Hybrid-Electric Drive Systems for Heavy Duty Vehicles

ISE Corporation

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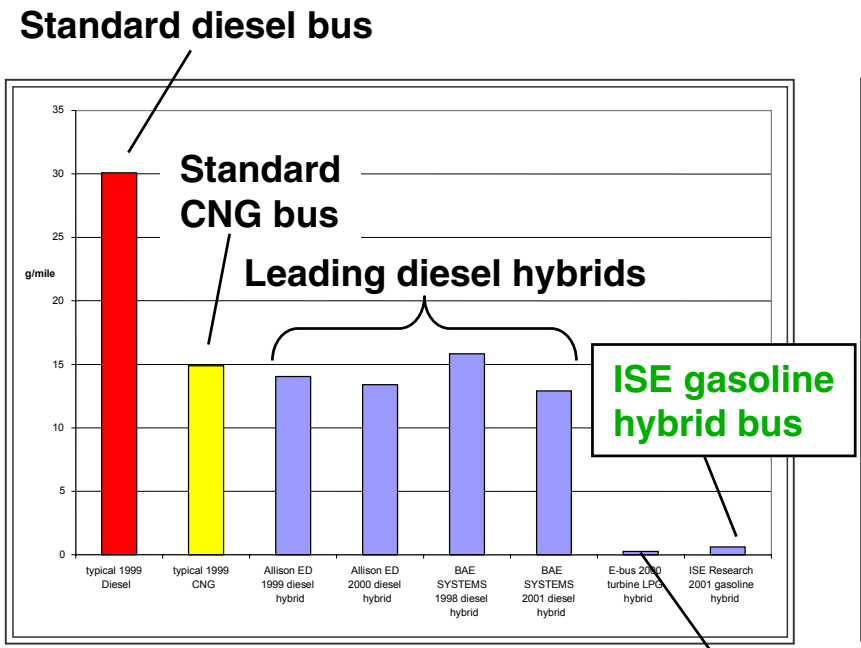
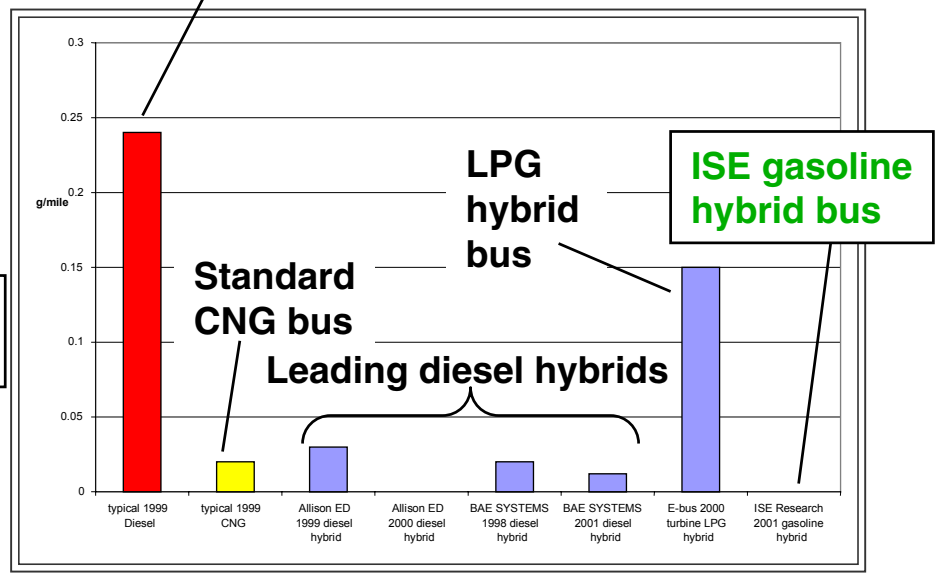
CARB CONFIRMS ISE DRIVE SYSTEM'S LOW EMISSIONS

