BATTERY COUNCIL INTERNATIONAL

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RESEARCH BRIEF

Motive (Forklift) Batteries:
Comparative Lifecycle Assessment of Lead and Lithium-Iron Phosphate Battery Production

The material handling sector is rapidly replacing gas-powered internal combustion forklifts to electric models. This is driving demand for both lead-based (Pb) batteries and lithium-iron phosphate (LFP) batteries as power sources. While each is sufficient, they have different sustainability profiles, especially during manufacturing.

This research brief summarizes key findings of a lifecycle assessment (LCA) of the two battery chemistries in North America. Foremost is this conclusion about their respective global warming potential:

The environmental impacts of manufacturing a lead-based motive battery are roughly three times less than manufacturing a similar lithium-iron phosphate motive battery.

Study Parameters

- **Batteries Compared:** Lead (Pb) and lithium-iron phosphate (LFP); each are 48V, 500 Ah (24kWh).
- **Battery Origin:** A lead battery produced and assembled in North America; LFP battery produced in Asian countries.
- **Application:** Forklift
- **Intended Use:** Rechargeable energy storage for the service lifetime of a forklift (10 years).
- **Geographic Area and Study Year:** North America, 2021
- **System Boundary is Cradle-to-Grave:** Includes raw material extraction and/or processing, inbound transport to production facility, battery materials manufacturing, battery assembly, use of the battery, and its end-of-life treatment over the lifetime of the application.
- **Global Warming Potential (GWP100) Impact Assessment Tool:** The latest Intergovernmental Panel on Climate Change characterization factors taken from the 5th Assessment Report (2013) for a 100-year timeframe.
- **Data Collection:** For Pb batteries, data supplied by North American battery companies. For LFP batteries, current literature available.

Summarized Findings:

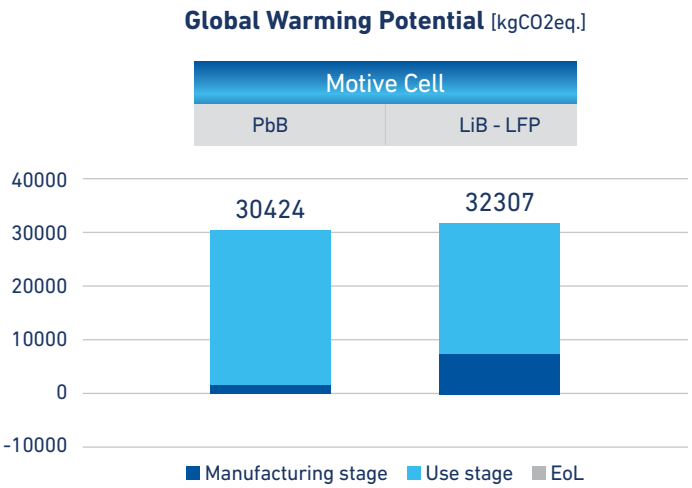
Manufacturing Impact

Overall, Pb battery manufacturing has a lower environmental impact compared to a lithium-ion battery, which includes the LFP battery.

- The environmental impacts of manufacturing a Pb motive battery are **roughly three times less** than manufacturing a similar LFP motive battery.
- Most impact categories showed small differences between both batteries assessed, with **lead batteries performing better** in the baseline scenario due to lower burdens in manufacturing (2 to 6 times lower), depending on the impact category.
- A significant contributor to the LFP manufacturing impact is the LFP's Battery Management System (BMS) that is required to ensure functional safety. The BMS shuts the battery down to protect the lithium-ion cells and the user if an unsafe condition is detected. **Pb batteries have a low fire risk**, and typically don't require a BMS.

Global Warming Impact

Global Warming Potential (GWP) is the most commonly used metric for quantifying the ability of greenhouse gas to trap heat in the atmosphere. Pb batteries have a lower GWP impact than LFP batteries, under the assumptions taken in the baseline scenario of the study.



Overall Life Cycle GWP per battery technology

How Recycling Affected Study Results

Determining the most accurate LCA of battery chemistries requires analyzing their end-of-life allocation, including recycling and recycled content. Two main approaches are commonly used: the Substitution Approach and the Cut-Off Approach. This study used the first.

The Substitution Approach

This is based on the perspective that material recycled into secondary material at end-of-life will substitute for an equivalent amount of virgin material. The approach rewards end-of-life recycling but not the use of recycled content.

Recycling Impact

Lead Batteries: Lead is the most efficiently recycled commodity metal, and lead batteries are the only battery system that is almost completely recycled. It has a well-established recycling infrastructure.

- Pb batteries have a 99% recycling rate.
- The vast majority of raw materials in a lead battery are recycled.
- Pb batteries all share the same basic chemistry and have minimal components. This creates a uniform, streamlined recycling process.

Lithium-Iron Phosphate Batteries: LFP batteries only use primary materials, including lithium carbonate and phosphorus, as well as electronics using precious metals (which are recovered). Challenges exist in recycling lithium-ion battery waste, a process that is in its infancy.

- Lithium-ion batteries have an estimated 15% collection rate and 5% recycling rate.
- Only the passive components, as well as electronics and battery case, are recycled, while the LFP cell is incinerated.
- Lithium batteries share several common features but their active materials and componentry greatly vary. This makes material recovery and recycling difficult.

Conclusion

Experts predict that global demand for motive batteries will increase by over 63%, from 41 GWh in 2022 to 67 GWh in 2030. To help mitigate global warming, electric forklift manufacturers must consider a motive battery's sustainable manufacturing profile. A comparative lifecycle assessment of motive lead (Pb) and lithium-iron phosphate (LFP) batteries used in electric forklifts in the United States has made this important conclusion:

The environmental impact of manufacturing a motive Pb battery is three times less than manufacturing a similar LFP battery.

About the Study

Author – "Comparative LCA of Lead and LFP Batteries for Automotive Applications" was conducted according to ISO 14040/44, the international standards on life cycle assessment (LCA), by Sphera Solutions. They specialize in ESG performance and risk management software, data and consulting services.

Sponsors – Battery Council International (BCI) and the International Lead Association (ILA) commissioned this study to better understand the environmental impact of lead-based battery production from cradle-to-grave and promote continuous improvement in the environmental sustainability of lead batteries.

Comparative Lifecycle Assessment of Motive Power Lead and LFP Battery Production – North America

The Circular Economy of Lead Batteries Info Brief

Circular Economy of Lead Batteries Infographic

BATTERY COUNCIL INTERNATIONAL Recently celebrating its 100th anniversary, BCI was formed in 1924 and joins together battery manufacturers and recyclers, marketers and retailers, suppliers of raw materials and equipment, and battery distributors from across North America and around the world. BCI members are committed to responsible manufacturing and recycling processes, and serve as a unified voice for environmental, health and safety stewardship.

Learn more at BatteryCouncil.org

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