



# Connecticut Diesel Emissions Control Technologies Forum



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UTC Fuel Cells



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8/17/05

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# United Technologies Corporation

- Operations in more than 180 countries
- Revenues of \$37 B
- 209,700 employees
- \$2.8 B R&D spending\*
- \* Includes customer funded R&D



**Carrier**



**Otis**



**Chubb**



**Pratt & Whitney**



**Hamilton Sundstrand**



**Sikorsky**



**Research Center**



**UTC Power/UTC Fuel Cells**

# UTC POWER Markets

Transportation  
Fuel Cells



On-Site Power



High Efficiency, Low Emissions, Energy Security

# On-Site Power Solutions

**PureComfort™ 240M**



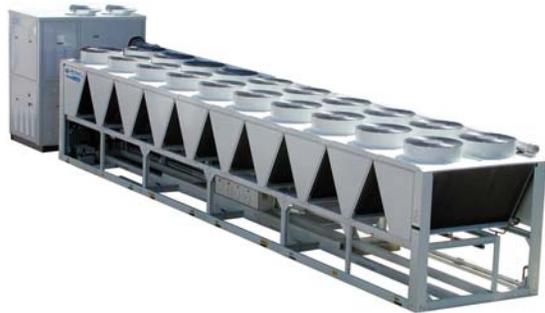
**PureComfort™ 300M**



**PureComfort™ 360M**



Power, Cooling and Heating



**PureCycle™**

“Free” fuel, power  
with zero emissions

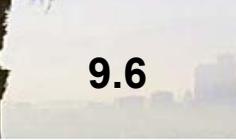


**PureCell™**

Reliable, durable,  
ultra low emissions

# Sustainable Energy

## Avoided emissions for a 1 MW building

	Annual Avoided CO <sub>2</sub> Emissions		Annual Avoided NO <sub>x</sub> Emissions	
	Tons	Equivalent acres of forest*	Tons	Equivalent number of cars**
5 x PureCell™ 200	 <b>3500</b>	 <b>750</b>	 <b>9.6</b>	 <b>495</b>
3 x PureComfort™ 360M	 <b>3000</b>	 <b>650</b>	 <b>9.5</b>	 <b>487</b>

\*Each acre of forest assumed to absorb 1.3 tons Carbon/acre/year (Ref: International Panel on Climate Change)

\*\*Each car assumed to generate 38 lbm/NO<sub>x</sub>/year (Ref: US EPA)

