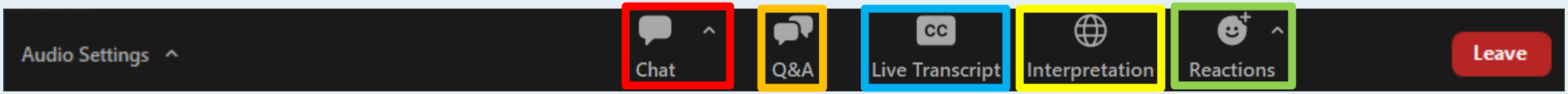
EPA CLEAN SCHOOL BUS

2023 CSB Rebates: Fleet Planning and Route Analysis w/ Joint Office of Energy and Transportation (JOET)
November 2, 2023 @ 1 PM ET

Office of Transportation and Air Quality
U.S. Environmental Protection Agency

Zoom Webinar Logistics



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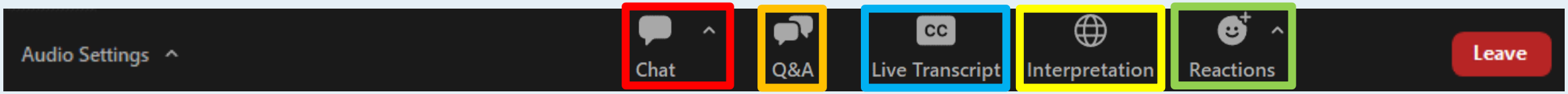

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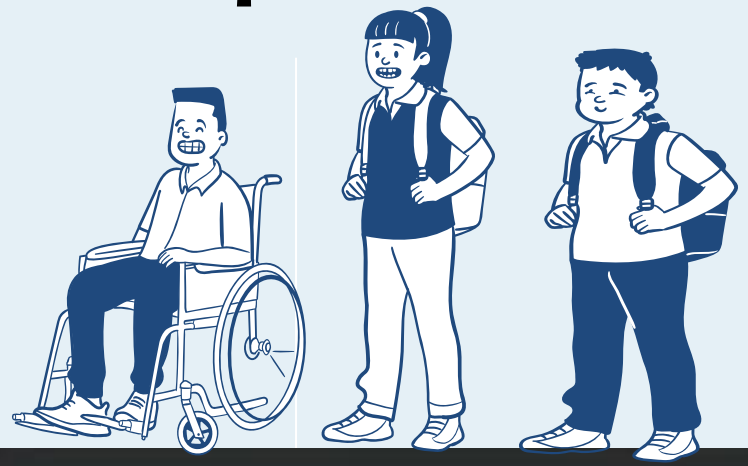

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AGENDA

Overview of the Clean School Bus (CSB) Program

2023 CSB Rebate Program Overview

Fleet Planning & Route Analysis w/ JOET

Q&A

Next Steps and Resources

Overview of the Clean School Bus Program

Bipartisan Infrastructure Law

- Under **Title XI: Clean School Buses and Ferries**, the Bipartisan Infrastructure Law (BIL) provides **$5 billion** over five years (FY22-26) for the replacement of existing school buses with zero-emission and clean school buses.

CSB Funding Opportunities

- EPA has offered rebates and grants in past funding opportunities.
- EPA is offering another round of rebate funding.
- The 2023 Rebates is the third CSB funding opportunity.

EPA

EPA CLEAN SCHOOL BUS

Why Clean School Buses?

Reduced Greenhouse Gas Emissions
CSBs emit zero or low tailpipe emissions.

Cleaner Air
CSBs result in cleaner air on the bus, in bus loading areas, and in the communities in which they operate.

Cost Savings
Replacing older diesel school buses with CSBs often reduces maintenance and fuel costs.

Resiliency
Vehicle-to-Grid (V2G) capable CSBs can provide power to the grid or buildings during power shutdowns.

Improved Student Attendance & Achievement
The transport of students with CSBs has been linked to student attendance and academic achievement improvements.

2023 CSB Rebate Program Overview

EPA is offering at least **$500 million** for clean school buses and ZE school buses. EPA may modify this amount based on the applicant pool and other pertinent factors. Funds are subject to availability and total awards may be higher or lower than the anticipated funds offered update if changed.

Eligible activities include the **replacement of existing internal-combustion engine (ICE) school buses with electric, propane, or compressed natural gas (CNG) school buses**, as well as the purchase and installation of **electric vehicle supply equipment (EVSE) infrastructure**.

EPA is prioritizing applications that will replace buses serving **high-need local education agencies, Tribal school districts funded by the Bureau of Indian Affairs or those receiving basic support payments for students living on Tribal land, and rural areas.** EPA is committed to ensuring the CSB Program delivers on the Justice40 Initiative.

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Application packages must be submitted to EPA no later than 1/31/24 at 4:00 p.m. ET.

