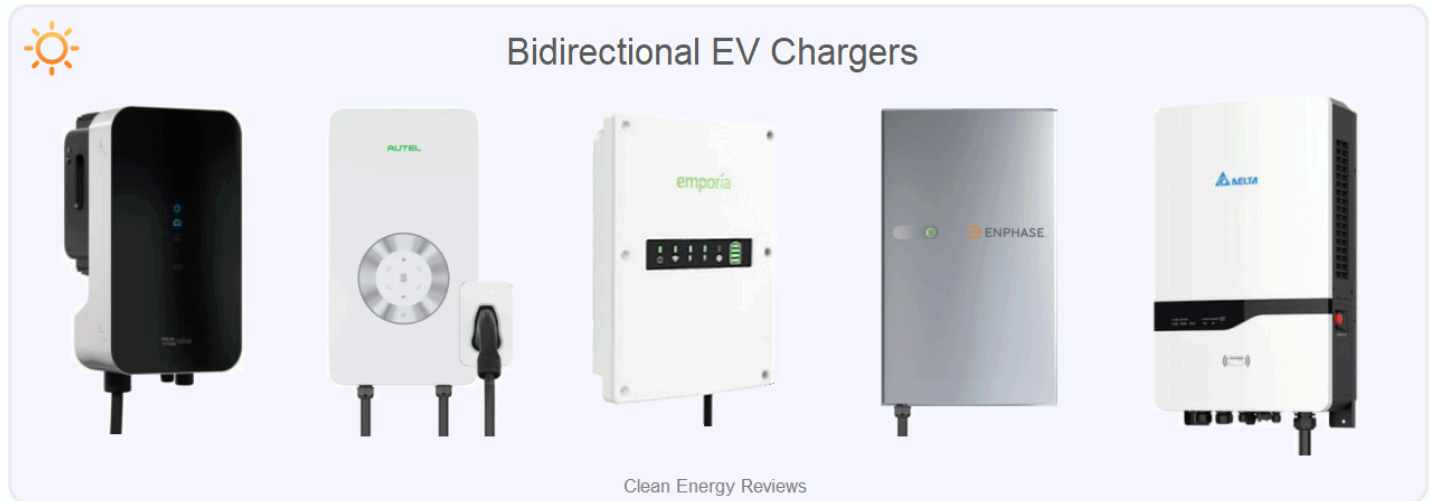


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26 MAR, 2024 • WRITTEN BY JASON SVARC

Bidirectional EV chargers Review



What is a bidirectional EV charger?

A bidirectional EV charger is an advanced EV charging system that enables two-way energy transfer, allowing electric vehicles (EVs) to send power to your home or back into the electricity grid. Unlike standard EV chargers, which use regular AC (alternating current) power for charging, bidirectional chargers perform complex power conversion, converting power from AC to high-voltage DC (direct current) during charging and the reverse during discharging.

[Bidirectional EV charging](#) is an exciting and emerging technology with the potential to revolutionise how electricity is generated and distributed, enhancing grid stability and offering cost-saving and backup power for homeowners. However, due to complex electrical regulations, bidirectional EV chargers are generally only available under special agreements or trials with grid operators in most countries.

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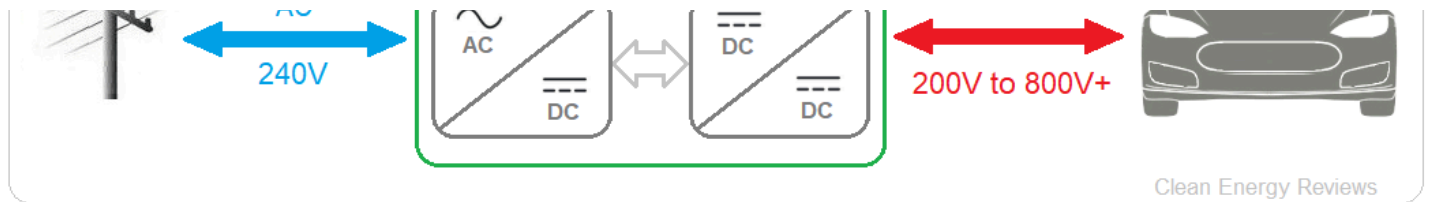
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Basic energy conversion diagram of a DC bidirectional EV charger.

What are bidirectional EV chargers used for?

Bidirectional EV chargers have two primary uses:

1. Vehicle-to-Grid (V2G)

A bidirectional charger enables Vehicle-to-Grid (V2G) functionality, allowing EVs to feed energy back into the grid during times of high electricity demand, such as the peak evening period. This concept is a form of decentralised energy generation that can transform the operation of our power grids. Learn more about [vehicle-to-grid \(V2G\)](#) here.

2. Vehicle-to-Home (V2H)

The second use of bidirectional chargers is for Vehicle-to-Home, allowing homeowners to use an EV to power their home. Using stored energy in the EV during peak times when electricity rates are higher, homeowners can reduce their energy costs and optimise renewable energy sources like solar power. Bidirectional chargers can also provide backup power sources during power outages, ensuring an uninterrupted electricity supply in emergencies. Learn more in our [V2L, V2H & V2G explained](#) article.

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Issues with Bidirectional EV charger standards

While bidirectional EV charging is a new, exciting technology, progress has been very slow and most governments have not certified bidirectional chargers due to grid compliance and regulatory issues. Vehicle-to-grid (V2G) standards are difficult and complex as they regulate the power, safety and electrical requirements when discharging energy into the grid. [UL9741](#) is a proposed safety standard still under development for bidirectional EV charging system equipment, built around the UL1741 (safety standard) and the IEEE1547 standard for interconnecting distributed energy resources (DER) with electrical power systems.

The latest standard for communication between an EV and a bidirectional charger is [ISO 15118:2014](#) - Road Vehicles - Vehicle-to-Grid Communication Interface. The purpose of this standard is to detail the communication between an EV (BEV or a PHEV) and the EVSE (Electric Vehicle Supply Equipment), more commonly known as an EV charger.

