown as well. The EPA data runs through 2018, and therefore does not capture any potential effects of recent closures of recycling facilities. It will be interesting to see whether the rate of recycling will be able to keep up with the growth in battery consumption absent of any intervention, or whether more investments need to be made in additional recycling facilities and supporting technologies. If there is not sufficient recycling capacity to keep up with the growth in overall demand, these high rates could be subject to change either by reducing the level of recycled content occurring, or as a growth in spent batteries and products for recycling outside of the U.S.

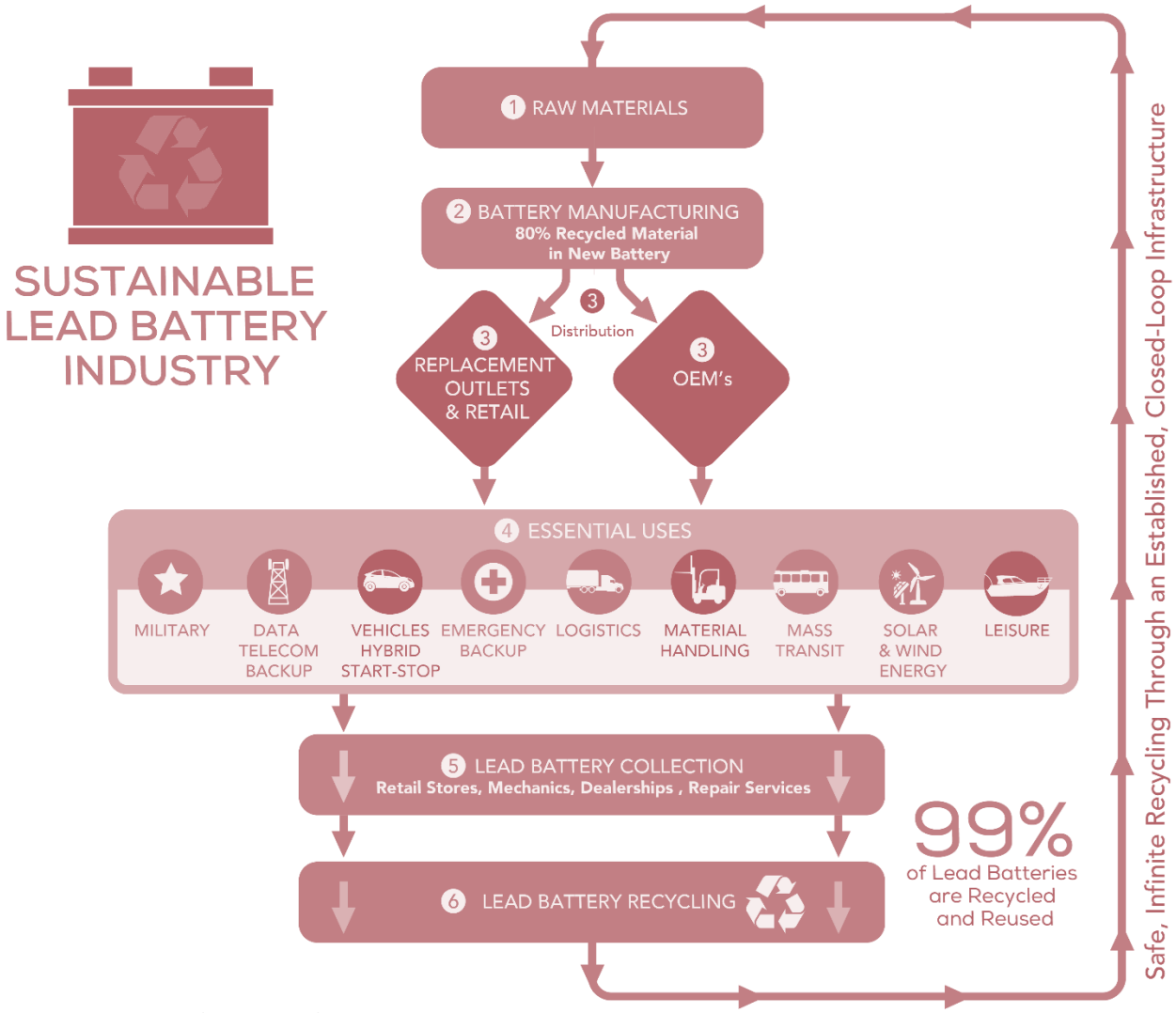
Figure 4. Lead Batteries Waste Management (1960 – 2018)



Source: EPA Facts and Figures about Materials, Waste and Recycling, 2018

The flowchart in Figure 5 illustrates how lead batteries are recycled and how their components are used to manufacture new batteries. This effective waste-reduction process is sometimes referred to as “cradle-to-cradle” production or a “closed-loop” industry. This model also supports domestic jobs and domestic supply of recycled materials to produce new lead batteries as demand increases.

Figure 5. Process of Recycling Lead Batteries



Source: Battery Council International, 2019.

Research & Development

Supporting new technologies and applications for lead batteries requires a commitment to constant innovation. In 2021 alone, the U.S. lead battery industry invested over $112.8 million in research and development to continue meeting the rapidly changing needs within transportation, renewable energy, communications, and many other sectors. Of U.S. lead battery industry research and development, Missouri lead battery companies invested $3.6 million. Additional advancements are expected from notable collaborations between public and private entities. Major lead battery manufacturers and suppliers are currently partnering with the U.S. Department of Energy's Argonne National Laboratory, Pacific Northwest National Laboratory, The University of

Toledo, the Missouri University of Science and Technology, and other institutions to research — and further advance — lead battery performance and energy storage applications.

Opportunities in Green Energy & Transportation

To date, innovation in lead battery production has significantly improved the lifespan of batteries and their ability to store energy. Lead batteries are a solution for renewable energy storage due to their long lifespan, ability to withstand extreme temperatures, and support of frequency regulation and load leveling. These features enable companies to store excess energy generated by wind turbines and solar panels when demand is low, and store energy for long periods of time. Lead batteries are also more affordable than comparable energy storage solutions, both up front and during decommissioning.

