Electric School Bus

Network Forum

April 8, 2026

ELECTRIC SCHOOL BUS NETWORK

Ice Breaker:
What is your favorite flower?

April 8, 2026

Forum Agenda

01. Introduction to ESB Network

02. V2G Standardization & Integration

- **02.1** Zach Woogen, Vehicle-Grid Integration Council
- **02.2** Luke Whittemore, Portland General Electric

03. Q&A and Discussion

05. Summary and Closing

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Electric School Bus Network

The Electric School Bus Network accelerates nationwide school bus fleet electrification through **peer-to-peer networking** and **dialogue-driven forum meetings** for school districts, advocacy organizations, government organizations, and industry representatives. The ESB Network provides access to educational tools, resources, and subject matter experts to help **support the electric school bus fleet transition**.

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Meet the ESB Team

Rachel Chard
Director

Ian Fried
Lead Program Manager

Sarah Stalcup-Jones
Lead Project Manager

Liza Walsh
Project Manager

Ibraheem Ameer
Project Manager

Jane Moore
Marketing Lead

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Electric School Bus Network Forum Meetings

- Forum meetings are not webinars—they are ongoing discussions where participation is encouraged
- **Goal: Ease the transition to electrify school bus fleets nationwide**
  - Facilitate conversations
  - Provide up-to-date information
  - Engage industry, agencies, operators, school districts, advocates, and more

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Zach Woogen, Vehicle-Grid Integration Council

State of Vehicle-Grid Integration

April 8, 2026

EVs represent **untapped potential** beyond mobility as distributed energy resources to support an affordable and reliable energy future

Vehicle-Grid Integration Council is focused on unlocking the value of managed charging, bidirectional charging, and DER-paired charging

VGIC MEMBERS / 2026

LEADERSHIP CIRCLE

Ford
gm
HONDA
NISSAN GROUP OF NORTH AMERICA

GENERAL MEMBERS

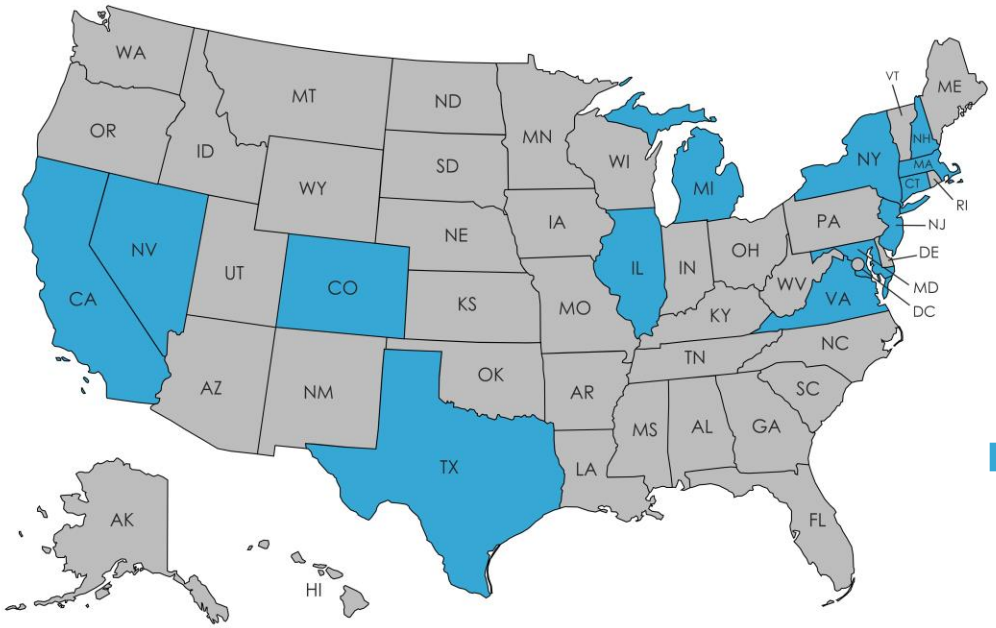
BIDIRECTIONAL ENERGY
BMW
bodeEV
chargepoint
ChargeScape
codibly part of spyrosoft
CRITICAL LOOP
dcbel
EATON Powering Business Worldwide
EnergyHub
ev.energy
Fermata Energy A NUVVE COMPANY
GRAVITY
ORANGE
Renew Home
RIVIAN
STELLANTIS
SWTCH
TESLA
THE MOBILITY HOUSE
TOYOTA
UL Solutions
WeaveGrid

ASSOCIATE MEMBERS

CPA CLEAN POWER ALLIANCE
CONNECTICUT GREEN BANK
LA DWP Los Angeles Department of Water & Power
MCE
SAN DIEGO COMMUNITY POWER
SMUD

VGIC U.S. Market Coverage

VGIC Shapes Outcomes Across the Nation



Proactive Advocacy, Tracking and/or Opportunistic Engagement

VGIC leverages its relationships with regulators and policy makers, and has submitted over 300 sets of regulatory comments, testimony, settlements, and other policy levers to capitalize on these opportunities

