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ABOUT ME

• Mechanical Engineer
• Robotics and Automation
• At Proterra for 2 years
ABOUT PROTERRA

Proterra’s Mission
Advancing electric vehicle technology to deliver the world’s best-performing transit vehicles

- Proterra makes:
  - Electric buses
  - Core technologies required to execute electric buses
- Founded in 2004
- Offices and manufacturing in CA and SC
- 300+ employees
- >60 customers; >500 vehicles sold
- >150 vehicles delivered; >4,000,000 service miles
EV CUSTOMERS SPAN THE UNITED STATES

512 buses sold to 64 customers across 29 states
Proterra is the market leader in electro-mobility

- Diesel and CNG buses are the primary fuel types used today
- As the leader of the electric transit bus market, Proterra is well positioned to capture immense growth

Source: National Transit Database 2016, management estimates.
1. Market data as total number of buses sold over life time of the respective companies
2. Frost and Sullivan
• Battery-electric vehicles have the lowest operational lifecycle cost

• High EV energy efficiency, low electricity rates, and high annual vehicle mileage combine to create significant fuel savings
  - Electric buses have a fuel efficiency of 2kWh/mi compared to diesel’s equivalent of ~10 kWh/mi
  - Electricity prices are also more stable and predictable than volatile fossil fuel prices

• Electric buses have 30% fewer parts, dramatically reducing maintenance and operating costs

Source: Management Estimates
(1) Assumes annual mileage of 34,000 miles
INDUSTRY LEADER IN HEAVY DUTY EV TECHNOLOGY

**Advanced Composite Body**
Lightweight and durable carbon-fiber-reinforced composite

**Heavy Duty Battery Pack**
High energy density, ruggedized and purpose built for commercial vehicles

**High Efficiency Drivetrain**
2X horsepower, 2X acceleration, 5X efficiency of diesel, 26.1 MPGe

**Universal Charging**
Industry standard plug-in and overhead high power Level 3 charging
THE PROTERRA CATALYST’S RANGE

*Depending on model. Nominal range = total energy/ projected Altoona efficiency. Actual range will vary with route conditions, battery configuration and driver behavior.

WORLD RECORD!

Catalyst E2 max
660 kWh

1101.2 miles

For 24-hour circulator routes
12-15 miles recharged per 5 min
55-72 miles nominal range*

Catalyst PC
79 kWh

Catalyst PC+
105 kWh

Catalyst XR
220 kWh

Catalyst XR+
330 kWh

Catalyst E2
440 kWh

Catalyst E2+
550 kWh

For low daily mileage
< 2.5 hrs. charge time
136-193 miles nominal range*

XR Series

For longest routes
< 4.5 hrs. charge time
251-350 miles nominal range*

E2 Series
PROTERRA’S CORE TECHNOLOGY IS APPLICABLE TO A VARIETY OF END-MARKETS

Proterra Core Technologies

- Bi-Directional Power Control Systems
- High Voltage Battery Packs
- High Power/Efficiency Drivetrain

Proterra Transit Vehicles

Heavy Duty Vehicle Electrification

Fleet Infrastructure

Stationary Storage
CELL SELECTION: DISCHARGE THROUGHPUT

Standard Battery Applications

EV Battery Application

30% more discharge throughput
The cell requirements to satisfy the “all-electric” heavy duty application are unique.
- There is a job to do that requires a guaranteed amount of energy for the service life of the battery.

Very high cycling life is required in combination with:
- Excellent safety tolerance and response
- Very high energy density
- High power
- Facilitates volumetric packing density
- Facilitates high level of mechanical robustness
- Facilitates reliable electrical interface

![Normalized Cell Energy Usage Requirements for Various Industries](image)

Heavy Duty applications require SIGNIFICANTLY more cell cycling capability than passenger vehicles or portable consumer applications (i.e. phones, tablets).
• Temperature is the most significant factor in battery degradation

• Proterra maintains optimal temperature of the cells with unique liquid cooling
  o Most advanced thermal controls in bus transit
  o Cells are individually liquid-cooled through spine of battery modules
  o Modules monitored individually

Sources: NREL
Factors in overcharging
- Regularly using a battery’s full capacity
- Regularly charging at too high a rate

Proterra uses proprietary battery control algorithms to ensure that battery charges and operates in the ‘Goldilocks Zone’
• Planned 2019 cell capacity increase: +5% (twice)

• Proterra maintains on-going R&D with the world’s leading cells suppliers

• Key Areas of Focus for New Developments
  - Cell Form Factor and other mechanical aspects
    - Safety, Cost, Energy Density,
  - Materials – separator, cathode, anode variations, coatings, and electrolytes additives
    - Safety, Cost, Cycle Life, Energy Density
THANK YOU