

Fuel Cells for Transportation Applications



Patrick B. Davis

Fuel Cells for Transportation Program

Office of Transportation Technologies

Office of Energy Efficiency and Renewable Energy

Solid State Energy Conversion Alliance Workshop

March 21, 2002

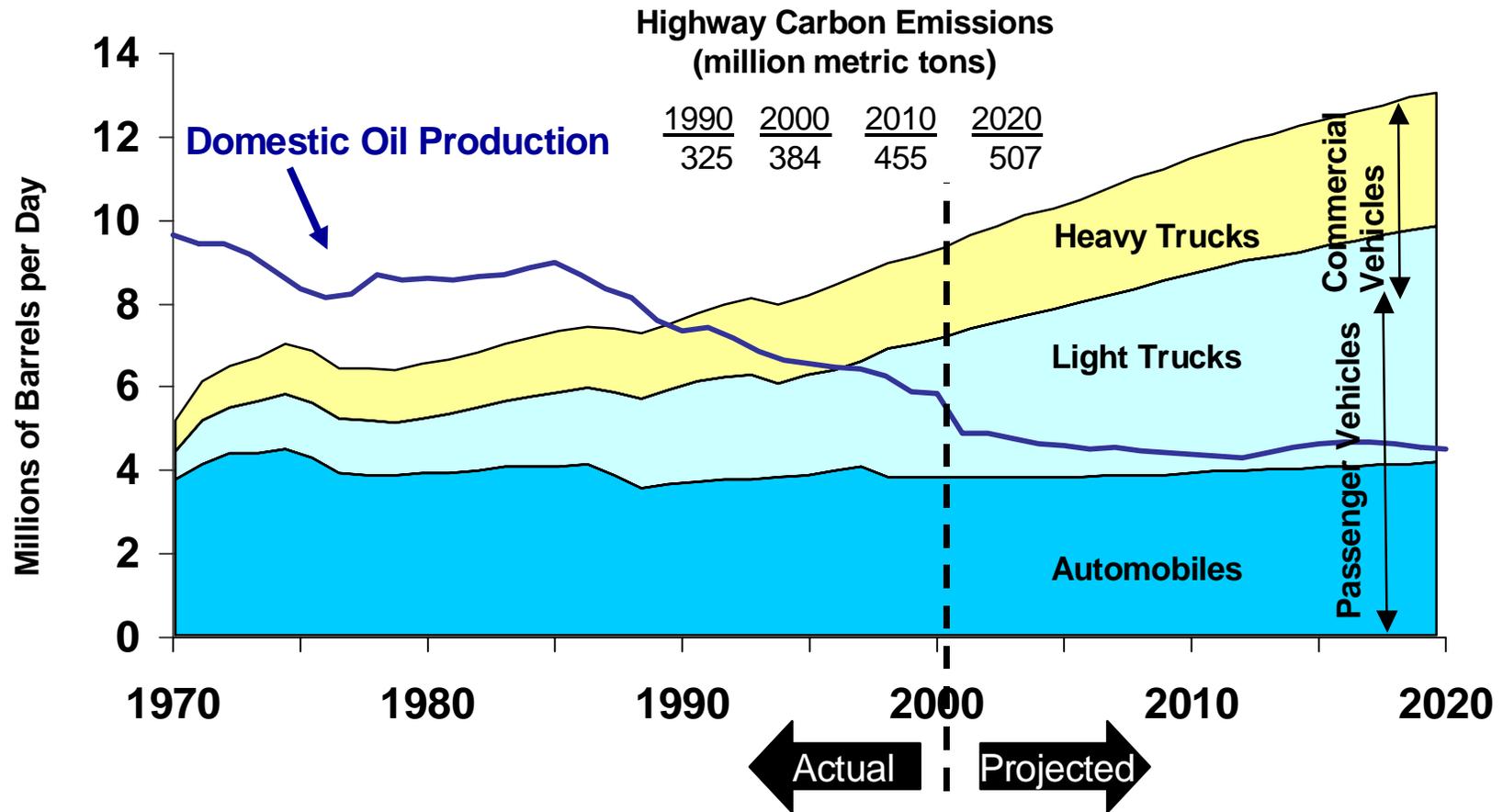


OTT Mission

...support the development and use of advanced transportation vehicles and fuels which will reduce energy demand, particularly for petroleum; reduce greenhouse gas emissions; and enable United States transportation to sustain a strong competitive position in domestic and world markets.



