



Economic Contribution of the Missouri Lead Battery Industry

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Report Prepared for:
The Doe Run Company

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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, affecting a variety of industry sectors.

Lead batteries are essential to everyday life, and with a recycling rate of 99 percent, they are the most recycled consumer product in the U.S. A new lead battery consists of 80 percent recycled material, and nearly 75 percent of its lead comes from recycling.¹ Lead battery manufacturing, recycling, and mining activities contribute to Missouri's economy 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.

Workers in Missouri's lead battery industry hold a variety of occupations, many of which are accessible to those who have only a high school diploma. The industry directly employs 3,210 workers and spends \$257 million annually on payroll. Doe Run accounts for 1,160 of these jobs and \$112.3 million in payroll. In addition to the workers Missouri's lead battery industry directly employs, it supports 2,350 supplier jobs and 2,590 jobs from worker spending in different industries.

Together, these statewide impacts total 8,150 jobs (including research and development jobs). Beyond its job impact, the Missouri lead battery industry annually supports

- \$527.3 million in labor income;
- \$1 billion in gross state product (GSP);
- \$2.5 billion in output or overall economic impact;
- \$227 million in tax revenue²; and
- \$2.5 million in R&D spending.

These impacts represent the lead battery's contribution to the Missouri statewide economy.³

¹ National Recycling Rate Study, Battery Council International, 2017.

² Taxes include employee contributions to social insurance, sales taxes, property taxes, motor vehicle license fees, severance taxes, corporate taxes, personal income taxes, and other miscellaneous taxes.

³ Gross state product (GSP) represents the total value of goods produced by the Missouri lead battery industry. Output represents total sales made by the industry. GSP is smaller than output because it excludes the cost of supplies. Labor income is a subset of GSP and GSP is a subset of output. Therefore, these figures should not be combined.

STUDY PURPOSE

The following study measures the statewide economic contribution of the Missouri lead battery industry in calendar year 2018. The analysis was conducted using an economic impact model called IMPLAN. A survey was used to collect data including annual employment and payroll information from Battery Council International (BCI) member companies with manufacturing, recycling, or mining operations in Missouri.⁴ Survey results were then added across companies to yield state-level activity that was put into a Missouri IMPLAN model. Impact results are presented in terms of jobs, labor income, gross state product, output, and tax revenue.

About EDR Group, an EBP Company

EDR Group was started with a core philosophy—to contribute to a better society by enhancing our understanding of economic processes and by improving the tools we have for decision-support regarding policies and investments. We focus on economic development and its relationship to public and private investments, programs and policies. The company maintains a select staff distinguished by three features: (1) technical excellence applying and furthering “state-of-the-art” analysis methods, (2) vision and leadership in communicating findings and helping clients use information for decision-making, and (3) ability to work effectively with others in teams to address client needs.

EDR Group initially built a practice based on evaluation of past projects, existing programs, and proposed future investments around North America. We have since expanded to serve a global clientele and to advise organizations on how to better implement processes for planning, prioritization, and funding decisions that consider wider benefit and impact factors. To further that objective, in 2016 we became an affiliate of EBP, an international group for interdisciplinary collaboration and innovation.

About Doe Run

Based in St. Louis, Missouri, USA, 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. For more information, visit www.doerun.com and www.sustainability.doerun.com.

⁴ All individual company data was kept confidential and company identities were not revealed as part of this study.

LEAD BATTERIES & INNOVATION

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 millions of people around the globe. Indeed, over 1 billion cars rely on lead batteries, including some hybrids and electric vehicles, and 75 percent of global renewable energy storage needs are met by this technology.⁵

Lead batteries are also among the most environmentally sustainable consumer products, with a recycling and reuse rate of 99 percent.⁶ By comparison, the recycling rate for aluminum cans is 55 percent.⁷ The average new lead battery is comprised of more than 80 percent recycled material.⁸ 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.⁹ 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.

Advanced lead batteries also facilitate new start-stop vehicle technologies, which allow cars to temporarily stop their engines while idling. By 2020, when most new cars will have this feature, start-stop is expected to eliminate 2 million tons of greenhouse gas emissions annually.¹⁰ This is equivalent to the annual energy use of 211,000 average U.S. households.

