

# Vehicle Technology Prospects and Challenges

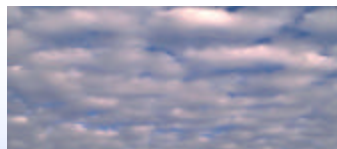
John German  
American Honda Motor Co.

USAEE  
July 10, 2004

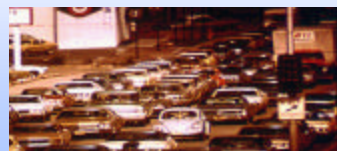
## 3 Issues for the Future Automobile:



Energy Supply & Demand  
Sustainability

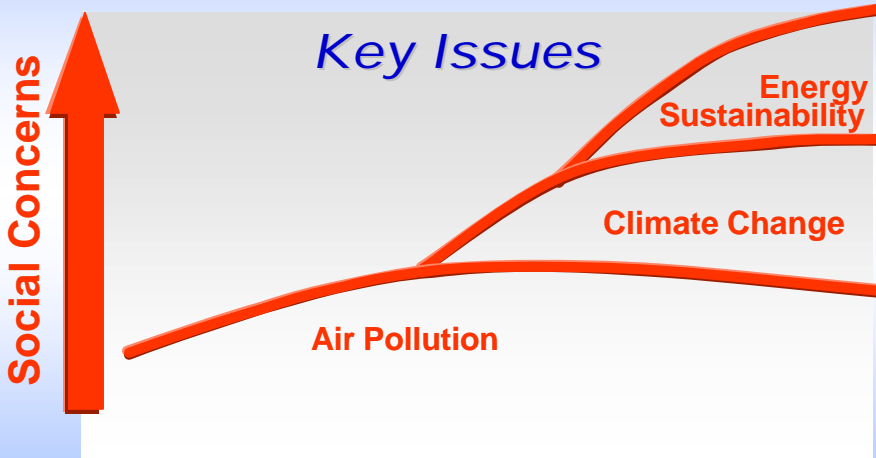


Climate Change

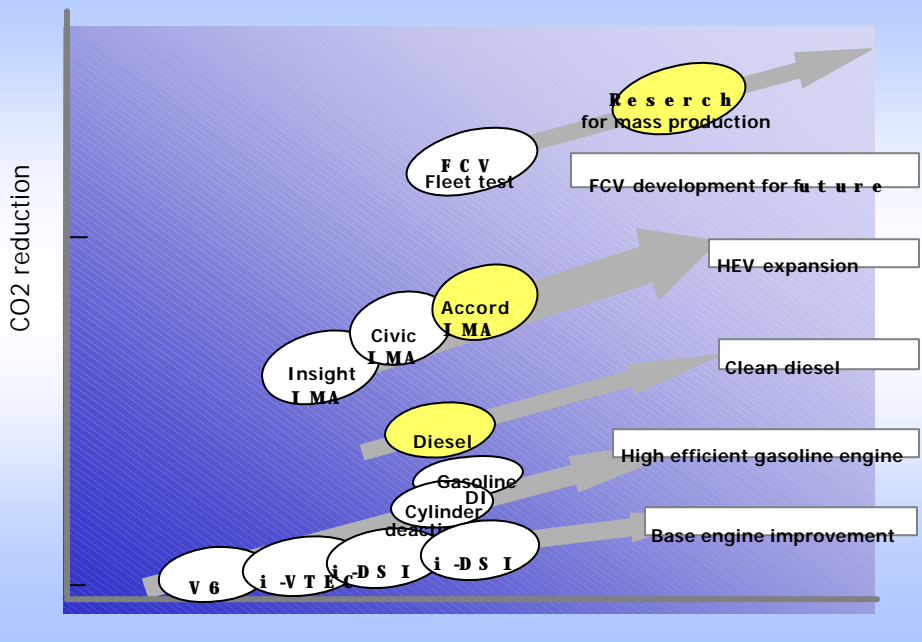


Urban Air Quality

# Transportation's Social Issues



# Power train progress for CO<sub>2</sub> reduction



## ***Clean & Fuel Efficient I.C.E. Power Plants***

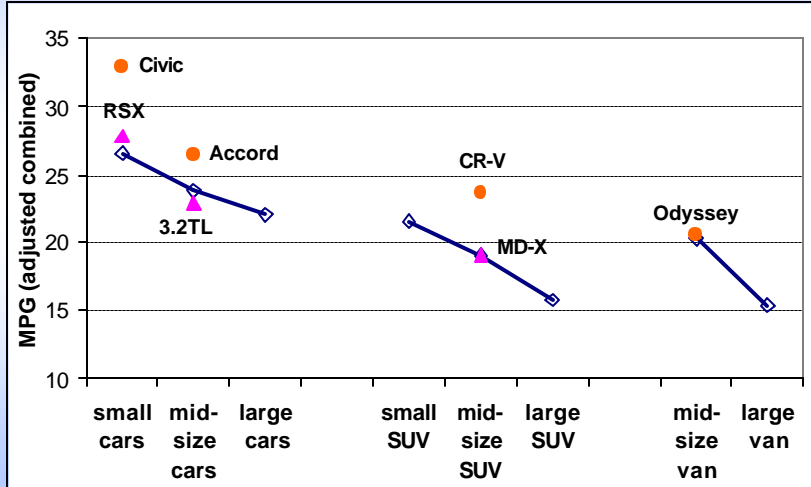


