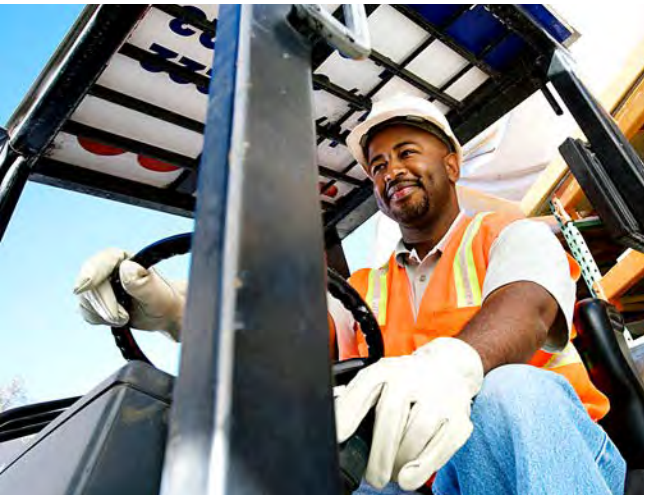
Zero-Emission Forklifts

Many communities are experiencing the catastrophic effects of climate change in the form of historic droughts, wildfires, floods and rolling blackouts. These natural and manmade disasters have accelerated the conversation around clean energy through proposed new energy policies and support for greater electrification. States are increasingly setting goals to produce 100% of retail electricity from carbon neutral resources in the coming decades. As policymakers seek to identify sustainable pathways to meet clean energy mandates and achieve economy-wide carbon neutrality, they can look to innovations in battery technology generally, and lead batteries, in particular, for solutions.

The forklift industry is one of the many sectors that has an opportunity to leverage lead battery technology. Lead batteries already power the majority of electric forklifts in a safe, reliable, and cost-effective manner. The following information compares available forklift battery technologies and details the advanced capabilities of electric forklifts powered by lead batteries.

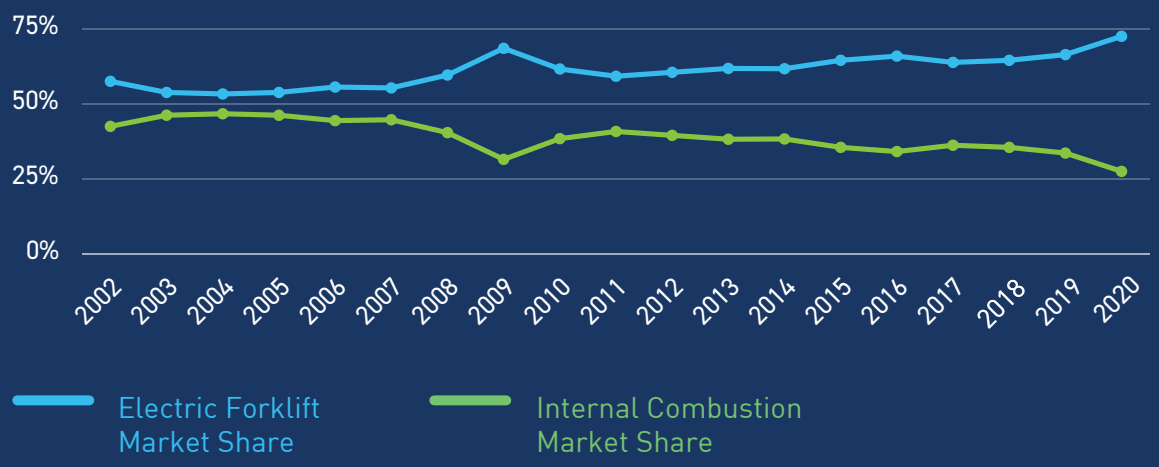


Electric Forklifts vs. Internal Combustion (IC) Forklifts

- Innovations in electric forklift technology have shown that modern electric forklifts can replace IC forklifts in every application with no loss in performance.
- A total cost of ownership (TCO) analysis shows that electric forklifts are the more efficient technology.
- Electric forklifts offer a significant environmental advantage.
- Electric forklifts are the clear choice moving forward.

Electric Industrial Truck Market Share

Electric forklifts continue to gain market share.



Total Cost of Ownership

Key factors that affect the TCO include:

- Initial cost of purchase
- Energy efficiency (how long the forklift can run on one battery charge or one tank of fuel)
- Cost of fuel or electricity
- Cost of maintaining air quality in a warehouse
- Cost to maintain the forklift, including such components as batteries (IC forklifts also have batteries), fluids, tires and filters
- Opportunity cost of infrastructure to accommodate refueling, battery charging stations, etc.
- Reliability (e.g., work time lost due to forklift scheduled down-time)
- Cost vs. credit for end of life of the battery

Other Factors that Influence Purchase Decisions

Total cost of ownership

Suitability of platform for specific application

Safety

Environmental sustainability

Product availability

Different Applications Require Different Technologies

- To determine the battery technology best suited to the task, users should understand how the forklift will be used in the facility.
- Proposed regulations should allow flexibility for customers to determine best fit battery chemistries.
- Feasibility and timing of transition to electric forklifts require a performance-based, technology neutral approach.

