BUILT BY
BLUE BIRD
POWERED BY
CUMMINS

Blue Bird Electric School Buses

July 21, 2020

All Roads Lead to Blue Bird Electric School Buses

A long history in alternative fuels

- Blue Bird was a pioneer and first school bus OEM to embrace EV technology
- 1994 - Collaborated with Westinghouse Electronic Systems to develop first battery-powered school bus
- 1996 - Collaborated with Electrosource, Inc. to produce transit style electric shuttle buses for the Atlanta Summer Olympics

Present Day

2016

- Blue Bird Received $4.4MM grant from US Department of Energy (US DOE) for the production of 10 V2G school buses.

2017

- Blue Bird Launched our current iteration of the Blue Bird EV bus at the STN Expo, Reno in July 2017

2018

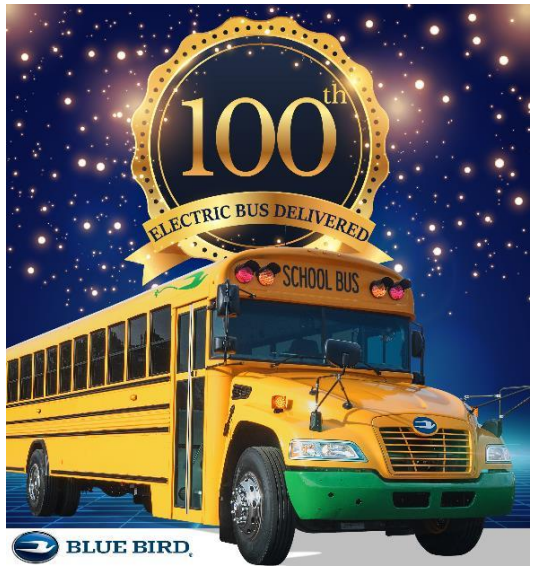
- Blue Bird delivered its first electric-powered school buses to customers in California and Ontario (Canada)

2020

- Blue Bird delivered its one hundredth electric-powered school bus

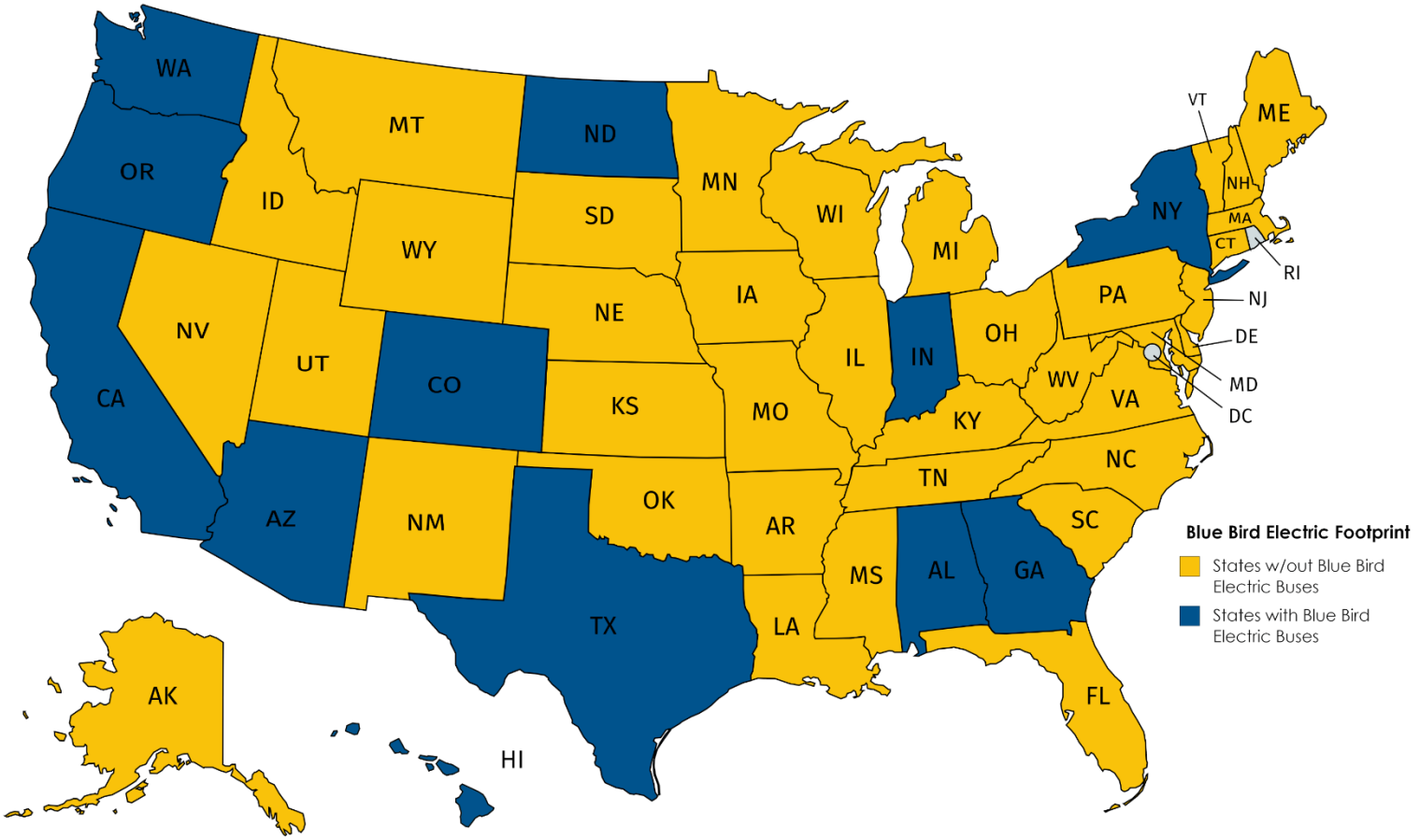
1 to 100 – in just 20 months!