Lead Battery Lifecycle

Rechargeable batteries are needed now more than ever to meet the energy demands of the growing U.S. and world populations. 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. The exception is lead batteries. Lead battery manufacturing is the most environmentally sustainable of all battery technologies. In addition, at a rate of 99 percent, lead batteries are the most recycled consumer product in the U.S.

⁵ “Renewable Energy Storage,” July 9, 2018, Essential Energy Everyday, https://essentialenergyeveryday.com/wp-content/uploads/2018/07/EEE_Energy_Brief.pdf.

⁶ Ibid.

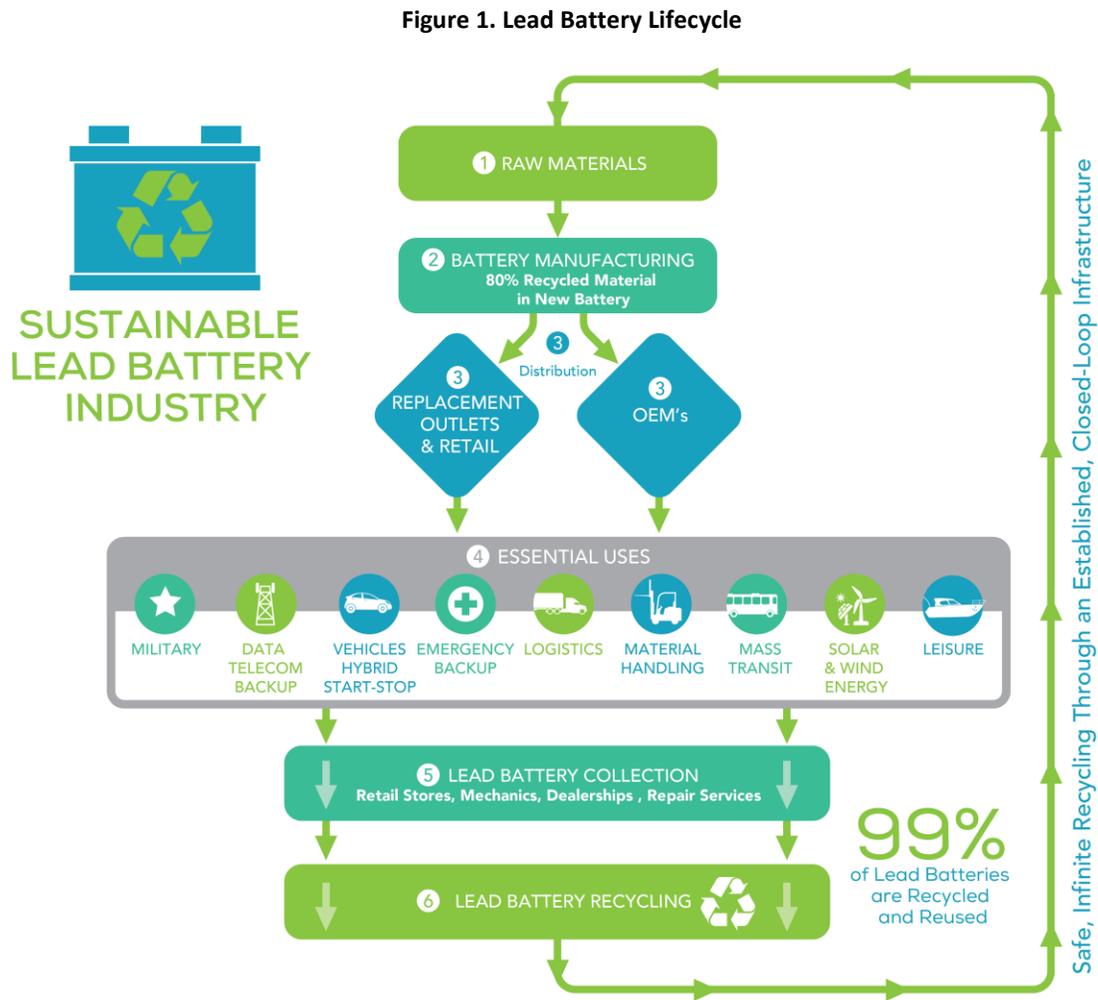
⁷ Advancing Sustainable Materials Management: 2014 Fact Sheet, Environmental Protection Agency, Nov. 2016

⁸ Environmental Impact and Life Cycle Assessment of Lead Battery and Architectural Sheet Production, The International Journal of Life Cycle Assessment, 2016.

