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HOW BATTERY STORAGE CAN HELP CHARGE THE ELECTRIC-VEHICLE MARKET

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People are reluctant to buy electric vehicles because of concerns about charging. But public, fast-charging infrastructure is not yet widely available or profitable. There is a way to resolve that conundrum.

Electric vehicles are beginning to win considerable attention but are still rarely sighted on American roads. Through the first half of 2017, fewer than 800,000 battery EVs (BEVs) had been sold in the United States, or about 1 percent of all cars.[1] But growth has been strong of late due to rising consumer acceptance, improved technology, and supportive regulation. McKinsey estimates that there could be ten to eleven million BEVs on US roads by 2030.[2]

For this to happen, though, access to charging infrastructure must improve. Although many BEVs are charged at home, public charging is necessary for owners who are travelling or if they don't own homes with garages. Right now, there are only about 16,000 public charging stations[3] in the United States; there are seven times as many gas stations. Fewer than 2,000 of these are fast charging stations because those are expensive and currently unprofitable with too few transactions to break even.[4]

It is a classic chicken-or-egg situation. People will be reluctant to buy a BEV if they worry that it will run out of juice. But unless more BEVs are sold, the charging infrastructure will not be built to serve them.

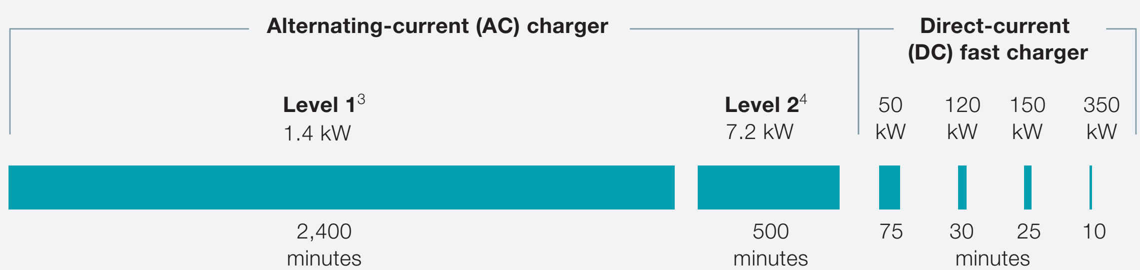
Two problems, one solution

There are two major problems.

First, there is convenience. Most public charging stations today are "Level 2," meaning that they deliver 7 to 19 kilowatt-hours (kWhs) of energy every hour (think of kWhs as equivalent to gallons of gas).[5] A BEV sedan with a 60-kWh battery would take five to ten hours to "fill up'" at a conventional (as opposed to fast-charging) Level 2 station. Having so few stations and such long service times turns off would-be buyers (Exhibit 1).

Exhibit 1 **Most charging stations are Level 2, but direct-current fast chargers can significantly reduce charging time.**

Time to "fill up" a 60-kWh electric-vehicle (EV)[1] battery using different chargers[2]



[1] This assumes that the EV can charge at the higher kW direct-current fast-charging stations; most EVs today cannot charge faster than 100 kW.
[2] This assumes that the EV can charge at maximum speed during the entire charge. In reality, the charging speed varies.
[3] Level 1 equipment provides charging through a 120-volt AC plug; it generally refers to a household outlet.
[4] Level 2 equipment provides charging through a 240-volt AC plug and ranges from 16 to 40 amps. The most common is the 240-volt, 30-amp charg which is 7.2 kW.

