Electric School Bus (ESB) Outreach Session: Electric Vehicle Supply Equipment (EVSE)

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Agenda

1. Introductions
2. Presentation of materials (part 1)
3. Break
4. Presentation of materials (part 2)
5. Participant questions

Goals of today's session

- Utility coordination
- Overview of electric vehicle supply equipment (EVSE) and installation
- Costs and financial incentives
- Charging best practices
- Alternative charging technology options
- Successes - case studies

Working with utilities

- Engage your utility **early and often**.
  - Request a site and fleet assessment to determine charging options and power needs.
  - Determine what site or equipment upgrades (if any) are needed.
  - Ask about lead times for equipment purchases and installation.
  - Ask how vehicle charging may impact your monthly electricity bills.
  - Identify funding opportunities, such as utility “make-ready” programs.
    - Make-ready programs are programs offered by utility companies that financially offset a portion of EVSE installation costs.
  - Discuss how your ESB plans could be beneficial to the utility.

Image: https://upload.wikimedia.org/wikipedia/commons/thumb/4/4b/Symbol_lightbulb_2.svg/640px-Symbol_lightbulb_2.svg.png

Charging basics

- ESBs typically have a battery size of 120-250 kWh
- There are 3 kinds of chargers available: Level 1, Level 2, and Level 3, also known as a direct current fast charger (DCFC)

	Level 1	Level 2	Level 3 (DCFC)
Voltage [1]	120 V AC	208 - 240 V AC	480 V – 1,000 V DC
Typical Power Output [2]	1 kW	7 kW - 19 kW	50 - 350 kW

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1. https://www.transportation.gov/rural/ev/toolkit/ev-basics/charging-speeds
2. https://www.transportation.gov/rural/ev/toolkit/ev-basics/charging-speeds

Charging basics

Level 1 and 2 charger head

Level 3 (DCFC) charger head CCS

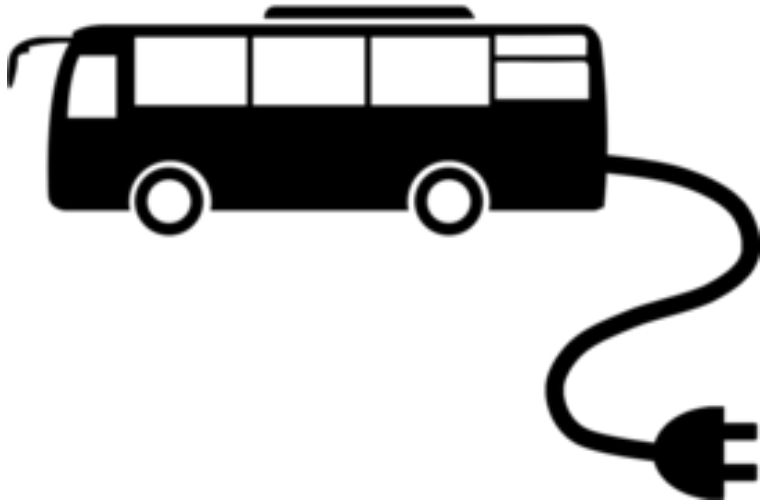
An ESB is capable of receiving electricity from any of the three charger types.

Image: https://www.newark.com/itt-cannon/j2ce3221-25l0a/ev-cable-sae-j1772-plug-free-end/dp/34AK0859?gad_source=1&gclid=EAIaIQobChMI0L-j1vmlhAMVuR6tBh11Mw-_EAQYAiABEgI76fD_BwE&mckv=_dc|pcrid||plid||kword||match||slid||product|34AK0859|pgrid||ptaid||&CMP=KNC-GUSA-GEN-Shopping-PMAX-Med-MARGIN-S43

Image: https://upload.wikimedia.org/wikipedia/commons/thumb/9/9d/Electric_vehicle_charging_station_at_Pippinger_Flur_06.jpg/640px-Electric_vehicle_charging_station_at_Pippinger_Flur_06.jpg

