



Adrian Bankhead <abankhead@avaenergy.org>

Bidirectional EV chargers

INDIRA BALKISSOON [REDACTED]
To: Adrian Bankhead <abankhead@avaenergy.org>

Wed, May 15, 2024 at 6:36 PM

Hello Adrian -

Per our discussion on May 13. I am sending you the information on bidirectional EV chargers. The Chair Ed Hernandez mention that this might be something that we could ask AVAs lobbyists to mention for potential legislation. Bidirectional chargers enable two-way energy transfer, allowing EVs to send power to your home or back into the electricity grid. Unlike standard EV chargers, which use regular AC power for charging, bidirectional chargers perform complex power conversion, converting power from AC to high-voltage DC during charging and the reverse during discharging. This technology would add EVs as an additional option to provide storage in addition to batteries.

I have attached an article from Clean Energy Reviews on bidirectional EV chargers.

Also, Oakland School District has recently added all electric school buses with the capacity for bidirectional charging.

I have also attached this article.

Best regards,
Indira
Indira Balkissoon
CAC Member North Region (Piedmont)
[REDACTED]

2 attachments

 **Bidirectional EV chargers Review — Clean Energy Reviews.pdf**
1451K

 **Zum Launches Nation's First School District with 100% Electric, Bidirectional V2G School Bus Fleet in Oakland.pdf**
141K

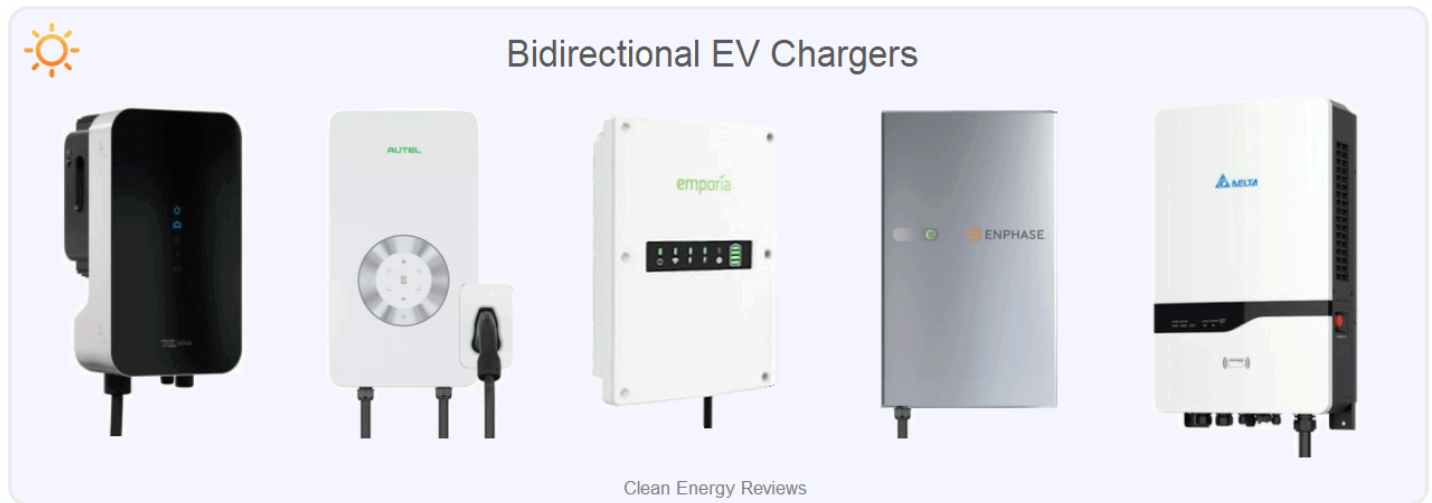
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26 MAR, 2024 • WRITTEN BY JASON SVARC

Bidirectional EV chargers Review



What is a bidirectional EV charger?

