Hydrogen Production and Northwest Transportation

2003 Conference
Seattle, Washington

Scott D. Smith
Freightliner LLC
Engineering & Technology

June 16, 2003

OUR FAMILY TREE.

DAIMLERCHRYSLER

Freightliner LLC and its affiliated businesses are part of DaimlerChrysler, the world's leading provider of diversified commercial transport solutions.

FREIGHTLINER LLC

COMPONENTS

Mercedes-Benz

FINANCING

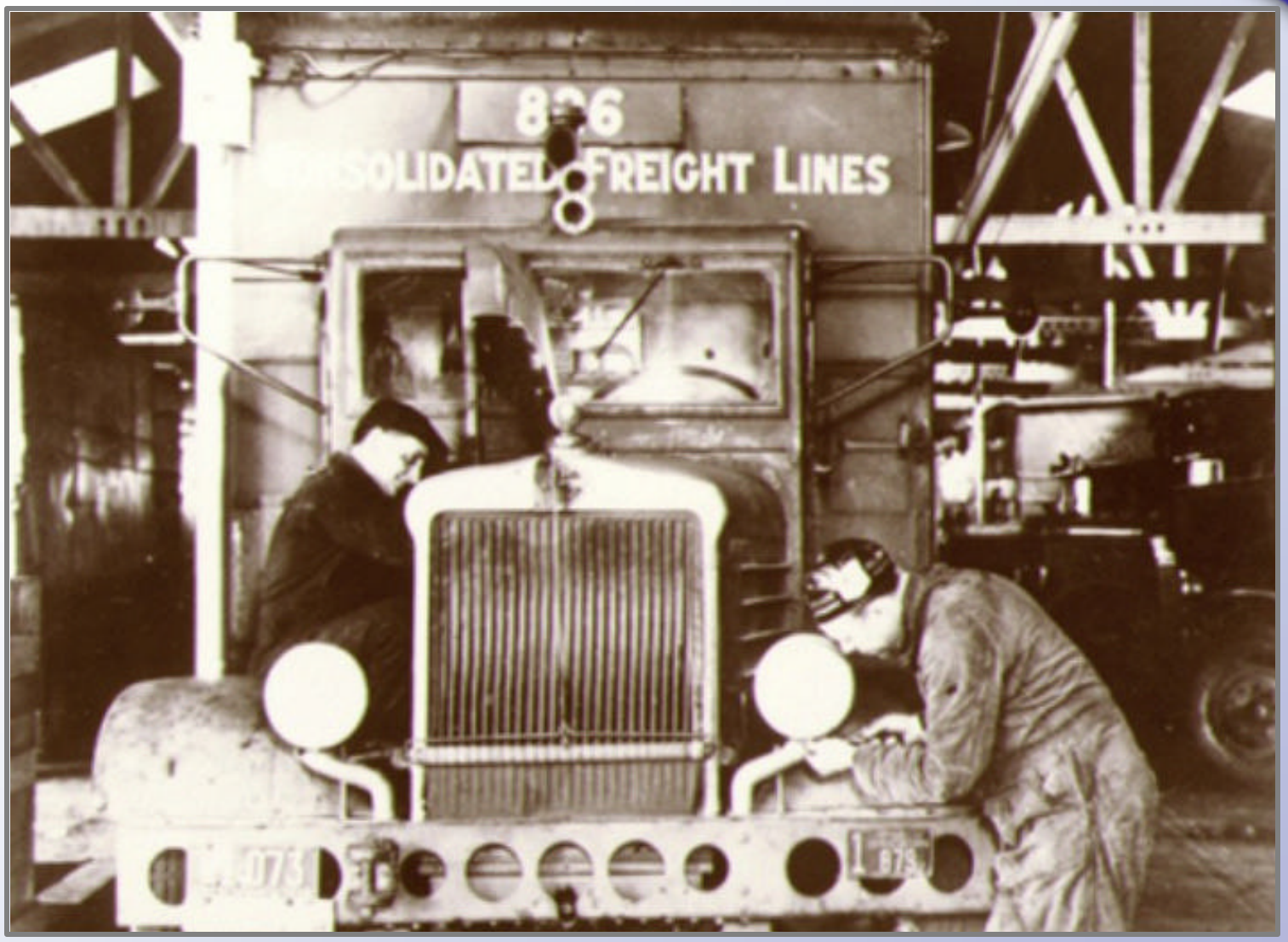
DaimlerChrysler Services
Commercial Vehicles