Charging basics

- Networked charging
  - Chargers are connected to the internet and a charging network, also known as “smart” charging.
  - Allows the charger to track energy data (start/stop time, SOC, power draw).
  - Networked charging requires cellular service or wireless/wired connection to the internet.[1]
  - Managed charging considers vehicle charging needs against grid impacts and pricing



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1. https://afdc.energy.gov/fuels/electricity_infrastructure_development.html

Image: https://upload.wikimedia.org/wikipedia/commons/thumb/9/91/Electric_bus_cable_icon.png/640px-Electric_bus_cable_icon.png

Charging basics

- Benefits of networked charging include:[1]
  - Radio-frequency identification (RFID), smart phone or credit card payment, e.g., use at other school's EVSE during athletic event.
  - Track and analyze usage.
  - Expedite customer service.
  - Chargers with Open Charge Point Protocol (OCPP) allow users to switch charging network providers without changing equipment.
- Non-networked charging alternatively allows for charging capabilities without these added services. This may be suitable for smaller fleets without demand charge concerns. Non-networked EVSE may lower up-front equipment costs.

1. https://afdc.energy.gov/fuels/electricity_infrastructure_development.html

Charging basics

- Example manufacturers
  - Chargepoint
  - Clipper Creek
  - Heliox Energy
  - Proterra
  - Flo
  - InCharge
  - Evgo
  - National EV

Charging basics

- EVSE Maintenance
  - Conduct regular preventative maintenance checks
    - Perform visual inspection of chargers and cables
    - Listen for unusual sounds/odors
    - Clean surfaces
  - Follow manufacturer's component replacement schedule
  - More involved charger maintenance is usually provided by the manufacturer / charging service provider.

Untrained staff should not perform maintenance on high voltage systems

Charging basics

- EVSE Warranty Options
  - EVSE manufacturer warranties typically 2-3 years
  - Plan ahead to reduce risk of charger/ESB downtime
  - Extended warranty/service options
    - Manufacturer extended warranty
    - Charge management service provider warranty
    - Maintenance/Reliability-as-a-service contracts
    - Full-service fleet operation contracts

Charger installation

- Key stakeholders
  - Electric utility
  - Superintendent
  - Transportation Director
  - Facilities Director
  - Landowner (if applicable)
  - First responders

- Depending on project complexity and power needs, equipping a facility to charge ESBs can take 1 week to 24 months.[1]
  - Both ends of this estimate are **extremes.**

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1. https://electricschoolbusinitiative.org/12-tips-electric-school-bus-adoption

Charger installation

- Additional considerations for installation include:
  - Type of EVSE – bollard/pedestal vs. wall mount
  - Additional space in layout for EVSE
  - Access to charging ports on ESBs
  - Potential for transformers, new panels

1. Images: https://www.chargepoint.com/businesses/ac-stations/cp6000
2. https://www.chargepoint.com/drivers/home

EVSE costs

Example charger costs[1]

	Dual Port?	Networked?	Cost per Port
Level 1	No	No	$813
	Yes	No	$596
	No	No	$1,182
Level 2	Yes	No	$938
	No	Yes	$3,127
	Yes	Yes	$2,793
Level 3 (DCFC)	No	Yes (50 kW)	$28,401
	No	Yes (150 kW)	$75,000
	No	Yes (350 kW)	$140,000

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1. https://www.epri.com/research/products/000000003002000577

EVSE Infrastructure Costs

Example installation costs per port for L2 chargers[1]

# installed in site	Materials	Labor	Permit	Total
1 Ports	$1,768	$2,329	$103	$3,370
2 Ports	$1,563	$2,595	$84	$3,624
3-5 Ports	$1,685	$2,181	$75	$3,354
6+ Ports	$547	$823	$24	$2,305

1. https://www.epri.com/research/products/000000003002000577

EVSE infrastructure costs

COST ELEMENT	LOWEST COST	HIGHEST COST
Level 2 commercial charger	$2,500 (7.7 kW)	$4,900 (16.8 kW); outlier: $7,210 (14.4 kW)
DCFC (50 kW)	$20,000	$35,800
DCFC (150 kW)	$75,600	$100,000
DCFC (350 kW)	$128,000	$150,000
Transformer (150–300 kVA)	$35,000	$53,000
Transformer (500–750 kVA)	$44,000	$69,600
Transformer (1,000+ kVA)	$66,000	$173,000
Data contracts	$84/year/charger	$240/year/charger
Network contracts	$200/year/charger	$250/year/charger
Cable cost	$1,500	$3,500

Note: DCFC denotes direct-current fast chargers.

