ECONOMIC HISTORY

Car Wars

BY KARL RHODES

Internal combustion cars zoomed past electrics more than 100 years ago, but is the horseless road race really over?

In February, the Electric Vehicle Association of America released specifications for standard plugs that would allow different makes of electric vehicles to use the same charging stations. If you don't remember reading about it, that's because this attempt at standardization occurred not last February, but in February 1914.

By 1914, electric vehicles (EVs) already had lost nearly all their market share to internal combustion cars. But at the turn of the century, EVs and steam-powered cars were leading the horseless road race. Counting motor vehicles for the first time in 1900, the U.S. Census Bureau captured data from 109 manufacturers that built 1,681 steamers, 1,575 electrics, and only 936 internal combustion cars.

In 1900, expectations for EVs were high, according to David Kirsch, associate professor of management and entrepreneurship at the University of Maryland, who has studied the technology competition between EVs and internal combustion cars. "If you had surveyed leading engineers and transportation experts, I think they would have said, 'We are just waiting for that breakthrough in battery technology, and then we are going to have electric cars everywhere.' And they probably would have said, 'Internal combustion is kind of smelly and noisy, not very efficient, and kind of dangerous. It's probably not going to go completely away, but it will just be a little sideline, never more than 2 percent of the market.'" The actual outcome, of course, was a mirror image of expectations.

Internal combustion cars won the first leg of the race, but EVs never disappeared completely from American markets. Electric delivery trucks survived into the 1920s, and electric golf carts and forklifts earned dominant roles on the links and inside factories and warehouses. Growing environmental concerns in the 1960s and the energy crisis of the 1970s rekindled interest in EVs. And during the 1980s and 1990s, some economists and historians started questioning whether automakers and motorists sped down the wrong technology path by choosing internal combustion.

Today, most economists would say that — with the invisible hand holding the reins — market forces made sure that the best horse won in the early 20th century. They also might suggest that this technology competition continues in the early 21st century. A group of engineers in Silicon Valley, for example, founded Tesla Motors in 2003 "to prove that electric cars could be better than gasoline-powered cars." And by some accounts, the company already has achieved that goal.

"The Tesla Model S outscores every other car in our test ratings," raved *Consumer Reports* in 2013. "It does so even though it's an electric car. In fact, it does so *because* it is electric."

Car and Driver ***magazine staged a race from Detroit to New York between a 2013 Tesla Model S and a 1915 Ford Model T. Find out which iconic car won at the end of this story.***

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The Electric Head Start

There were several reasons why steamers and EVs led the race in 1900. Engineers had more experience with steam engines, which had been powering ships and trains for decades. More recently, electric trolley systems had revolutionized transportation in urban areas, beginning with Richmond, Va., in 1888.

"The 1890s was the decade of traction — street cars, electrified trolleys — and the 1900s was going to be the decade of taking electricity off the rails," Kirsch says. "That's sort of what everyone expected."

Early conditions were favorable to EVs, agrees Stephen Margolis, professor of economics at North Carolina State University. "Automobiles were mostly used within cities for short trips — deliveries, things like that. That was the context in which electrics were at their best. You didn't have to worry so much about going someplace where you couldn't get a charge."

Internal combustion cars were faster than electrics, and the widespread availability of gasoline (a cheap byproduct of making kerosene) gave internal combustion cars much greater range. But in 1900, those advantages were less important. City streets were clogged with horses pulling buggies and wagons, and highways beyond urban areas were terrible.

The initial push for better roads came from bicycle promoters such as Albert Pope. His Pope Manufacturing Co. was the largest producer of bicycles in the United States in the 1890s, and in the late 1890s, the company also became the largest producer of motor vehicles in the United States — mostly electrics. In 1899, Pope's former motor carriage division merged with Electric Vehicle Co. (EVC), a new venture that was trying to monopolize transportation services in major U.S. cities by developing huge fleets of electric taxicabs. EVC also acquired George Selden's patent on the internal combustion car.

"What the promoters of a project based on the electric automobile wanted with a patent for a gasoline automobile was never spelled out," wrote automotive historian John Rae in his 1965 book, *The American Automobile*. "However, they were shrewd businessmen with a fondness for monopoly, and it was an understandable precaution for them to secure a foothold in the gasoline car field at a time when the course of automotive development was unpredictable."

EVC's ambitious plans to build and operate 12,000 cabs failed. "About two thousand were built and put into service," Rae reported, "but they were clumsy, expensive vehicles to operate, with batteries that weighed a ton and had to be replaced after each trip."

The company soon encountered major problems with its batteries, its business model, and its bottom line. When word got out that the company was losing lots of money, the press dubbed it the "Lead Cab Trust." EVC went into default in 1907, and its failure was blamed largely, perhaps unfairly, on electric vehicle technology, Kirsch says. "Far from creating an opportunity for the future development of an electric-vehicle-based urban system, the shadow of EVC hung over the industry for years."