PARTNER

TravelCenters of America

FREIGHTLINER® LLC
A DaimlerChrysler Company

FREIGHTLINER® LLC
A DaimlerChrysler Company



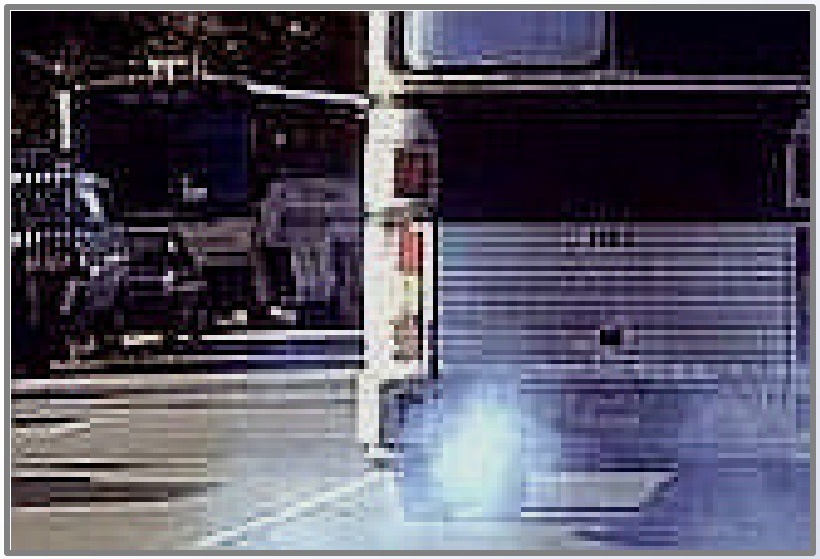
60 YEARS OF R&D

FREIGHTLINER LLC
A DaimlerChrysler Company

Freightliner’s First COE

Freightliner Century Class S/T

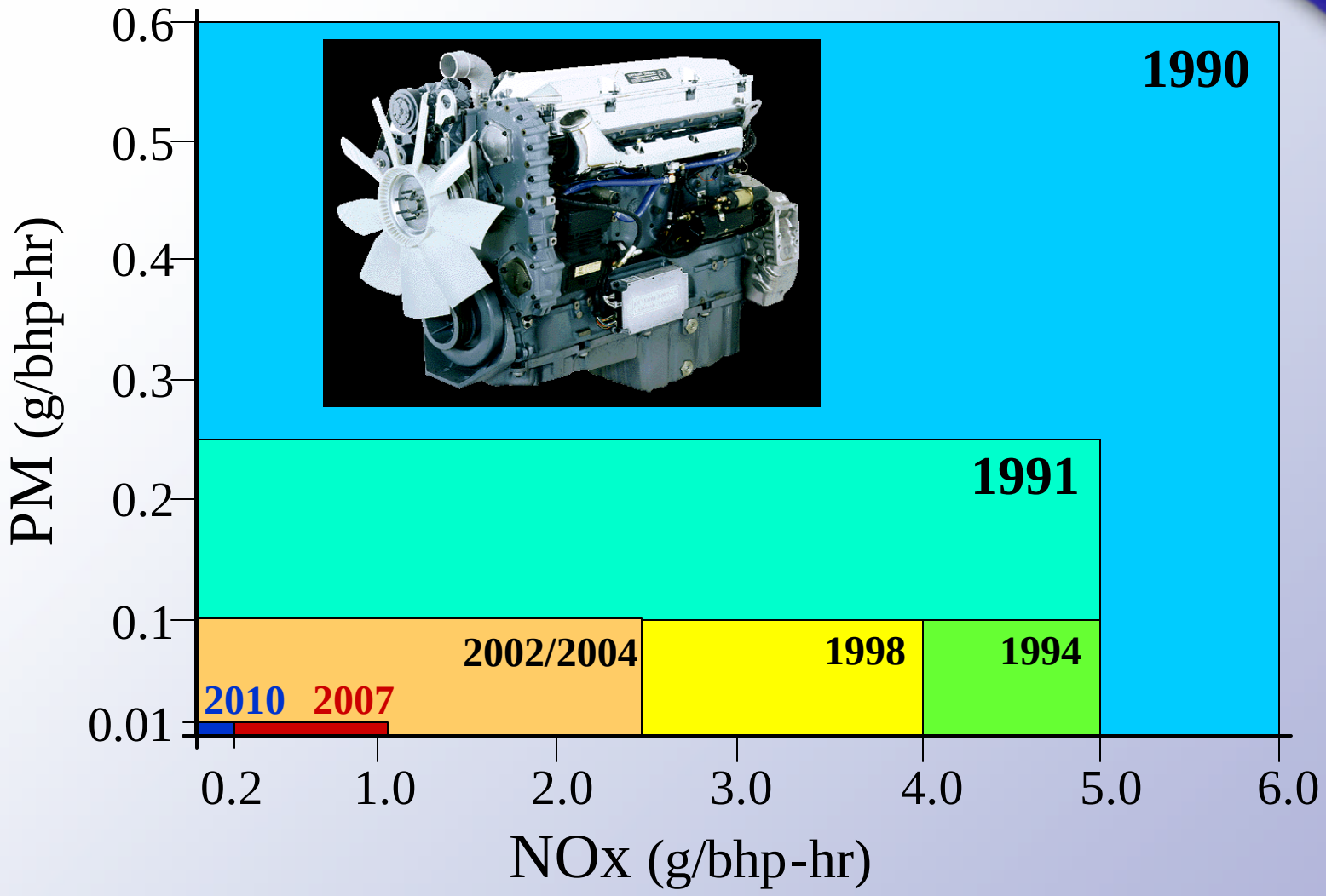
Industrialization



Low Emission Commercial Vehicles

FREIGHTLINER LLC
A DaimlerChrysler Company

Two Decades of Emissions Regulations



ENVIRONMENTAL CONSERVATION

FREIGHTLINER LLC
A DaimlerChrysler Company

- Engine Technology Reduce Emissions
- Cab Comfort Improvements Reduce Energy Loss
- On Board Energy Management Reduces Consumption
- Shore Power Connections Address Idling Concerns
- More Efficiency = More Miles per Gallon of Fuel Consumed

S-E-T Demonstration

S-E-T Demonstration

FREIGHTLINER LLC
A DaimlerChrysler Company

S – Safety

- Improve Highway Safety and Reduce Accidents and Injuries

E – Environment

- Reduce Exhaust Emissions and Energy Consumption

T – Technology

- Total Vehicle Approach to Technology and Systems Integration

S-E-T Demonstration

FREIGHTLINER LLC
A DaimlerChrysler Company

SAFETY

- Roll Advisor & Control
- Collision Avoidance
- Lane Departure Warning
- Driver Side Airbag
- Crashworthiness

S-E-T Demonstration

FREIGHTLINER LLC
A DaimlerChrysler Company

ENVIRONMENT

- Anti-Idling
- Driver Comfort & Convenience
- Noise Reduction
- Emissions Reduction
- Reduced Fuel Consumption

S-E-T Demonstration

FREIGHTLINER LLC
A DaimlerChrysler Company

TECHNOLOGY

- Integrated Electronics
- Ride, Handling, Vibration, Noise
- Rolling Resistance
- Weight Reduction
- SmartShift – Hands on the Wheel Shifting

Idling Reduction Background

FREIGHTLINER LLC
A DaimlerChrysler Company

- The Department of Energy Office of Heavy-Duty Technologies estimates that $1.17 billion is spent each year on fuel for idling, and an additional $1 billion is spent on engine wear and maintenance due to idling.
- Argonne National Laboratory estimates that there are 458,000 trucks in the U.S. that idle between 3.3 and 16.5 hours per day.
- Late model year idling trucks consume in excess of one gallon diesel per hour, and often idle up to ten hours each day or 50% of total engine run time.