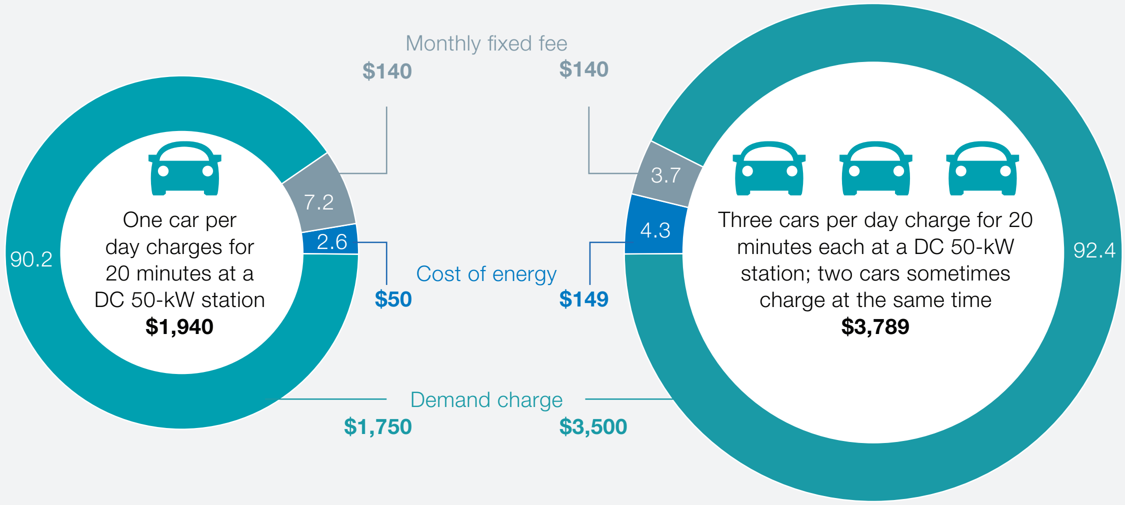
Second, there are the economics. Although direct-current fast-charging (DCFC) stations with 150 kilowatts of power can fill up a BEV sedan in about 30 minutes, they can cost up to $150,000 to install; a 50-kilowatt DCFC station can cost $50,000. The kilowatt number refers to the maximum amount of energy that can be drawn every hour; a higher kilowatt delivers more electricity faster. DCFC stations are also expensive to run.

One reason behind the expense is “demand charge” (see sidebar, “What are demand charges?”). All electricity customers pay for the energy they consume, as measured in kWh; this charge is like paying for gallons of water used. Nonresidential customers, including charging stations, also pay a demand charge for the maximum amount of energy used in any 15- to-30-minute period in a month. Measured in kilowatts (kW), a unit of power, this charge is like paying for overhead. It is assessed to recoup the fixed costs for power plants, power lines, transformers, and so on that connect customers to the grid and supply power even at times of high demand. Demand charges account for a significant fraction of consumers’ electric bills and can make EV-charging stations unprofitable (Exhibit 2).

In the specific case of BEV charging, as soon as a car plugs in, the station owner must pay a demand charge. This is based on several factors, including the number of chargers on the site, the maximum power in kilowatts used by the car when it plugs in,

Exhibit 2 **Demand charges can account for a significant fraction of an electric-vehicle station's electric bill.**

Breaking down the monthly electricity bill of an electric-vehicle station,[1] % share



[1] This assumes (i) the station has four direct-current fast-charging 50 kW chargers; (ii) each car charges for 20 minutes at 50 kW and draws approx 17 kWh; and (iii) the utility has the following rate profile: fixed monthly fee $140, variable energy consumption rate $0.10 per kWh, and demand charge rate $35 per kW.

What are demand charges?

A demand charge is a fee based on the highest rate, measured in kilowatts (kW), at which electricity is drawn during any 15- to 30-minute interval in the monthly billing period. This is separate from the charge paid for the actual energy consumed, which is measured in kilowatt-hours (kWh).

Let us compare two businesses that run air conditioners (ACs) that use 3.5 kWh an hour:

- Business A runs 10 ACs for two hours.
  It therefore uses 70 kWh of energy (10 ACs times two hours multiplied by 3.5 kWh). The highest rate at which energy is drawn is 35 kW (70 kWh over two hours).
- Business B runs 20 ACs for one hour.
  Like Business A, it uses 70 kWh of energy (20 ACs times one hour multiplied by 3.5 kWh). But the highest rate at which energy is drawn is double that of Business A (70 kWh over one hour equals 70 kW).

Even though Business A and B use the same amount of energy, Business B needs twice as much maximum energy every hour and therefore incurs a higher demand charge.

and the number of cars charging at the same time in any 15- to 30-minute segment.

Here is a hypothetical situation. A DCFC station has four 150-kilowatt chargers. In an average month, two or three cars a day show up to charge, none at the same time. Each car uses energy at a rate of 150 kilowatts and charges for at least 15 minutes; the peak is therefore 150 kilowatts for that month. If two cars showed up during the same 15 minutes, though, the peak energy used would be 300 kilowatts, which would double the demand charge for the month.

