

THE PROTERRA ZX5 ELECTRIC TRANSIT BUS



2021 MPTA Conference

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TOPICS

Introduction & Agenda

Proterra Overview

Where do we start?

Process of engagement

Charging and Infrastructure

Proterra ZX5 Electric Bus

5th generation vehicle

Battery Technology & Safety

Optimizing for Extreme Weather

2021 Low or No Emissions!

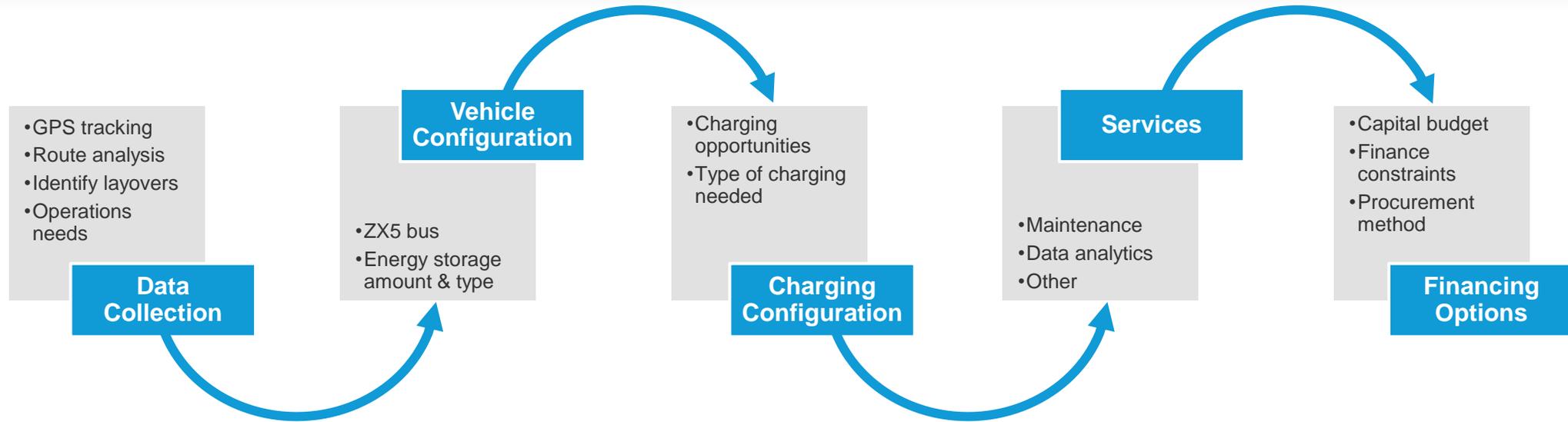


Proterra is a leader in the design & manufacture of zero-emission electric transit vehicles & EV technology for commercial applications.

- Over a decade of EV deliveries
- Offices & manufacturing in CA & SC
- **>1,000** buses sold to 130+ customers across 43 states & provinces
- **>16,000,000** service miles
- **>54 MW** installed charging infrastructure



THE PROTERRA PROCESS OF ENGAGEMENT



Proterra's approach is to work with you to identify the most efficient, most cost-effective way to electrify your high-priority routes. From riding your routes to structuring a financing package, we take a consultative approach and support you throughout the entire process. **Let's get started!**

SCENARIO: DEPLOYING ONE ELECTRIC BUS ROUTE ANALYSIS



The Proterra team performs a **detailed analysis** to make an **informed recommendation** on the right vehicle and charger configuration for your use case.

- Analysis shows efficiency different Proterra vehicles will achieve on your routes.
- Conservative approach – showing you how vehicles will perform in different weather conditions

Route Information	E2	E2MAX
Route Name	0L	
Distance	6 miles	
Duration	34 minutes	
Average Speed	10.4 mph	
Maximum Speed	33 mph	
Maximum Grade	1.2 %	
Average Day Results		
Passenger Count	40	
Ambient Temperature	51°F	
Efficiency	1.887 kWh/mi	1.852 kWh/mi
MPGe	19.9	19.2
Total Energy Consumed	11.3 kWh	11.7 kWh
Estimated range with full charge	186 miles	271 miles
System Energy Recovered by Regen	26%	30%
1 Lap Full SOC	95.5%	97.5%
Estimated 1 Lap Recharge Time (On route charge)	760	720
Environmental and Operating Impact		
Hot Day		
Passenger Count	40	
Ambient Temperature	89°F	
Efficiency	2.332 kWh/mi	2.397 kWh/mi
MPGe	16.1	15.7
Estimated range with full charge	157 miles	220 miles
Cold Day (F)		
Passenger Count	40	
Ambient Temperature	15°F	
Efficiency	3.346 kWh/mi	3.443 kWh/mi
MPGe	11.2	10.9
Estimated range with full charge	155 miles	152 miles