## **Honda is Committed to Clean and Efficient Gasoline Vehicles**

- Technically advanced F.E. leading models in the market
- Popular mass-market models with continual efficiency improvement
- Highest CAFE of major OEMs

# Wide FE Technology Application

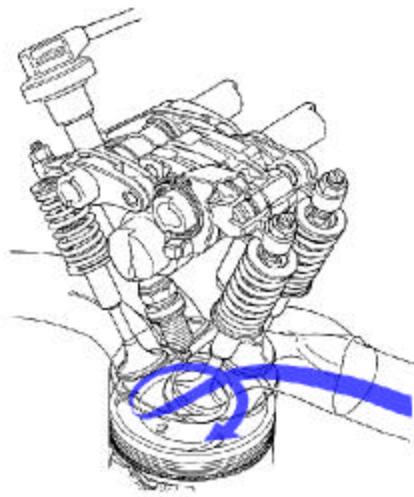
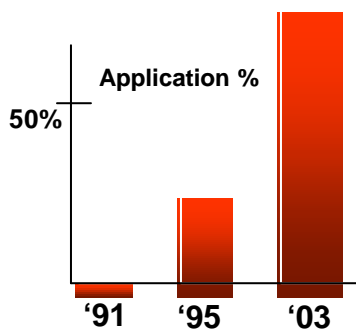
2003 Model Year Data from the 2003 FE Trends Report, US EPA



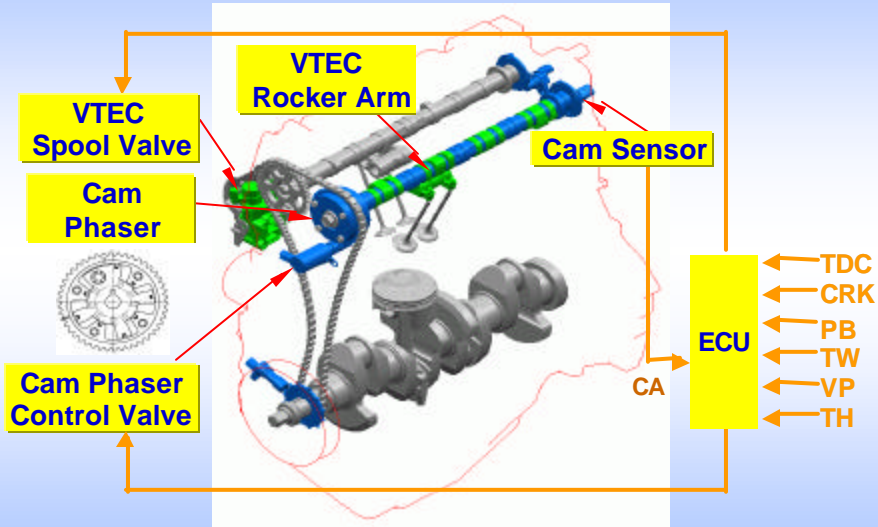
\*Odyssey is larger and heavier than average mid-size van: 4500 ETW versus 4345

