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RESEARCH BRIEF

Automotive Batteries:

Comparative Lifecycle Assessment of Lead and Lithium-Iron Phosphate Batteries

Today's automotive sector – specifically, ICE, start-stop and micro-hybrids – rely on both lead-based batteries and lithium-iron phosphate batteries. While each is necessary, they have different sustainability profiles, especially during their manufacturing phase. This research brief summarizes key findings of an in-depth comparative lifecycle assessment (LCA) of the two battery chemistries. Foremost, is this conclusion about their influence on global warming:

The environmental impact of manufacturing a lead-based automotive battery is four times less than manufacturing a similar lithium-iron phosphate automotive battery.

Study Parameters

Automakers face new and emerging battery options, many with an unknown impact on global warming. This study informs stakeholders on the environmental impact of two automotive battery chemistries, within these parameters:

- **Batteries Compared:** 12V lead-based (Pb) battery (or PbB) and a 12V lithium-iron phosphate (LFP) battery (also known as LiB-LFP).
- **Applications:** Internal combustion engines (ICE), start-stop vehicles, and micro-hybrid vehicles, defined as:
  - Conventional ICE vehicles use batteries to provide starter, lighting and ignition (SLI) functions.
  - Start-stop vehicles use batteries for an idle start-stop (ISS) system, which allows the ICE to automatically shut down under braking and then restart. This saves fuel.
  - Micro-hybrid vehicles use batteries for a system that combines start-stop functionality with regenerative braking and other micro-hybrid features. This type of duty requires higher resilience of the battery with deep-cycling and a high rate of charge acceptance.
- **Geographic Area and Study Year:** North America, 2021
- **System Boundary is Cradle-to-Grave:** This includes raw material extraction and/or processing, inbound transport to the production facility, battery materials manufacturing, battery assembly, use stage of the battery over the lifetime of the vehicle and end-of-life treatment.

Summarized Findings:
Lead Battery Sustainability Surpasses Lithium-Iron Phosphate in Manufacturing

Manufacturing Impact

Overall, Pb battery manufacturing has a lower environmental impact compared to an LFP battery.

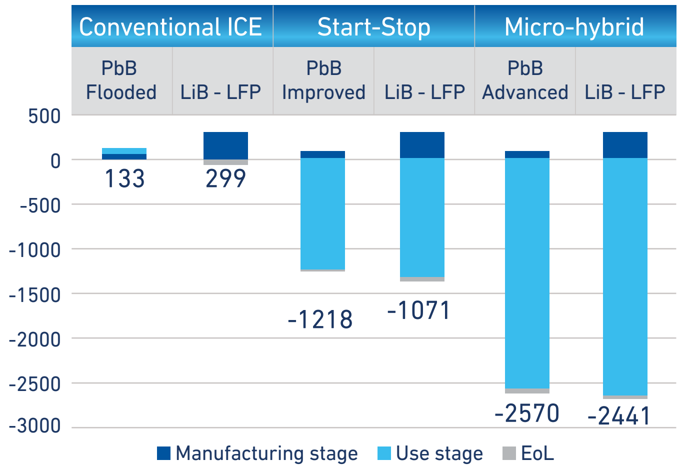
- The environmental impacts of manufacturing the LFP battery compared to manufacturing the Pb battery are roughly greater by a factor of four.
- Most impact categories showed small differences between all batteries assessed, with lead batteries performing better in the baseline scenario due to lower burdens in manufacturing (ranging from 90% to 39% depending on the impact category).

Further, despite the claimed weight, lifetime, and energy density advantages currently presented by LFP batteries, the overall environmental performance of lead and LFP batteries are roughly equivalent over the lifespan of the vehicle.

Global Warming Impact

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

Global Warming Potential [kgCO_2eq.]