TRANSPORTATION FOR A CLEAN PLANET

NOx Emissions

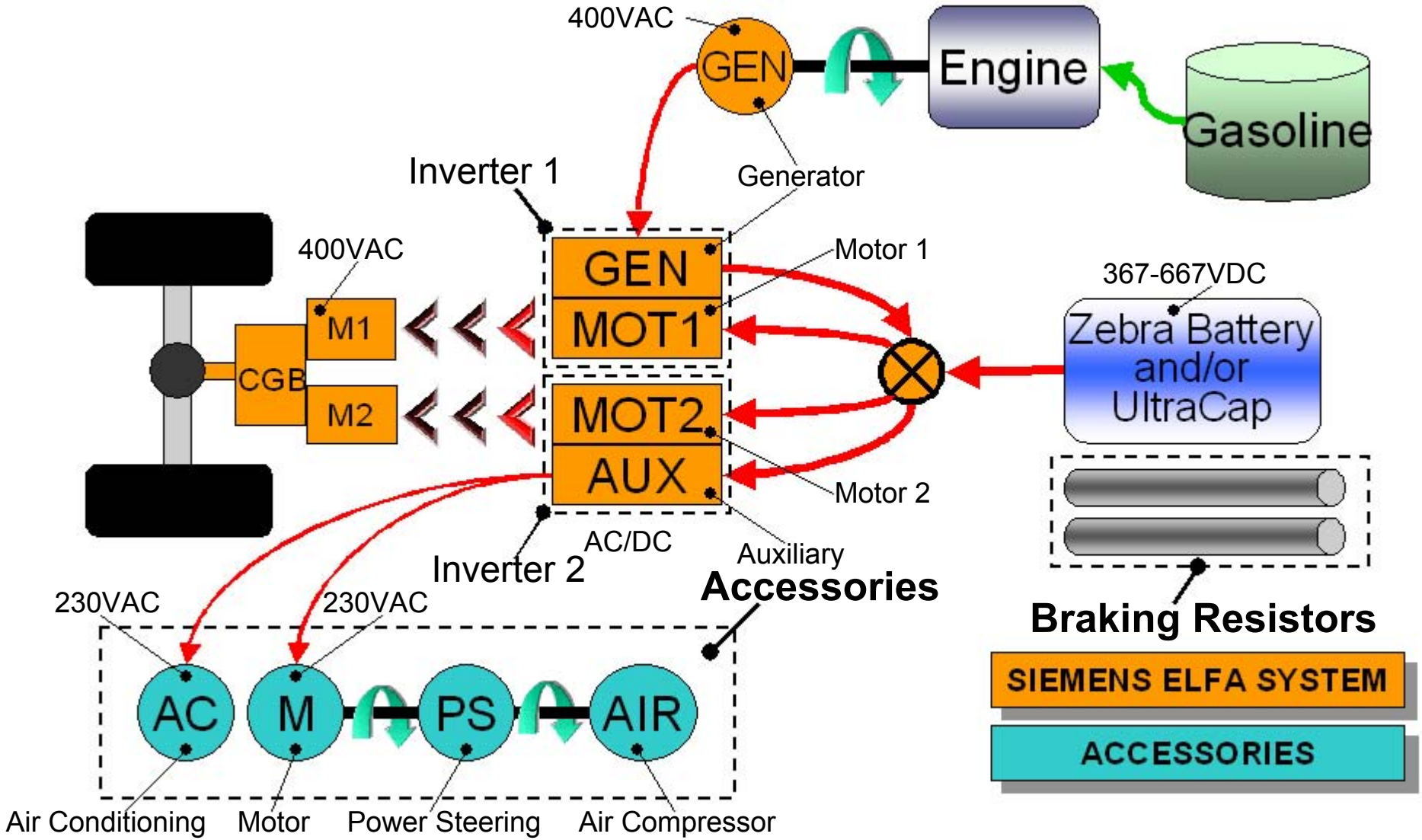


PM Emissions



ENERGY FLOW

TRANSPORTATION FOR A CLEAN PLANET



VEHICLE SUBSYSTEMS AND COMPONENTS

TRANSPORTATION FOR A CLEAN PLANET

Motive Drive System

Energy Storage

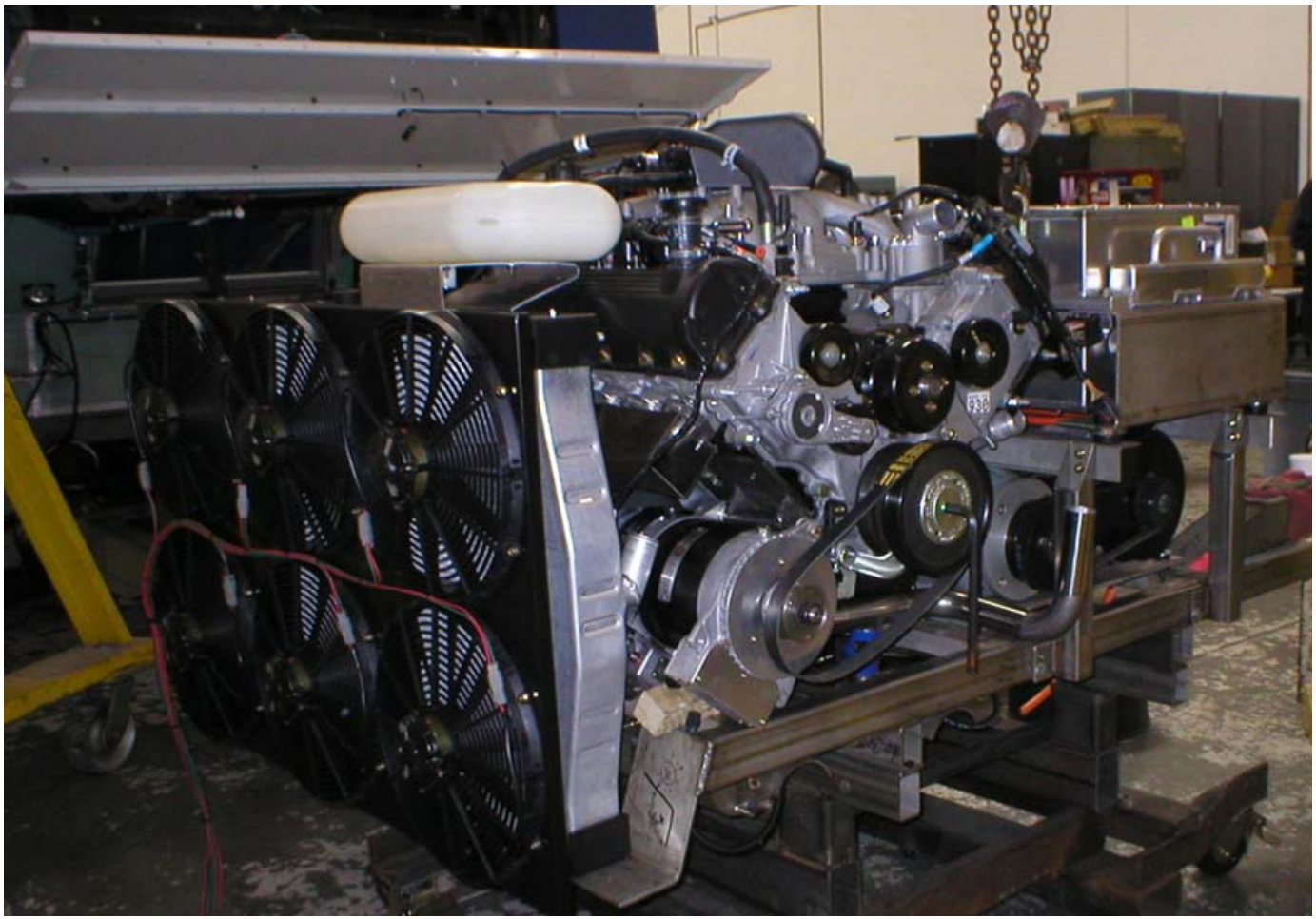
Vehicle Control (SAE CAN J1939)

Vehicle APU

Accessory Systems

Gasoline Hybrid Cradle Assembly

TRANSPORTATION FOR A CLEAN PLANET



ENERGY STORAGE SUBSYSTEM

TRANSPORTATION FOR A CLEAN PLANET

ZEBRA Battery Pack

- 20kWh Usable Energy
- 34kW Charge and Discharge Power/Module
- Integrated BMS, GFI, Contactors
- 100 WH/kg
- -40°C to 50°C with only fan cooling
- Expected life 2.5-5 years
- Weight 200kg/pack
- Recycling Program in place