## Honda VTEC Combustion:

- HIGHER EFFICIENCY
- LOWER EMISSIONS
- GREATER PERFORMANCE



# i-VTEC Engine



*Intelligent Valve Timing Control*

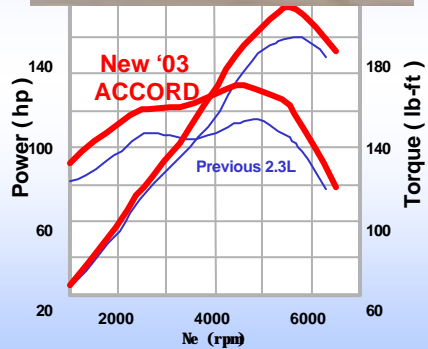
## Performance w/o Compromise



Increased Power  
**160 hp**

Increased Fuel Efficiency (AT)  
**24/33 city/highway mpg**

Reduced Emissions  
**LEV II: LEV & SULEV**



**More Power, Lower Fuel Consumption, and Near Zero Emissions**

# New Generation of Engine Technologies

## Engineering Concept

- Improvement of Volumetric Efficiency
- Combustion Efficiency & Combustion Control
- Reduction of Pumping Loss
- Reduction of Friction
- Lightweight & Compact

+

**Lean Burn Technologies**

+

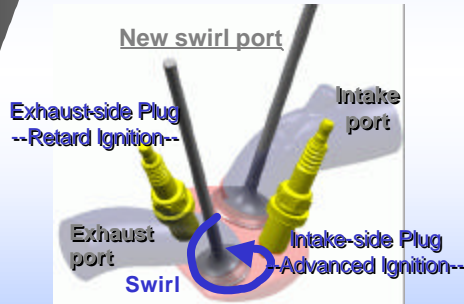
**VTEC Cylinder Idling**

**i-DSI**

Dual & Sequential Ignition

Twin Plug

Sequential Ignition



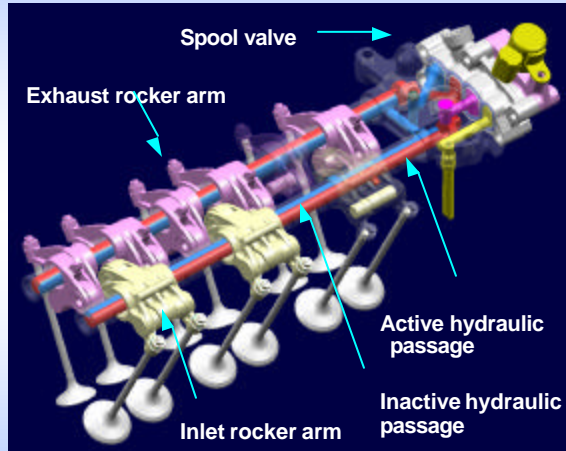
**Honda**

# CR-V Full Model Change - 2002

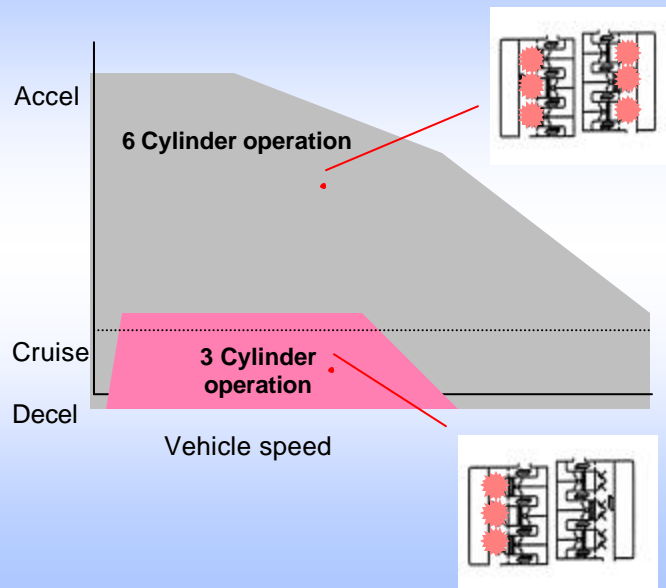
Attributes/Model	CR-V	
	2001	2002
ETW (lbs) AT 2WD	3375	3500
Range (MT, 4WD)	3375-3500	3500-3625
Length	178	179
Width	69	70
Height	66	66
Passenger vol	98	106
Cargo vol	30	33
Towing capacity	1000	1500
Engine size (L)	2.0	2.4
Horsepower@rpm	146@6200	160@6000
Torque (ft-lb)@rpm	133@4500	162@3600
Compression ratio	9.6:1	9.6:1
FE <sup>1</sup> : AT 2WD	22/25	23/28
AT 4WD	22/25	22/26
MT 2WD	---	---
MT 4WD	22/25	21/25

