Integrated Electric, Fuel Cell and Hybrid Powertrain Components Powering Clean Mobility
US Hybrid Business Focus is Medium and Heavy Duty Commercial Vehicles
We have been making and operating Fuel Cell Vehicle for decades.
Fuel Cell Powered Shuttle Bus, Utility truck and Cargo van Commercial Deployment

- **200kW Traction Motor**
- **Integrated Controller**
- **Hydrogen Fuel Storage System**
- **Li-Ion Battery System**
- **DC-DC**
- **Electric Driven Brake**
- **Electric Steering**
- **Charge Port J1772**
- **HD30 Fuel Cell System 30kW**
- **CV35 DC-DC 35kW**
- **Fuel Cell Cooling**
- **Hydrogen Tanks**
- **Direct Electric Drive Motor 200kW**
- **Electric Driven HVAC System**
- **Integrated Controller and VCU**
- **12V DC-DC Converter**
- **iDrive Wireless Telematics**
- **Li-Ion Battery System 28.4kWhr**
- **Safety Disconnect**
# Battery Dominant Fuel Cell Bus

## Electrical

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Power‡</td>
<td>6 - 80kW</td>
</tr>
<tr>
<td>Output voltage</td>
<td>375 - 750V&lt;sub&gt;DC&lt;/sub&gt; (Integrated dc-dc converter)</td>
</tr>
<tr>
<td>Ramp rate</td>
<td>50 kW/sec</td>
</tr>
</tbody>
</table>

## Efficiency

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Efficiency†</td>
<td>56.9 to 46.3% (10% to full power)</td>
</tr>
</tbody>
</table>

## Temperature

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Operating</td>
<td>-40 to 50°C</td>
</tr>
<tr>
<td>Cooling Inlet (50/50 WEG)</td>
<td>55 to 57°C</td>
</tr>
</tbody>
</table>

## Fuel

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Flow</td>
<td>5.2 kg/hr @ full power</td>
</tr>
<tr>
<td>Fuel Pressure</td>
<td>1200 ±300 kPa&lt;sub&gt;g&lt;/sub&gt;</td>
</tr>
<tr>
<td>Fuel Type</td>
<td>SAE J2719 Hydrogen</td>
</tr>
</tbody>
</table>

## Physical Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions (L x W x H)</td>
<td>916 x 879 x 614 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>248 kg</td>
</tr>
</tbody>
</table>

## Interface

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Communications</td>
<td>CAN SAE J1939</td>
</tr>
<tr>
<td>Startup</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Startup from Frozen</td>
<td>6 minutes</td>
</tr>
<tr>
<td>Shutdown</td>
<td>10 seconds</td>
</tr>
</tbody>
</table>
Fuel Cell is an engine with no combustion
Fuel Cell Engine; Most efficient electric power with Zero Emission

Integrated Solution for Medium and Heavy Duty Transportation

Volume: 0.51 m³
Weight: 190 kg

Volume: 1.6 m³
Weight: 1199 kg
Made to be integrated and used Just like an Engine

- Automotive Components, Accessible for service and Maintenance
- Integrated Air Processing Unit
- Integrated Fuel Processing unit
- Integrated Thermal Management System
- Integrated Isolated DC-DC Converter Technology
- Freeze Capable
- Integral Safety and Automatic Protection

Ease of Vehicle Integration, Operation and maintenance
Technology Readiness Level *(We are beyond this)*

Business Case Readiness Level

Supply Chain (Market) Readiness Level

Quality of Service and Operation Readiness Level

1. Operator and Service & Maintenance Readiness Level
   a. Public, Management and operators
   b. Facility and Infrastructure readiness
   c. Equipment (Diagnostics tools, safety systems, First Respondent)

2. Work-Force Readiness Level
   a. Operator Training
   b. Training; Self/External Training, Continuous education, teaming with local/state agencies

3. Documentation Readiness Level *(Should be included in contracting level)*
   b. Service Manual *(make sure your service people have accepted it).*
   c. Critical BOM List and cross reference for custom part numbers

4. Parts Inventory
   a. Supplier/OEM long lead items
   b. Off-the shelf parts
Fuel Cell buses have achieved Operation Safety; Building public and rider confidence is a part of our job.

- **FC Transit bus has Proven Reliability, Maintainability and Efficiency**
- The Vehicle and power plant safety and protection system has shown to be **effective with no safety incidents.**
- Vehicle and Facility **safety system has functioned as designed**
- There is no evidence of riders concern/perception with safety (fear factor) and are noticing the quite and smooth ride conveniences.
- AC Transit service and maintenance teams step-up to challenge and performed all the service and maintenance and **deserve all credits.**
- US Hybrid has trained 22 of the AC Transit technicians and will continue in training curriculum development in cooperation with ACT, local colleges and job centers.

**Fuel Cell Power Plant  Miles Before Road Call “MBRC” exceeds Comparable Diesel Engine with After treatment**

<table>
<thead>
<tr>
<th></th>
<th>Zeba</th>
<th>VH Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus MBRC</td>
<td>4,315</td>
<td>3,427</td>
</tr>
<tr>
<td>Propulsion MBRC</td>
<td>7,180</td>
<td>7,171</td>
</tr>
<tr>
<td>FC System MBRC</td>
<td>20,045</td>
<td>14,500*</td>
</tr>
</tbody>
</table>

Data: NREL September 2011 through August 2015
How did we achieve Reliability;

- PC40 Fuel Cell engine has exceeded 21,000 hours of operation with ZERO failure
- Millions of Miles and hundred thousands of hours with Zero Stack failure and >90% total availability
Fuel Type and Cost

- **Diesel**: 37.1 kWh/gal (Energy content), Engine Output: 4.5 kWh/kg
- **Gasoline**: 32.9 kWh/gal, (Energy content), Engine Output: 2.8 kWh/kg
- **Hydrogen**: 39.7 kWh/kg, (Energy content), FC Engine Output: 15 kWh/kg

(1 kg H2 = 11 gal @ 5000 psi, same as 2 gal of diesel fuel)

**Energy Storage Density**: Li-Ion Battery 0.11 kWh/Kg

- 1 kg of H2 (9 miles/kg) > 2-Gallons Diesel (3.8 mpg) 40’ Transit Bus
- 1 kg of H2 (12 miles/kg) > 2.5-Gallons Gasoline (5 mpg) Shuttle Bus

80 kW FCPP, price amortized
80kW Fuel Cell Power plant can meet Transit bus and Truck power demand, combine market to reduce cost.
Thank you!

Abas Goodarzi, Ph.D., PE. President

abas@ushybrid.com

www.ushybrid.com

www.usfuelcell.com

Tel: (1)310-212-1200
445 Maple Ave. Torrance, CA 90503