Internal Combustion Takes the Lead

Internal combustion cars were dirty, noisy, and smelly, and their crank-starting mechanisms were physically demanding and downright dangerous. Also, some manufacturers put internal combustion engines directly under the driver's seat. "There was a joke that went around that nobody is going to want a gas car because no one is going to want to sit on top of an explosion," says Matt Anderson, curator of transportation at the Henry Ford Museum in Dearborn, Mich.

Despite their drawbacks, internal combustion cars were gaining market share rapidly. By the time *Motor World* published the 1900 census data on automotive manufacturing in September 1902, internal combustion cars had taken the lead. The 1900 census "conclusively shows that conditions two years ago were not as they are today," the journal noted. "Gasoline undoubtedly leads in the total output of the three different classes of motor vehicles at the present time."

Kirsch contends that this turning point was created in part by consumer expectations that a miracle battery was "only a day away" — so it seemed prudent to postpone buying any electric car. Thomas Edison heightened those expectations in 1901, when he announced that he was on the brink of a major breakthrough. Edison's iron-nickel battery was better (and more expensive) than the lead-acid batteries of his day, but its performance fell far short of miraculous, and it did not make it to market until 1909 (not counting a false start in 1903). "During this period, many would-be electric drivers either bought no car at all or bought an internal combustion vehicle," Kirsch says.

EVs cost significantly more than internal combustion cars in 1900, but price was not the key issue at that time because automobiles were almost exclusively rich men's toys. The ability to tour the countryside was far more important to these men than short city trips, and internal combustion was by far the best option for touring.

Some wealthy families owned both an EV and an internal combustion car. But early automakers realized that it would be a stretch for most families to afford even one automobile. So they were trying to develop a "universal" vehicle that could satisfy the vast majority of service requirements at a price middle-class families could afford.

While EV enthusiasts waited for Edison to break the battery barrier, the top makers of internal combustion cars continued to improve their products, lower their prices, and increase their market shares. Most notably, Olds Motor Works produced more than 5,000 low-priced Oldsmobiles in 1904, more than the auto industry's combined output of EVs and steamers. In 1908, the Ford Motor Co. started selling the Model T for about $850, and it became a complete market-changer. Ford's advances in mass production allowed the company to increase quality and decrease cost at the same time. This development made it virtually impossible for EVs to compete for the mass market.

The Model T's price plummeted to $600 by 1912, the same year when Cadillac started selling cars with Charles Kettering's electric starter motor. Kettering's innovation "took away the final big hurdle to driving a gasoline car," says Anderson at the Henry Ford Museum. "I would say that was the last nail in the coffins of the electric car and the steamer."

Technology Choice

The horseless road race among EVs, steamers, and internal combustion cars has been called a quintessential technology choice. "The end result would have enormous consequences for the remainder of the twentieth century, economically and environmentally," wrote automotive historian John Heitmann in his 2009 book, *The Automobile and American Life*.

Did internal combustion win because it was inherently superior? Noted automotive historian James Flink says yes. But Kirsch insists that other key factors also contributed to internal combustion's rise and EVs' demise between 1900 and 1912. EVC, the electric taxicab company, may have bet on the wrong horse, he concedes, but the company also bet on the wrong business model: EVC relied on what Kirsch calls the "service model" of centralized public transportation instead of the "product model" of decentralized individual ownership.

Individually owned internal combustion cars owed much of their success to the nationwide distribution network for kerosene and gasoline that was already in place in 1900. In sharp contrast, electrification — the new standard for public transportation — was almost nonexistent in small towns and rural areas. So the charging infrastructure was good enough to support electric taxicabs in urban areas, but it was inadequate for individually owned EVs that ventured much beyond city limits. An electric's range was generally 40 to 60 miles on good, flat roads, and it took many hours to recharge its battery.

Social factors were significant too. Many women preferred EVs because they were relatively clean, quiet, odorless, and easy to start. Henry Ford's wife, for example, drove an EV. But most men preferred the superior range and power of internal combustion cars. And in 1900, men generally drove the cars and made the car-buying decisions.

Entrepreneurs also made a difference. "No outstanding automotive engineer appeared in an entrepreneurial role in connection with either steam or electric automobiles," Rae wrote in a 1955 article in *Explorations in Entrepreneurial History*. Edison and Ford collaborated briefly on two experimental electrics, but Ford was an internal combustion engineer from start to finish. "I don't think he ever really considered any other power source," Anderson says. "He would have appreciated the advantages in a gasoline engine being much lighter than either a steam-powered plant or an electric plant."

At least one historian, the late Charles McLaughlin of American University, claimed that steamers would have won the technology competition if Ford had chosen steam over internal combustion. In a 1965 speech to the Steam Automobile Club of America, McLaughlin noted that the Stanley brothers, Freelan and Francis, were building excellent steam-powered cars — Stanley Steamers — in the early 1900s. But the brothers eschewed mass production, ultimately leaving steam cars, like EVs, out of the running.

"The great triumph of mass production has left us without much technological choice," McLaughlin lamented. "It would be easier to assume that the smog-producing automobile of today is the end product of a technological evolution which has been automatically beneficient — that technical progress is unfaltering and always in the right direction. But I think we must look again at this story."