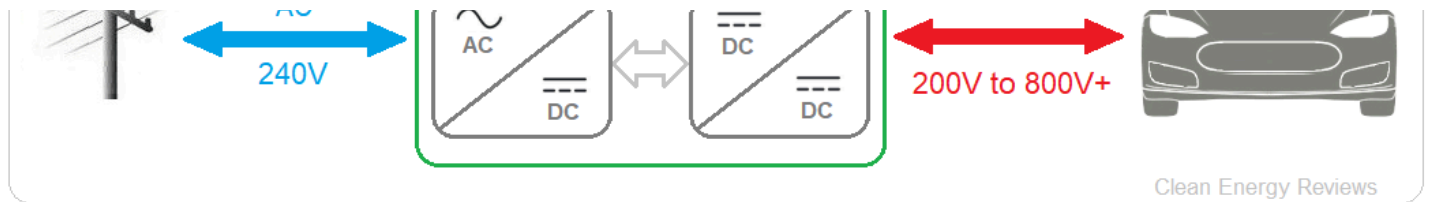
A bidirectional EV charger is an advanced EV charging system that enables two-way energy transfer, allowing electric vehicles (EVs) to send power to your home or back into the electricity grid. Unlike standard EV chargers, which use regular AC (alternating current) power for charging, bidirectional chargers 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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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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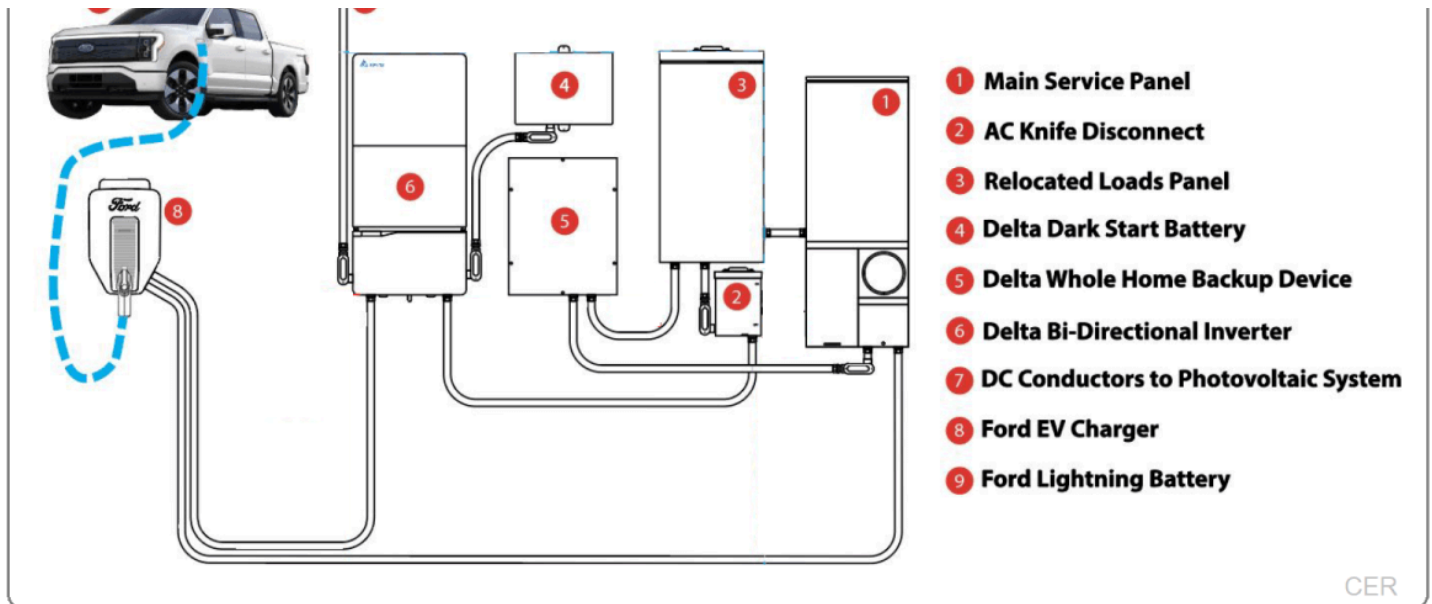
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The Ford Home Integration system includes the Delta 10kW bidirectional charger - Image credit Sunrun

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



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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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