# PureCell™ Installations



US Postal Service Facility - Anchorage Alaska



Central Park Police Station – New York, NY

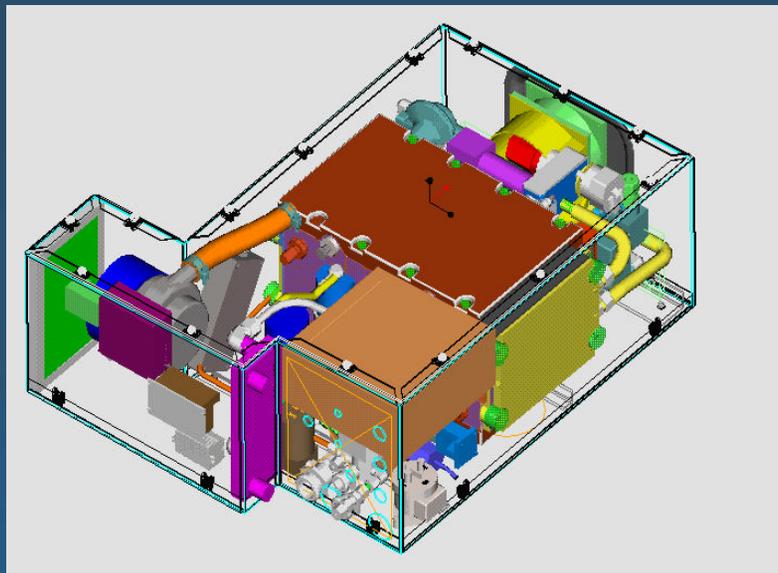


4 Times Square – New York, NY

# Transportation Fuel Cells



# Hydrogen Fueled Auxiliary Power Unit

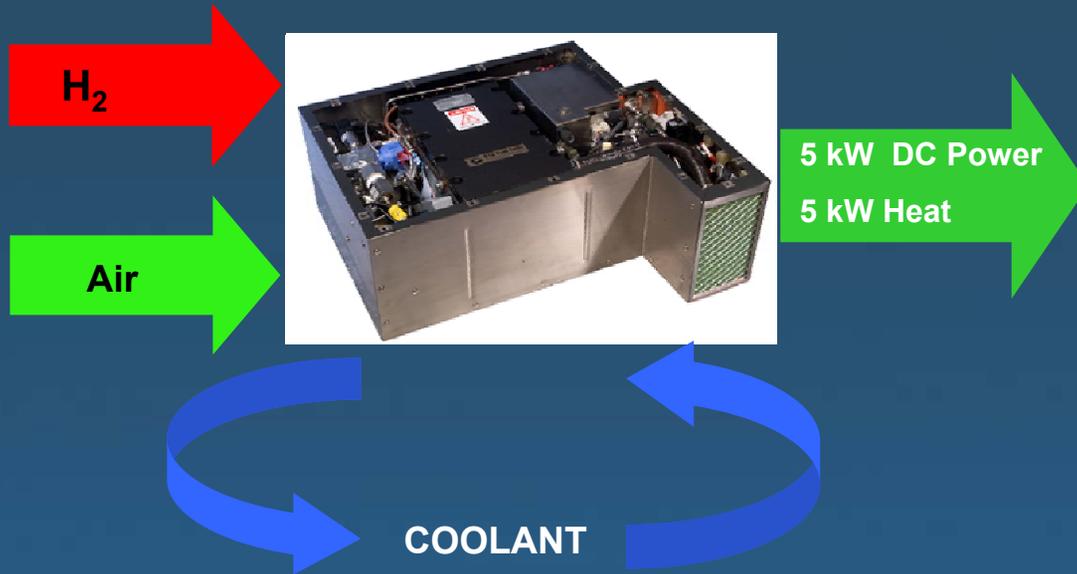


## Gen III

- 5KW
- Nominal 42Vdc
- Max Efficiency > 52%
- Process exhaust below 25% LFL
- Self contained



# Hydrogen Fueled Auxiliary Power Unit



## Sleeper Berth

- 2-3 kW power for
- Cooling
  - Accessories
- 2-3 kW for heating

## Vehicle

- 1 to 2 kW for
- Battery charging
  - Engine pre-heat for cold starts
  - Parking lights

## Benefits

- Eliminates Idling Emissions
- Extended Engine and Battery Life
- Reduced Noise
- Enables conformance to CA Idling Law