List of Bidirectional EV chargers

At present, the Wallbox Quasar, Highbury, and Fermata FE-15 are the only **universal** bidirectional chargers for home use (level 2); these are all of the DC variety and work with CHAdeMO (DC), while the recently announced Wallbox Quasar 2 works with the more common CCS (DC) vehicle charge port. The soon-to-be-released Ford F-150 Lightning EV is unique because it only works with the [Ford Charge Station Pro](#) and requires additional equipment to enable *bidirectional charging*. In early 2023, Tesla's senior vice president hinted at integrating bidirectional charging in their upcoming vehicles, potentially by 2025.

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Sigenergy SigenStor

The [Sigenergy SigenStor](#) is one of the most exciting products enabling bidirectional EV charging. Unlike the other dedicated bidirectional DC chargers, Sigenergy has developed a versatile hybrid system that integrates solar, battery storage and bidirectional EV charging in one compact unit. The system comprises 4 main components, a hybrid inverter, battery, backup box and bidirectional EV charger. The [hybrid inverter](#) is available in single-phase and three-phase models from 5kW to 25kW and features multiple solar PV inputs (MPPTs), which can be oversized up to 200%, enabling large solar arrays required for all-electric homes and EV charging. Battery capacity is scalable, using 5kWh and 8kWh modules with up to six units per stack, providing a maximum of 48kWh capacity.

On the EV charging side, the DC bidirectional charger will be available in two sizes: a standard 12.5kW unit or a large 25kW unit designed to be used with a 3-phase supply. However, the true innovation lies in the DC power bus, which enables direct DC charging from solar. Additionally, the battery-integrated DC-DC conversion boosts the relatively low 32V modules to 150V—1000V to match the various EV battery voltages.

Using the additional Gateway backup box, the system can operate in off-grid mode and provide true UPS (Uninterruptible Power Supply) power. It's worth noting that hybrid solar



Sigenergy SigenStor hybrid system including DC bidirectional EV charger.

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The Sigenenergy system was first released in Europe. The hybrid system and battery are currently being tested in Australia. However, the bidirectional EV charging component is pending regulatory approvals and should be completed by early 2025. Preliminary pricing appears very competitive, starting at around AU\$ 9,000, including the 5kW single-phase inverter, 8kWh battery module, and 12.5kW bidirectional charger.

Download the [Sigenenergy Sigenstor datasheet](#) or the [bidirectional charger specifications](#).

Wallbox Quasar

The [Wallbox](#) Quasar is the first bidirectional EV charger designed for home use and is the smallest charger of its kind to offer advanced two-way DC charging capabilities. It has a maximum power rating of 7.4kW (32A), but it's important to note it is only compatible with vehicles that feature a CHAdeMO DC vehicle connector. Currently, only the later generation Nissan Leaf EV and Mitsubishi Outlander plug-in hybrid can be used with the Wallbox Quasar.



Wallbox Quasar two-way DC charger

As explained earlier, bidirectional chargers can enable V2G or V2H but it is early days for this emerging technology, so some investigation will be required to ensure it can be utilised in your state or region. Additionally, some electricity retailers and regulators may not have approved using bidirectional EV charging. In Australia, regulatory approvals for bi-directional chargers are about to be ratified, along with several [V2G trials](#) already underway.

The Quasar is priced from US\$4000 to \$7000, depending on the country and local taxes.

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Wallbox Quasar 2

Wallbox recently announced the second generation [Quasar 2](#). The new bidirectional DC charger has been redesigned from the ground up and now offers up to 11.5kW (48A) of charging or discharging power. The styling has also completely changed from the previous model, which was rather unconventional, to a slick-looking slimline enclosure with no display. More importantly, the new Quasar 2 features a “blackout mode”, allowing a compatible vehicle to power your home in the event of a power outage. Wallbox claims it will be able to transition your home from grid supply to vehicle supply seamlessly; this implies that it works in conjunction with an external grid isolator (contactor), which is required to safely island your home from the grid. The full specifications have not yet been released, although the company website outlines that it will contain a vast array of communication options, including WiFi, Ethernet, Bluetooth and even 3G/4G.



Wallbox Quasar 2 with backup mode

Official pricing is not yet available for the Wallbox Quasar 2, but it is expected to range from \$5000 to \$7500.

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Rectifier Technologies is the second company to develop a compact residential two-way charger. The [Highbury bidirectional DC charger](#), available soon, claims to be 96% efficient and features a very modern, slim design. The Highbury, touted as the world's slimmest bi-directional DC charger, will be available in two sizes, the standard 7kW and a high power 11kW (46A).

Initially, it will enable EV owners to sell excess power to the grid via V2G, but additional functionality, including vehicle-to-home (V2H), will be available later. The Highbury will be compatible with both CHAdeMO or CCS-compliant electric vehicles.

Download the [Highbury bidirectional charger datasheet](#).

Pricing is not yet available for the Highbury charger.



Emporia V2X bi-directional charger

The V2X is a home bidirectional charger from the small Colorado-based company [Emporia](#), which specialises in smart home energy management products. The Emporia bidirectional charger is impressive and features an integrated silicon-carbide-based AC/DC inverter designed by BREK Electronics, rated at a maximum of 48A or 11.52kW. It's compatible with CSS Type 1 connectors and can be coupled with the Emporia Vue home energy management system to automate your energy use and storage needs. More notably, it also features 'off-grid islanding support', which implies it will function in off-grid mode by adding a compatible grid isolation device (contactor).

The price was listed at US\$1500, making this easily one of the most affordable universal bi-directional chargers. However, this price has not been verified, and the product is still in

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Fermata Energy FE-20

[Fermata Energy](#) is a US-based company founded in 2010 by Prof. Slutzky, a science and engineering professor at the University of Virginia. The FE-20 is the next-generation bidirectional charger after the FE-15, and is currently the most powerful two-way DC charger available in North America, with a 20kW charge and discharge power rating. However, the charger is currently only compatible with vehicles with a CHAdeMO DC connector. Based on the aesthetics and specifications, the wall-mounted charger is designed for performance, durability, and safety.



The FE-20 bidirectional charger is UL 9741 certified and is currently the only DC charger certified for use with the Nissan LEAF in the US. Fermata Energy has also developed a more powerful 3-phase 20kW bidirectional charger for use with small commercial electric vehicles.

The full Fermata Energy FE-20 bidirectional charger specifications and pricing is not yet available.

