



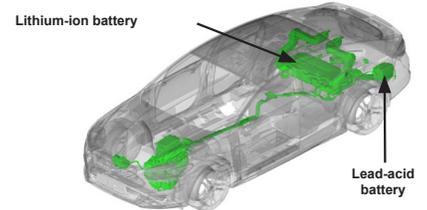
Do Hybrid Electric Vehicles Use Lead-Acid Batteries? Yes! Here's why.

From plug-in hybrids to vehicles equipped with “start-stop” technologies, lead-acid batteries are the ones most favored by automakers for starting, lighting and ignition (SLI) functions. The vehicles simply will not start without them. The 12 volt lead-acid battery for more than 50 years has been a mainstay of motor vehicles and this will continue for many years to come.

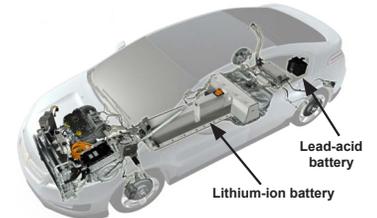
For high voltage “power assist” functions in hybrid electric vehicles, the nickel-metal hydride (NiMH) and Lithium-ion (Li-ion) systems are up to now the storage batteries of choice for automakers. Not so for the SLI function, where lead-acid batteries are clearly the necessary choice.

The best-selling hybrid electric vehicles (determined by hybrid CARS), like the Ford Fusion, all use lead-acid batteries for SLI functions. Even the Chevrolet Volt, one of the more prominent extended-range plug-in hybrids on the market, depends on its lead-acid battery not only for SLI functions, but for the control of high voltage contactors.

Ford Fusion Hybrid Battery System



Chevrolet Volt Battery System



Battery Systems in Best Selling Passenger Hybrid Electric Vehicles
2013 US (hybridCARS)

Vehicle	High voltage battery	SLI battery
Toyota Prius Liftback Hybrid	201.6 Volt Nickel-metal hydride	12 Volt Lead-acid
Toyota Camry Hybrid	244.8 Volt Nickel-metal hydride	12 Volt Lead-acid
Ford Fusion Hybrid	300 Volt Lithium-ion	12 Volt Lead-acid
Toyota Prius C Hybrid	201.6 Volt Nickel-metal hydride	12 Volt Lead-acid
Ford C-Max Hybrid	300 Volt Lithium-ion	12 Volt Lead-acid
Toyota Prius V Hybrid	201.6 Volt Nickel-metal hydride	12 Volt Lead-acid
Hyundai Sonata Hybrid	270 Volt Lithium-ion	12 Volt Lead-acid
Toyota Avalon Hybrid	244.8 Volt Nickel-metal hydride	12 Volt Lead-acid
Chevrolet Malibu-Eco	130 Volt Lithium-ion	12 Volt Lead-acid
Kia Optima Hybrid	270 Volt Lithium-ion	12 Volt Lead-acid

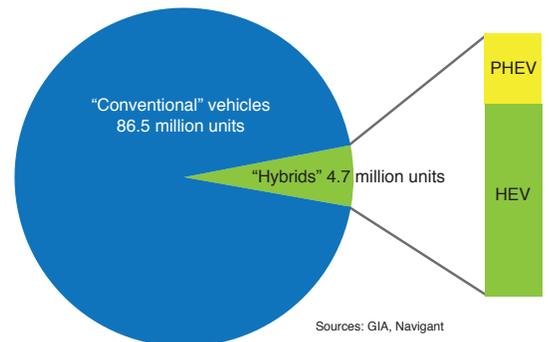
For more than 50 years, automakers have strived to make vehicles less dependent upon petroleum for a variety of reasons—environmental, economic and national security. The ability of the internal combustion engine industry (ICE) to keep up with this need for greater performance efficiency has been nothing short of miraculous, which is why ICEs will continue to be central to the auto industry even as improvements in electrification “power assist” technologies are made.

Lead-acid batteries—and will remain—central to the auto industry as well, because they have undergone their own remarkable evolution to keep up with the demand for greater efficiency. This is not to say that Li-ion and NiMH batteries cannot perform the SLI function. The best among them could, but not as affordably or sustainably as lead-acid, especially at temperatures below 20° centigrade.

Market analysts predict that while plug-in hybrid electric vehicles (PHEVs) will continue to grow in popularity, their sales will remain rather low because of their high prices arising mostly from battery issues. Most hybrids sold will be micro hybrids, those using start-stop and brake regeneration technologies that operate either with the existing 12V vehicle electric system or in the soon-to-come 48V dual battery systems. These relatively inexpensive start-stops provide limited hybrid power assist on launching and also for energy regeneration during braking.

Already, lead-acid batteries are serving all the power needs of start-stop vehicles throughout the world and also are becoming common in higher-end hybrid electric vehicles (HEVs). According to Navigant Consulting, the hybrids' share of the market will grow from the current two percent to three percent by 2017.