# UTCFC Fuel Cell Bus Experience



1998



Georgetown University

40 Foot NOVA Bus  
100 kW  
Phosphoric Acid  
Methanol  
FC/battery hybrid

2002



SunLine, AC Transit, LAMTA, Chula Vista

30 Foot Thor  
"Thunder Power" Bus  
60 kW S300 PEM  
Hydrogen  
FC/battery hybrid

2004



EMT Madrid, ATM Turino

40 Foot  
Irisbus  
60 kW S300 PEM  
Hydrogen  
FC/battery hybrid

2005



AC Transit/ Sunline

40 Foot Van Hool  
Bus  
120 kW S900 PEM  
Hydrogen  
FC/battery hybrid

# Fuel Cell Bus Advantages



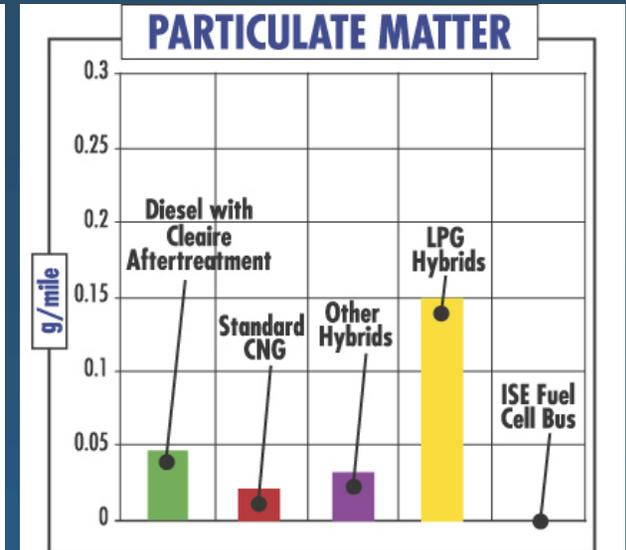
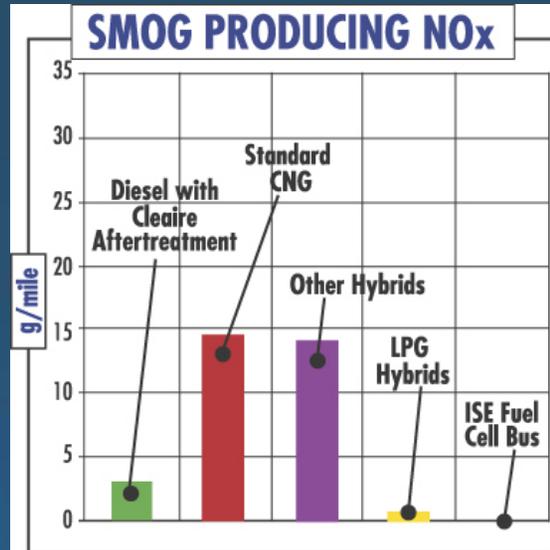
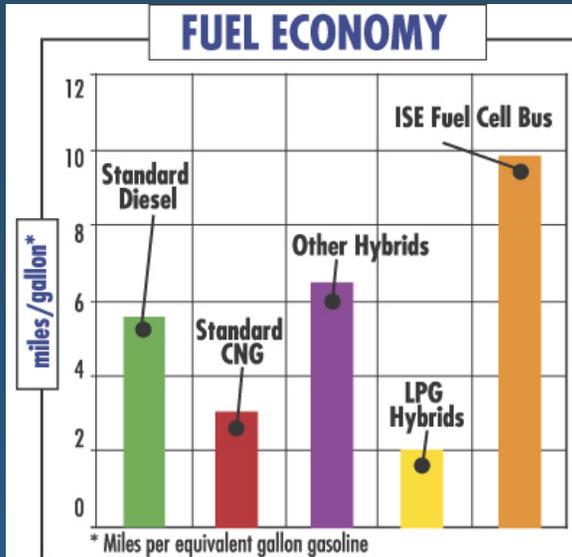
*Avoided emissions by using 4000 buses*

Converting a fleet of buses avoids...

Compared to...	CO <sub>2</sub>		NO <sub>x</sub>		PM
	Tons	acres	tons	# cars	tons
Diesel	391,000	301,000	4104	216,000	513

Notes: On an annual basis. Using Fleet of 4000 buses and 31,000 miles per bus per year. Each acre of forest is assumed to absorb 1.3 tons of CO<sub>2</sub> per year [IPCC]. Each car is assumed to emit 38 lbm/year of NO<sub>x</sub> [EPA]. Each car is assumed to emit 0.06 g/mile of PM per year [EPA]. "No<sub>x</sub>" above includes NO<sub>x</sub>, NMOG/NMOC's and CH<sub>4</sub> emissions... all ozone precursors.

# Transit Bus Comparisons



Source: AC Transit

PARAMETER	FUEL CELL BUS	DIESEL BUS
Acceleration (0-30)	17 sec	15 sec
Acceleration (0-50)	54 sec	40 sec
Top Speed	55 mph	65 mph
Weight	25,180 lbs	24,175 lbs
Interior Noise (Stopped)	57 dB	71 dB
Interior Noise (30 MPH)	65 dB	73 dB
Fuel Consumption	9.6 mi/ g.g.e.*	4 mi/ g.g.e.*

\*g.g.e.- Gasoline Gallon Equivalent. Source: EVS-20 Presentation, 11/18/03 by Jayson Cannon, ISE Corporation

# Advanced Fuel Cell Bus Program



PureMotion 120



- Hybrid-Electric
- Energy storage: Regenerative Braking
- Range: 250 – 300 miles
- Three buses for AC Transit ( Oct 2005)
- One bus for SunLine Transit (assembled at AC Transit)