September 2018



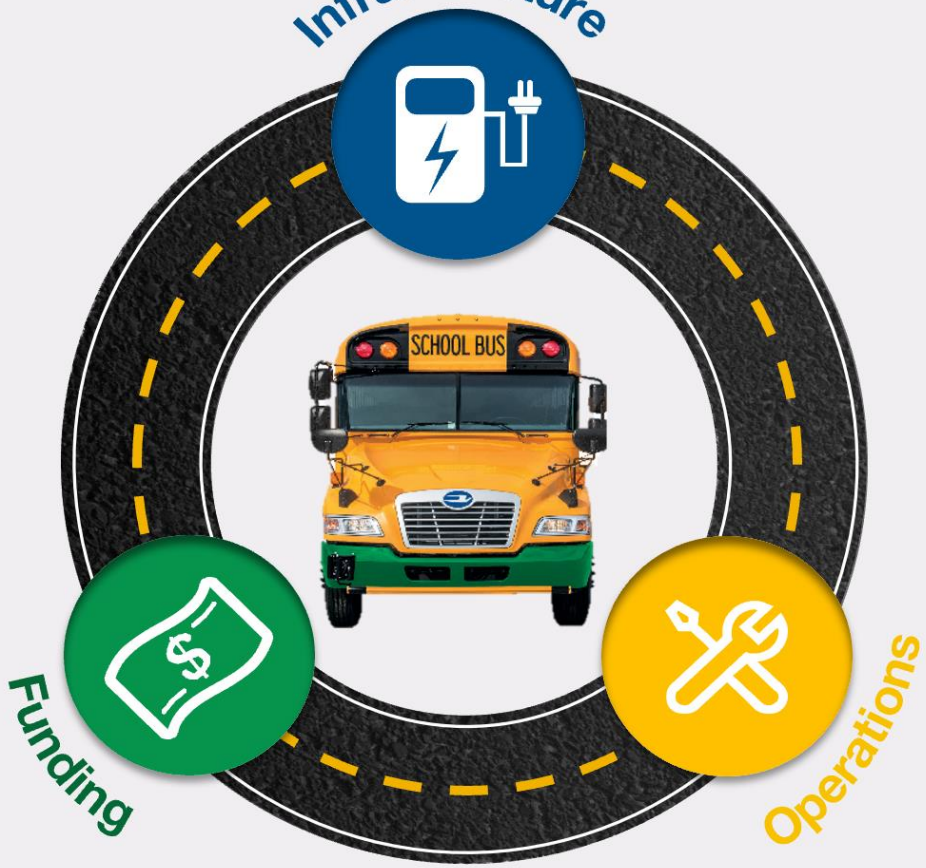
April 2020

Blue Bird – Electric School Bus Sales



BLUE BIRD

Turn-key solution



As Pioneers in the industry, Blue Bird has been navigating the electric bus landscape since the 90's. We've teamed up with the leading experts to bring you a school bus built on our legacy of quality, reliability and safety. Take a journey with us to see if Electric is the right choice for your fleet.

Total Cost of Ownership (TCO)

How do the acquisition cost and operational cost over the life of the vehicle compare to our current fleet?

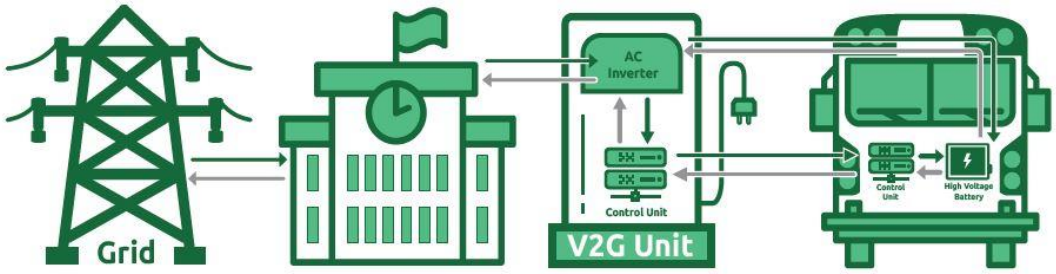
DIESEL VERSUS ELECTRIC COST OF OWNERSHIP

