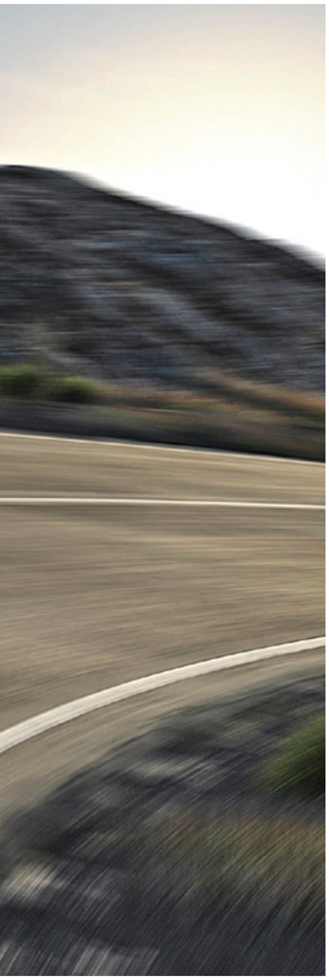
e-power

New Possibilities with 800-Volt Charging

____ The broad-based breakthrough of electromobility still requires significant technical improvements with regard to day-to-day usability. In addition to further improvements in terms of costs, the range offered and the availability of an adequate infrastructure are the most critical factors. 800-volt technology shows great potential in these areas and Porsche is advancing the technology.

By Volker Reber



800-volt charging connection on the Porsche Mission E

Practical experience shows that the overwhelming majority of currently available electric vehicles is designed as commuter vehicles or for use in urban areas. In most cases, frequent recharging is necessary and the driving performance is seldom adequate to meet other user requirements. Even with long charging procedures, for example overnight or during the workday, the range that is thereby gained remains relatively small due to the current limitations in terms of battery capacity.

With the Mission E concept study presented at the 2015 IAA, Porsche offered a glimpse of a vehicle that, both in terms of performance and range, is a true Porsche and a complete alternative to vehicles with combustion engines. The efficient drivetrain and high capacity of the battery enable a range of over 500 km in the NEDC (New European Driving Cycle). This would be sufficient to handle the vast majority of all trips over a period of days with a single battery charge. The need to recharge whenever the opportunity presents itself is significantly reduced. Alternating current (AC) is used for the power supply. Conversion into the direct current (DC) required by the battery is done through a charger integrated in the vehicle. Instead of obtaining fuel at a filling station, the car is simply charged at home.

For longer trips where making good time is of the essence, long waiting times for charging procedures can make a big difference and are generally not acceptable to users. To keep the charging process brief, high charging power is required. Such alternating current charging systems are no longer suitable for use in cars due to their weight and dimensions. For this reason, rapid-charging systems in which the conversion from alternating to direct current takes place in the charging station are used. The heavy, high-current charging device is not needed in the vehicle, leaving only the requisite safety and monitoring unit. ›