Goals

MAINTAIN

- Driver Comfort

REDUCE

- Diesel fuel and Lubricant Consumption
- Engine Wear
- Operator Costs
- Air Pollutants and Greenhouse Gas Emissions
- Noise and Vibration

Alternatives

- Few economical options are available to power accessories in the cab.
  - Using battery power overnight puts too much stress on the vehicle's batteries, which prematurely wear out.
  - Auxiliary generator sets are reported to be heavy, expensive, and noisy.
- Direct-fired heaters and absorption coolers can be used to assist in climate control
  - Does not provide the power for other accessories such as televisions and refrigerators.

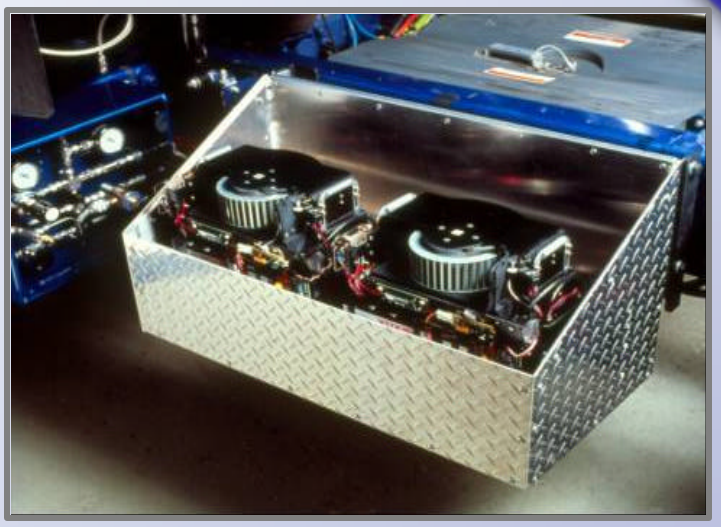
Fuel Cells in Transportation

- Mercedes plans to introduce 60 A-Class "F-Cell" FCVs powered by Ballard 85 kW fuel cells
- Will be available in limited numbers for tests by consumers and fleets in Japan, Europe, US in 2003

- Also putting 30 fuel cell Citaro buses into fleets in 10 major European cities in 2003
- Buses will be in revenue service on urban bus transport routes

First Prototype Specifications

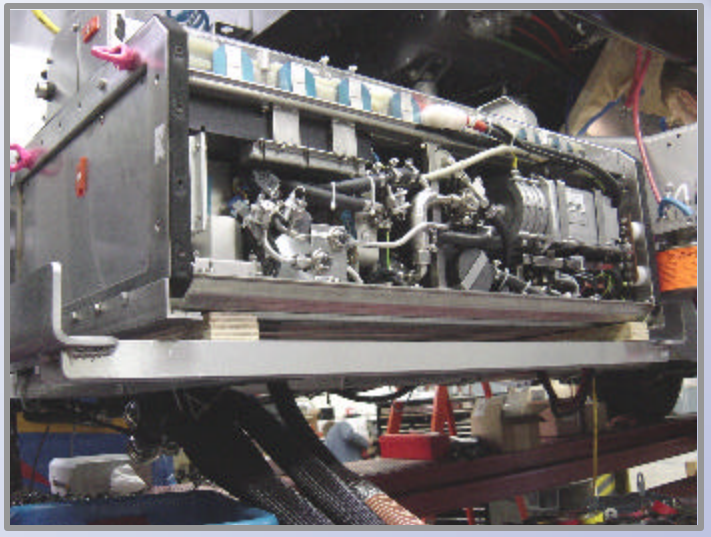
FREIGHTLINER LLC
A DaimlerChrysler Company



- Proton exchange membrane (PEM) fuel cell cell stacks generate up to 30 volts DC.
- An 1800 watt inverts DC output to 1.4 kW at 110/120 volts AC.
- 52 gallon tank of hydrogen at 2500 psi

S-E-T Demonstration
Second Fuel Cell APU Demonstration

FREIGHTLINER LLC
A DaimlerChrysler Company



- Proton exchange membrane (PEM) fuel cell cell stacks generate up to 42 volts DC
- 5 kW at 110/120 volts AC peak power
- 50 gallon tank of liquid Methanol Mix