Lead batteries are enabling growth in electric vehicles (EVs) by providing critical safety and security functions. If an EV's primary battery fails, the auxiliary lead battery ensures vital functions like braking and steering, which make them necessary. Lithium battery technology has a role to play in fueling EVs of the future, but not to the exclusion of auxiliary lead batteries. This becomes materially important after announcements by the Biden administration of their intention to roll out funding and incentive programs to build out production facilities and grow a green market.[7] The nearshoring of such vehicle manufacturing jobs can serve as a source for locally produced lead batteries. This also comes with the announcement of discussions with Mexico's President on talks of generating a local chip and lithium supply chain to fuel EV production.[8]

Preparing to Fulfill Future Needs

A key opportunity for lead battery manufacturers is to store more energy in each battery, while still allowing users to extract power on-demand as efficiently as possible. Companies are exploring bipolar battery construction processes that can make lead batteries lighter, cheaper, faster-charging, and longer-lasting. Beyond developing improved batteries, manufacturers and recyclers are also working to make their processes more efficient. To further advance lead batteries in the marketplace, lead battery manufacturers and recyclers are members of the Consortium for Battery Innovation (CBI). CBI is the only global pre-competitive research organization that promotes innovation in lead batteries for energy storage, motive, and automotive applications. CBI has created a market-driven research "roadmap" based on a detailed analysis of market trends and future technical requirements of end users.

Finally, research and development support long-term job creation and other economic impacts. When companies advance their products and production processes by adopting new

[7] https://www.whitehouse.gov/briefing-room/statements-releases/2022/10/19/fact-sheet-biden-harris-administration-driving-u-s-battery-manufacturing-and-good-paying-jobs/

[8] https://www.theregister.com/2022/09/14/us_mexico_chips_batteries/

technologies, they become more efficient and generate more sales, in turn allowing them to hire additional workers.

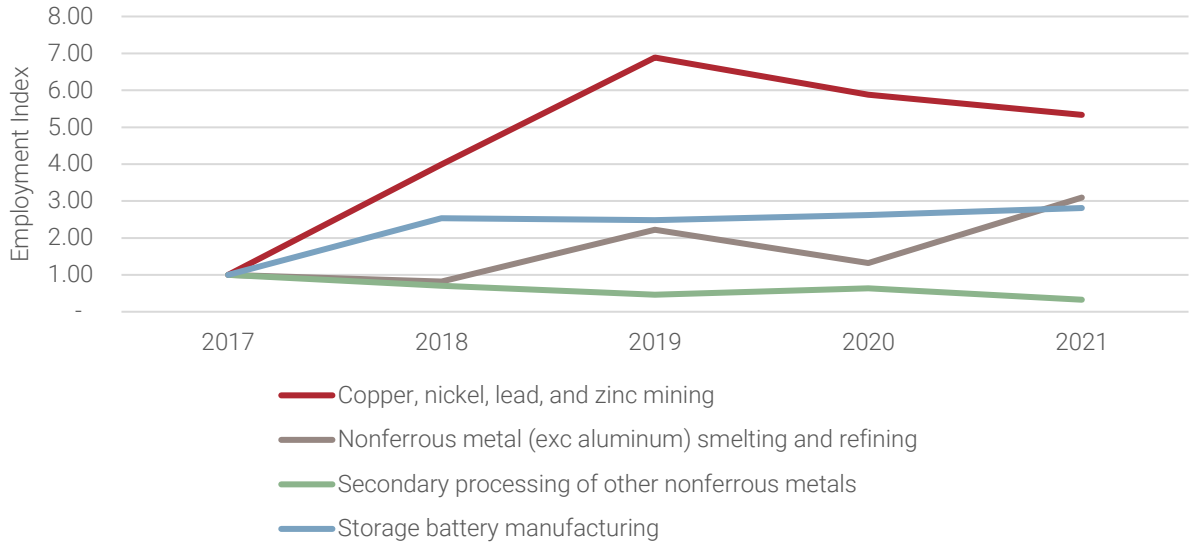
Impacts of COVID-19 on Supply Chains, Lead Battery Applications, and Doe Run

The lead battery supply chain within Missouri consists of three types of activity taking place across the state:

- Lead mining operations in areas along the Viburnum trend,
- Secondary smelting and refining activities related to lead battery recycling such as the Buick Resource Recycling Facility, and
- Lead battery manufacturing.

Each of these types of activities were impacted by the COVID-19 pandemic, and represent sectors affected by shifts in domestic and international behavior. Figure 6 looks at historical growth trends in each of the sectors relative to pre-pandemic levels (2017 – 2019) and mid-pandemic levels (2020-2021) to give an idea of the impact of the disruption on state employment.

Figure 6. The COVID effects on battery associated employment in MO (Index 1.0 = 2017 prepandemic levels)

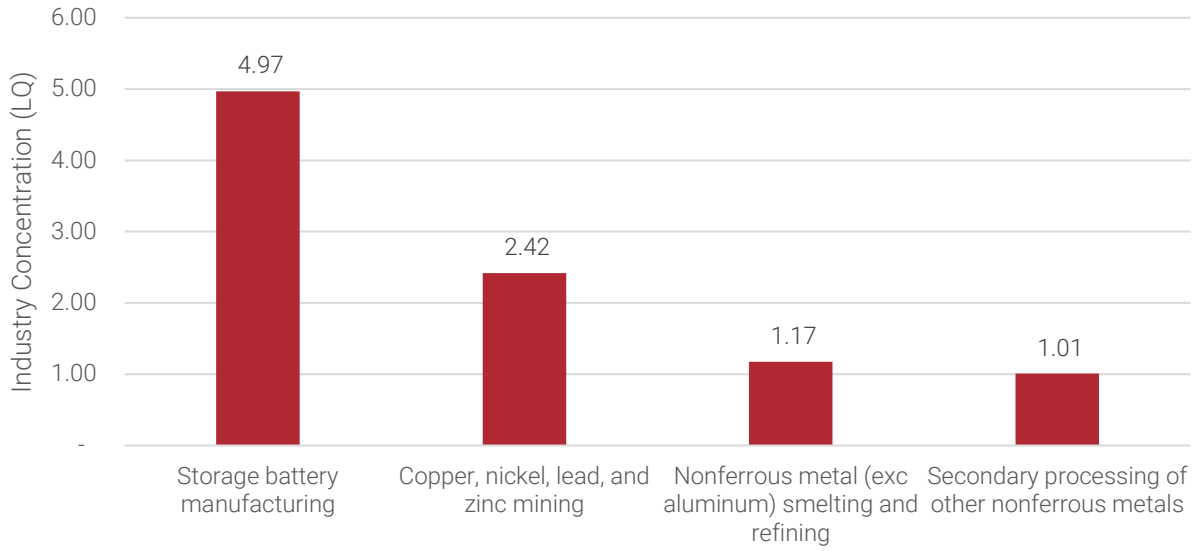


Source: EBP Analysis of IMPLAN Data

Historically, these sectors represent a cluster of specialized manufacturing for a growing supply chain that differentiates the state from other locations. The concept of a location quotient (LQ), applied in Figure 7 below, is helpful to identify industry specialization within Missouri by looking at how much more concentrated a sector is, relative to the background U.S. economy. Values