RMI – Cost estimates for chargers and associated infrastructure

1. https://rmi.org/wp-content/uploads/2020/01/RMI-EV-Charging-Infrastructure-Costs.pdf

Financial incentives

- Environmental Protection Agency (EPA) Clean School Bus Program[1]
  - Includes rebate and grant programs
  - High-need and rural areas prioritized
  - Infrastructure funding for customer-side (behind the meter) expenses
  - Level 2 EVSE must be Energy Star certified and BABAA-compliant
  - Future proofing expenses allowable/encouraged

1. https://www.epa.gov/cleanschoolbus

Financial incentives

- Environmental Protection Agency (EPA) Clean School Bus Program
  - 2023 rebate program (current round closes February 14, 2023)[1]
    - School districts and contractors are eligible
    - Applications for up to 25 buses
    - Funding per bus varies by bus size and prioritization status
    - Funds are awarded as a lump sum (buses + infrastructure)
    - Funding also available for workforce development

1. https://www.epa.gov/cleanschoolbus/clean-school-bus-program-rebates

Financial incentives

- Environmental Protection Agency (EPA) Clean School Bus Program
  - 2023 grant program (initial round closed Aug 2023)[1]
    - School district sub-program – 15-50 buses/application
    - Third party sub-program – 25 – 100 buses/application; must serve 4+ districts
    - Funding via lump sum.
    - PA school districts have been awarded $47,398,350 in grants for 120 ESBs to date.
  - See Section 1 of CSB Rebate Program Guide for other key differences between the grant and rebate programs.[2]

1. https://electrificationcoalition.org/resource/2023-csb-grant-program/
2. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1018JIT.pdf

Financial incentives – PA rebate winner

- Northern Potter SD in Pennsylvania was able to fund the purchase of their 2 ESBs and chargers using EPA CSB rebate award money.[1]
  - $375,000 was awarded for each bus. This was the maximum award available.
  - $34,445 was used for two Level 3 (DCFC) chargers out of the total infrastructure award ($40,000).

1. Personal communication, World Resources Institute Electric School Bus Initiative, 2024

Financial incentives

- Make-Ready Funding
  - Duquesne Light Company offers a Fleet Charging Program covering costs associated with design, building, and maintenance of EVSE infrastructure from the power grid to the charging station.[1]
  - PECO Energy Company offers a Public Benefit Charging Program which includes up to 50% of the project's installation, equipment, and make-ready work costs, or $60,000 max funding per project. The program also offers funding on a per-port basis.[2]
    - Other eligible costs include customer-side electric service upgrades, service panels, electrical cabinets, junction boxes, and conduit.

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1. https://www.duquesnelight.com/docs/default-source/default-document-library/fleet_programguide_final.pdf
2. http://peco.com/ev