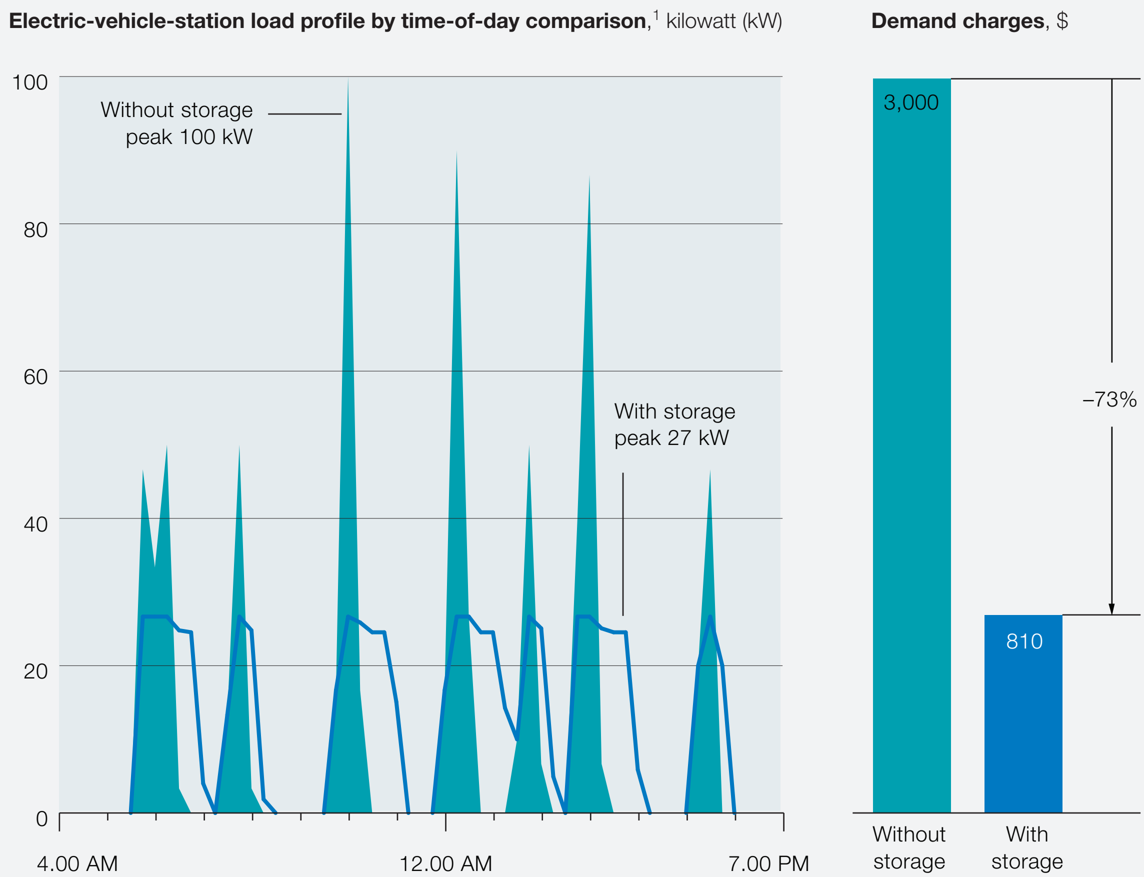
Demand charges can be as little as $2 per kilowatt all the way to $90 per kilowatt[6]; paradoxically, they tend to be higher in states where BEVs are more popular, such as California, Massachusetts, and New York. In a high-charge state, with no cars charging at the same time, the monthly demand charge could be $3,000 to $4,500. For the BEV owner, that could translate into $30 to $50 per session, plus the cost of the actual energy. Customers just will not pay that.

Clearly, if there were more customers, the cost per session would fall. But because current costs are so high, investors have been slow to build stations, and because there are not enough charging stations, consumers have been slow to buy BEVs.

There is a way to resolve this conundrum: stationary battery storage (Exhibit 3). On-site batteries can charge and discharge using direct current (DC) and connect to the grid through a large inverter. They can then charge from the grid at times when costs are lower, store the power, and release it when demand is higher (a practice known as peak shaving). When a car arrives, the battery can deliver electricity at 150 kilowatts without drawing power from the grid. If two vehicles arrive, one can get power from the battery and the other from the grid. In either case, the economics improve because the cost of both the electricity itself and the demand charges are greatly reduced.