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[Delta Electronics](#) is a large, innovative company specialising in energy efficiency and power conversion equipment, including solar and energy storage. With a long history in designing and building EV chargers and huge research and development capabilities, it's not surprising Delta has produced a range of bidirectional EV chargers for commercial and residential applications.



The Delta V2H is a 3-phase vehicle-to-home (V2H) bidirectional charger in two models rated at 11kW or 22kW. The charger can operate in on-grid and off-grid (backup) modes but is currently only compatible with CHAdeMO vehicle connectors and features a very high operating efficiency of 95%, along with a range of safety systems. A smaller 6kW single-phase version is also in development, but details are limited at this stage.

Download the full [Delta V2H bidirectional charger specifications](#).

Autel MaxiCharger V2X

[Autel Energy](#) is a US-based company established in 2004 that specialises in intelligent automotive products and services. Over recent years, the company developed high-quality home EV chargers, a range of fast DC chargers, and commercial EV charging solutions.

The MaxiCharger V2X from Autel is a high-power 12kW bidirectional charger that offers both V2G and V2H functions, or vehicle-to-everything, hence the term V2X. It will be available with either CCS1 or CHAdeMO and offers a full range of communication options, including Bluetooth, WiFi, ethernet, CAN and RS485, along with the OCPP 1.6j communication protocol. More notably, the CCS1 version operates with a wide DC voltage

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Enphase bidirectional EV charger

Enphase Energy was founded in 2006 and is the world's leading manufacturer of solar microinverters. The Enphase bidirectional EV charger is unique because it's built around the IQ8 microinverter technology, enabling both V2G and V2H functionality. The IQ8 microinverters are micro-bidirectional inverters that can operate in on-grid and off-grid modes. Hence, they are an ideal foundation for building a bidirectional charger and enabling seamless integration into the Enphase home energy ecosystem. The bidirectional charger is very similar to the Enphase Encharge battery system, but in the case of the EV charger, the battery is inside the vehicle. Learn more about the Enphase battery and bidirectional charger in our detailed [Enphase Review](#).

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it is assumed that the power ratings will be relatively modest at around 5kW. Enphase has released an excellent [white paper](#) explaining the various features and bidirectional functions. The charger is due to be released in early 2024.



Enphase bidirectional EV charger

SolarEdge bidirectional EV charger

[SolarEdge Technologies](#) is a well-known solar company that manufactures solar inverters for residential and commercial applications. Founded in 2006, SolarEdge is unique among inverter suppliers as they do not manufacture conventional string [solar inverters](#) but what the company refers to as intelligent inverter systems using panel-mounted DC power optimisers. The SolarEdge bidirectional charger is a unique DC-coupled EV charger that integrates with the SolarEdge ecosystem built around a high-voltage DC bus (interconnection). Many modern home battery systems use a [DC-coupled](#) HV battery and a bidirectional (hybrid) inverter. Building on this, SolarEdge made the clever move to integrate an EV charger using the bidirectional capability of the solar inverter. The EV charger itself will be the part that connects to the vehicle and manages the charging.



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is due to be released in mid to late 2024.

Ford Charge Station Pro

The Charge Station Pro is a Ford exclusive EV charger rated at a maximum of 80-Amps, or 19.2kW (240V), which was released along with the new [Ford F-150 Lightning](#) Electric Pickup in mid-2022. The charger was developed in collaboration with Siemens eMobility. It will allow the F-150 EV to power a home, providing up to 9.6kW of power when installed with the Home Integration System to enable what Ford has dubbed [intelligent backup power](#).

However, the Ford Charge Station Pro only functions as a bidirectional charger when combined with Ford's home integration system, which consists of a 10kW bidirectional charger, monitoring equipment, energy meters and a transfer switch to enable islanding (grid isolation) during a blackout.

The home integration system currently offered by Sunrun in collaboration with Ford contains a 10kW **Delta** Bidirectional charger (DBI) similar to the unit listed previously. The Delta DBI works much like a high-voltage hybrid solar inverter and combines a high-voltage battery input with four solar trackers (MPPT inputs) to enable direct DC charging from solar. Additional equipment is required for whole home backup, as displayed in the diagram below.

The official price of the Ford Charge Station Pro is US\$1310 plus installation. Pricing for the Ford Home integration (Delta DBI and associated backup equipment) is approximately \$ 12,000 to \$ 15,000 for the complete system.



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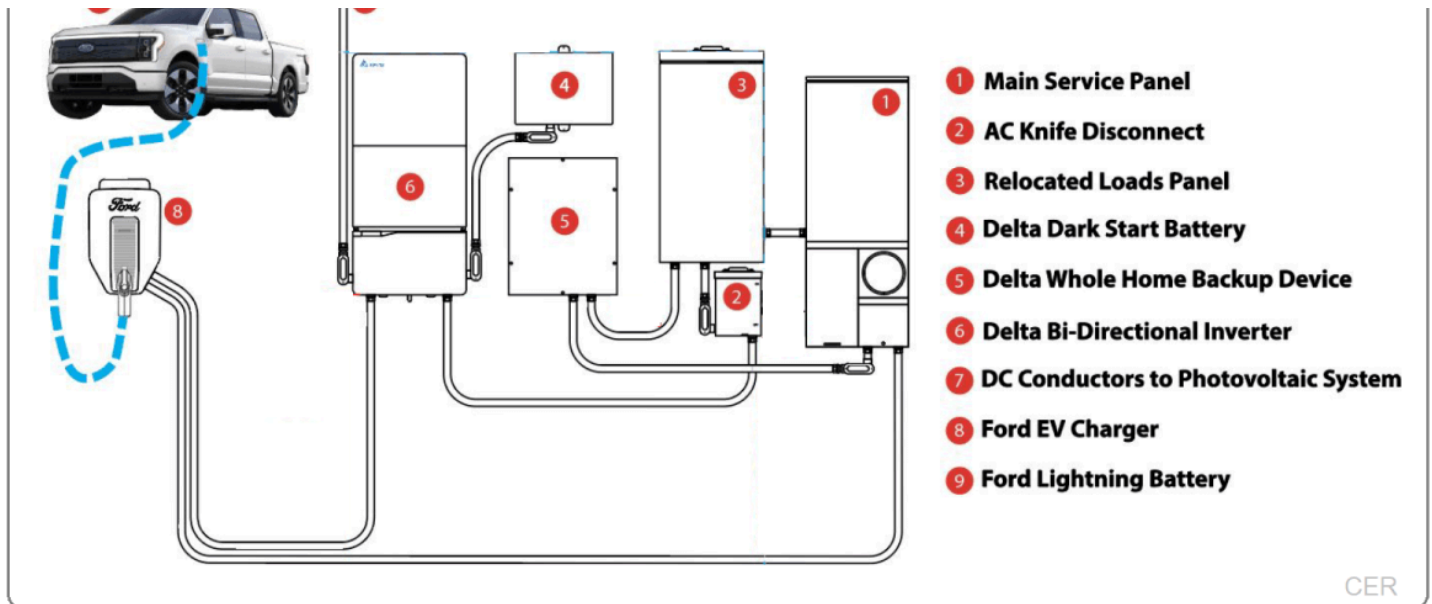
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The Ford Home Integration system includes the Delta 10kW bidirectional charger - Image credit Sunrun