The "Oil Gap" is Growing

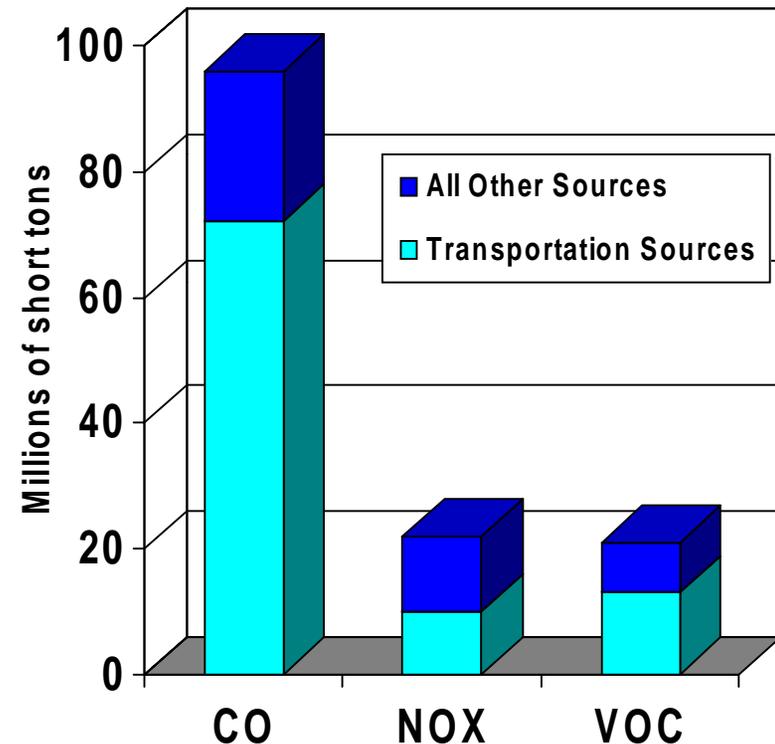


Source: Transportation Energy Data Book: Edition 21, DOE/ORNL-6966, September 2001, and EIA Annual Energy Outlook 2002, DOE/EIA-0383(2002), December 2001



Transportation Emissions Remain an International Concern

- Transportation produces:
 - 79% of carbon monoxide,
 - 50% of nitrogen oxides,
 - 36% of volatile organics, and
 - 42% of carbon dioxide emissions
- Over 100 million people live in areas not meeting National Ambient Air Quality Standard (EPA, Oct. 1995)