							Difference		Diesel	Electric	Savings
	Diesel Bus Cost		$100,000		Electric Bus Cost	$350,000	$250,000.00		15 Yr lifetime	15 Yr lifetime	**Over lifetime**
	Buy down		$0	*** Annual**	Grant Funding	($167,000)		*** Annual**			
	Replacement cycle		180	**Cost over**	Replacement cycle	180		**Cost over**			
	Resale		$0	**15 Years**	Resale	$0	$0.00	**15 Years**			
	Acquisition Cost:		**$100,000**	**$6,666.67**	**Acquisition Cost:**	**$183,000**	**$83,000.00**	**$12,200.00**			
	Maintenance Costs:				**Maintenance Costs:**						
	LOF		$380.00		LOF	$0	-$380.00		$5,700.00	$0.00	**$5,700.00**
	Fuel Filter		$110.00		Fuel Filter	$0	-$110.00		$1,650.00	$0.00	**$1,650.00**
	Trans service		$250.00		Trans service	$0	-$250.00		$3,750.00	$0.00	**$3,750.00**
	Tires		$733.33		Tires	$733	$0.00		$10,999.95	$10,999.95	**$0.00**
	Air Filter		$200.00		Air Filter	$0	-$200.00		$3,000.00	$0.00	**$3,000.00**
	Coolant Flush		$209.80		Coolant Flush	$209.80	$0.00		$3,147.00	$3,147.00	**$0.00**
	Hyd Fluid		$100.00		Hyd Fluid	$100	$0.00		$1,500.00	$1,500.00	**$0.00**
	Brakes		$600.00		Brakes	$150	-$450.00		$9,000.00	$2,250.00	**$6,750.00**
	Belts		$200.00		Belts	$0	-$200.00		$3,000.00	$0.00	**$3,000.00**
Annual Maintenance Total:			**$2,783.13**		**Annual Maintenance:**	**$1,193.13**	**($1,590.00)**		**$41,746.95**	**$17,896.95**	**$23,850.00**
	**** Fuel Costs:**				**** Fuel (Charging) Costs:**				**15 Yr Maintenance Savings:**		**($23,850.00)**
	Diesel Cost	$2.50	per gallon		*** Per kwh	$0.10			**15 Year Fuel Savings:**		**($59,273.44)**
	MPG	6			**** MPGe	24.78	136 kWh per 100 miles		**15 Year Total Savings:**		**($83,123.44)**
	Gallons/ year	2250			Kwh annually	18,360					
	DEF Cost	$2.89	(2.5% per diesel gal)						**Breakeven at $83,000 over the cost of a diesel bus.**		
	DEF Gal/year	56.25									
Annual Fuel Costs:		**$5,787.56**			**Annual Charging Costs:**	**$1,836.00**	**($3,951.56)**				
Diesel TCO:		**$15,237.36**	**Annually**		**Electric Bus TCO:**	**$15,229.13**	**Annually**	**($8.23)**	**Saving $8.23 annually over the 15 year life of the bus, so $123.45 total saved.**		
Diesel cost per mile		**$1.13**			**Electric cost per mile**	**$1.13**					

Vehicle-To-Grid

V2G

What is Vehicle-To-Grid?



V2G creates opportunities for utilities to "buy back" stored energy that the buses are not using.

V2G also creates the ability redirect the excess power to other structures like the building or fuel island.

This is valuable for peak season consumption times, as well as natural disasters when energy needs increase.

Standard Offering – 60kW V2G System

School Bus Fleets Attractive Partners for Utilities

- Are a better source of distributed power because their usage patterns are predictable.
- They are idle at precisely the times when energy demand is at its peak — midday and during the hottest summer months.
- By storing or drawing power from a fleet of parked school buses, utilities can avoid wasting surplus energy from renewables or cranking up a natural gas power plant, for example.
- NightTime Charging provides favorable Utility Rates.

V2G Charger Requirements

- We have partnered with Nuvve for 60kw DCFC and V2G
- Due to the lack of ISO standards in the industry we are working with Nuvve to develop the language to enable V2G capability

The Nuvve DC Heavy-Duty Charging Station (EVSE-HD60) is designed specifically for vehicle-to-grid (V2G) applications and is the ideal solution for the rapid, smart charging of heavy-duty fleet vehicles such as electric school buses. The EVSE-HD60 is fully controllable through Nuvve's fleet management app and our V2G platform (GIVeTM) enables unidirectional charging of any vehicle or full, bidirectional V2G and vehicle-to-building (V2B) services when connected to a V2G-compatible vehicle.

