

BATTERY POWER

Nearing the Promise of the Micro-Hybrid Vehicles: Technology Improvements and New Markets

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Until very recently, many consumers were unfamiliar with the type of vehicle defined as micro-hybrid. Even though leading research firms such as Lux Research have been predicting the vast proliferation of micro-hybrids for years; the most recent study predicts that there will be 39 million on the road by 2017. Outside of Europe, the technology has remained in the shadows of flashier electric vehicles (EVs) and more popular and ubiquitous hybrid vehicles such as the Toyota Prius.

Today, however, the tide is beginning to change. Major automakers such as BMW, Ford, Volkswagen and Kia will all begin offering stop-start technology, a defining characteristic of micro-hybrids, in their latest models in North America for as little as \$300 extra. Internationally, micro-hybrids are already common in Europe and rapidly catching on in China. As the technology for micro-hybrids systems becomes more sophisticated, we see two pervasive trends: automakers are continuing to search for the optimal battery chemistry to support the unique and increasing demands of the stop-start system, and global automotive OEMs increasingly have their sights set on China as the next major market and view the country as a strategic partner in the global stop-start industry.



The Promise of Micro-Hybrids

Micro-hybrid vehicles are traditional gasoline or diesel-powered cars with automatic battery-powered stop-start systems that shut off the engine while the vehicle is at rest, such as at a red light, and restart it instantly and automatically upon engaging the gas pedal. Although integrated stop-start systems don't offer any hybridization of the drive-train, the technology is increasing in popularity because it offers maximum fuel efficiency improvement for the lowest cost on either a dollars per grams of CO2 reduction basis, or dollars per MPG improvement basis. At prices as low as \$300 per system, the technology is one of the most cost effective ways of improving fuel efficiency. Current micro-hybrid technology can improve fuel economy by 5 to 10 percent, while future systems may achieve savings as high as 15 percent. If widely adopted, the technology can substantially reduce fuel consumption and air pollution from idling vehicles.

Micro-hybrids have already achieved widespread adoption in Europe. Today, more than 40 percent of cars in Europe have stop-start technology, according to the AAA. By 2015, battery maker Johnson Controls predicts that automatic start-stop systems will be standard in 70 percent of all vehicles sold in Europe. With aggressive emissions regulations and high gas prices, Europe has been a fertile market for stop-start technology thus far. Many vehicles in Europe today are already sold with start-stop functionality as a standard feature.

The US has seen slower adoption of stop-start technology due to less stringent emissions regulations and lower gas prices compared with Europe. In a stance that has further stunted stop-start's proliferation in the US, the Environmental Protection Agency has estimated that the technology won't achieve its promised fuel savings due to US driving patterns, which tend to be less stop-and-go centric than those in Europe. However, as gas prices continue to climb, consumers in the US are increasingly interested in seizing the low hanging fruit of fuel efficiency. Likewise, automakers such as Ford and BMW have already demonstrated their belief in American consumers' interest in the promised fuel savings.

Micro-hybrids are also starting to gain traction in China. While today there are only roughly 200,000 vehicles sold in China each year that carry automatic stop-start systems, there is enormous potential in this market. With strict emissions standards, lightning-fast technology adoption and a recent government priority shift from EVs toward safer and economical near-term CO2 abatement solutions, China's micro-hybrid adoption could quickly eclipse that of Europe.

The stop-start technology itself is advancing as well. Second generation stop-start vehicles are becoming commonplace in Europe. While first generation technology relied on just a simple stop-start system for the engine, second generation systems incorporate features such as energy recuperation. As third generation systems begin to emerge, we'll see implementation of more advanced concepts such as shutting off the engine during coasting (not just when stopped), as well as some mild levels of electric boost during acceleration. All of these features will impose even greater loads, and require enhanced performance capabilities from the batteries.

Battery Chemistries for Micro-Hybrids

To date, the main challenge to the widespread implementation and adoption of such next-generation micro-hybrid features, at an acceptable cost, has been the performance limitations of current battery technologies. Nickel Zinc (NiZn) offers several advantages over existing technologies, and is a real single source energy storage system that is perfectly suited to meet both the technical and cost challenges of advanced micro-hybrids.

The current reigning battery chemistry is lead-acid, which automakers grudgingly use while acknowledging its shortfalls for the needs of micro-hybrids. Compared with lead-acid, NiZn chemistry can offer up to 65 percent weight reduction and twice the service life, resulting in further improvement in fuel consumption. Furthermore, MPG gains resulting from use of lead acid batteries in stop-start systems decrease gradually to as low as 2 percent within one year of use, vastly due to loss in dynamic charge acceptance (DCA). However, MPG improvement offered by NiZn is expected to remain steady at 8 to 12 percent for up to five years under persistent stop-start use, as one of NiZn's primary benefits over lead-acid is that it retains consistently high DCA over its lifespan.

Other advanced battery chemistries are competing to capture the opportunity of micro-hybrids. There are also some improvised lead-acid technologies available on the market today. Advanced glass matt (AGM) batteries, for example, offer somewhat better performance than traditional lead-acid batteries, and are more widely used in second generation micro-hybrids in Europe.