Financial incentives – utility providers in PA

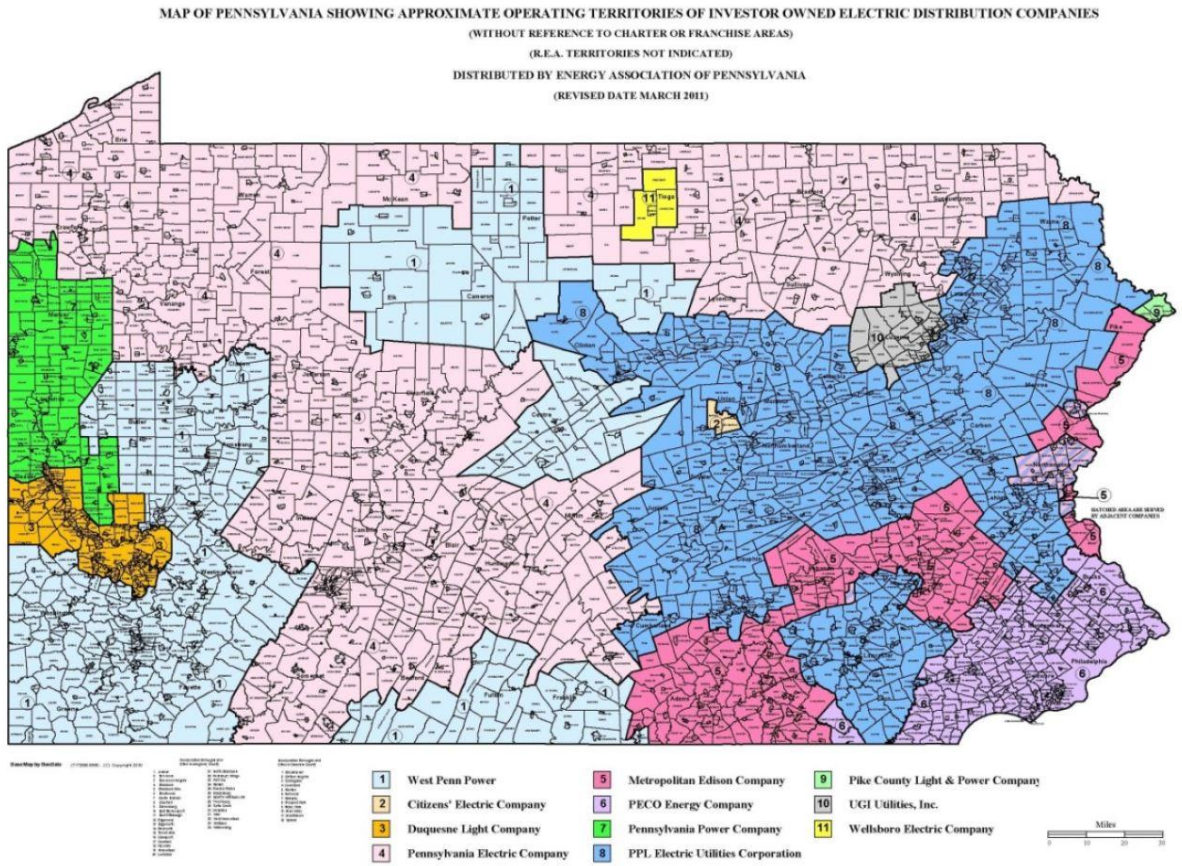

Image: https://www.alphathree.com/news/alpha-3-contributes-2022-pa-infrastructure-report-card

Financial incentives

- EPA Diesel Emissions Reduction Act (DERA) Funding[1]
  - Program targets diesel engines operating in areas not in attainment of national ambient air quality standards.[2]
  - The DERA program will provide funding for one charger per ESB.[3]
    - Eligible costs - charger purchase and installation, pedestal, mount, and charging cable
  - As of 2017, matching funding for eligible DERA projects can be provided through the Pennsylvania Environmental Mitigation Trust Agreement (aka the VW settlement).[4]

1. https://www.epa.gov/dera
2. https://epa.maps.arcgis.com/apps/MapSeries/index.html?appid=8fbf9bde204944eeb422eb3ae9fde765
3. https://www.epa.gov/grants/2022-2023-diesel-emissions-reduction-act-dera-national-grants-closed-announcement-fy-23
4. https://www.dep.pa.gov/Business/Air/Volkswagen/pages/environmental-mitigation-trust-agreement.aspx

Financial incentives

- EPA Clean Heavy-Duty Vehicle Program[1]
  - $1 billion available from 2024-2031. $400 million for nonattainment areas.
  - Will replace current heavy-duty trucks and buses, including school buses, with clean and zero-emission options.
  - Includes funding for chargers and associated infrastructure.
  - Notice of funding opportunity expected this spring.