BATTERY STORAGE • EV CHARGING • V2G

Jason Svarc

Jason Svarc is an accredited solar and battery specialist who has been designing and installing solar and battery systems for over a decade. He is also a qualified engineer and taught the off-grid solar design course at Swinburne University (Tafe). Having designed and commissioned hundreds of solar systems for households and businesses, he has gained vast experience and knowledge of what is required to build quality, reliable, high-performance solar power systems.

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Zum Launches Nation's First School District with 100% Electric, Bidirectional V2G School Bus Fleet in Oakland



NEWS PROVIDED BY

Zūm →

May 15, 2024, 10:00 ET

Oakland Unified School District's 74 EV school buses and charging infrastructure provides up to 2.1 gigawatt hours of energy back to the grid, reduces 25,000 tons of emissions annually

OAKLAND, Calif., May 15, 2024 /PRNewswire/ -- **Zūm**, the modern student transportation platform, announced today that Oakland Unified School District (OUSD) will be the first major school district in the U.S. to transition to a 100% electrified school bus system with groundbreaking vehicle-to-grid technology. Zum is providing a fleet of 74 electric school buses and bidirectional chargers in Oakland, managed through its AI-enabled technology platform. The all-EV fleet will not only transport students sustainably, but also play a critical dual role as a Virtual Power Plant (VPP), giving 2.1 gigawatt hours of energy back to the power grid at scale annually.

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Zum is providing a fleet of 74 electric school buses and bidirectional chargers in Oakland, managed through its AI-enabled technology platform. The all-EV fleet will not only transport students sustainably, but also play a critical dual role as a Virtual Power Plant (VPP), giving 2.1 gigawatt hours of energy back to the power grid at scale annually.



Zum, the modern student transportation platform, announced today that Oakland Unified School District (OUSD) will be the first major school district in the U.S. to transition to a 100% electrified school bus system with groundbreaking vehicle-to-grid technology.

"We at Zum strongly believe it is time to move beyond pilots and deploy sustainability solutions at scale. Converting the Oakland Unified school bus fleet to 100% electric with VPP capability is the right step in that direction," said Ritu Narayan, Founder and CEO of Zum. "This historic milestone is a win-win proposition: Electric school buses with V2G provide students with cleaner, fume-free transportation and allow us to send untapped energy from the bus batteries back to the grid, creating an enormous impact on grid resilience. Zum is proud to have delivered on this ambitious project a year ahead of schedule."

Student transportation is the largest mass transit system in the nation, moving 27 million students twice daily. Today, over 90% of the nation's 500,000 school buses run on carbon-based fuels, releasing over 8.4 million tons of greenhouse gases annually exposing students and communities to harmful gases every day.

"Oakland becoming the first in the nation to have a 100% electric school bus fleet is a huge win for the Oakland community and the nation as a whole," said Kim Raney, Executive Director of Transportation at Oakland Unified School District. "The families of Oakland are disproportionately disadvantaged and affected by high rates of asthma and exposure to air pollution from diesel fuels. Providing our students with cleaner and quieter transportation on electric school buses will be a game changer ensuring they have an equitable and stronger chance of success in the classroom."

Electrification of such a large fleet with V2G capabilities requires a vast ecosystem of partners. Federal and California State programs that have been critical to the acceleration of this project are: the Environmental Protection Agency's (EPA) Clean School Bus program, California Air Resource Board (CARB), Heavy Vehicle Incentive Program (HVIP) vouchers, Bay Area Air Quality Management District (BAAQMD) and Clean Mobility Operations (CMO) programs.

The acceleration of the EV transition was the result of Pacific Gas and Electric Company's, Zum's utility partner, ability to provide 2.7 megawatts of load to Zum's Oakland EV-ready facility in record time.

"PG&E is proud to work closely with Zum and Oakland Unified in deploying what is the largest electric school bus fleet and vehicle-based, grid-supporting resource in the country," said Mike Delaney, Vice President of Utility Partnerships and Innovation, PG&E. "Oakland is PG&E's headquarters, it is home to many of our customers and co-workers, and a city we've proudly served for more than a century. Achieving this advanced fleet electrification and vehicle-grid-integration milestone for the people and students of Oakland reflects our commitment to delivering excellent customer service outcomes for our hometowns using breakthrough thinking, collaboration and swift execution."

Zum has set a goal of electrifying 10,000 bidirectional school buses which will create the potential to supply 300 gigawatt hours of energy to the power grids annually. In addition, Zum is electrifying school buses in its fleet in districts across the country, with San Francisco Unified and Los Angeles Unified – which are three and six times the size of Zum's Oakland school bus fleet, respectively – to soon follow.

About Zūm

Zum is a modern transportation solution transforming school transportation, the largest mass transit system in the U.S. Today, the company provides turnkey modern transportation solutions to school districts in California, Colorado, Connecticut, Illinois, Maryland, Massachusetts, Missouri, Nebraska, Pennsylvania, Tennessee, Texas, Washington, Utah, and Virginia, and is expanding rapidly nationwide. Recognized globally for its innovative transportation and energy as a service platform, Zum has been featured among Fast Company's World Changing Ideas, CNBC Disruptor 50, CNBC Changemakers, World Economic Forum and Financial Times' Fastest Growing Companies. Learn more about Zum at www.ridezum.com.