\* Current partners shown Source: AC Transit



**UTC Fuel Cells**  
A United Technologies Company

# Advanced Fuel Cell Bus Configuration



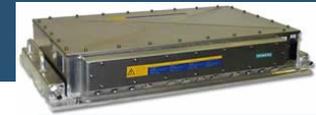
Batteries



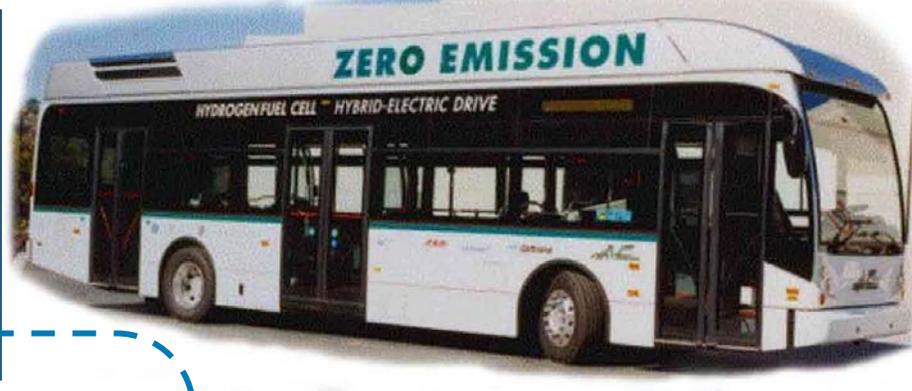
H2 tanks



Electric Drive Motor



Inverter



Controls

Auxillaries (Lights, HVAC, Kneeling, etc)



Fuel Cell Engine

UTCFC's PureMotion™ 120:  
Hydrogen → 120 kW DC Power  
Zero Emissions



Non-UTCFC Photos from VanHool, Dynetek, and ISE websites

# PureMotion™ 120 - Overview



## Product Benefits



## Specifications:

- Hydrogen fueled PEM
- 120 kWnet DC out
- 290 to 580 VDC
- >46% efficiency (tank to DC)
- 24 kW/s transient
- Liquid cooled
- <2 kW 24 VDC input
- -10 to 49 C ambient
- 900 kg
- 1030 x 1490 x 1177 mm
- <70 dB at 1.23 m
- Zero Emissions (water vapor)

# Oakland Energy Station - Hydrogen



- Teaming of Chevron and Oakland
- Onsite NG Steam Reformer
- 150 kg daily fuel supply
- Mobile Fueler
- Stationary Fuel Cell – Facility Power
- Maintenance Center for Buses

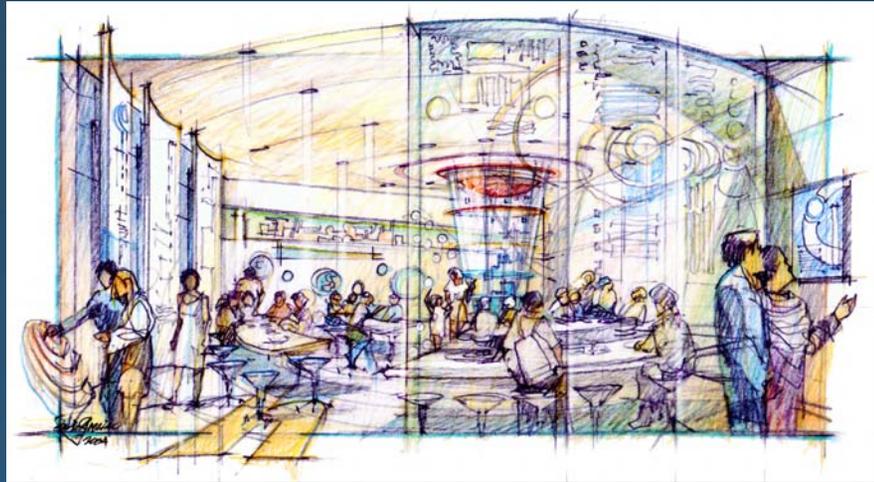


Mobile Fueler



# Educating the Public

- Interior Bus Dioramas
- Publications and DVDs
- Speakers' Bureau
- \$2.4 million Curriculum Grant
- Internet Education
- HyRoad Learning Center



## EPA Involvement

- Fuel Cell Delivery Vehicle Program
- EPA provided H<sub>2</sub> refueling facility in Ann Arbor, MI
- In Aug 2004, UPS initiated testing of fuel cell vehicles under real world conditions
- EPA gaining official data, certifying vehicles, strengthening fuel cell effort (National Vehicle and Fuel Emission Lab)