	ZX5+ 450 kWh	ZX5 MAX 675 kWh
Temperate weather	Estimated range 215 miles	331 miles
Hot weather	Estimated range 181 miles	263 miles
Cold weather	Estimated range 155 miles	223 miles

Example figures for illustrative purposes

Route Testing Summary

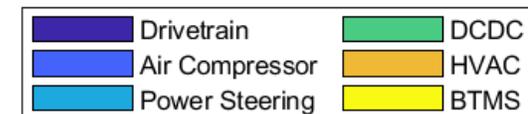
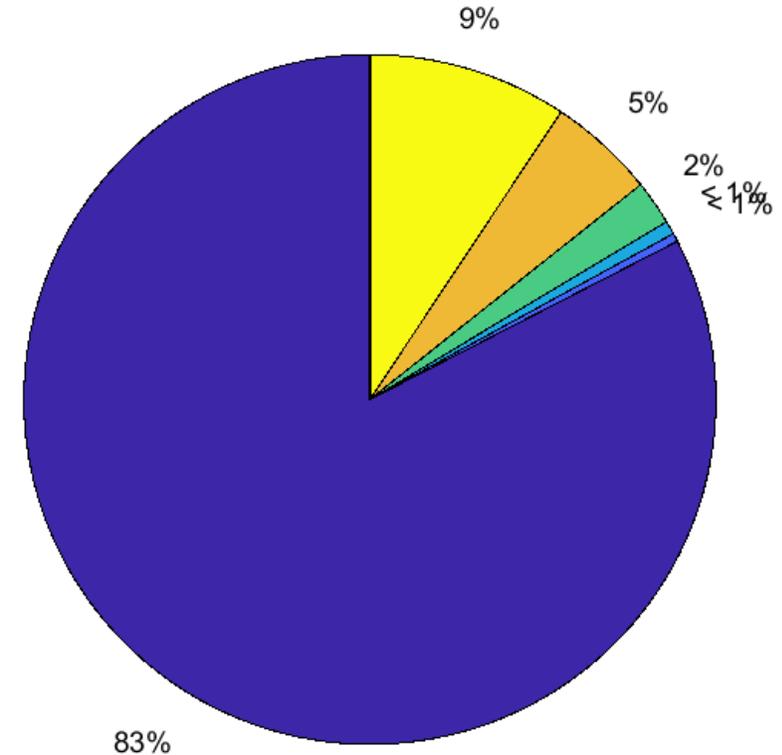
Denver RTD in Feb 2021



VIN	7JZTH13J9LL000261
Date	1/25/2021 mm/dd/yyyy
Start time	10:30 AM hh:mm
End time	11:40 AM hh:mm
Simulated Load	37 Passengers
Simulated Load	5,550 lbs
Average Ambient Temp	41.8 degF
Average Speed	37.9 mph
Distance	42.3 miles
Net energy used	88.59 kWh
Regen Energy	30.65 kWh
Overall Efficiency	2.096 kWh/mi
Starting SOC	91.5%
Ending SOC	73.9%
Extrapolated Max Range*	289 miles

*Assuming 100% use of 90% usable energy for ZX5 Max (675 kWhr nameplate)

Energy Distribution



INTRODUCING PROTERRA ENERGY FLEET SOLUTIONS TURN-KEY ENERGY DELIVERY FOR ELECTRIC FLEETS



PROTERRA ENERGY™ FLEET SOLUTIONS



LARGE FLEET SOLUTIONS



1.5 MW



SMALL FLEET SOLUTIONS



75 kW



150 kW



250 kW



500 kW

OVERHEAD CHARGING EXAMPLE



PROTERRA® **ZX5**



REFINED BODY

- Streamlined roof to accommodate additional battery packs
- Reduced height to cover even more routes
- Flexible charging with additional front port

