Key Challenges

- New, Practical Customer Features
- Beating Competition
- Government Regulations
- Improve Quality
- Simplify Manufacturing
- Improve Profitability
Liberty Functions

- Appropriate Technologies
- Pursue New Concepts
- Total Vehicle Concepts
- “Concept” Prototype Vehicles
- Proportion, Style, and Package
- Manufacturing Feasibility
- Build Prototype Vehicles
- Financial Feasibility
- Transfer New Concepts
- Define New Concepts
Liberty

Program Management
Chassis
Packaging
Manufacturing
Technical Affairs
Body
Powertrain / Electrical
Advanced Batteries Fuel Cells
ESX2 & 3 (U. S. “PNGV”)

- GOV’T, GOV’T LABS, FORD, GM, DAIMLERCHRYSLER
- VOLUME PRODUCTION BY 2007
- REQUIREMENTS:
  - MIDSIZE CAR - NO CUSTOMER TRADE-OFFS
  - 80 MPG WITH TODAY’S PERFORMANCE
  - 1/2 TODAY’S EMISSIONS
MYBRID

Motor Controller

Battery Pack Disconnect

Li-ion Batteries 150 volts

Fan

1.5 l CIDI Diesel Engine

FAMS

Clutch

EMAT

Electric Steering
Body System

Minimized number of structural body pieces

Structural body system is enhanced by filling the cavities with lightweight structural foam

Surface finish applied in mold

Lightweight metal “sparse” frame

Improvements in:
- Safety
- Structural Integrity
- Ride & Handling
- NVH (noise, vibration & harshness)
ESX3 Body Construction

- Aluminum Tube Frame
- Plastic Body Panel Inner
- Structural Foam
- Adhesive Bonding
- Plastic Body Panel Outer
- Adhesive Bonding
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Status</th>
<th>PNGV Goal</th>
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<tbody>
<tr>
<td>Curb Weight</td>
<td>2250 pounds</td>
<td>1960</td>
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<tr>
<td>Fuel Economy</td>
<td>72 mpg (comb. - gas equiv.)</td>
<td>up to 80</td>
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<tr>
<td>Fuel</td>
<td>Fischer-Tropsch Diesel</td>
<td>Any</td>
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<tr>
<td>Emissions</td>
<td>Meets Original PNGV Goals</td>
<td>Tier 2</td>
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<tr>
<td>Acceleration 0-60 MPH</td>
<td>&lt;11.0 seconds</td>
<td>12.0</td>
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<tr>
<td>Fuel Tank Capacity</td>
<td>6 gallons</td>
<td>As required</td>
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<tr>
<td>Range</td>
<td>400 miles</td>
<td>380</td>
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<tr>
<td>Passengers</td>
<td>5</td>
<td>5-6</td>
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<tr>
<td>Cargo</td>
<td>16 ft³</td>
<td>16.8</td>
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<tr>
<td>Aerodynamic Drag Coefficient C_d</td>
<td>0.22</td>
<td>0.20</td>
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<td>Price Premium</td>
<td>$7,500 U.S.</td>
<td>0</td>
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<td>U.S. Federal Safety Standards</td>
<td>Meets (except mirrors)</td>
<td>Meets</td>
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<tr>
<td>Recyclability</td>
<td>&gt;80%</td>
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</table>
Chrysler Citadel
Today’s 4x2

Today’s 4x4

“TTR”
Jeep Commander
In essence:
Only fuel cells appear capable of satisfying 3 key technical criteria

- High Fuel Economy
- Low Emissions
- Long Range

Many other criteria must also be met before the gasoline engine will be displaced: cost, weight, volume, reliability, safety, fuel availability, etc.
So what is a fuel cell and how does it work?

The diagram shows a fuel cell with the following components:

- **Anode** with a fuel (H₂) inlet and a catalyst.
- **Cathode** with an oxidant (O₂) inlet and a catalyst.
- **Electrolyte** to facilitate the flow of electrons.
- **Cooling/Bipolar Element** with gas/water channels.
- **Stack with End Plates and Connections** for integration into a larger system.

The fuel cell converts chemical energy directly into electrical energy through an electrochemical reaction, utilizing hydrogen and oxygen to produce water as a byproduct.
Jeep Commander

‘Gasoline’ - Fuel Cell

1. Fuel Vaporizer: By applying heat, liquid gasoline is converted to gases to ensure cleaner, soot-free combustion.

2. POX: Vaporized fuel is combined with some air in a Partial Oxidation reactor, producing hydrogen and carbon monoxide.

3. Water-gas shift: Steam acts with a catalyst to convert most of the carbon monoxide to harmless carbon dioxide and additional hydrogen. Carbon monoxide is harmful to fuel cells and must be reduced to less than 10 parts per million.

4. PROX: In the Preferential Oxidation stage, injected air reacts with remaining carbon monoxide over a catalyst to produce carbon dioxide, leaving hydrogen-rich gases.

5. Fuel cell stack: Hydrogen gas, combined with air, produces electricity to move the vehicle with virtually no pollution — emitting primarily water vapor.
Necar 3 hardware is being hybridized (better performance) in a 4WD Jeep Commander and is being split up (more interior space).
Dodge Charger
Dodge Charger
Compressed Natural Gas (with ISS) - SI Engine
BATTERIES

- **NiMH**
  - SAFT (LIQUID COOLED)
  - GM-O (AIR COOLED)
  - VARTA (AIR COOLED)
  - PANASONIC (AIR COOLED)

- **Li-Ion**
  - SAFT (AIR COOLED)
  - JAPANESE COS.

- **LITHIUM POLYMER**
  - HYDRO-QUEBEC (LIQUID COOLED) (WARM - 80 DEGREES C)
Next Hybrid Steps

- Sport Utilities - 4X4
- Truck - 4X4
- Minivans - AWD
Why Hybridize

- Reduce Fuel Consumption
- Maintain Vehicle Utility
- Reduce Vehicle Emissions
- Supplement Electric Vehicle Battery Limitations