HYDROLLEY

Fuel Cell Bus

Tomorrow’s Solution – TODAY

Presented by:
Dale Hill – Chairman

Hydrolley

Proterra
COST-EFFECTIVE SOLUTIONS FOR CLEAN TRANSPORTATION
HOW WE MAKE hydrolley
A REALITY IN UNDER
TWO YEARS
hydrolley

FACT
or
FICTION?
Proterra’s Products

- Purpose built designs that achieve maximum performance improvements
- Best fuel economy
- Low maintenance
- Built to last
- Functional designs

Total Vehicle Solutions

- 20-40% weight reduction
- 40%+ longer life
- Less costly to maintain than conventional metal bodies
- Improved safety with crash resistant composite structure

Composite Technologies

- Enables all-electric commercial vehicles in fixed-route applications today
- Uses existing power sources
- Makes it possible to reduce the amount of on-board energy storage and associated costs

TerraCharge™ Rapid Charging Systems

- 200-400% improvement in fuel economy
- Starts as an all-electric system to maximize fuel savings
- Add any small APU to extend vehicle range
- Up to 92% regenerative braking recapture
- Uses all electric components

TerraVolt™ Energy Storage Systems

- Can be fully charged in less than 10 minutes
- Ultra safe system design
- Outlasts the vehicle
- Scales to suit vehicle type and duty cycle needs

Bus and Truck ProDrive™ Systems
Our team has deep related experience that reduces our time to complete designs.

Our past experience enables us to avoid pitfalls and minimize development costs.

Our experience building scalable infrastructure will help us achieve our business objectives.

Team Experience by Experience Type*

- Hybrid design and manufacturing: 55 years
- Composite design and manufacturing: 120 years
- Vehicle design and manufacturing: 200 years
- Other design and manufacturing: 215 years
- Sales & Scalable Infrastructure Development: 170 years

* Sum exceeds cumulative experience of team (625 years) since some individuals have experience in multiple areas simultaneously.
# Management – Seasoned Team

Proterra’s team combines proven and innovative talent from several companies:

<table>
<thead>
<tr>
<th>Prior Position</th>
<th>Strengths</th>
</tr>
</thead>
</table>
| **Jeff Granato**  
CEO & President                                     | Seasoned CEO & CFO, managing, organizing and leading business growth for over 20 years.                                                                                                                   |
| **Dale Hill**  
Founder, CTO, Chairman                              | Developed the most successful fleet of CNG hybrid buses in the world, which carried 150 million passengers to date.                                                                                           |
| **To Be Announced**  
VP Operations                                          | 20 years experience in operations, advanced manufacturing, engineering and Lean Sigma. Deep experience in vehicle and vehicle system manufacturing and product development.                                     |
| **Ben van der Linden**  
Director - Product Prototyping                         | Considerable global bus industry, R&D, manufacturing experience, and launched the world’s first composite body bus.                                                                                           |
| **Stephen Misencik**  
Director – Composites Tech.                           | Technology transfer of high strength marine composites to the bus industry, and has over 25 years experience in composite engineering design and manufacturing setup.                                               |
| **Joshua Goldman**  
Director - Business Development                        | Led the development of hybrid drive systems for ISE, co-chairs several standards boards and is widely considered an industry expert in hybrid drive systems.                                                    |
| **To Be Announced**  
Director - Marketing                                    | Lead engineer on game changing electric powertrain for the Chevy Volt electric vehicle; directed the daily activities of all electric drive unit product development teams.                                      |
HOW WE MAKE HYDRAIL A REALITY IN UNDER TWO YEARS
Battery Dominant Fuel Cell Bus

In just 20 months

Model

Concept

Alpha Unit
### FTA National Fuel Cell Bus Stated Goals

<table>
<thead>
<tr>
<th>Status</th>
<th>Goal Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieved Bus 2</td>
<td>(1) Achieve a fuel cell bus vehicle cost of no greater than 5 times that of a commercial transit bus.</td>
</tr>
<tr>
<td>5-7000 hr - Up from 4000</td>
<td>(2) Achieve a 4–6 year or 20,000–30,000 hours of durability for the fuel cell propulsion system.</td>
</tr>
<tr>
<td>Testing validates 10 + mpg</td>
<td>(3) Achieve a doubling of the fuel efficiency compared to a commercial transit bus to enhance energy security.</td>
</tr>
<tr>
<td>Yes</td>
<td>(4) Achieve fuel cell bus performance equal to, or better than, equivalent commercial transit bus (acceleration, grade-ability, range, braking distance, etc.).</td>
</tr>
<tr>
<td>Yes – ZEV</td>
<td>(5) Exceed the 2010 heavy-duty bus emissions standards.</td>
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<tr>
<td>Yes</td>
<td>(6) Foster economic competitiveness in fuel cell bus technologies.</td>
</tr>
<tr>
<td>Yes</td>
<td>(7) Increase public acceptance for fuel cell bus technologies.</td>
</tr>
<tr>
<td>PROGRAM OBJECTIVES</td>
<td>STATUS</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------</td>
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<tr>
<td>• Develop a fuel cell bus that, once economies of scale are reached, can be sold in the range of $1 M</td>
<td>Yes</td>
</tr>
<tr>
<td>• Design a <em>Technology Specific</em> Bus with composite body to reduce weight, provide better weight distribution and lower CG</td>
<td>Yes</td>
</tr>
<tr>
<td>• Design a bus that is &quot;White Book &quot; compliant</td>
<td>Yes</td>
</tr>
<tr>
<td>• Design a bus that is battery dominant to reduce fuel cell size to that of an automotive size fuel cell</td>
<td>Yes</td>
</tr>
<tr>
<td>• Develop a new energy storage system employing the latest battery technologies and battery management and system control and integration</td>
<td>Yes</td>
</tr>
<tr>
<td>• Engineer a fuel cell arrangement that will maximize stack life</td>
<td>Yes</td>
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</tbody>
</table>
Program Objectives cont’d