VGIC Strategic Focus Areas

Compensation Working Group

- EV-Specific Utility Programs (e.g., managed charging programs)
- Utility Time-of-Use Rates and Export Credits
- Tech-Agnostic Programs (e.g., Virtual Power Plant programs)

Technical Working Group

- DER/V2G Interconnection Requirements and Processes
- EV/DER Control Architecture & Communication Protocols
- Telematics Testing & Standards
- Islanded Backup Power Policy

Infrastructure and Planning Working Group

- VGI Technology Deployment Incentives and Equipment Rebates
- VGI Forecasting, Utility Grid Planning, and Charging Infrastructure Planning
- EV Make-Ready Infrastructure Funding and Proactive Planning

VGIC Partnerships

Global Collaboration

New York Policy Advocacy

New England Policy Advocacy

Texas Policy Advocacy

Utility Collaboration

And informal collaboration with…

National Market Development:

- Advanced Energy United (AEU)
- Alliance for Automotive Innovation
- Alliance for Transportation Electrification (ATE)
- CALSTART
- Environmental Defense Fund
- Interstate Renewable Energy Council (IREC)
- National Association of Regulated Utility Commissioners (NARUC)
- National Association of State Energy Officials (NASEO)
- National Rural Electric Cooperative Association (NRECA)
- RMI Virtual Power Plant Partnership (VP3)
- Solar Energy Industries Association (SEIA)

Local Policy Advocacy:

- California Electrification Transportation Coalition
- California Energy + Demand Management Council
- California Energy Storage Alliance (CESA)
- California Solar and Storage Association (CalSSA)
- Chesapeake Solar and Storage Association
- Colorado Solar and Storage Association (COSSA)
- Michigan Energy Innovation Business Council (MEIBC)
- New York Battery Energy Storage Consortium (NY-BEST)
- Texas Electric School Bus Partnership (TESBP)
- The Climate Center

Market Intelligence and Best Practices:

- Australia Renewable Energy Agency (ARENA)
- CharIn North America
- U.S. Department of Energy
- Veloz
- World Resources Institute (WRI)

Convenings:

- Electric Power Research Institute (EPRI)
- EV Charging Summit and Expo
- Smart Grid Observer

Program Implementation:

- Massachusetts Clean Energy Center
- Resource Innovations

What is Vehicle-Grid Integration (VGI)?

VGI encompasses the suite of ways EVs can provide services to the grid and increase the value proposition of EVs:

Managed Charging	Grid-Isolated Bidirectional Charging	Grid-Parallel Bidirectional Charging	Flexible Service Connection	DER-Paired Charging
• Passive or active load shift	• Islanded configuration to power a home, building, or microgrid	• Utility-interconnected to minimize customer bills and/or provide grid services	• Minimizing time and costs for infrastructure deployment using load management solutions and/or distributed energy resources (DER)	• Co-located or integrated with customer generators and/or stationary energy storage

Why VGI Now?

- Accelerate Transportation Electrification
- Support the Evolving Power Sector
- Increase Affordability of Electricity
- Improve Community Resilience
- Foster Economic Activity

Accelerating Transportation Electrification

- **Managed charging** led to 25% - 50% savings in annual charging costs in recent analysis for Stockton Unified School District

Table 1: Summary of Charging Analysis Results by Scenario

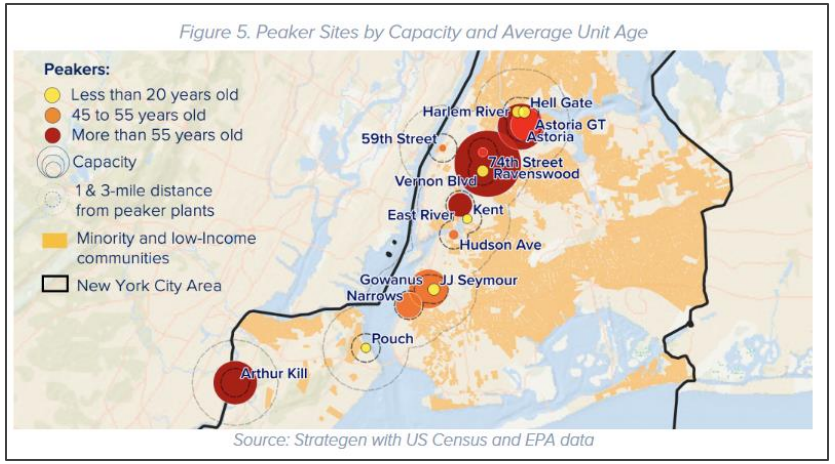
Scenario	AC Only	DC Only	AC + DC	AC + PV
Annual Energy Cost Without CEM	$405K	$399K	$406K	$287K
Annual Energy Cost With CEM	$244K	$237K	$298K	$134K
Energy Cost Savings With CEM	39.7%	40.6%	26.6%	53%

