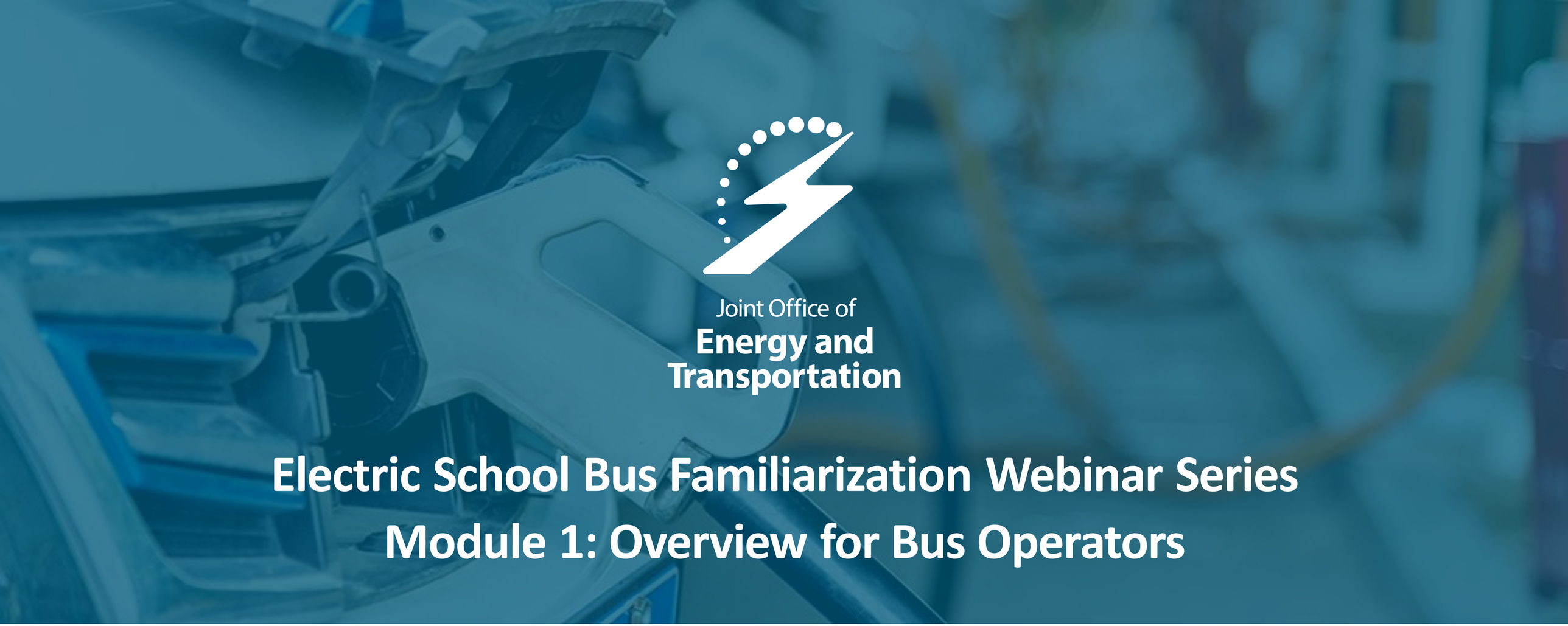


Joint Office of
Energy and
Transportation

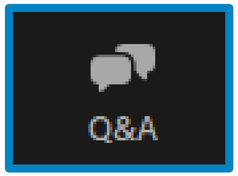
Electric School Bus Familiarization Webinar Series
Module 1: Overview for Bus Operators

4/10/2024

driveelectric.gov

Zoom Tips and Housekeeping

- Controls are located at the bottom of your screen. If they aren’t appearing, move your cursor to the bottom edge.
- Submit questions using the “Q&A” window



Disclaimer

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Mission and Vision

JOINT OFFICE OF
Energy and
Transportation

Mission

To accelerate an electrified transportation system that is affordable, convenient, equitable, reliable, and safe.

Vision

A future where everyone can ride and drive electric.

BIL Programs Supported by the Joint Office

The Joint Office will provide unifying guidance, technical assistance, and analysis to support the following programs:

National Electric Vehicle Infrastructure (NEVI) Formula Program (U.S. DOT)
$5 billion for states to build a national electric vehicle (EV) charging network along corridors

Charging & Fueling Infrastructure (CFI) Discretionary Grant Program (U.S. DOT)
$2.5 billion in community and corridor grants for EV charging, as well as hydrogen, natural gas, and propane fueling infrastructure

Low-No Emissions Grants Program for Transit (U.S. DOT)
$5.6 billion in support of low- and no-emission transit bus deployments

Clean School Bus Program (U.S. EPA)
$5 billion in support of electric school bus deployments

Clean School Bus Technical Assistance

The Joint Office of Energy and Transportation (Joint Office) is providing **FREE** technical assistance for the EPA's Clean School Bus program

Technical Assistance Offerings:

- **Fleets receiving funds or planning to apply are eligible**
- Proactive and reactive, hands-on assistance tailored to each fleet
- New and updated tools and resources.

Clean School Bus Technical Assistance

CleanSchoolBusTA@nrel.gov

driveelectric.gov/contact

Examples of How We Can Help

- Electric utility coordination
- Identifying available funding and incentives
- Analyzing charging infrastructure needs
- Conducting route analysis and planning
- Conducting training and workforce development
- Bus evaluation
- Analyzing energy needs and grid impact
- Identifying solar and battery storage opportunities

Agenda

Introduction from Ryan Frasier, National Renewable Energy Laboratory (NREL)

Presentations moderated by the International Transportation Learning Center (ITLC)

- *What is an Electric Bus and Why?*
  - Albert Burleigh, Blue Bird Corporation
- *Standard Operations, Controls, and Driving*
  - Brandon Reid, Lion Electric
- *Charging Procedures and Infrastructure*
  - Mark Richardson, Thomas Bus/Daimler Truck

Audience Q&A

New Electric School Bus Familiarization Webinar Series

Brought to you by:

- Joint Office of Energy and Transportation
- National Renewable Energy Laboratory (NREL)
- International Transportation Learning Center (ITLC)
- School bus manufacturers

- Four-part module-based series for operators, technicians, and other school bus fleet members.
- Learn fundamentals of electric school bus (ESB) technology.
- Live Q&A during each session.
- Recordings with testing materials for internal training programs.

Register for ESB Familiarization Webinars

Webinar topics:

- Module 1: Operator Overview (April 10)
- *Module 2: Electric School Bus Technology Overview
- *Module 3: High Voltage Safety Considerations
- *Module 4: Charging Considerations

Register at:
driveelectric.gov/webinars

Registration for Modules 2, 3, and 4 coming soon!

Today’s Moderator

Maurice Beard

International Transportation Learning Center (ITLC)

Fundamentals Of Electric School Buses

2024

Four Sessions

Session 1

ESB Overview for Operators

Session 2

ESB Technical Overview

Session 3

High Voltage Safety Considerations

Session 4

ESB Charging Methods and Considerations

Fundamentals Of Electric School Buses

2024

Topics for Today

Presentation 1

What is an Electric Bus and Why?

Albert Burleigh

Presentation 2

Standard Operations, Controls & Driving

Brandon Reid

Presentation 3

Charging Components, Procedures & Infrastructure

Mark Richardson

BLUE BIRD®

Presentation 1
What is an Electric Bus and Why?