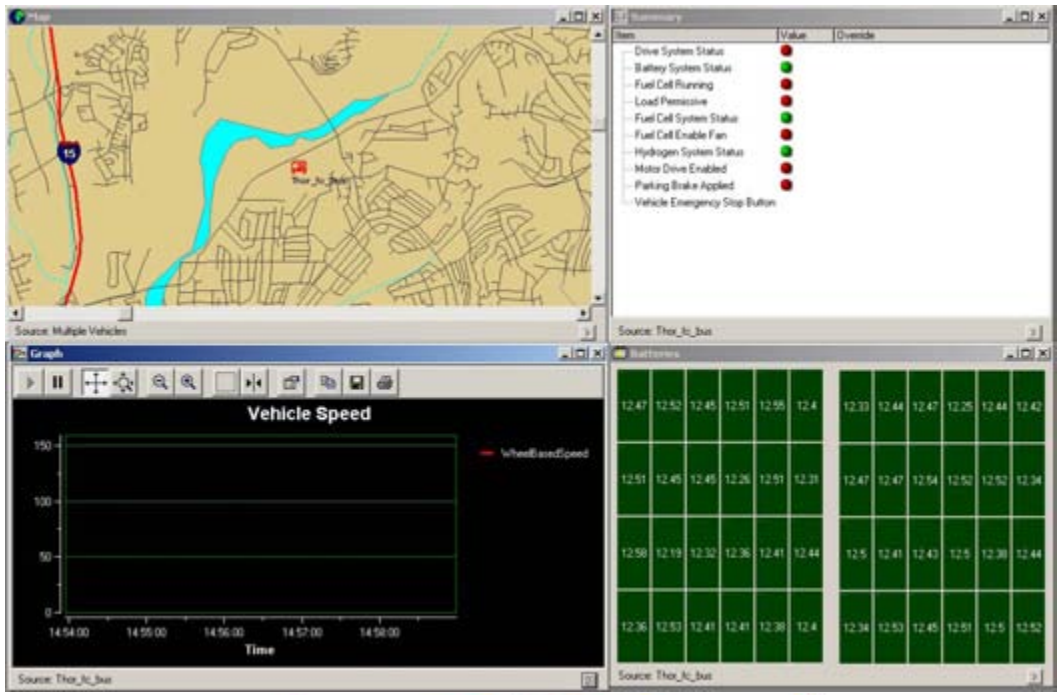
ThunderVolt II™ Ultracapacitor Pack

- 200 kW Usage/Discharge Current
- Total Energy Stored: 0.407kWh
- Peak Voltage: 403V
- Rated Current: 400A
- -35°C to 65°C Operating Temperature
- Optional Fire System

REMOTE DIAGNOSTIC UNIT (RDU) & VEHICLE OPERATIONS CENTER

TRANSPORTATION FOR A CLEAN PLANET

- **RDU**
  - Wireless link from vehicle allows real time data access via internet
  - Customer can monitor operation and troubleshoot issues remotely
  - Component suppliers can have their experts help troubleshoot remotely
  - 80211 (Wireless Ethernet) allows high data rate transmission upon return to yard
  - ISE will keep database of all vehicle data which customer can access as required
- **Vehicle Operations Center**
  - First two to be installed at AC Transit and SunLine Transit