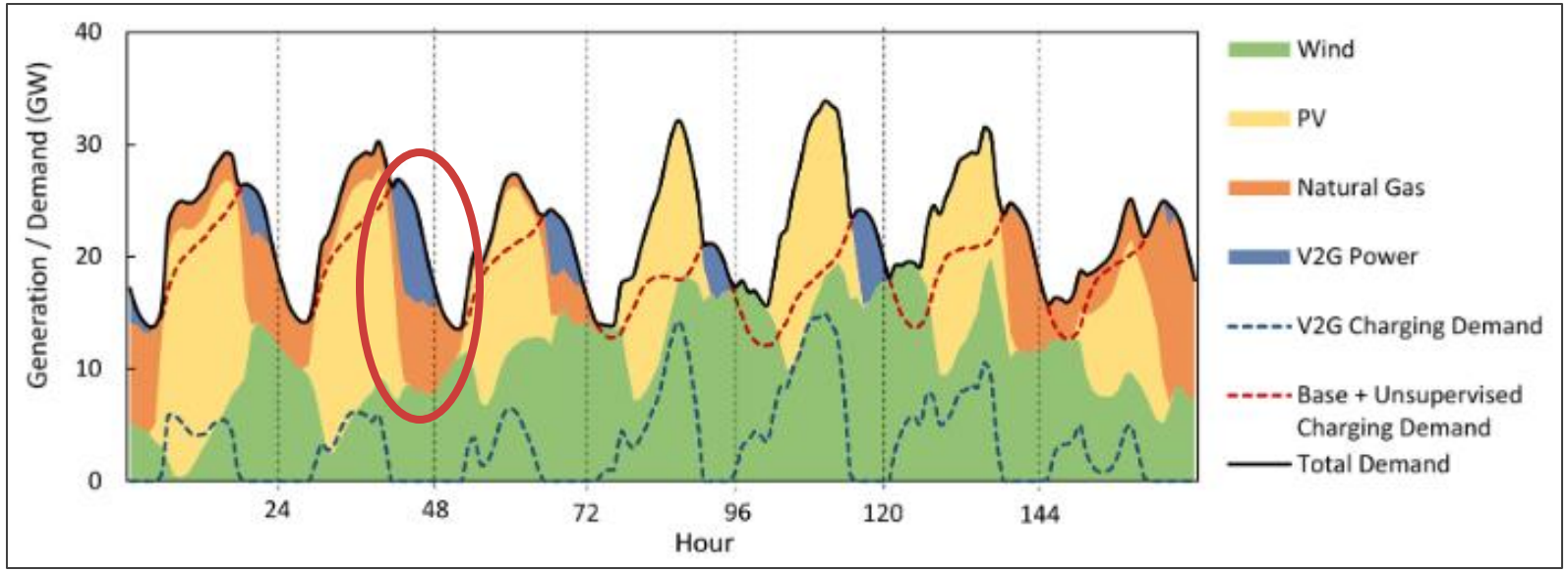
- Beverly Public Schools report earning ~$10,000/bus/year by **bidirectional charging** in their utility's demand response program!

Source: https://www.energy.ca.gov/sites/default/files/2023-03/CEC-600-2023-028_0.pdf
https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M502/K977/502977248.PDF

Support the Decarbonizing Power Sector

Managed charging and bidirectional charging can help offset the use of old, polluting "peakers"





Source: https://pubs.rsc.org/en/content/articlepdf/2022/ya/d2ya00204c
https://www.cleanegroup.org/wp-content/uploads/Fossil-Fuel-End-Game.pdf