Albert Burleigh

INTERNATIONAL TRANSPORTATION LEARNING CENTER

Learning Outcomes

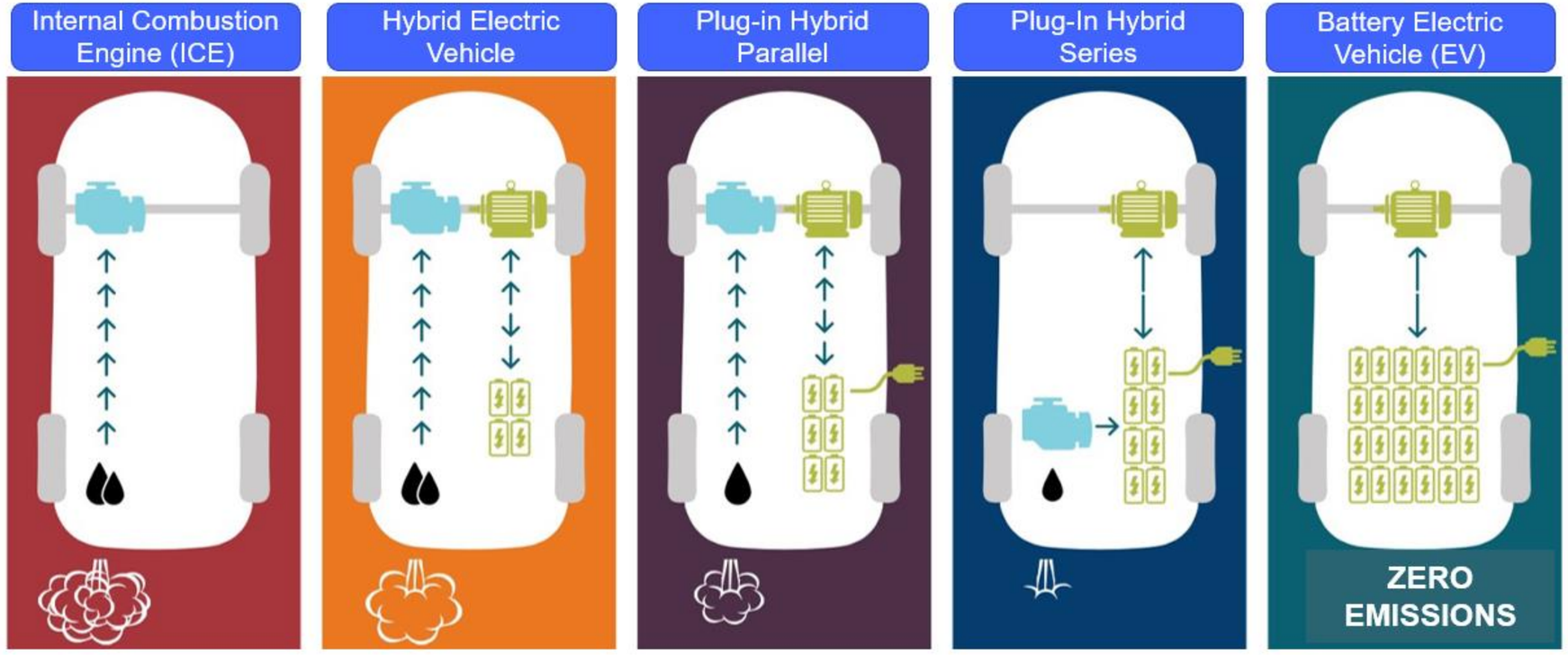
- Define an electric school bus.
- List the benefits associated with electric school buses.
- Explain general safety and emergency preparedness.
- Describe the process of regenerative braking.

What is an Electric Bus and Why?

Defining a Battery Electric Bus

A vehicle is a *Battery Electric Vehicle* if:

- Its propulsion system is powered only by batteries
- These batteries are primarily charged by an external power source



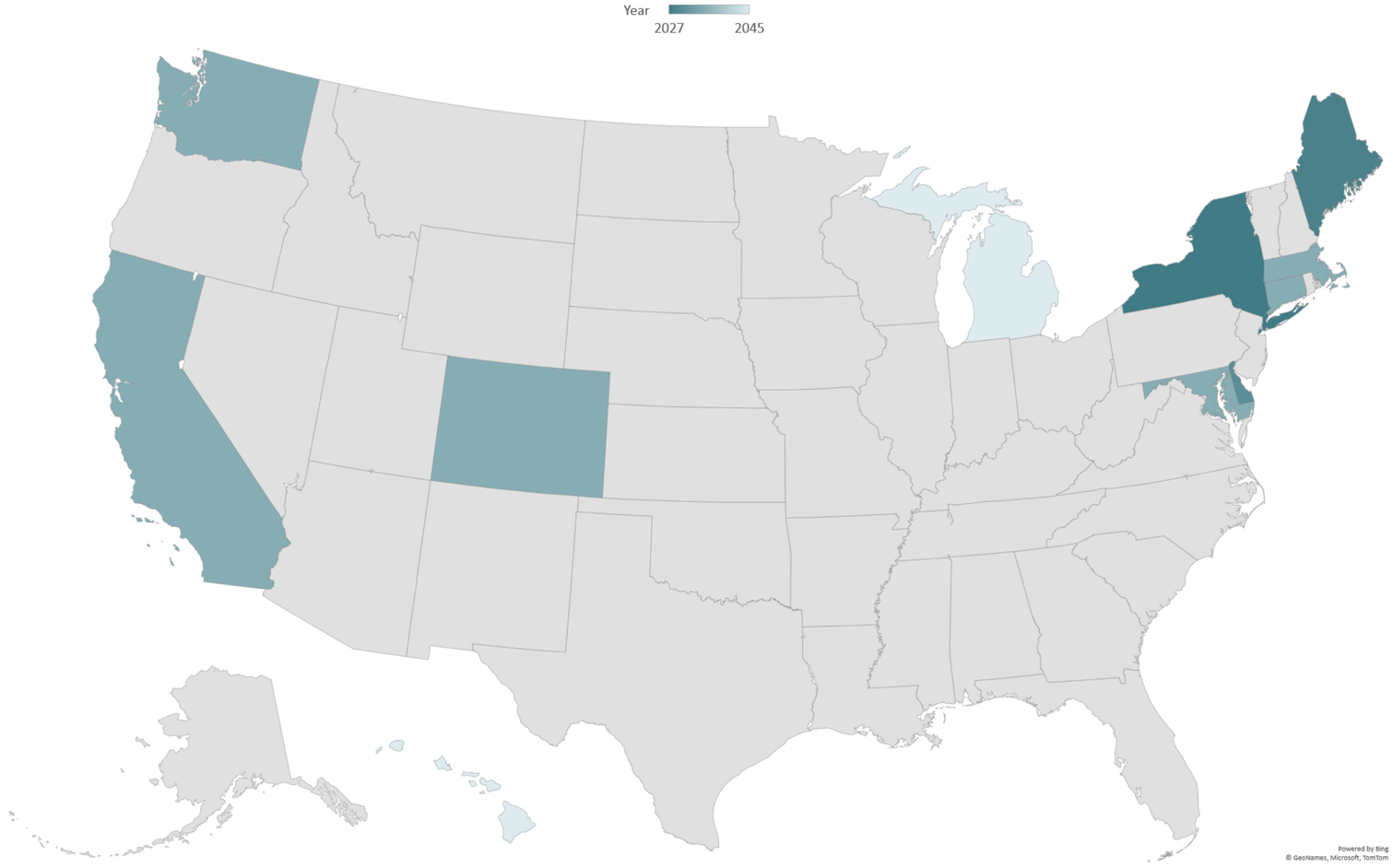
What is an Electric Bus and Why?

Overview and Benefits of Electric Propulsion

- **Zero Emissions**
- **Grant Funds Available**
- **Reduced Maintenance Costs**
- **Outstanding Performance**
- **Quiet Operation**
- **Vehicle to Grid Technology**

What is an Electric Bus and Why?

States with EV Emissions Reduction Legislation or Goals



California	2035
Colorado	2035
Connecticut	2035
Delaware	2030
Hawaii	2045
Illinois	2028
Maine	2035
Maryland	2035
Massachusetts	2025
Michigan	2045
New York	2027
Washington	2035

What is an Electric Bus and Why?

Overview and Benefits of Electric Propulsion – Grant Funds

EPA CLEAN SCHOOL BUS

As of January 2024, EPA has awarded approximately $1.84 billion to fund 5,103 clean school buses – 96% of which are electric – and related charging infrastructure at 642 school districts in most states and territories, and at schools operated by federally recognized Tribes

*EPA Clean School Bus Program: Third Report to Congress, Fiscal Year 2023 (EPA-420-R-24-001, February 2024)

What is an Electric Bus and Why?

Overview and Benefits of Electric Propulsion – Reduced Maintenance

- Electric school buses have much fewer moving parts, requiring less maintenance
- Little to no fluid changes
- Operational savings of 60%-80% compared to ICE buses

What is an Electric Bus and Why?

Overview and Benefits of Electric Propulsion – Quiet Operation

- Electric school buses are much quieter than their diesel counterparts
- Allows drivers to hear what's happening inside and outside the bus
- Reduces noise pollution in the neighborhoods where they operate
- A sound generator is installed to alert students and other pedestrians that the bus is approaching

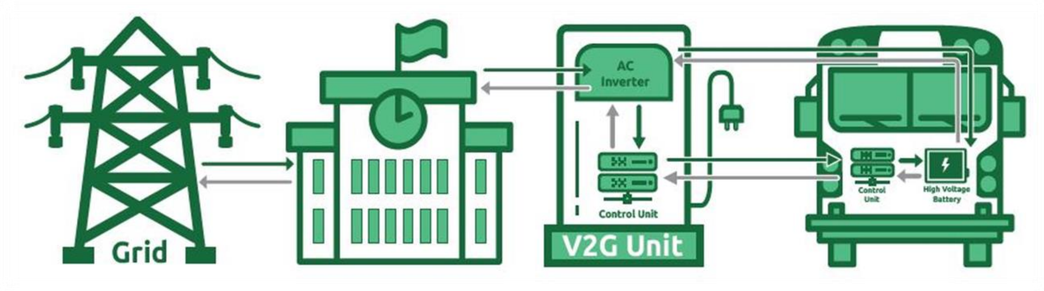
What is an Electric Bus and Why?