greater than 1.00—for example, 4.97 in battery manufacturing as shown in Figure 7—can be interpreted as saying that the concentration of employment within the Missouri state economy on equivalent activity is 4.97 times higher than would be typically expected in the U.S. This is a differentiator for the state, especially given the growing supply chain for electric vehicles and the supporting role lead batteries play alongside other technologies such as lithium.

Figure 7. Lead Battery Industry Specialization in Missouri (2021)

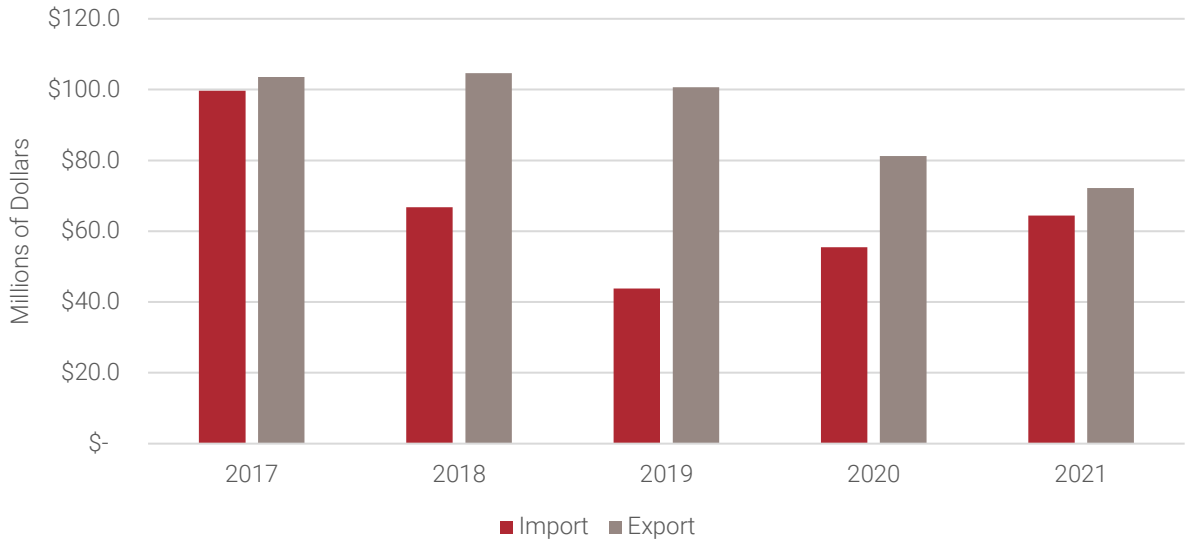


Source: EBP Analysis of IMPLAN data

Note: Industry concentration, as represented by the location quotient (LQ), is relative to activity within the greater U.S. economy. A location quotient of 1.00 is equal to industry concentration in the U.S. economy.

The effects of COVID-19 are broader and farther reaching than the logistical problems endured by businesses over the last few years. Lead batteries have historically enjoyed a strong domestic supply chain, which has enabled them to weather international events from a supply chain perspective. However, lead batteries are not immune to sweeping events that alter demand, such as reductions in the availability of downstream applications like cars due to manufacturing shutdowns and supply shortages, or the forced pandemic isolation marked by stay-at-home orders. We can track the national trends in the import and export of lead batteries using U.S. trade data to examine the last few years of activity. Figure 8 highlights the value of Missouri-specific lead battery trade (exports and imports) over the preceding 5 years, highlighting a shift in trends between pre-pandemic levels (2017 – 2019) and the tail end of the pandemic (2020-2021).

Figure 8. Broader Missouri Lead Battery Trade with the World



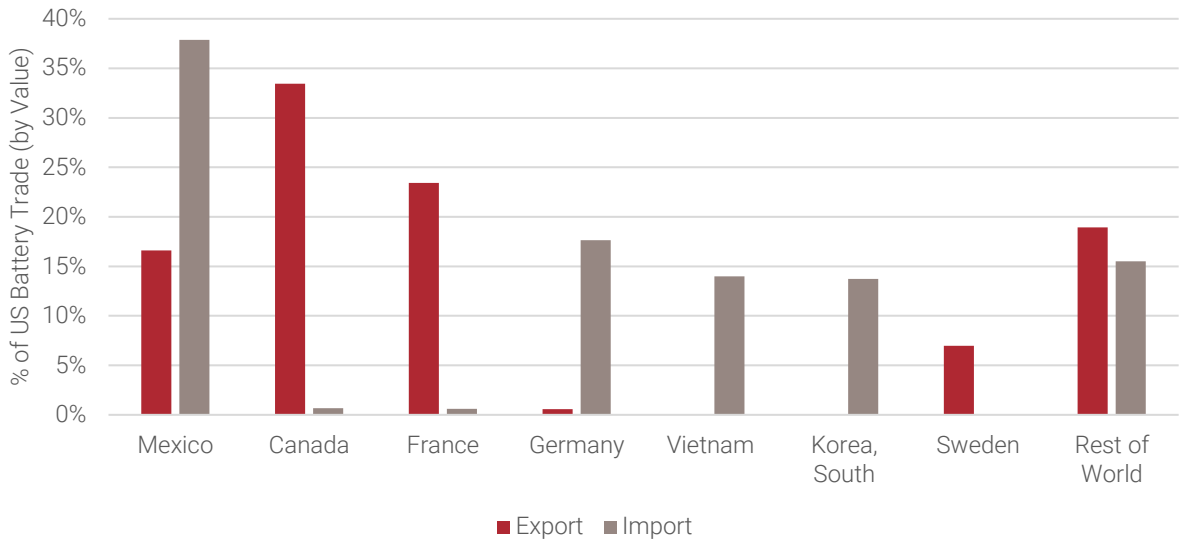
Source: EBP Analysis of USA Trade data

International exports were a strong part of pre-pandemic activity within the state, along with a decreasing reliance on imported batteries to support consumer and industrial needs. Once COVID-19 hit, much of the activity switched over to supporting a surging domestic market of aging vehicles, while the supporting lead mining sector faced downward pressure on the commodity price of lead, which finally stabilized in early 2020.