Projected Worldwide Passenger Vehicle Sales 2017



Lead-acid's own remarkable innovations

For many years, the standard flooded lead-acid cell battery has served—and continues to serve—the basic SLI function within the vehicle. Lead and lead dioxide plates interact with a sulfuric acid solution to provide electricity to all loads in the vehicle. The classic “flooded” lead-acid battery allows for venting and maintenance if needed. This design costs up to \$100/kWh—by far the lowest among the various battery chemistries.

Within the past 50 years, the sealed valve regulated lead-acid battery (VRLA) was developed so that the battery would no longer need maintenance (continuous monitoring of electrolyte level) because there no longer is any release of liquids or gases in normal operation.

VRLA batteries are designed in two ways: gel electrolyte and absorbed glass mat (AGM). Gel batteries, introduced in the 1960s, use electrolyte in gel form for greater stability. They are outstanding in deep cycling and long-term energy storage systems. The AGM battery, which came to market in the 1980s, uses porous glass mats to absorb and hold the electrolyte, providing mechanical compression to the plates and internal recombination conditions for oxygen released at the end of charge. The AGM batteries are particularly popular in hybrid and other “high performance” vehicles and they also are used in industrial applications.

In recent years, the lead-acid industry has come through with another great innovation, the advanced “lead-carbon,” or LC design. This new battery greatly expands the cycle life of the traditional VRLA battery by sharply reducing the sulfation of the negative plate under high rate pulse charge at partial state of charge. The use of carbon with the negative plate dramatically increases battery life to the point where an advanced lead-carbon battery can now equal—and in some cases even exceed—the performance of nickel-metal hydride (NiMH) and lithium-ion (Li-Ion) batteries, but at far lower cost. This has been proven in tests conducted under the supervision of the US Department of Energy.

The graphic above shows how the lead-acid battery has met—and continues to meet—the evolving requirements of the auto industry. From meeting the basic needs of starting, lighting and ignition with standard, maintenance-free lead-acid batteries to meeting the needs of the new drive train assist technologies with lead-carbon batteries, the lead-acid battery industry continues to meet and exceed all challenges.

The Advanced Lead-Acid Battery Consortium (ALABC) is working on the next challenge in this continuing evolution: Development of the new LC Super Hybrid, that meets all the standards of full hybrid electric vehicles with economic and sustainable technologies that combine the low costs of a micro hybrid with the fuel and CO₂ efficiency of full hybrids.

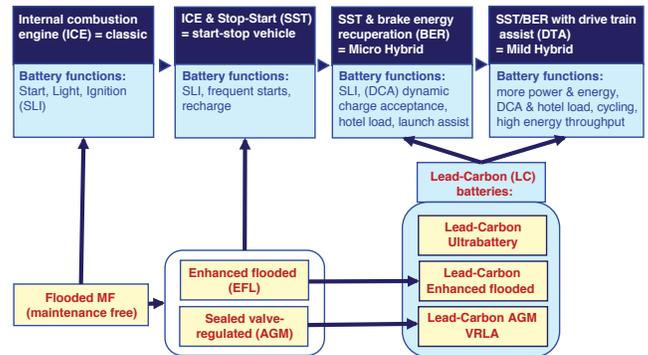
Lead-acid's unmatched sustainability

In addition to their cost advantage, lead-acid batteries have another crucial advantage over NiMH, Li-Ion and all other battery chemistries: sustainability. The lead-acid industry's undisputed economic advantage is due in large part to the fact that their batteries are almost completely recycled. From lead to sulfuric acid to even the plastic cases, all new lead-acid batteries—even those made with advanced lead-carbon technologies—can be recycled. The recycled materials used in the manufacture of new batteries are cheaper than batteries made only with new materials. This is because considerably less energy is required – and less CO₂ emitted—to manufacture and recycle batteries than to make them only from “virgin” materials. No other battery chemistry can make that claim.

This cost advantage resulting from recycling has been quantified by the US Department of Energy's Argonne National Laboratory, which directly compared the life-cycle “cradle-to-gate” production costs of lead-acid, lithium-ion, nickel-metal hydride, nickel-cadmium and sodium-sulfur batteries. A similar comparison shows lead-acid having a significant advantage over other chemistries in the amount of CO₂ emitted during the production process.

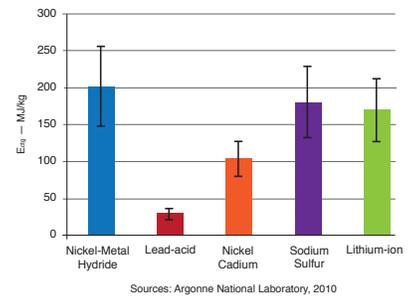
When considering why automakers choose lead-acid batteries for the SLI functions of hybrid vehicles, the reasons are obvious. Lead-acid batteries have been proven through more than 50 years to be more reliable, economic and environmentally sustainable than the competition. It will remain this way for many years to come.

The Micro Hybrid Technology Evolution



The Continuing Lead-Acid Battery Evolution

Energy Consumption—Cradle-to-Grave
MegaJoules per kilogram



Average CO₂ Emissions
per kg of various battery technologies