Project Partners

- Freightliner LLC
  - ITS Davis
- Ballard Power Systems
- University of Alabama
- US Army National Automotive Center (NAC)

Project Goals

FREIGHTLINER LLC
A DaimlerChrysler Company

- Integration of Fuel Cell APU systems on a Class 8 Highway Tractor
- Optimization of System Performance
- Vibration
- Noise
- Thermal Signature
- Demonstrations
- Mileage Accumulation
- Driver Surveys and Related Studies

Fuel Cell Auxiliary Power Unit

FREIGHTLINER LLC
A DaimlerChrysler Company

- Trucks idle 40% or more at Truck Stop
- Emissions include NOX, Particulates and CO2
- Noise levels in cab are 15 db more with engine idling
- Idling shortens engine life
- Fuel consumption during idling can exceed 1 gallon/hr
- Fuel & Maintenance cost can reach $1800/truck/yr

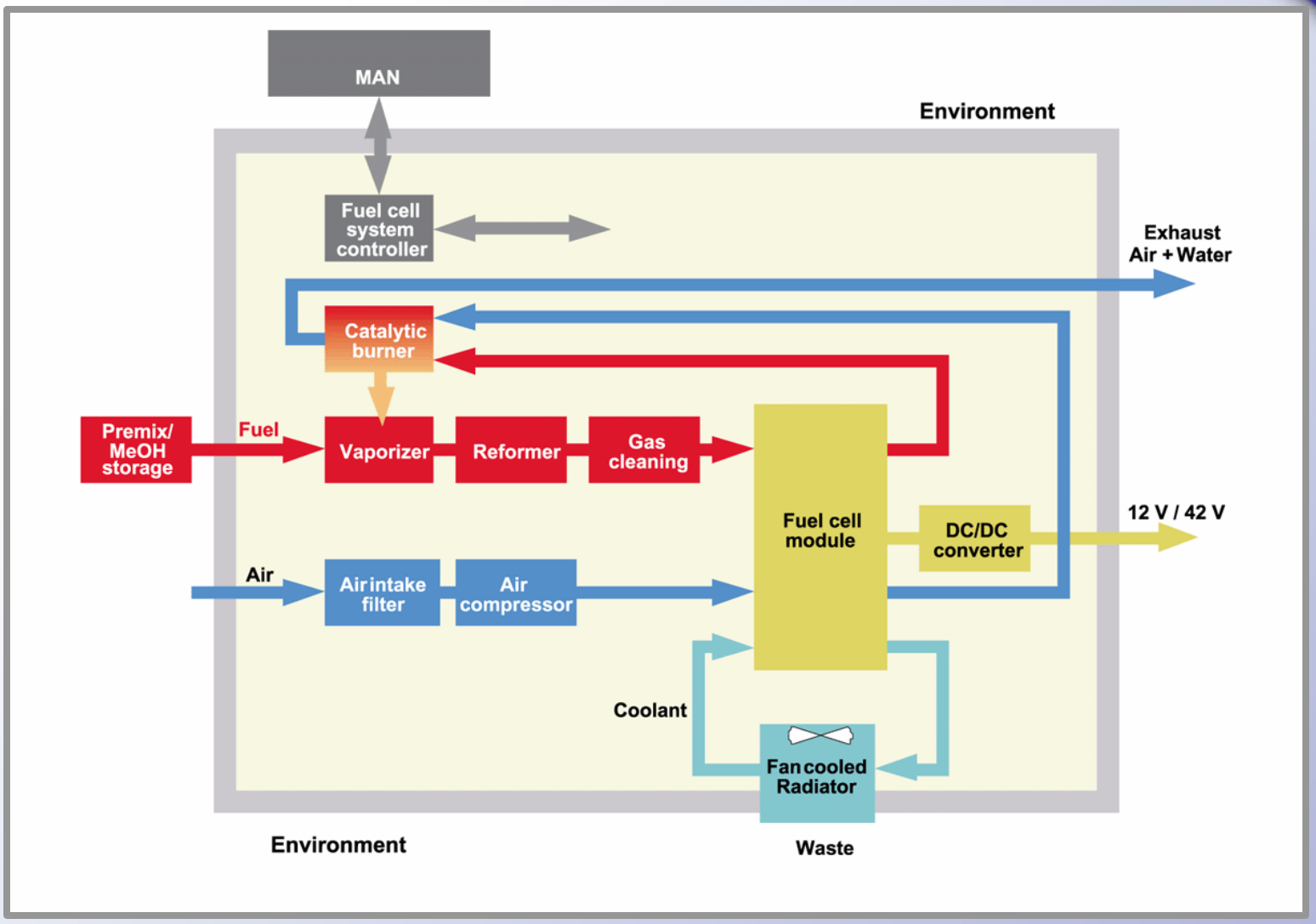
Fuel Cell Auxiliary Power Unit

FREIGHTLINER LLC
A DaimlerChrysler Company

- Methanol Mixture is Reformed to produce Hydrogen Gas
- Byproducts are H2O and Small amount of CO2
- 5 KW Peak, 42V DC Output
- Inverters transform to 12V DC and 120V AC
- Supplies “Hotel” Load Power for Computers, Microwave, Heat, A/C, TV, VCR, etc