BUILT FOR SCALE

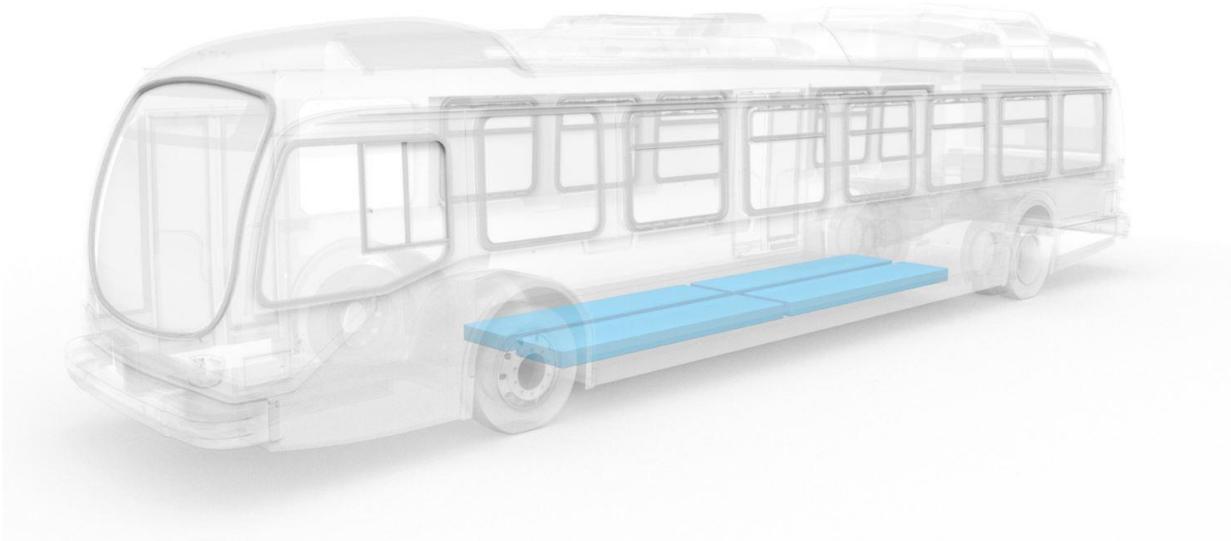
- Enhanced manufacturability for scaled production
- More commonality across platforms
- More advanced automotive approach

SMOOTHER RIDE

- New shocks and ride height system
- Improved maneuverability, faster kneeling
- Enhanced comfort and ergonomics of driver area

Proterra buses are purpose-built from the ground up to be electric, enabling the safest placement of batteries

- Underneath and outside of passenger compartment
- Separated by a sealed bulkhead below the floor of the bus
- Avoids placing batteries in the rear of bus, which is a common crash zone
- Battery placement creates a lower center of gravity for greatest vehicle stability



THE PROTERRA ZX5 PLATFORM

ADVANCED COMPOSITE BUS BODY



	COMPOSITE	ALUMINUM	STEEL
LIGHTWEIGHT	●	●	●
IMPACT-RESISTANT	●	●	●
CORROSION-FREE	●	●	●

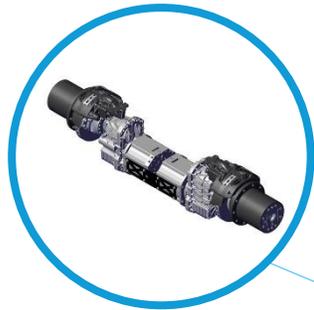
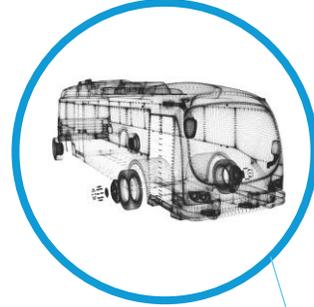
Proterra's use of advanced composite materials makes the Proterra ZX5 not only the most **efficient** vehicle in its class, but extremely **durable and safe** as well.