Overview and Benefits of Electric Propulsion - Performance

- Large electric motors with exceptional power for acceleration
- Lower center of gravity and better weight distribution for superior handling

What is an Electric Bus and Why?

Overview and Benefits of Electric Propulsion – Vehicle to Grid



Vehicle-To-Grid (V2G)

- V2G creates opportunities for utilities to “buy back” stored energy that the buses are not using.
- V2G also creates the ability to redirect the excess power to other structures like the building or fuel island.

Fundamentals of Electric Buses

Regenerative Braking

A unique aspect of an electric bus is being able to charge the main batteries using the energy available in a moving bus. When the throttle is released, the electric motor will act as a generator to slow the bus down, while at the same time feeding energy back into the batteries.

If the batteries are >80- 90% State Of Charge (SOC), the regenerative braking effect will be limited.

Fundamentals of Electric Buses

Regenerative Braking: Scenario Example

A driver complains regenerative braking is not working when beginning a route at 100% charge

When battery is fully charged, no space for more power to be stored through regenerative braking.

Regenerative braking works only when the batteries are below 80% - 90% charged.

Safety and Emergency Preparedness

Keys to Safety in Operating Electric Bus

General Safety Guidelines

All Buses	EV Unique
Thorough Pre / Post Trip Inspection	High Voltage System Awareness
Vigilant Driving Standards	Proper System Enablement & Disablement
Proper driver training	Quiet Operation Awareness

Keys to Safety in Operating Electric Bus

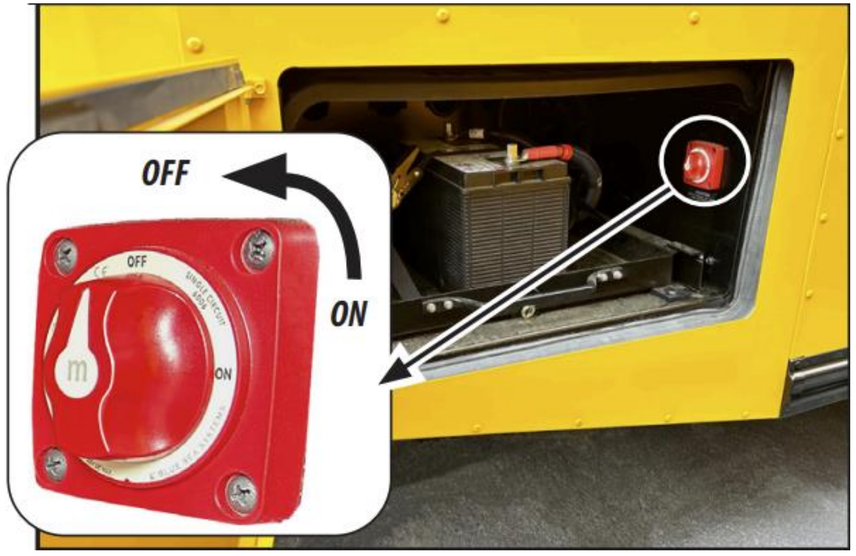
High Voltage

For automotive applications, any voltage **greater than 30 volts AC (or 60 volts DC)** is considered high or hazardous voltage due to the potential to produce serious injury or death due to electric shock.

Keys to Safety in Operating Electric Bus

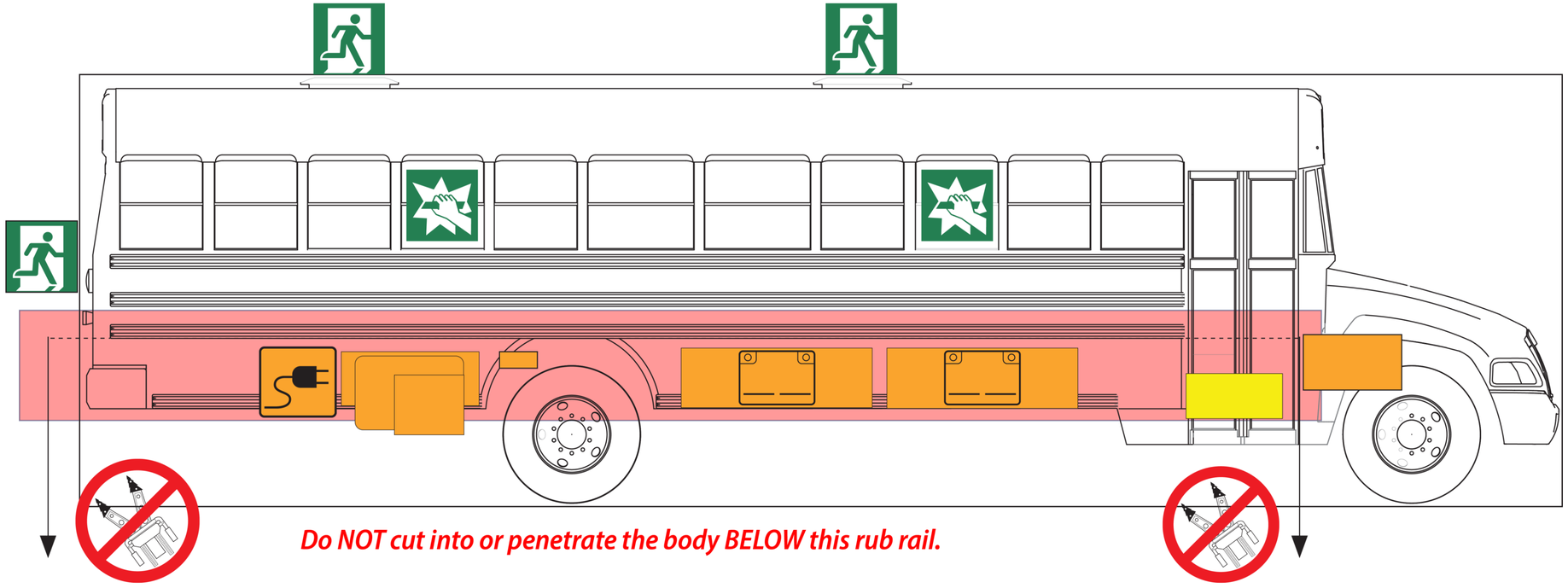
Disabling High Voltage

- Remove the key from the ignition.
- Look for disconnect switch in 12V battery compartment



Safety and Emergency Preparedness

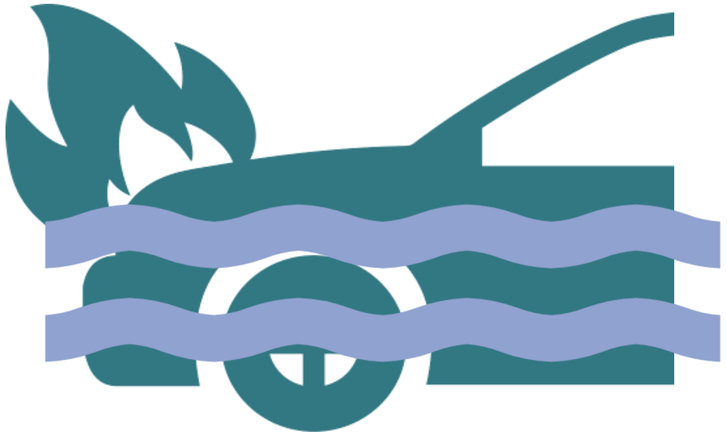
Keys to Safety in Operating Electric Bus



Charge Port	High Voltage Battery	Disconnect High Voltage	Low Voltage Battery	Disconnect Low Voltage	High Voltage Component	High Voltage Power Cable	Emergency Exit	Break to obtain access

Safety and Emergency Preparedness

Keys to Safety in Operating Electric Bus



Fire / Submerged

- **Call Emergency Response**
- **Submersion:** HV system isolated from chassis and designed not to shock or energize surrounding water
- **Fire:** Evacuate and stand upwind of fumes if safe

Keys to Safety in Operating Electric Bus

Towing Electric Bus

From Rear:
No need to remove drive shaft

From Front:
De-couple rearmost driveshaft before towing to prevent damage (caused by turning the input shaft of the motor)

LION ELECTRIC

Presentation 2
Standard Operations, Controls, & Driving

Brandon Reid

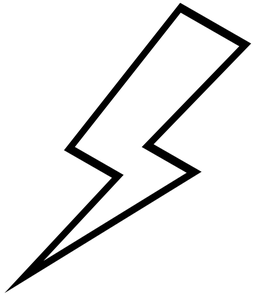
INTERNATIONAL TRANSPORTATION LEARNING CENTER

Learning Outcomes

- Describe the functions and controls of an Electric School Bus (ESB).
- Identify procedures for effective operation of an ESB.
- Identify key similarities and differences to traditional ICE (internal combustion engine) buses.

