

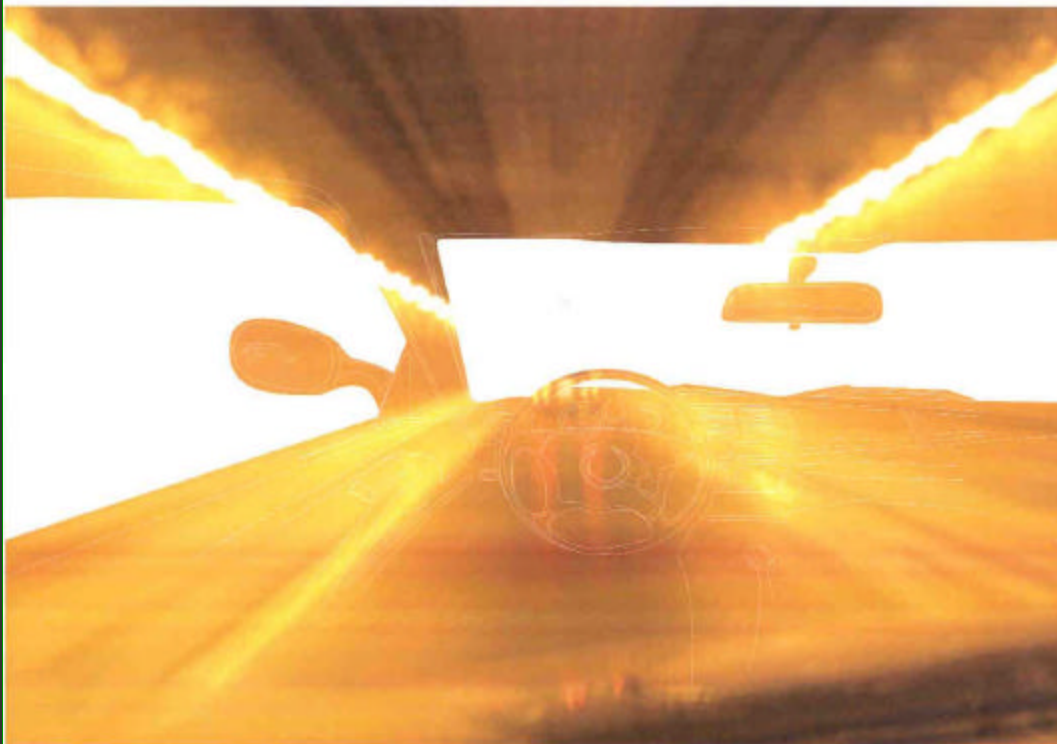
# Hydrogen-Powered Vehicles: Pathways and Challenges

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# Fuel Cell Vehicles

Technology, Market, and Policy Issues



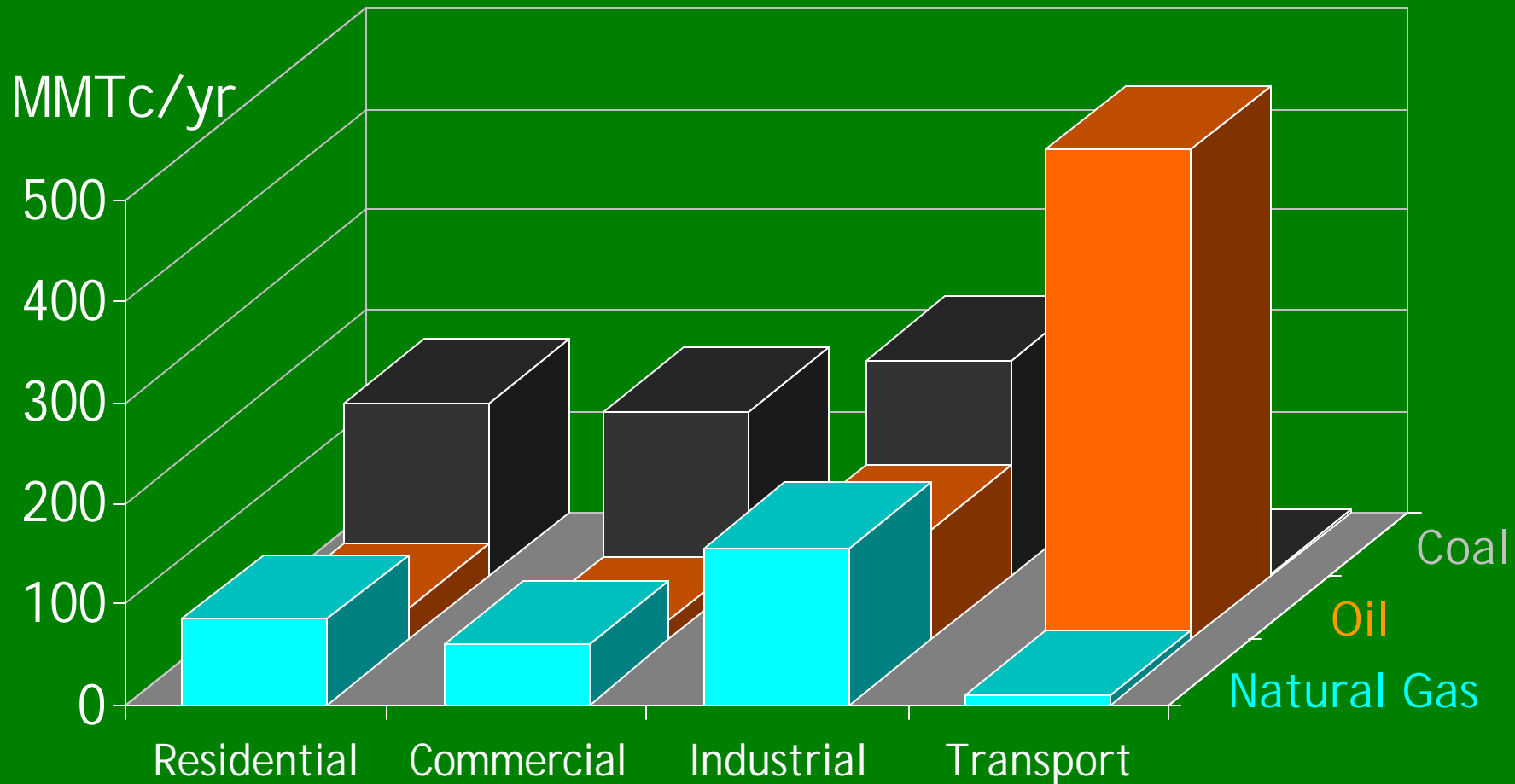
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**SAE** Research Report