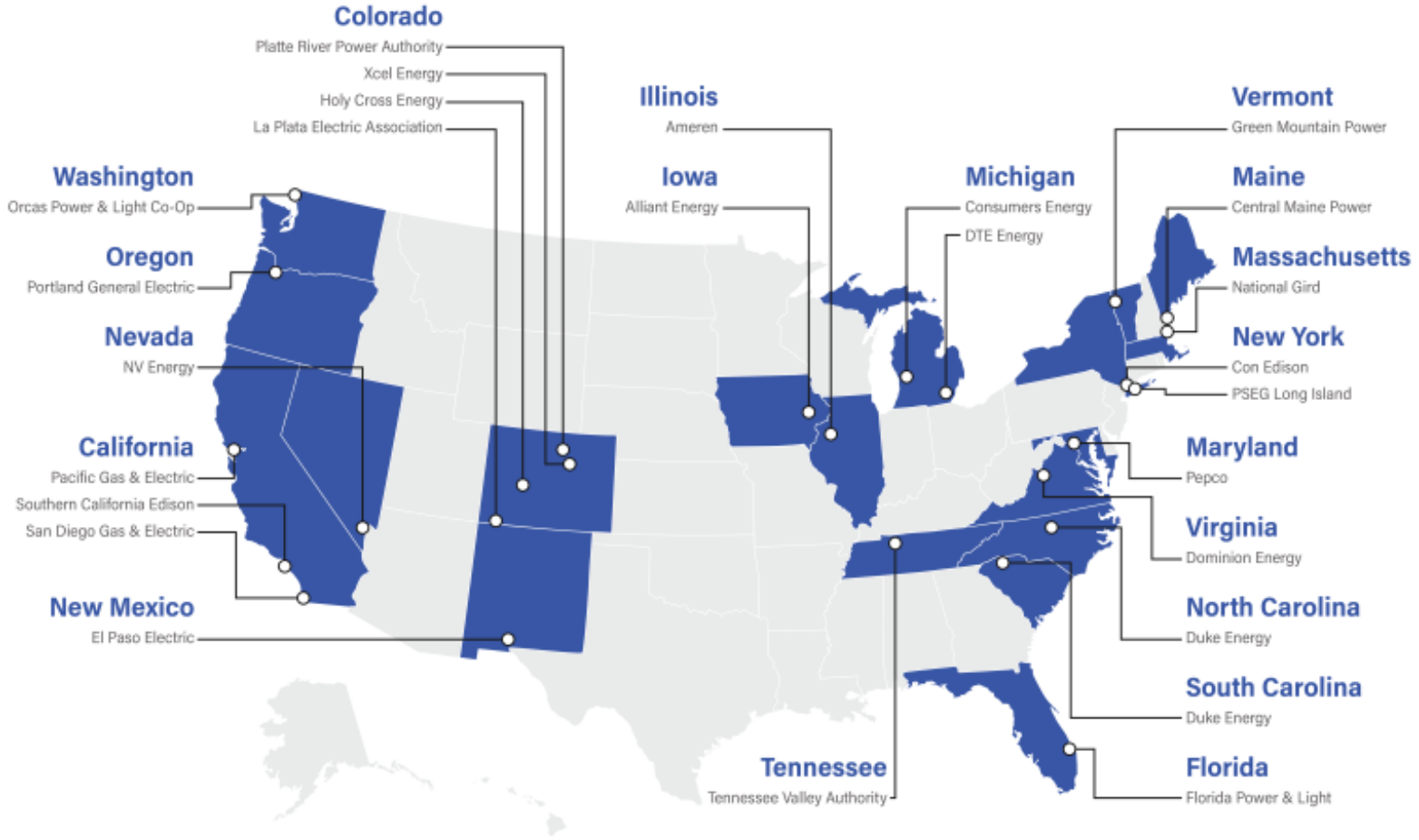
Why Electric School Buses for Bidirectional Charging?

- Due to predictable schedules and alignment with summer evening peaks, electric school buses have been first to implement **grid-parallel** bidirectional charging
- Vehicles and chargers are *generally* interoperable, though implementations may still require addressing unexpected bugs:

Electric School Bus Manufacturers
BlueBird
BYD / RIDE
Thomas Built
IC Bus
MicroBird
Evolectric

Charger	Capacity
Tellus Power Green	20, 30, 40, or 60 kW
InCharge	22, 44, 66 kW
Heliox	44 kW

Bidirectional Electric School Bus Site Map



Source: Authors.