Standard Operations, Controls, & Driving

Internal Combustion Engine (ICE) Bus Vs. Electric School Bus (ESB)



Main difference is the ESB **high voltage electric powertrain components**:

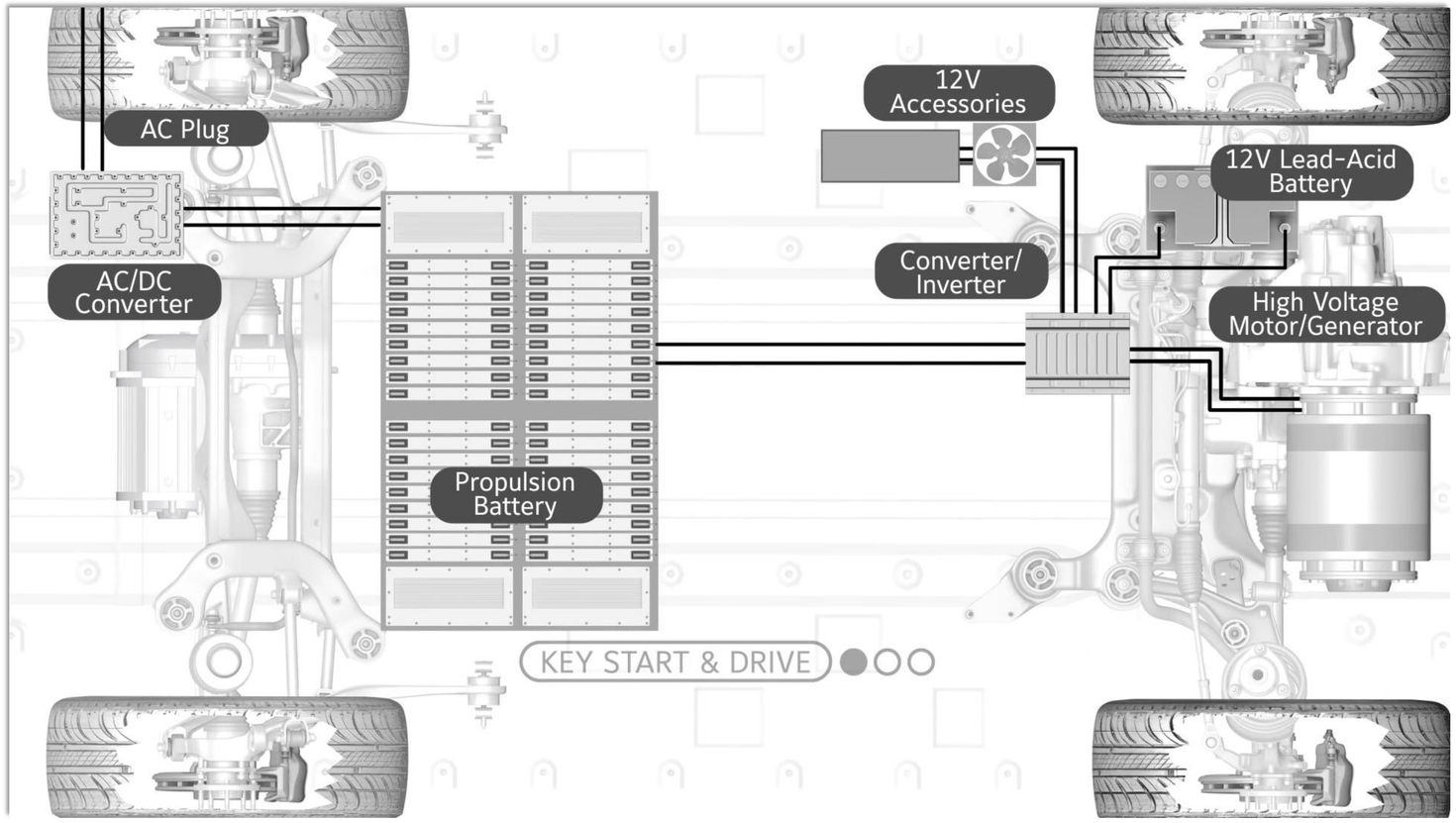
- Motor & inverter supplies propulsion
- Pumps move fluids for steering & (hydraulic) braking
- Compressor supplies pneumatic brakes, suspension, etc.

Steering, suspension, interior controls, and brake components use standard low voltage 12 or 24v systems.

Some manufacturers also offer high voltage powered Heating and Air Conditioning (HVAC) systems.

Standard Operations, Controls, & Driving

Three Cycles in the Operation of an Electric Vehicle



1. Propulsion

2. Regenerative Braking

3. Charging

Standard Operations, Controls, & Driving

Functions and Controls

Traditional Arrangements & Parts of Driver Seating Area:

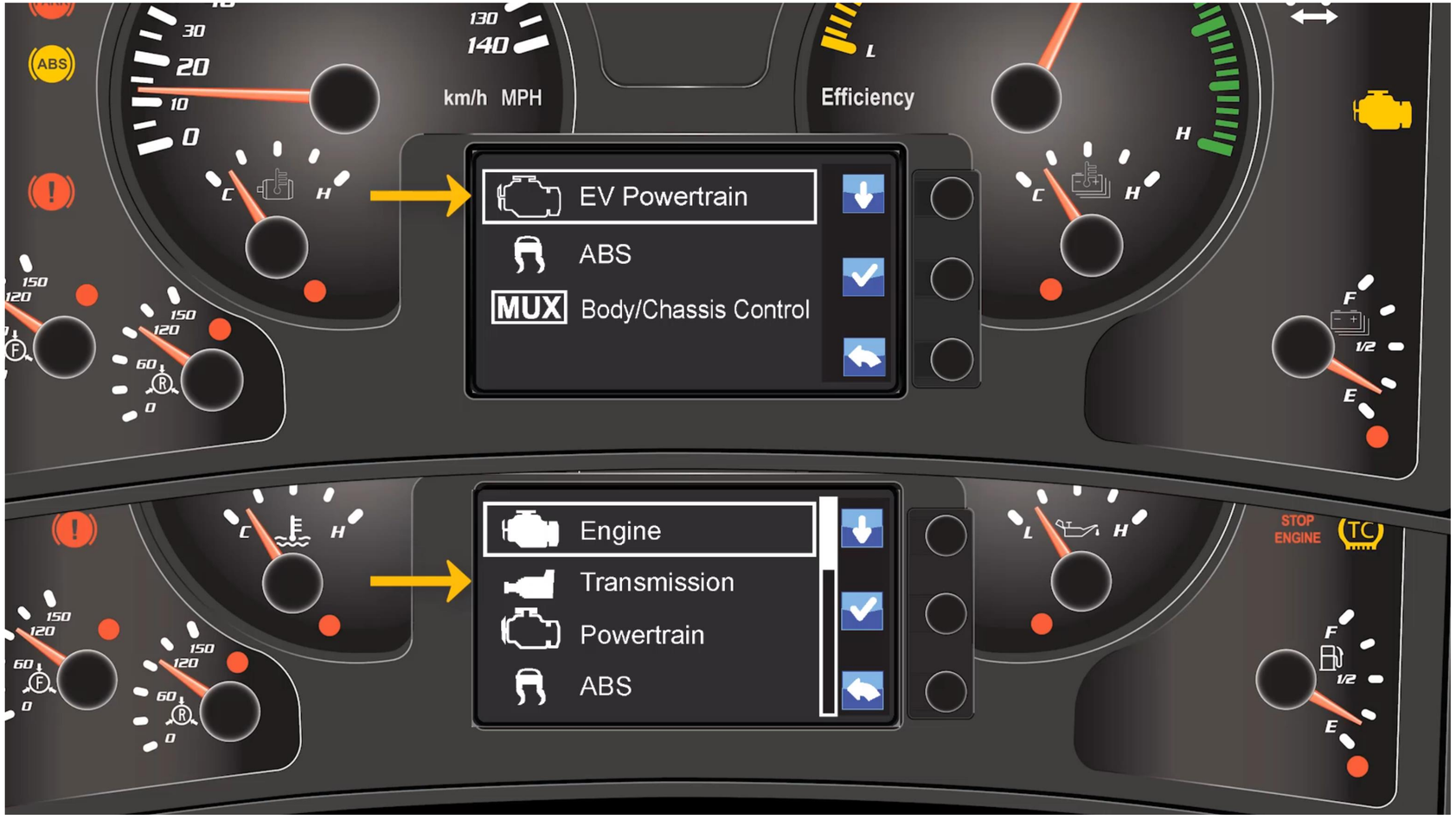
- Analog gauges
- Standard cluster indicators
- HVAC & radio controls
- Light & function switches
- Turn signals & wiper controls
- Mirrors
- Seats