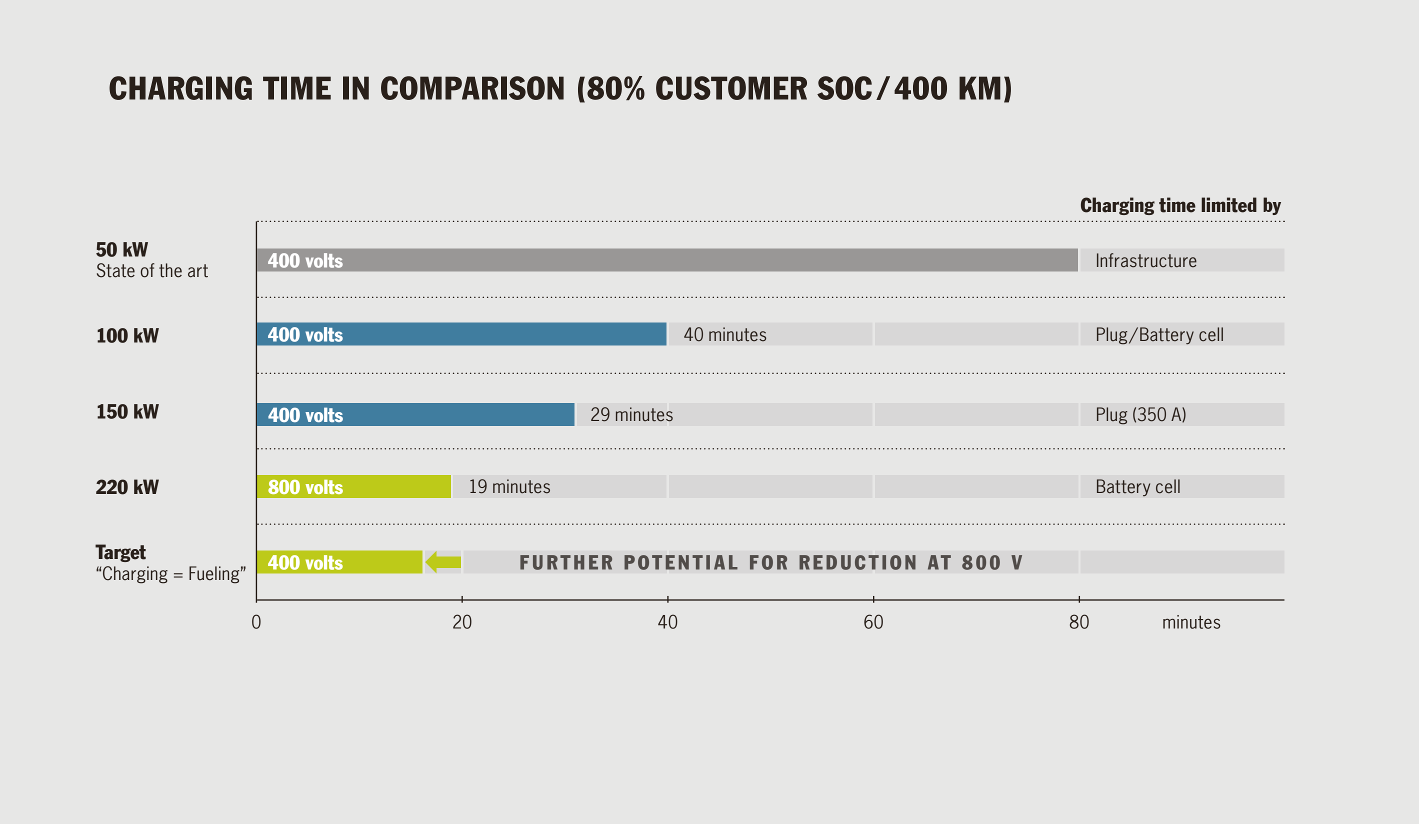


Figure 1

800-volt charging technology: Porsche turbo charging in the best time

A suitably designed rapid-charging infrastructure must be tailored to customary user behavior during long trips and offer a convenient ratio of driving time to break periods. It should be possible to get a sufficient charge for roughly 400 kilometers within the usual break time of 15 to 20 minutes. It is mainly technical factors that currently stand in the way of this objective (figure 1).

Today's DC rapid-charging stations for electric cars usually work with a voltage of around 400 volts. The charging power is roughly in the range of 50 kilowatts, meaning that the charging time for the desired 400 kilometers of range would add up to about 80 minutes. If one increases the capacity of such a 400-volt charging station, the capacity of the charging pins in the charging plug maxes out at roughly 100 kilowatts. Under these conditions, it takes about 40 minutes to transmit the energy for 400 kilometers of range. To enable further increases in terms of charging power, new cooling concepts are required. Various companies are currently working on such systems in parallel. Currently, the use of cooled charging plugs increases the charging power of 400-volt charging stations to the extent that the desired increased range can be achieved with a charging time of nearly 30 minutes.

