How Much Capability Do Electric Vehicles Need to Meet Customer Demands?

By Brendan M. Conlon

EARLY ELECTRIC VEHICLE (EV) offerings were small vehicles with limited capability due to the natural capability of the technology. Over time, EVs have grown in size and increased in performance, but most are still smaller and less capable than larger gasoline-powered vehicles such as sports utility vehicles, vans, or pickup trucks. Range-extended EVs have been developed to provide quick refueling and essentially unlimited range, but these are still limited in continuous power by the size of the engine, which is typically smaller than the peak power of the electric drive. As EVs increase in size, the demands on the propulsion system are increased, especially if the EVs match capabilities such as trailer towing. Increasingly, designs will need to evolve to meet the new requirements, e.g., by moving to higher system voltages. How far in this direction should EVs go to meet the expectations of the customer? It may be that many of the expectations defining what a vehicle must be capable of doing are based on the experience of 100 years of combustion engine vehicles and reflect both the strengths and weaknesses of that solution.

As EV technology has evolved over the last 20 years, the trend has been toward higher performance. In my opinion, it is reasonable to expect this trend to continue, for several reasons. One of the core strengths of EVs is smooth acceleration and responsive, on-demand power, which is highlighted in higher-performance vehicles. Another characteristic of electric drives is that they have the capability to be efficient at light to moderate loads; therefore, they can be designed to minimize efficiency degradation as peak power capability is increased. Finally, the trends toward increased range and larger battery packs; improvements in battery capability over time; and high-power, fast charging capabilities all result in increased battery power, creating vehicles that are more powerful than their predecessors.

Broadly, the capability measures of a vehicle that depend on the powertrain can be separated into range, capacity (i.e., passenger, cargo, and trailering), performance, and efficiency. In different vehicle applications, the ratio of peak to continuous power may be different. For example, both a large, slow vehicle and a small, fast one may have the same peak power. However, the power needed to cruise on the highway may be dramatically different for each. Thus, the power specification becomes not a single number but rather a curve versus time. With this view of power, at the level of the propulsion system, the three requirements of interest are energy, power, and efficiency.

Since power and energy are related, it is useful to look at these requirements together. Figure 1 shows the

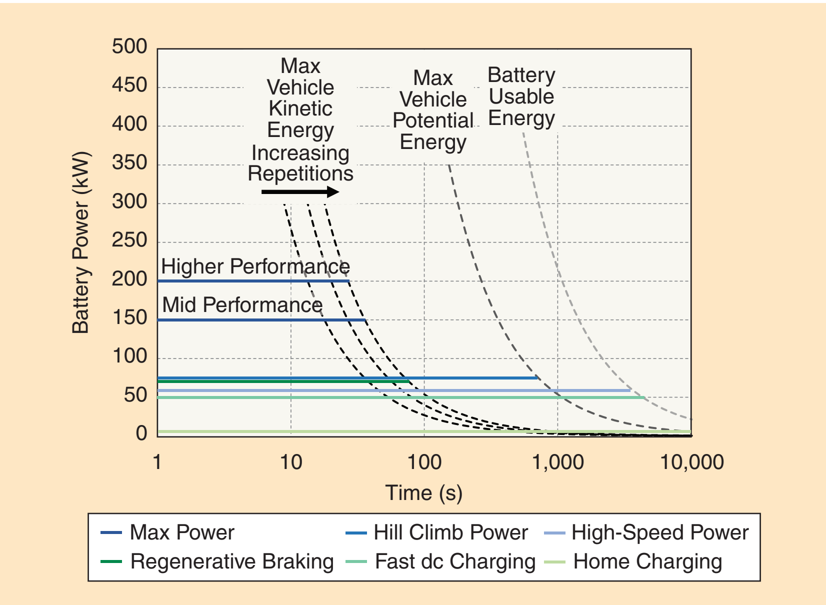

Figure 1. A chart of example power requirements for a small vehicle with limited capability.

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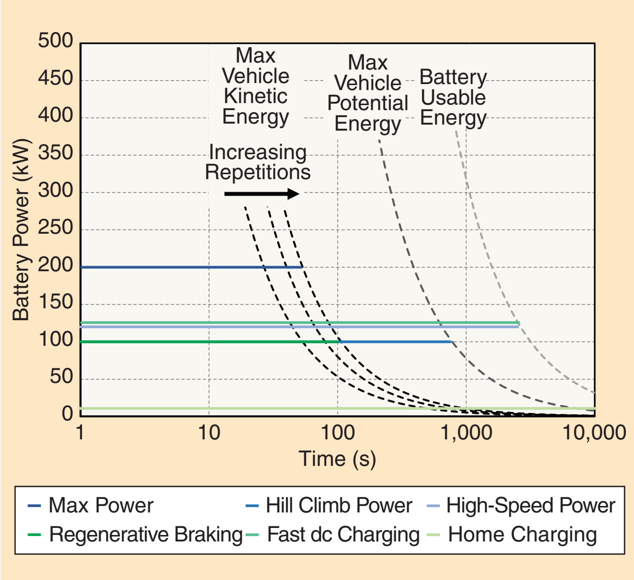

