Breaking Energy

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The Case for Electric Vehicles, Part 1: The Driving Experience

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I recently had the opportunity to test drive the Tesla Model S P85, the high-performance version of the highly acclaimed all-electric luxury sedan. Like many drivers of the Model S, I was thoroughly impressed by the performance of this machine and after examining the engineering I am increasingly convinced that electric vehicles (EVs) are the future for automobiles. I will examine the case for EVs in a two part article.

The push towards EVs has mostly been driven by environmental concerns, the desire to limit CO2 emissions driving climate change as well as limiting harmful air pollution from the combustion of gasoline and diesel fuel. Energy security concerns and the desire to break the grip of petroleum on transportation markets are also part of the EV agenda. But why would a driver who is either unconcerned or uninformed about the environment and geopolitics of oil want to drive an EV?

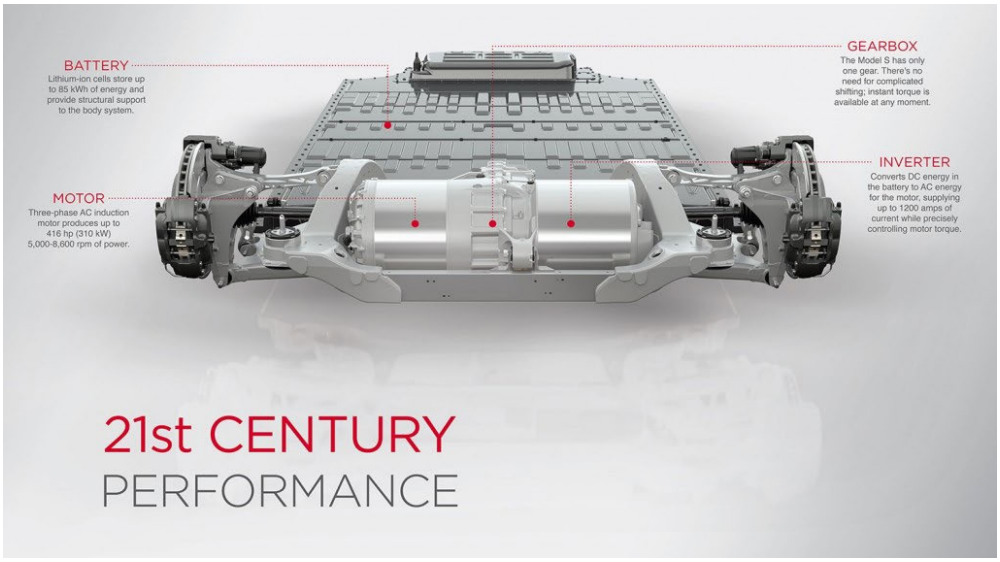
My thesis is that superior driving performance and soon-to-be realized lower cost of ownership will make EVs and Hybrid-EVs the default choice for all drivers in the coming years. It will take time for the transition to occur but similar technology transitions have happened many times over and are ultimately driven by favorable economics as technology matures.

Tesla Model S P85, photo by author

EV's are defined by having an electric motor for propulsion and battery pack to store electricity that is charged from the power grid. Hybrid-EV's come in many varieties that use an internal combustion engine (ICE) as either parallel drive train or as an electric generator or combination thereof. For my purposes I will define a Hybrid-EV as a vehicle that uses the electric motor for the drive train and ICE as an electric generator to charge the batteries.

The Chevy Volt is the most popular Hybrid-EV using a gasoline generator and has been very popular with drivers. Assuming that liquid hydrocarbons retain their decisive advantages over batteries in energy density and refueling times, there will continue to be a role for hydrocarbons in high horsepower and long distance applications such as big trucks, ships and airplanes, but electric motors provide their own advantages in torque and precision control. Locomotives pulling trains have used electric motors coupled with diesel generators since the 1950's to create 5,000 horsepower and more, demonstrating that there are no practical limits in power and performance to Hybrid-EV engineering.

An electric drive train provides a noticeably different driving experience from an ICE vehicle. The hallmark of the EV is the instant torque that the electric motor provides when the accelerator is pressed, delivering immediate power and acceleration to the wheels. Building up speed in a conventional ICE vehicle requires the engine to wind up and for the transmission to progress through a series of gears. The feeling of shifting through gears is familiar to anyone who has ridden in a normal car, but the EV feels totally different and is particularly noticeable in the high performance P85 version of the Model S. There is only one gear in the Tesla and no transmission, when the driver presses on the pedal 270kW of power is immediately fed to the wheels generating 443 pound-feet of torque and 416 horsepower. The car does 0-60 mph in 4.2 seconds which is very fast and it is easy to make passengers' heads snap back. Tesla engineers were concerned with not providing too much power that could cause the tires to spin and the car to lose control.