⁹ “The Circular Economy of Lead Batteries,” April 18, 2019, Essential Energy Everyday, <https://essentialenergyeveryday.com/wp-content/uploads/2019/04/Circular-Economy-Brief.pdf>.

¹⁰ International Lead Association, 2017.

The flowchart in Figure 1 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.



Research & Development

Doe Run’s exploration, research, and technical development group is staffed with highly skilled research personnel including PhDs and other advanced-degree personnel focused on metallurgical extraction. The group engages in exploration activities for lead resources to feed mine operations, mineral recovery research to improve the quality of concentrates and create more value from the mineral resources, and research on advanced hydrometallurgy processes to improve the recovery of economic elements from concentrates, including the production of high-purity (99.999% pure) lead metal for use in advanced battery technologies. Other branches of the research include advanced processing scenarios specifically focused on lead battery recycling.

Doe Run spends approximately \$2.5 million per year on research and development.

LEAD BATTERIES & THE ECONOMY

Types of Economic Impact

The lead battery industry contributes to the Missouri economy by generating jobs, income, GSP, and output (business sales) in three separate ways:

- **Direct impacts:** When battery manufacturing and recycling companies employ workers and generate business income.
- **Supplier impacts:** When battery manufacturing and recycling companies purchase goods and services from recyclers, manufacturers, and other suppliers (e.g., equipment, parts, materials, facilities, and utilities).
- **Worker spending impacts:** When workers at battery manufacturing and recycling companies and workers at supplier companies spend their after-tax income on consumer goods (e.g., food, housing).

Direct Economic Impact

BCI members represent almost complete coverage of the Missouri lead battery manufacturing, recycling, and mining industries. In 2018, Missouri's lead battery industry paid \$257 million in wages to 3,210 employees (Table 1). Doe Run alone paid \$112.3 million in wages to 1,160 employees and spent \$2.5 million on R&D in 2018.

Table 1. Direct Jobs & Payroll at Missouri Lead Battery Companies in 2018

	Missouri		Doe Run (included in Missouri totals)	
	Jobs	Payroll	Jobs	Payroll
Lead Battery Manufacturing	1,950	\$137.5 million	-	-
Lead Mining	810	\$78.4 million	810	\$78.4 million
Lead Battery Recycling	440	\$41.2 million	350	\$34 million
Total	3,210	\$257 million	1,160	\$112.3 million

Note: Missouri jobs do sum exactly to 3,210 due to rounding.
Sources: BCI company survey and IMPLAN.

Lead Battery Wages & Occupations

The lead battery industry pays high wages relative to other industry sectors. Average payroll-per-worker among Missouri battery companies is \$80,100. This is higher than in manufacturing, professional services, transportation, construction and maintenance, and retail and wholesale trade (Table 2).

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

Industry	Payroll-per-Worker (2018\$)
Lead Battery Companies	\$80,100
Manufacturing	\$70,400
Professional Services	\$54,900
Transportation	\$49,700
Construction & Maintenance	\$39,600
Retail & Wholesale Trade	\$39,400

Sources: BCI company survey for lead battery companies and IMPLAN for other sectors (inflated to 2018 dollars).

Direct jobs in the lead battery industry are filled by workers in a variety of occupations (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	52.5%
Architecture and engineering occupations	10.0%
Office and administrative support occupations	9.5%
Management occupations	8.1%
Transportation and material moving occupations	4.7%
Business and financial occupations	4.2%
Installation, maintenance, and repair occupations	3.8%
Sales and related occupations	3.3%
Computer and mathematical occupations	2.1%
All other occupations	1.7%
Total, all occupations	100%

Note: Percentages do not sum to 100 due to rounding.

Source: United States Bureau of Labor Statistics, 2018. Data is for NAICS 335900: Other electrical equipment and component manufacturing, which includes battery manufacturing.

Many occupations in the lead battery industry are accessible to workers who have only a high school diploma or equivalent education (e.g., GED)¹¹:

- 75% of all office and administrative support occupations
- 63% of all production occupations
- 54% of all installation, maintenance, and repair occupations
- 41% of all transportation and material moving occupations
- 30% of all sales and related occupations
- 17% of all management occupations

Green Jobs

Some of the most common occupations in the lead battery industry are also those that comprise the greatest number of green jobs (Table 4). Green jobs are considered those that are involved in the production of goods or services that provide an environmental benefit.¹² Many jobs in the lead battery industry are considered green jobs because the process generates an environmental benefit by diverting materials from landfills.