NUVVE – EVSE-HD60

Safety and Product

Major System Components

Safety – Protecting What is Most Important

Crash Testing

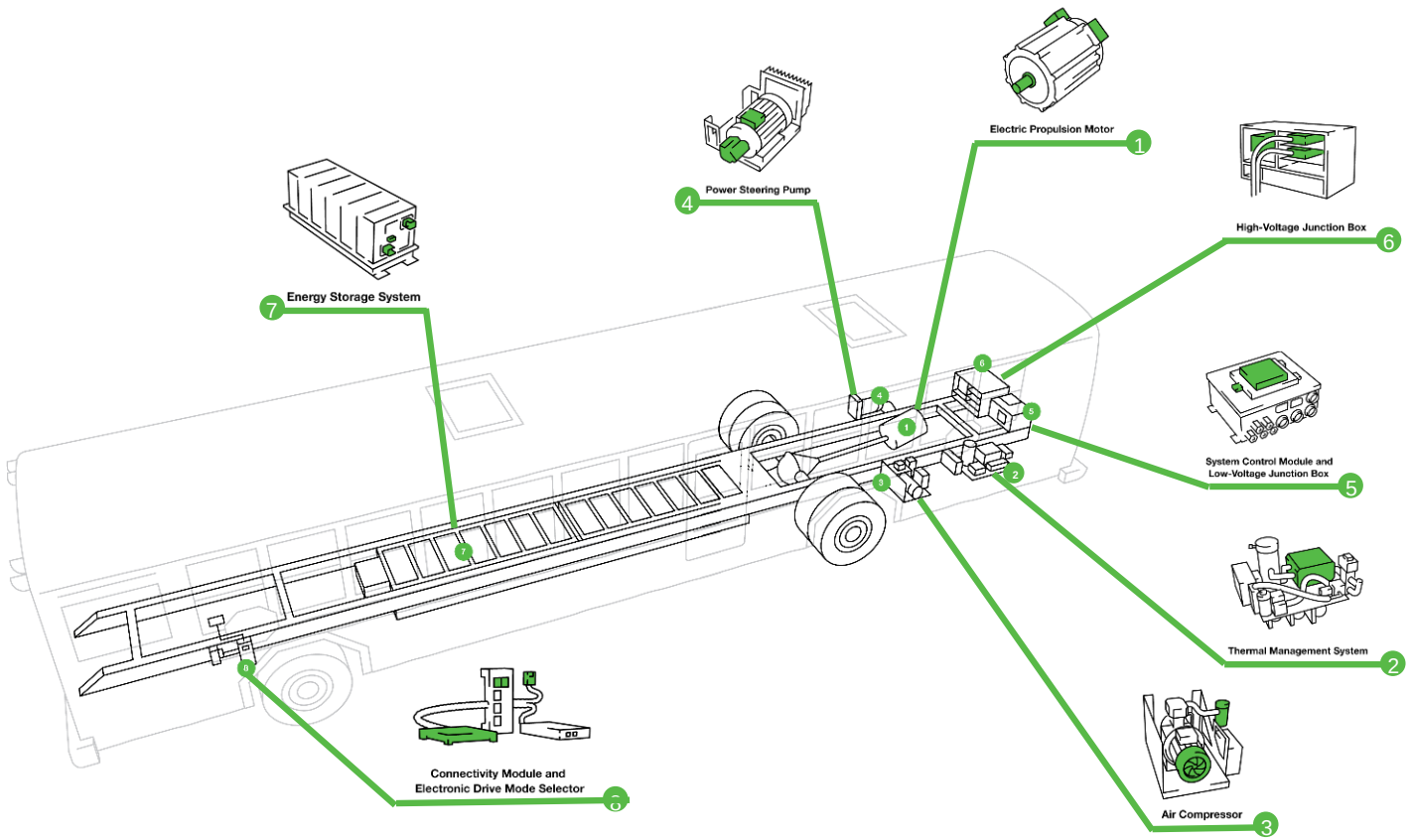
- ✓ Blue Bird is certified to the Canadian Motor Vehicle Safety Standard **CMVSS 301.1** testing protocol, higher than US
- ✓ 4,000 lbs. @ 30 MPH
- ✓ Angled side and rear impact

Other Features

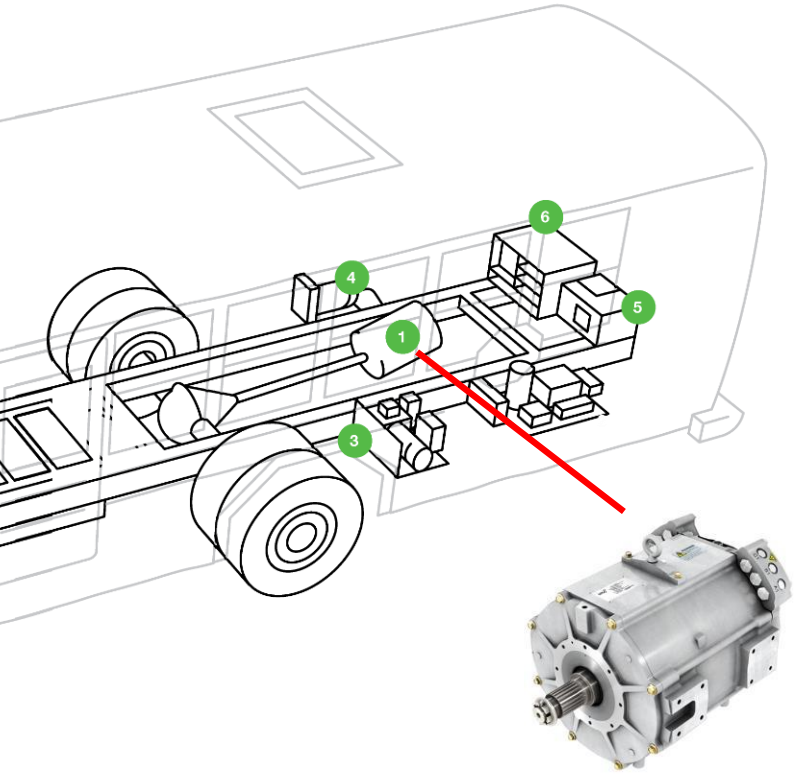
- ✓ **Colorado Rack Test and the Kentucky Pole Test**—are engineered specification requirements at Blue Bird.
  - *Colorado Rack Test: Ensures that the structural integrity of the bus remains intact in the event of a rollover accident*
  - *Kentucky Pole Test: Ensures the strength of the school bus roof in case of a pole, or another sharp object impacts the bus during a rollover*