Figure 9 highlights the critical import and export markets in 2021 by breaking down the top countries trading with Missouri by value of Missouri imports and exports for lead batteries.[9] The figure highlights the relative importance of Mexico as a source of imported batteries, some of which are from recycled materials exported across the border, as well as the importance of Canada as a major export destination for finished goods.

[9] Note the lead batteries are defined as the following HS codes which describe Secondary Batteries:
850710 – Electric accumulators; lead acid of a kind for starting piston engines
850720 – Electric accumulators; lead acid other than for stating piston engines
Not enough detail in the UN COMTRADE database to identify lead-acid primary batteries over other technologies.

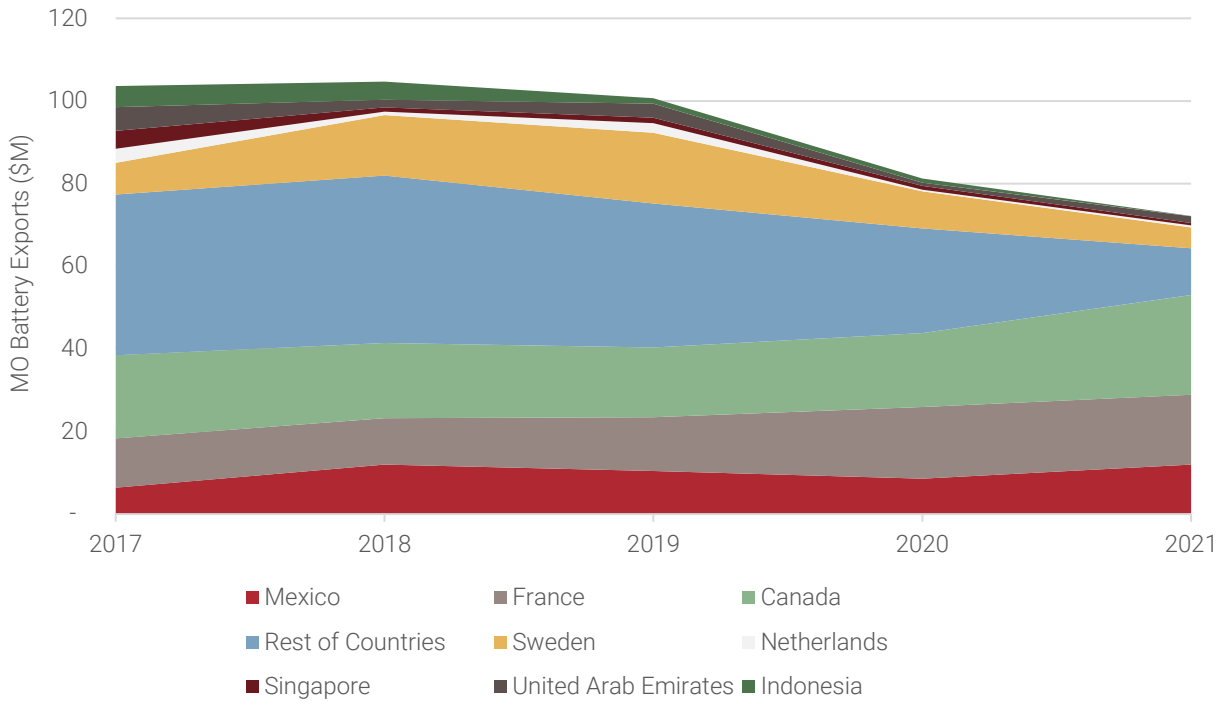
Figure 9. Major Missouri Markets for Lead Batteries by Trade Value, 2021



Source: EBP Analysis of USA Trade data

The decrease in overall exports of Missouri-manufactured lead batteries also represents a shift in international demand which served to, at least temporarily, concentrate markets in places such as Mexico, Canada, and France. This was offset by decreased shipments to previously large customers coming from countries including Indonesia, the United Arab Emirates, Singapore, and the Netherlands. Figure 10 highlights changes from 2017 to 2021 in Missouri-manufactured lead battery export destinations by country.

Figure 10. Change in Missouri Manufactured Lead Battery Export Destinations

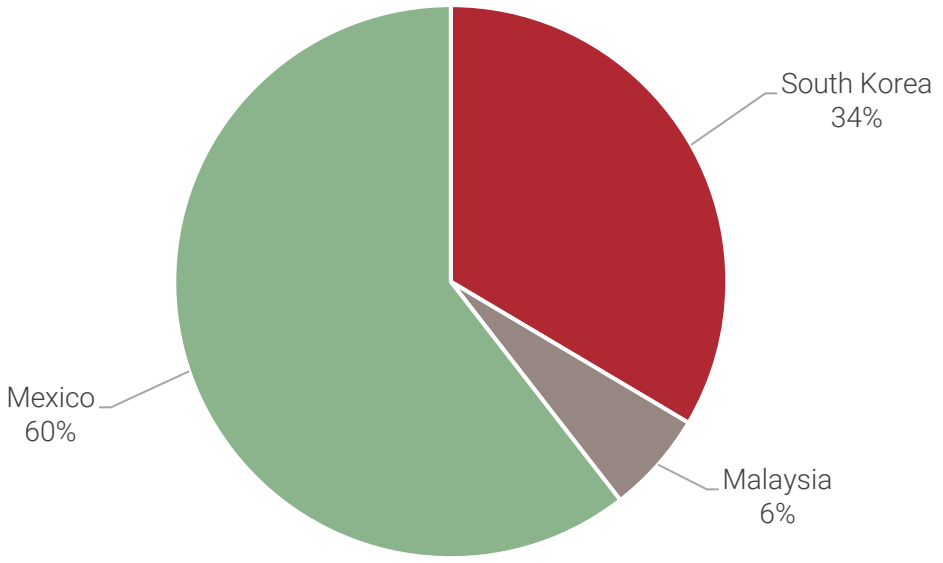


Source: EBP Analysis of USA Trade data

When batteries are used up, much of their contents are recycled domestically, however, the U.S. still exports spent cells out of the country to external facilities for recycling. Much of the volume of recycled batteries involves cross-border destinations. Figure 11 highlights both the volume of exports as well as the key export destinations of spent batteries.[10] Mexico represents a major supply chain partner, though in the past few years South Korea has seen a growing share of battery waste.