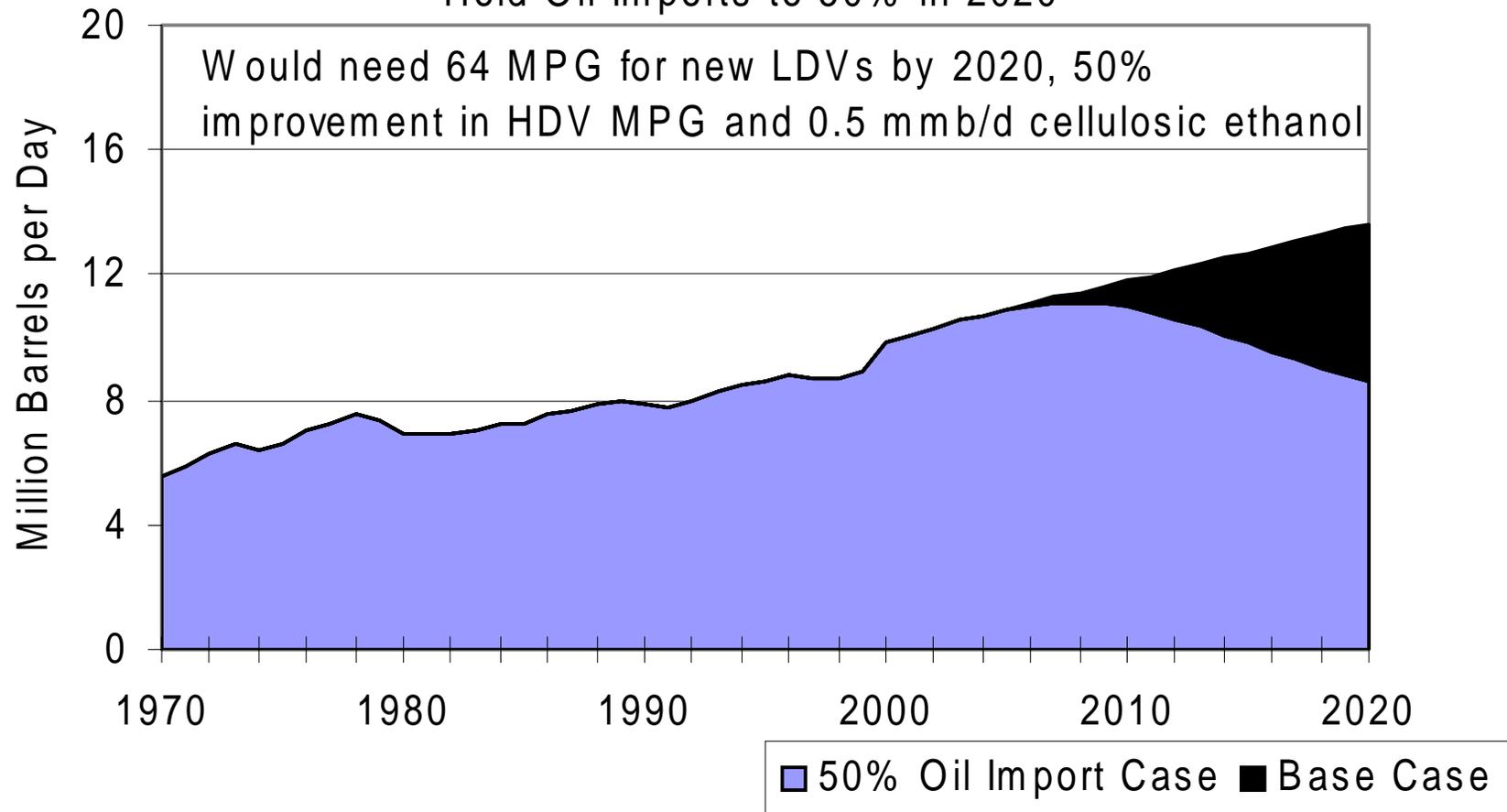
Closing the Oil Gap

- ✓ **Increase the Supply of Oil**
- ✓ **Reduce the Demand for Oil**
 - **Improve the Fuel Economy of Vehicles & other Oil Using Equipment**
 - **Replace Oil with Alternative Fuels (& Feedstocks)**



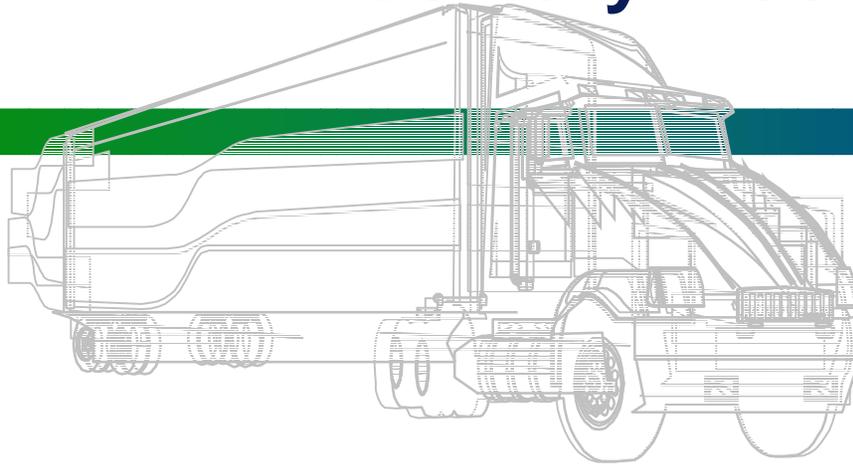
Energy Security – Reducing Petroleum Imports to 50%

5 MMB/D Savings in Highway Vehicle Energy Use Would Help
Hold Oil Imports to 50% in 2020





21st Century Truck Partnership



Industry Participants

- | | |
|----------------------|-----------------------------------|
| Allison Transmission | General Motors |
| BAE SYSTEMS Controls | Honeywell |
| Caterpillar | International Truck
and Engine |
| Cummins | Mack Trucks |
| DaimlerChrysler | NovaBUS |
| Detroit Diesel | Oshkosh Truck |
| Eaton Corporation | PACCAR |
| Freightliner | Volvo Trucks North America |



Department of Energy

DOE/EE/OTT
Heavy Vehicle
Technologies R&D



Department of Defense

Army/TACOM
NAC Military
Vehicle R&D



Department of Transportation

Intelligent Vehicle
and Highway
Safety R&D

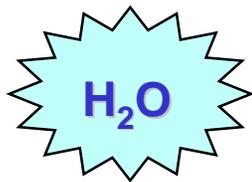


**Environmental
Protection Agency**

Vehicle
Emissions
Regulations

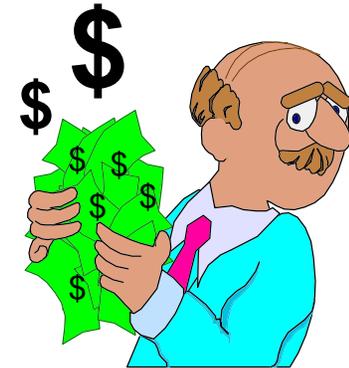


Fuel Cells For Transportation Program Goal

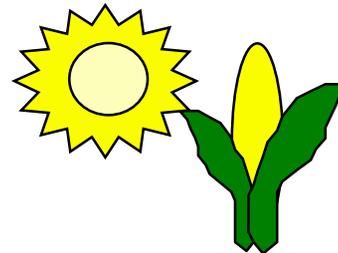
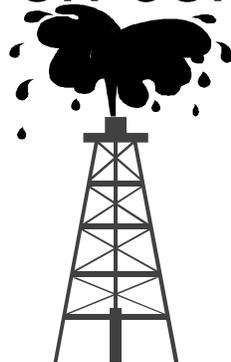