Table 4. Occupations with Significant Numbers of Green Jobs

Occupation Category	Percent of Industry Workers in Green Jobs
Transportation and material moving occupations	19.3%
Production occupations	15.9%
Office and administrative support occupations	14.1%
Installation, maintenance, and repair occupations	6.2%
Business and financial occupations	5.8%
Management occupations	5.7%
Architecture and engineering occupations	5.7%

Sources: Brookings Institution, 2011.

¹¹ United States Bureau of Labor Statistics, 2018.

¹² Brookings Institution, 2011, https://www.brookings.edu/wp-content/uploads/2016/06/0713_clean_economy_appendix.pdf.

Total Economic Contribution

The Missouri lead battery industry generated the following job impacts statewide in calendar year 2018:

- **Directly employed 3,210 workers in manufacturing, recycling, and mining**, 1,160 of whom are employed by Doe Run.
- **Supported an additional 2,350 supplier jobs**, 1,110 of which are supported by Doe Run. Supplier impacts (indirect impacts) result from companies in the lead battery industry spending money on goods and services.
- **Supported an additional 2,590 jobs from worker spending**, 1,210 of which are supported by Doe Run. Worker spending impacts (induced impacts) result from workers at lead battery companies and their suppliers spending their wages throughout the economy.
- **Spent \$2.5 million on R&D.**

Together these impacts total 8,150 jobs statewide. In addition to its job impact, Missouri's lead battery industry supported:

- \$527.3 million in labor income (includes wages and benefits);
- \$1 billion in gross state product (GSP); and
- \$2.5 billion in output or overall economic impact.

These impacts represent the lead battery's contribution to Missouri's statewide economy in 2018 (Table 5).¹³

Table 5. Economic Impacts of the Missouri Lead Battery Industry in 2018 (millions of dollars)

	Jobs	Labor Income	GSP	Output
Direct Impacts	3,210	\$257.1	\$585.7	\$1,657.2
Indirect Impacts (Suppliers)	2,350	\$155.8	\$252.3	\$456.0
Induced Impacts (Worker Spending)	2,590	\$114.4	\$198.7	\$351.4
Total	8,150	\$527.3	\$1,036.7	\$2,464.6

Sources: Analysis by EDR Group based on industry survey and IMPLAN economic model for Missouri.

¹³ Gross state product (GSP) represents the total value of goods produced by the Missouri lead battery industry. Output represents total sales made by the industry. GSP is smaller than output because it excludes the cost of supplies. Labor income is a subset of GSP and GSP is a subset of output. Therefore, these figures should not be combined.

The impacts in Table 6 represent Doe Run’s contribution to Missouri’s statewide economy in 2018. These impacts are included in the total Missouri impact.

Table 6. Economic Impacts of Doe Run in 2018 (included in Missouri totals) (millions of dollars)

	Jobs	Labor Income	GSP	Output
Direct Impacts	1,160	\$112.3	\$342.8	\$787.0
Indirect Impacts (Suppliers)	1,110	\$74.9	\$122.8	\$216.9
Induced Impacts (Worker Spending)	1,210	\$53.2	\$92.3	\$163.2
Total	3,480	\$240.4	\$557.9	\$1,167.1