- Advanced carbon-fiber-reinforced composite material
- Super strong, lightweight and impact-resistant
- Non-conductive and rust-resistant

HIGHLY DIFFERENTIATED AND FULLY INTEGRATED HEAVY DUTY TECHNOLOGY PLATFORM

Advanced Composite Body

Lightweight and durable
carbon-fiber-reinforced composite

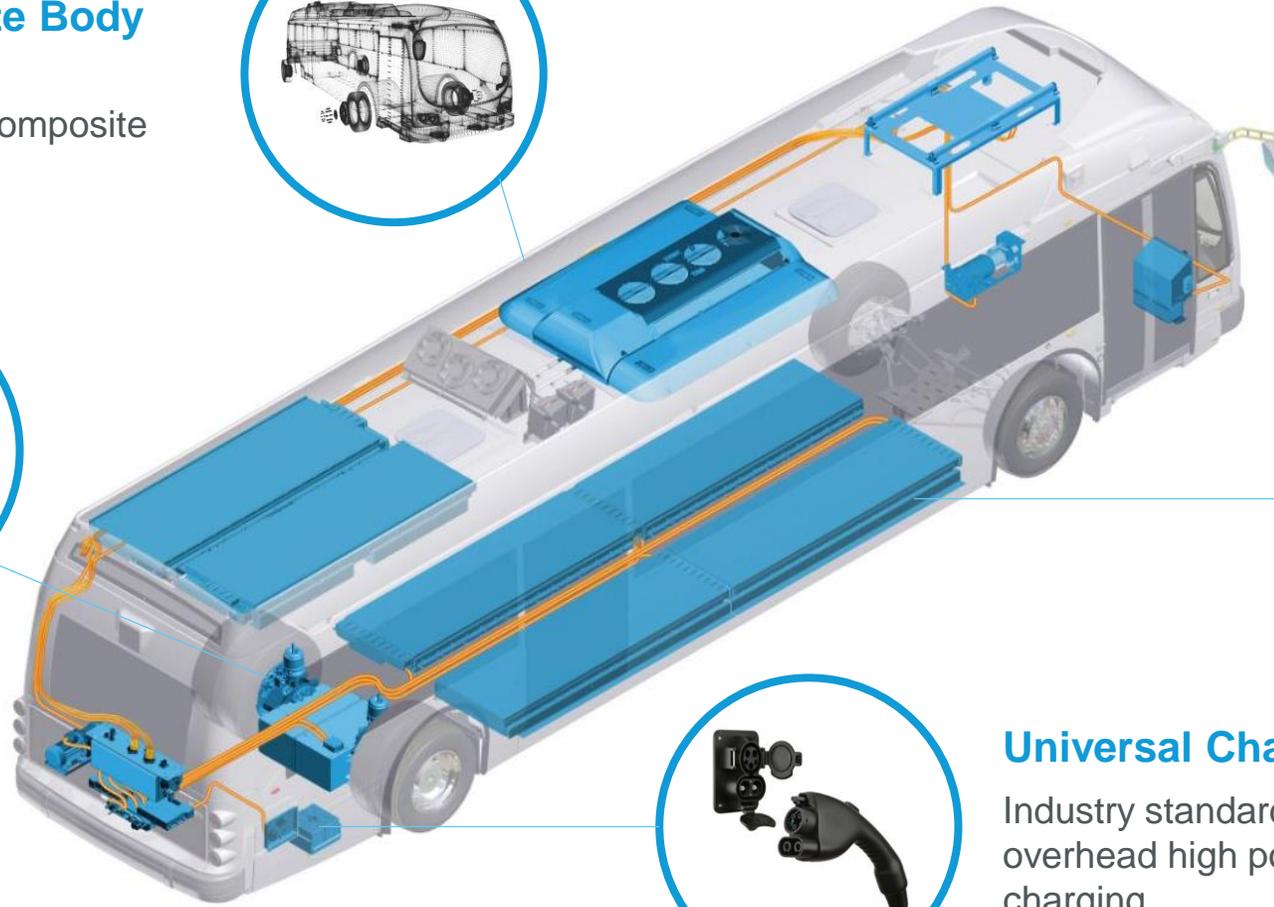
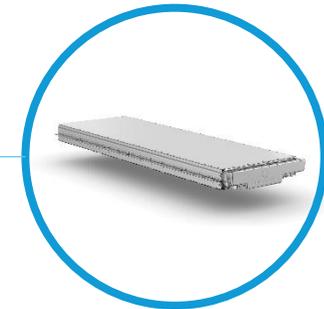


High Efficiency Drivetrain

5x efficiency of diesel
Greatest horsepower
Fastest acceleration

Heavy Duty Battery Pack

High energy density,
ruggedized battery packs
purpose built for commercial
vehicles



Universal Charging

Industry standard plug-in and
overhead high power Level 3
charging

Proterra battery packs have undergone extensive testing to meet the highest safety standards.