More MPG

Develop highly efficient,
low- or zero-emission,
cost-competitive

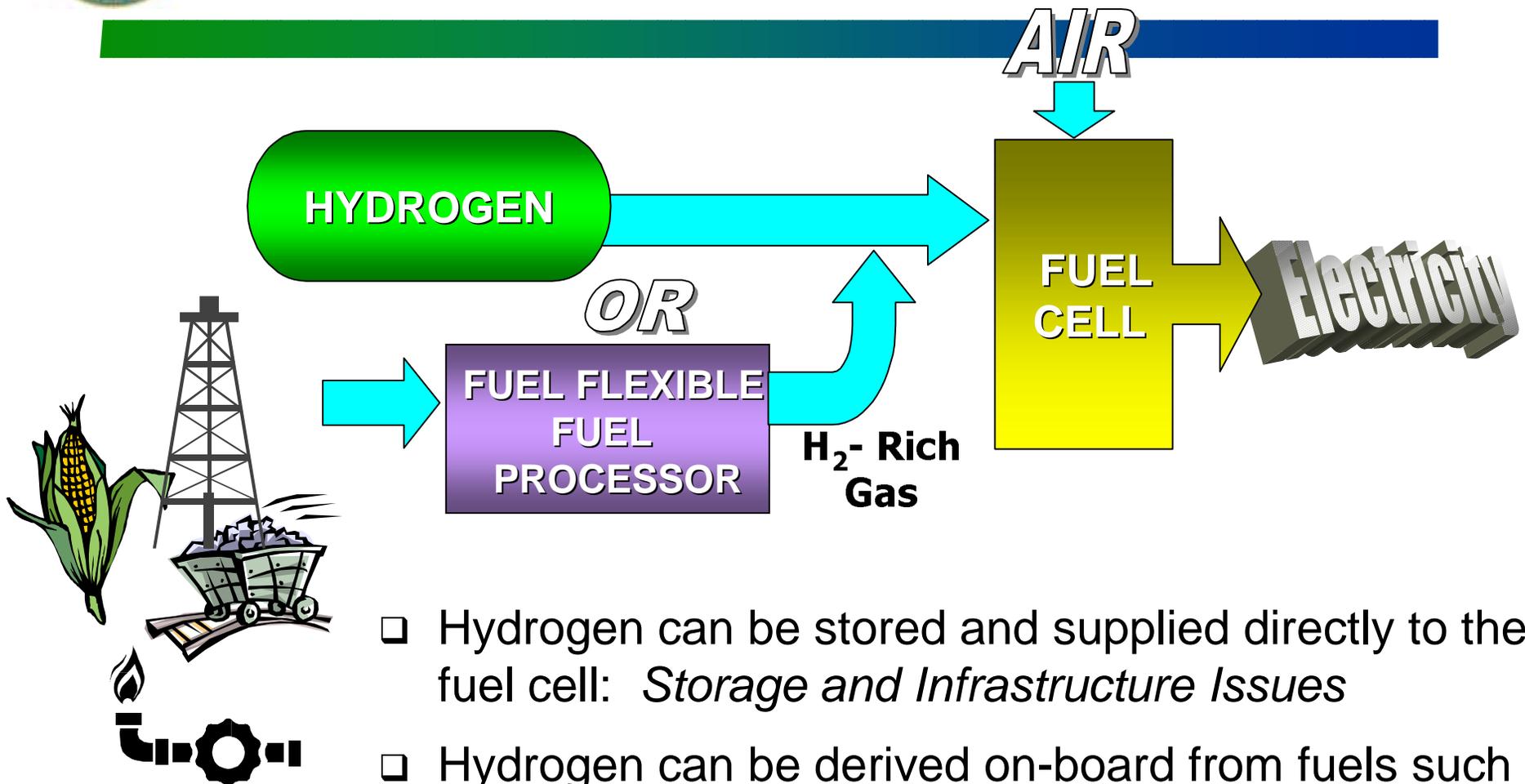


automotive fuel cell power system technologies
that operate on conventional & alternative fuels.





Fuel Strategy for Automotive Fuel Cells



- ❑ Hydrogen can be stored and supplied directly to the fuel cell: *Storage and Infrastructure Issues*
- ❑ Hydrogen can be derived on-board from fuels such as ethanol, methanol, natural gas, gasoline or FT fuels: *Complexity, Cost, and Start-up Issues*



Program is Focused on Critical Technical Challenges

Significant technical and economic challenges will keep fuel cell vehicles from making significant market penetration for up to 10 years.

Major Challenges for Automotive PEM Fuel Cells:

- Cost**
- Performance (Durability, Efficiency)**
- Air Management (Compressor Technology)**
- Startup (Fuel Processor Thermal Mass)**
- Thermal/Water Management**



Project Areas and Funding

Total Fiscal Year 2002 Budget: \$41.9M

2003 Budget Request: \$50M

Systems

- Benchmark 50 kW fuel cell power systems
- 50 kW stack subsystems
- system modeling
- thermal/water management
- sensors

Fuel Processing

- 50 kWe fuel processor subsystem
- emissions testing
- advanced fuel processing catalysts
- fuel stream clean-up devices

Stack Subsystem Components

- low-cost bipolar plates
- low-cost membrane electrode assemblies
- air management systems (compressor, expander, motor, controller)
- gas diffusion layers
- advanced fuel cell catalysts
- high temperature membranes



DOE is a Member of the CALIFORNIA FUEL CELL PARTNERSHIP



Goals

- Demonstrate vehicle technology
- Demonstrate the viability of alternative fuel infrastructure technology
- Explore the path to commercialization
- Increase public awareness