Blue Bird / Cummins Partnership

Major System Components

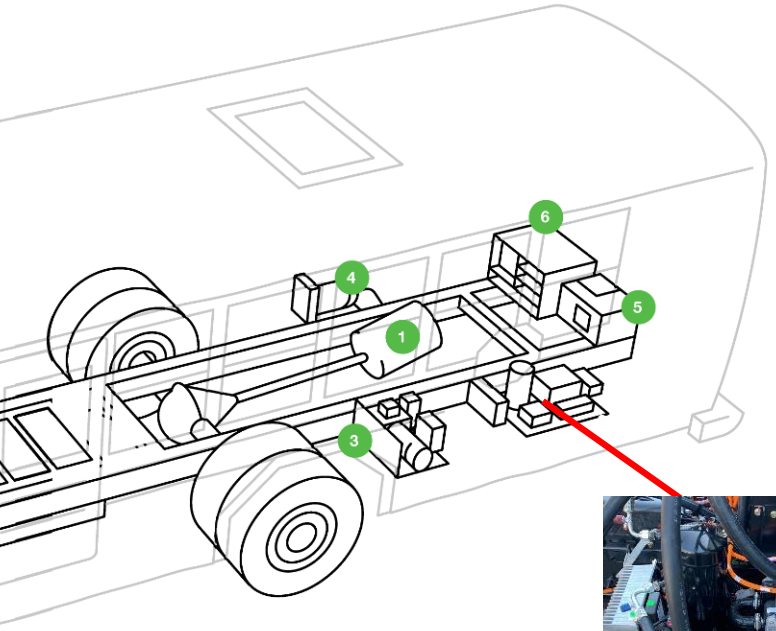


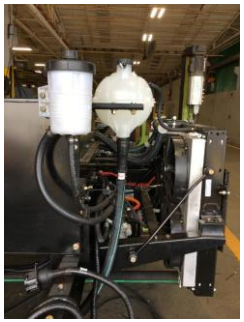
Product – Electric Propulsion Motor



- **TM4 SUMO Motor is a six-phase AC permanent magnet induction motor – Standard motor in the EV school bus industry.**
- **We use model – HV3000-6P**
- **Requires water cooled inverter to change 600V battery DC to AC current**
- **Motor rated at 315 HP / 2,176 ft-lb torque;**
- **No Transmission. Direct coupled to the rear drive axle with short drive shaft**
- **No transmission means only two gears = forward + reverse**
- **Drive motor max torque and power at very low RPM's enables acceleration at greater rate than other fuel types**