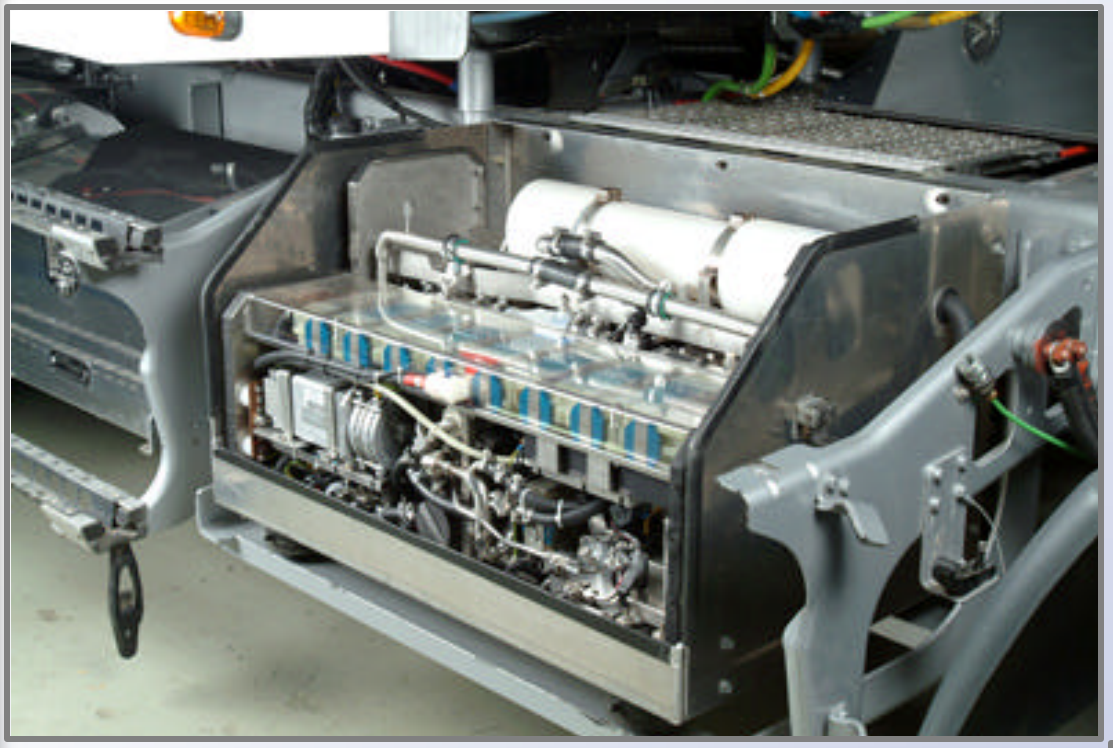
Fuel Cell Auxiliary Power Unit

System Schematic



Fuel Cell Auxiliary Power Unit

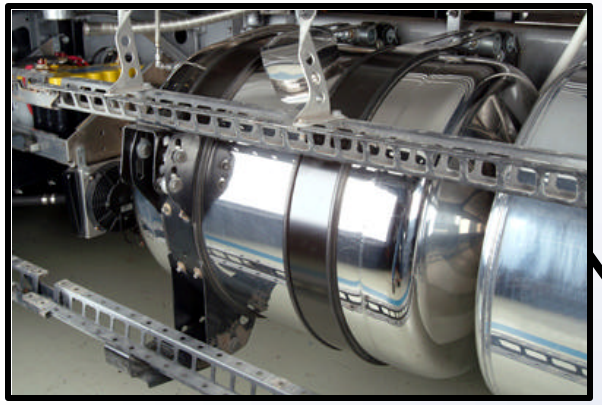
FREIGHTLINER LLC
A DaimlerChrysler Company



Fuel Cell Auxiliary Power Unit

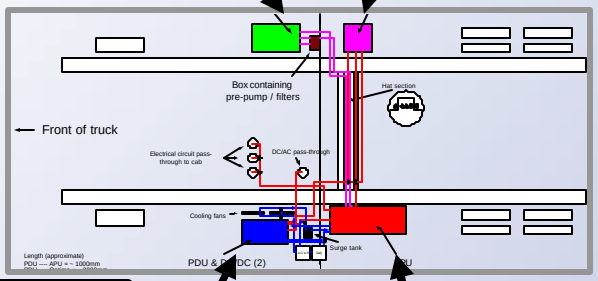
System Components

FREIGHTLINER LLC
A DaimlerChrysler Company

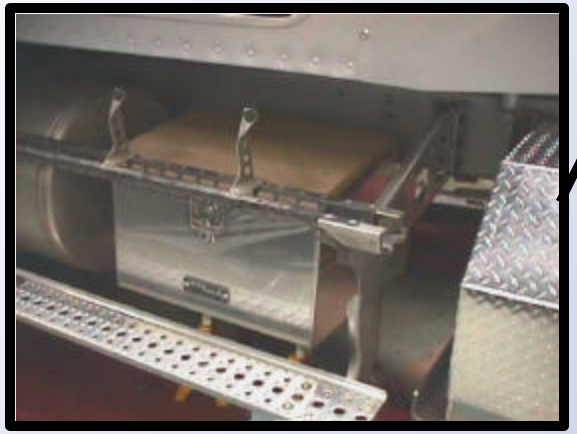


Pre Mix Tank

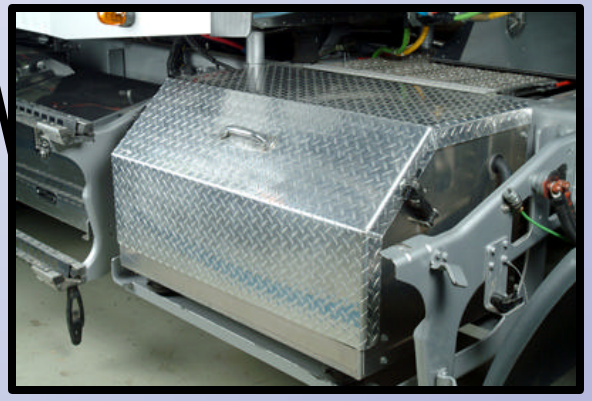
Batteries



PDU & DC/DC



Fuel Cells



Fuel Cell Auxiliary Power Unit

System Components

DC/AC Inverter

Batteries

Fuel Cell Auxiliary Power Unit

System Components

External 110V AC Outlet Powered by APU

110V Cooling/Heating Unit (16,000 BTU/Hr)

Fuel Cell Auxiliary Power Unit

System Components

APU Bunk Displays

Fuel Cell APU

Additional Anti-Idling Systems

FREIGHTLINER LLC
A DaimlerChrysler Company

- Detroit Diesel Optimized Idle
- Espar Diesel Fired Heater
- Engine Block Heater
- Microwave
- TV/VCR
- Shore Power
- External 110v AC Outlet Powered by APU

S-E-T Demonstration