Members

- State of California (CARB/CEC/SCAQMD)
- Auto Manufacturers (DaimlerChrysler/Ford/Honda/Hyundai/Nissan/Volkswagen/General Motors/Toyota)
- Energy Providers (BP/Shell Hydrogen/Texaco/ExxonMobil)
- Fuel Cell Companies (Ballard/IFC/XCELLSiS)
- Associates (Air Products/Methanex/Praxair/Hydrogen Burner/Pacific G&E)
- Proton Energy/Stuart Energy/AC Transit/SunLine)
- Federal agencies (DOE/DOT)



SECA-Related R&D



OTT is developing fuel cells for auxiliary power units (APUs) in diesel trucks, and addressing the related technical challenges:

- **Diesel Reforming**

- eliminate carbon formation
- remove sulfur and/or develop sulfur tolerant catalysts

- **Solid Oxide Fuel Cells**

- develop rugged, low cost cell materials
- reduce startup time

Current R&D efforts are being carried by LANL, NETL, and ANL under the Transportation Fuel Cell Program.

Small businesses and universities will carry out R&D through the Cooperative Automotive Research for Advanced Technology (CARAT) Program.

Analyses of APUs for light and heavy vehicle applications being conducted.



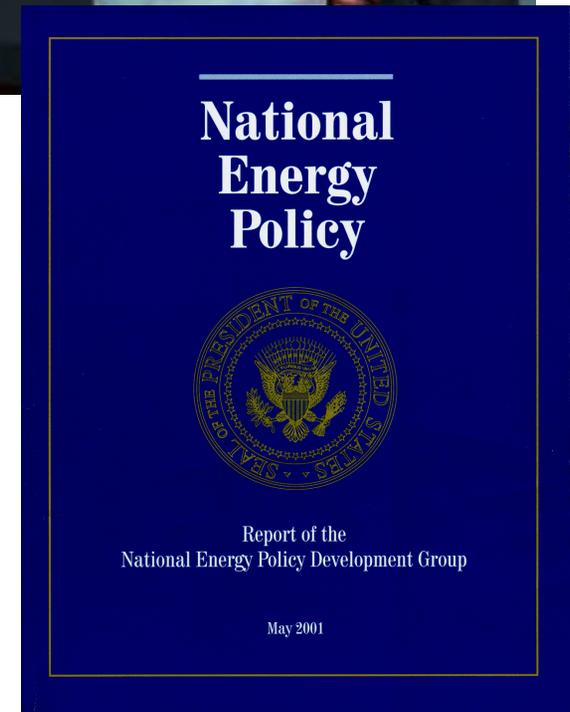
National Energy Policy

Directs the Secretary Of Energy “to develop next generation technology including hydrogen...

“Focus research and development efforts on integrating current programs regarding hydrogen, fuel cells, and distribution...

Develop legislation to provide for a temporary income tax credit available for the purchase of new hybrid or fuel cell vehicles.”

*“The President’s Plan directs us to explore the possibility of a hydrogen economy....”
Spencer Abraham, Secretary of Energy*





FreedomCAR



January 9, 2002
Secretary Abraham announces
the FreedomCAR 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)



Energy Security Through FreedomCAR Technology

America's Transportation Freedoms

- **Freedom from dependence on foreign petroleum**
- **Freedom from pollutant emissions**
- **Freedom to choose the vehicle you want**
- **Freedom to drive where you want, when you want**
- **Freedom to obtain fuel affordably and conveniently**



Strategic Approach

- ❑ **Develop technologies to enable mass production of affordable hydrogen-powered fuel cell vehicles and assure the hydrogen infrastructure to support them.**
- ❑ **Continue support for hybrid technologies and advanced materials that can dramatically reduce oil consumption and environmental impacts in the nearer term.**
- ❑ **Develop technologies applicable across a wide range of passenger vehicles.**



Goals

- ❑ **Develop reliable systems for future fuel cell powertrains with costs and performance comparable to conventional internal combustion engine/automatic transmission systems.**
- ❑ **Enable clean, energy-efficient vehicles operating on clean, hydrocarbon-based fuels powered by either internal combustion powertrains or fuel cells.**
- ❑ **Enable reliable hybrid electric vehicles that are durable and affordable.**



Goals

- ❑ **Enable the transition to a hydrogen economy, ensure widespread availability of hydrogen fuels while retaining the functional characteristics of current vehicles.**
- ❑ **Develop material manufacturing technologies for light weight, high volume production vehicles.**



2010 FreedomCAR Technology Specific Goals

	Efficiency	Power	Energy	Cost**	Life	Weight
Fuel Cell System	60% (hydrogen) 45% (w/ reformer)	325 W/kg 220 W/L		\$45/kW (2010) \$30kW (2015)		
Hydrogen Fuel/ Storage/ Infrastructure	70% well to pump		2 kW-h/kg 1.1 kW-h/L	\$5/kW-h \$1.25/gal (gas equiv.)		
Electric Propulsion		≥55 kW 18 s 30 kW cont.		\$12/kW peak	15 years	
Electric Energy Storage		25 kW 18 s	300 W-h	\$20/kW	15 years	
Materials						50% less
Engine Powertrain System*	45% peak			\$30/kW	15 years	

* Meets or exceeds emissions standards.