1. https://www.epa.gov/inflation-reduction-act/clean-heavy-duty-vehicle-program

Financial incentives

- State of Pennsylvania (DEP) funding:
  - PA Alternative Fuels Incentive Grants (AFIG) Program [1]
    - $5 million/year funding for alternative fuels limited to $300,000 per applicant; prioritizes zero-emission transportation projects.
    - Covers vehicle replacement, infrastructure, training, deployment, and vehicle retrofits.
    - To reopen spring of 2024.
  - Driving PA Forward Grant and Rebate Program [2]
    - Includes the PA State Clean Diesel Grant Program which provides a total of $9 million in funding for projects that reduce diesel emissions, and the On-Road Rebate Program which provides a total of $52 million in funding that can be applied towards ESBs.

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1. https://www.dep.pa.gov/Citizens/GrantsLoansRebates/Alternative-Fuels-Incentive-Grant/Pages/default.aspx
2. https://storymaps.arcgis.com/stories/6f5db16b8399488a8ef2567e1affa1e2

Financial incentives

- IRS tax credit program
  - Alternative Fuel Vehicle Refueling Property Credit (30C): Provides up to $100,000 “per charging unit” to schools in qualifying low-income and non-urban areas.[1]

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1. https://electricschoolbusinitiative.org/statement-irs-releases-guidance-tax-credit-electric-vehicle-and-electric-school-bus-charging
Image: https://upload.wikimedia.org/wikipedia/commons/thumb/c/cd/Electric_vehicle_charging_station_at_Pippinger_Flur_01.jpg/640px-Electric_vehicle_charging_station_at_Pippinger_Flur_01.jpg

Charging best practices

- Minimize charging ESBs during peak demand hours (8am-9pm) to avoid higher electricity pricing and demand charges.
  - Demand charges incurred due to charging during peak hours can account for up to 90% of a facility's energy bill when using Level 3, or up to 75% for Level 2 charging.[1]

- Charging ESBs up to 80% SOC and minimizing the time below 20% promotes long-term battery health and life.[2]

1. https://doi.org/10.1016/j.epsr.2020.106694
2. https://electricschoolbusinitiative.org/how-electric-school-bus-owners-can-maximize-battery-performance-limiting-aging

Smart charging

- Charge management software can schedule when charging begins and ends for buses plugged into chargers.
- Allows for remote control of charging without staff on the premises.
- Districts can take advantage of cheaper energy rates and avoid peak demand charges.

Image: https://upload.wikimedia.org/wikipedia/commons/thumb/d/d2/Pictograms-Electric_vehicle_charging_service.svg/640px-Pictograms-Electric_vehicle_charging_service.svg.png

Charging technology options

- Non-permanent charging[1]
  - Movable charging units are available.
  - These units can be brought to a site and then moved later.
  - These can serve as a temporary strategy for EVSE if necessary due to construction delays or other factors. Permanent installation will lower TCO.

1. https://bppulsefleet.com/fleet/products/non-permanent-and-mobile-charging/

Image: https://bppulsefleet.com/fleet/products/non-permanent-and-mobile-charging/

Charging technology options

1. https://www.pairedpower.com/

Image: https://www.pairedpower.com/

Charging technology options

1. https://beamforall.com/product/ev-arc-2020/

Image: https://beamforall.com/product/ev-arc-2020/

Charging technology options

- Future Considerations: V2X
  - V2X refers to the capacity of vehicles to serve as a power source.
  - Some options include selling energy back to the grid at peak demand hours and connecting to buildings to provide electricity during power outages.
  - The EVSE and the bus must both be V2X capable (bi-directional).