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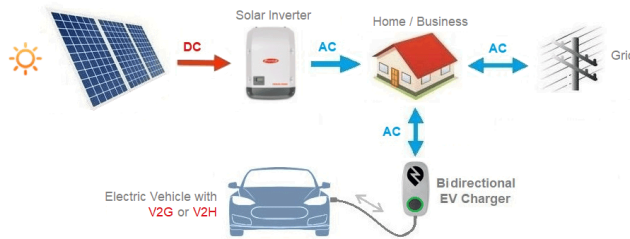
Jenny Mayfield, Vice President of Communications - press@ridezum.com

SOURCE Zūm



2 OCT, 2023 • WRITTEN BY JASON SVARC

Bidirectional EV charging explained - V2G, V2H & V2L



EVs with bidirectional (two-way) charging capability can be used to power a home, feed energy back into the electricity grid and even provide backup power in the event of a blackout or emergency. An EV is essentially a large battery on wheels, so bidirectional chargers can enable a vehicle to store cheap off-peak electricity or solar power to reduce household electricity costs. This emerging technology, known as [vehicle-to-grid \(V2G\)](#), could revolutionise the way our power grids operate, with the potential for tens of thousands of electric vehicles to supply power simultaneously during times of peak electricity demand. For those new to electric vehicle chargers, see our [EV charging explained](#) article.

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advanced EV charger capable of two-way charging; this might sound relatively simple, but it's a complex power conversion process from AC (alternating current) to DC (direct current) instead of regular unidirectional EV chargers that charge using AC.



Wallbox Quasar bidirectional charger

Unlike standard EV chargers, bidirectional chargers operate much like an inverter, converting AC to DC during charging and the reverse during discharging. However, bidirectional chargers can only work with vehicles compatible with two-way DC charging. Unfortunately, there is currently a very small number of EVs that are capable of bidirectional charging, the most well-known being the later model Nissan Leaf. Due to bidirectional chargers being far more sophisticated, they are also much more expensive than regular EV chargers since they incorporate advanced power conversion electronics to manage the energy flow to and from the vehicle.

To supply power to a home, bidirectional EV chargers also incorporate equipment to manage the loads and isolate the house from the grid during an outage, known as islanding. The basic operating principle of a bidirectional EV charger is very similar to [bidirectional inverters](#), which have been used for backup power in home battery storage systems for over a decade.

Learn more about [bidirectional EV chargers](#), along with prices and availability.

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What are the uses of bidirectional charging?

Bidirectional chargers can be used for two different applications. The first and most talked about is Vehicle-to-grid or [V2G](#), designed to send or export energy into the electricity grid when the demand is high. If thousands of vehicles with V2G technology are plugged in and enabled, this has the potential to transform how electricity is stored and generated on a massive scale. EVs have large, powerful batteries, so the combined power of thousands of vehicles with V2G could be enormous. Note that V2X is a term that is sometimes used to describe all three variations described below.

1. **Vehicle-to-grid or V2G** - EV exports energy to support the electricity grid.
2. **Vehicle-to-home or V2H** - EV energy is used to power a home or business.
3. **Vehicle-to-load or V2L *** - EV can be used to power appliances or charge other EVs

** V2L does not require a bidirectional charger to operate*

The second use of bidirectional EV chargers is for Vehicle-to-home or V2H. As the names suggest, V2H enables an EV to be used like a home battery system to store excess solar energy and power your home.

y system, such as
' of 13.5kWh. In
city of 65kWh,

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1. Vehicle-to-grid - V2G

[Vehicle-to-grid](#) (V2G) is where a small portion of the stored EV battery energy is exported to the electricity grid when needed, depending on the service arrangement. To participate in V2G programs, a bidirectional DC charger and a compatible EV is required. Of course, there are some financial incentives to do this and EV owners are given credits or reduced electricity costs. EVs with V2G can also enable the owner to participate in a [virtual power plant](#) (VPP) program to improve grid stability and supply power during peak demand periods. Only a handful of EVs currently have V2G and bidirectional DC charging capability; these include the later model [Nissan Leaf](#) (ZE1) and the Mitsubishi Outlander or Eclipse plug-in hybrids.

Despite the publicity, one of the problems with the roll-out of V2G technology is the regulatory challenges and lack of standard bidirectional charging protocols and connectors. Bidirectional chargers, like solar inverters, are considered another form of power generation and must meet all regulatory safety and shutdown standards in the event of a grid failure. To overcome these complexities, some vehicle manufacturers, such as Ford, have developed simple AC bidirectional charging systems that only operate with Ford EVs to supply power to the home rather than exporting to the grid. Others, such as Nissan,

al chargers such as
more detail below.

[V2G technology](#).

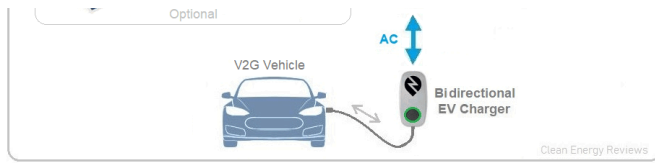
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Vehicle to Grid (V2G) energy flow diagram using a DC bidirectional charger.

Nowadays, most EVs are equipped with the standard CCS DC charge port. Currently, the only EV that uses a CCS port for bidirectional charging is the recently released [Ford F-150 Lightning](#) EV. However, more EVs with CCS connection ports will be available with V2H and V2G capability in the near future, with VW announcing its ID electric cars may offer bidirectional charging sometime in 2023.

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2. Vehicle to Home - V2H

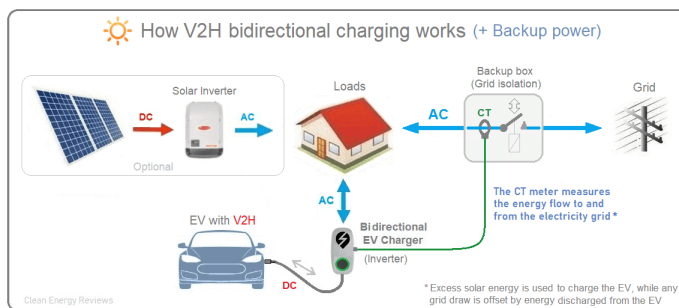
Vehicle-to-home (V2H) is similar to V2G, but the energy is used locally to power a home instead of being fed into the electricity grid. This enables the EV to function like a regular household [battery system](#) to help increase self-sufficiency, especially when combined with rooftop solar. However, the most

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Compatible



the grid. Likewise, when the system detects energy being exported from a rooftop solar array, it diverts this to charge the EV, which is very similar to how [smart EV chargers](#) work. To enable **backup power** in the event of a blackout or emergency, the V2H system must be able to detect the grid outage and isolate it from the network using an automatic contactor (switch). This is known as islanding, and the bidirectional inverter essentially operates as an off-grid inverter using the EV battery. Grid isolation equipment is required to enable backup operation, much like [hybrid inverters](#) used in backup battery systems.