For more information, please visit *www.epa.gov/cleanschoolbus.*

EPA CLEAN SCHOOL BUS

CSB Funding per Replacement Bus

School District Prioritization Status	Replacement Bus Fuel Type and Size					
	ZE – Class 7+*	ZE – Class 3-6*	CNG– Class 7+	CNG – Class 3-6	Propane – Class 7+	Propane – Class 3-6
Buses serving school districts that meet one or more prioritization criteria	Up to $345,000 (Bus + Charging Infrastructure)	Up to $265,000 (Bus + Charging Infrastructure)	Up to $45,000	Up to $30,000	Up to $35,000	Up to $30,000
Buses serving school districts that are not prioritized	Up to $200,000 (Bus + Charging Infrastructure)	Up to $145,000 (Bus + Charging Infrastructure)	Up to $30,000	Up to $20,000	Up to $25,000	Up to $20,000

**Funding levels include combined bus and EV charging infrastructure. Recipients have flexibility to determine the split between funding for the bus itself and the supporting infrastructure.*

ADA-Compliant Buses:
Applicants can request up to an **additional $20k** to purchase ADA-compliant clean school buses of any fuel type equipped with wheelchair lifts.

High Shipping Costs:
Applicants in non-contiguous U.S. states and territories will receive up to an **additional $20k** per bus to cover high bus shipping costs.

Tax Credits:
Selectees may be eligible for IRA tax credits applicable to their bus and infrastructure purchase(s) not reflected in the funding table.

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***For more information, please visit** www.epa.gov/cleanschoolbus.*

Infrastructure Funding Restrictions

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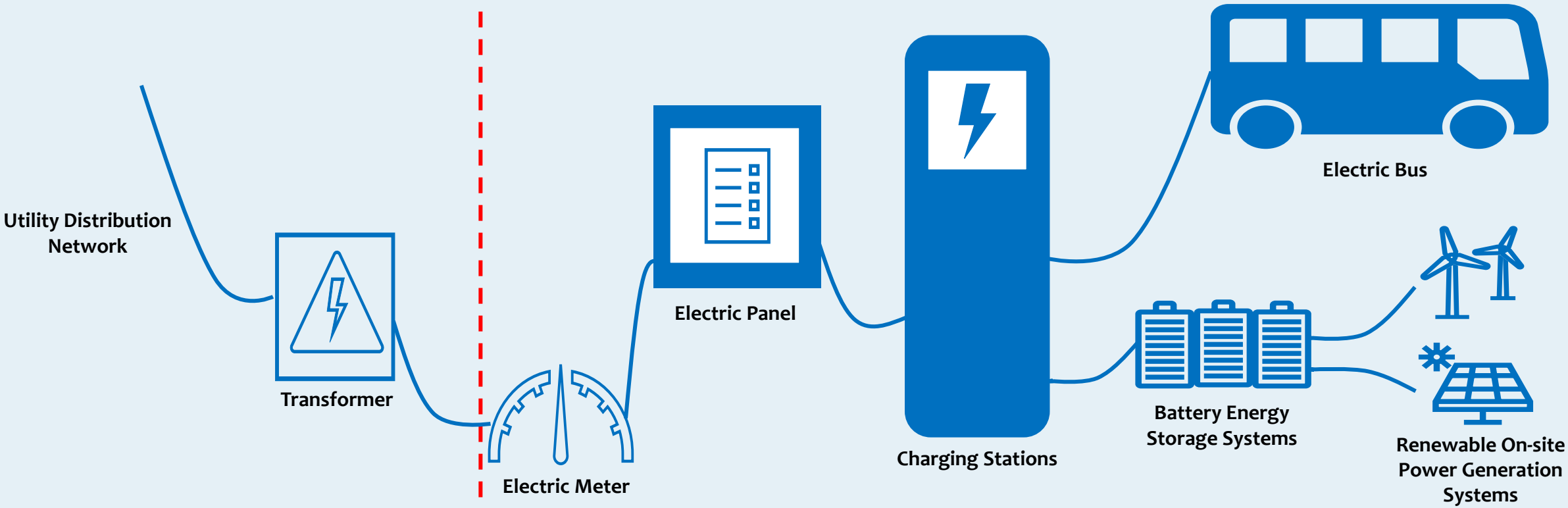
Non-Eligible Expenses

Eligible Expenses



Front-of-the-Meter (FTM)

Behind-the-Meter (BTM)

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CSB Program Website Tools and Resources

Technical Assistance

- Clean School Bus Technical Assistance
- Charging and Fueling Infrastructure Resources

Workforce Development

- Bus Manufacturer Job Quality and Workforce Development Practices
- Workforce Development and Training Resources

Educational Materials

- Clean School Bus Reports to Congress
- Benefits of Clean School Buses

All links can be found on: *epa.gov/cleanschoolbus*

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EPA Utility Engagement Pledge

A primary barrier school districts are facing is uncertainty around charging infrastructure deployment and how to engage with electric companies

- **Installation of charging infrastructure can undergo long lead times and requires close coordination with the local utility**

EPA is working with national electric utility company organizations to support school districts through a Utility Pledge that includes:

- **Facilitating Communication Between Electric Providers and School Districts**
- **Providing Technical Support and Assistance**
- **Increasing Funding and Deployment**

Additional information on the Utility Pledge and other technical assistance resources are available on: epa.gov/cleanschoolbus technical assistance