** Cost references based on CY2001 dollar values.



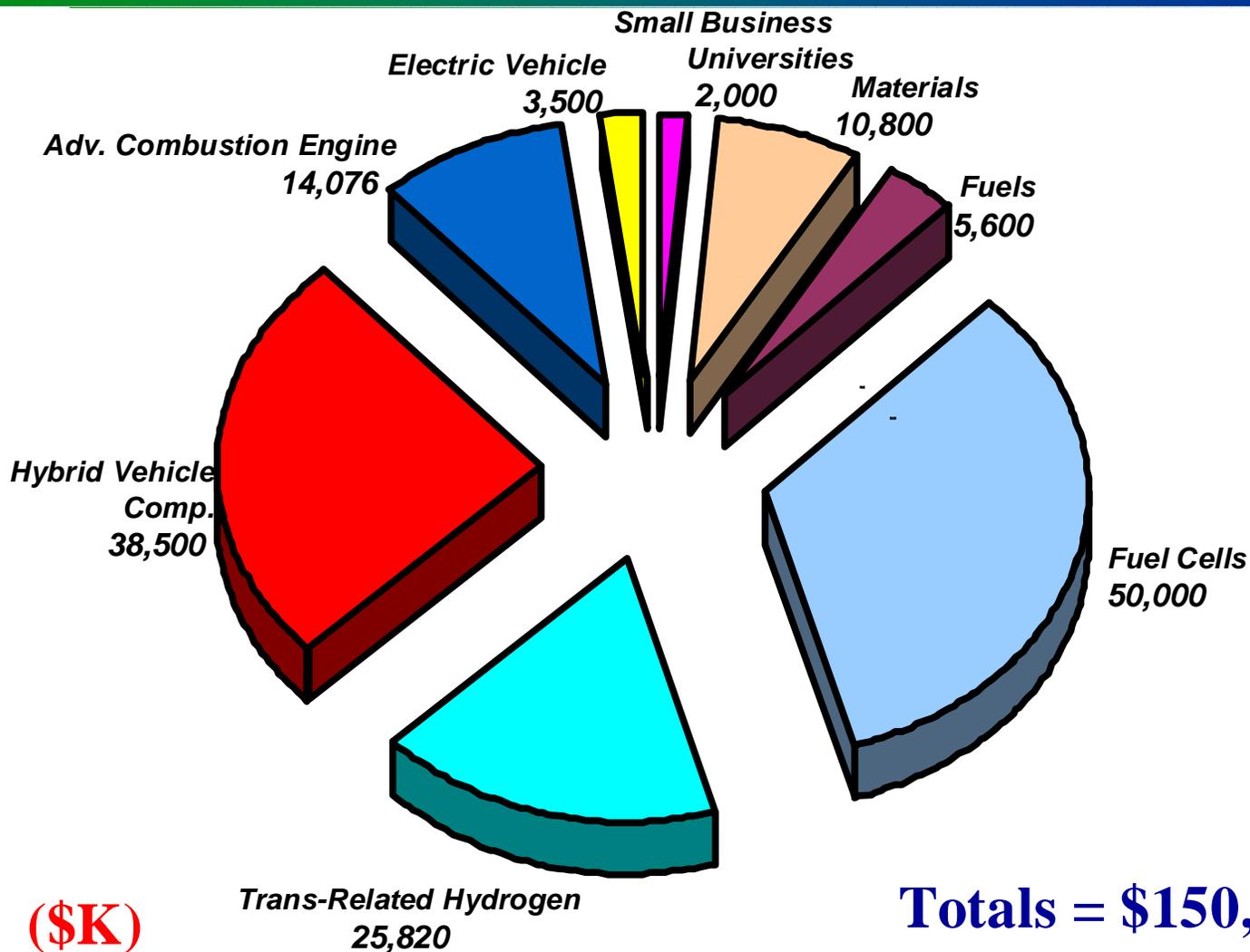
Organization



* Number & Composition of Technical Teams TBD



FreedomCAR FY03 Budget Request Reflects Fuel Cell and Hydrogen Priorities



(\$K)

Totals = \$150,296



Fuel Cell Vehicles and Advanced Hybrids Share Much Technology

FreedomCAR encompasses support for technologies with the potential to dramatically reduce oil consumption and environmental impacts in the period prior to the introduction of affordable fuel-cell vehicles.