Path Dependence and Lock-In

The market dominance of internal combustion cars is an example of what economists call path dependence. In other words, events at the beginning of the 20th century established a technology path based on internal combustion that cannot be abandoned without incurring substantial costs.

As early adopters of automotive technologies experimented with EVs, steamers, and internal combustion cars, they gradually learned which technology served them best. At some point between 1900 and 1905 — for a variety of reasons — the vast majority of those early adopters chose internal combustion cars, and as their numbers grew, the relative appeal of internal combustion was magnified.

"People who learned to drive in their parents' or friends' car powered by an internal combustion engine almost certainly were drawn to similar cars," wrote economist Richard Nelson in his 2005 book, *Technology, Institutions, and Economic Growth*. "At the same time, the ascendency of automobiles powered by gas-burning internal combustion engines made it profitable for petroleum companies to locate gasoline stations at convenient places along highways. It also made it profitable for them to search for new sources of petroleum, and to develop technologies that reduced gasoline production costs. In turn, this increased the attractiveness of gasoline-powered cars to car drivers and buyers."

Similar network effects could have accrued to other horseless technologies, concluded Nelson, who studied and taught economics at Yale and Columbia. "If the roll of the die early in the history of automobiles had come out another way, we might today have steam or electric cars." Nelson is echoing the arguments of former Stanford economist Brian Arthur, who asserted in 1989 that seemingly insignificant historical events can sometimes give a significant head start to an inferior technology that becomes locked-in even when another technology would be significantly better.

Margolis, the economics professor at N.C. State, takes the more conventional view that if motorists ever decide that EVs or steamers would serve them better, entrepreneurs would facilitate a transition as soon as the total benefits of switching — including attractive profits for the entrepreneurs — clearly exceed the total costs of switching. "I am skeptical, but for all we know, Tesla is doing that right now," he says.

One wrinkle in this cost-benefit calculation, however, is accounting for the cost of air pollution caused by internal combustion cars versus that of EVs. It is impossible for governments to reduce or redistribute these costs with 100 percent equity, but tighter emission standards, a carbon tax, or significantly higher gas taxes could favor EVs or some other technology from the past, present, or future. These measures also could favor various combinations of those technologies.

"Someone said a few years ago that the Prius was 'yester-tech' and that electric cars were the future. But the reality is that nearly every manufacturer that makes a car now makes hybrids," said Bill Reinert, the retired national manager of Toyota's advanced technology group. In an interview with *Yale Environment 360*, Reinert promoted gas-electric hybrids as the most promising motive technology. "If you look at Le Mans race cars, they're all 230-mile-per-hour hybrids that have both phenomenal power and phenomenal fuel economy. And we continue to improve them."

Reinert predicted, however, that the market for EVs will remain small. "Given that the bar gets raised all the time, it's hard to see where the case for an electric car really comes in. Is it for carbon reduction? No, you'd have to decarbonize the whole grid to make that case, and that's not likely to happen."

Back to the Future?

Plugs for charging stations still have not been standardized, as the EV association recommended in 1914, but some of the other barriers that stymied the development of EVs in 1900 are shrinking. Electricity is cheap and ubiquitous in the United States, and EV batteries are far more energy-efficient, reliable, and durable. Do these developments, coupled with concerns about carbon emissions, signal an EV resurgence?

EV enthusiasts have been predicting the second coming of electric cars since the mid-1960s. "From the *New York Times* to *Motor Trend*, one can hardly pick up a newspaper or magazine today without encountering an article about electric automobiles," Arizona anthropologist Michael Brian Schiffer wrote in his 1994 book, *Taking Charge: The Electric Automobile in America*. "Even television is lavishly covering 'the car of the future.'" Two years later, General Motors started a pilot program to lease its EV1 electric vehicle to a small group of early adopters, but the company scrapped the market test — and the cars themselves — when the experiment became too costly.

Since then, a new breed of automotive engineers have picked up the EV baton, but even well-funded Tesla Motors still struggles with some of the same challenges that discouraged the adoption of EVs more than 100 years ago. The Tesla Model S price — starting around $70,000 — is beyond the reach of most middle-class motorists. And charging the battery every 200 miles or so takes the spontaneity out of cross-country touring.

Car and Driver magazine recently staged a road race between a 2013 Tesla Model S and a 1915 Ford Model T from Detroit to New York. The Model S won the 682-mile race by about one hour, but only because the Model T experienced a breakdown along the way and because it had to take a less-direct route to avoid expressways.

In a forum on Tesla's website, owners of the Model S noted that the Model S would have won easily if *Car and Driver* had waited until Tesla installed supercharging stations along the route. They also noted that after-market modifications had made the Model T significantly faster than it was in 1915. (*Car and Driver* highlighted both of these issues in its coverage of the race.)

"It's not an exact comparison," Margolis concedes, "but I find the race interesting in the context of the claim that electric cars could have been better than contemporary gasoline cars." The Tesla Model S represents "the best of contemporary technology — taking advantage of all we have learned about electronics, semiconductors, electric motors, and materials." On the other hand, "the Model T was not the best car in 1915. It was just the best value. So they are comparing an elite car from our era to the workman's car from 1915, and the workman's car didn't come out too badly." **EF**

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