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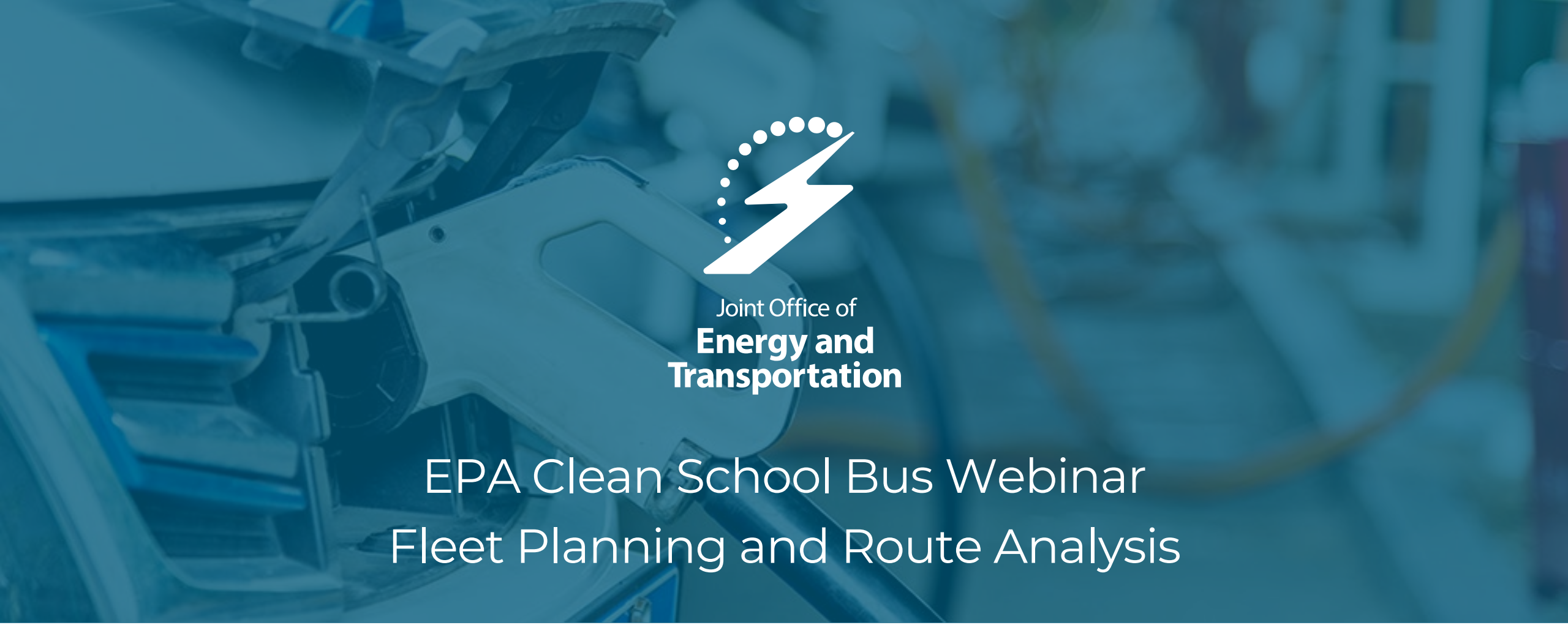


Joint Office of
Energy and
Transportation

EPA Clean School Bus Webinar
Fleet Planning and Route Analysis

Nov. 2, 2023

driveelectric.gov

Welcome!

The National Renewable Energy Laboratory (NREL) and the Joint Office of Energy and Transportation (Joint Office) are partnering with the U.S. Environmental Protection Agency (EPA) to offer clean school bus technical assistance to school districts.

CleanSchoolBusTA@nrel.gov

- Electric School Bus (ESB) Fleet Planning

Power (kW)

- Kilowatts (kW)
- Charging station ratings

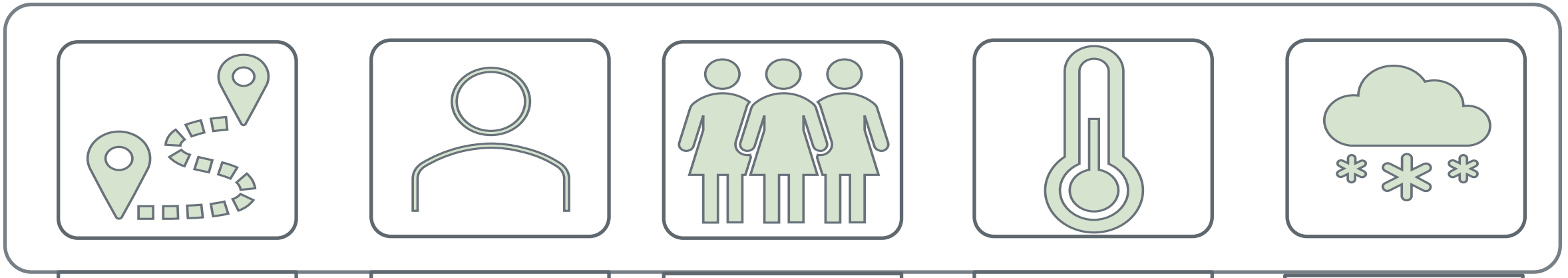
Energy

- Kilowatt hours (kWh)
- Battery size
  - Route energy usage
  - Charge needed

Battery Size (kWh)

- ESB battery sizes range from under 100 kWh to over 300 kWh
- Larger batteries = longer range
- Some ESB models offer multiple battery sizes

Bus Range



Duty Cycle

- Traffic, average speed, number of stops, terrain

Driver Style

- Aggressive drivers will lower range

Bus Loading

- More weight/ riders = less range

Ambient Temp.