- ✓ Hybrid Electric Drivetrains
- ✓ Advanced Internal Combustion Engines
- ✓ On-Board Fuel Processors for Fuel Cells
- ✓ Lightweight Materials, Energy Storage, Electronic Components



FreedomCAR Partnership

**A Long-Term Effort to Achieve
Clean Energy-Efficient Automotive Transportation
Based on Hydrogen-Powered Fuel-Cell Vehicles**

With

✓ **Intermediate Goals and Metrics
to Ensure Measurable Progress**

While

✓ **Ensuring America's Transportation Freedoms**



Fuel Cell Report to Congress

FY02 Interior Appropriations Bill

“The Department should report to the House and Senate Committees on Appropriations, within twelve months of the date of enactment of this Act, on the technical and economic barriers to the use of fuel cells in transportation, portable power, stationary, and distributed generation applications. The report should include recommendations on program adjustments based on an **assessment of the technical, economic, and infrastructure requirements needed for the commercial use of fuel cells for stationary and transportation applications by 2012.**”



Fuel Cell Report to Congress - Continued

House/Senate Conference Report:

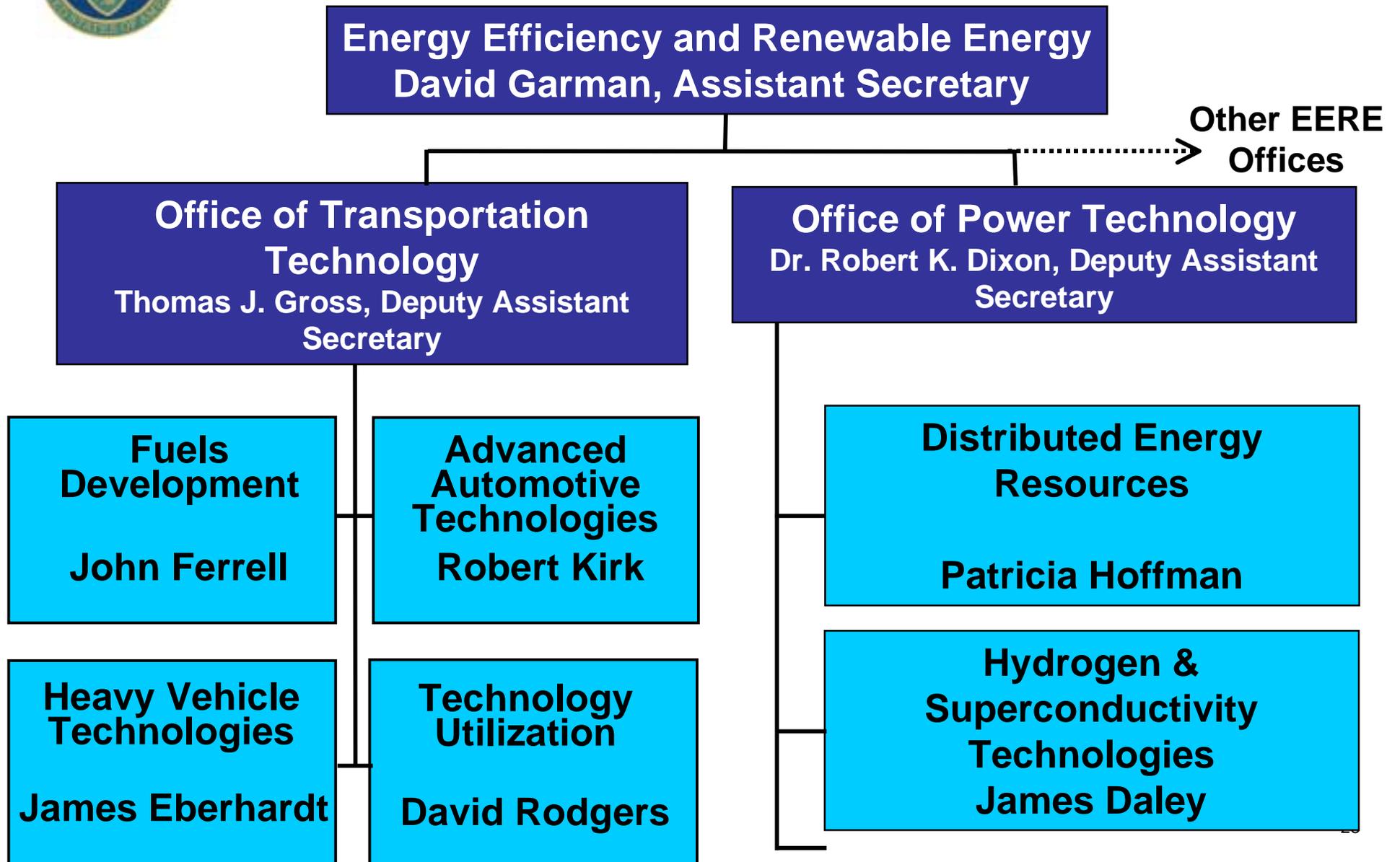
Interim Report: “Within six months of the date of enactment of this Act, the Department should also provide an **interim assessment** that describes preliminary findings about the **need for public and private cooperative programs to demonstrate the use of fuel cells in commercial scale applications.**”