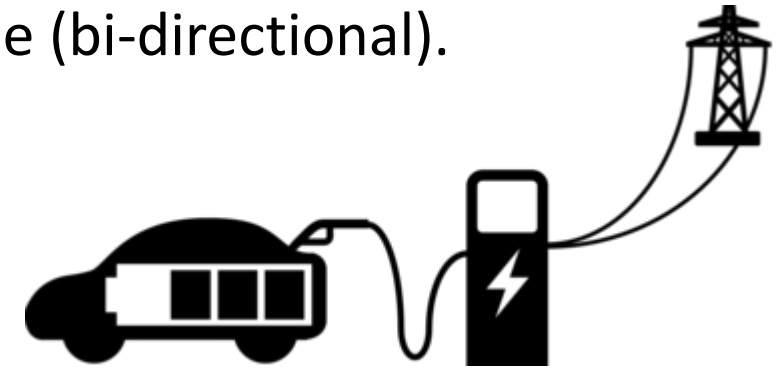

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Image: https://upload.wikimedia.org/wikipedia/commons/thumb/1/1c/Electric_car_as_storage_battery_for_electricity_grid_-_Vehicle-to-grid_-_V2G_icon.png/640px-Electric_car_as_storage_battery_for_electricity_grid_-_Vehicle-to-grid_-_V2G_icon.png

Charging technology options

- Integrating distributed energy resources (DER)
  - Electricity from solar canopies or other on-site power generating units can charge ESB batteries.
  - Reduces utility bills.
  - Reduces reliance on the grid during power outages.
  - Through V2X and V2G technology, power generated on-site and stored in ESBs can be sold back to the grid during peak demand periods.

Case Study #1

- Fairfax County Public Schools[1]
  - Dominion Energy helped school districts procure 50 ESBs and EVSE infrastructure.
  - Provided technical support, covered incremental bus costs, and funded installation.
  - Dominion also maintains the charging infrastructure.
  - In return, the utility owns the bus batteries and the propulsion system. Hopes to take advantage of V2G capabilities in the future.

1. https://electricschoolbusinitiative.org/electric-school-bus-series-electrifying-partnership-fairfax-county-virginia

Case Study #2

- Cajon Valley Union School District[1]
  - The district is piloting vehicle to grid technology.
  - Current ESBs can send 24-45 kW to the grid.
  - Use managed charging to charge during off-peak hours.
  - Eligible for their utility's Emergency Load Reduction Program (ELRP) which pays $2/kWh for energy sent to the grid or reduced energy use during emergency situations between May and October.

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1. https://electricschoolbusinitiative.org/electric-school-bus-series-powering-grid-cajon-valley-union-school-district
Image: https://electricschoolbusinitiative.org/electric-school-bus-series-powering-grid-cajon-valley-union-school-district

References

- Bppulse: Inrush – More information on a provider of mobile charging units.
- Department of Energy Alternative Fuels Data Center: ESB Education – A video series focused on everything ESBs including cost factors and vehicle requirements.
- Duquesne Light Company: Fleet Charging Program – Make-ready funding from Duquesne Light Company.
- Environmental Protection Agency: DERA Program – An overview of EPA's DERA program.
- Environmental Protection Agency: Clean Heavy Duty Vehicle Program – An overview of EPA's clean heavy duty vehicle program.
- Environmental Protection Agency: Clean School Bus Program – An overview of EPA's clean school bus program.
- PECO Energy Company: Public Charging Program – Make-ready funding from PECO energy company.

References

- Pennsylvania Department of Environmental Protection: Alternative Fuels Incentives Grants – Information on one of Pennsylvania's clean vehicle grants.
- Pennsylvania Department of Environmental Protection: Driving PA Forward – Information on one of Pennsylvania's clean vehicle grants.
- World Resources Institute Electric School Bus Initiative: An Electrifying Partnership in Fairfax County, Virginia – Fairfax County's experience utilizing utility provider funds.
- World Resources Institute Electric School Bus Initiative: IRS Tax Credits – A summary of the available IRS charging credits.
- World Resources Institute Electric School Bus Initiative: How Electric School Bus Owners Can Maximize Battery Performance by Limiting Aging – A resource for maintain good battery health.
- World Resources Institute Electric School Bus Initiative: Powering the Grid with Cajon Valley Union School District – Cajon Valley's pilot program for vehicle to grid.

Thank you for attending

Please fill out our bus operator survey
https://erg.qualtrics.com/jfe/form/SV_1TSWbJ9oxxD0EBM

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