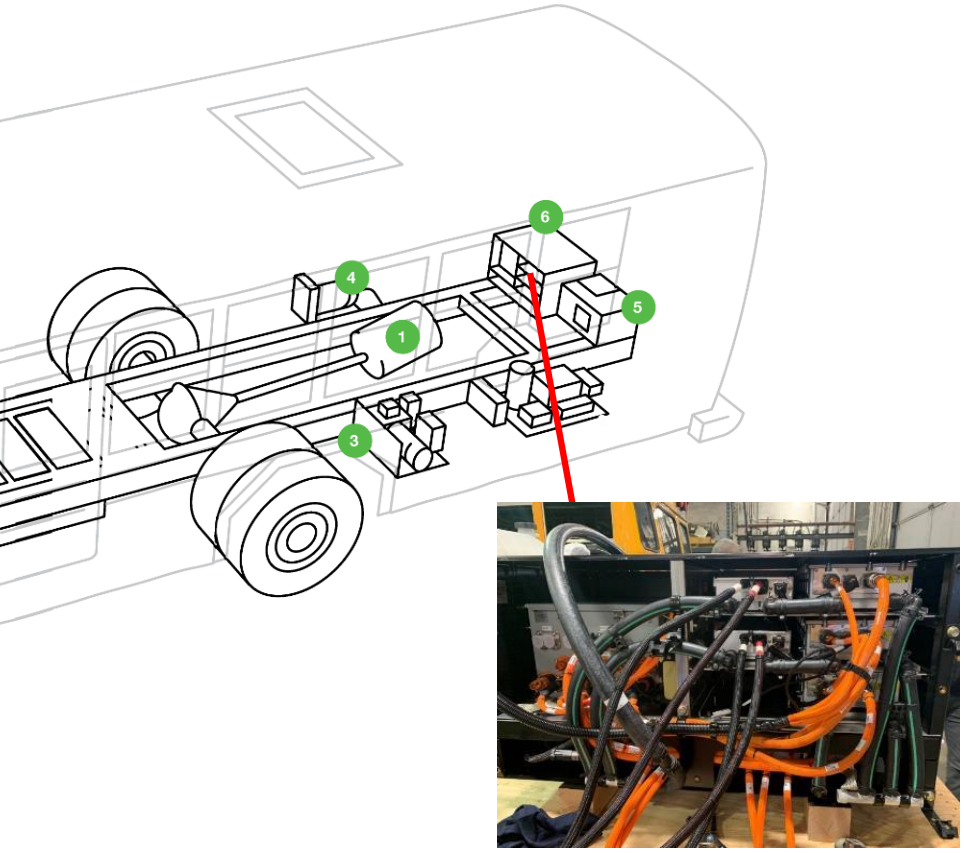
Product – Thermal Management System





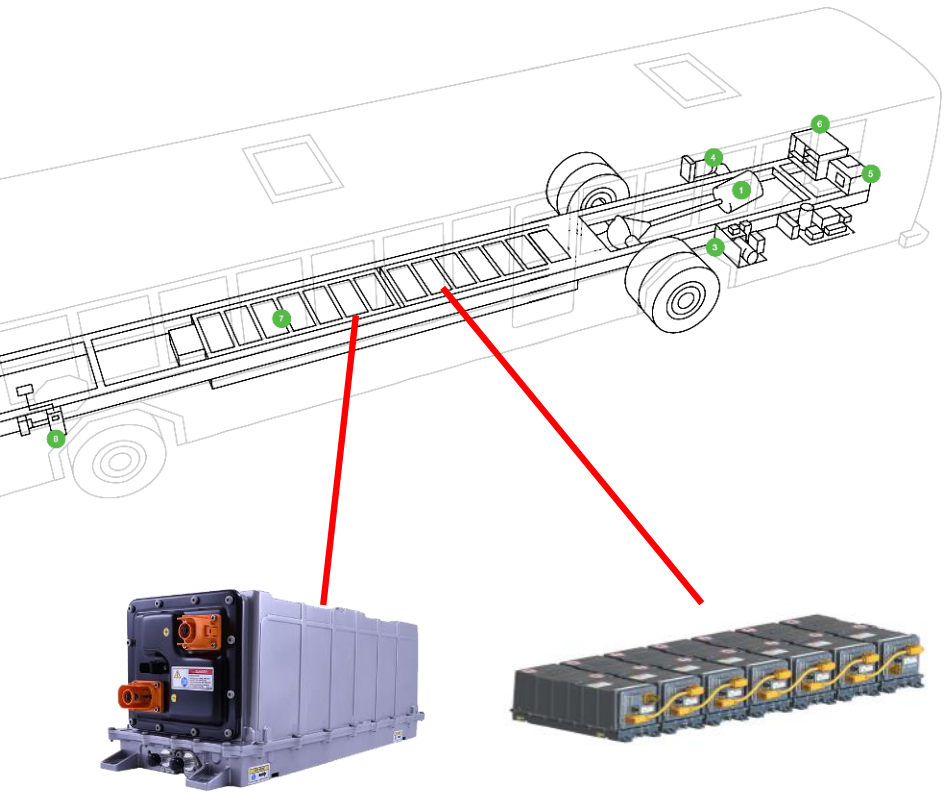
- **Responsible for controlling the temperature of the batteries, drive motor, body and HV module**
- **Batteries must maintain a certain temperature, about 75-80° to maximize efficiency**
- **Comprised of 3 heater modules. <u>One</u> dedicated 12.5 kilowatt battery heater heats the coolant if the batteries are not warm enough to charge. <u>Two</u> - 12.5 kilowatt heaters are dedicated to the body to include the defroster, entrance heaters and underseat heaters =Total 84,000 BTU**
- **One - Chiller module chills coolant to cool batteries, motor and HV module when needed.**
- **The TMS also incorporates the coolant system run by a standard radiator with 4 cooling fans. Same radiator on our gas and propane buses.**

Product – High Voltage System



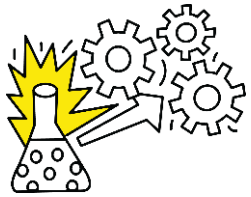
- Receives HV power from the 14 batteries. Distributes that power to a variety of components…air compressor, power steering pump and main drive motor
- Receives power from the on board chargers to send into the HV batteries
- Houses both high and low voltage components
- Acts as common electrical distribution point for both high and low voltage components
- None of the components in this module are serviceable
- The T3 and CV use the same high voltage module just mounted in a different place

Product – Batteries



- Batteries are XALT Energy XPAND Modular Pack (XMP)
- They are referred to as Li-NMC-G batteries, which is Lithium-Nickel Manganese Cobalt-Graphite
- CV and RE use 14 batteries divided into two groups of seven. Each group of seven is called a string
- Each battery weighs 170 pounds and rated at 88.3 Volts each
- Wired in series and parallel to provide 620-700 volts and roughly 240 amps to power the bus.
- Each battery is cooled or heated with orange Dex-Cool that is controlled by the thermal management system
- Total capacity is 155 kWh

Product – Batteries



- **Batteries are rated for 3,000 charge cycles; Cycle is 0% SOC to 100% SOC**
- **Opportunity charging is only a percentage of a charge**
- **Projected life is 8-10 years with approx. 80% charge capacity**

What causes batteries to degrade or discharge?