- HVAC affects efficiency

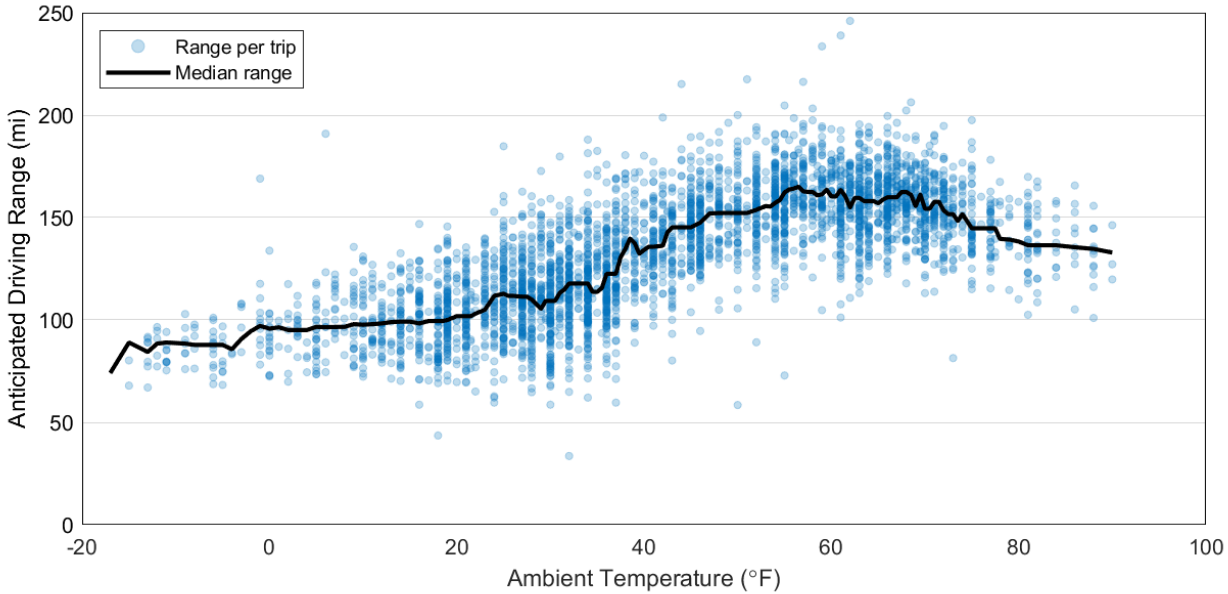
Adverse Weather Conditions

- Snow and rain

Real World Cold Weather Examples: ESB and Battery Electric Bus (BEB) Fleets

Duluth Transit Authority – Duluth, MN

- 2019-2021 study saw a range decrease of approximately 33% for a temperature decrease of 30°F. (https://www.nrel.gov/docs/fy22osti/83038.pdf)
- BEBs are approximately 3x as energy efficient as the diesel fleet.
- BEBs utilize auxiliary cabin heaters in colder weather.



Tok Transportation – Tok, AK

- Has operated one Type C ESB since 2020 with only electric heat.
- Successfully completing routes under -35° F.
- Experiences an efficiency decrease of 20%-25% for every temperature decrease of 30°F, which maxes out around 55% efficiency decrease at negative 10-20°F.
- Bus is stored and charged inside.

- ESB Range Impacts

- Best Case
  - 60-70°F day
  - Little/no HVAC usage
  - Perform pre-trip while charging
  - Efficient regenerative braking capture (20%-30%)
  - These days you can experience at or within 10%-15% of OEM rated efficiency

- Worst Case
  - Extreme cold/heat
  - Forget to pre-condition while charging
  - Traffic/long stops
  - Poor regenerative braking/aggressive driving
  - These days MAY cause range to be reduced by 50%-60%

How to Maximize Range in ESBs

- Train your drivers on good habits
- Pre-condition the bus prior to each route while plugged in
- Consider indoor storage and charging
- Turn off cabin heat when students exit
- Monitor telematics to identify inefficiencies
- Minimize door opening times
- Consider auxiliary heaters in extreme cold

Bus Efficiency (kWh/mile)

- Efficiency = battery size ÷ range
- More efficient bus = lower efficiency number

OEM Rated Efficiencies

Type	Make/Model	Battery Size	Range	Efficiency
A	Bluebird Microbird G5	88	100	0.88
A	BYD Type A	141	105	1.34
A	Collins Type A	125	130	0.96
A	Greenpower Nano Beast	118	140	0.84
A	LionA (80 kWh)	80	75	1.07
A	LionA (160 kWh)	160	150	1.07
C	Bluebird Vision Electric	155	120	1.29
C	IC Bus Electric CE	315	200	1.58
C	LionC (126 kWh)	126	100	1.26
C	LionC (168 kWh)	168	125	1.34
C	LionC (210 kWh)	210	155	1.35
C	Thomas C2 Jouley	226	138	1.64