[10] Note trade data not available for Lead, though the majority of activity taking place is believed to be related. Using HS Code 854810 (Waste and scrap of primary cells, primary batteries and electric accumulators).

Figure 11. Destinations of U.S. Exports of Spent Batteries for Recycling



Source: EBP Analysis of USA Trade data

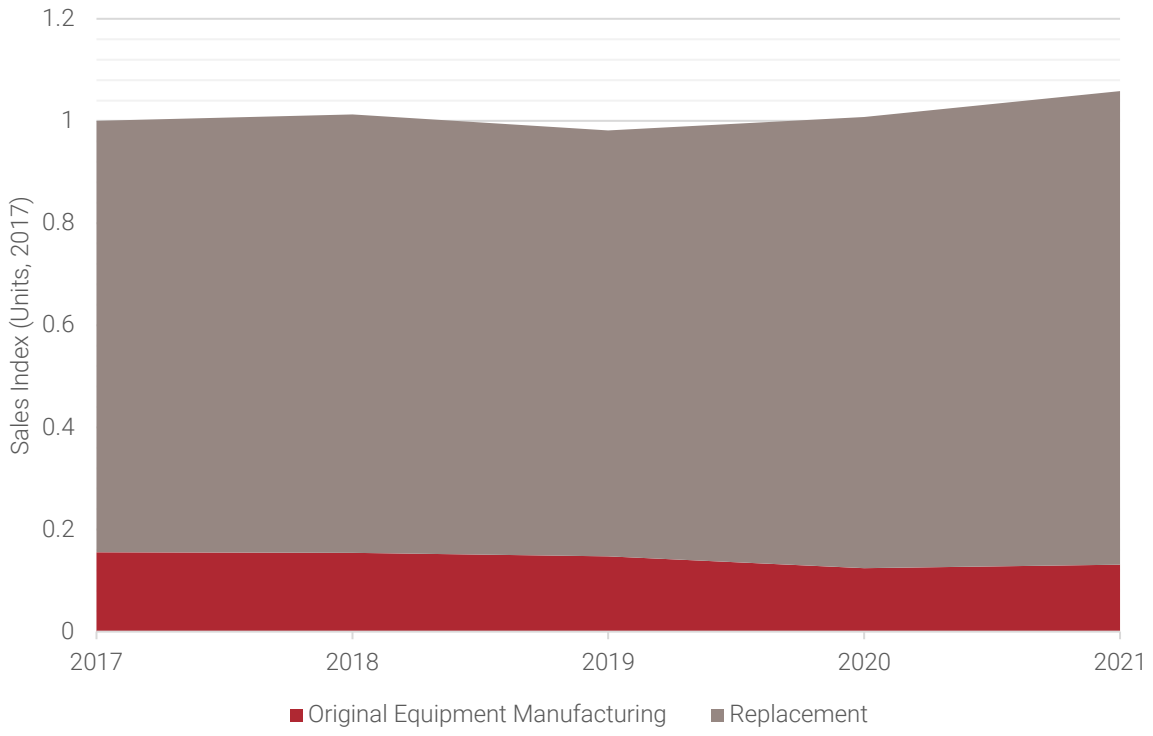
Effects of COVID-19 on Lead Battery Applications

COVID-19 has impacted more than just the supply chains of businesses – it has also had broader implications on the application of lead battery usage. Most lead battery applications have been focused on automobile usage for starting, lighting, and ignition (SLI) applications. Historically, roughly 15% of those lead battery sales have been in the form of batteries in new cars. With the supply chain disruption in the Chinese automaking market, this could have spelled a downtick in sales for lead batteries. What prevented more serious decreases in lead battery manufacturing output are the shift in overall usage. While automobile manufacturing was temporarily halted due to a range of factors (shortage of electronics, halting of Asian ports), lead battery producers were able to weather the storm by merit of the versatile applications of the batteries. Figure 12 depicts U.S. lead battery sales for SLI applications by use, thanks to proprietary data provided by BCI.

Two things are immediately evident from the data:

First, the lead battery market is resilient in its handling of the supply chain crisis and has grown its sales of SLI lead battery applications despite being heavily reliant on a constrained automobile industry. As shown in Figure 12, it is estimated that SLI applications have increased roughly 6% beyond pre-pandemic levels in 2021. The lead battery market has been adapting to global conditions.

Figure 12. U.S. Lead Battery SLI Sales: Index (2017 = 1.0)



Source: BCI Member Data

Second, the adaptation taking place was in the form of a surge in replacement batteries. As automobile owners were faced with similar challenges in acquiring new vehicles, they were forced to hold onto and maintain their existing vehicles as for many, new vehicles were simply too costly. Simultaneously, with a large segment of the workforce forced to quarantine and remain at home, a spike in demand/use of recreational vehicles further bolstered sales of replacement batteries. We can see this in the decreasing size of the OEM application index above, relative to the overall indexed unit sales. However, that is not to say that the battery manufacturing sector did not experience challenges in keeping their supply chains going: just like any business, they have had to deal with changing logistics and labor issues.

Impacts of COVID-19 on BCI Members

Much can be learned from BCI member experiences during the COVID-19 pandemic. Insight into how the crisis impacted their businesses and altered their outlook on market challenges demonstrates the strength of the battery manufacturing supply chain. As part of this study's survey, member companies were asked a series of questions, including:

1) How the supply chain crisis has impacted sales,
2) How it has impacted operations, and the businesses' approach to sourcing and shipping goods to market, and

3) How it altered their outlook on the next 5 years regarding the market and their ability to effectively operate within it.

