Vehicle Electrification: Disrupting the Automotive Industry and Beyond

Around the globe, governments are announcing mandates that will bring about the demise of the internal combustion engine. China has led the charge by requiring 8 percent of new vehicles on the road to be "new energy" or zero emission vehicles in 2018, a huge growth over the current 2 to 3 percent on the road today. Similar strong government regulations limiting the future of the internal combustion engine have passed around the world, and the importance and growth of the hybrid and fully electric automobile industry can't be overstated. Volvo has possibly taken the strongest stance of the automotive manufacturers by pledging to make only hybrid or fully electric cars by 2019 and committing to sell more than 1 million electric vehicles by 2025. "This announcement marks the end of the solely combustion engine-powered car," said Hakan Samuelsson, president and CEO of Volvo, in a July 2017 statement.

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More Than Just EV/HEV

The move from internal combustion to hybrid and then fully electric power plants represents only the most visible portion of the aggressive growth of power electronics systems in vehicles. Electrification applies just as significantly to vehicle subsystems. As recently as 10 years ago, a fully mechanical coupling between the steering wheel and the front wheels was not unusual. The steering wheel connected to a shaft that connected to a rack-and-pinion system that turned the wheels, and even a more efficient hydraulic version of the system still maintained a mechanical coupling between the steering wheel and the tires. The story is similar for the accelerator pedal and manual transmission.

The explosion of drive-by-wire technology throughout the modern vehicle has changed this paradigm. A sensor, a remote actuator, and multiple control systems have replaced the mechanical linkage. Instead of a direct connection between the steering wheel and the front tires, a sensor on the steering column now measures the angle of the wheel. An embedded controller then translates that measurement into an angle and sends the value to the vehicle's communication bus. Elsewhere on the communication bus, another controller picks up the value, translates that into an angle of the wheel potentially based on vehicle speed and driver settings, and then commands an actuator to move the wheel to a desired angle. In many vehicles, a safety system sits in the middle of this drive-by-wire steering system to make sure the vehicle stays in the traffic lane and avoids obstacles in the roadway. As the number of power electronics subsystems in the vehicle grows, the automobile itself begins to look like an electrical microgrid with a common power bus connecting a growing list of sources and sinks of power, each managed by an independent embedded control system.

The Broader Impact

Taking a slightly broader look at the implications of government automotive mandates, the exponential growth in electrification and the impending end of internal combustion engines represent a radical change in the infrastructure required to support the shift in vehicle power plants. A car with an internal combustion engine requires roughly 10 minutes at nearly any street corner's gas station to fill up its tank for another 300 miles of driving. However, even with a dedicated supercharger, a similar pit stop requires at least an hour for a fully electric vehicle to charge. Even for the slow recharge associated with a daily commute, the required charging hardware needs some thought. For homeowners, installing an overnight charging station might be as simple as putting in a high-current circuit in the garage, but this becomes more complicated for a renter in a house or an apartment. If a car owner happens to live in a city and parks on the street, the concept of a home-charging station might be completely impossible.

Looking at the future of vehicle electrification from the prospective of the electrical utility, the cyclic demands based on the daily workforce schedule combined with the high-load demands of fast charging present incredible new challenges for the electrical grid. If an entire workforce returns home at 5:00 p.m. and plugs in its electric vehicles around the same time, this shifts the timing of the typical peak demand on the grid and refocuses the regional peak consumption from heating or cooling toward transportation. On the larger scale of a gas station, a collection of the superchargers for fast charging will require an amount of energy similar to that of a medium-sized neighborhood.

The government-mandated trend of electric vehicles directly leads to growth in the complexity of vehicles and indirectly leads to an immediate need for growth in infrastructure. The future of the automotive industry will drive the future of the grid, which will require smarter control systems. Turning this into reality represents a truly interdisciplinary challenge to build safe and reliable control systems among other needs. To get to market quickly, this will require an increased reliance on real-time test, production test, and ecosystem partners who have vertical expertise building tools on top of an industry-leading, flexible, and open platform. With the right tools, engineers can adapt to the disruptive technologies vehicle electrification will require.