Graphics by Tesla

For my drive, I took the Model S from the downtown Washington D.C. showroom and out into Virginia along the beautiful George Washington Parkway following the Potomac River. From a red light it took just a slight touch of the pedal to get the car up to speed leaving nearby cars behind. On the highway, at 60 mph the car leaps up to 80 when you need to pass. No timing of the engine is needed, no shifting gears, just immediate power. But for all that speed the car sticks to the road, the Model S is noticeably heavy and feels solid as the battery pack is a third of the weight of the car and is located across the bottom of the frame lowering the center of gravity. The Tesla is thrilling to drive and impossible for auto enthusiasts to ignore.

The second hallmark of an EV is the silence, the motor makes virtually no noise (and no noxious exhaust). The first time I started the car I did not even realize it was on. I pulled through the parking garage and it felt like I was coasting in neutral. The effect was downright strange when I began going up the ramp to get out on to the street. The car is just quiet and still. Once moving at highway speeds there is of course some road vibration and barely perceptible wind noise, but with the air suspension the ride is very smooth and overall quiet.

The third difference when driving an EV is the regenerative braking which uses the motor to slow down the car and recharge the batteries instead of using the normal wheel brakes. Regenerative braking has been around for years on hybrids like the Toyota Prius and is not new to Tesla. For the driver it gives the feeling of a noticeable slowdown when your foot is removed from the accelerator, it takes a little getting used to and adjustment to keep the car moving smoothly in traffic. The benefit is that it recharges the battery and saves wear on the brake pads extending their life. The display shows the charge going back into the battery and the regenerative braking can be turned off with a button depending on driving conditions. It is fun when you can see that you are saving power and it is said that in stop-and-go traffic it is possible to use barely any battery power, unlike an ICE vehicle which burns fuel in traffic.

While all that high performance is a lot of fun, the down side of EV's is range and recharging. Aside from the Tesla, all the EV's and hybrids on the market today are small cars with battery packs less than 30 kWh and electric ranges less than 100 miles. Vehicles with these specs are suitable for daily errands and commuting, but not suitable for road trips or high horsepower work. Numerous studies have demonstrated that 80% or more of daily mileage in personal vehicles are distances under 50 miles that are readily accommodated by EV's. The 85kWh battery on the Tesla is rated at 265 miles of range with reports of some drivers getting over 300 miles. Hybrids with a fuel generator extend the range and power and allow refueling at gas stations.

Recharging infrastructure is actively being built out, but it will take some time for complete market penetration. Standard AC electrical outlets can be used and the higher the amperage the faster the charge. The J1772 connector is the North American standard for all EV's and can utilize 120V or 240V current up to 80 Amps. While a typical 110V/12A household wall outlet offers little more than a trickle charge, a standard 240V/24A outlet used for appliances is reasonable for a complete charge in a few hours and is easy for a homeowner to install. Tesla offers an option of outfitting the car with dual chargers that allows for twice as fast charging if 80A power is available, but public charging stations vary in the amperage they provide.

DC High Speed charging bypasses the AC-DC rectifier and charges batteries directly but currently suffers from competing technical standards. Japanese developed CHAdeMO is favored by Nissan, Mitsubishi and Toyota while the J1772 Combo standard is backed by GM, Ford, VW and BMW. Tesla's proprietary Supercharger (480V/200A) is the fastest of all and they have opened up their patents in hopes of

becoming the new industry standard. High-speed charging offers 80% charges in 20-40 minutes, charging times vary by how charged the battery is, slowing down as the battery approaches full.

Tesla Supercharger Station, photo by Tesla

Early adopters of EVs must navigate the hassles of incomplete charging infrastructure and competing high-speed charging standards. These practical issues will be sorted out in time though, as it is in the interests of both the industry and consumers to adopt a common standard for DC high-speed charging that will allow robust networks to be built out and reasonable recharges for drivers in the time it takes to have a meal or complete a shopping trip. Gas station owners should be worried since charging stations are much cheaper to build and operate and can be widely dispersed throughout communities. EVs will change the relationship car owners have with refueling as they become accustomed to charging at home or in parking lots without special trips to the gas station. Lack of charging infrastructure is a short-term disadvantage to EVs but in time EVs will likely prove easier to “refuel”.

Metered charging is a business opportunity for garage owners and power utilities. Street side charging requires a more expensive investment but municipalities may feel justified in contributing to the cost due to the reduction in air pollution and improvement in air quality. Air pollution is a major source of illness and health care costs and EVs provide an obvious means to improve the public health situation.

While critics may dismiss the driving performance of the Tesla Model S by saying it is merely an expensive toy, I believe it is the vanguard of emerging technology. Imitators and competitors can replicate most, if not all, of what Tesla has achieved and as manufacturing expands, costs will come down. Conventional ICE vehicles have been manufactured for decades with intense efforts by major industries to reduce costs and improve performance. Given time, EVs will benefit from the same level of attention and they will become common. Thrilling driving performance combined with clear public health and environmental benefits ensure there will be continued efforts to reduce EV costs and expand charging infrastructure.

The next article in this two-part series will examine the costs of EV’s.

Topics: Battery Electric Vehicles, Battery Technology, Diesel, Electric Vehicle Charging, Electric Vehicle Market, Electric Vehicles, EVs, Gasoline, Internal Combustion Engine, Tesla, Tesla Model S, Tesla Motors