

GE's "Plug in" to Hybrid and Battery Technologies



GE researchers are developing the advanced technologies needed to bring the hybrid locomotive to market. They also are creating new hybrid and battery technologies to accelerate the electrification of several other transportation platforms such as tugboats, buses and passenger cars. These advancements are expected to impact applications in the energy sector as well.

Background:

When you look at key trends in the transportation and energy sectors, one thing is becoming increasingly clear. New advancements in hybrid and battery technologies are changing the way we transport and power the world.

In transportation, we are witnessing increased hybridization across the transportation infrastructure from big locomotives to small passenger cars. With continued fuel price volatility and heightened concerns about the environment, new breakthroughs in hybrid and battery technologies will promote cleaner transportation alternatives.

Today, the world has fuel cells, batteries, ultracapacitors and motors to make it work. Demonstration vehicles are on the streets today. The challenge is making the necessary technological advances to bring these solutions to market in a safe, reliable, and economical way. Can we develop batteries and hybrid systems for vehicles that make them as affordable as vehicles running on gasoline or diesel fuels? And can it be done while also delivering enhanced performance?

In energy, cost-effective battery technology has the promise to help distribution systems manage their peak load, allowing infrastructure upgrades in substations and transmission wires to be deferred. Batteries also could help enable much higher penetrations of renewable power on the grid by serving as a reliable source of backup power when the wind isn't blowing and sun isn't shining.

GE's deep understanding of electric power and extensive experience integrating electric power into complicated systems such as a power plant, locomotive, airplane and even passenger cars, makes us uniquely positioned to change the way we power and transport the world.

GE Technology Focus:

Today, GE has dedicated research teams working in advanced battery and hybrid systems technologies to accelerate the electrification of transportation and help enable a cleaner, more diversified energy portfolio.

In transportation, GE researchers are developing the battery and hybrid systems technology needed to bring the hybrid locomotive to market. GE's hybrid locomotive will provide an additional 10% fuel savings and 10% emissions reduction, capturing energy in the braking process and storing it in batteries to provide a ready supply of clean power to supplement the diesel engine during acceleration.

Beyond the railways, GE Global Research is working to hybridize our highways and waterways as well. We have several ongoing initiatives to get the cost, performance, reliability and lifetime of batteries where they need to be to begin having real impact in the marketplace. These activities include:

- **Development of novel electrochemistries** to increase energy and power density, while minimizing battery degradation;
- **Cell-level packaging** for better robustness and reliability;
- **In-depth testing** to assess battery performance and life prediction;
- **New controls** to allow for vehicle system integration and optimization; and
- **New manufacturing processes** for improved design, cost and quality systems.

As part of our work, we have had significant experience with all types of batteries, including lithium-ion and sodium batteries. We have good insight into lithium-ion battery technology, in part, through a research partnership with A123Systems. Here, we have supported development of their battery for automotive applications.

GE's efforts on sodium batteries also have been significant. For the past four years, we have been developing sodium metal halide battery technology for our hybrid locomotive. This type of battery, which is very durable and can store a lot of energy, is ideal for mega-hybrid applications like a locomotive or heavy-duty commercial vehicle where energy storage is a premium.

In addition to these projects, GE researchers are engaged in several projects with various government and industry partners to drive hybrid and battery technology advancements. Highlights include:

- A **hybrid off-highway vehicle project** with the U.S. Department of Energy (DOE) that resulted in the successful demonstration of the world's first and only hybrid mine haul truck;
- A \$13 million project with the Federal Transit Administration (FTA) to develop and demonstrate a **zero emissions hybrid fuel cell bus**; and
- A joint project with the C-MAR Group to develop a **hybrid tugboat**.

In addition to transportation, GE researchers also are studying batteries for potential long-term energy storage solutions in the stationary power sector. From power plants, wind farms and the grid to oil and gas pumping stations, GE's business portfolio touches many different types of energy systems. In each of these systems, energy storage continues to arise as an opportunity to improve efficiency, offer environmental benefits and deliver performance.

GE research and development activities in hybrid and battery technologies are all part of GE's ecomagination initiative. Ecomagination represents the company's commitment to develop new environmentally friendly technologies and products to solve our toughest environmental challenges. Under ecomagination, GE has pledged to more than double its level of investment in the development of cleaner energy technologies from \$700 million to \$1.5 billion during the next five years. GE Global Research is looking at technology across the transportation and power sectors to deliver cleaner, more sustainable solutions.

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