In addition, the costs of batteries are decreasing, from $1,000 per kWh in 2010 to $230 per kWh in 2016, according to McKinsey research.[7] So are the

Exhibit 3 **On-site battery storage at an electric-vehicle station can help smooth out load profile charging from the grid when no vehicles are present.**



[1] This assumes (i) the station has four direct-current fast-charging 50 kW chargers; (ii) 11 charging sessions occur during the time period profiled (4AM to 6PM); (iii) there is at least one instance where two cars charge simultaneously; (iv) the demand charge rate is $30 per kW; and (v) the battery-storage system is 150 kWh and can discharge at up to 75 kW.

costs of the rest of the system, such as the inverter, container, software and controls, site design, construction, and connection to the grid.

Here is how it could work. A station owner installs a battery system capable of charging and discharging at a power of 150 kilowatts and builds in 300 kWh of battery cells to hold the energy. When no vehicles are present, the battery system charges up to ensure that energy is available and does not trigger a higher demand charge. When a car arrives, the stationary battery delivers the needed juice without calling on the grid. When two vehicles come in, the battery could provide power to one and the grid could provide power to the other.

A battery with a 300-kWh capacity can manage the peak demand through several two-vehicle charges and recharge in between, thus keeping peak demand below 150 kilowatts. A system configured this way could reduce demand charges to a minimum; that would be $3,000 a month that would not need to be passed on to consumers, which would substantially cut costs. Tesla has already said it is going in this direction, and others may "follow suit.[8]

When and if BEVs hit the roads in high numbers, batteries will no longer be able to reduce peak demand efficiently because there will not be enough time to recharge them as cars queue up for power. At this point, though, economies of scale will kick in, and the demand charge will be absorbed by the many cars coming through the station.

That does not mean that on-site batteries will become obsolete. They can still be a source of value. Where costs vary widely by the hour, such as in California, batteries can reduce the per-kilowatt-hour cost of electricity. They can also generate revenue by providing additional grid services such as frequency regulation and demand response.

■ ■ ■

There is considerable optimism about EVs, and for good reason, given rising concerns about the environment, volatility in oil prices, and falling costs. McKinsey estimates that EVs, which now account for less than 1 percent of the global fleet, could hit 20 percent by 2030 (for cars) and 12 percent (for commercial vehicles).

But these are hypothetical scenarios. In reality, it is consumers who will ultimately decide the destiny of EVs. Accustomed to the ease of conventional cars, they want the same from EVs. For that to happen, charging must become cheaper and easier. By helping cut operating costs, enhance revenues, and improve reliability, battery storage could play a crucial role in this evolution. ■

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[1] *Global EV outlook 2017: Two million and counting*, Organisation for Economic Co-operation and Development/International Energy Agency, 2017, iea.org; Matthew Klippenstein, *Electric vehicle sales in the United States: 2017 half-year update*, FleetCarma, September 2017, fleetcarma.com.

[2] Bernd Heid, Russell Hensley, Stefan Knupfer, and Andreas Tschiesner, "What's sparking electric-vehicle adoption in the truck industry?," September 2017, McKinsey.com.

[3] This figure does not include Tesla charging stations that are not accessible to non-Tesla drivers.

[4] Operating cost assumptions include cost of electricity at $0.12/kWh, demand charge of $25/kilowatt, fixed costs of $3,000–$4,000 per year for maintenance, networking fees, utility and meter fees, customer and data management, and other selling, general, and administrative costs.

[5] Level 1 charging also exists and refers to equipment that enables charging through alternating current usually at 120 volts and 20 amps for a power of 1.4 kW. This is effectively the use of a standard household outlet to charge a vehicle and does not require any charging equipment beyond the charging cable.

[6] *Maximum demand charge rates for commercial and industrial electricity tariffs in the United States*, National Renewable Energy Laboratory, November 2017, data.nrel.gov.

[7] David Frankel and Amy Wagner, "Battery storage: The next disruptive technology in the power sector," June 2017, McKinsey.com.

[8] Fred Lambert, *Elon Musk teases new 'Tesla Supercharger 3,' Electrek*, December 2016, elektrek.co.

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