Range/Efficiency Impacts

- Battery Size: 150 kWh
- OEM Rated Range: 100 miles
- OEM Rated Efficiency:
  - 150 kWh/100 miles = 1.5 kWh/mile
- 20% Less Range:
  - 150 kWh/80 miles = 1.875 kWh/mile
- 50% Less Range:
  - 150 kWh/50 miles = 3.0 kWh/mile

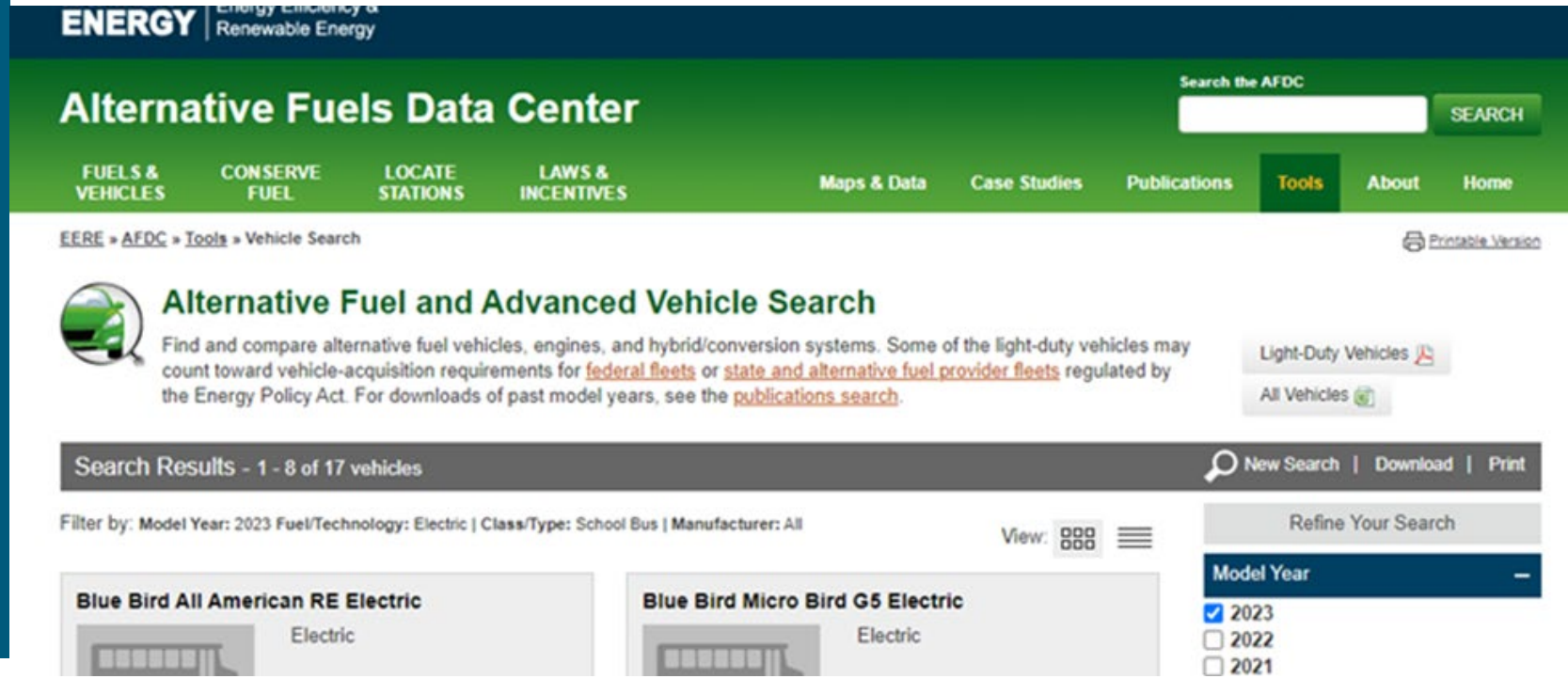
Route Analysis Step 1:

- Understand your bus efficiency (kWh/mile) in worst case scenario

ESB Resources

- AFDC Vehicle Search Tool
- School Transportation News Buyer's Guide
- CALSTART ZETI Tool

1. Consult with your OEM/dealer.
2. Consult with local ESB fleets.
3. Reach out to cleanschoolbusTA@nrel.gov.



Bus Efficiency Example

1. OEM has seen buses in region with your specs up to 2.1 kWh/mile.

2. Local ESB fleet has seen a max of 30% range/efficiency reduction in their similar buses.
   - 150kWh ÷ 70 miles = 2.14 kWh/mile

3. NREL/Joint Office calculates 2.3 kWh/mile.

Route Analysis Step 2:

- Determine your Route Energy Usage (kWh)

Route Energy Usage (kWh) =
Bus Efficiency (kWh/mile) x Route Distance (miles)