A shift to a higher voltage is therefore inevitable in the quest to achieve charging times in the desired corridor. This is derived from the formula for electrical energy $E = U \times I \times t$, where U is the voltage, I the current and t the time. The charging time $t = E / (U \times I)$ can thus be achieved with a constant current I by increasing voltage U. By switching to a two-fold higher voltage of approximately 800 volts, the charging time can theoretically be reduced to about 15 minutes with the same electrical load on the charging pins. If one takes into account the paying process, the goal of "charging like filling up" is thus nearly within reach. Porsche has introduced its pioneering development work on this concept as Porsche Turbo Charging.

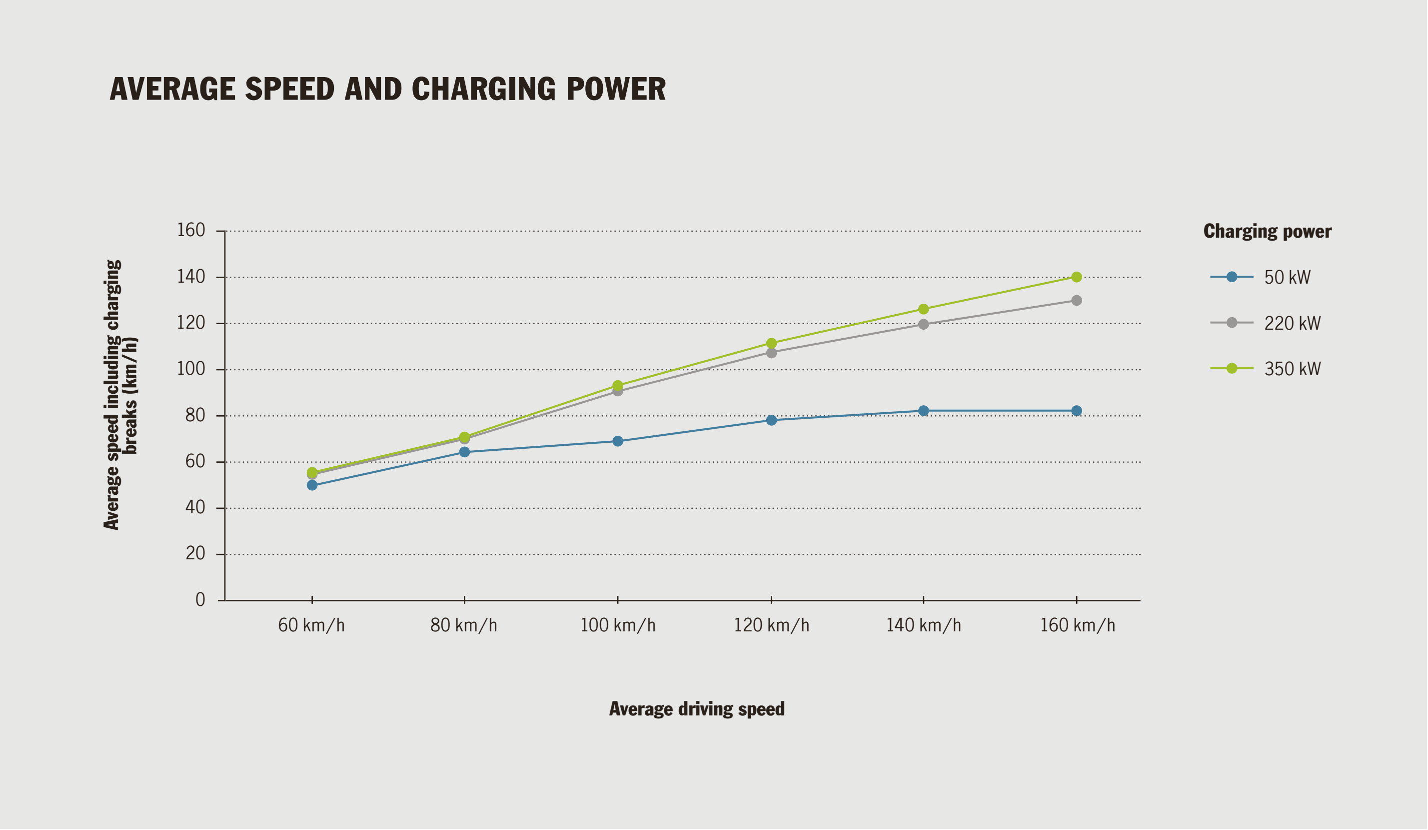


Figure 2

Prototype of an 800-volt DC charging station (cooperation between Porsche Design and the Charging Systems department at Porsche AG)

Get there faster with shorter charging times

The usefulness of a powerful charging infrastructure is illustrated by the example of the achievable average speed over a longer trip in relation to the charging power (figure 2).

A charging station with a 50-kilowatt charging power impacts the average speed over the entire route drastically due to long charging times. The use of a 220-kilowatt charging infrastructure would enable a noticeable improvement in the achievable average speed and accordingly shorter travel times. What that means in practice is demonstrated by the example of a long route: from Berlin to Lindau (see figure 3 on page 14).

For the route of approximately 720 kilometers, the example assumes one filling stop for a conventional vehicle with a combustion engine. At a good speed, the trip thus takes about 5.5 hours. If the same route is driven with an electric vehicle traveling at the same speed, two recharging breaks would be necessary. What that means is that with the currently › available rapid-charging infrastructure, the same trip would require 45% more time. Using the rapid-charging technology with the target charging power of up to 350 kilowatts, the total travel time would be only about 10% longer.

In the future, the charging break for an electric vehicle will be no different, or only minimally so, than the average re-fueling stop today: The driver parks the vehicle at the charging station and starts the charging procedure. In the meantime, the driver can engage in normal break activities such as buying articles in the station, having a meal or using the restroom. Payment can be carried out while the charging is under way. Once all of this is finished, the drive can continue without delay in the recharged vehicle.

Economic benefits through disproportionately higher sales

For the operators of the charging infrastructure, both the investments and the economical operation of the charging station are relevant factors. A high-power charging infrastructure that can fulfill the described requirements requires extensive technological measures. The requisite investments for charging stations are therefore relatively high. Through a holistic view of the system from the grid connection to the charging socket, with a suitable design of the topology significant savings can be achieved for the cost-driving components. In a comparison of the specific costs (euro per kilowatt of charging power), a high-power charging infrastructure turns out to be significantly less expensive than the currently available 400-volt-based rapid-charging infrastructure. The reason for this is that the requisite base components are already in place and can thus be used more effectively.

The functional scope of the envisioned 800-volt high-power charging station enables charging of the currently available models as well as the next generation of electric vehicles with 400-volt technology. The interface to the vehicle is functionally and geometrically adapted to the CCS charging standard (Combined Charging System) and completely downward compatible.