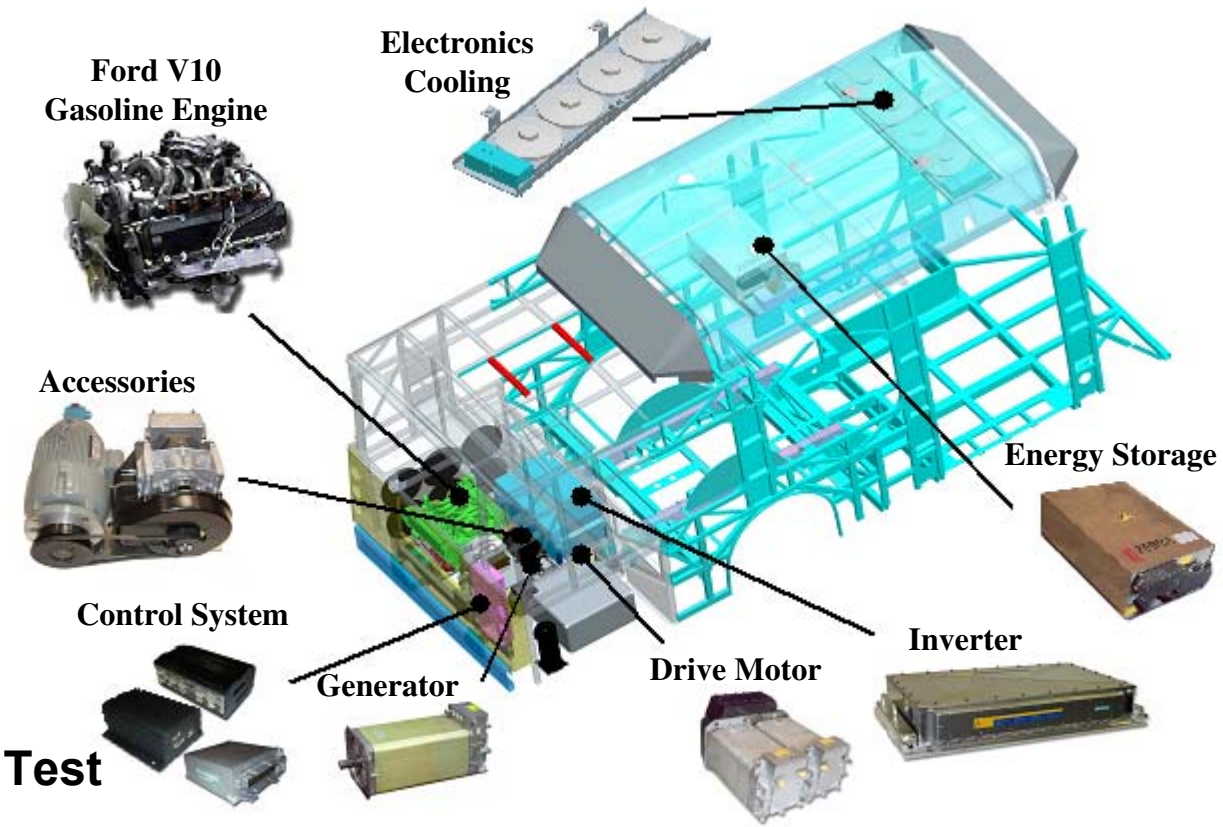


ISE HYBRIDS ARE DESIGNED TO REDUCE EMISSIONS

TRANSPORTATION FOR A CLEAN PLANET

- Ford ULEV-rated engine
- Runs on standard gasoline
- Siemens electric drive
- 40’ New Flyer bus
- In service at Omnitrans

- Fleet Model Bus in Altoona Test



HIGH EFFICIENCY, ZERO EMISSION FUEL CELL BUS

TRANSPORTATION FOR A CLEAN PLANET

- ThunderPower Joint Venture with Thor Industries
- Equipped with UTC Fuel Cells 60kW PEM fuel cell
- Fuel Cell Subsystem Operates at Over 50% Net Efficiency
- Battery Hybrid Drive System Improves Efficiency ~25%
- Achieves 7-11 MPG (9.8MPEG Average in Palm Springs Service)
- First Fuel Cell Bus in Revenue Service in California