- Bus Efficiency 2.3 kWh/Mile
- 25-mile morning route/25-mile afternoon route

  - Mid-Day Charging
    - 2.3 kWh/mile x 25 miles = 57.5 kWh
  - No Mid-Day Charging
    - 2.3 kWh/mile x 50 miles = 115 kWh

- Why Mid-Day Charging?
  - Can reduce battery size needed
  - Can reduce charger size needed
  - Can enable longer routes
- Why Not?
  - If you are subject to prohibitive time-of-use rates or demand charges

Route Analysis Step 3:

- Determine if your bus battery size meets your requirements

- Consider battery degradation
  - All batteries will lose capacity over time
  - Most batteries are now warrantied to 80% for 8-12 years

- Consider minimum State-of-Charge (SOC)
  - Give drivers extra confidence on range
  - Build in a buffer

Battery Size (kWh) x (Degradation % - Minimum SOC %) = Usable Battery Capacity

150 kWh x (.8 - .1) = 105 kWh

- Mid-Day Charging = 57.5 kWh route energy

- No Mid-Day Charging = 115 kWh route energy

Route Analysis Step 4:

- Determine your Power (kW) Needs

Charger Power Needed (kW) =
Route Energy Usage (kWh) ÷ Charging Time (hours)

- Example Charge Times
  - Mid-Day: 9 a.m. return/1 p.m. depart = 4 hours
  - Evening: 4 p.m. return/6 a.m. depart = 14 hours

- Charge battery to 100% during mid-day:
  - 57.5 kWh ÷ 4 hours = 14.4 kW

- Charge battery to 100% during evening:
  - 57.5 kWh ÷ 14 hours = 4.1 kW

- Additional Considerations:
  - Not all ESBs are compatible with Level 2 AC charging.
  - BTMS will use charger power to maintain battery temperature on cold days (≈5-10kW), consult OEM.

Charger Selection

	Level 2 AC	DC Fast Charger (DCFC)
Power Levels	3-19 kW	15-350+ kW
Facility power	Single or 3-phase	Typically requires 3-phase power
Cost	$-$$	$$$-$$$$
Applicability	Lower power, longer durations *should be sufficient for most bus routes	Quick top offs and longer routes that require mid-day charging
Bus compatibility	AC charging not available on certain ESB models	DCFC is compatible on all current ESB OEM offerings
CSB requirements	Energy Star Certified required	NRTL Listing recommended
Grid impact	Less infrastructure required	More infrastructure required

Determine Optimal Charging Power Level

	Variable	Formula					
A1	Charger Power Level (kW)		6.2	6.3	6.4	6.5	6.6
A2	Battery Size (kWh)		150	150	150	150	150
A3	Range (Miles)		100	100	100	100	100
A4	Route Energy (kWh)		57.5	57.5	57.5	57.5	57.5
A5	Mid-Day Charge Time		4	4	4	4	4
A6	Evening Charge Time		14	14	14	14	14
A7	Battery After Morning Route (kWh)	A2-A4	92.5	92.5	92.5	92.5	92.5
A8	Battery Before Afternoon Route (kWh)	A1*A6+A5	117.3	117.7	118.1	118.5	118.9
A9	Battery After Afternoon Route (kWh)	A7-A4	59.8	60.2	60.6	61	61.4
A10	Battery After Evening Charge (kWh)	A1*A8+A9	146.6	148.4	150.2	152	153.8

- Additional Considerations:
  - Not all ESBs are compatible with Level 2 AC charging.
  - BTMS will use charger power to maintain battery temperature on cold days (≈5-10kW), consult OEM.

NREL/Joint Office ESB Route Analysis Tool

The Electric School Bus (ESB) Route Analysis Tool is a spreadsheet tool designed to assist school bus fleets in determining the bus energy usage and charger power needs for their unique routes.

Lowest Expected Temperature (°F):	30°+	*See NCEI Climate at a Glance for local temperatures:	https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/county/time-series

Bus Info		**Route Info**							**User Selections**		**Energy/Power Results**		**Charger Selection**	
Bus Type	**ESB Make/Model**	**Route #**	**Morning Route Distance (miles)**	**Morning Depart Time**	**Morning Return Time**	**Afternoon Route Distance (miles)**	**Afternoon Depart Time**	**Afternoon Return Time**	**Cabin Heater**	**Mid-Day Charging**	**Max Energy Used (kWh)**	**Estimated Minimum Charger Power Level (kW)**	**Charger Size (kW)**	**Expected Minimum SOC (%)**
TypeC	IC Bus Electric CE (315 kWh)	1	50	6:30 AM	8:30 AM	60	12:30 PM	4:30 PM	Electric	Yes	157.5	20.3	20.0	11%
TypeC	LionC (210 kWh)	2	30	6:30 AM	8:30 AM	40	12:30 PM	4:30 PM	Electric	Yes	90.3	13.3	19.2	48%
TypeC	Bluebird Vision Electric	3	35	6:30 AM	8:30 AM	40	12:30 PM	4:30 PM	Electric	Yes	86.1	15.2	19.2	20%
TypeC	BYD Type C	4	20	6:30 AM	8:30 AM	40	12:30 PM	4:30 PM	Electric	Yes	109.9	13.8	19.2	58%

cleanschoolbusTA@nrel.gov https://www.epa.gov/cleanschoolbus/clean-school-bus-technical-assistance