• Develop a drive system that will double fuel economy over a conventional diesel bus
• Develop a shorter bus that will carry as many passengers as a 40’ bus
• Develop an integrated, redundant control system
• Develop a vehicle that operates on 100% Domestic Energy
• Develop a bus that will be a battery dominant hybrid electric vehicle that can accept a variety of Auxiliary Power Units, including fuel cells in order to maximize FTA design dollars

STATUS

Yes –
10 mpg
34’ 9”
37 seated pass.

Yes

Yes

H² % Elec.

Yes
roof mounted all-electric air conditioning
forward roof mounted radiator
gaseous fuel storage
master control system
TerraVolt Energy Storage System mounted in floor cavity
removable drive assy cradle includes:
drive motor
transmission
air compressor
heater
apu
inverters
air dryer
37 seats on a 35’ bus
composite body
FUEL CELLS

TWO HYDROGENICS 16 kW PEM Fuel Cells

- Parallel Connected
- Alternate operation adaptable
- Constant output for extended life
The tests met and exceeded Proterra’s expectations

- 400 + hours fuel cell testing completed to date
- Vehicle initialization completed in two days vs. two weeks planned
- Control system allows two fuel cells on the same network
- 20 second startup
- Total power output: 18.6kW
- Heat load: 15.7kW
**Patented ‘TerraVolt’ Energy Storage System**

### Core System Components
- Battery Management System
- TerraVolt Energy Storage
  - Module
  - Pack
  - Strings

### Customer Benefits
- Industry’s only system that can be fully charged in less than 10 minutes
- Ultra safe system design
  - Puncture and heat resistant
  - Sophisticated battery management system operates at the ‘cell’ level
- Energy storage system outlasts the vehicle or longer
- Scales in size and energy capacity based on vehicle type and duty cycle needs
### Estimated Efficiency of the Hybrid System

**>80% Efficient Drive Train Without APU**
- Battery System = 98.5% Avg.
- Traction Motor = 92.5% Peak; 85% Avg.

**45% Efficient APU**
- DC-DC Converters = 94% Peak; 90% Avg.
- Fuel Cells = 55% Peak; 50% Avg.

**85% Efficient Hotel Loads**
- HVAC: 85% Efficient -11.8kW Peak; 9kW Avg.
- Power Steering: 80% Efficient - 5kW Peak; 1kW Avg.
- DC-DC Converters: 90% Efficient; 1kW Avg. Waste

>55% Efficiency at 32kW/hr
Build upon cell and module level testing and full vehicle system testing to add confidence to our lifetime and durability of the ESS as applied to the Foothill proposed drive cycle

Have partnerships with NREL and FTA (Penn State University) as well as UC-Davis for various portions of the complete ESS testing

Once complete we can then address long term warranty of the complete ESS
## Transitioning to Rail

<table>
<thead>
<tr>
<th></th>
<th><strong>Bus</strong></th>
<th><strong>Light Rail</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>27,000 lb</td>
<td>110,000 lb</td>
</tr>
<tr>
<td>Passengers</td>
<td>67</td>
<td>220</td>
</tr>
<tr>
<td>HP</td>
<td>150 kW</td>
<td>450 kW</td>
</tr>
<tr>
<td>Rolling Resist.</td>
<td>.01</td>
<td>.002</td>
</tr>
<tr>
<td>Energy Usage @ 60 mph</td>
<td>2 kWh/mile</td>
<td>7.5 kWh / mile</td>
</tr>
<tr>
<td>Fuel Cell Requirement</td>
<td>32 kW</td>
<td>120 kW</td>
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</tbody>
</table>
WHY MOVE TO HYDROGEN?

= $4MM/MILE
= Unsightly
= Ability to extend system
= Ability to store night time energy