Overall Life Cycle GWP per battery technology, and type of vehicle application

Circular Economy of Lead Batteries

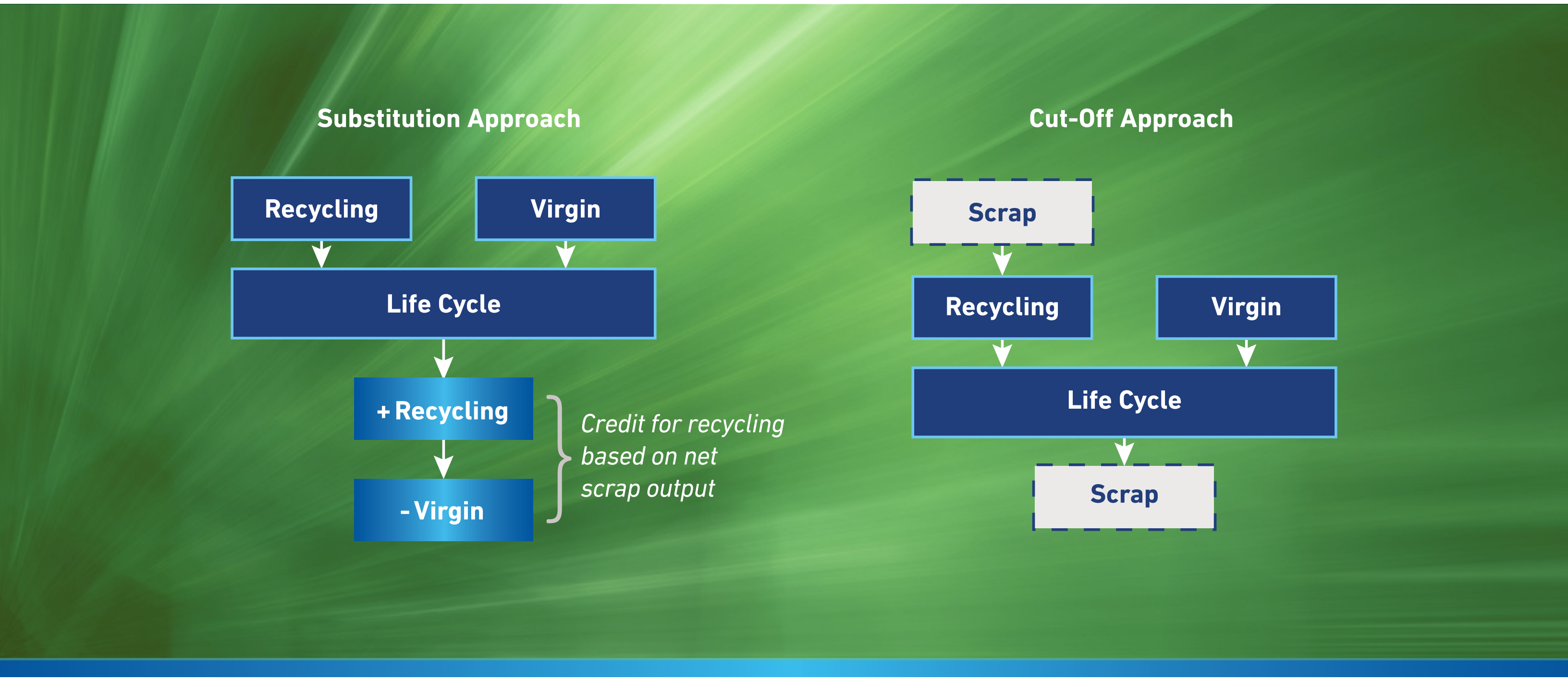
- Currently, it is not economically viable to recover lithium, iron and phosphate from the cathode of the LFP battery system.
- Pb batteries have a proven circular economy that models how to responsibly source, use, reuse and manage manufacturing materials to create valuable, new, battery grade materials.

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 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.

LFP only use primary materials, including lithium carbonate and phosphorus, as well as electronics using precious metals (which are recovered). Challenges exist in recycling lithium 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

A comparative lifecycle assessment of automotive lead-based (Pb) batteries and lithium-iron phosphate (LFP) batteries has made this conclusion:

The environmental impact of manufacturing a Pb battery is four times less than manufacturing a similar LFP battery. To help mitigate global warming, it will be essential to consider an automotive battery's sustainable manufacturing profile within green transportation options.

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 12V lead-based battery production and promote continuous improvement in the environmental sustainability of lead batteries.

"Comparative LCA of Lead and LFP Batteries for Automotive Applications"

The Circular Economy of Lead Batteries Info Brief

Circular Economy of Lead Batteries Infographic

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

Learn more at BatteryCouncil.org

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