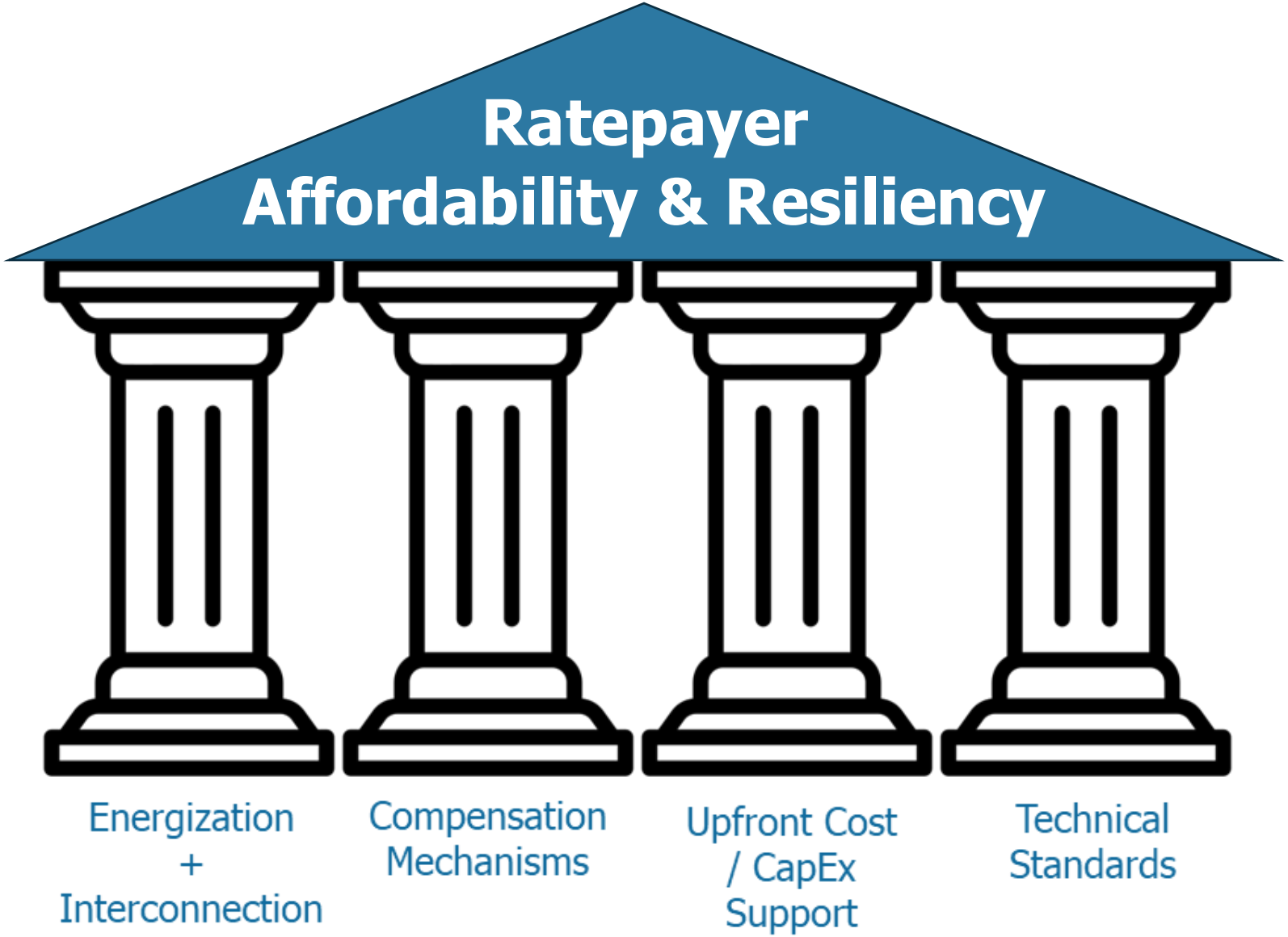
25.04.17

Electric School Bus INITIATIVE

WORLD RESOURCES INSTITUTE

Source: https://pubs.rsc.org/en/content/articlepdf/2022/ya/d2ya00204c
https://www.cleanegroup.org/wp-content/uploads/Fossil-Fuel-End-Game.pdf

VGIC's Four Pillars for Vehicle-Grid Integration at Scale



Importance of Bidirectional Charging Technical Standards

- Bidirectional charging standards and protocols can be generally split into:
  - **Safety and Protection Standards**
  - **Communication Protocols**
- Relevant standards organizations to U.S. market include:
  - Institute of Electrical and Electronic Engineers (IEEE)
  - Underwriters Laboratories (UL)
  - Society of Automotive Engineers (SAE)
  - International Organization for Standardization (ISO)
  - Open Charge Alliance (OCA)
  - OpenADR Alliance

Today's Application of V2G DC Standards

- **Safety & Protection:** UL 1741 SB ensures alignment with IEEE 1547-2018
  - Several states/utilities require UL 1741 SB certification for distributed generation (DG)/distributed energy resource (DER) interconnection
- **Communication Protocols:**
  - **EV-EVSE** implementations of bidirectional power transfer may be**:**
    - Proprietary implementations
    - Proprietary implementations *based on* DIN 70121 or ISO 15118-2
    - Early implementations of ISO 15118-20 Amendment 1
  - **EVSE-"dispatcher":** proprietary integrations, OCPP, and/or OpenADR
    - In practice, many successful V2G "dispatches" to date have been via *email* from the utility to the aggregator managing the EVSE

Interconnection Rules for Bidirectional Charging Systems – Case Studies

Clarifications and minor enhancements to existing DG/DER rules *may* be needed

Maryland
Explicit pathway for both DC and AC equipment

California
Explicit pathway for both DC and AC equipment

New York
Explicit pathway for DC equipment

Massachusetts
Explicit pathway for DC equipment

Connecticut
Explicit pathway for DC equipment

Michigan
Clarity for backup-only systems

Pending: Nevada, Colorado, and Texas

Bidirectional Charging Compensation – Case Studies

New England utilities' Connected Solutions

~$250/kW-yr

Xcel Colorado Aggregator VPP

~$240/kW-yr

CEC Demand Side Grid Support

~$90/kW-yr

CA IOUs Emergency Load Reduction Program

~$60/kW-yr

New York Value of DER Tariff

Location-dependent export credit

Customer Bill Optimization

TOU optimization and/or demand charge management

Pending: Connecticut, Maryland, and Illinois

Bidirectional Charging System Upfront Cost Support – Case Studies

Portland General Electric V2G School Bus
Up to $60,000 / charger

California Zero-Emission School Bus Adder
Up to $95,000 / charger

Massachusetts V2X Demonstration
$6 million in free installations across residential, commercial, and school bus

PG&E V2X Pilots
$2,500 – $5,000 / charger

Section 30C Tax Credit (expires June 2026), Make-Ready Funding, and Equipment Rebates
Without incremental incentives for bidirectional charging systems

Pending: National Grid (Massachusetts)

Who Can Overcome Key Barriers?