ESB Route Analysis Tool – Main Inputs

- Risk Factor (Low/Medium/High)
  - Efficiency loss from driving and other factors
  - Default – High Risk

Risk Factor:	High Risk

- Battery Degradation Level (%)
  - Expected % of original battery capacity expected at the end-of-life
  - Default – 80%, *Typical battery warranties cover 80% of original capacity

Battery Degradation Level (%):	80%

- Minimum State-of-Charge (%)
  - The lowest % capacity that the battery should experience on each route
  - Default – 10%

Minimum State-of-Charge (%):	10%

- Temperature (°F)
  - Drop down selection
  - Select the lowest expected temperature

Lowest Expected Temperature (°F):	30°+	*See NCEI Climate at a Glance for local temperatures:	https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/county/time-series

ESB Route Analysis Tool – Route Specific Inputs

- Bus Info
  - Class and Make/Model
  - Drop down selections

- Route Info
  - Route #
  - Mileage and dwell times
  - Unique entries

- User Selections
  - Heater type
  - Mid-day Charging Options

Bus Info		Route Info							User Selections		Energy/Power Results		Charger Selection	
Bus Type	ESB Make/Model	Route #	Morning Route Distance (miles)	Morning Depart Time	Morning Return Time	Afternoon Route Distance (miles)	Afternoon Depart Time	Afternoon Return Time	Cabin Heater	Mid-Day Charging	Max Energy Used (kWh)	Estimated Minimum Charger Power Level (kW)	Charger Size (kW)	Expected Minimum SOC (%)
TypeC	IC Bus Electric CE (315 kWh)	1	50	6:11 AM	9:30 AM	45	1:57 PM	4:55 PM	Electric	Yes	151.4	21.4	24.0	20%
TypeC	LionC (210 kWh)	2	30	7:20 AM	10:02 AM	50	2:22 PM	4:24 PM	Electric	Yes	130.3	16.2	19.2	16%
TypeC	Bluebird Vision Electric	3	35	5:57 AM	8:45 AM	28	2:11 PM	5:25 PM	Electric	Yes	86.9	11.1	19.2	24%
TypeC	BYD Type C	4	20	6:30 AM	9:00 AM	21	2:00 PM	4:30 PM	Electric	Yes	66.6	11.3	19.2	55%

ESB Route Analysis Tool - Results

- Energy/Power Results
  - Maximum energy used (kWh)
    - Factors in mid-day charging selection
  - Estimated Minimum Charger Power Level (kW)
    - Guidance for minimum charger size in yellow section

- Charger Selection
  - Charger Size (kW)
    - Drop down user selection
  - Expected Minimum State-of-Charge (SOC) (%)
    - Reflects the lowest % SOC that the battery will experience during the day based on charger size selected

Bus Info		Route Info							User Selections		Energy/Power Results		Charger Selection	
Bus Type	ESB Make/Model	Route #	Morning Route Distance (miles)	Morning Depart Time	Morning Return Time	Afternoon Route Distance (miles)	Afternoon Depart Time	Afternoon Return Time	Cabin Heater	Mid-Day Charging	Max Energy Used (kWh)	Estimated Minimum Charger Power Level (kW)	Charger Size (kW)	Expected Minimum SOC (%)
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TypeC	BYD Type C	4	20	6:30 AM	9:00 AM	21	2:00 PM	4:30 PM	Electric	Yes	66.6	11.3	19.2	55%

ESB Route Analysis Tool – Compare Bus Models

- Requires DCFC indicates this specific model is not compatible with Level 2 charging

- Not compatible indicates route energy is higher than battery capacity
  - Select larger bus battery option

- Red lettering indicates SOC lower than desired

Bus Info		Route Info							User Selections		Energy/Power Results			Charger Selection	
Bus Type	ESB Make/Model	Route #	Morning Route Distance (miles)	Morning Depart Time	Morning Return Time	Afternoon Route Distance (miles)	Afternoon Depart Time	Afternoon Return Time	Cabin Heater	Mid-Day Charging	Max Energy Used (kWh)	Estimated Minimum Charger Power Level (kW)		Charger Size (kW)	Expected Minimum SOC (%)
TypeC	Bluebird Vision Electric	1	35	6:30 AM	9:00 AM	40	2:00 PM	4:30 PM	Electric	Yes	86.1	12.6		19.2	31%
TypeC	BYD Type C	1	35	6:30 AM	9:00 AM	40	2:00 PM	4:30 PM	Electric	Yes	109.9	16.7		19.2	33%
TypeC	IC Bus Electric CE (105 kWh)	1	35	6:30 AM	9:00 AM	40	2:00 PM	4:30 PM	Electric	Yes	100.0	NOT COMPATIBLE		19.2	-17%
TypeC	IC Bus Electric CE (210 kWh)	1	35	6:30 AM	9:00 AM	40	2:00 PM	4:30 PM	Electric	Yes	103.7	13.5		19.2	28%
TypeC	LionC (126 kWh)	1	35	6:30 AM	9:00 AM	40	2:00 PM	4:30 PM	Electric	Yes	84.0	15.9		19.2	22%
TypeC	Thomas C2 Jouley	1	35	6:30 AM	9:00 AM	40	2:00 PM	4:30 PM	Electric	Yes	93.3	12.4	*REQUIRES DCFC	19.2	38%