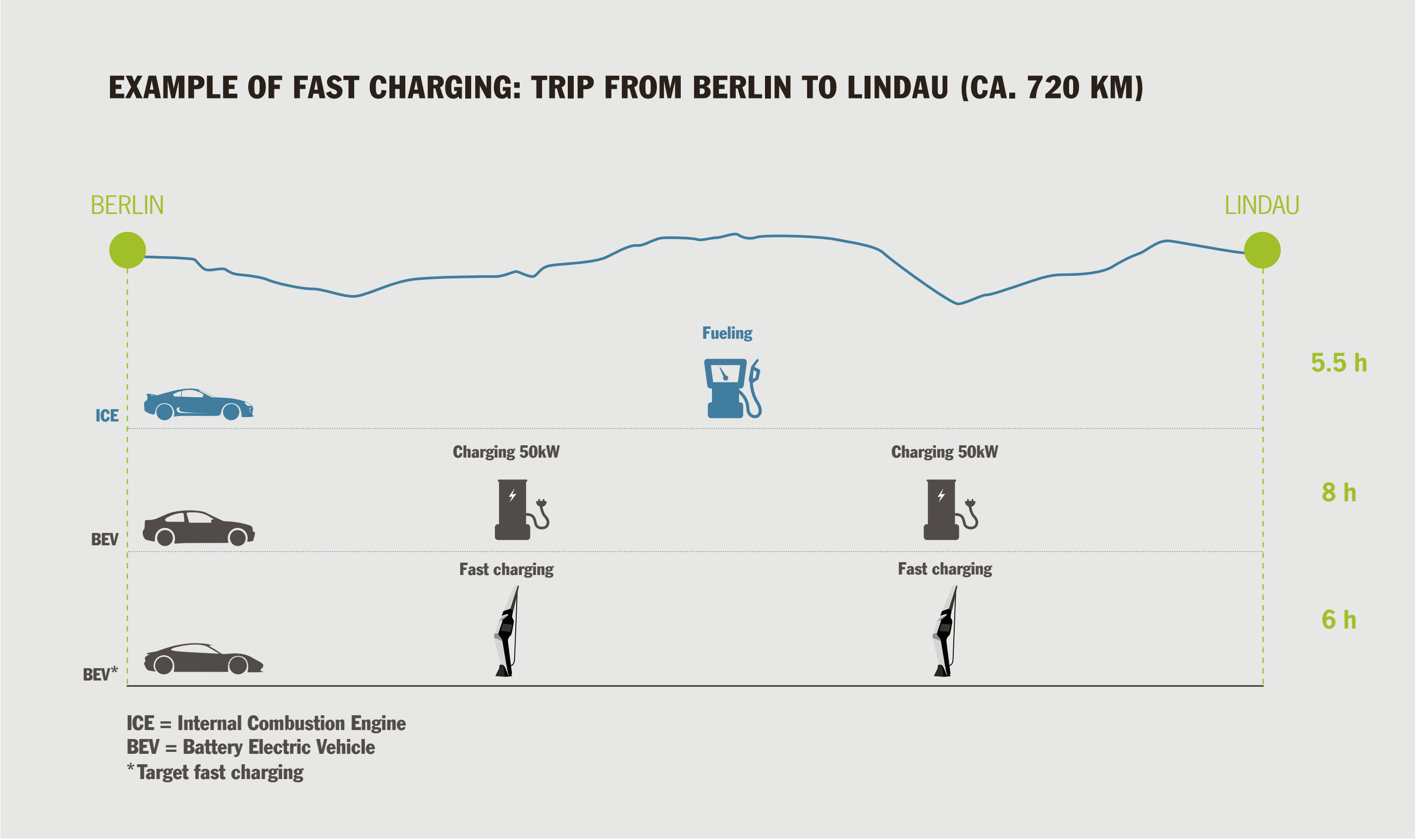


Figure 3

Mission E: tribute to tomorrow

Adaptation of the charging interfaces could also enable compatibility with other charging standards and vehicle categories. The power unit, comprised of the transformer, DC/DC converter and rectifier, remains unchanged. The charging voltage and charging power are configured in accordance with the requirements of the vehicle through the power unit. Only the interface to the vehicle has to be adapted, which would enable such options as inductive charging and charging via a pantograph for electric buses and commercial vehicles. And through substantial standardization of the components of the power unit, significant cost benefits could be achieved through scaling effects compared to the technology currently used on the market.

Improved prospects for electromobility

Raising the voltage to 800 volts in the infrastructure will enable significant reduction in charging times. Even working with the currently available cell chemistry, charging times are possible that would fit perfectly well with the travel profile of long-distance trips. The analysis of the technology required for that shows that this infrastructure can be implemented from a technical standpoint. And the economic efficiency is also compelling in terms of the customer benefit for both operators and users. ■