SAE Research Report  
RR-010

see [fuelcells.sae.org](http://fuelcells.sae.org)

# U.S. Fossil Carbon Emissions by End-Use Sector and Primary Fuel



Derived using 1999 data from DOE/EIA Annual Energy Outlook 2001

# Key Question

What does it take to make the  
**Business Case**  
for production investments  
(moving beyond R&D)  
in new automotive technology?

# Issues for Commercialization

- Status of the Technology
- Market Needs
- Policy Considerations
- The Technological Competition

# Barriers Faced by Fuel Cell Vehicle Technologies

Technology Area	Type of Barrier				
	F	D	M	E	I
Hydrogen PEM stack			↘	↘	
Ancillary devices		↘	↘	↘	
Fuel processors (liquids)	↘	↘	↘	↘	
Fuel storage (hydrogen)	↘	↘	↘	↘	↘
Fuel supply (H <sub>2</sub> , CH <sub>3</sub> OH)				↘	↘
Electric drive components			↘	↘	

**F** = Fundamental,    **D** = Developmental,    **M** = Maturity,  
**E** = Experience,    **I** = Infrastructure

# Realistic Expectations for Fuel Cell Vehicles

- For several reasons,
  - » time needed to gain experience and reduce costs for any electric-drive vehicle system
  - » ongoing improvements in gasoline technology
  - » the fuel choice dilemma

fuel cell vehicles may be widely affordable no sooner than profound infrastructure change becomes feasible.

- Given such a long time horizon, many other needs (non-energy-related) could reshape the personal transportation system in profound ways.
- It is not obvious that any new, “drop in” fuels and technologies, including fuel cells, of themselves will provide benefits compelling enough for change.

# Status of Factors for Change

- Market Forces
  - » Weak interest in higher efficiency, even at European fuel prices
  - » Value for higher-power on-board electricity
- Air Pollution
  - » Upcoming LEV 2, Tier 2 standards offer another order-of-magnitude reduction per vehicle.
  - » Gasoline vehicles will remain competitive on air quality grounds for at least two more decades.
- Oil and Carbon
  - » United States has no real commitment to change
  - » We lack the equivalent of a NEPA or CAA



# All Electro-Drive Vehicles (EDVs) Face a Value Gap

- Except for limited applications or low-volume production, all EDVs face a gap between costs and benefits, even benefits broadly construed.
- HEVs are closest to closing the gap.
- The profound value hurdles for those EDVs that need new fuel infrastructures cannot be researched (or demonstrated) away.
- Fleet or niche solutions are no solutions at all unless a path to mainstream is clearly defined.

# Policy Considerations

- Air Quality
  - » Fuel cells (or other ZEV/alternative technologies) are not generally needed for foreseeable future.
- Greenhouse Gas Emissions
  - » Fuel cell technology not sufficiently available for affecting near- mid-term (2010-2020) emissions
  - » Long-term effects depend strongly on the fuel, for fuel cells and any other prime mover
- Research & Development
  - » Sustained commitment is important, but need to hedge the R&D portfolio.
  - » Many alternative vehicle technology RD&D efforts reflect dated premises and need to be updated.

# Finding Pathways for Progress

- Council on Competitiveness (1998):

"... development of advanced technologies, like hybrid vehicles, will require more than industrial or government R&D funding. Even joint partnerships can do little to offset the lack of market demand."

- Toward oil and carbon management
  - » Need to create a sense of imminent inevitability
  - » Provide market discipline needed to stimulate intelligent investments
  - » Find ways to start small (state, local, private), to prove workability and gain experience.