- Interior volume: + 9%
- Weight: +4%
- Displacement: +20%
- Horsepower: +10%
- Torque: +22%
- Towing capacity: +50%
- Fuel Economy: + 3-4%

## VTEC VCM valve train



## Variable Cylinder Management



## **VCM Development Sequence**

- 2003 Civic IMA (hybrid)
  - Used similar mechanism for cylinder deactivation on deceleration
- 2003 Inspire for Japanese market
- 2004 New mini van for Japanese market
- U.S. Honda light truck model for 2005 model year
- 2005 Accord IMA (hybrid)

## **Transmission Advances**

- Computer controls are enabling a variety of improved transmission designs
  - Improved shift points and lock-up strategies
  - Lapillier 6-speed automatic
  - Dual-clutch automated manual
  - Continuously Variable Transmission (CVT)
- Not yet clear which is most cost effective, but efficiency improvements of at least 5 percent are likely



## Incremental FE Technology

- Engine technology
  - High specific output (including 4 valve/cylinder)
  - Variable valve timing/lift
  - Cylinder deactivation
  - Direct injection
  - Precise air/fuel metering
- Transmission efficiency
  - 5/6 speed-AT/6-speed MT
  - CVT
  - Dual-clutch automated MT
- Reduced losses
  - Lightweight materials
  - Low drag coefficient
  - Low resistance tires
  - Lower accessory losses

### Cost and value issue

- These technologies are continuously being incorporated into vehicles.
- However, consumers value other attributes more highly, such as performance, safety, utility, and luxury.
- Putting in technologies just to improve fuel economy may not be valued by customers.

### Fuel Economy Improvement - ???

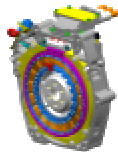
Depends on how much is already incorporated into fleet and synergies (or lack of synergy) between technologies

## Hybrid Vehicles

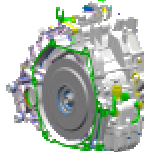


Efficient hybrid engine

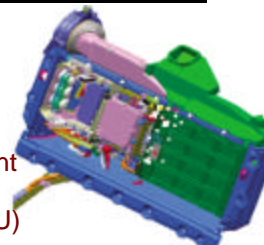
Electric Motor



CVT

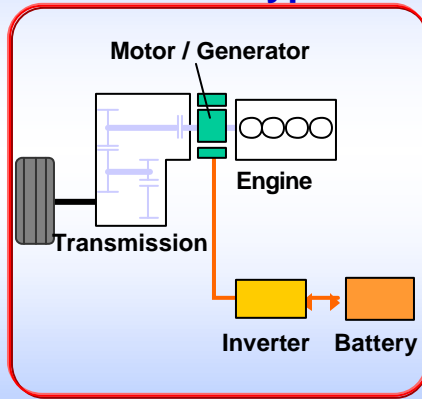


Intelligent Power Unit (IPU)