ESB Route Analysis Tool – Evaluate Bus Options

Lowest Expected Temperature (°F):	10°	*See NCEI Climate at a Glance for local temperatures: https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/county/time-series

Bus Info		Route Info							User Selections		Energy/Power Results		Charger Selection	
Bus Type	ESB Make/Model	Route #	Morning Route Distance (miles)	Morning Depart Time	Morning Return Time	Afternoon Route Distance (miles)	Afternoon Depart Time	Afternoon Return Time	Cabin Heater	Mid-Day Charging	Max Energy Used (kWh)	Estimated Minimum Charger Power Level (kW)	Charger Size (kW)	Expected Minimum SOC (%)
TypeC	IC Bus Electric CE (210 kWh)	1	25	6:30 AM	9:00 AM	32	2:00 PM	4:30 PM	Electric	Yes	95.7	14.2	19.2	44%
TypeC	IC Bus Electric CE (210 kWh)	1	25	6:30 AM	9:00 AM	32	2:00 PM	4:30 PM	Auxiliary	Yes	77.8	11.9	19.2	51%
TypeC	IC Bus Electric CE (210 kWh)	1	25	6:30 AM	9:00 AM	32	2:00 PM	4:30 PM	Electric	No	170.5	NOT COMPATIBLE	19.2	-1%
TypeC	IC Bus Electric CE (210 kWh)	1	25	6:30 AM	9:00 AM	32	2:00 PM	4:30 PM	Auxiliary	No	138.5	11.9	19.2	14%

cleanschoolbusTA@nrel.gov https://www.epa.gov/cleanschoolbus/clean-school-bus-technical-assistance

Joint Office of
Energy and Transportation

Thank You

Nov. 2, 2023

CleanSchoolBusTA@nrel.gov

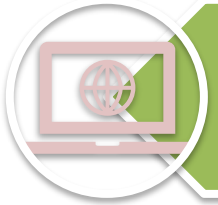
driveelectric.gov

Question & Answer Session

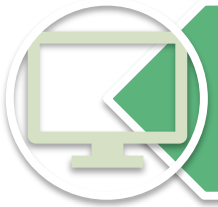
Upvote and comment on questions similar to your own.
Type your full thought so we can follow-up with an answer.
Speak slowly and clearly for the captioner/interpreter.

cleanschoolbus@epa.gov **epa.gov/cleanschoolbus**

Next Steps – *How to Apply*



1. Visit the Clean School Bus Website for Tools & Resources



2. Register your Organization with SAM.gov

3. Complete your Application Form and Supplemental Applicant Forms

4. Submit Application Package by **January 31st, 2024 at 4:00pm ET**

EPA

Application packages must be submitted to EPA no later than 1/31/24 at 4:00 p.m. ET.
For more information, please visit *www.epa.gov/cleanschoolbus.*

EPA CLEAN SCHOOL BUS

Upcoming Webinars

November 14, 2023	Panel Discussion: Transportation Directors with Q&A
December 5, 2023	IRS/Treasury: Tax Credits Overview
December 13, 2023	OIG: Fraud Prevention & Best Practices with Q&A
January 10, 2024	Popular Q&A with Extended Q&A Session
January 24, 2024	CSB Outreach: Topic TBD
February 7, 2024	2023 Rebates Feedback and Next Steps

**Please note: Webinar topics are subject to change. To view the most up-to-date list of CSB webinars and register, please visit: www.epa.gov/cleanschoolbus/events-related-clean-school-bus-program*

EPA

Application packages must be submitted to EPA no later than 1/31/24 at 4:00 p.m. ET.
For more information, please visit www.epa.gov/cleanschoolbus.

EPA CLEAN SCHOOL BUS

Summary

2023 CSB Rebates

- Applications must be submitted to EPA no later than **1/31/24 at 4:00 p.m. ET.**
- Dates and topics for future webinars are on our website under the 'Webinars' section.

Future Funding Opportunities

- EPA encourages school districts to consider which competition structure (grants or rebates) best suits their needs.
- EPA anticipates opening a grant program in Spring 2024.

Resources

- EPA's CSB Program website
- The Joint Office of Energy and Transportation (cleanschoolbusTA@nrel.gov)
- The CSB helpline (cleanschoolbus@epa.gov)

Stay in Touch

- Learn more about the 2023 CSB Rebates at www.epa.gov/cleanschoolbus/clean-school-bus-program-rebates
- Submit questions to cleanschoolbus@epa.gov
- Don't miss any updates! To sign up for the listserv, please visit epa.gov/cleanschoolbus.

Application packages must be submitted to EPA no later than 1/31/24 at 4:00 p.m. ET.
For more information, please visit *www.epa.gov/cleanschoolbus.*

EPA CLEAN SCHOOL BUS

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