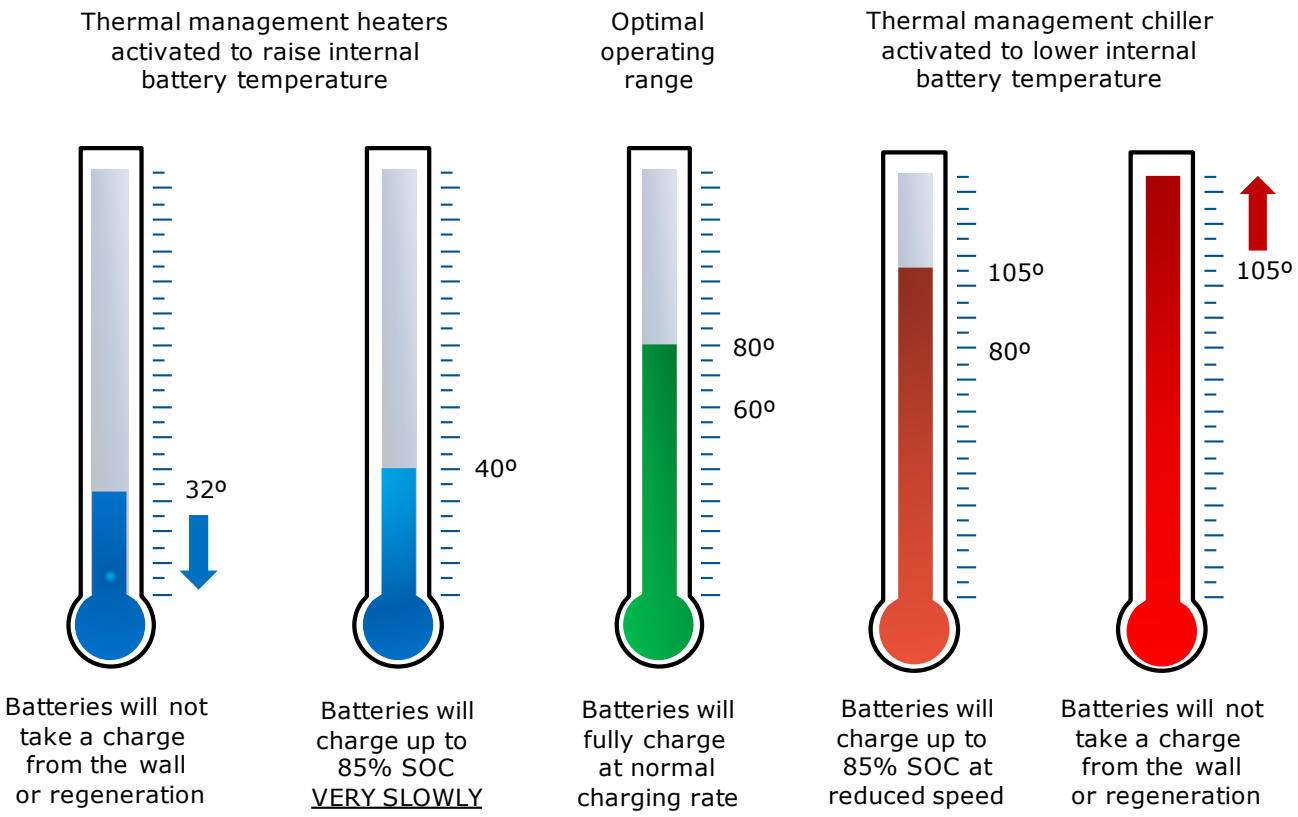
DEGRADE – On-going reduction in ability to charge to full nominal capacity

- Calendar Degradation – Approximately 1.5% per year
- Usage Degradation - Variable
  - Charging (Rate and Number of Cycles)
  - Discharging (Rate and Number of Cycles)
  - High Temperature
  - Sitting at a High SOC
  - Sitting at a Low SOC
- "Exercising" the batteries during long idle times will help maintain life of the batteries

DISCHARGE – Losing battery power while idle

- Will naturally discharge at a rate of approx. 2% per month at 70F. More if hotter and less if colder

Battery Temperature & SOC



Planning Considerations

BUS STORAGE – Cold Climates

- Park the bus inside of a heated building at night, over the weekend and holidays.
- If inside charging is not feasible, park in a protected area out of the wind as much as possible.
- Using the heaters will reduce the range by approximately 20-25%. Turn off heaters when comfortable.
- Likewise, using the AC (if selected as an option) will reduce the range by approximately 30%. Turn off AC when comfortable.
- Opportunity charge in the middle of the day while the bus is warm after the morning route.
- Charge the bus as soon as the last route is complete while it's still warm.

Product
Preventive Maintenance

Maintenance Differences

Diesel Powertrain

- Cummins ISB – 15 Quarts of Oil and Filter every 6 months. Disposal
- Allison Transmission – Replace Filter every 50K miles. Fluid every 48 months.
- Fuel System – Primary Filter/Water Separator – 6 months
- Exhaust System – DEF Filter, DEF Tank Head Unit Filter
- Air Intake Filter – 12k miles/12 months

Electric Drivetrain

- Sumo Electric Motor – No lubricating oil
- No Transmission
- No Fuel Filters
- No Exhaust
- Does not require air filter

Approximately 80% Reduction in Maintenance Costs

Electric Bus Preventative Maintenance

- **Air Compressor – Oil Change**
  - First oil change – 6,000 miles or 6 months
  - After this every 18,000 miles or 12 months
- **Drive Motor**
  - Torque hardware every 12 months
  - No other maintenance required
- **Thermal Management System**
  - Check coolant level every 12 months
  - Drain and refill every 5 years/150,000 miles
  - Change coolant filter once indicator is on RED
- **Electric Power Steering**
  - Check and maintain fluid level every 12 months/20,000 miles
- **Battery System**
  - Torque hardware every 12 months/20,000 miles

Vehicle Range and Charging Options

Range: Type C & D

Vision Electric

GVWR: Up to 33,000 lbs.
Range: Up to 120 miles

All American RE Electric

GVWR: Up to 36,200 lbs.
Range: Up to 120 miles

Range will be dependent on terrain, driver habits and the use of heating and A/C.

Charging: Blue Bird EV Standard Feature

1) AC Level 2

2) DC Fast Charge (Note: Vehicle to Grid “V2G” requires a level 3 charger)

AC Charging, Level 2, SAE J1772

- **Connector** – SAE J1772 Plug. Three pins used to transfer ac current from EVSE to the bus. Two pins used for communication link between chargers and EVSE.
- **Power Required** - For maximum 19.2kw/hour charge rate, each EVSE must be supplied with single phase, 240v, 80 amp ac current with a 100 amp fuse. If only a 50 amp circuit breaker is available, the bus will charge at a rate up to 9.6 kW/hour
- **Charge Time** – Approximately 8 hours
- **Charger Cost –** Approximately $2,000-$5,000, for the hardware without installation.