- **State Funding:** State energy offices/commissions can help by:
  - Establishing a clear deployment target for bidirectional charging
  - Administering "virtual power plant" programs that leverage EVs as grid assets
  - Offsetting the cost of bidirectional charging equipment (to cover the higher cost relative to traditional chargers)
  - Directly supporting emerging bidirectional charging solution providers and startups
- **Utilities:** Different utilities face different pressures, which can influence their motivations to support or be reluctant toward these solutions
- **Utility Regulators:** The Public Utilities Commissions (PUCs) set the "rules of the road" for regulated utilities, including the utilities' return on investment, fines, and penalties. PUCs can encourage utility engagement in bidirectional charging by:
  - **Directing utilities to (1) compensate bidirectional charging customers for their discharged energy, (2) streamline the connection of bidirectional chargers to the grid, and (3) help pay for bidirectional charging equipment installation**
  - Tie return on investment to bidirectional charging customer deployment or related *performance incentive metrics*
  - Allow utilities to earn a return on initiatives and platforms needed to enable bidirectional charging

Best Practices and Recommendations for Utilities and Regulators

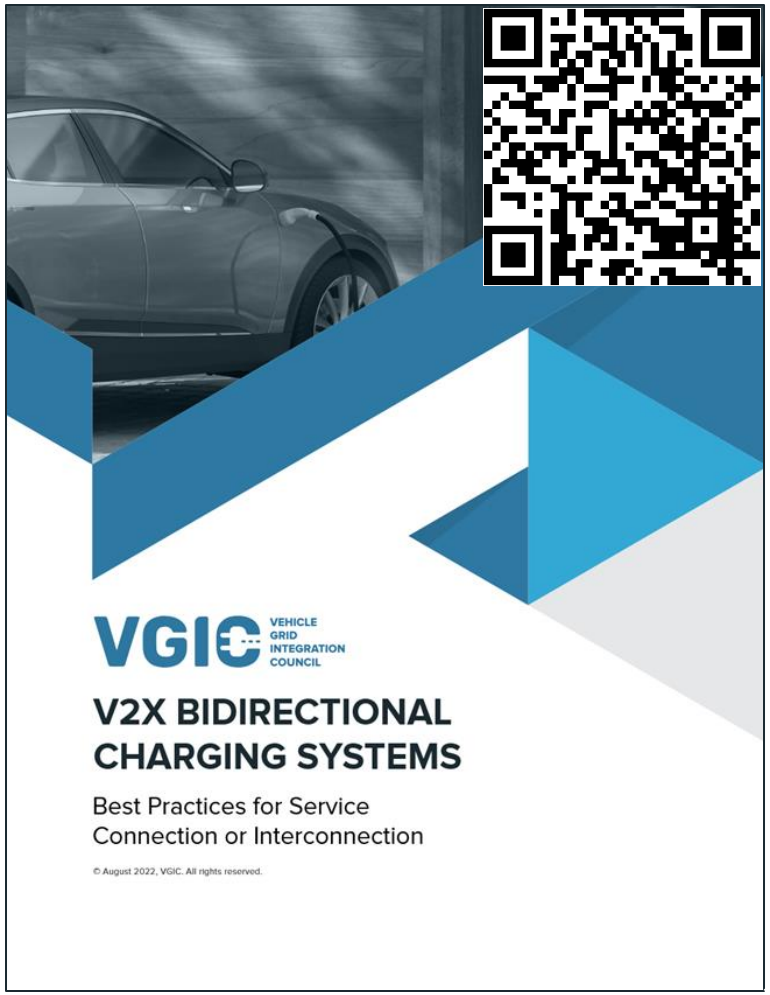
VGI Vision

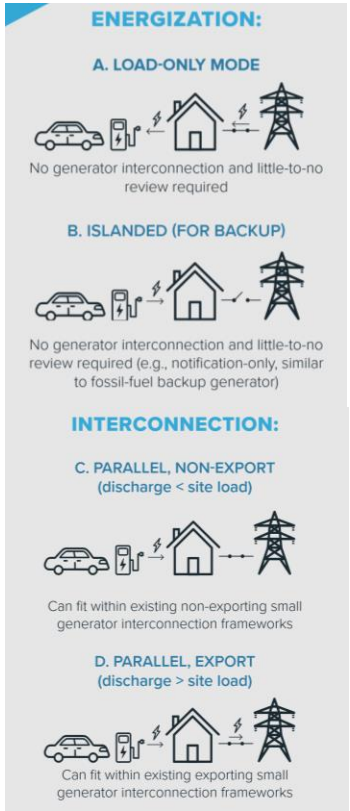
Pilot and Program Design

Customer Engagement and Retention

Vehicle-to-Everything (V2X) Bidirectional Charging Interconnection

Vehicle Telematics and Embedded EV Supply Equipment (EVSE) Submetering





VGIC VEHICLE GRID INTEGRATION COUNCIL

presents

EVOLVE

ACCELERATING VGI

REGISTRATION NOW OPEN!