Tests performed to account for possible incidents such as:

- Vehicle crash
- Road debris striking the battery pack
- Street manhole cover explosion
- Defective or failed cell within pack
- Overcharge of high voltage system
- Coolant flood internal to battery pack
- Fuel fire external to the vehicle (collision with a combustion engine vehicle)

EXTENSIVE BATTERY TESTING TO HIGHEST QUALITY STANDARDS



Safety/Abuse Tests	Conditions	Reference	Performed
Mechanical Shock - Crash	10G, 100ms, X and Y axis	ECE R80	Yes
Impact/Underside Abuse	Manhole Cover, Pyramid, Ballistics	Proterra Internal	Yes
Drop	2m drop, concrete floor	SAE J2464 Sec 4.3.2	Yes
Battery Enclosure Integrity - Crush	100kN of force	SAE J2929 Sec 4.6 UL 2580 Sec 38 ECE R100 Annex 8D	Yes
Passive Propagation Resistance	Max Temp, Max SOC	SAE J2464 Sec 4.4.5 UL 2580 Sec 43	Yes
Forced Thermal Runaway	Confidential	Proterra Internal	Yes
Simulated Vehicle Fire	3 min exposure to fire underneath pack	SAE J2929 Sec 4.7 ECE R100 Annex 8E	Yes
Short Circuit	5mΩ hard short, 20mΩ soft short	ECE R100 Annex 8F SAE J2929 Sec 4.8 SAE J2464 Sec 4.5.1 UN 38.3	Yes
Coolant Flood	Forced cooling system leak internal of pack enclosure	Proterra Internal	Yes
UN/DOT Transportation	T.1, T.2, T.3, T.4, T.5	UN 38.3	Yes
Single-point and Multi-point Over Charge	Uncontrolled charge	SAE J2929 Sec 4.9 SAE J2464 Sec 4.5.2 ECE R100 Annex 8G	Yes
Single-point and Multi-point Over Discharge	Uncontrolled discharge	SAE J2929 Sec 4.10 SAE J2464 Sec 4.5.3 ECE R100 Annex 8H	Yes
Single-point and Multi-point Thermal Control Failure	Charge and Discharge without thermal management	SAE J2929 Sec 4.11 SAE J2464 Sec 4.4.3 ECE R100 Annex 8I	Yes
Fault Analysis	Fault analysis of battery system	SAE J2929 Sec 4.12	Yes
Protection Against High Voltage Exposure	IP2xB	SAE J2929 Sec 4.13	Yes

Note: Proterra Internal Reliability Requirements have been developed using specifications for from standards bodies such as SAE, ISO, and IEC and meet or exceed external standards.

- **Quality**

- Manufactured by Tier 1 cell supplier, LG Chem
- Tier 1 cell suppliers have higher quality requirements, more stringent spec tolerances, larger qualification sample requirements
- Manufacturing in a cylindrical form factor has been optimized and mastered over more than a century

- **Safety**

- With thousands of cylindrical cells in each battery pack, if a single cell stops working it will have a minor impact on the whole pack
- If a single cell has a thermal event, it's easier to contain with a small cell than with larger pouch cells
- Cylindrical cells are used widely in consumer goods and many applications; they are well standardized and produced by every Tier 1 battery manufacturer in the world

- **Energy Density**

- Proterra has the most energy dense cells out of battery-electric bus manufacturers in North America