Basic energy flow diagram of a DC bidirectional charger using V2H to power a home, plus CT meter to measure grid energy flow.

Only a few EVs currently feature V2H technology, including the later model Nissan Leaf and Mitsubishi Outlander PHEV, which use the older-style CHAdeMO connector. The new Ford F-150 Lightning EV is unique because it can operate in V2H mode using a CCS connector via an in-vehicle bidirectional charger. However, it can only function with the [Ford Charge Station Pro](#) and the Ford Home Integration System.

Vehicle-to-load (V2L)

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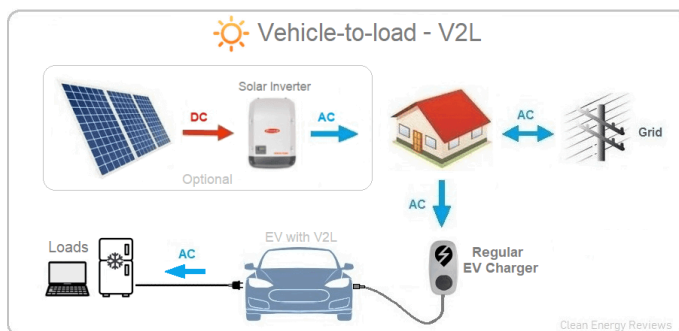
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...also sometimes referred to as VTOL. Vehicles with V2L have a built-in bidirectional charger and standard AC power outlets, which can be used to plug in any regular household AC appliances. However, some vehicles use the EV charging port and a special V2L adapter to provide power via a lead. In an emergency, extension cords can be run from the vehicle into a home to power essential loads, including lighting, computers, fridges, and cooking appliances.



Ford F-150 lightning (EV) has four V2L AC power outlets rated at 2.4kW each.

The new Ford F-150 Lightning has V2L capability via four 2.4kW AC power outlets for a total of 9.6kW of power. Other vehicles with V2L technology include the new [Hyundai IONIQ 5](#) and Kia EV6, which have internal and external AC power outlets, and the [BYD](#) electric vehicle range, including the Yuan Plus, also known as the BYD Atto 3. Clean Energy Reviews conducted a V2L load test on the BYD Atto 3, and you can see the [results here](#).



Basic energy flow diagram of an EV with an AC power outlet which is known as vehicle-to-load or V2L.

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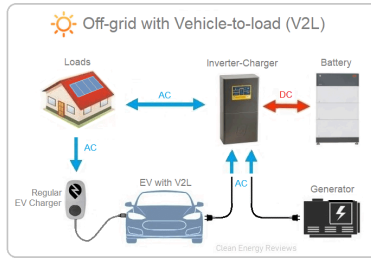
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V2L for Off-grid and backup power

Vehicles with V2L can provide backup power using extension leads to run selected appliances.

However, it is also possible to connect the V2L supply directly to a backup switchboard or even the main distribution board using a specialised AC transfer (change-over) switch.



Off-grid using V2L - **Click on image to learn more**

A vehicle with V2L can also be incorporated into an off-grid solar power system to reduce or even eliminate the need for a backup generator. Most [off-grid solar power systems](#) contain a bidirectional inverter, which can technically use power from any AC source, including a vehicle with V2L. However, it would need to be installed and configured by a solar specialist or qualified electrician to do this safely.

[Learn more about using V2L for backup power and to enhance off-grid systems.](#)

Vehicles with bidirectional charging V2G V2H & V2L

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ently available, or

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VEHICLE	MODEL	Type	V2G	V2H	V2L
	Nissan Leaf ZE1	Chademo	YES	YES	No
	Outlander PHEV	Chademo	YES	YES	No
	Hyundai Ioniq 5	CCS	No	No	YES 3.6kW
	KIA EV6	CCS	No	No	YES 3.6kW
	Genesis GV60	CCS	No	No	YES 3.6kW
	BYD Atto 3	CCS	No	(No)	YES 2.4kW *
	BYD Seal	CCS	No	(No)	YES 2.4kW *
	Ford F-150 Lightning	CCS	(TBC)	YES	YES 9.6kW
	MG ZS EV (2022)	CCS	No	No	YES 2.2kW
	VW ID Models	CCS	Yes (TBC)	YES **	(TBC)
	Cupra Born EV	CCS	Yes (TBC)	Yes (TBC)	(TBC)

(*) The V2L peak power rating was determined via [load testing](#). Continuous V2L rating is 10A (2400W)

(**) [Volkswagen officially announced](#) a bidirectional charging station (allowing the CCS DC

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ility is limited to (battery) station



[Bidirectional chargers review.](#)

(#) The **Cupra Born** EV has been confirmed by the EV charger manufacturer Wallbox to be compatible with the second-generation Wallbox Quaser 2 bidirectional charger, enabling both V2H and V2G. See the official [Wallbox press release](#).

Tesla V2G Bidirectional Charging Test Successful

An unmodified Tesla Model 3 and Model Y were successfully tested using a V2H/V2G bidirectional charger. The tests were conducted by Finish company **InterControl** in collaboration with German bidirectional charger manufacturer **Ambibox**. The test system was externally controlled via the HEMS-supplied home energy management system, which confirms that Tesla has partially implemented [ISO15118-2 standard 11](#). However, Tesla has not officially endorsed bidirectional capability in either the Model 3 or Model Y.



Tesla model 3 bidirectional charging test - Image credit Ambibox

See more details and analysis of the [Tesla Model 3 and Model Y bidirectional charging test](#).