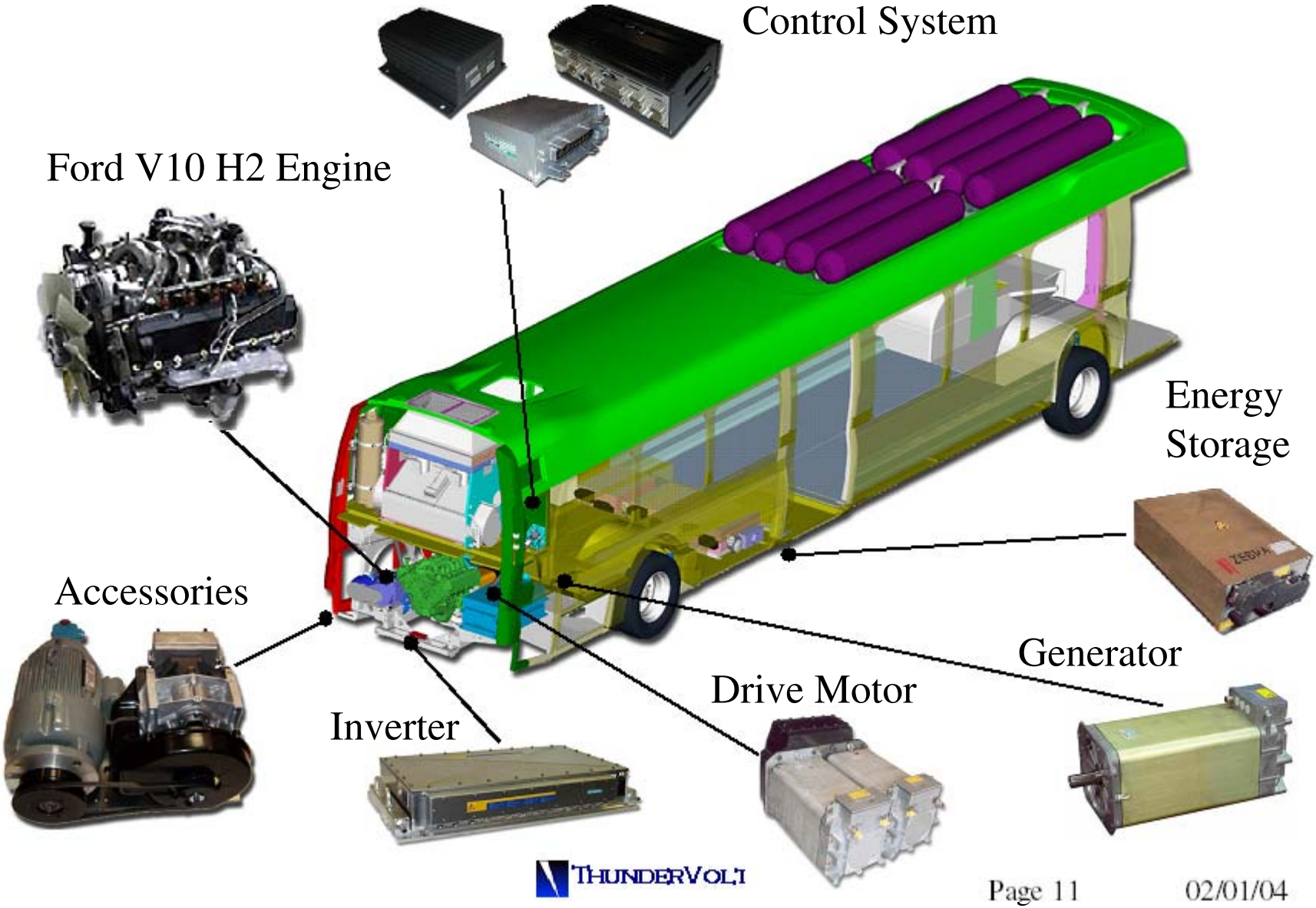
AC TRANSIT & SUNLINE TRANSIT FUEL CELL BUSES

TRANSPORTATION FOR A CLEAN PLANET

- Custom Fuel Cell Bus Chassis Produced by Van Hool
- Powered by 120kW UTC PEM Fuel Cell
- Uses ISE-Siemens Hybrid Drive System
  - Siemens 170kW Motors and Inverters, DC-DC Converter
  - Three Zebra NaNiCl Battery Packs
  - Fab Industries/SCI Hydrogen Fuel System
  - ISE Controls, Accessories, Thermal Control Systems
- Demonstration of Three Buses at AC Transit and One at SunLine Transit Scheduled to Begin in Early 05

HYDROGEN ICE HYBRID BUS CONFIGURATION

TRANSPORTATION FOR A CLEAN PLANET



Comparing Emissions from Conventional and Hybrid Buses

TRANSPORTATION FOR A CLEAN PLANET

DRIVE / EMISSIONS	NOx (g/mi)	PM (g/mi)	CO2 (g/mi)	EFFICIENCY	AVERAGE
Conventional Diesel	30	0.25	2500	33-35%	Poor
Conventional CNG	15	0.02	2400	26-28%	Poor
Hybrid Diesel	15	0.02	2400	40-42%	Good
Hybrid CNG	1	0.001	2300	31-33%	Very Good
Hybrid Gasoline	0.5	0	2300	33-35%	Very Good
Hybrid Hydrogen ICE	0.5	0	0	40-42%	Excellent
Conventional Fuel Cell	0	0	0	45-55%	Excellent
Hybrid Fuel Cell	0	0	0	50-60%	Excellent

HYDROGEN FUELED GOAL:

ZERO EMISSIONS TRANSPORTATION POWERED BY CLEAN RENEWABLE ENERGY