2020 EV

2020 ICE

Standard Operations, Controls, & Driving

Instrument Cluster Comparison



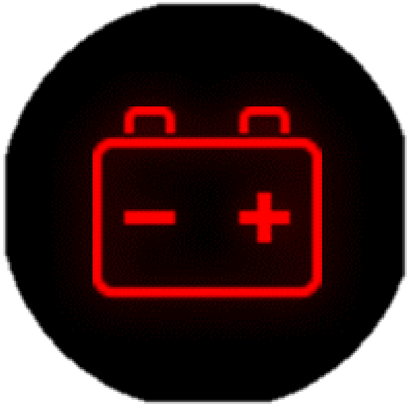
EV vs ICE – Features different

- State-of-charge Gauge vs. Fuel-level Gauge
- Power-usage-efficiency Gauge vs. Tachometer
- Battery-temperature Gauge vs. Oil-pressure Gauge
- EV motor temperature vs. Engine temperature

Form, Functions, and Controls

Low Voltage Power Supply, Power Accessories

Each Electric Vehicle School Bus has 12-volt batteries to power a low voltage system



This system powers items such as:

- Dashboard
- Electrical panel
- Lights
- Accessories
- Emergency buzzers
- DC/DC Converter

Standard Operations, Controls, & Driving

Functions and Controls

DC/DC Converter

=

This is the alternator of an ESB!

Low voltage power supply, power accessories

- This module installs between the high volt and the low volt systems
- Converts ***high volt*** power from EV batteries to ***low volt*** power to supply 12v accessories
- Regulates and feeds power to 12v batteries

Standard Operations, Controls, & Driving

Functions and Controls

Heating, Ventilation, and Air Conditioning (HVAC) Types and Options are the same:

Electric Heating

- Heat pumps
- Thermal heating elements
- Electric fluid heaters & fans

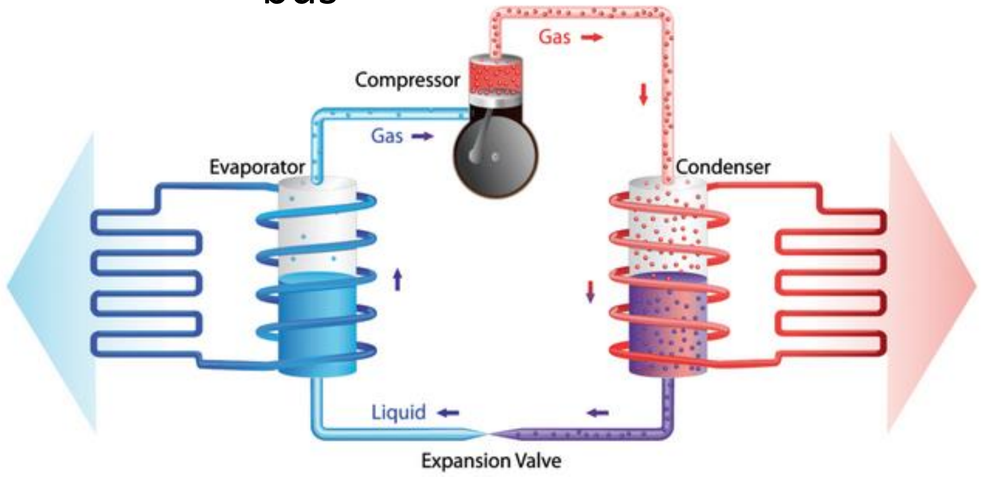
Ventilation

- Fan moves air into & through cabin
- Same vents as a traditional bus

Air Conditioning

- Heat pumps
- High Voltage AC Compressor

  * Both use compressed refrigerant



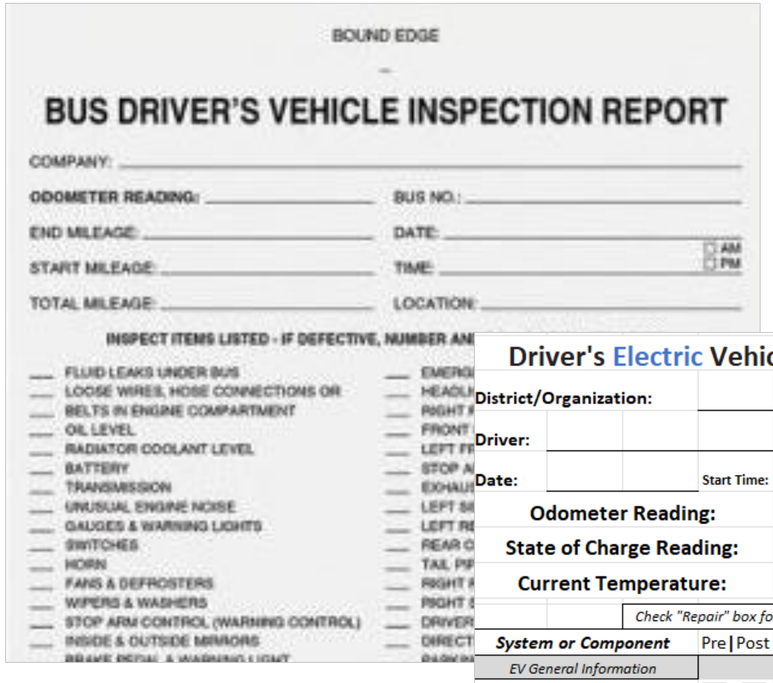
Standard Operations, Controls, & Driving

Effective Operation

Pre & Post Trip Inspections:

- Can use specific forms and methods
- Similar systems mean pre-trip testing procedures remain the same

Fewer fluids to check!



BOUND EDGE

BUS DRIVER'S VEHICLE INSPECTION REPORT

COMPANY: _____

ODOMETER READING: _____ BUS NO.: _____

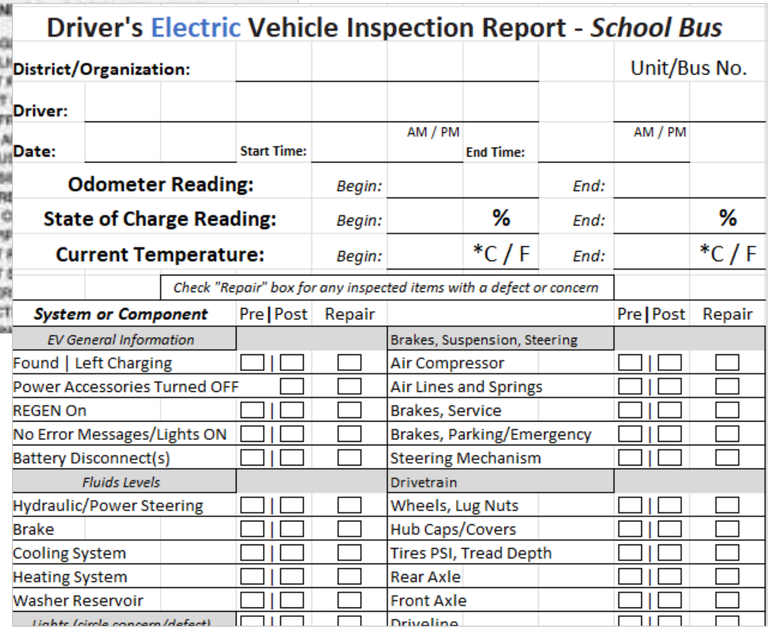
END MILEAGE: _____ DATE: _____

START MILEAGE: _____ TIME: _____ ☐ AM ☐ PM

TOTAL MILEAGE: _____ LOCATION: _____

INSPECT ITEMS LISTED - IF DEFECTIVE, NUMBER AN

___ FLUID LEAKS UNDER BUS
___ LOOSE WIRES, HOSE CONNECTIONS OR
___ BELTS IN ENGINE COMPARTMENT
___ OIL LEVEL
___ RADIATOR COOLANT LEVEL
___ BATTERY
___ TRANSMISSION
___ UNUSUAL ENGINE NOISE
___ GAUGES & WARNING LIGHTS
___ SWITCHES
___ HORN
___ FANS & DEFROSTERS
___ WIPERS & WASHERS
___ STOP ARM CONTROL (WARNING CONTROL)
___ INSIDE & OUTSIDE MIRRORS