The members who responded represented a diverse spectrum of businesses spread across the supply chain, each operating in different markets, and under varying degrees of exposure to the pandemic's effects. Despite the variation in background, there were some common themes regarding their experiences:

- Many companies noted that impacts were felt in the form of labor shortages and higher turnovers – part of the great resignation, a trend felt across much of the U.S., and transcending the battery sector as workers took the quarantine process as an opportunity to look to renegotiate and redefine their work life. This is also part of a broader awareness that the success of the battery industry is reliant on its ability to find a skilled and motivated workforce to maintain its competitive position.
- During this time, the movement of goods slowed – competition with skyrocketing ecommerce-based retail, and skyrocketing costs of fuel, container shortages, and myriad other factors led to longer lead times and more delays on both upstream and downstream applications, with lost sales being a lamented outcome.
- In response to these harsh realities, businesses responded with various approaches. Where it made sense, some businesses relied on higher inventory carrying costs as a way of mitigating delay of inputs, accepting the effects on their bottom line as a necessary evil.
- Some businesses ended up consolidating their sales along existing functioning logistics routes to continue service. Those with the ability to flexibly react to the situation began casting around for more adaptive responses: identifying opportunities for potential redundancy in their network in the form of alternate suppliers and seeking out new means of shipping their goods and forging relationships with shippers.

Lead Batteries and the Economy

Types of Economic Impacts

The lead battery industry creates jobs and generates business activity throughout Missouri's economy. The total economic impacts of lead battery industry include activity directly supported by companies within the lead battery industry as well as additional multiplier effects on suppliers throughout the country and on businesses where workers spend their income.

Each type of impact is quantified using the measures of jobs and value added (business revenue minus the cost of purchased goods and services). Value added impacts also reflect the lead battery industry's contribution to GDP.

Figure 13. Direct and Multiplier (Indirect and Induced) Impacts Generated by the Lead Battery Industry

Source: EBP US.

Direct Economic Impact

BCI's members represent almost complete coverage of the Missouri lead battery manufacturing, recycling, and mining industries. In 2021, the lead battery industry paid over $293.7 million in wages to 4,110 employees, as shown in Table 1. Doe Run alone paid $103.8 million in wages to 1,080 employees and spent $3.6 million on research and development in 2021.

Table 1. Direct Jobs and Payroll at Missouri Lead Battery Companies in 2021

	Missouri		Doe Run	
	Jobs	Payroll ($M)	Jobs	Payroll ($M)
Lead Battery Manufacturing	2,890	$184.2	-	-
Lead Mining	730	$70.9	730	$70.8
Lead Battery Recycling	490	$38.6	350	$33.0
Total	**4,110**	**$293.7**	**1,080**	**$103.8**

Source: BCI company survey and IMPLAN.
Note: Direct jobs and payroll for Doe Run are included within the Missouri totals.

Missouri Lead Battery Wages and Occupations

The lead battery industry pays high wages relative to most other industry sectors in Missouri. Average payroll-per-worker for Missouri lead battery sectors was $71,500. For Doe Run, payroll-per-worker was $96,300. Doe Run's payroll-per-worker is higher than that in professional services, while the average payroll-per-worker for all Missouri lead battery sectors is higher than that in, construction and maintenance, retail and wholesale trade, and agriculture, as shown in Table 2.

Table 2. Payroll-per-Worker in the Missouri Lead Battery Industry and Other Sectors

Industry	Payroll-per-Worker ($2021)
Doe Run Company	$96,300
Professional Services	$72,600
All Missouri Lead Battery Sectors	$71,500
Construction & Maintenance	$65,200
All Private Sector Industries	$60,500
Retail & Wholesale Trade	$52,600
Agriculture	$33,900

Source: BCI company survey for bolded rows and IMPLAN for non-bolded industries.
Note: All Missouri Lead Battery Sectors represents the average payroll-per-worker across all lead battery sectors represented in the BCI company survey.

Direct jobs in the lead battery industry are filled by workers in a variety of occupations, illustrated in Table 3. Production occupations account for more than half of all jobs in the lead battery industry, while high-skilled engineers, administrators, and managers account for another quarter.

Table 3. Occupations Included in the Lead Battery Industry

Occupation Category	Percent of Industry Workers
Production Occupations	53.9%
Architecture and Engineering Occupations	9.9%
Office and Administrative Support Occupations	8.5%
Management Occupations	7.4%
Business and Financial Operations Occupations	5.0%
Transportation and Material Moving Occupations	4.6%
Installation, Maintenance, and Repair Occupations	4.0%
Sales and Related Occupations	3.2%
Computer and Mathematical Occupations	1.8%
All other occupations	1.7%

Source: United States Bureau of Labor Statistics, 2021. Data is for NAICS 335900: Other electrical equipment and component manufacturing, which includes battery manufacturing.

Total Missouri Economic Contribution

The Missouri lead battery industry generated the following job impacts statewide in calendar year 2021:

- **Directly employed approximately 4,110 workers in manufacturing, recycling, and mining industries.**
- **Supported an additional 2,170 supplier jobs.** Supplier impacts (indirect impacts) result from companies in the lead battery industry spending money on goods and services.
- **Supported an additional 2,270 jobs from worker spending.** Worker spending impacts (induced impacts) result from workers at companies in the lead battery industry and their suppliers spending their wages throughout the economy.
- **Invested $3.6 million in research and development.**

Together these impacts total to 8,550 jobs statewide. In addition to its job impact, the lead battery industry supported approximately:

- $553.7 million in labor income (includes wages and benefits),
- $981.9 million in gross state product (GSP), and
- $2.3 billion in output or overall economic impact.

These impacts represent the lead battery industry's contribution to the Missouri economy in 2021, detailed in the table below.[11]

Table 4. Economic Impacts of the Missouri Lead Battery Industry in 2021

Impact	Jobs	Labor Income ($M)	GSP ($M)	Output ($M)
Direct Impacts	4,110	$293.7	$542.6	$1,433.6
Indirect Impacts (Suppliers)	2,170	$149.2	$242.7	$478.2
Induced Impacts (Worker Spending)	2,270	$110.8	$196.7	$349.2
Total	**8,550**	**$553.7**	**$981.9**	**$2,260.9**

Source: Analysis by EBP based on industry survey and IMPLAN economic model for Missouri.

[11] Gross Domestic Product (GDP) represents the total value of goods produced by the U.S. lead battery industry. Output represents total sales made by the industry. GDP is smaller than output because it excludes payroll, profits, and the cost of supplies. Labor income is a subset of GDP and GDP is a subset of output. Therefore, these figures should not be combined.

The impacts in Table 5 represent Doe Run's contribution to Missouri's economy in 2021. These impacts are included in the total Missouri impact.