OCTOBER 6, 2026
PANELS & NETWORKING

OCTOBER 7, 2026
MEMBERS-ONLY MEETING

SF BAY AREA, CA

Thank you!

Vehicle Grid Integration Council (VGIC) is a national 501(c)(6) membership-based trade association committed to advancing the role of electric vehicles and vehicle-grid integration through policy development, education, outreach, and research.

VGIC VEHICLE GRID INTEGRATION COUNCIL

vgicouncil.org

Zach Woogen, Executive Director, VGIC | zwoogen@vgicouncil.org

Appendix

Making V2G Projects "Pencil"

- Common upfront costs that can be incrementally higher for V2G vs V1G (embedded or revealed):
  - Charger dispensers and cables, wall boxes, power cabinets
  - Inverters
  - Utility interconnection application fees
  - System design and engineering costs
  - Customer panel, sub-panel
  - Utility meters, submeters
  - Branch circuits, feeders, relays, conduit
  - Customer payments toward upstream utility-side infrastructure upgrades
  - Trenching and construction labor
  - Permitting and inspection
  - Energy management systems, CT coils/clips, power control system, communications gateway
- Revenue opportunities:
  - Customer peak load reduction for demand charge management and customer bill savings
  - Export compensation mechanisms under utility demand response program, utility export tariff, non-utility program or credits, and/or wholesale market participation

Luke Whittemore, Portland General Electric

Portland General Electric

School Bus Vehicle-to-Grid Demonstration

Luke Whittemore | Lead TE Engineer

CALSTART's Electric School Bus Network Forum | April 2026

PGE's Transportation Electrification Strategy

PLAN

- Improve EV load **forecasts** for bulk system, distribution system, and individual customers
- Identify future grid **constraints**
- Early engagement & **tracking** of planned EV load

SERVE

- **Build** infrastructure to enable EV adoption in a grid-friendly way
- Focus on **underserved** communities
- Grow network of distributed EV charger **resources** to increase flex load potential

MANAGE

- **Manage** charging to connect EV load without T&D upgrades
- Enable EV load **control** via Virtual Power Plant
- Use TE flex load to integrate more **renewables** while maintaining reliability

TE Programs

PGE Electric School Bus Fund

SINCE LAUNCH IN 2020

$20M
Funded

87
Electric School Buses

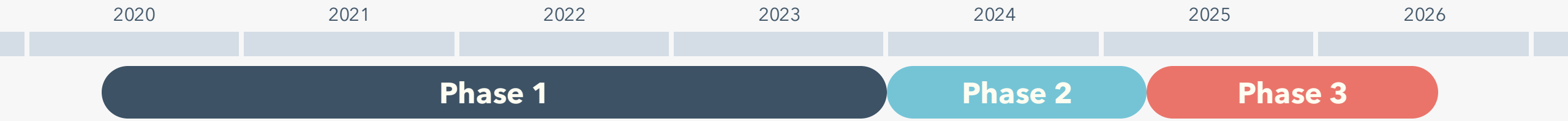
16
School Districts

- Funded by the Oregon Clean Fuels Program
- Annual grant program for school districts and their transportation contractors
- Pays for the incremental cost of electric school buses (up to 3 per school district)
- Also provides optional funding for charging infrastructure
- Benefits underserved communities and supports STEM education programs

School Bus V2G Demonstration Objectives

- **Test** the technology's ability to reliably discharge to the grid during peak events
- Measure impacts to understand potential **grid value**
- Understand **customer** willingness, impacts, and overall experience
- Evaluate how bidirectional charging fits within utility **interconnection process**
- Inform **product roadmap** and program design

School Bus V2G Demonstration: Timeline



Phase 1

Location: Sherwood, OR
1x Blue Bird Bus (Gen1)
60 kW BorgWarner V2G Charger
Nuvve software

- PGE funded V2G-capable bus, charger, and infrastructure
- Installed V2G charger
- Completed interconnection process
- Performed functional test to confirm discharging capability
- Explored potential IEEE 2030.5 integration

Phase 2

Location: Sherwood, OR
1x Blue Bird Bus (Gen2)
60 kW BorgWarner V2G Charger
Nuvve software

- Replaced with Gen2 bus
- Called demand response events during the summer
- Used email and manual processes
- Tested functional reliability
- Collected data on grid benefits
- No V2G compensation

Phase 3 (in progress)

Beaverton
2x BYD/RIDE Buses
2x 60 kW BorgWarner OpConnect

Gresham
3x Blue Bird (Gen3)
3x 44 kW Heliox Ampcontrol

- New locations, bus OEM, charger hardware and software
- Called events during school year
- Automated process using dashboard
- One site is using ISO15118-20
- Testing functional reliability
- Collecting data on grid benefits
- No V2G compensation

Successes

- Strong interest from some early-adopter school bus fleets
- School buses have good availability during utility peak times
  - Not used in the summer
  - Back by 5 or 6 pm on school days
  - Winter mornings on non-school days
- No opt-outs from customers
- Large load reduction potential per participant
- Flexibility on discharge rate vs duration
- Interconnection process uses existing energy storage process
- Success depends on buy-in from all stakeholders:
  - Utility
  - Customer
  - Software Provider
  - Charger Manufacturer
  - Bus OEM

