“Hydrogen-Powered Vehicles: Pathways and Challenges”

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**Key Messages**

**EERE Fuel Cell and Hydrogen Activities:**

- Aligned with the National Energy Policy
- Aimed at valuable national benefits
  - energy security via lower oil imports
  - reduced air pollution
  - lower carbon emissions
- Rely on extensive collaborations
- Focus on critical technology needs
Stabilizing Concentrations

• Net emissions must eventually decline to virtually ZERO

...has non-trivial implications for energy.

...requires fundamental change in the energy system.
World Vehicle Registrations

Source: OTT Analytic Team
FreedomCAR is a Partnership

- The CAR in FreedomCAR is for Cooperative Automotive Research

- The Partners are:
  - U.S. Department of Energy
  - U.S. Council for Automotive Research

  (USCAR is a cooperative endeavor of DaimlerChrysler, Ford and General Motors to conduct pre-competitive research)

January 9, 2002
Secretary Abraham announces the FreedomCAR Partnership
Technical Barriers

There are significant technical and economic barriers that will keep fuel cells from making significant market penetration for 10 years.

- Fuel Cell Cost & Durability
- Safety/Codes & Standards
- Fuel Infrastructure
Fuel Cost

**Today (within 5 years)**

Large on-site steam methane reformers

**Tomorrow (within 10 years)**

Distributed hydrogen generation at local refueling station from natural gas, and from electrolysis

**Future**

Production from renewable, fossil with sequestration and nuclear systems
Proposed SMR Assembly
Hydrogen Storage

**Today** (within 5 years)
- Composite wall tanks that contain 5000 psi @ room temperature

**Tomorrow** (within 10 years)
- Composite wall tanks that contain 5,000 to 10,000 psi hydrogen gas, or low-temperature or cryo-gas tanks
- Metal hydride tanks

**Future**
- Carbon-based or chemical hydride systems
# Fuel Cell Cost and Durability

<table>
<thead>
<tr>
<th>Today (within 5 years)</th>
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<tbody>
<tr>
<td>High cost</td>
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<tr>
<td>$200/kW @ 500,000 UNITS</td>
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<tr>
<td>Low durability</td>
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<tr>
<td>1000 hours</td>
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<th>Tomorrow (within 10 years)</th>
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<tbody>
<tr>
<td>Cost</td>
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<tr>
<td>$125/kW @ 500,000 UNITS</td>
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<tr>
<td>Durability</td>
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<tr>
<td>2000 hours</td>
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<th>Future</th>
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<tr>
<td>Cost</td>
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<tr>
<td>$45/kW @ 500,000 UNITS</td>
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<tr>
<td>Durability</td>
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<tr>
<td>5000 hours</td>
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Power Park Concept

Natural Gas Pipeline

Renewable energy

Co-production of H₂ (Fleet Refueling) and Electricity (Electric Grid)

Hydrogen Storage

Reversible Fuel Cell

Fuel Cell

Hydrogen

Electricity

Electricity

Renewable energy

Power Park Concept
Stabilization (S)

S = Zero or Very Low Carbon Emissions

**Production**

= Renewable

Fossil Fuels with Sequestration

Nuclear

**Utilization**

= ICE

Turbines

Fuel Cells
Conclusions

• If world economies adopt a stabilization policy, then hydrogen becomes a leading fuel for mobile applications

• There are no technical breakthroughs necessary for the implementation of a hydrogen vehicle

• There is a significant “chicken and the egg” issue involved in the implementation of a totally new infrastructure

• Public/private partnerships will be necessary to facilitate the transition