## Integrated Motor Assist Hybrid (Honda Civic Hybrid)

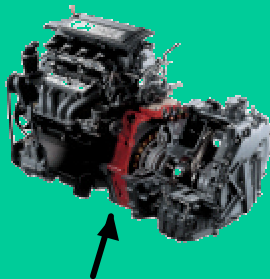
### Parallel - Type



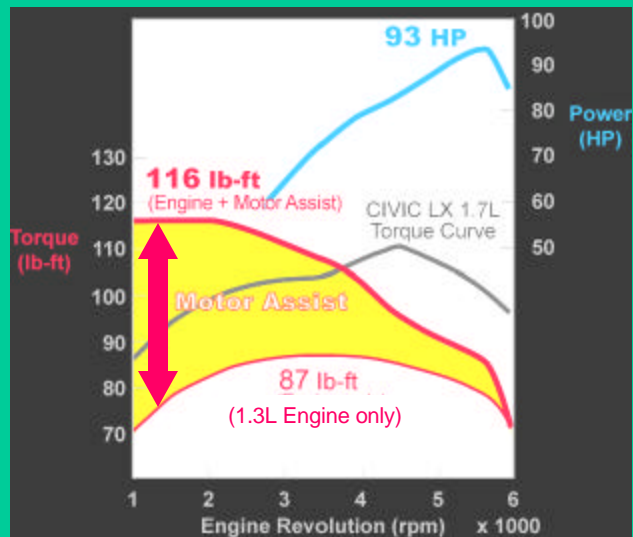
- Relatively Simple, Lightweight & Compact
- Efficient in City and Highway driving

## Engine and Motor Output Characteristics

### CIVIC HYBRID

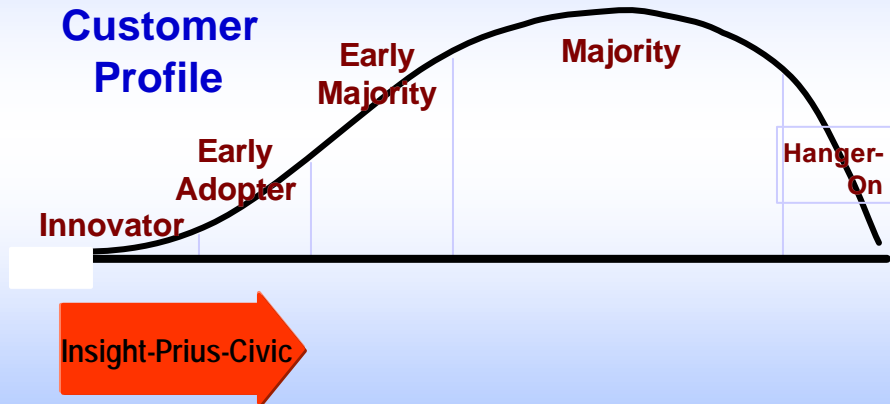


High Efficiency,  
High Torque  
Electric Motor



## Hybrids: Who is the buyer?

### Customer Profile



## Attractive Hybrid Features



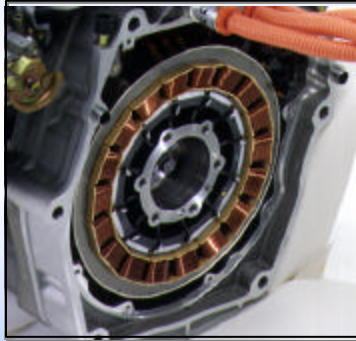
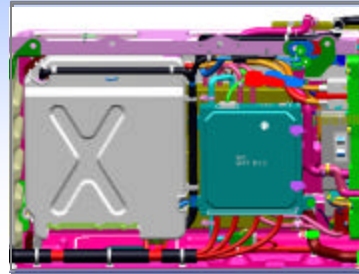
Integrated Electric Motor



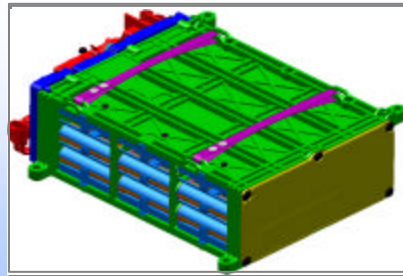
- Best "Idle" Quality: **Beats any Luxury Car!**
- Superior Driving Range: **Fewer Trips to the Station!**
- Low Operating Cost: **Fuel Savings!**
- Pride of Ownership: **Social Benefits!**

## *Future Hybrid Cost Reduction ?*

POWER ELECTRONICS



MOTOR-GENERATOR



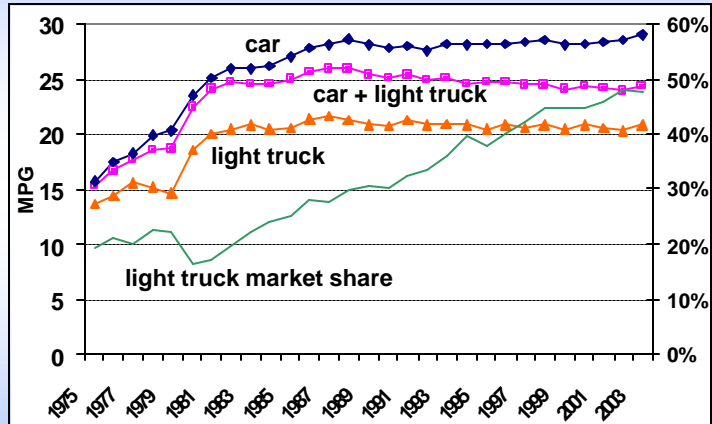
BATTERIES

## **Barriers to Achieving Potential Fuel Economy Increases**

- Tradeoff with other attributes
- Declining fuel cost
- Consumers versus society