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Jason Svarc

Jason Svarc is an accredited solar and battery specialist who has been designing and installing solar and battery systems for over a decade. He is also a qualified engineer and taught the off-grid solar design course at Swinburne University (Tafe). Having designed and commissioned hundreds of solar systems for households and businesses, he has gained vast experience and knowledge of what is required to build quality, reliable, high-performance solar power systems.

[Solar system fault finding guide & solutions](#)

[Trina Solar Panels Review](#)

Solar Panels

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[Getting Started with Electric Vehicles](#) > Vehicle to Everything (V2X) Pilot Programs

Feedback

Vehicle-to-Everything (V2X) pilot program

Keep your lights on using your EV

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Get started

New [bidirectional charger technology](#) allows you to use the power in your electric vehicle's battery. PG&E's Vehicle to Everything (V2X) pilots offer incentives to help customers access this technology.

- Power your property temporarily when there is an electrical outage
- Charge your vehicle when electricity is less expensive and use vehicle power when it's more expensive (4-9 p.m.)
- Earn additional incentives by sending electricity to the grid during times of high demand



[Program details](#)

Understand the technology

Get started

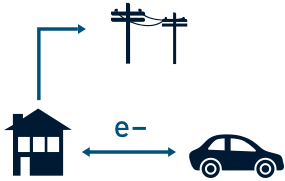
Frequently asked questions



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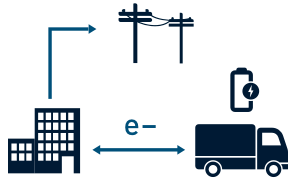
There are three Vehicle to Everything pilot programs:

Pilot	Incentives	Eligibility and Requirements
<p>V2X Residential</p>  <p>Enrollment target: 1,000 (or when incentives are exhausted)</p>	<p>\$2,500 upfront (\$3,000 for customers in Disadvantaged Communities)</p> <p>Up to \$2,175 additional for performance</p>	<p>Residential customers within PG&E service area that have a standard split-phase 240v electrical service and select from one of the vehicles/chargers listed in the Getting Started tab.</p> <p>Enrollment in customer group A,5 Vehicle-Grid Integrations of the Emergency Load Reduction Program (ELRP) is required and offers additional incentives.</p>

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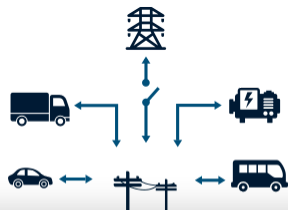
Pilot

V2X Commercial



Enrollment target:
200 (or when incentives are exhausted)

V2X Microgrids



Incentives

3-phase bidirectional charger less than 50 kW:

- Up to \$2,500 upfront (\$3,000 for customers in Disadvantaged Communities), up to \$3,625 for performance

3-phase bidirectional charger greater than or equal to 50 kW:

- Up to \$4,500 upfront (\$5,000 for customers in Disadvantaged Communities), up to \$3,625 for performance

Up to \$5,000 for performance
Can stack incentives with V2X Residential or Commercial

Eligibility and Requirements

Commercial customers within PG&E service area that have standard 3-phase electrical service and select from one of the vehicles/chargers listed in the Getting Started tab.

Enrollment in customer group A,5 Vehicle-Grid Integrations of the [Emergency Load Reduction Program \(ELRP\)](#) is required and offers additional incentives.

PG&E customers who are connected to a multi-customer microgrid subject to Public Safety Power Shutoffs and select from one of the vehicles/chargers listed in the Getting Started tab. Customers who are eligible for

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Pilot	Incentives	Eligibility and Requirements
200 (or when incentives are exhausted)		

Understand the technology

Bi-directional Charging

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Get started

- Download the [application checklist \(PDF\)](#) to find everything you need to enroll. At this time, customers don't need to include aggregator information in their application.
- Before you buy anything, use this [key question guide \(PDF\)](#) to discuss your facility's readiness for V2X with an electrician.
- Select a vehicle and its compatible charger from the eligible products list below.
 - **Note:** New products continue to be added to the list. Please check back for updates.

Eligible Product List for the V2X Residential Pilot

Vehicle Model	Charger Model	Eligibility
Ford F-150 Lightning 2022 or 2023	Ford 80 Amp Charge Station Pro paired with the Sunrun Home Integration System	Backup Power Only (0% already subscribed)

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i Note to Manufacturers: If you want to see your product listed here, please contact vgipilotcommunications@pge.com.

Frequently asked questions

Customer FAQs

How long can the vehicle provide power to a property? 

How much do V2X Pilot incentives offset the costs for bidirectional technology? 

What happens if I need an electric panel or service upgrade? 

How much does it cost to connect my bidirectional electric vehicle system to the PG&E grid? 

Do I need to be enrolled in a specific rate to be eligible to participate? 

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Contractor FAQs

How do I comply with the Electric Vehicle Infrastructure Training Program (EVITP) certified electrician requirement? 

When should I contact PG&E Service Planning? 

Does the system need to be interconnected under Electric Rule 21? 

What if the customer also has rooftop solar or other renewable technology on Solar Billing Plan? 

Additional incentives available:

- [EV Savings Calculator](#)
- [Residential and commercial resources](#)

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For additional questions, contact vgipilotcommunications@pge.com.

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Empower EV program

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DISTRIBUTED ENERGY

California's Bidirectional Charging Mandate Would Create Microgrids on Wheels & Turbocharge Resiliency

A California bill calling for bidirectional electric vehicles is "the most important bill of the year in California," and would create mobile microgrids, said Peter Asmus, executive director, Alaska Microgrid Group.

[Lisa Cohn](#)

July 19, 2023



California has proposed requiring all electric vehicles (EVs) to be equipped with bidirectional charging beginning in model year 2030 – a move that would create

microgrids on wheels that could support the grid, cut the need for fossil-fired peaker plants, reduce air pollution and provide resilience to disadvantaged communities during outages.

The California Assembly Energy Committee approved the bill July 12. During that same week, a heat wave in California prompted utilities to email customers encouraging them to purchase fossil-fuel backup generators, said Kurt Johnson, director of community energy resilience for the Climate Center, which sponsored the bill, [SB 233](#).