Comparison of Forklift Battery Technologies

Technology	Pros	Cons
Lead Batteries	• Established, reliable reputation, easily deployed and supported • Sufficient power for majority of MHI applications • 99% recycling rate • Most economical industry • Ample, domestic production capacity • Can be fast charged or opportunity charged	• Capacity limited in some applications • Requires maintenance • Requires charging infrastructure • May require changing infrastructure due to associated battery rooms
Enhanced Lead Batteries	• Improved performance/higher daily throughput • Faster recharge/power density • Recyclability (same as lead-excellent) • Charge in forklift/eliminates battery change infrastructure • Industry production capacity available (same as lead) • Maintenance-free (some offerings)	• Capacity shortfall in very high throughput applications • Requires maintenance (some offerings) • Requires charging infrastructure
Lithium-ion	• High performance/productivity • Faster recharge/power density • Maintenance-free • ROI is best in the highest capacity demand applications	• High cost of ownership • End of life: Disposal, limited recycling (15% recycling rate) • Limited industry production capacity • ROI marginal in less demanding applications • Requires charging infrastructure
Hydrogen	• Easy refuel/available for 24-hour operation • One fuel cell battery per forklift/ eliminates battery changes and associated resources	• Very high cost of ownership/poor ROI • Hydrogen fuel is more expensive than electricity • End of life: Disposal not recycle • Very limited industry production capacity • Units are underpowered for many applications • Complicated and expensive fuel delivery system • Large fleets > 50 forklifts required to even approach economic feasibility

Environmental Sustainability

The logistics and transport sector accounts for around 2.8 billion tons of equivalent carbon dioxide, which is approximately 5.5% of the total greenhouse gas emissions (GHG).

A comparable fleet of electric forklifts will use 83.5% less CO2 than its IC counterpart.

Additional benefits from electric forklifts include:

- No engine, transmission or coolant fluid changes.
- No need to dispose of used fluids, oil, and filters.
- Reduced noise pollution
- Cleaner goods in warehouses and factories

The lead batteries powering the electric forklifts are part of a true circular economy, with recycled lead, electrolyte, and casings used to manufacture new batteries.

Lead batteries, including forklift batteries, are the most recycled product in North America, according to the EPA.

Robust, Ready to Scale Infrastructure

- Lead batteries have an existing manufacturing, collection and recycling footprint.
- This closed-loop supply chain ensures feedstock for lead batteries remains available and protected from global disruptions.
- Unlike lithium batteries, they are not reliant on imported critical materials or specialty metals.
- Approximately 90% of North American lead battery demand is met by North American manufacturers.

In the U.S., lead batteries maintain a 99% recycling rate using a closed-loop recycling network that keeps **130 million lead batteries** from landfills annually.

Technology	Health & Safety Considerations
Internal Combustion	• Vehicle emissions are potentially hazardous to user and other personnel. • Produces long term, potentially damaging noise levels. • Fuel is flammable, combustible.
Lead Batteries	• Spill concern for flooded products, and electrolyte is corrosive. • Materials handling concern for a battery room.
Enhanced Lead Batteries	• For Absorbent Glass Mat (AGM)/Gel products, proper ventilation must be provided (gases can form from electrodes). • Electrolyte is corrosive. No spill concern for AGM/Gel products.
Lithium-ion (all types)	• Thermal runaway from overcharge or over discharge can lead to propagative fires that are difficult to control, especially for higher energy density variants. • Electrolyte is flammable, anodes can ignite with exposure to air. • Known concerns regarding end-of-life, batteries have been known to create fires at land fills, scrap warehouses, and during distribution/shipping.
Hydrogen	• Fuel is highly flammable. • Maintenance of fueling equipment, hoses, seals, and tanks is important - prone to leakage.

Advanced Lead Battery R&D: Trends in Lead Battery Innovation

Decrease in Lead Content

↓ 46%

New types of lead batteries utilize more of the active material and have replaced lead weight with recyclable plastics.

Carbon electrodes in lead batteries for industrial and automotive batteries also contribute to decreases in lead content.

Increase in Deep Cycle Life

3x

500 → 1500 cycles

Since 2019, many lead battery manufacturers have introduced products with longer lifetime.

Better Recharge Capability - Opportunity Charging/Higher Charge Acceptance

2x

1.0 → 2.0 A/Ah
+8 hrs → 4-5 hrs

The ability for lead batteries to accept charge has increased, leading to further benefit of lead batteries in automobile hybridization and much faster recharge times for forklift batteries.

Conclusion

The global shift to clean energy requires industry efforts to curb greenhouse gas emissions and deploy sustainable power sources in a meaningful way. Given the unique attributes of lead batteries, this technology can readily provide safe and reliable power for electric forklifts, with minimal to no environmental impact and a low total cost of ownership compared to other technologies.

The use of lead battery technology for electric forklifts and other clean energy applications is critical for helping industry sectors and policymakers achieve zero-emission energy mandates, and most importantly, curb climate change.

essential energy everyday
Powered by Sustainable Lead Batteries

Essential Energy Everyday (EEE) exists to increase awareness of the critical importance of lead batteries to power our daily lives. EEE encourages continued investment in sustainable lead battery technology to store and provide energy on demand. The initiative is supported by Battery Council International.

Battery Council INTERNATIONAL

Battery Council International (BCI) is a not-for-profit trade association formed in 1924 to promote the interests of the lead battery industry. BCI has member companies worldwide engaged in every facet of the industry: lead battery manufacturers and recyclers, marketers and retailers, suppliers of raw materials and equipment, and expert consultants. As the industry's principle association, BCI's member services have a global impact.

Learn more at Essential Energy Everyday.

- United States Factory Shipments, 2021
- National Recycled Rate Study, Battery Council International, 2019
- Circular Economics of Lead Batteries, 2020
- Safe Fact Sheet, 2020