# CAFE History

Historical combined car and light truck CAFE

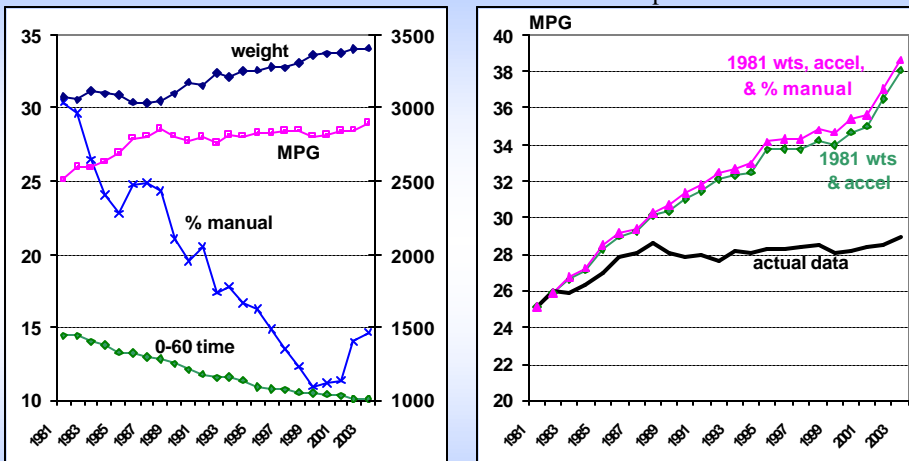


Since 1987:

- Car CAFE up 0.9 mpg, light truck CAFE down 0.8 mpg
- LDT market share increased from 28% to 48%
- Combined CAFE decreased by 1.5 mpg

# Effect of Attribute Tradeoffs - Cars

Car Data from EPA's 2003 FE Trends Report

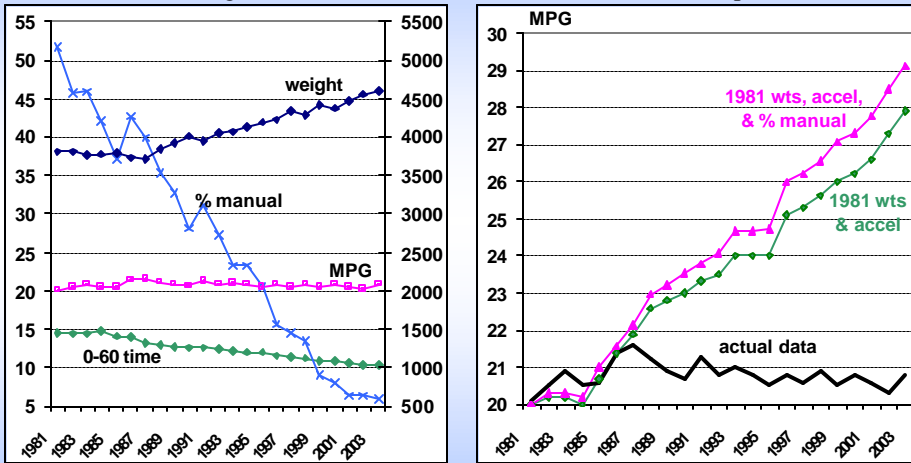


Fuel efficiency has increased by about 1.5% per year since 1987

However, this has all been used to increase other attributes more highly valued by the customer, such as performance, comfort, utility, and safety