Driver's Electric Vehicle Inspection Report - *School Bus*

District/Organization:					Unit/Bus No.
Driver:					
Date:	**Start Time:**	AM / PM	**End Time:**	AM / PM	
Odometer Reading:	*Begin:*		*End:*		
State of Charge Reading:	*Begin:*	%	*End:*	%	
Current Temperature:	*Begin:*	*C / F	*End:*	*C / F	

Check "Repair" box for any inspected items with a defect or concern

System or Component	Pre	Post	Repair		Pre	Post	Repair
EV General Information				Brakes, Suspension, Steering			
Found | Left Charging	☐	☐	☐	Air Compressor	☐	☐	☐
Power Accessories Turned OFF		☐	☐	Air Lines and Springs	☐	☐	☐
REGEN On	☐	☐	☐	Brakes, Service	☐	☐	☐
No Error Messages/Lights ON	☐	☐	☐	Brakes, Parking/Emergency	☐	☐	☐
Battery Disconnect(s)	☐	☐	☐	Steering Mechanism	☐	☐	☐
Fluids Levels				Drivetrain			
Hydraulic/Power Steering	☐	☐	☐	Wheels, Lug Nuts	☐	☐	☐
Brake	☐	☐	☐	Hub Caps/Covers	☐	☐	☐
Cooling System	☐	☐	☐	Tires PSI, Tread Depth	☐	☐	☐
Heating System	☐	☐	☐	Rear Axle	☐	☐	☐
Washer Reservoir	☐	☐	☐	Front Axle	☐	☐	☐
Lights (circle concern/defect)	☐	☐	☐	Driveline	☐	☐	☐

Standard Operations, Controls, & Driving

Effective Operation: Battery Preconditioning

For better performance and maximum range!

Options to heat and cool the cabin as well!

What is it?

A function of all ESB that engages high voltage components to **pre-heat** **or** **cool** your electric vehicle's battery and cabin before you start driving.

How does it work?

Scheduling features allow operators to set specific times for preconditioning

- Optimizes the process and ensures the vehicle is ready when needed

Relies on power an **external grid-powered source**, such as a charging station

- By using electricity from the grid, instead of the vehicle's battery, eliminates the impact on driving range

In **hot** weather:

- The system cools the battery using air conditioning or coolant

In **cold** weather:

- A heating system warms the batteries to their optimal operating temperature

Standard Operations, Controls, & Driving

Effective Operation

Startup & Shutdown

Starting: ESB is very similar to a traditional vehicle

- Upon ignition engagement, a starting module sends a signal to engage the high voltage propulsion system
- No starter & flywheel to spin, you are turning on a computer!
- Typically find a manufacturer-specific indicator or order that should be followed for error-free startup
- This operation is very quiet or silent

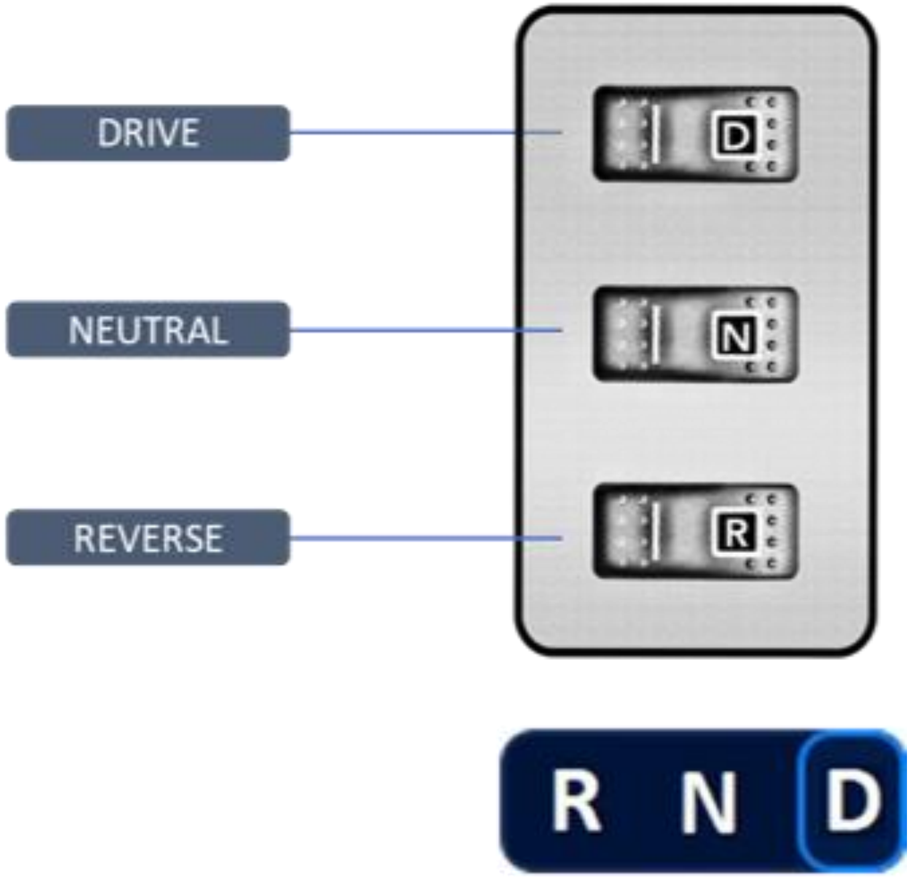
Shutdown: ensure all high voltage modules are OFF before charging or errors may occur

Standard Operations, Controls, & Driving

Effective Operation

Shifting

Since the electrical motor is directly attached to the driveline without any gears nor transmission, there is only a drive position and a reverse position to move the bus, in addition to the neutral position when it is stationary.



Standard Operations, Controls, & Driving

Effective Operation

ESB Braking System

Air brakes:

- Same components as ICE bus
- Many ESB have a HV-powered air compressor to feed the pneumatic system

OR

Hydraulic brakes:

- Run on a hydro-boost system fed by the power steering system as there is no vacuum in an electric bus
- Many ESB also come with a low voltage back up pump to provide emergency braking capabilities to stop the bus in case of HV failure

Regenerative braking plays a large role in slowing the bus down!

Standard Operations, Controls, & Driving

Effective Operation

Interpreting Power Usage:

All electric vehicles are equipped with control modules and a graphical interface that analyze and display *live* power consumption

Same graphical user interface can also show what is considered efficient and what is not.

Each manufacturer differs in their offerings, on average, the displays show efficiency gauges and range estimates.

All ESB operators should be able to:

- Understand the information displayed by the bus
- How to use it to become more familiar with environmental impacts on range
- How to use less energy and become a more efficient driver

<u>It is up to the operator to drive the vehicle efficiently!</u>

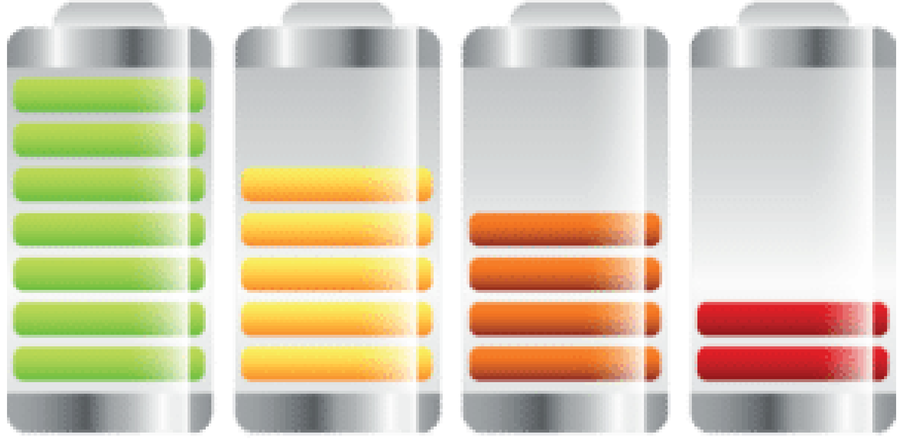
Standard Operations, Controls, & Driving

Effective Operation

Low Battery State of Charge (SOC)

If a driver notices low SOC on route they should:

1. Immediately turn off all non-critical electrical loads
2. *BE EFFICIENT!* Rigorously use regenerative braking, minimal usage of the accelerator, drive at minimum safe speed
3. Unload if convenient
4. Stop in a safe area and tow the vehicle to a charger



Low SOC = low fuel in an ICE bus

General Route Planning...