Lead-carbon is another alternative, but is more commonly adopted as a dual battery solution alongside another lead-acid battery, typically an AGM. While this system provides some performance gains compared to a sole lead-acid battery, the dual system also makes the overall architecture considerably heavier and more expensive, with increased system integration complexity.

Another alternative solution is placing ultra-capacitors alongside lead acid batteries, which has been adopted by some auto manufacturers like Peugeot. Under this solution, the ultra-capacitors accept and deliver high amounts of burst power during energy recuperation and engine crank respectively. While this process works in theory, it is very expensive and severely degrades the system value proposition. The system will still suffer from loss of DCA of the lead-acid battery. Also, ultra-capacitors face issues with safety, since they typically carry flammable electrolytes. In comparison, NiZn offers a vastly improved value proposition over such systems, and the technology is considerably simpler to install.

Lithium-Ion (Li-Ion) is a well-known chemistry currently being proposed for use in a number of hybrid and electric vehicles. While Li-Ion offers some of the same benefits as NiZn in terms of performance enhancements, such as sustained high DCA, the technology is considerably more expensive than NiZn. Li-Ion has faced a number of safety issues as well, fundamentally because the chemistry uses a petroleum based electrolyte, which is flammable. As a result, a number of high profile battery fires over the past couple of years have somewhat tarnished the reputation of Li-Ion, especially for use as a single battery solution for micro-hybrids, where the 'under-the-hood' environments often tend to be harsh and unforgiving.

Another key issue that Li-Ion faces is its lackluster performance at cold temperatures. While stop-start systems themselves are typically only activated between -5°C to 35°C, the battery must be able to perform all basic SLI (starter, lighting and ignition) functions across a much wider temperature range, if used as a single battery solution. The batteries must be capable of cold cranking engines at temperatures as low as -30°C, a temperature where it is very stressful for starting diesel engines in particular, which are very commonly used in passenger cars throughout Europe. Performance of NiZn is not masked with such limitations, making it an ideal single source advanced battery solution for micro hybrids.

An important consideration in the landscape of existing chemistries is also the availability of raw materials. Nickel and zinc, for example, are cheap and abundantly available with stable pricing. These are also highly recyclable materials. Li-Ion availability depends on balancing demand from a number of markets. If the battery were purely used for stop-start systems, the materials would probably be available in sufficient amounts, but with EVs, stationary storage and other applications already adopting Li-Ion, the pricing will start to become more volatile and dependant on fluctuations in raw material pricing.

In the past, some automakers have relied on lead-acid, despite its shortcomings, due to skepticism over adopting advanced battery chemistries developed by start-up companies. Unfortunately, this skepticism has only been reinforced by high profile advanced battery company failures in recent months. However, many of these start-ups have evolved into fully established, commercialized companies that have already proven themselves over a decade or more of operations. In particular, companies that have already crossed the commercialization chasm, PowerGenix is one, have the benefit of experience with production and sales on a large scale. Those companies that have shown longevity are increasingly being considered by major auto OEMs, who are actively testing alternatives to lead-acid for micro-hybrids.

New Markets: China

Since 2008, China's automotive industry has been the largest in the world measured by automobile unit production. The market for vehicles in China is also enormous and continuing to grow; there are more than 100 million passenger vehicles on the road in China today, and officials predict that Chinese roads will need to absorb 200 million cars by 2020. However, with more vehicles come more problems, such as traffic congestion and pollution. As a result, many Chinese cities are introducing measures to restrict car sales. For example, Beijing city authorities announced this year that they will only allow 240,000 new-vehicle registrations, which is roughly one-third of the total registrations in 2010.

China has also announced aggressive plans to curb CO2 emissions. By 2020, the country is committed to reducing CO2 emissions by 40 to 45 percent from 2005 levels, while using non-fossil fuels for 15 percent of its energy. Furthermore, with sales of EVs falling short of government targets, China has recognized that it will not be able to achieve its emissions goals with EVs alone and needs to begin shifting its focus to more cost-effective ways to curb CO2. Bloomberg New Energy Finance recently reported that EV sales from 2009 to 2011 totaled about 13,000 vehicles, putting China at a disadvantage in reaching its target of 5 million EVs by 2020.

As a result, China is a very nascent and fertile market for micro-hybrid technology. PowerGenix projects that China's micro-hybrid vehicles sales will vastly increase from 200,000 in 2012 to 2.4 million by 2015 and 3.6 million by 2017. Likewise, Johnson Controls projects that battery sales in China will increase from 1.9 million in 2012 to 8.5 million by 2015 and 17 million by 2017.

What's Next

Rising global fuel prices combined with President Obama's recent Corporate Average Fuel Economy (CAFE) emissions standards offer an enormous opportunity for automotives across the hybridization spectrum. Micro-hybrids, in particular, present a near-term opportunity to improve fuel economy for drivers in the US and other international markets. With automobile OEMs forming significant on-the-ground partnerships in China, consumers in the US and China will soon see millions of micro-hybrids on the road. Furthermore, the right battery chemistry to move the industry forward is already available. NiZn batteries offer the best balance of performance and cost to enable the proliferation of micro-hybrid technology, and its clear economic and environmental benefits, across the globe.

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