Table 5. Economic Impacts of Doe Run on the Missouri Economy in 2021

Impact	Jobs	Labor Income ($M)	GSP ($M)	Output ($M)
Direct Impacts	1,080	$103.8	$180.6	$419.8
Indirect Impacts (Suppliers)	780	$57.3	$94.6	$178.4
Induced Impacts (Worker Spending)	760	$37.1	$65.8	$116.8
Total	**2,620**	**$198.20**	**$341.0**	**$715.0**

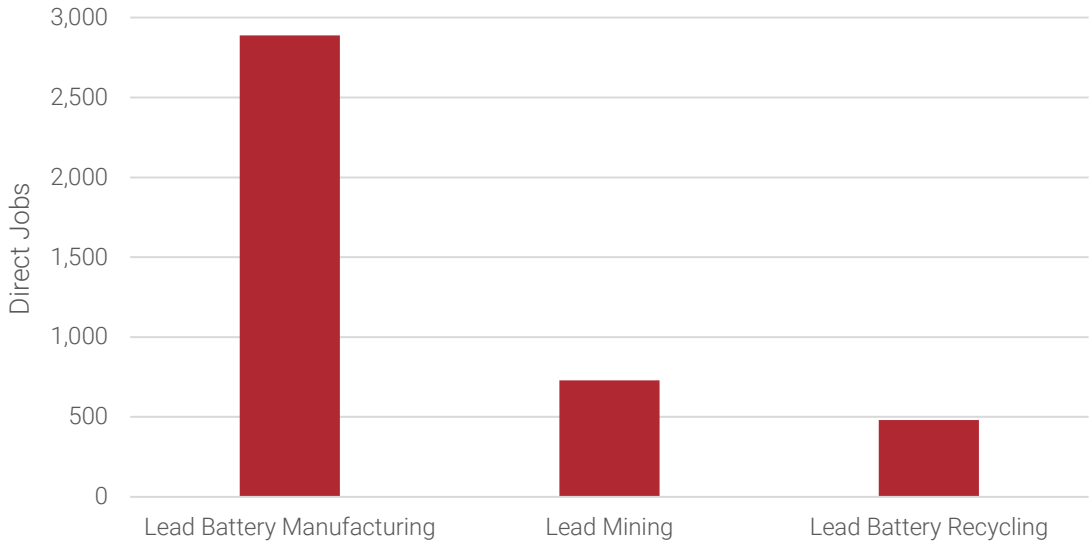
Source: Analysis by EBP based on industry survey and IMPLAN economic model for Missouri.
Note: The impacts in this table are included in the total lead battery industry impacts to the Missouri economy.

Note: Because lead battery manufacturers use both virgin and recycled lead, some lead mining and recycling companies support manufacturers within the same industry. Similarly, lead battery manufacturers depend on some transportation and distribution companies upstream in their value chain. The supplier impact from battery manufacturing reflects this fact by not counting jobs twice, and other impacts resulting from the purchase of virgin and recycled lead content.

Job Impacts by Industry

Missouri lead battery companies support direct jobs in several areas. Direct jobs are those that exist at actual companies in the lead battery industry. These include about 2,890 jobs in manufacturing, 730 in mining, and 480 in recycling. The figure below illustrates direct jobs by activity within the lead battery industry.

Figure 14. Direct Jobs Supported by the Missouri Lead Battery Industry in 2021

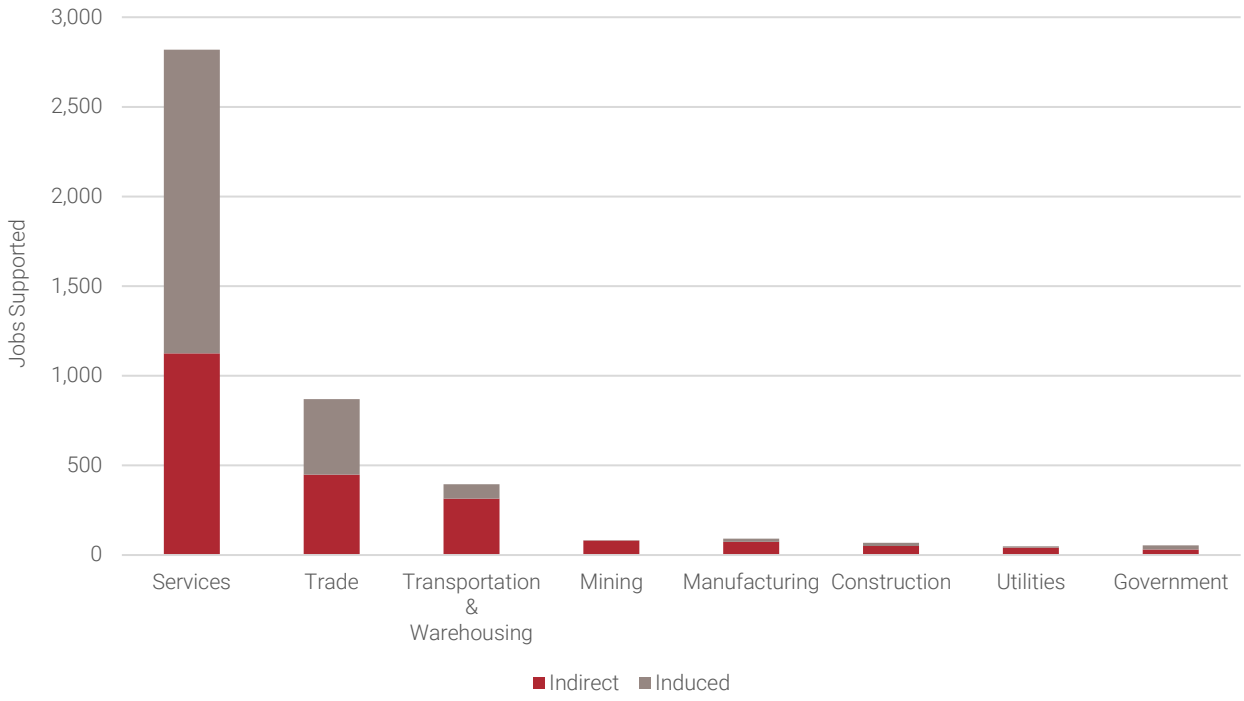


Source: Analysis by EBP based on industry survey and IMPLAN economic model for Missouri.

By purchasing goods and services from suppliers and paying wages that workers spend throughout the economy after paying taxes, the lead battery industry supports a variety of industries, shown in Figure 15. Over 2,800 of these supplier and worker spending jobs are in the services sector and approximately 1,300 are in the trade and transportation & warehousing sectors.