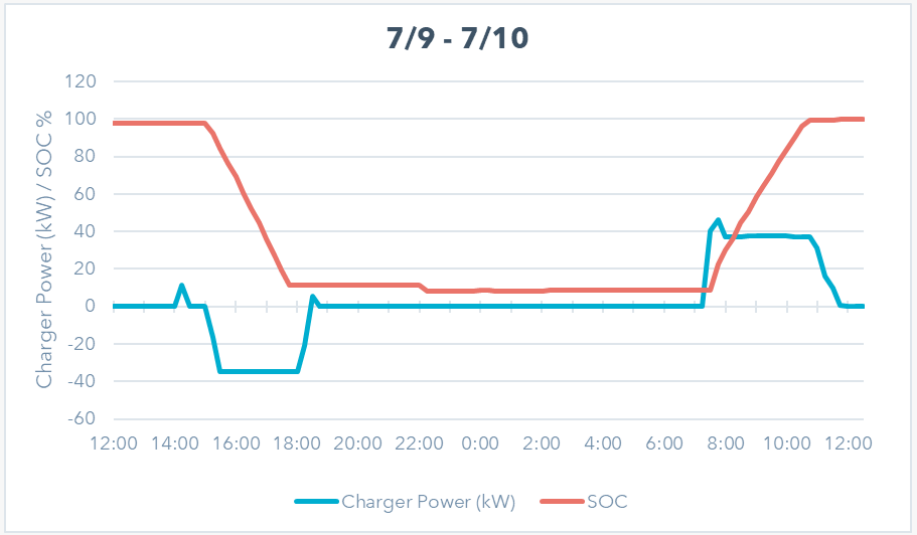
Challenges

Market Challenges

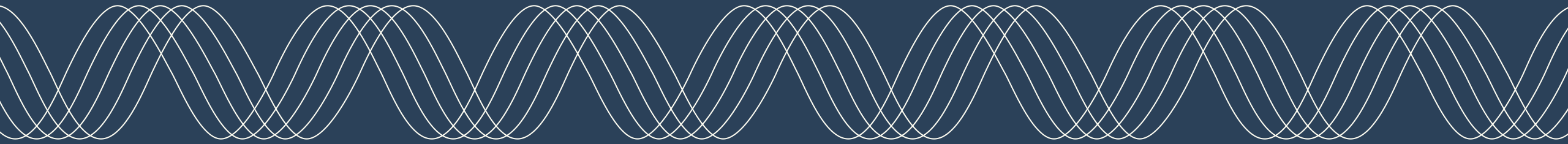
- Very few V2G-capable chargers available in an unstable market
  - BorgWarner announced exit from EV charging business in 2025
- Very limited number of CMS providers with actual V2G experience
- Some school bus OEMs don't have V2G capability even though they advertise that they do
- High upfront cost of V2G chargers/infrastructure (10x Level 2 cost)
- Early V2G capabilities built on proprietary integrations

Technical Challenges

- Not "plug-and-play"; requires many hours of troubleshooting and testing solutions
- Issues following managed charging schedule after discharging ends
- Issues starting discharging when bus is "asleep" after charging complete for many hours



Looking Ahead



Electric School Bus Charging Incentives

Incentives that lower the up-front charger and infrastructure costs while preparing for a flexible and reliable grid

INCENTIVE DETAILS

- **V2G Make-Ready Infrastructure Incentive**
  - Up to **$10,000 per make-ready port**
  - Up to **$300,000 per site**
  - Or up to **100% of actual costs**, whichever is lowest
- **V2G EV Charger Incentive**
  - **90% of actual V2G charger cost**
  - Up to **$50,000 per charger**
  - Up to **$500,000 per site**
- Both can be combined with PGE's Electric School Bus Fund and Fleet Partner programs to help reduce upfront costs.

Webpage link: Electric School Bus Charging Incentives | PGE

V2G CHARGER REQUIREMENTS

- Minimum power rating of 30 kW per port
- UL 1741-SB, ISO15118-20, OCPP 2.1
- Meets all other minimum requirements for PGE qualified chargers, as vetted by EPRI
- Must be paired with PGE-qualified software provider

ELECTRIC SCHOOL BUS NETWORK

Questions and Discussion

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ELECTRIC SCHOOL BUS NETWORK

Thank You for Participating!

- A follow-up email will be sent **Friday, April 10,** with the following:
  - Recording of the meeting
  - Copy of the slide deck
- Keep an eye out for our Charger Preventative Maintenance Best Practices Resource coming soon!
- The next ESB Network Newsletter will be sent on **Tuesday, April 14**
- This is the last ESB Network Forum of the school year.
  - **See you in the fall!**
- Please email schoolbusteam@calstart.org with questions for our team

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www.electricschoolbusnetwork.org

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