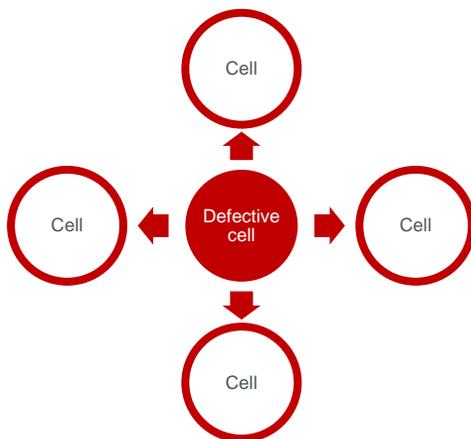


Cylindrical cell



WITHOUT PPR

Defective cell can cause cascading failure of adjacent cells

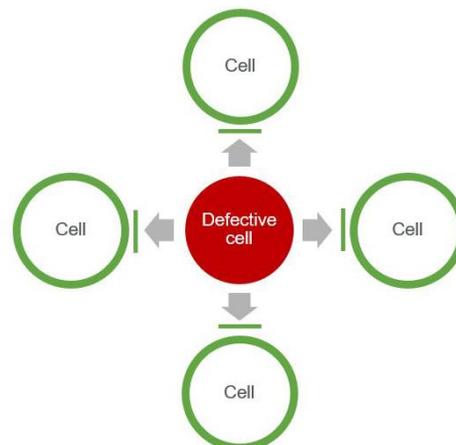


UNSAFE BATTERY DESIGN

Alternate battery design

WITH PPR

Adjacent cells are unaffected by defective cell



SAFE BATTERY DESIGN

Proterra battery design

PROTERRA BATTERY DESIGN ENABLES PPR

- Small format, cylindrical cells
- Pack is designed such that a defective cell will be isolated and will not cause complications throughout the entire pack



PROTERRA

THE PROTERRA ZX5 OPTIMIZED FOR COLD WEATHER



All Proterra ZX5 buses come standard with features for optimal operation in cold weather:

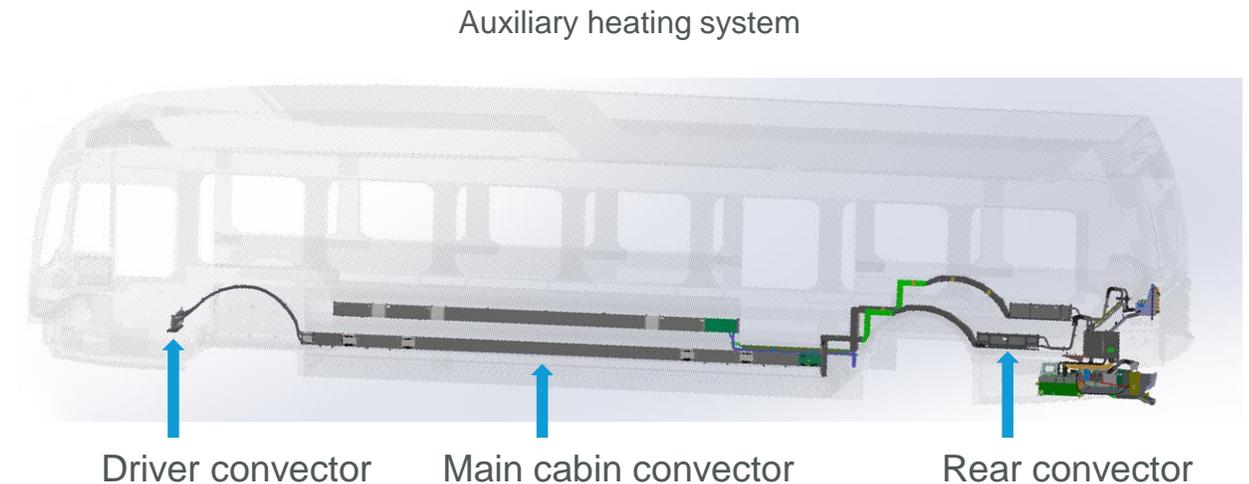
- Battery thermal management
 - Coolant heater
- Heated overhead charging
 - Standard for all buses configured for overhead charging
- Heated exterior mirrors
- Heating duct to front door area
- Standard HVAC system & defroster



Proterra bus in Park City, Utah departing overhead charger – January 2019

Cold weather package:

- **Auxiliary heating system**
 - Fuel-fired aux heat provides 2x total heating capacity, heating the bus faster and increasing range
- **Heated driver's seat**
 - Reduce reliance on HVAC & defroster
 - More comfortable operator experience
- **Fabric ducting**
 - More efficient airflow helps bus heat faster and draws less energy from batteries
- **Heated rear doorway**
 - Safety feature provides better grip for passengers when floor is icy



\$180 MILLION AVAILABLE IN LOW-NO GRANTS

APRIL DEADLINE TO APPLY



- **\$180 million is available** in FTA grants for low or no emission buses and chargers
 - Most funding in the history of the Low-No Program
 - Electric buses, chargers, and associated electric bus infrastructure are eligible
- **Partner with Proterra**
 - Applicants may partner with Proterra and satisfy federal competitive procurement requirements
 - Proterra can help you apply and meet the April 12th deadline



Transit agencies who partnered with Proterra during previous rounds of Low-No funding received the majority of all Low-No funding awarded for battery-electric buses with a partner, representing more than \$177 million in grant funds.

THANK YOU!



PROTERRA



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