The reason such a variety of sectors benefit from the lead battery industry is because workers at individual companies and their suppliers spend their wages on food, housing, healthcare, transportation, recreation, and other goods and services.

Figure 15. Indirect and Induced Jobs Created by the Missouri Lead Battery Industry in 2021



Source: Analysis by EBP based on industry survey and IMPLAN economic model for Missouri.

Tax Revenue Contribution

By paying local, state, and federal taxes, Missouri lead battery companies contributed $184 million in government revenue in 2021, as shown in Table 6. The industry provided $114.3 million in revenue to the federal government and $69.7 million in revenue to the State of Missouri and various localities.

Table 6. Tax Revenue Generated by the Missouri Lead Battery Industry in 2021

Revenue Type	Revenue ($M)
Federal Tax Revenue	$114.3
State and Local Tax Revenue	$69.7
Total	**$184.0**

Source: Analysis by EBP based on industry survey and IMPLAN economic model for Missouri.

Conclusion

The Missouri lead battery industry is comprised of battery manufacturing, lead recycling, and lead mining companies that also engage in research and development. The industry is also supported by numerous suppliers, retailers, and marketing companies. In 2021, the lead battery industry directly employed 4,110 workers and had a total payroll of $293.7 million in Missouri.

Production by the lead battery industry also generated indirect impacts through transactions with their suppliers, and induced impacts through workers at both member companies and suppliers spending their earnings on goods and services. When direct, supplier, and worker spending impacts are combined, the industry contributed the following to the Missouri economy in 2021:

- **8,550 jobs,**
- **$553.7 million in labor income,**
- **$981.9 million in GSP,**
- **$2.3 billion in output, and**
- **$114.3, and $69.7 million in federal, state and local tax revenue respectively (combined $184.0 million).**

These impacts are spread across a variety of industries, with services, trade, and transportation & warehousing benefiting the most. Finally, by paying local, state, and federal taxes, the Missouri lead battery industry contributes $114.3 million annually in federal tax revenue and $69.7 million annually in state and local tax revenue. Of the total state impacts for the lead battery industry, The Doe Run Company is responsible for generating:

- **2,620 Jobs,**
- **$198.2 million in labor income,**
- **$341.0 million in GSP,**
- **$715 million in output, and**
- **$40.1, and $32.1 million in federal, state and local tax revenue respectively (combined $72.2 million).**

Appendix

Methodology

This analysis was conducted based on 2021 industry data and using the 2019 IMPLAN economic model for Missouri. All results are in 2021 dollars. A survey process was used to collect limited

but key annual data from BCI member companies. Compilation of the survey-derived and supplemental information represents direct impacts. The survey probed annual employment, payroll, and sales revenue information by industry. The corresponding direct output (business sales or value of production) was estimated using national output-to-jobs ratios from IMPLAN before aggregating direct effects across companies within each of the subsectors comprising the BCI membership. There were several instances where direct payroll or direct employment were estimated using national employee compensation-to-jobs ratios because survey respondents chose not to report annual payroll or employment.

Definition of Terms

Input-output models are commonly used to conduct economic impact analysis. There are several input-output models available, including IMPLAN.[12] Many economists use IMPLAN for economic contribution analyses because the tool measures output and employment impacts, is available on a county-by-county basis, and is flexible for the user. IMPLAN has some limitations and qualifications, but it is one of the best tools available to economists for input-output modeling. Understanding the IMPLAN tool, its capabilities, and its limitations helps ensure the best results from the model. The Missouri IMPLAN model used for this study estimates economic and tax revenue impacts at a statewide level. Tax revenue impacts include local, state and federal revenue, estimated using average tax rates for each jurisdiction.

Several IMPLAN-specific definitions are essential to properly interpreting the results of an IMPLAN analysis. These definitions follow, with some quoted from the IMPLAN glossary.[13]

Direct Impact

Direct impacts represent changes in industry production or expenditures resulting from companies. These initial changes are determined by an analyst to be a result of a specific activity (e.g., sales made by a given company). Applying these initial changes to the multipliers in an IMPLAN model will then display how the region will respond economically to these initial changes.

Economic Contribution

Economic contribution represents a "gross change in economic activity associated with an industry, event or policy in an existing regional economy."[14] This is different from an economic impact, which represents a net change in economic activity.

Indirect Impact (Supplier Impact)

[12] See www.implan.com for more information.

[13] https://implanhelp.zendesk.com/hc/en-us/categories/115001507908-Knowledge-Base

[14] Determining Economic Contributions and Impacts: What is the Difference and Why Do We Care? *The Journal of Regional Analysis and Policy 37*(2): 1-15, 2007.

Indirect impacts result from local industries buying goods and services from local supplier industries. As a company increases its production it will require more inputs from local suppliers, in turn increasing the production at those supplier companies. This indirect impact is calculated by applying direct effects to what are called Type I Multipliers.

Induced Impact (Worker Spending Impact)

Induced impacts represent the response of an economy to an initial (direct) change that occurs through re-spending of income. This money is recirculated through household spending patterns causing further local economic activity. A variety of industries benefit from induced impacts because workers at companies experiencing the initial change in production, plus workers at their local supplier companies, spend their wages on food, housing, transportation, recreation and other goods and services.

Jobs

An IMPLAN job equals the annual average of monthly jobs in that industry (this is the same definition used by several government sources). Thus, one job lasting 12 months equals two jobs lasting six months each or three jobs lasting four months each. A job can be full-time or part-time.

Labor Income

Labor income includes all forms of employment income, including employee compensation (wages and benefits) and proprietor income. Proprietor income consists of payments received by self-employed individuals and unincorporated business owners.

Output

Output represents the value of industry production. In IMPLAN these are annual production estimates for the year of the data set. For manufacturers, output equals sales plus or minus the change in inventory. For service sectors, output equals sales. For retail and wholesale, trade output equals the gross margin and not gross sales.

Total Impact

The total impact is the summation of the direct, indirect, and induced impacts.

Value Added (GSP/GDP)

Value added or gross state/domestic product (GSP/GDP) represents the difference between an industry's total output and the cost of its intermediate inputs (consumption of goods and services purchased from other industries or imported). Value added consists of employee compensation, taxes on production and imports less subsidies and gross operating surplus.