

The Electric

The Electric: 13 Teams Compete to Invent the Most Powerful Superbattery



Wright Electric CEO Jeff Engler, whose company is a contestant in Arpa-E's competition to invent a 1,000 watt-hour per kilogram battery. Photo: Luke MacGregor/Bloomberg/Getty

By Steve LeVine

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Amid grave investor doubts about the viability of next-generation batteries, a half-dozen U.S. companies and seven universities are competing in a government-sponsored contest to quadruple the energy density of the world's best commercial electric vehicle batteries.

In February, Arpa-E, the Department of Energy's research arm, selected 13 teams for a three-year contest to invent the world's most powerful practical transportation battery. They are competing for financial support and bragging rights; Arpa-E is negotiating contracts with the contestants ahead of the competition's start in the summer.

As we recently reported, many automakers are resisting the idea that they must adopt next-gen silicon or lithium-metal batteries when conventional batteries are already delivering good performance, and improving every year. The Arpa-E competition—an attempt to eclipse silicon, lithium metal and everything else under commercial study—is a counterpoint to this thinking. The goal—a battery with an energy density of 1,000 watt-hours per kilogram—would require a massive technological leap and may not be possible for decades. But the benefits would be significant: In an EV, such batteries would power a motorist for 2,000 miles on a single charge. That would be far in the future, however. As a first stage, Arpa-E wants to electrify regional airliners carrying 100 passengers up to 1,000 miles, passenger trains and ships plying coastal waters. Electrifying those forms of transportation—an objective more challenging than building EVs—would have a huge societal impact.

Commercial state-of-the-art batteries able to power an EV for 500 miles generally have energy densities of around 280 watt-hours per kilogram. It took battery makers more than a decade to reach that level, from 180 Wh/kg. Since 2017, the DOE has been running a program to more than double that density to 500 Wh/kg, a level thought sufficient to make nearly any EV competitive with combustion in range and cost, but researchers hope to reach the goal only in 2026. Two companies—**Amprius Technologies** of Fremont, Calif., and China's **Contemporary Amperex Technology Ltd.**, the largest maker of EV batteries—have said they have achieved 500 Wh/kg in prototype cells, but neither has released them commercially.

Ping Liu, an engineering professor at the University of California, San Diego, which is participating in the DOE's 500 Wh/kg program, said that when he first heard of the Arpa-E program, he scratched his head and wondered if it could be serious. "If we had a method to go from 500 Wh/kg to 1,000, we would have done that a long time ago. Why would we hold it back?" he said. But then he discussed the idea with colleagues, and realized that the typical requirements for a battery—that it operate at room temperature, be rechargeable and require little or no external pressure—wouldn't be practical for an airliner. He joined a team led by **Aurora Flight Sciences**, a Boeing subsidiary, which came up with an idea that Liu says isn't really a battery at all but an "aluminum fuel hybrid power system." In a series of reactions, aluminum fuel would create hydrogen, which would power a fuel cell. The fuel cell would create "a tremendous amount of heat," he said, which would drive a turbine and power the plane, ship or train.

Wright Electric, an Albany, N.Y., company, has also proposed a system using aluminum—and also is using a broad definition of what a battery is. Its system uses aluminum as a fuel, similar to how workers used to feed wood and coal into a furnace to power trains and ships. “Think of it like a cassette or a cartridge,” said CEO Jeff Engler. “With each flight you put in a new aluminum cartridge, and at the end you take out the aluminum cartridge, and you put in a new one for the next flight or for ground-based operations.”

Professors from the University of Michigan and the Massachusetts Institute of Technology have co-founded two startups that are contestants in the program. Venkat Viswanathan, a mechanical engineering professor at Michigan, and Yet-Ming Chiang of MIT launched California-based **And Battery Aero**, along with **Propel Aero**, a company in Ann Arbor, Mich. Viswanathan said the companies were proposing two distinct approaches to reaching the goal. “A thousand Wh/kg is a very difficult goal, so we have more than one shot on goal to be able to get there,” he said.

Batteries are often compared to transistors as life-changing technology, but the comparison is not perfect. Transistors were invented in 1948, and 76 years later they have transformed much of the world around us. Batteries were invented in 1799, and only now are beginning to enable EVs to compete with combustion. But they have come a long way, says Halle Cheeseman, director of the Arpa-E program. The first commercial lithium-ion battery powered a hand-held Sony video camera released in 1991. The batteries inside cost \$4,000 per kilowatt hour. If someone had used those batteries at the time in an EV, “the battery alone would be \$300,000,” Cheeseman said.

A commercial 1,000 Wh/kg battery could take decades of work—if it can be done at all. Cheeseman said the likelihood is that such batteries would first go to customers less concerned with cost—like the military. Whatever their path, Cheeseman said he expects at least one team to reach the finish line. That would be submitting a working 1 kilowatt-hour prototype of their system, a milestone that will set the winners apart from mere lab experiments. Whatever happens, he said, it’s worth trying. “We wouldn’t have batteries at all if people had given up on them as quickly as people want to give up on some things,” he said.

Steve LeVine is editor of The Electric. Previously, he worked at Axios, Quartz and Medium, and before that The Wall Street Journal and The New York Times. He is the author of The Powerhouse: America, China and the Great Battery War, and is on Twitter @stevelevine