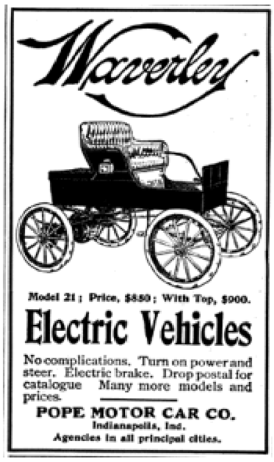
Better batteries or better Electric Vehicles

Tesla recently announced its plans to be as big as Apple within 10 years (a bold statement given the electric car company sold 35,000 cars last year, just beating out the 30,000 iPhones Apple sold each hour last quarter). Regardless of Tesla's promises, the future of electric cars hinges on advances in batteries which, in turn, hinge on how companies?and the country?choose to pursue those advances.



Since before the turn of the century, the automobile industry has been pursuing breakthroughs in battery technology. The turn of the 20th century, that is. Electric cars had promise in 1900, but nobody could find a way to make the batteries reliable and affordable. They stopped trying when the internal combustion engine became the dominant standard, with its greater power, lower weight, and longer range. And now, just when it looks like the electric vehicle may finally see its day in the sun, those pesky batteries are getting in the way again.

Once again, a battery breakthrough could unleash the full potential of the electric vehicle. As Kevin Bullis writes in ?Why We Don't Have Battery Breakthroughs,?
A better battery could change everything. But while countless breakthroughs have been announced over the last decade, time and again these advances have failed to translate into commercial batteries with anything like the promised improvements in cost and energy storage. Some well-funded startups, most notably A123 Systems, began with bold claims but failed to deliver .
Today's EV batteries are what historian Thomas Hughes calls a reverse salient?a military term refering to locations along an advancing military front that are holding out and, as a result, preventing the entire line from moving forward. Hughes has argued that technological systems advance in the same way, as different elements advance at different rates and those that move more slowly hold back the entire platform.[1] . The electric vehicle is just such a system?a network of components that make up the car (e.g., batteries, motors, suspension, etc?) and of complementary elements that surround the car (e.g., consumers, dealers, charging stations, etc?). The EV battery is holding back the field. But that doesn't mean all battery advances are equally valuable for advancing that field.

Executives, entrepreneurs, investors, and policy makers often show a breakthrough bias that favors the pursuit of novel technological leaps over incremental improvements. Sounds like a good strategy but, as history shows time and again, it's the incremental steps that most often lead to the significant advances.

The EV battery provides a great example of this challenge. Technologies can advance along one of two paths: towards their greatest potential (achieving a technological breakthrough) or towards their best fit within and contribution to an existing network (advancing the field).

In greenfield markets, where there is little in the way of an established network or an established role for the new technology, breakthroughs can enable other elements to emerge and complement the best aspects of this new technology. In brownfield markets, where introducing a new technology means fitting it within an established role (and displacing established alternatives), the new technology must find its best fit by sacrificing its own performance to the performance of the entire system.[2] Transportation is a brownfield market.

If we choose to pursue breakthroughs in EV batteries in research labs, the criteria will likely focus on achieving its own potential?making the best battery, as defined by the researcher and the research question, independent of the network it must ultimately fit within.[3] And that network has a much more complicated set of performance criteria: how well it fits within a battery maker's supply chain; a carmaker's bill of material, marketing requirements document, or assembly plant; a battery pack inside an electric vehicle on a customer's daily commute; or on a trip to Tahoe for the weekend; and so forth.

In this way, as Dr. Yet-Ming Chiang, MIT professor of material science and founding CEO of defunct batterymaker A123, once told an audience at the ARPA-E conference, ?Basic research is one-dimensional, it's about solving one problem. Commercialization requires solving many different problems. All at the same time.? A123 was founded on the a doped nanophosphate material developed in Dr. Chiang's lab, but foundered amidst the challenges of fitting within (or displacing) the existing battery technologies and battery suppliers already entrenched in the auto industry?where experience, scale production, and the ability to design a battery that fit the needs of the carmakers were all ultimately more important criteria.

EV batteries work as part of a larger and very well-established system where performance isn't about capacity, range, charge times, temperature stability, longevity, or cost. It's about all of them (and others). Most of which won't be defined while the technology is still in the lab. Indeed, most will change in the next few decades as carmakers continue to tweak the designs of the batteries, the motors, the chargers, the controls, the manufacturing process, and so many other variables and customers continue to tweak their behaviors and preferences.

And it's these incremental improvements that will ultimately add up to big advances. That's the dynamic at work in Tesla's and Panasonic's relationship and with their Giga-factory. As Kevin Bullis notes:
The most successful recent effort to cut the price of batteries and improve their performance? hasn't come from a breakthrough but from the close partnership between Tesla Motors and the major battery cell supplier Panasonic. Since 2008, the cost of Tesla's

battery packs has been cut approximately in half, while the storage capacity has increased by about 60 percent. Tesla didn't attempt to radically change the chemistry or materials in lithium-ion batteries; rather, it made incremental engineering and manufacturing improvements. It also worked closely with Panasonic to tweak the chemistry of existing battery materials according to the precise needs of its cars.[4]

Pursuing breakthroughs in battery technology may result in a novel battery that forces the rest of the system to adapt to it. But the time when cars were a greenfield market is long since gone and the major advances will come from incremental changes. Changes driven by novel partnerships across the industry, tweaking the ways that existing technologies can work better together. It's a different type of innovation but no less powerful a force.

As an aside, when new technologies emerge seemingly overnight, it's often because the last remaining reverse salient is finally overcome (or replaced). It may look like a breakthrough but the rest of the system?including the scientists, engineers, entrepreneurs, investors, and often leading customers?has been waiting and watching for some time. ?

Even in brownfield markets, the networks can adapt to take advantage of inherent strengths of a new technology?but only once that technology has secured its position and contribution. ?

For example, the Advanced Projects Research Agency-Energy (ARPA-E) was established in 2007 by the Dept. of Energy with the mission developing and deploying early stage transformational technologies, which was interpreted as investing in only novel technologies with breakthrough potential. For EV batteries, this meant investing only in novel chemistries and materials like A123 ($249M grant) and Envia ($4M). Both of these efforts did not end well ((see ?What Happened to A123?? and ?The Sad Story of the Battery Breakthrough that Proved Too Good to Be True?). ?

Why We Don't Have Battery Breakthroughs ?