# Effect of Attribute Tradeoffs - LDT

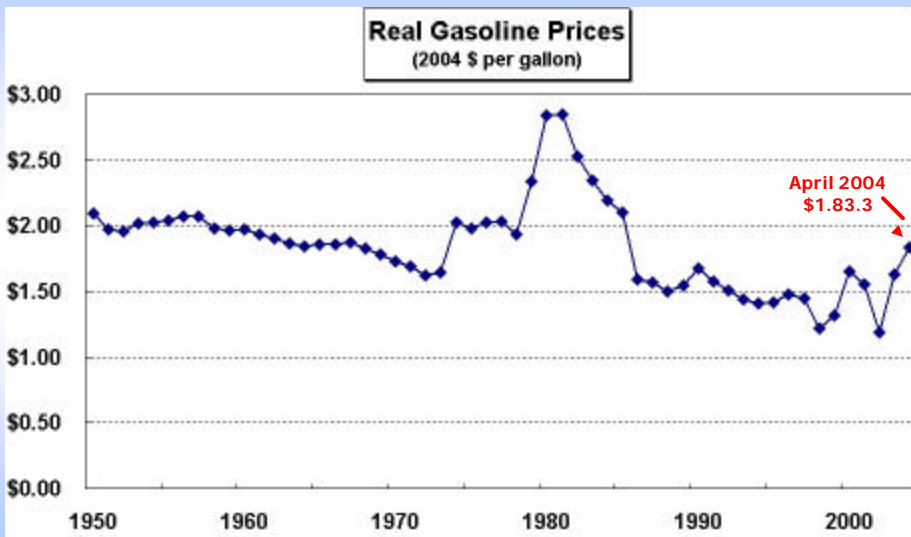
Light Truck Data from EPA's 2003 FE Trends Report



Fuel efficiency has increased by about 1.9% per year since 1987

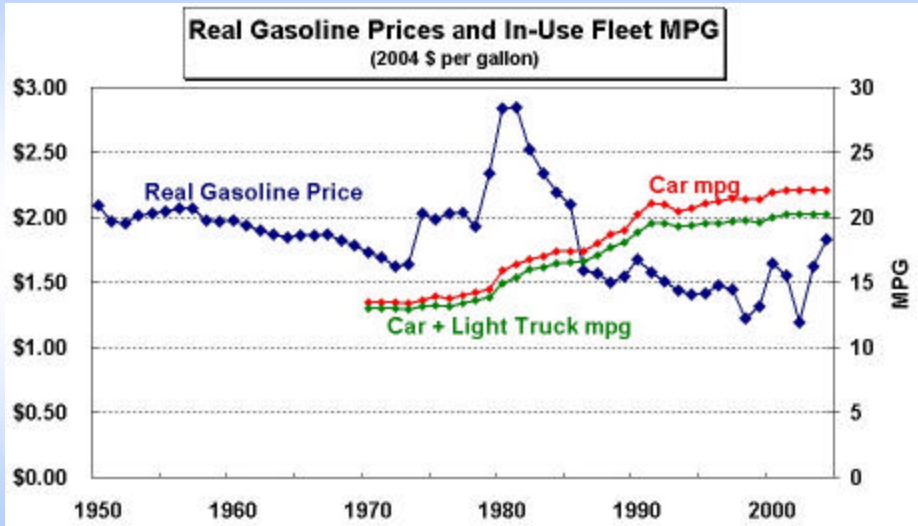
However, this has all been used to increase other attributes more highly valued by the customer, such as performance, comfort, utility, and safety

# Real Gasoline Price



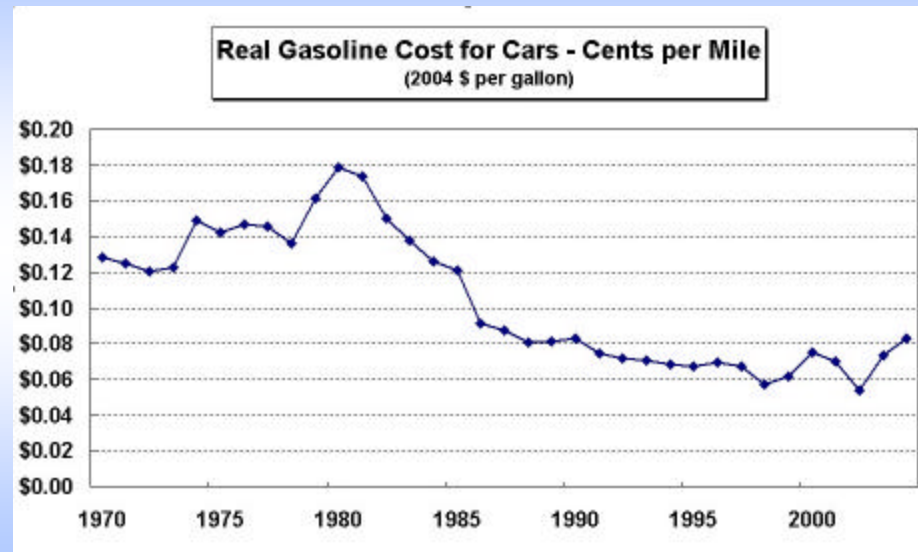
Motor Gasoline Regular Retail Prices, U.S. City Average, adjusted using CPI-U