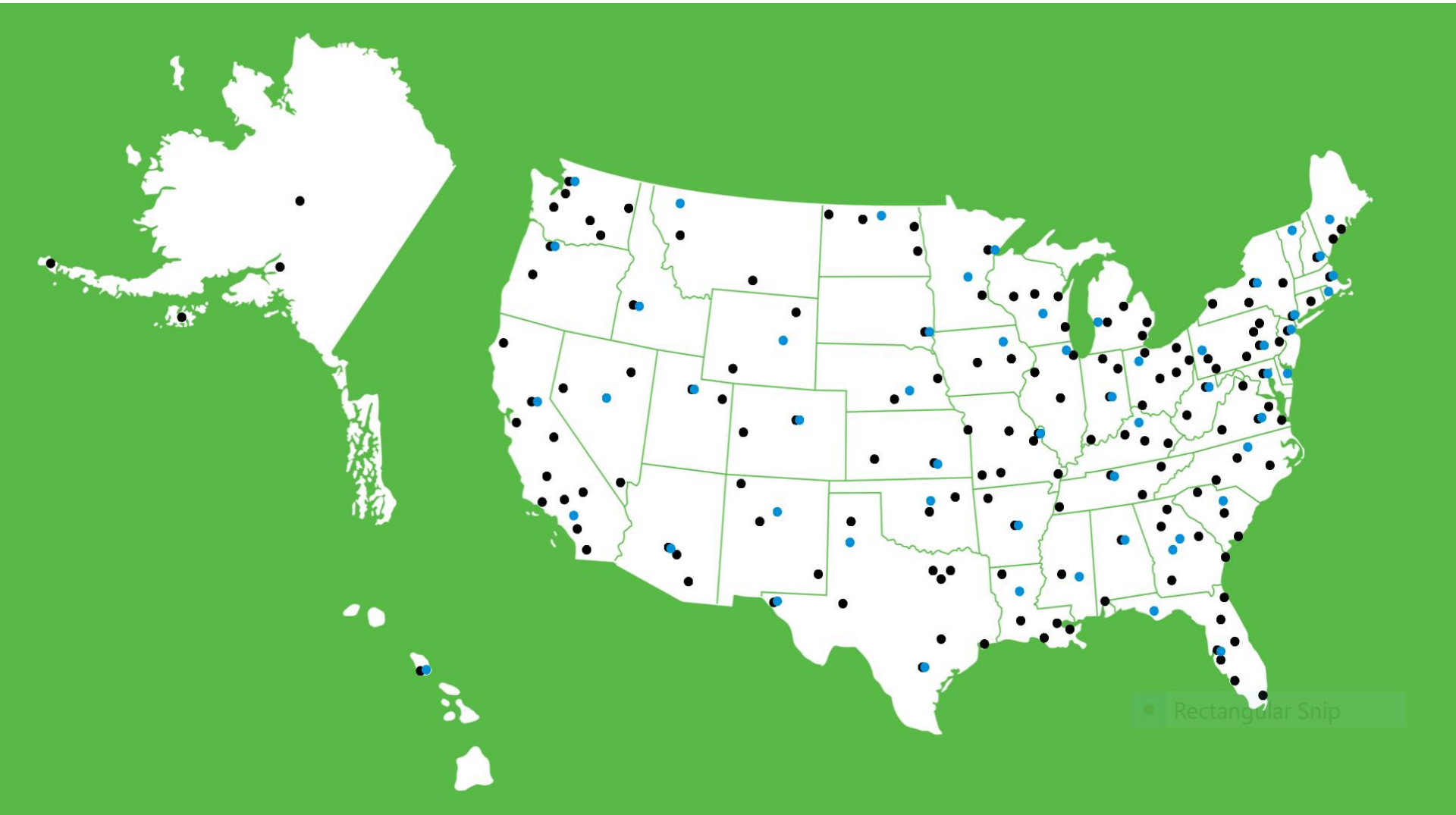
DC Fast Charge (DCFC), Level 3, CCS1

- **Connector** - The plug is a Combined Charging System Level 1 (CCS1). Combines a J1772 plug with two extra pins for dc current
- **Power Required** - For maximum 60kw/hour charge rate, each station must be supplied with three phase, 480VAC, 130 amp continuous.
- **Charge Time** - Charging time will go to approximately 3 hours
- **Charger Costs** - DC Fast Charging systems are more expensive: $20,000 - $60,000 for hardware not including installation.

Service and Training

SERVCE : Blue Bird Support and Cummins Service Centers

Dedicated Blue Bird Dealers Across North America
Combined with Vast Cummins Service Footprint



Service

Cummins Dealer

- All High Voltage Components
  - High Voltage System
  - Low Voltage System
  - Batteries
  - Motor
  - TMS System

Blue Bird Dealer

- Not allowed to service any High Voltage Components
- Serviceable items by Blue Bird Dealer
  - Coolant & Filter - TMS System
  - Power Steering Fluid
  - Air Compressor Oil Change
  - Torque Motor and Battery Hardware

Training

https://vantage.blue-bird.com/Portal/Vantage-Home.aspx

Online, On Location, and at the Blue Bird Plant

- EV Driver Training
- Technician Training
- Technical Training Events
- EVSE (Electric Vehicle Supply Equipment)

Thank You!

For more information visit:
www.electricdreambus.com

Albert Burleigh
Blue Bird Corporation
Albert.Burleigh@blue-bird.com
(478) 919-7311