Figure 2. A chart of example power requirements for a larger vehicle with increased capability.

typical requirements for a small vehicle, which may have medium- to high-acceleration performance but otherwise has limited capability (no trailering, with a top speed of less than 100 mi/h). The discharge power requirements can be divided into three regions based on duration. Each region is bounded according to the total energy available. At the left are requirements driven by the performance expectations of the vehicle, which might include repeated accelerations from rest to top speed. Maximum energy depends on the mass and top speed of the vehicle and is on the order of a few kWh. The second region includes hill climbing, with power set by the vehicle type and trailering capacity; the energy is bounded by the length of large hills that result in durations in the range of 20 min and energies of about 15 kWh. For longer durations, sustained high-power conditions tend to be high-speed driving at speeds up to vehicle maximum. Here, the energy is limited only by the total battery energy. Charging power required due to regenerative braking and dc fast charging is lower and does not dictate the size or rating of propulsion electrical components.

As vehicles evolve to more demanding applications, including larger vehicles with more frontal area, higher top speeds, trailering capability, and higher performance, propulsion systems will need to increase in both peak and sustained power capability, as shown in Figure 2. The long-duration discharge power increases substantially, and the dc charging requirements, based on expected future capability of up to 350 A, increase to the point where they will require changes to the system to accommodate the increased power, potentially increasing electrical component size. Higher dc charging voltage and power levels currently under study could increase the

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media sites such as Facebook, LinkedIn, Twitter, and IEEE Collabratec.

A Distinguished Lecturer program was established by the TEC in 2016. Several lectures have been provided by TEC experts, including four lectures by Prof. Grant Covic from the University of Auckland in New Zealand, with a focus on contactless charging; two lectures by Prof. Kaushik Rajashekara from the University of Houston, with a focus on more-electric vehicles, especially aircraft; and one lecture by Dr. Stacy Prowell of Oakridge National Laboratory and the University of Tennessee at Knoxville, with a focus on vehicle cybersecurity. In addition to these three experts, Prof. Stefan Östlund is a TEC Distinguished Lecturer, with a focus on railway system electrification. TEC members also gave several keynote addresses and other presentations at IEEE conferences worldwide. A workshop organized by the TEC occurred on 24–25 February 2016, "Exploring Cybersecurity Challenges in Electrified Transportation: A Focused Workshop." The workshop was held in Washington, D.C., and drew in industry, government, and academic experts.

In 2016, the TEC revamped its eNewsletter with four quarterly issues for March, June, September, and December 2016. The first issue included general transportation electrification topics, June's theme was on cybersecurity in electrified transportation systems, the third-quarter theme was on aerospace transportation electrification, and the December eNewsletter's theme focused on railway electrified transportation systems. Formal calls for articles have been announced to TEC members and will continue to be issued every quarter. In 2018, the plan is for the eNewsletter to become bimonthly or possibly monthly.

The year 2017 is expected to be very busy and productive for the TEC. Several conference and workshop sponsorships are being organized as well as eNewsletters with themes in marine electrified transportation, V2G, and other topics. Cooperation with multiple outside organizations is expected (e.g., the American Institute of Aeronautics and Astronautics and the Society of Automotive Engineers), along with further growth in the Distinguished Lecturers program. Additionally, a leading webinar program is being established with three webinars already in the pipeline.

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Viewpoint

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size or rating of components further. The increase in sustained power has a greater effect on system design choices, as it is not possible to rely on the thermal capacity of the motor, battery pack, and high-voltage distribution. Instead, it becomes necessary to provide cooling or reduce the losses. As in other electrified applications, as power increases, the advantages of a higher system voltage also increase, and the choice of system operating voltage will likely evolve upward over time to take advantage of higher-voltage-rated semiconductors and reduce the size of power electronics and high-voltage wiring. These changes will need to occur in conjunction with evolving charging standards and infrastructure to maintain compatibility.

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If EVs are to move beyond the present state to higher-duty applications, the designs will need to evolve to meet these challenges. However, since range has long been the drawback of EVs, by addressing that issue, longer-range EVs will likely meet a large portion of the typical customer needs and may be successful in the marketplace even if all aspects of capability do not match that of equivalently sized fuel-powered vehicles. The marketplace will be the true test of which capabilities customers really value in an EV.

Biography

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