To avoid low SOC situations with an ESB, Route Planning should include:

- Bus quoted or calculated total range
- Efficiency of the driver
- Environment, Temperature, Weather
- Mid-route charging availability and time if needed

Standard Operations, Controls, & Driving

Effective Operation

Drivers must create new, efficient habits!

Electric vehicles shine in conditions where stopping and starting are common, such as a bus route, where multiple slowdowns/stops can be used to regenerate energy

Here are some habits to become more efficient:

- Minimize frequent acceleration
- Eliminate aggressive acceleration & excessive speed
- Keep HV accessory usage to a minimum (HV heat, HV A/C, etc.)
- If selectable REGEN power is available only use the maximum setting
- Modulate the accelerator pedal to slow the bus down with REGEN brake
- Preheat the cabin when the bus is connected to a charger
- Crest hills at a speed that allows you to coast all the way down
- Use hilly routes to your advantage by maximizing REGEN braking

YOU make the difference!

Presentation 3
Charging Components, Procedures, & Infrastructure

Mark Richardson

Learning Outcomes

- Explain the difference between AC and DC charging.
- Identify different types of charging stations and their components.
- Review recommended trip inspection and operation procedures as it relates to charging and ESBs.

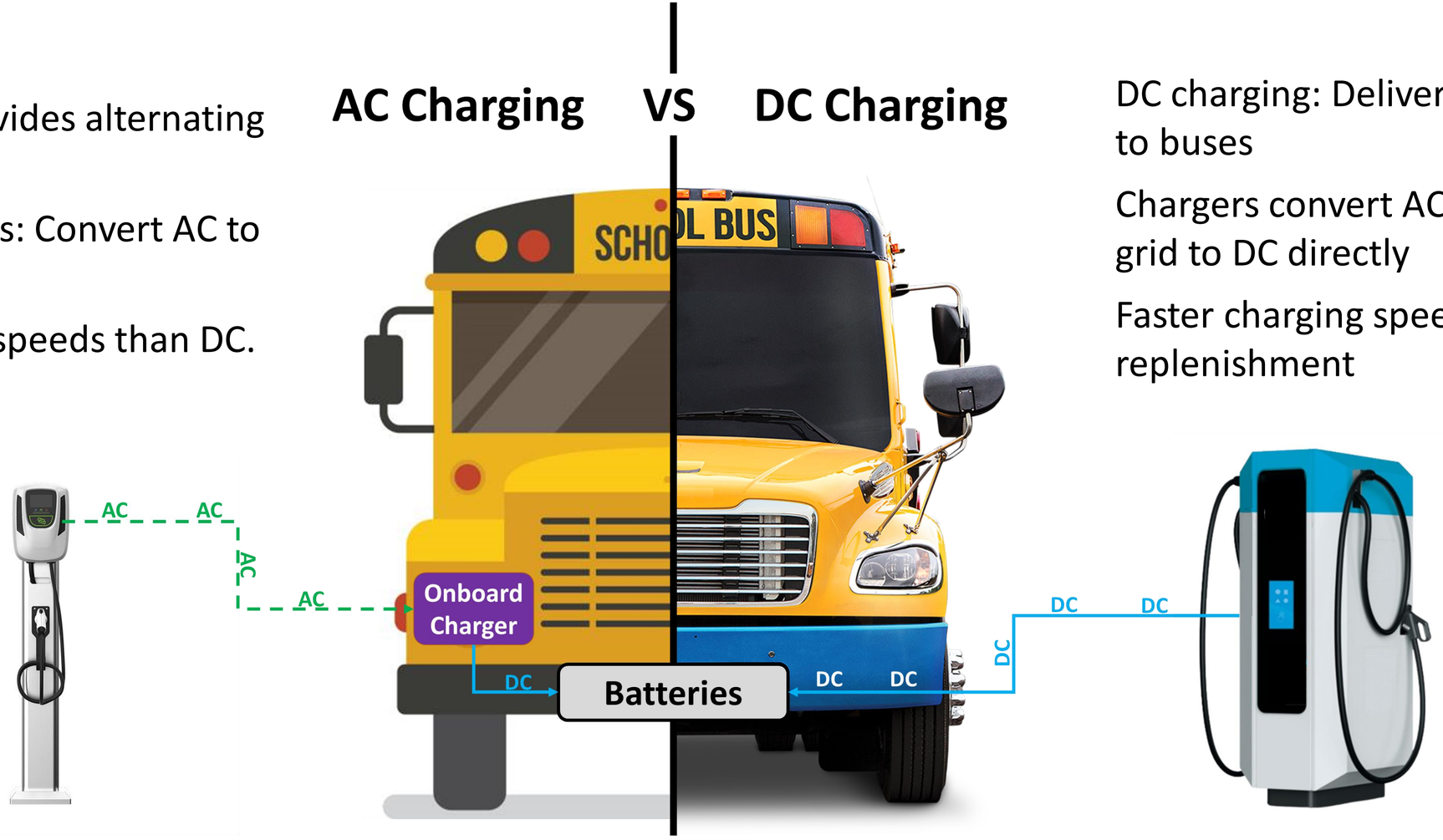
Charging Differences

AC Vs. DC

AC charging: Provides alternating current to buses.

Onboard chargers: Convert AC to DC for batteries.

Slower charging speeds than DC.



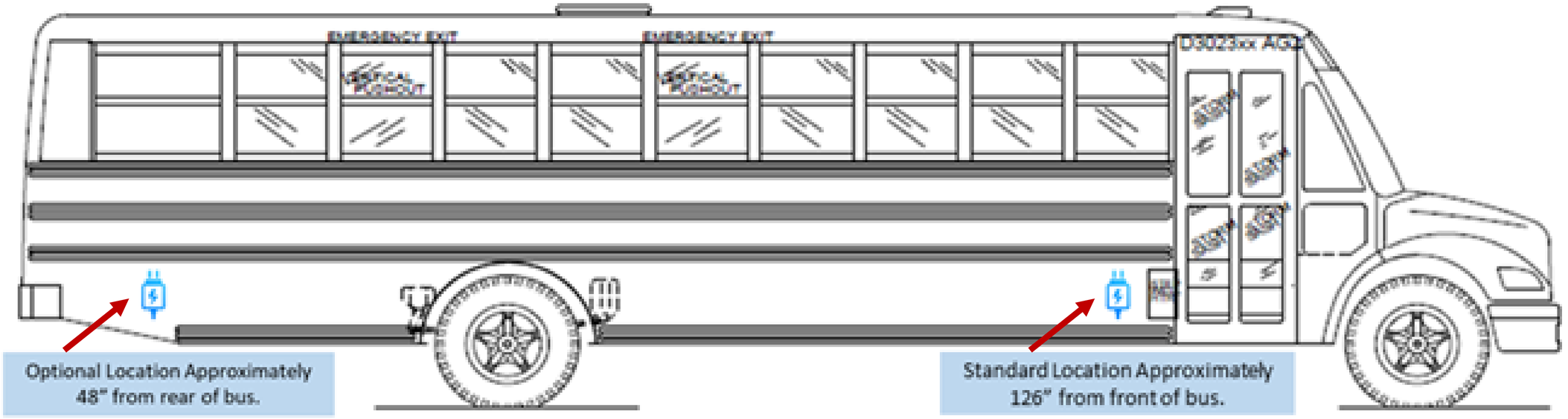
DC charging: Delivers direct current to buses

Chargers convert AC power from grid to DC directly

Faster charging speeds for quicker replenishment

Charger Components & Port Locations

Port Locations



Charger Components & Port Locations

Ports and Plugs

J1772 AC Plug

CCS DC Plug

J1772 AC Port

CCS DC Port

Charging Procedures

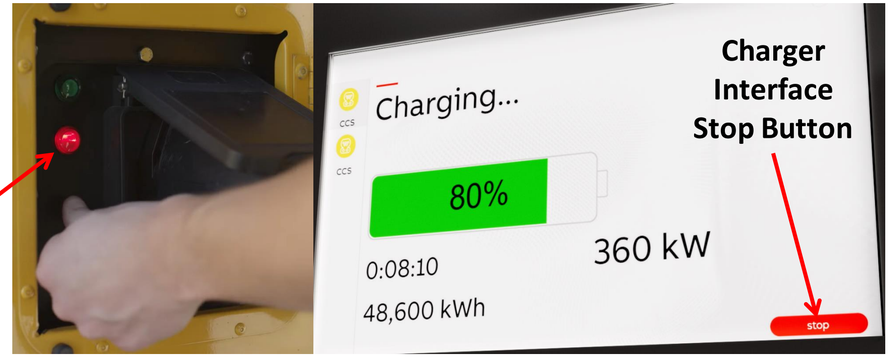
Five Step Charging Procedure

1. Inspect charge head for cleanliness and damage
2. Open charge port door and cover
3. Plug in charger and listen for a click
4. Look for a blinking indicator light to confirm communication between charger and bus, dashboard indicators display charging status
5. To stop charging, typically stop buttons are next to the charge port and on the charger itself
    - Example: Press stop button on bus, observe green indicator light turning off and red light turning on to indicate safe disconnection of charge head
    - The lock motor release on the charge port is typically heard as well

1.