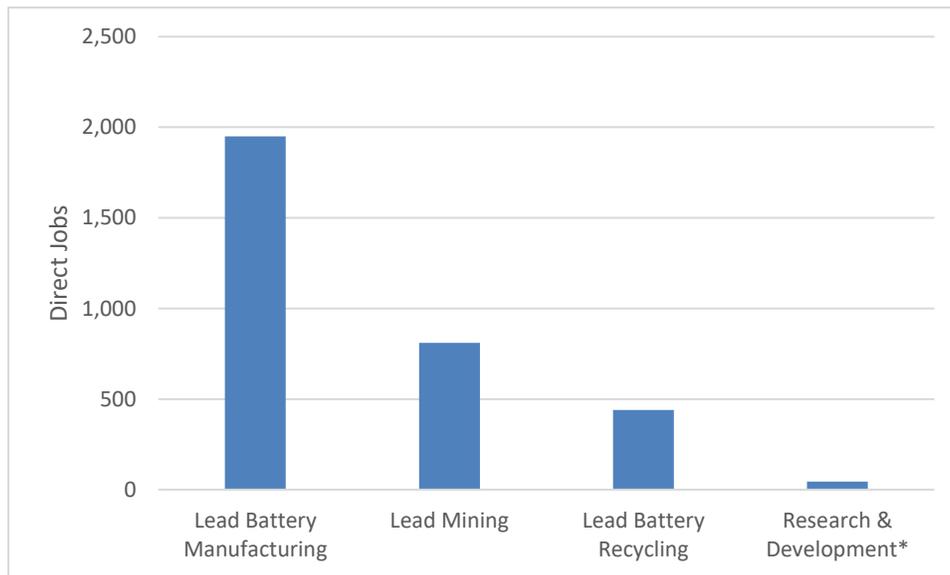
Sources: Analysis by EDR Group based on industry survey and IMPLAN economic model for Missouri.

Note: Lead battery manufacturers use both virgin and recycled lead. This means that manufacturers, mining companies, and recycling companies support one another within the economic model used for this analysis. For this reason, we ensure that jobs are not counted twice in the analysis (i.e., some recycling jobs supported by manufacturers are the same recycling jobs reported in the survey).

Job Impacts by Industry

Missouri lead battery companies support direct jobs in several areas. Direct jobs are those that exist at actual lead battery companies. These include 1,950 jobs in manufacturing, 810 jobs in mining, and 440 jobs in recycling (Figure 2).

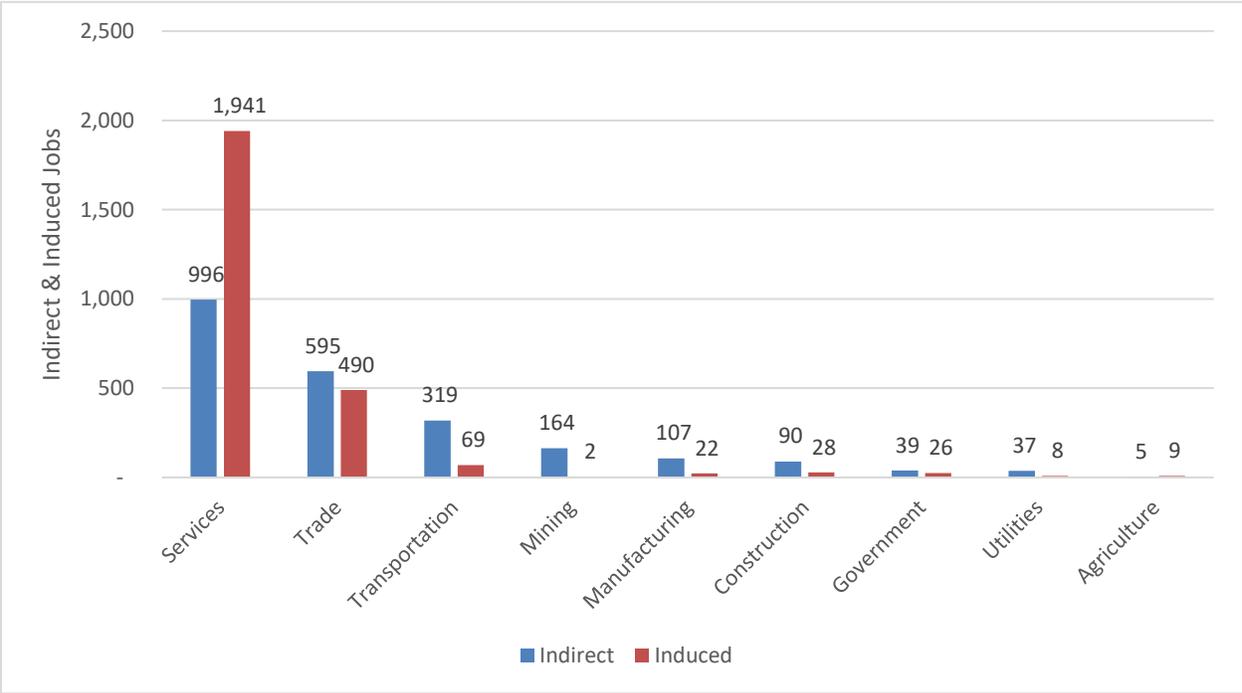
Figure 2. Direct Jobs Supported by the Missouri Lead Battery Industry in 2018



Source: Analysis by EDR Group based on industry survey and IMPLAN economic model for the U.S.
 *R&D jobs are included in other job categories and should therefore not be combined.