# Fleet Fuel Economy

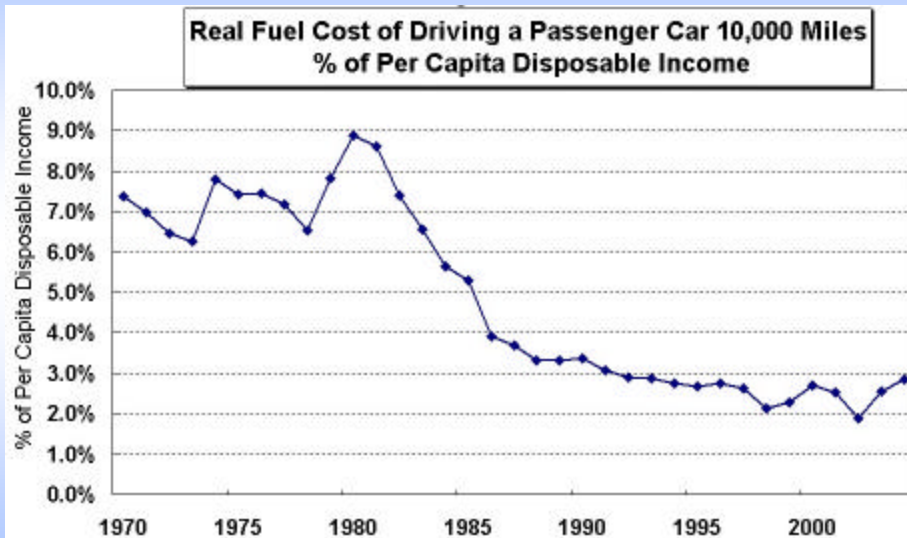


In-Use MPG from Transportation Energy Data Book: Edition 23, October 2003

# Gasoline Cost per Mile



## Real Fuel Cost - % of Disposable Income



Per Capita Disposable Income from BEA, Table 2.1, Personal Income and It's Disposition

## Willingness to Pay for FE

### J.D. Power Hybrid Vehicle Acceptance Study

March 6, 2002 Press Release

- Consumer interest in hybrid vehicles increases as gasoline prices rise
- 30% of buyers would “definitely” consider - another 30% indicate a strong consideration
- Of these, 1/3 would buy even if fuel cost savings during their ownership period would be less than the extra cost of the hybrid option

**2/3 would not pay more than fuel savings during ownership period**



## Customer Value of Hybrid Fuel Savings

(Savings for the first 50,000 miles @ U.S.\$1.80/gallon)

Hybrid fuel economy increase	Small car	Midsize car	Large truck
	34 mpg baseline	23 mpg baseline	14 mpg baseline
+ 20%	\$441	\$652	\$1,071
+ 40%	<b>\$756</b>	<b>\$1,118</b>	<b>\$1,837</b>
+ 80%	\$1,176	\$1,739	\$2,857

J.D.Power survey on hybrids found that “Consumers indicate a willingness to pay more – \$1,000 to \$1,500 – for a hybrid powertrain...”

## Technology Conclusions

- Technology is available to improve fuel economy
- Challenge is customer's low value of fuel economy
  - Real cost of driving very low
  - Other attributes (performance, utility, comfort, safety) valued more highly
  - Most customers only consider fuel savings during their period of ownership
- Hybrid technology is being widely promoted and is progressing rapidly
  - J.D. Power predicts over 20 hybrid vehicle models and sales of about 350,000 per year in 2008 (Oct 2003)
  - Cost is the key issue to be solved in order to sell to the mainstream mass market