2-4.

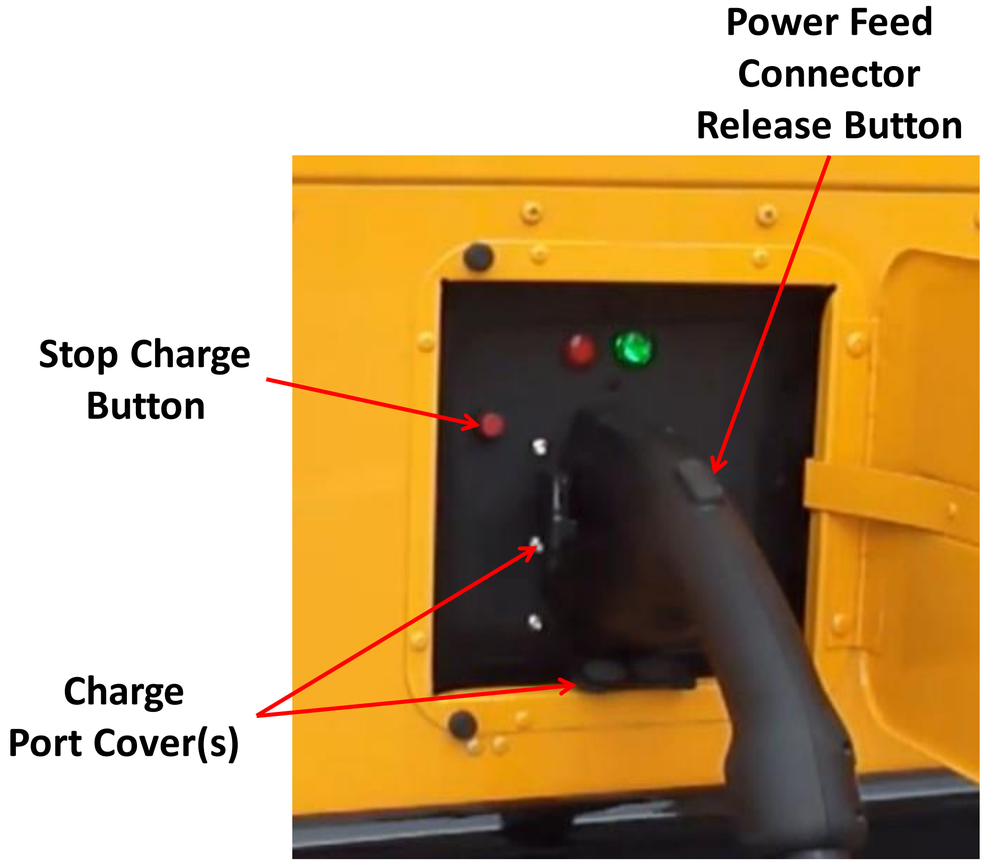
5.



ESB Trip Inspection Procedures

Example Outside of the Bus: Part 1

1. Perform the initial walk-around ensuring all exterior panels are closed.
2. Review charger to confirm “State of Charge”.
3. Press the STOP CHARGE button located on the Charge Plate to stop the charging session if needed.
4. After ending the charge, the connector lock should release.
5. Press the button on the Power Feed Connector and pull out to disconnect it from the Charge Port.



ESB Trip Inspection Procedures

Example Outside of the Bus: Part 2

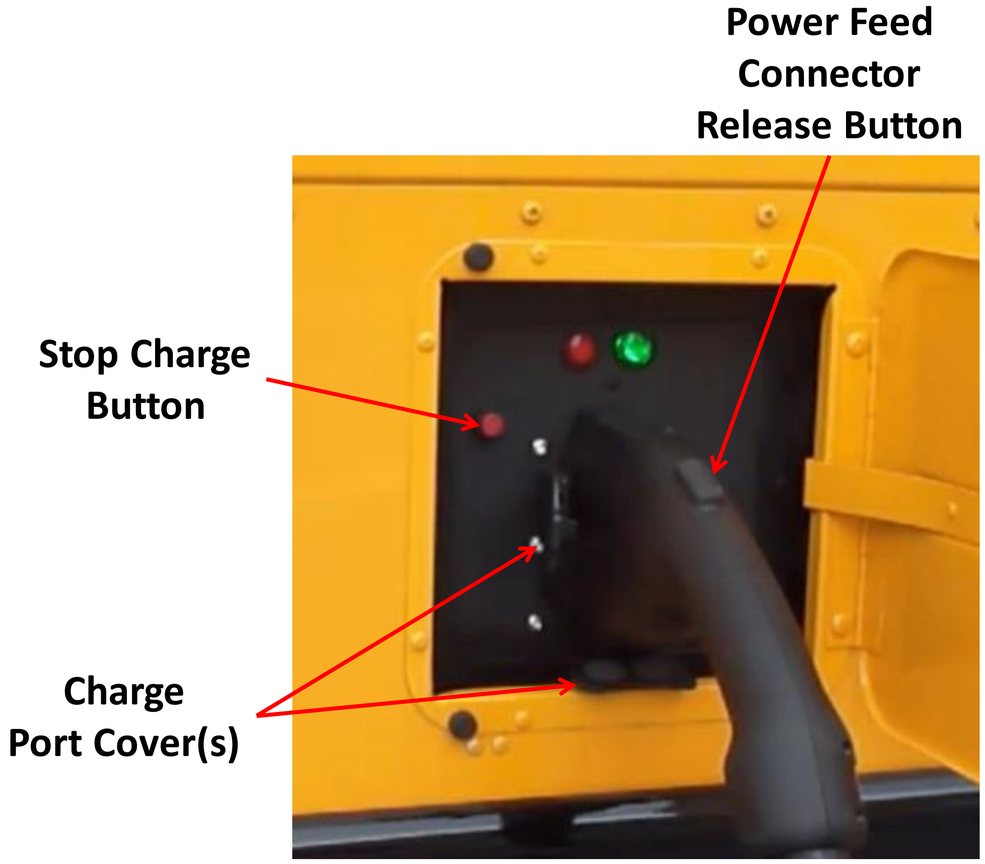
6. Place the Power Feed Connector back into the charger retaining port.

7. Close the Charge Port cover(s) and the access door.

8. Perform the power off / down portion of the pre-trip inspection.

9. The front hood can be opened to inspect fluid levels, steering components, and brake system.

10. Close the hood and all open panels / access door once complete.



ESB Trip Inspection & Operation Procedures

Example: Part 1

1. Turn the Ignition Switch to the ON position.

   Note: You will hear the sound of relays, electric pumps, and fans starting and operating. Both visual and audible alarms will start, then shut-off within a few seconds.

2. Check to ensure that the parking brake is engaged. Pull out the yellow parking switch to engage, if needed.

3. Turn the Ignition Switch to the Start / Crank position and release. The Power ON process may take up to 1 minute. The Vehicle HV Enabled indicator will illuminate.

4. After the startup function checks are completed, ensure that there are no faults shown on the driver's display.

ESB Trip Inspection & Operation Procedures

Example: Part 2

5. Perform the “Pre-trip” inspection at this time.

   Note: Please follow your fleet’s Pre-trip inspection guidelines

6. Once “Pre-trip” is complete, return to the driver's seat and depress the foot-brake.

7. Press the yellow “Parking Brake” switch to release.

8. Press the forward or reverse drive selector, as necessary.

ESB Trip Inspection & Operation Procedures

Example: Part 3

9. Remove your foot from the foot-brake, and press the accelerator pedal to start driving.

10. Once trip is complete, stop the bus in a safe location.

11. Place the bus in neutral by pressing the "N" button on the push button shifter.

12. Set the parking brake by pulling up on the yellow control switch.

13. Turn the Ignition Switch to the OFF position to shut down the bus.

Questions and Answers

Thank you!

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Module 1: Overview for Bus Operators

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