Peter Asmus, executive director of the Alaska Microgrid Group, a nonprofit that designs and builds microgrid projects in Alaska, said he's cautiously optimistic the bill will pass. If it makes it to Gov. Gavin Newsom's desk, Newsom will likely sign it because he has supported many climate initiatives, Asmus said.

Bidirectional charging is in its infancy in the U.S. The best known example of this technology is the Ford F-150 Lightning. Drivers have boasted on social media that these electric trucks – which are sold equipped with bidirectional charging – have kept the lights on in their homes during power outages.

To use the technology, EV drivers need to purchase bidirectional chargers that can both charge the car and discharge the energy in the car's battery to homes, buildings or the grid. Only a few bidirectional chargers are available right now, including chargers from Fermata Energy and Dcbel.

Bidirectional EVs as distributed energy resources

As electrification efforts continue – especially with the deployment of more EVs – the bidirectional EVs can supply clean energy to the grid when it's needed. Failing to take advantage of the growing number of EVs as clean distributed energy resources would be a lost opportunity, Asmus said.

In addition, bidirectional EVs, serving as mobile microgrids, can be driven to disadvantaged communities – where residents can't afford solar, storage and microgrids

– to provide resilience during outages. They could also be driven to communities experiencing weather-related outages. In addition, the EV batteries could be aggregated to create a virtual power plant.

Such applications reduce dependence on fossil-fueled peaker plants and cut greenhouse gas emissions.

The “most important bill” in California

“I think this is the most important bill of the year in California,” said Asmus. “As California goes, so does the nation.” When California created refrigeration standards, manufacturers didn’t want to create a refrigerator for California and one for other states. So they focused on producing refrigerators for the entire U.S. that met California’s standards, he said.

“SB 233 is the most important climate legislation in history,” added John Sarter, Dcbel West Coast smart home integration partner. “The bill will enable all electric vehicles to become renewable energy partners to the grid, rather than a strain upon it. This enables a continually expanding excess capacity to be utilized by the grid for peak energy demands,” he said.

SB 233 was introduced by California Sen. Nancy Skinner, D-Oakland, and directs the California Energy Commission (CEC) and California Air Resources Board (CARB), working with the California Public Utilities Commission, to clarify, by December 2024, the definition of bidirectional-capable EVs to help the industry move toward the requirement of the bill.

According to the Climate Center, the bill also:

- Requires that by model year 2030, all EVs sold in California are bidirectional capable, except EVs exempt as determined by CARB.
- Directs the CEC and CARB to revise existing incentives for EVs to provide higher incentive levels for bidirectional-capable EVs and EV equipment, focusing first on

investments in disadvantaged communities.

- Directs the CEC, in consultation with CARB, to establish state vehicle-to-home, vehicle-to-building and vehicle-to-grid goals to support emergency backup, electrical grid reliability and electric vehicle grid integration goals.

A small percentage of bidirectional EVs could do a big job

California has about 1.5 million EVs on the road and expects an estimated 8 million by 2030. If the state's EVs become bidirectional, it would only take a small percentage of the 8 million to provide enough power to help avoid blackouts and create a more resilient grid. This would create cleaner air because renewable energy stored in EV batteries could be released during periods of high demand, said Johnson.

“I do think EVs are the distributed energy resources of the future,” said Asmus. “This also means we'll need more microgrids. With more and more EVs, we'll need a resilient grid to support EV charging.”

In addition, bidirectional EVs can serve as resources for microgrids, he said.

From a grid planning perspective, bidirectional EVs are less expensive than paying for new power plants, said Johnson. A study by the Electric Power Research Institute found that utilities and ratepayers could save **\$1 billion** a year with vehicle-to-grid technologies.

Pacific Gas & Electric (PG&E), which implements public safety power shutoffs during fire season in its territory, hasn't taken a position on the bill, said Mike Gazda, spokesman for PG&E.

“PG&E supports the expansion of vehicle-to-grid technologies, such as bidirectional charging, and has a company goal of enabling 2 million electric vehicles in its service territory to participate in vehicle-grid integration applications by 2030,” he said.

PG&E is one of many utilities presenting on important grid transformation issues at T&D World Live

Sept. 12-14 in Sacramento: Learn more here

Grid Transformation for an Electrified World

Tiptoeing into bidirectional charging

A few utilities and organizations are giving bidirectional charging a test run.

PG&E's [vehicle-to-everything](#) pilot provides incentives for people to try vehicle-to-home, vehicle-to-commercial property and vehicle-to-microgrid charging.

The Alliance Center, a Denver, Colorado, nonprofit that models innovative green building technologies, is installing a Fermata Energy bidirectional [charger](#) with demand-peak predictive software to reduce energy costs while tackling climate change.

EVs can become part of the shared economy

Fermata Energy is one of the first companies to develop bidirectional charging technology. And Dcbel, recently received Underwriters Laboratories' [approval](#) of its bidirectional charger. The Dcbel R16 is a solar inverter combined with a two-port bidirectional EV charger, said Sarter. It can manage all home energy, including a stationary battery, and export to the grid. And Emporia Energy plans to release in 2024 a [bidirectional charger](#).

And Tesla, known for being an opponent of bidirectional charging, has said it will release an EV with the capability in [two years](#).

Bidirectional EV technology takes advantage of assets that sit idle 90% of the time. Owners of EVs with this technology may soon join Airbnb renters and Uber drivers who also make use of assets sitting idle – at home or in a garage.

“I think that’s the wave of the future, and this fits into more of a shared economy,” said Asmus.





About the Author

Lisa Cohn | Contributing Editor

I focus on the West Coast and Midwest. Email me at lcohn@endeavorb2b.com

I've been writing about energy for more than 20 years, and my stories have appeared in EnergyBiz, SNL Financial, Mother Earth News, Natural Home Magazine, Horizon Air Magazine, Oregon Business, Open Spaces, the Portland Tribune, The Oregonian, Renewable Energy World, Windpower Monthly and other publications. I'm also a former stringer for the Platts/McGraw-Hill energy publications. I began my career covering energy and environment for The Cape Cod Times, where Elisa Wood also was a reporter. I've received numerous writing awards from national, regional and local organizations, including Pacific Northwest Writers Association, Willamette Writers, Associated Oregon Industries, and the Voice of Youth Advocates. I first became interested in energy as a student at Wesleyan University, Middletown, Connecticut, where I helped design and build a solar house.

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