Reorganization of Energy Efficiency and Renewable Energy

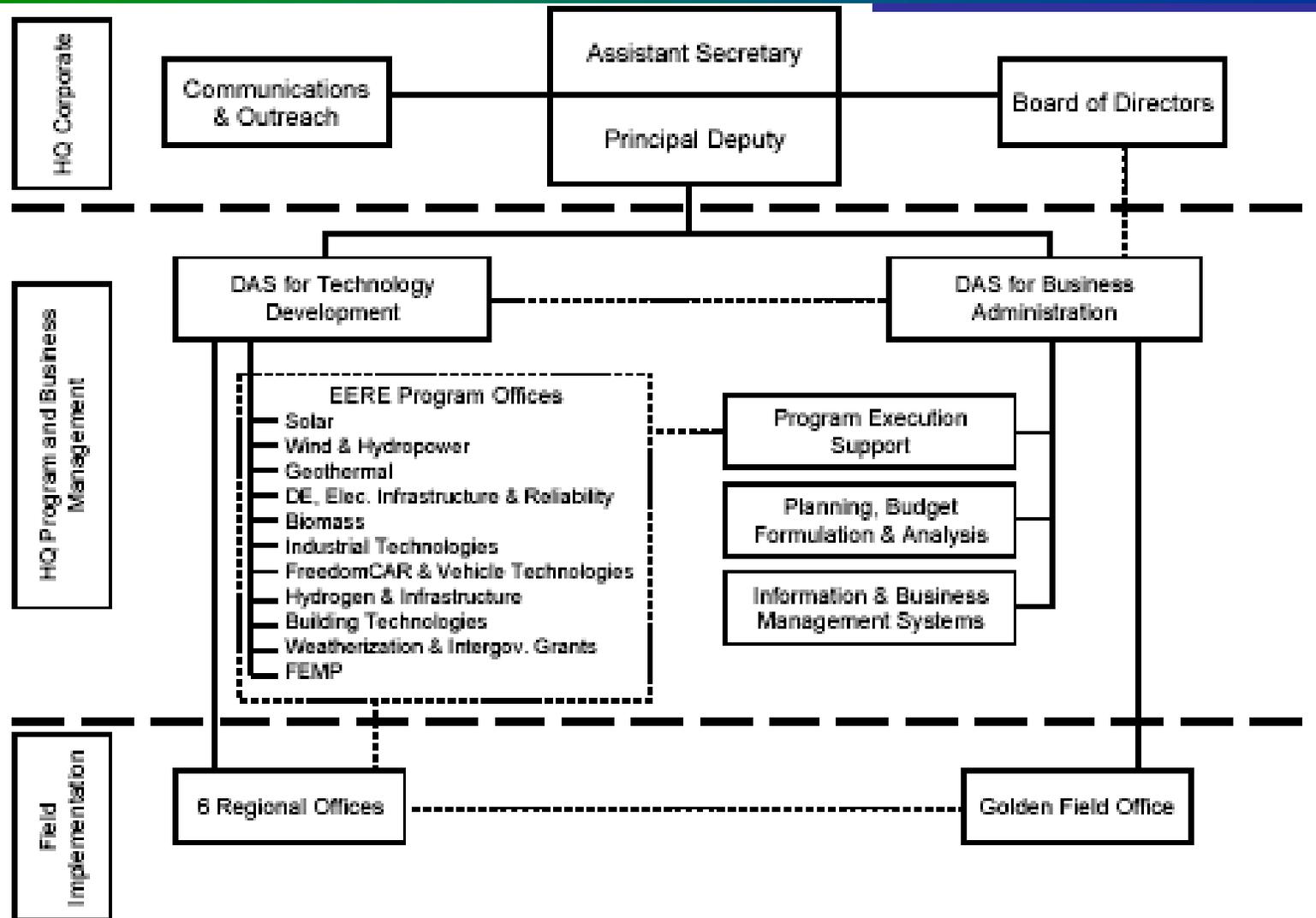


Current Organization (Fuel Cell Related)





Reorganization of Energy Efficiency and Renewable Energy





New Program Office for Hydrogen and Infrastructure

- Within EE, accomplishes NEP goal of “integrating current programs regarding hydrogen, fuel cells, and distribution”.
- Hydrogen and Infrastructure Includes: OTT/Fuel Cells, OPT/Hydrogen Program, DER/Fuel Cells and any other Hydrogen system-specific R&D related work.
- FreedomCAR and Vehicle Technologies Includes: Everything under Office of Transportation Technologies EXCEPT: Fuel Cells for Transportation, Clean Cities, Grants programs and Bio-fuels.
- No information available about staffing of this organization, but will be determined in the next week. Staff are expected to be drawn from existing programs.



Summary

- ❑ **DOE's Office of Transportation Technologies is addressing the key technical challenges in the development of fuel-efficient vehicles for both light duty and heavy duty applications.**
- ❑ **Government-Industry partnerships are critical to the success of OTT's Vehicle Technology Programs.**
- ❑ **OTT's Fuel Cell Program has made tremendous progress; however, major technical challenges remain which prevent the introduction of fuel cell vehicles today.**
- ❑ **The new structure of transportation programs under Energy Efficiency and Renewable Energy will consolidate fuel cell and hydrogen related work.**

For more information, visit the OTT Web Site:
www.ott.doe.gov