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 (Figure 3). Over 2,900 of these supplier and worker spending jobs are in the services sector and nearly 1,800 jobs are in either trade, transportation, mining, or manufacturing. Workers at individual companies and their suppliers spend their wages on food, housing, transportation, recreation, and other goods and services.

Figure 3. Indirect & Induced Jobs Supported by the Missouri Lead Battery Industry in 2018



Source: IMPLAN analysis conducted by EDR Group.

Tax Revenue Contribution

By paying local, state, and federal taxes, Missouri lead battery companies contributed \$227 million in government revenue in 2018 (Table 7).¹⁴ The industry provided \$125.5 million in revenue to the federal government and \$101.5 million in revenue to the State of Missouri and various localities.

Table 7. Tax Revenue Generated by the Missouri Lead Battery Industry in 2018 (millions of dollars)

Revenue Type	Revenue
Federal Tax Revenue	\$125.5
State and Local Tax Revenue	\$101.5
Total	\$227

Source: Analysis by EDR Group based on the IMPLAN economic model and state average rates for local, state, and federal taxes.

¹⁴ Taxes include employee contributions to social insurance, sales taxes, property taxes, motor vehicle license fees, severance taxes, corporate taxes, personal income taxes, and other miscellaneous taxes. Mining royalties paid to the government are also included in the form of property income.

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 2018, the lead battery industry directly employed 3,210 workers and had a total payroll of \$257 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 2018:

- **8,150 jobs**
- **\$527.3 million in labor income;**
- **\$1 billion in GSP; and**
- **\$2.5 billion in output.**

These impacts are spread across a variety of industries, with services, trade, manufacturing, and transportation benefiting the most. Finally, by paying local, state, and federal taxes, the Missouri lead battery industry contributes \$125.5 million annually in federal tax revenue and \$101.5 million annually in state and local tax revenue.

APPENDIX

Methodology

This analysis was conducted based on 2018 industry data and using the most recently available IMPLAN economic model for the U.S. All results are in 2018 dollars. A survey process was used to collect limited but key annual data from BCI member companies.¹⁵ Compilation of the survey-derived and supplemental information represents direct impacts. The survey probed annual employment and payroll information by industry.¹⁶ The corresponding direct output (business sales or value of production) was estimated using state-specific output-to-jobs ratios from IMPLAN before summing output across companies within each of the three subsectors comprising the BCI membership. There were several instances where direct payroll was estimated using state-specific employee compensation-to-jobs ratios because survey respondents chose not to report annual payroll.

Definition of Terms

Input-output models are commonly used to conduct economic impact analysis. There are several input-output models available, including IMPLAN.¹⁷ 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 national 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. Specifically, taxes include employee contributions to social insurance, sales taxes, property taxes, motor vehicle license fees, severance taxes, corporate taxes, personal income taxes, and other miscellaneous taxes. Mining royalties paid to the government are also included in the form of property income.

Several IMPLAN-specific definitions are essential to properly interpreting the results of an IMPLAN analysis. These definitions are below, with some quoted from the IMPLAN glossary.¹⁸

¹⁵ Some of these companies have multiple establishments, hence the distribution across 30 states.

¹⁶ Since the last study, there has been a shift from primary battery manufacturing to storage battery manufacturing within the lead battery industry. This change, which has allowed companies to produce more rechargeable batteries and expand the number of consumer and commercial applications, also changed the composition of the IMPLAN inputs and the average economic multipliers.

¹⁷ See www.implan.com for more information.

¹⁸ <https://implanhelp.zendesk.com/hc/en-us/categories/115001507908-Knowledge-Base>

Economic Contribution

Economic contribution represents a “gross change in economic activity associated with an industry, event or policy in an existing regional economy.”¹⁹ This is different from an economic impact, which represents a net change in economic activity.

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.

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.

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.

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.

Indirect Impact (Supplier Impact)

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.

¹⁹ 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.

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.

Total Impact

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